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Journal of Transportation Management

Editorial Policy

The primary purpose of the JTM is to publish managerial and policy articles that are relevant to academics, policymakers, and practitioners in the transportation, logistics and supply chain fields. Acceptable articles could include conceptual, theoretical, legal, case, and applied research that contributes to better understanding and management of transportation and logistics. Saying that, our policy requires that articles be of interest to both academics and practitioners, and that they specifically address the managerial or policy implications of the subject matter. Articles that are strictly theoretical in nature, with no direct application to transportation and logistics activities, or to related policy matters, would be inappropriate for the *JTM*. Articles related to any and all types of organizations, and of local to global scope, will be considered for publication.

Acceptable topics for submission include, but are not limited to, broad logistics topics, logistics and transportation related legal issues, carrier management, shipper management of transportation functions, modal and intermodal transportation, international transportation issues, transportation safety, marketing of transportation services, transportation operations, domestic and international transportation policy, transportation economics, customer service, and the changing technology of transportation. Articles from related areas, such as third party logistics, purchasing and materials management, and supply chain management, are acceptable as long as they are related to transportation and logistics activities.

Submissions from practitioners, attorneys or policymakers, co-authoring with academicians, are particularly encouraged in order to increase the interaction between groups. Authors considering the submission of an article to the *JTM* are encouraged to contact the editor for help in determining relevance of the topic and material.

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From the Editor…

Welcome to the Summer, 2015 issue of the Journal of Transportation Management, being Vol. 26 No 1! This issue of the *Journal* starts with an article on the new U.S. Mexico Air Services Agreement, includes an article on logistics concepts in freight transportation modeling, moves on to an article on using visual data mining in highway traffic safety analysis and decision making, and concludes with an article on the dimensions of logistics service quality in an online B2c context.

The first article is an excellent overview of the new U.S.-Mexico Air services Agreement and the new opportunities it presents for carriers. The Agreement further elevates and strengthens the dynamic commercial and economic relationship between the United States and Mexico by facilitating greater trade and tourism. The second article reviews various models used in macro freight transportation modeling by transportation planning agencies. The review suggests that European freight models are more developed than North American freight models. The third manuscript examines the use of visual data mining in highway traffic safety analysis, with implications for truck safety analysis. The authors develop a visual data mining tool-kit that allows for understanding safety datasets and evaluating the effectiveness of safety policies. The fourth article reviews the literature on service quality and results in the identification of a set of key dimensions for measuring online logistics service quality in a B2C environment. This allows for development of a new scale for measuring online logistics service quality.

At the *Journal,* we are continuing to make a number of changes that will improve the visibility of JTM, and improve its position in the supply chain publishing world. These include registering and updating journal information with several publishing guides, placing the journal content with the EBSCO, Gale and JSTOR databases faculty have access to, and placing abstracts of all past journal articles on an open area of the Wayne State University Journal web page. Full journal article PDF's continue to be available to subscribers on the web page at www.business.wayne.edu/gscm

I look forward to hearing from you our readers with questions, comments and article submissions. The submission guidelines are included at the end of this issue's articles and I encourage both academics and practitioners to consider submitting an article to the Journal. Also included in this issue is a subscription form and I hope you will subscribe personally, and/or encourage your libraries to subscribe.

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Enhancing Competitiveness and Connectivity: The New US-Mexico Air Services Agreement

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ABSTRACT

Beginning this year, U.S. cargo and passenger airlines will have an opportunity to compete for a bigger share of freight trade and traffic between the U.S. and Mexico. This opportunity will occur as a result of the new Air Services Agreement (ASA) between the U.S. and Mexico that took effect in January, 2016. This ASA further elevates and strengthens the dynamic commercial and economic relationship between the United States and Mexico by facilitating greater trade and tourism. It is a key element of the U.S.-Mexico High Level Economic Dialogue (HLED) that aims to promote competitiveness and connectivity, foster economic growth, productivity and innovation, and partner for regional and global leadership (U.S. Department of State 2014). This paper (i) explains the genesis and impact of HLED, (ii) provides a brief historical perspective on air services agreements in general and freedoms of the air, (iii) summarizes the major principles of the previous US-Mexico ASA of 1960, as amended in 2005, (iv) outlines the essential elements of the new US-Mexico ASA that is scheduled to take effect in January 2016, (v) describes the likely effects of the new ASA on regional and global air cargo traffic and supply chains, and lastly (vi) provides some directions for future scholarly research.

INTRODUCTION

In commenting on this new air services agreement with Mexico, U.S. Transportation Secretary Anthony Foxx said (DOT 105-14, 2014):

> "Travelers, shippers, airlines, and the economies of both countries will benefit from competitive pricing and more convenient air service. This agreement is the result of the commitment on both sides of the border to strengthen the strong bonds of trade and tourism between our two countries, and demonstrate our shared commitment to a competitive, market-based international economic system."

The Secretary is alluding to the fact that the U.S. Department of State's Economic and Business Affairs Bureau reached an agreement, ad referendum, in November, 2014, on a new civil aviation agreement between the Governments of the United States of America and the United Mexican States. This agreement further elevates and strengthens U.S. and Mexico's dynamic commercial and economic relationship by facilitating greater trade and tourism. It is a key element of the US-Mexico High Level Economic Dialogue (HLED) that aims to promote competitiveness and connectivity, foster economic growth, productivity and innovation, and partner for regional and global leadership (U.S. Department of State, 2014). The new agreement will benefit U.S. and Mexican passenger and cargo airlines, airports, travelers, and businesses by allowing significantly increased market access for airlines to fly between any city in the U.S. and any city in Mexico.

This paper (i) explains the genesis and impact of HLED, (ii) provides a brief historical perspective on air services agreements in general and freedoms of the air, (iii) summarizes the major principles of the previous US-Mexico ASA of 1960, as amended in 2005, (iv) outlines the essential elements of the new US-Mexico ASA that is scheduled to take effect in January 2016, (v) describes the likely effects of the new ASA on regional and global air cargo traffic and supply chains, and lastly (vi) provides some directions for future scholarly research.

THE GENESIS OF HIGH LEVEL ECONOMIC DIALOGUE

The United States and Mexico share more than just a 2,000+ mile border. These strategic allies and critical economic partners also share a dynamic commercial relationship that generates over $500 billion in two-way trade that supports millions of jobs in both countries (International Trade Administration, 2015). Together with Canada, the U.S. and Mexico comprise one of the most competitive and successful regional economic trading platforms in the world. The success and sustained competitiveness of this trading bloc is dependent in large measure on continued and deepened economic and commercial cooperation, integration and policy alignment. To this end, the presidents of the U.S. and Mexico established the High Level Economic Dialogue (HLED). Presidents Obama and Nieto announced the creation of the HLED in May of 2013 (White House, 2014). Economic integration and bi-national cooperation seek to strengthen close and productive bilateral economic and commercial ties, enhance competitiveness, create additional trade and economic opportunities, and foster economic growth, productivity, entrepreneurship, and innovation all in an effort to position North America as the most competitive and dynamic trade region in the world.

The HLED is led at the cabinet level in the U.S., and was envisioned as a flexible mechanism intended to advance strategic economic and commercial priorities central to promoting mutual economic growth, job creation, and sustained global competitiveness.
The HLED is organized around three broad pillars: (i) promoting competitiveness and connectivity; (ii) fostering economic growth, productivity, and innovation; and (iii) partnering for regional and global leadership. The HLED is intended to build on, but not duplicate, existing successful bilateral dialogues. Further, the HLED's three pillars were selected to coordinate shared interests and priorities affecting the growth and competitiveness of the U.S. and Mexican economies, focusing on the areas in which collaboration can promote mutual prosperity. Each year, cabinet-level representative from each country meet to establish the next years' strategic goals and set the agenda for future cooperation. Priorities are set up annually and embarked upon in a cumulative fashion henceforth. One of the first priorities set during the first year of the HLED was the updating of the US-Mexico Air Services Agreement in order to foster the pursuit and realization of the goals set forth in the three pillars of the HLED.

The new Air Services Agreement (ASA) is borne from HLED. President Obama and President Nieto identified the updating of US-Mexico Air Services Agreement as a crucial strategic priority in HLED. Before we discuss the essential elements of the new ASA, it is important to provide a brief historical perspective of air services agreements in general for the reader to have an understanding of two core constructs: (i) freedoms of the air, and (ii) open skies.

AIR SERVICES AGREEMENTS: AN HISTORICAL PERSPECTIVE

Commercial aviation has always been hampered by national security and protectionist concerns. Traditionally, an airline needed the approval of the governments of the various countries involved before it could fly in or out of a country, or even fly over another country without landing. Prior to World War II, this did not present too many difficulties since the range of commercial planes was limited and air transport networks were in their infancy and nationally oriented. However, in 1944, an International Convention was held in Chicago (later to be referred to as the Chicago Convention) to establish the framework for all future bilateral and multilateral agreements for the use of international air space. But despite these agreements and the immense growth in international air traffic since World War, international commercial passenger and cargo transportation remains tangled in a thicket of protectionist legislation that most countries use to keep their airline markets closed or semi-closed to foreign airlines. The General Agreement on Trade in Services ("GATS") did not affect this as the GATS annex on air transport explicitly limits coverage of air services to only aircraft repair and maintenance, computer reservation systems, and the selling and marketing of air transportation (U.S. DOT, 2015).

There are of course some legitimate concerns that have been cited as justification for these protectionist restrictions, among them: (i) national development and economic interests, (ii) economic interests of national airlines, (iii) trade and tourism needs, (iv) aviation safety, (v) job creation and preservation, (vi) national security, (vii) foreign exchange earnings (Van Fenema (2002) citing the ICAO survey of Contracting States, May 2001). Therefore, the fact remains that "if there is any single serious barrier to achieving air transport liberalization, it is [national] airline ownership and control restrictions. Since the U.K. and the U.S. signed the first Bermuda agreement in 1946, the nationality clauses contained in virtually all bilateral ASAs have limited the companies designated to provide services to airlines owned and managed by nationals of the respective countries." (Chang et al., 2004).   The following paragraph summarizes the key points typically addressed in these agreements:

- "Bilateral agreements typically regulate carrier and route designations, capacity and frequency of services, pricing, and other commercial aspects of doing business. Bilateral agreements are based on the principle of reciprocity, an equal and fair exchange of rights between countries very different in size and with airlines of varied strength. Bilateral agreements vary in form, but they generally specify services and routes to be operated between the two countries, designate airlines and capacity to be provided by each airline, stipulate fare setting mechanisms, and specify conditions under which passengers may be taken or picked up in each country and flown to third countries (ûfth freedom rights). There is, at present, an extensive network of bilateral agreements. Each international airline faces a complex web of bilateral air services agreements signed by its home state. The existence of these bilateral agreements has greatly constrained the freedom of individual scheduled airlines, and limited competition in the international air transport industry," (Oum and Yu, 1998, Ch. 3).

The U.S. has taken the lead in recent years in trying to loosen some of these restrictions by pursuing various bilateral initiatives with other countries to further liberalize international commercial air traffic. Since 1992, the U.S. Department of Transportation's Office of International Aviation along with the U.S. Department of State, have pursued an "open-skies" policy designed to eliminate government involvement in airline decision-making about routes, capacity, and pricing in international markets (U.S. Department of Transportation, 2015). In summary:

- "Open skies agreements have vastly expanded international passenger and cargo flights to and from the United States, promoting increased travel and trade, enhancing productivity, and spurring high-quality job opportunities and economic growth. Open skies agreements do this by eliminating government interference in the commercial decisions of air carriers about routes, capacity, and pricing, freeing carriers to provide more affordable, convenient, and efficient air service for consumers . . . . By allowing air carriers unlimited market access to our partners' markets and the right to fly to all intermediate and beyond points, open skies agreements provide maximum operational flexibility for airline alliances. " (U.S. Department of State, 2015).

Currently, the U.S. has in force, or provisional, "Open Skies" bilateral aviation agreements with over 118 countries. In addition to bilateral open skies agreements, the U.S. has negotiated two multilateral open skies accords: (1) the 2001 Multilateral Agreement on the Liberalization of International Air Transportation (MALIAT) with New Zealand, Singapore, Brunei, and Chile, later joined by Samoa, Tonga, and Mongolia; and (2) the 2007 and 2010 "Open Skies Plus" Air Transport Agreement with the European Union and its 27 Member States. Table 1 reviews the U.S. Open Skies partners, either in force or provisional as of 2015.

The key goal of these open sky agreements is to expand the number of available "Freedoms of the Air" (Table 2 below).

Five freedom rights were initially designated and these first five freedoms were regularly exchanged between pairs of countries in ASAs. The remaining freedoms are the subject of newer open skies ASAs. Though in an ideal world, ASAs would provide all nine freedoms, in practice the eighth and ninth freedoms (both types of cabotage) are quite rare. So any agreement which includes at least the first seven freedoms is realistically as good as it gets.

THE PRIOR US-MEXICO AIR SERVICES AGREEMENT

The first ASA between the U.S. and Mexico came into force in August of 1960. At the outset, Mexico strived to protect its national airline, Aeromexico, from stiffened competition from numerous successful airlines based in the U.S. The agreement specified certain city-pairs, and limited to two the number of airlines in each country to fly between these city pairs. One popular Mexican destination, Acapulco, was limited to one airline. In 1977, the two countries renegotiated this provision and allowed a second airline to fly to this increasingly popular tourist destination in order to avoid any possibility of monopolizing this route. The air services agreement remained relatively unchanged over the next 18 years.

In 2005 the original agreement was amended to include the following city pair service agreements (these remain in effect through 2015):

- Each party (U.S. and Mexico) shall be entitled to designate two carriers with respect to routes between Mexico City (Benito Juarez International Airport) and the following cities: Chicago, Dallas/Ft. Worth, Dayton. Houston, Laredo, Miami, New York, and San Francisco.
- Each party (U.S. and Mexico) shall be entitled to designate three carriers with respect to routes between Mexico City (Benito Juarez International Airport) and Los Angeles.
- The carriers designated by the United States of America shall be permitted to operate air services from Dallas/Fort Worth and San Antonio to Mexico City, Toluca and Acapulco, and beyond to points in Panama and beyond; From New York, Washington, Baltimore, Los Angeles and Houston to Mexico City and Toluca, and beyond to a point or points in Central and/or South America.
- The airline or airlines designated by the Government of the United Mexican States shall be entitled to operate air services on each of the air routes specified, in both directions, and to make scheduled stops in the United States at the following: from Acapulco, Hermosillo, Mexico City, Toluca, Monterrey, Oaxaca, Puerto Escondido, Tampico, Veracruz, Villahermosa, and Zihuatanejo to Chicago, Kansas City, Minneapolis/St. Paul and St. Louis, and beyond to Canada; from Acapulco, Chihuahua, Guadalajara, Guaymas, Hermosillo, Huatulco, La Paz, Loreto, Manzanillo, Mazatlan, Mexico City, Toluca, Monterrey, Puerto Escondido, Puerto Vallarta, San Jose del Cabo, and Zihuatanejo to Cleveland, Detroit, Philadelphia, Washington, and Baltimore, and beyond to Canada; From Acapulco, Guadalajara, Huatulco, Loreto, Manzanillo, Mazatlan, Mexico City, Toluca, Monterrey, Puerto Vallarta, San Jose del Cabo, and Zihuatanejo to Boston and New York, and beyond to Europe; From Cancun, Cozumel,

TABLE 1
U.S. OPEN SKIES PARTNERS

Country	Application	Date
Netherlands	In force	1992
Belgium	Provisional	1995
Finland	In force	1995
Denmark	In force	1995
Norway	In force	1995
Sweden	In force	1995
Luxemburg	In force	1995
Austria	In force	1995
Iceland	In force	1995
Switzerland	in force	1995
Czech Republic	In force	1995
Germany	Provisional	1996
Jordan	In force	1996
Singapore	In force	1997
Taiwan	In force	1997
Costa Rica	In force	1997
El Salvador	In force	1997
Guatemala	In force	1997
Honduras	Provisional	1997
Nicaragua	In force	1997
Panama	In force	1997
New Zealand	In force	1997
Brunei	In force	1997
Malaysia	In force	1997
Aruba	In force	1997
Chile	In force	1997
Uzbekistan	In force	1998
Korea	In force	1998
Peru	In force	1998
Netherland Antilles	in force	1998
Romania	In force	1998
Italy	Provisional	1998
United Arab Emirates	In force	1999
Pakistan	In force	1999
Bahrain	In force	1999
Tanzania	Provisional	1999
Portugal	In force	1999
Slovak Republic	In force	2000
Namibia	C&R	2000
Burkina Faso	In force	2000
Turkey	In force	2000
Gambia	in force	2000

Nigeria	Provisional	2000
Morocco	In force	2000
Ghana	In force	2000
Rwanda	In force	2000
Malta	In force	2000
Benin	NA	2000
Senegal	In force	2000
Poland	In force	2001
Oman	In force	2001
Qatar	Provisional	2001
France	In force	2001
Sri Lanka	In force	2001
Uganda	In force	2002
Cape Verde	In force	2002
Samoa	In force	2002
Jamaica	In force	2002
Tonga	In force	2003
Albania	In force	2003
Madagascar	Provisional	2004
Gabon	In force	2004
Indonesia	C&R	2004
Uruguay	In force	2004
India	In force	2005
Paraguay	In force	2005
Maldives	In force	2005
Ethiopia	In force	2005
Thailand	In force	2005
Mali	In force	2005
Bosnia & Herzegovin	In force	2005
Cameroon	Provisional	2006
Cook Islands	In force	2006
Chad	Provisional	2006
Kuwait	In force	2006
Liberia	In force	2007
Canada	In force	2007
Bulgaria	Provisional	2007
Cyprus	Provisional	2007
Estonia	Provisional	2007
Greece	Provisional	2007
Hungary	Provisional	2007
Ireland	Provisional	2007
Latvia	Provisional	2007
Lithuania	Provisional	2007
Slovenia	Provisional	2007
Spain	Provisional	2007
United Kingdom	Provisional	2007
Georgia	In force	2007
Australia	In force	2008
Croatia	In force	2008
Kenya	In force	2008
Laos	In force	2008
Armenia	In force	2008
Zambia	In force	2010
Israel	In force	2010
Trinidad & Tobago	In force	2010
Barbados	NA	2010
Japan	In force	2010
Colombia	In force	2010
Brazil	NA	2010
Saudi Arabia	In force	2011
St. Kitts	In force	2011
Montenegro	In force	2011
Surinam	In force	2012
Sierra Leone	In force	2012
Macedonia	C&R	2012
Seychelles	C&R	2012
Yemen	C&R	2012
Guyana	C&R	2013
Bangladesh	C&R	2013
Botswana	In force	2013
Equatorial Guinea	In force	2014
Burundi	C&R	2014
Togo	In force	2015

Compiled from U.S. Department of State, May 29, 2015.
http://www.state.gov/e/eb/rls/othr/ata/114805.htm

TABLE 2
FREEDOMS OF THE AIR

First Freedom The negotiated right for an airline (from country (A) to overfly another country's (B) airspace.

Second Freedom The right for a commercial aircraft(from country (A) to land and refuel (commonly referred to(as a technical stop) in another country (B).

Third Freedom The right for an airline to deliver revenue passengers from the airline's home country (A) to another country (B).

Fourth Freedom The right for an airline to carry revenue passengers from another country (B) to the airline's home country (A).

Fifth Freedom (Sometimes referred to as beyond rights) The right for an airline to take passengers from its home country (A), deposit them at the destination (B) and then pick up and carry passengers on to other international destinations (C).

Sixth Freedom (Combination of Third & Fourth Freedoms) The right for an airline to carry passengers or cargo between two foreign countries (B and C), provided the aircraft touches down in the airline's home country (A).

Seventh Freedom The right for an airline to carry on flights that originate in a foreign country (B), bypass its home country (A), and deposit the passengers at another international destination (C).

Eighth Freedom The right for an airline to carry passengers from one point in the territory of a country (B) to another point within the same country on a flight that originates in the airline's home country (A). This freedom is also known as **cabotage**, and is extremely rare outside of Europe.

Ninth Freedom The right for an airline from a particular country (A) to originate a flight in a foreign country (B) and carry passengers from one point to another within the foreign country. This is also known as **stand alone cabotage.** It differs from the aviation definition of cabotage in that it does not directly relate to one's own country.

Guadalajara, Merida, Mexico City, Toluca and Monterrey to Houston and New Orleans, and beyond to Canada and Europe; From Guadalajara, Huatulco, Merida, Mexico City, Toluca and Oaxaca to Miami, and beyond.

Accordingly, after 2005, many city pairs allowed a third national carrier into service, but surprisingly, Mexico City remained at two. Mexico City stayed at two because they believed adding a third carrier would erode market share of Aeromexico. In response to the post-9/11 operating environment, which was characterized by heavy scrutiny and terror preparedness, the agreement was revised to require that pilots flying airlines between city pairs be permanent residents of the country they are flying from or to. Likewise, both countries were called upon to assist each other in their security provisions and procedures to ensure flights in and out of both countries were secure (U.S. Department of State, 2005).

The ASA, as amended in 2005, governed air services between the two countries for the next decade relatively untouched. Change was brought about by a new policy initiative between the two governments. This new initiative was a quest to strengthen the region as a trading bloc; pursue synergies and mutual economic prosperity; and enable innovation and global leadership.

THE NEW U.S.-MEXICO AIR SERVICES AGREEMENT

Negotiator Intentions and Interpretations

Delegations representing the U.S. and Mexican governments met in Mexico City on November 5-7, 2014, to conclude discussions and initialize a text of an agreement that would update and modernize the 1960 ASA, as amended in 2005 (U.S. Department of State, 2014). The delegates reaffirmed their resolve to promote a competitive international aviation system to facilitate the flow of passengers and goods. The delegates acted upon the identified importance of bilateral air transport relationships as codified in the U.S. HLED, and especially the HLED priority to promote competitiveness and connectivity through a modernized and updated air transport agreement. The delegates from each country intended to recommend to their respective governments that this text supersede the prior agreement.1 However, in discussing Article 2, Paragraph 2 (Grant of Rights), the delegations noted their mutual understanding that nothing in the new agreement grants cabotage rights. The text is subject to codifying by the corresponding authorities of each country.

Both delegations noted that any surface transportation company operating under Article 8, paragraph 8 (Commercial Opportunities), is subject to the laws, rules, and regulations that are applied on a reasonable and non-discriminatory basis and do not constitute an effective denial of the intermodal rights in the new Agreement. The delegations also noted their mutual understanding that the exercise of rights of airlines pursuant to Article 8, paragraph 8, to operate their own surface transportation within the territory of the other country for intermodal operations would be in accordance with the applicable international obligations, laws, rules, and regulations for surface transportation companies (U.S. Department of State, 2014).

Furthermore, with respect to Article 12, paragraph 2 (Pricing), both delegations expressed the expectation that the aeronautical authorities requesting pricing for informational purposes would seek to minimize the administrative burden on airlines of providing the requested information. The delegations noted that they expect airlines of both countries to comply with the regulations of either country concerning the filing of pricing information, as applied on a non-discriminatory basis, and any filings retained by the requesting aeronautical authority would not be made available to competing air carriers.

In discussing Article 18 (Entry into Force), the delegations noted that should the necessary internal processes of both countries be completed prior to January 1, 2016, the target date, the civil aeronautical authorities by mutual understanding might consider application of the new rights that will be available under the new Agreement and consistent with the applicable laws and regulations of each country.

Both delegations noted that the new agreement represents a significant step forward in the aviation relationship, creates opportunities in a new and modern pro-competitive environment, and sets the stage for substantial public benefits.

Essential Elements of the Agreement

A quick summary of the major objective of each of the 18 Articles of the new US-Mexico ASA" can be found in Appendix 1; while Appendix 2 includes the full text of the agreement. All the city pair provisions of the prior US-Mexico ASA as amended in 2005 became moot on January 1, 2016. That is, any airline can fly to any Mexican city from any American city, and vice versa. The new agreement states:

Route Schedule: Combination Services (Persons, Cargo and/or Mail)

1. The airline or airlines designated by the Government of the United States of America shall be entitled to operate combination air services on each of the air routes specified, in both directions, and to make scheduled stops in Mexico at the points specified in this paragraph:

a. From a point or points in the United States to a point or points in Mexico.

b. From Dallas/Fort Worth and San Antonio to Mexico City, Toluca, and Acapulco, and beyond to points in Panama and beyond.

c. From New York, Washington, Baltimore, Los Angeles, and Houston to Mexico City and Toluca, and beyond to a point or points in Central and/or South America.

d. From a point or points in the United States, via an intermediate point or points, to a point or points in Mexico, and beyond, as mutually agreed in writing by the aeronautical authorities of the Parties.

2. The airline or airlines designated by the Government of the United Mexican States shall be entitled to operate combination air services on each of the air routes specified, in both directions, and to make scheduled stops in the United States at the points specified in this paragraph:

a. From a point or points in Mexico to a point or points in the United States.

b. From Acapulco, Hermosillo, Mexico City, Toluca, Monterrey, Oaxaca, Puerto Escondido, Tampico, Veracruz, Villahermosa, and Ixtapa/Zihuatanejo to Chicago, Kansas City, Minneapolis/St. Paul, and St. Louis, and beyond to Canada.

c. From Acapulco, Chihuahua, Guadalajara, Guaymas, Hermosillo, Huatulco, La Paz, Loreto, Manzanillo, Mazatlan, Mexico City, Toluca, Monterrey, Puerto Escondido, Puerto Vallarta, San Jose del Cabo, and Ixtapa/Zihuatanejo to Cleveland, Detroit, Philadelphia, Washington, and Baltimore and beyond to Canada.

d. From Acapulco, Guadalajara, Huatulco, Loreto, Manzanillo, Mazatlan, Mexico City, Toluca, Monterrey, Puerto Vallarta, San Jose del Cabo, and Ixtapa/Zihuatanejo to Boston and New York, and beyond to Europe.

e. From Cancun, Cozumel, Guadalajara, Merida, Mexico City, Toluca, and Monterrey to Houston and New Orleans, and beyond to Canada and Europe.

f. From Guadalajara, Huatulco, Merida, Mexico City, Toluca, and Oaxaca to Miami, and beyond.

g. From a point or points in Mexico, via an intermediate point or points, to a point or points in the United States, and beyond, as mutually agreed in writing by the aeronautical authorities of the Parties.

3. Without limitation, airlines of each Party may enter into cooperative marketing arrangements with an airline or airlines of either Party, or of a third country, to provide scheduled combination services to intermediate points and to points behind or beyond the territory of either Party.

Accordingly, the new agreement with Mexico provides the first seven freedoms of the air including unlimited market access for U.S. and Mexican air carriers, improved intermodal rights, pricing flexibility, and other important commercial rights (DOT 105-14, November 21, 2014). The ASA will remove the numerical limitations on the number of airlines that may provide passenger service in all Mexico-U.S. city pairs. Beginning January 1, 2016, any airline may serve any city. Many markets could see the entrance of new carriers for the first time in many years. Additionally, some carriers are likely to start to serve markets that were heretofore denied or unavailable. “Travelers, shippers, airlines, and the economies of both countries will benefit from competitive pricing and more convenient air service," said U.S. Transportation Secretary Anthony Foxx (DOT 105-14, 2014). "This agreement is the result of the commitment on both sides of the border to strengthen the strong bonds of trade and tourism between our two countries, and demonstrate our shared commitment to a competitive, market-based international economic system."

In addition to the international city pairs, if new airlines enter markets they had previously not served, a natural expansion of hub and spoke services is sure to follow. The new agreement could also positively impact some connecting services deeper into Latin America and also within the U.S. market. Larger airports in states such as Florida, Texas, California and Arizona are likely to see the most changes although the expansion would also impact existing large hubs such as Chicago, New York, Atlanta, Denver and others. Each designated airline has the right to set up operations in the other country for operational, ticketing and support purposes, including ground-handling.

THE EFFECT OF THE NEW ASA ON AIR CARGO TRAFFIC AND SUPPLY CHAINS

Though the new ASA is undoubtedly a bonanza for passenger traffic between the U.S. and Mexico, we would like to focus here on the effect of the new agreement on air cargo and global supply chains. The new agreement states:

- Route Schedule: All-Cargo Services (Cargo and/or Mail)

1. The airline or airlines designated by the Government of the United States of America shall be entitled to operate all-cargo air services on each of the air routes specified, in both directions, and to make scheduled stops in Mexico at the points specified in this paragraph:

    a. From a point or points in the United States, via an intermediate point or points, to a point or points in Mexico, and beyond.

    b. From a point or points in Mexico to any point.

2. The airline or airlines designated by the Government of the United Mexican States shall be entitled to operate all-cargo air services on each of the air routes specified, in both directions, and to make scheduled stops in the United States at the points specified in this paragraph:

    a. From a point or points in Mexico, via an intermediate point or points, to a point or points in the United States, and beyond.

    b. From a point or points in the United States to any point.

3. Without limitation, airlines of each Party may enter into cooperative marketing arrangements with an airline or airlines of either Party, or of a third country, to provide scheduled all-cargo services to intermediate points and to points behind or beyond the territory of either Party.

Thus, cargo carriers will see numerous expanded possibilities, including opportunities to provide service to destinations that were not available under the current agreement, and to offer services from the U.S. to Mexico and further to other countries beyond Mexico. This "stretching" of the supply chain as a consequence of the new ASA is pregnant with potential. Not only do carriers stand to gain by serving new markets, but shippers stand to gain as well by reaching distant markets through Mexico, while maintaining supply chain visibility.

Air cargo, despite being the most expensive form of cargo transportation, has boomed in the last few decades. Global air cargo has increased from 16,150 Cargo Revenue Ton-Miles (in millions) in 1991 to 64,875 in 2014 (U.S. DOT – Bureau of Transportation Statistics, 2015). There are many reasons for this, among them: (i) the need to reduce inventories and cut down the time it takes to move products to market, especially those products with shorter product life spans and subject to just-in-time (JIT) supply chain pressures (e.g., consumer electronics, pharmaceuticals, and designer clothes); (ii) the speed of air transportation over long distances is necessary for goods subject to spoilage (e.g. fresh cut flowers), goods requiring next morning delivery (e.g. newspapers); (iii) air transportation's lower risk of losing or damaging shipments is an advantage because the cargo has a high ratio of value to size, i.e., air cargo charges for these valuable and time-sensitive goods are usually small in comparison with the value of the items; (iv) wherever total distribution cost (TDC) framework suggests minimum TDC can be achieved by using air cargo because inventory costs are very high relative to freight costs (Zhang, and Zhang 2002).

Air cargo is even more dependent on the fifth and seventh freedoms than passenger traffic. Since time immemorial, international trade routes are logistically better in triangles or wider networks of stops. Cargo is also different from passenger traffic in two other critical ways:

- First, whereas humans prefer to fly non-stop to their destination, and if a transfer is needed, they prefer the waiting time at the hub airport to be as short as possible in an attractive airport environment (see, e.g., Carlton et al., 1980), cargo is relatively indifferent to such preferences . . . . More critically, cargo flows are unbalanced, or ''unidirectional,'' e.g., much more flows from Asia to the US than from the US to Asia. By contrast, passenger air travel is more balanced - passengers tend to make a two-way journey (from home to destination and back again). As a result, all-cargo carriers sometimes design their networks with ''big circle'' routes.

The fifth and seventh freedoms are necessary to make these "big circle" routes and any route with multiple stops to take on and discharge air cargo in different countries. The fifth freedom ("beyond rights") means that for example a U.S. carrier could fly cargo from Chicago to Mexico City, unload, and then pick up cargo in Mexico City and transport it to Buenos Aires. This would allow carriers to consolidate air freight shipments heading to Mexico and points further south in Central and South America more efficiently. The World Air Cargo Forecast predicts air cargo growth in the Latin America - Europe and Latin America - North America flows to exceed the world average at 4.8% and 5.2% growth respectively over the next twenty years. And not surprisingly Mexico is the U.S. and Canada's largest Central American air trade partner and accounted for more than half of the air cargo tonnage shipped between North America and Central America. See Tables 3 and 4 below for summary information on these flows.

However, the air cargo market that has seen the fastest recent growth has undoubtedly been air express. International express traffic grew at nearly triple the rate of total worldwide air cargo traffic, averaging more than 22% annually from 1992 to 2000, as measured in revenue ton-kilometers (RTK). After more moderate growth in the early 2000s and a steep but temporary decline after the economic crisis of 2008, the upward trend continued in 2012 and 2013 with 8.9% and 5.8% growth respectively. And two U.S. giants continue to dominate the global air express market - UPS and FedEx with 19.6% and 14.2% global market shares each in 2014. The seventh freedom rights (third country hubbing rights) could allow UPS and FedEx to set up intermodal mini-hubs in Mexico to service the Central and South American air express market and link them to their ground delivery business.

Stronger Connectivity Creates Enhanced Competitiveness

One primary pillar of HLED is enhanced competitiveness and stronger connectivity. It is fitting that the first major public policy initiative to that end was modernizing the U.S.-Mexico Air Services Agreement. The new ASA will facilitate enhanced competitiveness as astute carriers and shippers will have greater access to enrich their supply chain connectivity and competitiveness. Yuan, et al. (2010) found support for the notion that there potentially exists both an accelerator effect and a multiplier effect between and amongst investments in international airports and air cargo supply chains' performance. Thus, not only do carriers and shippers stand to gain, but infrastructure partners as well (Murphy et al. (1989)). For instance, with the loosening of the city pairs restrictions, many markets never served or underserved under the original and modified ASA have the potential to see both passenger and cargo traffic drastically increase.

Air cargo enables nations, regardless of location, to efficiently connect to distant markets and global supply chains in a speedy, reliable manner (Kasarda and Green, 2005). Thus, cargo carriers are likely to applaud the developments in the agreement. As a result, this Agreement will benefit passengers, cargo carriers, and the economies of both countries. Importantly, the new ASA meets other goals and directives of the HLED. The dialogue continues a proactive approach to strengthen transportation initiatives in meeting the goals and directives of the HLED policy initiative (White House, 2015).

DIRECTIONS FOR FUTURE RESEARCH AND CONCLUSIONS

One research arena ripe with potential is to model the new networks bound to develop once the city pair restrictions are lifted. Hub and spoke network prediction can be fruitful in first determining the critical explanatory variables and in predicting the new market entries by the carriers, and in identifying potential opportunities for supply chain expansion. Furthermore, how will the astute shipper respond to a more liberal ASA in extending its supply chain and/or in creating a more visible supply network where control is paramount? The new ASA ought to provide the ability to increase that visibility and control via new freedoms. Thus, another promising research avenue is in the identification of those drivers and enablers, or conversely, will newly unidentified impediments arise?

The likely outcomes of the new ASA are far-reaching. More liberalized trade policies are likely to lead to stronger supply chain networks across North America, advancing the realization of one tenet of the HLED: to position North America as one of the strongest trading blocs in the world. The new ASA will likely impact other bilateral and multilateral air services agreements across the globe in an effort to modernize and contemporize policy and practice. By enhancing both connectivity and competitiveness, the new ASA will likely provide a benchmark for other HLED and trade initiatives in the future.

The ASA will become effective on January 1, 2016. It is more than just a tactical initiative designed to strengthen partnerships and enhance the countries' collective and individual economies, it is a testament to the valence of the HLED as a policy driver. Parilla and Berube (2013) argue that to be successful the HLED must include sub-national leaders, not merely cabinet-level decision-making. Furthermore, they advocate involvement for metropolitan and civil leaders in the cities that drive each nation's GDP. This leads to a call for treating Mexico as a partner rather than a competitor in production manufacturing and a commitment to shared production. The U.S. must embrace Mexico if the U.S. is to realize its vision of a "production renaissance (Parill and Berube, 2013). Consequently, the benefits stemming from a liberalized ASA should be bilateral, and synergistic. The US-Mexico Air Service Agreement is a robust proving ground for the HLED.

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TABLE 3
LATIN AMERICA-NORTH AMERICA AIR CARGO TRADE SUB-REGIONS

South America	Central America	Caribbean
1,036,000 tons	265,000 tons	75,000 tons
Chile 23.9%	Mexico 52.7%	Dominican Republic 36.8%
Colombia 23.4%	Costa Rica 18.23%	Turks & Caucos Island 36%
Brazil 18.5%	Guatemala 8.98%	Trinidad & Tobago 8.4%
Peru 13.1%	Panama 6.02%	St. Vincent/Grenadines 6.2%
Ecuador 6.9%	Honduras 5.15%	Jamaica 4.3%
Argentina 6.2%	Nicaragua 4.48%	Between 1-2% each:
Venezuela 4.8%	El Salvador 4%	Bahamas, Barbados, Grenada
Less than 1% each:	Less than 1%: Belize	Haiti, Saint Maarten
Bolivia, Falkland Islands		Less than 1% each:
Islas Malvinas, French		Anguilla, Aruba, Antigua &
Guiana, Guyana, Paraguay		Barbuda, Bermuda, British
Surname, Uruguay		Virgin islands, Cuba, Curacoa,
		Dominica, Cayman
		Islands, Saint Lucia,
		Guadalupe, Montinegro,
		Montserrat

Percentages represent each country's share of tonnage.

(World Air Cargo Forecast, 2014-2015)

TABLE 4
LATIN AMERICA - NORTH AMERICA COMMODITITY PERCENTAGES

Northbound	Southbound
830,000 Tons	549,000 Tons
Flowers 26.2%	Industrial and specialized machinery 57.2%
Fish 23.3%	Small package and shipments 9.7%
Vegetables 18.4%	Computers 9.3%
Small package and shipments 15.1%	Ferrous products 5.6%
Fruits 6%	Electrical machinery 4.3%
Other 6%	Automotive 4.3%
	Chemical 3.5%
	Telephones 3.2%
	Other 3%

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APPENDIX 1
ANNEX I
ESSENTIAL ARTICLES OF THE NEW US-MEXICO ASA*

Article 1	**Definitions**	Legal nomenclature established
Article 2	**Grant of Rights**	Reciprocal rights granted from one party to the other (e.g., Freedoms of the Air)
Article 3	**Designation & Authorization**	Each country may designate as many airlines as it wishes to conduct international air transport with this Agreement. Process of other party agreeing to designation and provisions that must be met.
Article4	**Revocation of Authorization**	Conditions outlined for either party to revoke, suspend, or limit operating authorizations.
Article 5	**Application of Laws**	Specifies laws and regulations adhered to by parties in each pothers' respective countries.
Article 6	**Safety**	Establishes safety recognitions standards and compliance (e.g., certificates of airworthiness, certificates of competency, and licenses issued or validated).
Article 7	**Aviation Security**	The Parties affirm that their obligation to each other to protect the security of civil aviation against acts of unlawful interference forms an integral part of this Agreement. Without limiting the generality of their rights and obligations under international law, the Parties shall in particular act in conformity with the provisions of the Convention on Offenses and Certain Other Acts Committed on Board Aircraft, done at Tokyo September 14, 1963, the Convention for the Suppression of Unlawful Seizure of Aircraft, done at The Hague December 16, 1970, the Convention for the Suppression of Unlawful Acts against the Safety of Civil Aviation, done at Montreal September 23, 1971, the Protocol for the Suppression of Unlawful Acts of Violence at Airports Serving International Civil Aviation, Supplementary to the Convention for the Suppression of Unlawful "Acts against the Safety of Civil Aviation, done at Montreal February 24, 1988, and the Convention on the Marking of Plastic Explosives for the Purpose of Detection, done at

		Montreal March 1, 1991, as well as any other convention relating to the security of civil aviation that is in force for both Parties
Article 8	**Commercial Opportunities**	Rights to establish offices in each others' country. Rights to bring in staff and support. Operational provisions established.
Article 9	**Customs Duties & Charges**	Specifies exemptions.
Article 10	**User Charges**	Ensures fairness and equitable treatment vis-à-vis charges.
Article 11	**Fair Competition**	Ensures fair and equal opportunity for the airlines of both parties to compete in providing the international air transport governed by this Agreement.
Article 12	**Pricing**	No filings required. Access defined.
Article 13	**Consultations**	Consultations within 60 day limit upon request by one party.
Article 14	**Amendments**	Agreement may be amended in writing, taking effect 30 days' post given diplomatic processes followed.
Article 15	**Settlement of Disputes**	Establishes arbitration and arbitral tribunal
Article 16	**Termination**	Identifies process and appropriate governing body notifications.
Article 17	**Registration with ICAO**	This Agreement and all amendments will be registered with the International Civil Aviation Organization
Article 18	**Entry Into Force**	Date of January 1, 2016 and shall supersede the Agreement signed at Mexico, August 15, 1960, as amended.

* For a complete copy of the new ASA, please contact the lead author at: Astapleton@uwlax.edu or 608-785-6667

APPENDIX 2
ANNEX II
FULL TEXT OF THE NEW US-MEXICO AVIATION AGREEMENT

SCHEDULED AIR TRANSPORTATION

A. Route Schedule: Combination Services (Persons, Cargo and/or Mail)

1. The airline or airlines designated by the Government of the United States of America shall be entitled to operate combination air services on each of the air routes specified, in both directions, and to make scheduled stops in Mexico at the points specified in this paragraph:

   a. From a point or points in the United States to a point or points in Mexico.

   b. From Dallas/Fort Worth and San Antonio to Mexico City, Toluca, and Acapulco, and beyond to points in Panama and beyond.

   c. From New York, Washington, Baltimore, Los Angeles, and Houston to Mexico City and Toluca, and beyond to a point or points in Central and/or South America.

   d. From a point or points in the United States, via an intermediate point or points, to a point or points in Mexico, and beyond, as mutually agreed in writing by the aeronautical authorities of the Parties.

2. The airline or airlines designated by the Government of the United Mexican States shall be entitled to operate combination air services on each of the air routes specified, in both directions, and to make scheduled stops in the United States at the points specified in this paragraph:

   a. From a point or points in Mexico to a point or points in the United States.

   b. From Acapulco, Hermosillo, Mexico City, Toluca, Monterrey, Oaxaca, Puerto Escondido, Tampico, Veracruz, Villahermosa, and Ixtapa/Zihuatanejo to Chicago, Kansas City, Minneapolis/St. Paul, and St. Louis, and beyond to Canada.

   c. From Acapulco, Chihuahua, Guadalajara, Guaymas, Hermosillo, Huatulco, La Paz, Loreto, Manzanillo, Mazatlan, Mexico City, Toluca, Monterrey, Puerto Escondido, Puerto Vallarta, San Jose del Cabo, and Ixtapa/Zihuatanejo to Cleveland, Detroit, Philadelphia, Washington, and Baltimore and beyond to Canada.

   d. From Acapulco, Guadalajara, Huatulco, Loreto, Manzanillo, Mazatlan, Mexico City, Toluca, Monterrey, Puerto Vallarta, San Jose del Cabo, and Ixtapa/Zihuatanejo to Boston and New York, and beyond to Europe.

   e. From Cancun, Cozumel, Guadalajara, Merida, Mexico City, Toluca, and Monterrey to Houston and New Orleans, and beyond to Canada and Europe.

   f. From Guadalajara, Huatulco, Merida, Mexico City, Toluca, and Oaxaca to Miami, and beyond.

g. From a point or points in Mexico, via an intermediate point or points, to a point or points in the United States, and beyond, as mutually agreed in writing by the aeronautical authorities of the Parties.

3. Without limitation, airlines of each Party may enter into cooperative marketing arrangements with an airline or airlines of either Party, or of a third country, to provide scheduled combination services to intermediate points and to points behind or beyond the territory of either Party.

B. Route Schedule: All-Cargo Services (Cargo and/or Mail)

1. The airline or airlines designated by the Government of the United States of America shall be entitled to operate all-cargo air services on each of the air routes specified, in both directions, and to make scheduled stops in Mexico at the points specified in this paragraph:

   a. From a point or points in the United States, via an intermediate point or points, to a point or points in Mexico, and beyond.

   b. From a point or points in Mexico to any point.

2. The airline or airlines designated by the Government of the United Mexican States shall be entitled to operate all-cargo air services on each of the air routes specified, in both directions, and to make scheduled stops in the United States at the points specified in this paragraph:

   a. From a point or points in Mexico, via an intermediate point or points, to a point or points in the United States, and beyond.

   b. From a point or points in the United States to any point.

3. Without limitation, airlines of each Party may enter into cooperative marketing arrangements with an airline or airlines of either Party, or of a third country, to provide scheduled all-cargo services to intermediate points and to points behind or beyond the territory of either Party.

C. Operational Flexibility for Combination and All-Cargo Services

1. For all services authorized under Paragraphs A and B of this Annex, each of the designated airlines is permitted, at its option, to:

   a. operate flights in either or both directions;

   b. combine different flight numbers within one aircraft operation;

   c. serve behind, intermediate, and beyond points and points in the territories of the Parties in any combination and in any order;

   d. omit stops at any point or points;

   e. transfer traffic from any of its aircraft to any of its other aircraft at any point;

f. serve points behind any point in its territory with or without change of aircraft or flight number and hold out and advertise such services to the public as through services;

g. make stopovers at any points whether within or outside the territory of either Party;

h. carry transit traffic through the other Party's territory; and

i. combine traffic on the same aircraft regardless of where such traffic originates;

without directional or geographic limitation and without loss of any right to carry traffic otherwise permissible under this Agreement; provided that, with the exception of all-cargo services, the transportation is part of a service that serves a point in the homeland of the airline.

2. Neither Party shall impose unilateral restrictions on an airline or airlines of the other Party with respect to capacity, frequencies, or type of aircraft employed in any service authorized in Paragraph A or B of this Annex.

3. Airlines of either Party designated to serve Baltimore may hold out, sell and provide services to Baltimore as services to Washington. Similarly, airlines of either Party designated to serve Washington may hold out, sell and provide services to Washington as services to Baltimore.

4. Airlines of either Party designated to serve Cuernavaca, Toluca, Puebla, or Queretaro may hold out, sell and provide all-cargo services to or from Mexico City. Airlines of either Party designated to serve Toluca may hold out, sell and provide combination services to or from Mexico City. This subparagraph shall not be construed to authorize air services not otherwise authorized to or from Benito Juarez International Airport.

CHARTER AIR TRANSPORTATION

Section 1

A. Airlines of each Party shall have the right to carry, in both directions, international charter traffic of passengers (and their accompanying baggage) and/or cargo (including, but not limited to, freight forwarder, split, and combination (passenger/cargo) charters):

1. For passenger and combination services,

   a. between any point or points in the territory of a Party and any point or points in the territory of the other Party; and

   b. from a point or points in the territory of a Party, via an intermediate point or points, to any point or points in territory of the other Party, and beyond, as mutually agreed in writing by the aeronautical authorities of the Parties, provided that such service constitutes part of a continuous operation, with or without a change of aircraft, that includes service to the homeland for the purpose of carrying local traffic between the homeland and the territory of the other Party.

2. For all-cargo services, between any point or points in the territory of a Party and any point or points in the territory of the other Party, and beyond, and between a point or points in the territory of the other Party and any point or points in a third country or countries.

B. For all services authorized under Paragraph A, in the performance of services covered by this Annex, airlines of each Party shall also have the right: (1) to make stopovers at any points whether within or outside of the territory of either Party; (2) to carry transit traffic through the other Party's territory; (3) to combine on the same aircraft traffic originating in one Party's territory, traffic originating in the other Party's territory, and traffic originating in third countries; and (4) to perform international air transportation without any limitation as to change, at any point on the route, in type or number of aircraft operated; provided that, except with respect to cargo charters, in the outbound direction, the transportation beyond such point is a continuation of the transportation from the territory of a Party and in the inbound direction, the transportation to the territory of a Party is a continuation of the transportation from beyond such point.

C. Each Party shall extend favorable consideration to applications by airlines of the other Party to carry traffic not covered by this Annex on the basis of comity and reciprocity.

Section 2

A. Either Party may require an airline of either Party performing international charter air transportation originating in the territory of either Party, whether on a one-way or round-trip basis, to comply with the administrative procedures applicable to charter operations in the country of origin of the operation, provided that such procedures do not limit the rights provided for in section 1 of this Annex. In the application of such administrative procedures, the Parties will grant to airlines treatment no less favorable than that given to its own airlines or airlines of other countries that provide similar international service.

B. However, nothing contained in the above paragraph shall limit the rights of either Party to require airlines to adhere to requirements relating to the protection of passenger funds and passenger cancellation and refund rights.

Section 3

Except with respect to the consumer protection rules referred to in the preceding paragraph, neither Party shall require an airline of the other Party, in respect of the carriage of traffic from the territory of that other Party or, in the case of cargo services, of a third country on a one-way or round-trip basis, to submit more than a declaration of conformity with the applicable laws, regulations and rules referred to under section 2 of this Annex or of a waiver of these laws, regulations, or rules granted by the applicable aeronautical authorities.

LOGISTICS CONCEPTS IN FREIGHT TRANSPORTATION MODELING

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ABSTRACT

The purpose of this paper is to review logistics concepts used in macro freight transportation modeling by various planning agencies at the national, state and city level. The chronological development of freight modeling endeavors are studied here and the logistics component incorporated in the modeling is identified. The key modeling tools are identified and analyzed to identify the efficacy of the model, ease of use, and data required to implement the model. The conclusion was that European freight models were more developed than North American freight models. The tools most widely used are the aggregate-disaggregate-aggregate model, input-output model, artificial neural network model, matrix estimation method and PCOD model. This paper will give transportation modelers a better idea of the freight modeling tools available.

INTRODUCTION

Macro freight modeling is an integral part of transportation planning, undertaken by government agencies and metropolitan organizations to estimate present and future transportation demand. Freight modeling has undergone major developments and transformations since its inception to suit the dynamic nature of transport modeling. A significant amount of knowledge has been added over time with the goal of connecting the various stages of freight transport modeling including: production and consumption, trade (sales and sourcing), logistics, transport, and network services (Tavasszy, 2006). Traditionally, the four stages, in passenger transport modeling have been linked to research and studies in freight modeling. It is generally observed that a significant number of freight models, both regional and national, fail to incorporate real life logistics dimensions (e.g. distribution centers) into their framework (Jong et al., 2005). The term logistics includes all activities related to planning and implementing the movement of raw materials, inventory and finished goods from origin to final destination. The logistics decision making process includes inventory control, material handling, ordering processes, plant and warehouse selection, mode choice, and warehouse and storage decisions. It is understood that all these varied decision can be taken in isolation or may be related to each other. A review of existing literature on freight modeling found significant research on mode choice of freight shipments, but not much research on selections of distribution center, warehouse, and in some cases intermodal terminals. Business entities' logistics decisions are dynamic and constantly updated based on input from external agents, including: transportation rates of competing modes, change in demand, price fluctuation, availability of raw materials, and numerous other factors in the business environment.

Observed increases in world population and rapid globalization have fueled growth in U.S. trade from $889 billion to $3.4 trillion between 1990 and 2008 (BTS, 2010). This growth in trade is reflected by increased volumes of freight at U.S. freight gateways and corresponding domestic connections. Considering the economic growth witnessed in recent years, it is unreasonable to model future freight demand in a satisfactory manner without incorporating logistics dimensions in the freight model (Jin et al., 2005). Freight forecasting models, indeed, need to incorporate logistics factors in the modeling process. However, a review of existing research revealed that most of the models need considerable development in this area. It is widely understood that incorporating some of these logistics decisions in the modeling framework can be extremely challenging given that these factors are specific to individual business entities. The data requirement can be immense even if a small sample size is used in a study. In order to implement a logistics model, there is a need to develop a much higher resolution data base for production, attraction, distribution and storage location of individual commodities or commodity groups. The logistics model will not only determine the origin, destination, and intermediaries, but it will also identify the mode of transport most suitable for moving the freight. In urban freight models, mode choice is not a significant issue since the majority of the freight moves by trucks.

Based on data availability and degree of accuracy required, different researchers have used different mathematical models to predict freight flow. This paper aims to present a holistic view of the importance of incorporating logistics into the freight modeling process. This is done by reviewing existing logistics concepts, followed by reviewing existing freight logistics models in Europe and the United States. Special attention is given to identify mathematical models employed to incorporate logistics concepts into freight modeling. We have also looked into data requirements in each of the freight models that do incorporate logistics dimensions.

FREIGHT MODELING CONCEPTS AND EMERGING ISSUES

Commodity and Trip Based Models

Freight modeling, can be broadly classified into two categories namely trip-based and commodity-based models (Holguin-Veras and Thorson, 2003). In trip-based models truck trips are estimated from observed parameters like the number of employees in an organization, floor area of the organization, sales volume and other related factors. In the trip-based approach, commodities produced and consumed are not considered for estimation purpose. The commodity-based approach estimates the quantity of a commodity that is moved between each origin-destination (OD) pair. In the final stage of the modeling, the commodity flows are converted into truck trips, based on the type of vehicle used and the corresponding payload of those vehicles. Some modelers prefer the trip based model, because the trip based model needs fewer data elements compared to the commodity based model. The data needed for trip based modeling is obtained from a survey of truck trips. The main disadvantage of the trip based model is its disconnection with the economy. This disconnection makes it difficult to forecast, based on economic growth.

Commodity based modeling can forecast truck traffic based on economic growth and other parameters of production and consumption of goods and services. The principal drawback of commodity based modeling is its inability to capture the behavioral content of freight flows. The other disadvantage is the detailed input-output data requirements to model the flows.

Logistics Cost Optimization and Simulation Models

There are a number of logistics models which can be used for cost optimization to estimate freight flows. One of these classes of model is known as the economic order quantity (EOQ) model. In this model the optimal lot size is determined, which in turn will affect the type of vehicle used for delivery as well as the number of annual shipments. The EOQ model estimates the optimal order quantity as $Q = \sqrt{2DS / hC}$ where Q is the optimal lot size, D is the annual demand; S is the ordering cost per lot; h is holding cost; and C is the cost per item. There can be a number of modifications of this basic EOQ model based on specific business scenarios. This model can be modified for number of items included in one order. The order frequency in this case is defined as $n = \sqrt{(D_1C_1h + D_2C_2h + \cdots\cdots + D_nC_nh) / 2S}$ where D_n is the demand of n^{th} item, and C_n is the cost of n^{th} item. The other modification of the base EOQ model would be to include discounted cost based on the lot size. There are some heuristics methods available to estimate the optimal quantity based on the discounted price. This model can be further improved by incorporating uncertainty in the demand, and then solving the stochastic model to estimate Q.

Another important concept in logistics and freight modeling is that of network design. The network design is formulated based on the objective of maximizing customers' satisfaction and firms' competitive position. These models determine location of logistics facilities including production centers, warehouses, and distribution centers. This model also estimates the capacity of each of the locations. The choice between available transportation services is determined by the logistics requirements such as the availability of vehicles, warehouses, consolidation, and terminal facilities. Boerkamps et al., (2000) described the transportation systems as a collection of supply chain linkages. According to the authors, a supply chain linkage is a trade relationship between the shipper and the receiver in a network of interconnected linkages between raw material suppliers, producers, trading companies, retailers, and end users. Supply chain linkages may involve a number of distribution channels, for instance direct distribution (shipper to receiver) or intermodal distribution (shipper to intermodal facility, intermodal facility to receiver). See Figure 1.

We present here a simple transshipment model which can be used to determine optimal shipping patterns and shipment sizes for networks with a consolidation terminal and cost functions. A standard model formulation of such a transshipment model is given below.

$$Min \sum_i\sum_j\sum_m X_{ijm} \times D_{ij} \times C_{ijm} + \sum_i\sum_k\sum_m X_{ikm} \times D_{ik} \times C_{ikm} + \sum_j\sum_k\sum_m X_{jkm} \times D_{jk} \times C_{jkm} +$$
$$\sum_j\sum_k\sum_m X_{jkm} \times HC_{im} + \sum_j\sum_k\sum_m X_{jkm} \times HC_{im} + \sum_j\sum_k\sum_m X_{jkm} \times HC_{jm} +$$
$$\sum_j\sum_k\sum_m X_{jkm} \times HC_{jm} + \sum_i\sum_k\sum_m X_{ikm} \times HC_{km} + \sum_j\sum_k\sum_m X_{jkm} \times HC_{km}$$

Subject to:

$$P_{im} - \sum_k X_{ikm} - \sum_j X_{ijm} \geq 0; \forall i, m$$
$$\sum_i X_{ikm} - \sum_j X_{jkm} + A_{km} \geq 0; \forall i, m$$
$$\sum_i \sum_m X_{ijm} - CAP_j \leq 0; \forall j$$
$$\sum_i X_{ijm} - \sum_k X_{jkm} \geq 0; \forall j, m$$
$$X_{ijm}, X_{ikm}, X_{jkm} \geq 0; \forall i, j, k, m$$

Indices, decision variables, and parameters used in the model formulation are presented in Table 1. The model objective function (1.1) minimizes the sum of total transshipment and handling costs in a given freight network involving production, consumption and intermediate facilities. The model output determines the optimal shipping patterns and shipment sizes for the networks and the number and location of intermediate facilities to operate.
C_{ijm}, C_{ikm} *and* C_{jkm}, which are the unit cost of shipment for different legs of the shipment. These depend on the type of shipment and whether it is truck load (TL), less than truck load

FIGURE 1
LIKELY RATIONALE BEHIND THE EVOLUTION OF FREIGHT LOGISTICS MODELING

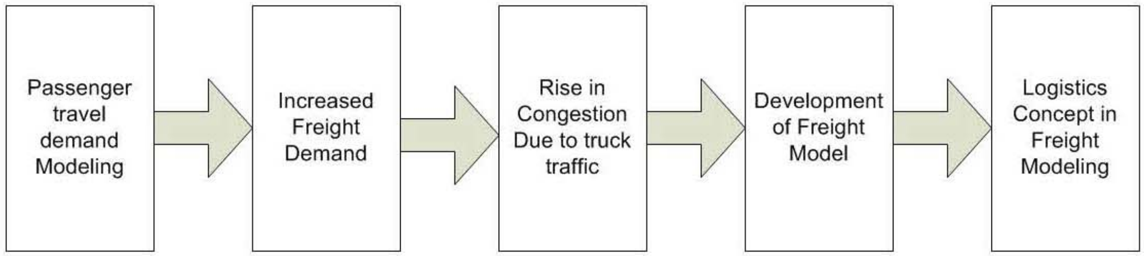

TABLE 1
DESCRIPTION FOR TRANSSHIPMENT MODEL FORMULATION

<u>Indices:</u>
m: type of goods
i: production location
j: intermediate facilities
k: consumption location
<u>Decision Variables:</u>
X_{ijm}: unit of type m goods transshipped from production point i to intermediate facility j
X_{ikm}: unit of type m goods transshipped from production point i to consumption point k
X_{jkm}: unit of type m goods transshipped from intermediate facility j to consumption point k
<u>Parameters:</u>
D_{ij}: distance between production point i and intermediate facility j
D_{ik}: distance between production point i and consumption point k
D_{jk}: distance between intermediate facility j and consumption point k
C_{ijm}: unit cost of shipping type m goods from production point i to intermediate facility j
C_{ikm}: unit cost of shipping type m goods from production point i to consumption point k
C_{jkm}: unit cost of shipping type m goods from intermediate facility j to consumption point k
HC_{im}: unit cost of handling (loading/unloading) type m goods at production point i
HC_{jm}: unit cost of handling (loading/unloading) type m goods at intermediate facility j
HC_{km}: unit cost of handling (loading/unloading) type m goods at consumption point k
P_{im}: production of type m goods at production point i
A_{km}: consumption of type m goods at consumption point k
CAP_j: transshipment capacity of intermediate facility j

(LTL) or small package shipment. For TL shipment the truck configuration will have a big impact on the cost. Some of these rates are available from published rate sources for different shipment types. More specific information is obtained by surveying shippers and carriers. In many instances, there is rate negotiation between shippers and carriers, and most often it is difficult to get these negotiated rates due to issues related to confidentiality.

Constraint sets (1.2) and (1.3) are the production and attraction constraints, which ensure that demand at consumption points are satisfied with the supply generated at production points. Constraint (1.4) is the capacity constraint for intermediate facilities, which limits the amount of total inflow to the intermediate facilities; ensuring available transshipment capacities are not exceeded. Constraint set (1.5) is the flow conservation constraints in the transshipment network, which ensures that the sum of inflow to any intermediate facility is equal to the sum of the outflow from that intermediate facility. Finally, the nature of decision variables is defined in (1.6); all decision variables are non-negative real number values. The proposed model can easily be improved by introducing the following system design aspects to the model formulation: inventory, modes of transportation, shipment size, shipment unit, and multiple planning periods.

Many distribution networks are influenced by third-party logistics (3PL) providers. A 3PL is a third party company that manages the delivery of logistics services (Hertz and Alfredsson, 2003). More and more firms are outsourcing their logistics activities to 3PL companies. Tian et al. (2009) have undertaken research to understand the relationship between a 3PL and its customer firms. This research found that 3PL's significantly improve the logistics process of customer firms. Distribution network design by a shipper differs considerably from a network design by 3PL service providers. 3PL service providers would consolidate shipments from suppliers and direct it to manufacturing plants based on the available consolidation center of the 3PL providers (So *el al,* 2007).

The other concept, which is becoming increasingly important, is reverse logistics. Reverse logistics has a shorter product lifecycle and also a more demanding customer (Daugherty *et al*., 2001). Reverse logistics needs an efficient network design to minimize the cost of transporting returned goods under new sets of supply, demand and capacity constraints. This network design is much more complex, because of the higher degree of uncertainty (Lieckens and Vandaele, 2007).

Two other concepts which are increasingly becoming important in logistics network design are "lean" supply chains and "green" supply chains. Lean supply chains aim at reducing waste and elimination of non-value added activities which includes time, labor, equipment, and inventory (Corbett and Klassen, 2006). Green supply chain strategy tries to minimize the negative impact of supply chains on the environment. Participation of suppliers, customers; and internal operations and processes managers, is required to make the supply chain green (Corbett and Klassen, 2006; Mollenkopf, 2010).

LITERATURE REVIEW OF MACRO FREIGHT LOGISTICS MODELS

Chronological Development of Freight Logistics Models

Tavasszy (2006) emphasized the integration of logistics factors into freight models. He traced early developments in the Netherlands in the first half of the 1990s, which took more than a decade before being recognized elsewhere. Tavasszy also indicated that development in freight logistics in general can be directly linked to local priorities in freight policy. He also points out that freight modeling has taken different directions in different countries and continents. For example, freight modeling development in Europe has taken a different course compared to that of the U.S. The chronological development of various freight logistics models are shown in Table 2.

TABLE 2
CHRONOLOGICAL DEVELOPMENTS OF LOGISTICS IN FREIGHT MODELING

Date	Mode / Levels	Study	Description	Country of Origin
1990	National	LMS	Joint assignment of passenger and freight vehicles	Netherlands
1992	National	TEM	Forecasting model based on the observed data of 1992	Netherlands
1996	National	SISD	Disaggregate RP mode choice models and assignments	Italy
1996	National	WIVER	Reproduce vehicle flows on transport infrastructure	Germany
1997	National	NEMO	Considers rail, road, and sea simultaneously. Simulates competition between modes	Norway
1997	International	NEAC	Models the distribution between production and attraction on basis of value added per sector	Europe
1998	National	SMILE	Routing of freight flows via distribution centers	Netherlands
1998	International	STEMM	Methodology for modeling multi-modal chains for passenger and freight transport	Europe
1999	National	GOODTRIP	Connects activities of consumers, distribution centers and producers	Netherlands
1999	International	STEEDS	Output of model is decision support system	Europe
2000	International	SLAM	Supply path choices	Europe
2000	Regional	WFTM	Uses a multimodal network assignment; implemented in a NODUS software	Belgium
2001	National	SAMGODS	Used to evaluate modal shifts, uses multi-sector input/output tables for the country	SWEDEN
2001	National	BVWP	Works on levels of aggregated flows	Germany
2002	International	SCENES	Drivers of Transport demand, External and policy scenarios, Infrastructure and pricing scenarios	Europe
2002	International	EUFRANET	Rail scenarios are projected for 2020 horizon	France, Germany, Netherlands
2004	National	PCOD	Depicts interrelationship between spatial distribution of freight	Denmark
2005	International	ASTRA	Aggregate model to describe overall economic activity	Europe
2005	International	EUNET2.0	Logistics using spatial input-output modeling	United Kingdom
2005	Regional /Urban	Cube Cargo	Simulate regional and urban truck/freight movements	USA
2006	Urban	INTERLOG	Rule based freight transport simulation system; traffic conditions and regulatory measure	Germany
2007	Urban	Tokyo Model	Commercial traffic in Tokyo metro area	Japan
2007	Urban	Calgary Model	Reproduce commercial vehicle flows on transportation infrastructure	Canada
2007	National	ADA	Model national freight traffic	Germany
2009	National	SYNTRADE	Focused on Food retailing sector; Furness Method, Monte-Carlo Simulation, Gravity Model, Optimization Model	Germany

European Macro Freight Models

Traditionally most freight models were developed in Europe, probably due to the interconnectivity of European nations and the need to accurately portray rising freight costs associated with shipping freight within and across national borders. Some prominent and widely used European freight models are:

SAMGODS Model

SAMGODS was developed by the Swedish Institute for Transport and Communications Analysis (SIKA) in 2001. The Aggregate-Disaggregate-Aggregate (ADA) modeling tool in SAMGODS is also used in NEMO, which is the freight model developed for Norway. NEMO and SAMGODS incorporated logistics aspects into the freight modeling process (Jong *et al*., 2005).

SMILE Model

SMILE (Strategic Model for Integrated Logistics and Evaluations), originally initiated in 1998 in the Netherlands, and was the initial aggregate freight model developed to estimate freight flows via distribution centers using discrete choice modeling (Tavasszy *et al*., 1998). SMILE is applied on a national scale, with the principal objective of modeling future freight flows on the transport network by precisely modeling a path from one region to the other (Friedrich and Liedtke 2009). The path of freight flow and mode choice is analyzed jointly based on logistics costs and warehouse costs. Another model similar to the SMILE is the SLAM (Spatial Logistics Appended Module), which is a European level transport model, defining supply path choices similar to that in SMILE.

GOODTRIP Model

The GOODTRIP model closely followed the development of the SMILE model and has the potential of determining the costs, performance, and impacts of long term transportation policy making and implementation (Tavasszy, 2006). GOODTRIP was initially intended to assess the general logistical performance and environmental impacts of alternatives policies. This later narrowed down to the food, retail, and bookstores sector because of potentially larger differences in distribution structure of various products and consumer behavior (Boerkamps and Binsbergen 1999). As a disaggregate model, GOODTRIP aimed at evaluating changes in supply chain networks, consumption and distribution patterns, delivery requirements, mode choices, and environmental impacts. The GOODTRIP model is different from the SMILE model in two ways (Yang *et al*., 2009). In the GOODTRIP model, activities and vehicle tours are estimated from land use. In the case of the SMILE model, activities and vehicle flows are generated from commodity flows.

EUNET2.0 Model

EUNET2.0 is a regional economic and freight logistics model that was developed in 2003 as a pilot model, to enhance the understanding of existing and ongoing research in logistics using spatial input-output modeling in the United Kingdom (Jin *et al*., 2005). In this model, freight flow is segmented into a number of logistics stages, according to commodity type.

A significant number of origin-destination (O-D) matrices are divided into commodity type, and various distribution phases, which include distribution centers, ports and local depots. This model captured the effect of logistics centers and the national economy on freight movement (Jin *et al.*, 2005).

PCOD Model

Holmblad (2004 proposed the PCOD freight transport model. This PCOD model illustrates the interrelationship between the spatial distribution of freight and transportation patterns emanating from an existing transport network. The PCOD model converts the PC matrix into an O-D matrix. The PC matrix contains information on amount of goods produced at the production zone and the amount of goods consumed at the consumption point. Logistics nodes are introduced in between these terminal points to model the actual flow and develop the O-D matrix. With the incorporation of indirect transport, Holmblad (2004) predicted that the transport of goods through logistics nodes would be more cost efficient, owing to the fact that logistics operators would have the choice of scheduling their transport needs to optimize existing transportation resources.

North American Macro Freight Models

In general, the evolution of freight modeling in the United States can closely be linked to passenger travel modeling. A significant number of models developed are simplistic adaptations of urban travel demand models. Hamburg (1958) indicated that attempts to formulate truck freight models can be traced back to Detroit. Subsequent initiatives have been made to adapt passenger travel forecasts to truck modeling. Some metropolitan authorities and states have customarily overlooked freight models or have used rudimentary estimates of truck movement in their modeling process (RAND Europe et al. 2002). However, in recent years, there has been a shift towards more elaborate models with improved data granularity (e.g. commodity flow survey). The United States has two distinct freight models: commodity flow models and truck flow models developed at the urban, state and national levels (RAND Europe et al. 2002). The dichotomies between these two models are attributed to the difference in priorities at each level (Tavasszy, 2006). Presently, there is lack of information about the number of existing truck models in the United States. It is general observation that most freight models do not represent the existing strategic link between the economy and the transportation network (RAND Europe et al. 2002).

Some of the most promising freight models in the United States are the Seattle FASTrucks Mode, the New York City Best Practice Model, the Oregon TLUMIP Commercial Travel Model, and the Los Angeles County Metropolitan Transportation Authority (MTA) freight transportation planning model. The vast majority of U.S. models are based on the four-stage passenger modeling framework and lack logistics dimensions. The MTA model for Los Angeles is promising in terms of incorporation of logistics factors and does so by applying methodologies similar to that in SMILE and the GOODTRIP model (Fischer *et al.*, 2005).

REVIEW AND ANALYSIS OF MODEL TYPES

Aggregate-Disaggregate-Aggregate Model

Aggregate-Disaggregate-Aggregate models involve a number of demand matrices, which are specific for a particular commodity, and show the quantity of goods transported from one zone to another. As discussed by Ben Akiva et al. (2008), aggregate models tend to be based on cost minimization behavior of firms, while disaggregate models include more detailed policy-relevant variables for firms' decision making. In practice, disaggregate models have several drawbacks. One of these is the need for more detailed data, which is difficult to generate because of cost and confidentiality (Winston, 1983 and Oum, 1989). Although difficult in practice, disaggregate models produce more accurate individual mode choice forecasts by representing the cause and effect relationships in firms' decision making processes. However, aggregate and disaggregate approaches should be considered complementary, not competing (Ben Akiva et al. 2008). Integrated aggregate-disaggregate modeling approaches benefit from aggregate data when representing collective behavior, and from disaggregating when the data represents the behavior of individual decision making processes (Ben Akiva et al. 2008 and Samimi et al. 2009).

The disaggregate logistics model is undertaken in a series of steps. The first step is the disaggregation of flows from one firm to another firm. The second step is the logistics decisions by firms, and finally aggregating freight to O-D flows for network assignment (Jong et al. 2005). The logistics model helps to determine shipment size and transport chain (e.g. mode, vehicle and terminal types, and loading unit utilized). The ultimate decision making process at the firm level is the minimization of total logistics costs. The total yearly logistics costs are estimated by the equation below

$$G_{rskmnql}=O_{kq}+T_{rskql}+D_{k}+Y_{rskl}+I_{kg}+K_{kq}+Z_{rskq}$$

Where, ***G*** is total yearly logistics costs; ***O*** is the order cost; ***T*** is the transport, consolidation and distribution costs, ***D*** is cost of deterioration during the hauling process; ***Y*** is capital cost of goods in transit; ***I*** is inventory costs; ***K*** is cost of inventory and ***Z*** is the stock out costs.

Input-Output Models

Input-output models provide an overview of the flow of goods and services to analyze the economic progress and show intermediate transactions between producers and customers. Input-output tables show goods and services produced in a year through domestic production, imports, consumption of goods by customers, and exports. The demand generated by domestic industries and imports is disaggregated by different industries. Input-output coefficients represent the amount of input required to generate one unit of output necessary to satisfy the demand generated by domestic industries and imports. Input-output models can be used to represent single-region and multi-region commodity flows. According to Ben-Akiva et al. (2008), multi-region input-output models usually perform better than single-region input-output flows. Ben-Akiva *et al*., (2008) pointed to major multi-region input-output models undertaken by Chenery (1953), Moses (1955), Leontief (1936), Bon (1984) and Cascetta (2001). The main difference among these models is the way in which the effects of technical coefficients and trade flow coefficients are estimated in the modeling structure. In freight demand modeling, changes in transportation infrastructure can directly affect the amount of transportation service available and can affect trade flows. Therefore, changes in freight movement networks have inevitable impacts on input-output coefficients.

Using Leontief's Input-Output model, a generalized form of the EUNET2.0 model shows total consumption, demand, and the total amount of a given commodity ***m*** that is used for producing commodities as

$$D^m = Y^{mo} + \sum_n a^{mn} X^n \; \forall m$$

Where:
D^m is total consumption of commodity m, Y^{mo} is the quantity of final demand of commodity m X^n, is the quantity of production of commodity m and, $\sum_n a^{mn} X^n$ is the quantity of commodity m that is used for producing all commodity n.

Artificial Neural Networks

The artificial neural network (ANN) is a type of network structure in which the nodes are the "artificial neurons" and the edges connecting these nodes are the "synapses". In the ANN model the computation is done replicating the way the brain handles information. The input and the output of the computational information process is received and sent via synapses from and to the other artificial neurons, respectively. The order of input and output transfers is performed according to the information processing state of the artificial neuron in the artificial neuron network. The information processing structures of artificial neurons may vary; artificial neurons can be designed to perform very simple operations (i.e. adding to input values) or very complex operations (i.e. there can be sub-artificial neuron networks within an artificial neuron). It is also possible to group artificial neurons in different layers. In such a case, artificial neurons are typically organized in three layers: the input layer which accepts the model inputs; the output layer which provides the final model output; and the hidden layer which functions as the computational information processing structure (Bilegan et al. 2007).

There has been a variety of artificial neural network applications in the area of transportation. A comprehensive review of artificial neural network applications in transportation is presented by Dougherty (1995). It is observed that in the area of freight demand modeling, the use of artificial neural networks is relatively new. According to Bilegan et al., (2007), artificial neural network applications in freight demand modeling have potential to improve the performance of predictive models.

Matrix Estimation Methods

Production-consumption (P-C) and origin-destination (O-D) matrices are the basic trip matrices for freight planning and management. The P-C matrix represents the economic trade patterns between zone pairs; primary producers to final customers. The origin-destination (O-D) matrix represents the actual physical movements in the transportation infrastructure, from production zones to consumption zones. In short, the O-D matrix represents the actual freight movement of the P-C matrix (Williams and Raha 2002).

There is a compromise between model complexity and data accuracy in choosing an adequate representation of transportation demand. The reason for the compromise is that the detailed description of trip data, between origin and destination pairs, is not always available. The feasibility of collecting trip data, including the origin, the destination, all intermediate stops (warehouses, intermodal facilities), the exact time, the route, and the purpose of the trip is a challenging task. Even if the data collection process is feasible, the amount of information would be unmanageable. Therefore, reasonable representation of demand should be somewhere in between these two extremes (Williams and Raha 2002).

The O-D and P-C matrices are reproduced data. The following are the important points to consider when generating O-D matrices from original data sources (Williams and Raha 2002):

- All of the available observed data resources like prior matrix and traffic counts should be used efficiently.
- Data from different sources like different sampling fractions and inaccurate data may not be consistent.
- Use of data sources can be weighted based on the data source reliability, accuracy of measurements, and sampling errors.
- Matrix estimation procedures should consider trends in different commodity categories, economic and industry trends
- Future changes in transportation infrastructure and transportation costs should be considered including logistics cost.

Our review indicates that a critical improvement has taken place in freight modeling is the inclusion of logistics dimensions. In the next section of this article we present a discussion of the mathematical tools used to incorporate logistics aspect in freight models.

PCOD Models

The principal objective behind the inclusion of distribution centers in a supply chain or goods flow network is to reduce overall transportation costs. The PCOD model proposed by Holmblad (2004) is an effort to model freight flow through a network using distribution and consolidation centers. Certain assumptions are required to introduce logistics in transforming the P-C matrix into an O-D matrix. This is evidenced in Holmblad (2004) who indicated that traditionally, due to potential complexities, logistics structure in the production-to-consumer chain is generally approximated. Contrary to existing and most recent advances in transport logistics models, which undertake the bottom up modeling approach with an extensive treatment of modes and networks, the PCOD modeling approach applies a top to bottom modeling framework. This is characterized by meso-economic, aggregate transport logistics modeling, using regional transport centers with transport decision making at the micro and macro levels (Holmblad 2004). Holmblad (2004) indicated that the PCOD model has two principal features that make it suitable for freight modeling. In general, the modeling of freight movement in the transport system can be undertaken using a heuristic technique, in which the unit cost of transport is dependent on the volume of transport.

First, as previously mentioned, the PCOD model follows a cost minimization approach using the heuristics framework. It converts the regional trade flow to regional transport flow, thereby providing better modeling results relative to a macroscopic approach. Second, by representing the transport system and network by a limited number of parameters, the PCOD model formulation provides a simplistic and easy to understand approach to freight transport using distribution centers. To begin with, the PCOD model divides the general area of interest into zones that have both production output (P_r) in zone r and final consumption (C_s) in zone s. This main level of the model building process is referred to as the P-C land or level 1.

The second level, described as distribution-consumption (D-C) land, is characterized as a transport only zone with no likely production or consumption. Transport is not restricted within D-C land, but in P-C land it can be direct transport only ($l=r$ *and* $m=s$). The connection between P-C and D-C land can be denoted by a matrix element $PCOD^w_{rslm}$, which is a depiction of transport between the zone r and the zone s (PC_{rs}) that constitutes the total transport OD^w_{lm} from l to m. The matrix element representing the connection between P-C and D-C land ($PCOD^w_{rslm}$) corresponds to transport from zone l to zone m. The matrix representing the connection between levels in the PCOD model is as follows

$PC_{rs}: (PCOD^w_{rslm})$, where

$$PCOD^w_{rslm}=PC_{rs} \text{ or } PCOD^w_{rslm} = 0$$

The entire system is formulated as a system of linear equations; however, a method at arriving at the cost of transportation and handling at the distribution centers is necessary so as to minimize the system costs.

CONCLUSIONS

This paper illustrates that freight modeling efforts are not fully realized, without considering logistics components in the modeling process. The majority of freight models have closely followed traditional four stage passenger travel demand models. The need to improve and incorporate logistics concepts is understood by transportation modelers both in Europe and the United States, but incorporation of these dimensions into models has been slow. This slow development might be explained partly by the lack of data needed to incorporate logistics elements in freight models, and partly by the inability of existing modeling tools to incorporate these dimensions. In this paper we have traced the emergence of freight models in different parts of the world and the chronological order of this development. We have focused on the mathematical tools used in these models as well. In many modeling endeavors, the key obstacle is to adapt the right mathematical tool. This paper should assist modelers in adapting the right tool based on the modeling objectives.

We have categorized the modeling endeavor into European freight models and North American freight models. We suggest that European freight models seem to be more developed, as far as inclusion of logistics aspects in freight modeling is concerned. We have identified that *SAMGODS, SMILE, GOODTRIP, EUNET2.0, PCOD* are pioneering freight models which have incorporated logistics dimensions into the modeling process. The modeling technique used in many of these freight models are varied, but the prime modeling tools used are aggregate-disaggregate-aggregate models, input-output models, artificial neural network models, matrix estimation methods and the PCOD model. Based on the objectives and data availability, these modeling tools are implemented and various additions and alternations are undertaken to arrive at more realistic results for successful implementation.

Logistics decisions, in a business entity, are dynamic and are reshaped constantly by changing business needs. These decisions play major roles in the direction of freight movement within and beyond the domestic boundaries of a country. Some of the logistics concepts like reverse logistics; 3PL and green supply chains were not observed in most of the logistics concepts introduced to macro freight models. The learning curve for freight modeling is improving, and it can be anticipated that newer concepts in logistics will be adapted in freight modeling. Finally, it should be recognized that more work can be done in this area.

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USING VISUAL DATA MINING IN HIGHWAY TRAFFIC SAFETY ANALYSIS AND DECISION MAKING

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ABSTRACT

An ongoing, two-fold challenge involves extracting useful information from the massive amounts of highway crash data and explaining complicated statistical models to inform the public about highway safety. Highway safety is critical to the trucking industry and highway funding policy. One method to analyze complex data is through the application of visual data mining tools. In this paper, we address the following three questions: a) what existing data visualization tools can assist with highway safety theory development and in policy-making?; b) can visual data mining uncover unknown relationships to inform the development of theory or practice? and c) can a data visualization toolkit be developed to assist the stakeholders in understanding the impact of public-policy on transportation safety? To address these questions, we developed a visual data mining tool-kit that allows for understanding safety datasets and evaluating the effectiveness of safety policies.

INTRODUCTION AND LITERATURE REVIEW

Transportation accidents levy a significant cost on societies in terms of personal death or injury in addition to the economic costs. Road traffic injuries are the eighth leading cause of death, and the leading cause of death for individuals aged 15-29 (Lozano et al., 2012; World Health Organization, 2008). In 2010, transportation injuries have resulted in 1.24 million fatalities worldwide according to the World Health Organization (WHO), World Health Organization (2013, p. v). In addition to the lost lives, the costs associated with road traffic crashes runs to billions of dollars (Jacobs, Aeron-Thomas, & Astrop, 2000). These numbers are unacceptably high, especially since many of these fatalities can be avoided with evidence-driven road safety interventions.

Road safety interventions can be effective in reducing the number of accidents and/or mitigating their effects. The WHO states that "adopting and enforcing legislation relating to important risk factors – speed, drunk–driving, motorcycle helmets, seat-belts and child restraints – has been shown to lead to reductions in road traffic injuries" (World Health Organization, 2013, p. v). These five risk factors are a sample of a larger pool of behavioral factors that lead to accidents. There are increasing regulations worldwide that have been passed to cover these behavioral factors. However, "in many countries these laws are either not comprehensive in scope or lacking altogether. Governments must do more to ensure that their national road safety laws meet best practice, and do more to enforce these laws" (World Health Organization, 2013, p. v) The problem is complex in the U.S., since highway safety policies can be different in neighboring states and the identification of best practice is often unclear (Governors Highway Safety Association, 2013).

One approach to identifying best practices is to investigate the causes of vehicle crashes, assess the factors that are correlated with high severity/frequency accidents, and propose interventions that can prevent/mitigate these accidents. Examples are provided in the works of Shibata and Fukuda (1994), Massie, Campbell, and Williams (1995), Shankar, Mannering, and Barfield (1995), Al-Ghamdi (2002), K. K. W. Yau (2004), Aarts and van Schagen (2006), and Kent, Coulter, and Coulter (2011). These papers followed a common framework that started with identifying (or using previously identified) causal factors and then validating how these factors contribute to traffic crashes. While these approaches are built on a solid statistical foundation, they are often difficult to understand by the stakeholders due, in a large part, to the number/complexity of variables and relationships in the data. Additionally, it is difficult to evaluate whether differences among locations affect the generalizability of their conclusions across geographical regions with different environmental and behavioral conditions.

Another approach to identify the best practices is to retrospectively evaluate whether safety regulations have been effective in reducing accident, injury and/or fatality rates. It should be noted that such studies not only capture the differences pre and post regulation changes, but they can also assess the impact of varying enforcement levels (especially if they compare across states and/or counties). Thus, these studies can be seen to measure whether the policies are comprehensive (or effective), an important consideration highlighted above in the WHO report. These studies investigated several behavioral-related regulations, including: a) the impact of hand-held cell phone bans on reducing fatalities (Jacobson et al., 2012; Nikolaev, Robbins, & Jacobson, 2010; Sampaio, 2012); b) the impact of medical marijuana legislation on reducing fatal crashes involving alcohol through substitution effects (Anderson & Rees, 2011); and c) the effectiveness of seatbelt laws in reducing the number of teenage traffic fatalities (Carpenter & Stehr, 2008). The results of this research are usually explained by statistical summaries and p-value tables, which are singularly unconvincing to non-scientist public policy decision makers. In addition, the general public must frequently be convinced politically to support the rationale behind changes to existing laws; and complex statistical analyses can be ineffective in making a convincing argument.

This research proposes that there is a need for new and innovative data-driven traffic safety models that can be both useful for researchers in uncovering promising areas for safety research, and tools for improving how safety research findings can be presented to and understood by the different stakeholders (general public, policy-makers, researchers, etc.). In this paper, a new approach to showing how visualization tools can address this gap is presented, with a focus on their use in detecting trends in highway safety and affecting safety policy making.

In the following sections, the field of Visual Data Mining (VDM) is discussed, and the concept of using this method to generate insights from spatiotemporal datasets is introduced. Following that we present a brief description of the methodology and the datasets used in providing some examples of how VDM tools could be used for this purpose. We try to provide some simple, obvious examples of how data visualization tools can uncover relationships that may not be captured by traditional modeling methods. Finally, examples are used to demonstrate how the developed visualization toolkit can assist in evaluating the impact of safety policy changes.

VISUAL DATA MINING

VDM is a tool which can aid in exploring hidden information and uncovering trends and patterns from other non-visual methods, It is a data mining approach that is based on the integration of multiple concepts. Visualization techniques which provide powerful and useful visual capabilities in a hypothesis testing mode for users are designed to support data mining tasks before the analysis actually begins (De Oliveira & Levkowitz, 2003). Visual data mining can overcome the gap between interacting with massive datasets and acquiring more intelligent information from the the analysis(Simoff, Böhlen, & Mazeika, 2008, p. i). Presenting data visually has been found to be one of the simplest and most effective way to discover trends in data so that humans can make better decisions (Greitzer, Noonan, & Franklin, 2011; Han & Kamber, 2011; Keim, Müller, & Schumann, 2002; Simoff et al., 2008).

The use of "visualizations" (visualization applications) to uncover patterns is not a new phenomenon in public safety. In disease control, in 1854, John Snow plotted a massive cholera outbreak overlaid on a map of the city of London in order to discover the cause of cholera. This is said to be the first geographical analysis of disease data (Rajaraman, Leskovec, & Ullman, 2012, p. 3-4). Wickham (2013) briefly reviews the history of how statisticians used visualization techniques to assist in the interpretation of complex analytical results. Good design of graphical displays can help to understand complicated procedures and algorithms and solve complex problems without making assumptions. When automated data mining tools fail, visualization for exploring data can be used to support model explanations and lead to better results.(Keim et al., 2002).

It is important to mention that not all graphical representations of data are useful, and some can be misleading. Wickham (2013, p. 39-40) includes a list of some of the formal instructions on the effective use of visualizations that was written in 1901 by the International Institute of Statistics. Below, we repeat these oft-forgotten recommendations:

1) "We must keep symbols to a minimum, so as not to overload the reader's memory. Some ancient authors, by covering their cartograms with hieroglyphics, made them indecipherable."
2) "One of us recommends adopting scales for ordinate and abscissa so the average slope of the phenomenon corresponds to the tangent of the curve at an angle of 45 degrees."
3) "Areas are often used in graphical representations. However, they have the disadvantage of often misleading the reader even though they were designed according to indisputable geometric principles. Indeed, the eye has a hard time appreciating areas."
4) "We should not, as it is sometimes done, cut the bottom of the diagram under the pretext that it is useless. This arbitrary suppression distorts the chart by making us think that the variations of the function are more important than they really are."
5) "To increase the means of expression without straining the reader's memory, we often build cartograms with two colors. And, indeed, the reader can easily remember this simple formula: 'The more the shade is red, the more the phenomenon studied surpasses the average; the more the shade is blue, the more phenomenon studied is below average."

While there are no universal visuals that will work for every application domain and problem, there are several factors/guidelines that can help in selecting/developing informative statistical graphics. For example, Tufte (1983, p. 13-15) introduced the term graphical excellence to reflect on graphics that communicate complex ideas with clarity, precision and efficiency. Keim et al. (2002) provided some general rules for expressive and effective information visualization. These guidelines were used in developing the graphics for traffic safety presented in this paper.

METHODS AND DESCRIPTION OF DATASETS

The purpose of this investigation is to develop and apply a small subset of data visualization tools to a large, complex dataset of transportation safety data for the purposes of addressing three research questions:

RQ1. What existing data visualization tools might be appropriate to inform researchers in theory development and decision makers in setting transportation safety policy?

RQ2. Can a data visualization tool be developed to assist in uncovering previously unknown constructs/relationships to inform the development of theory or practice?

RQ3. Can a data visualization tool be developed to assist decision makers in applying and evaluating public policy choices in order to improve transportation safety in practice?

RQ1 will be answered through a focused literature review on data visualization tools used in the context of transportation and safety, as well as a consideration of tools applied successfully in other contexts. A small number of tools will be developed based on this review. RQ2 and RQ3 will be answered by applying the tools developed against “real world” transportation data in an effort to demonstrate efficacy and at least minimal utility of the general approach.

Transforming accident related data into graphical information in order tofacilitate further analysis is our basic principle. Three common types of data in the transportation safety area of interest are temporal, spatiotemporal, and the effectiveness of policymaking (before-after comparison). The temporal data was analyzed by a calendar-based clustering application, and the graphical results show the characteristic of the clusters; thereby aiding researcher insight and theory development. Next, the mapping tool combines the geographic data with accident related information and statistical reports displayed on a map as an example of the treatment of spatiotemporal data. It consists of the Visual Basic Application-based (VBA) dataset and Microsoft MapPoint. The constraint for the mapping tool is the limitation of VBA functions. The speed of executing the tool relies on the quality and quantity of the VBA codes and dataset. While the current application is scalable, additional refinement is needed when the volume of the dataset increases. The current application can handle up to 1,048,576 rows by 16,384 columns of data and its execution speed is a function of computing resources.

In this paper, we have used two datasets to depict the effectiveness of the proposed/ developed visual data mining tools in enhancing our understanding of emerging patterns and trends that are related to traffic safety. Both datasets are collected for U.S. traffic by state and/or governmental agencies. The first dataset consists of traffic flow counts per hour collected by the Alabama Department of Transportation (ADoT) using a traffic camera between January 2005 and December 2010 (Alabama Department of Transportation, 2011). We did not use the 2011 and 2012 data in our dataset since they involved a massive amount of missing data. The data captures directional traffic flows caught hourly by the sensors on a busy interstate highway (I-85, sensors located 6.0 miles south of Macon Co. Line). The sensor captures whenever a motor vehicle passes the location and counts for a record. It is important to note that traffic volume is one of the measures traditionally used to normalize accident data (Gregoriades et al., 2011; Ivan, 2004; Laessig & Waterworth, 1970; Stamatiadis, Agent, & Bizakis, 1997). However, the estimation of the target variable may contain misleading information because the traffic volumes vary by location and time. Thus, we investigate how visual data mining tools can be used to disaggregate traffic flows to account for seasonal variations and emerging patterns.

The second dataset was gathered using the Fatality Analysis Reporting System (FARS) from the National Highway Traffic Safety Administration (NHTSA) (National Highway Safety Adminstration, 2012). For the purpose of our analysis, the captured data frame is for commercial vehicles (trucks and buses) involved in the fatal accidents from 2002 to 2011 within 12 U.S. southeastern states. Commercial vehicles are trucks with gross vehicle weight greater than 10,000 lb. or buses that can hold more than 10 passengers. The 12 southeastern states under consideration are: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. These states have similar demographic factors and weather conditions, which reduces the exogenous effects of weather, demographics and urban/rural differences. We have used this dataset to demonstrate the reality of visualized spatiotemporal safety data and the impact of policy-making on commercial vehicle safety.

REVIEW OF RELEVANT DATA VISUALIZATION TOOLS SUBSET

Visualization tools can be used in research to observe the occurrence of traffic events and explore the information from the events. One of the concerns for practitioners is to provide more efficient and understandable results for the stakeholders by improving the current approaches or developing other useful techniques. The key is to know how to connect the data and the result presentation. We introduce the highlights of recent transportation safety research and emphasize some of the appropriate data visualization tools that can be used.

For a large dataset, it is difficult to move forward without understanding the basis of the contents. The histogram, one of the basic visualization tools, can indicate the distribution of information. The daily pattern and seasonal trends of the fatal crash data from 2001 to 2011 can be explored in histograms, according to N. Yau (2013). From the results, he stated that most of the crashes occur in the evening in terms of time of day, and trends can also be found regarding the day of the week and month. Instead of looking at the meaning of each data point, the aggregate values of the data sometimes extract more hidden information.

Another example can be found in traffic volumes, which researchers started to study in the mid 1960’s (Roddick & Spiliopoulou, 2002). Except for various plots, cluster analysis was initially adopted to analyze traffic volumes in the 1990’s (Black, 1991; Flaherty, 1993). Weijermars and van Berkum (2005) classified highway flow patterns by the daily flow profile chart and defined the characteristic of clusters by a summary table. Based on the data selected, only 118 days were included in their analysis. In addition, the summary table and the presentation of the daily pattern charts from the dataset do not interpret the results clearly. Van Wijk and Van Selow (1999) developed a calendar-based clustering application to present daily patterns and seasonal changes in employee and power demand, which displays the results on a calendar. This was the approach adopted for this research used to analyze traffic flows. The details are interpreted in the following section.

Some researchers have used Geographic Information Systems (GIS) to transform data into a map to analyze traffic accidents (Erdogan et al., 2008; Liang, Mo’soem, & Hua, 2005; Yi et al., 2001). Besides using a GIS, a large number of practitioners constructed internet-based mapping tools to monitor different safety related incidents such as the Global Incident Map and the National Incident Map. They used graphics to display where the incidents occurred. A text box with detailed information is also shown with the selected incident. The text box may contain useful information, but the detailed information sometimes causes difficulty in interpretation and communication. In addition, the information could not be extracted or synthesized among multiple points. Some advanced mapping tools are designed and displayed on the websites such as Baton Rouge Traffic Incident Map, CrashMap, and English Road Safety Comparison to show the incidents with selected variables.

The behavioral factor determination includes finding important factors in the accident analyses and evaluating the effectiveness of safety policymaking. A histogram and bar chart showing the data exploration are usually embraced in the analyses. Nevertheless, none of the transportation safety research has used visualized statistical results such as heat map. The heat map can show the significance of testing results transforming from the statistical reports.

DEVELOPING A VDM TOOLKIT

In the last section, we presented some of the visualization tools that are relevant to transportation safety.. Here, two tools are used to demonstrate the power of visualization in uncovering unknown contrasts, which can be used in informing the relevant stakeholders. First, we present how the approach of Van Wijk and Van Selow (1999) can be used to detect seasonal trends in the Alabama traffic flows. Animation can then be used to highlight how spatiotemporal traffic accidents can be depicted on a map.

Uncovering Seasonal Patterns in Traffic Flows

Using the ADoT dataset and the approach of Van Wijk and Van Selow (1999), we examine the traffic flows for 2005. Since the approach is based on k--means clustering, we also explore the effect of the number of clusters (k) on the observed patterns. One can think of the choice of the value for k as the degree of granularity required for the data analysis. Typical values of k can range from 2-12 depending on the application and a priori theoretical framework. The result for k=2 is portrayed in Table and Figure 1.

The table shows a “traditional” calendar-based approach to showing the layout between two clusters on a day-day basis. For each month in the calendar, every day of the week in that month is coded for each respective means cluster, while the grayed out cells represent days falling into an adjacent month. By contrast, the Figure breaks down the daily data into hourly segments- and reveals the reason why the two clusters are statistically separable. The y-axis represents the average traffic volume per cluster, the x-axis represents the time of the day, and the two lines correspond to the different clusters. Prior to the analysis, one could hypothesize that using k=2 should result in distinguishing between weekdays and holidays. However, the two clusters depicted in Figure 1 show that in general Fridays have a different pattern than weekdays with larger counts of vehicles on the road starting from around 9 am until midnight. This pattern is also observed on spring/summer Sundays as well as days around holidays (Martin Luther King, Jr. Day, Fourth of July, Thanksgiving, Christmas, etc.) as depicted by the calendar based table.

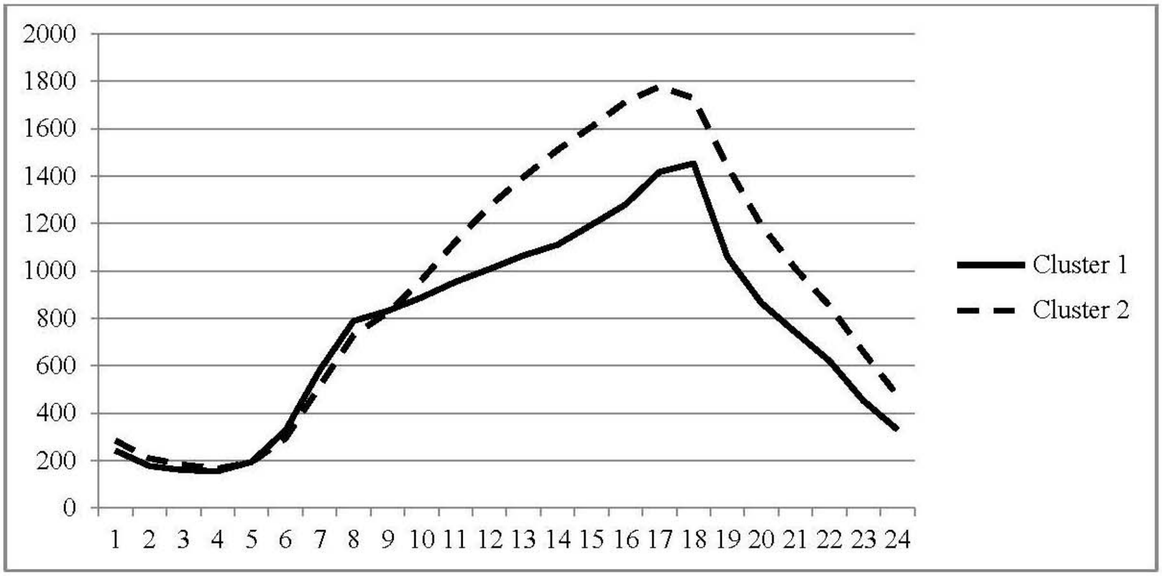
If more detail is needed, the VBA tool allows the user to pick the value of k and see the corresponding effect. Table and Figure 2 provides the results for k=5 clusters. Here, one can see that the patterns become different (i.e. not only magnified, but having different shapes) for the different clusters. For example, the cluster corresponding to Saturdays (cluster 3) shows a uniform traffic flow peak between 9 am and 5 pm. Such a pattern is quite distinct from the regular weekday patterns (clusters 4 and 5) where the peak is around 5 pm when most day shift employees travel home. Cluster 4 indicates that employees leave work earlier (and in greater numbers) on Fridays, which is an expected outcome. Thus, the use of clustering can provide evidence for daily and seasonal effects, which can inform hypotheses and research regarding traffic volumes. The calendar view allows the observer to capture all the information in one screen (which presents the contribution of the work of Weijermars and van Berkum (2005)). We present the case of k=8 in Table and Figure 3. While the increase in number of clusters have resulted in clusters that are almost identical (i.e.

clusters 5 and 6), we were able to capture a significant departure from the patterns described above in cluster 3. Cluster 3 is significant even though it captures only five Saturdays in the Fall. This result suggests an underlying phenomenon not previously anticipated by the two principle investigators due to their unfamiliarity with local custom. Upon further investigation, the researchers uncovered a local cultural phenomenon driving increased traffic volumes. These days correspond to five out of eight Saturdays when the Auburn University college football team played home games. With a stadium capacity over 87,000, these football games result in heavy commuter traffic on I-85 which passes through the city of Auburn. It is interesting to mention that all these five games were morning/early-afternoon games with a latest start of 2:30 PM local time. On the other hand, the remaining three games (Sept. 3rd, Oct 1st and Nov. 12th) were all evening games with an earliest start of 6 PM local time. Therefore, cluster 3 captured a coherent set of events that have a tremendous impact on the local community and that has a unique traffic pattern consistent with alumni driving to Auburn from Mobile and Montgomery (two of the largest cities in the state) to watch the game. Note that Station 44 is approximately 40 miles away from Auburn and I-85 is the only interstate which can be used to drive to Auburn University. This simple (somewhat obvious to North American followers of NCAA football) example serves simply to illustrate the the ability of this form of analysis to highlight unusual, event driven phenomenon.

TABLE 1
TRAFFIC VOLUME, 2 CLUSTER MEANS, TABULAR

S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
January							**February**							**March**						
						1			1	1	1	2	1			1	1	1	2	1
2	1	1	1	1	1	1	2	1	1	1	1	2	1	2	1	1	1	1	2	1
1	1	1	1	1	2	1	1	1	1	1	1	2	1	2	1	1	1	1	2	1
1	2	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	1	2	1
1	1	1	1	1	1	1	1	1						1	1	1	1	1		
1	1																			
April							**May**							**June**						
					2	2	2	1	1	1	1	2	1				1	1	2	1
2	1	1	1	1	2	2	2	1	1	1	1	2	1	2	1	1	1	1	2	1
2	1	1	1	1	2	1	2	1	1	1	1	2	1	1	1	1	1	1	2	1
2	1	1	1	1	2	1	2	1	1	1	2	2	1	2	1	1	1	1	2	2
2	1	1	1	1	2	1	1	2	1					2	1	1	1	2		
July							**August**							**September**						
					2	1		1	1	1	1	2	2					1	2	2
1	2	2	1	2	2	2	2	1	1	1	1	2	1	1	1	1	1	1	2	1
1	1	1	1	1	2	1	2	1	1	1	1	2	1	1	1	1	1	1	2	1
2	1	1	1	1	2	1	2	1	1	1	1	2	1	1	1	1	1	1	2	1
2	1	1	1	1	2	2	2	1	1	1				1	1	1	1	1	2	
2																				
October							**November**							**December**						
						2			1	1	1	2	1					1	2	1
1	1	1	1	1	2	1	2	1	1	1	1	2	1	1	1	1	1	1	2	1
2	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1
2	1	1	1	1	2	1	1	1	2	2	1	2	2	1	1	1	1	2	2	1
2	1	1	1	1	2	1	2	1	1	1				1	2	2	2	2	2	1
1	1																			

FIGURE 1
TRAFFIC VOLUME, 2 CLUSTER MEANS, GRAPHICAL



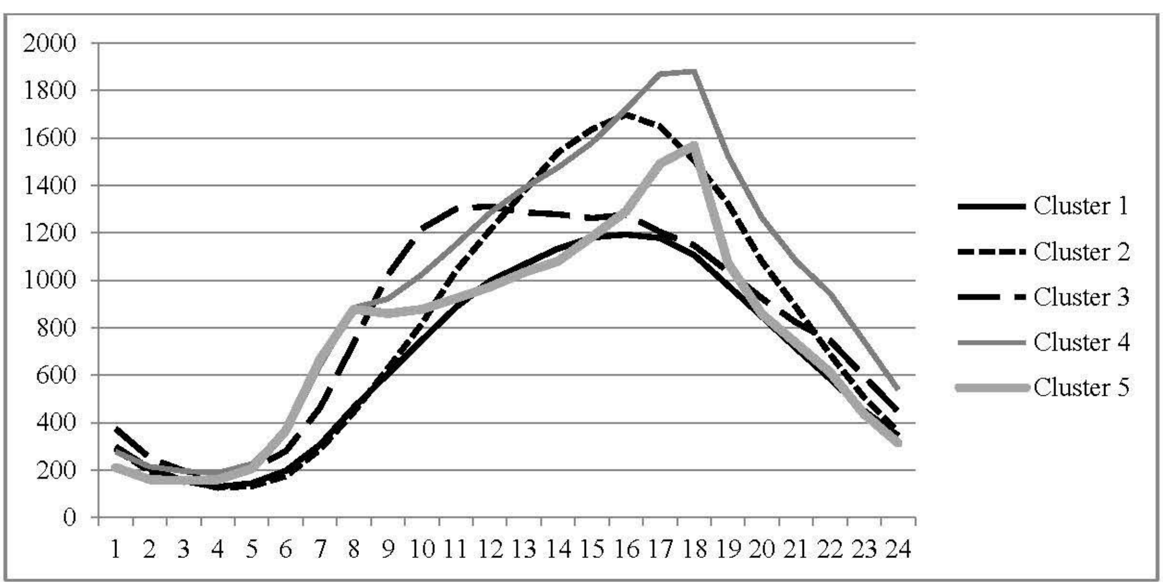
While this may seem like an "obvious" factor to consider for those familiar with the popularity of American college football, two points need to be made. First, not all transportation safety researchers are familiar with all characteristics of human behavior that may drive traffic patterns. The tool can discover "local" or "unique" factors the researchers may be unaware of *a priori*. Second, this visualization can also be used to uncover a previously unaccounted for phenomenon, and explain or highlight its impact on traffic patterns. This was the case for two of the researchers on this project. For example, the tool can then be used to drive policy decisions for government (increased policing on game days, re-routing of commercial traffic, postponement of lane closures, etc.) and industry (alternative routing during congestion, timing of travel through congested lanes, etc.) alike. The tool can be used for both discovering and alleviating the impact of "predictable" event-driven safety and efficiency factors.

This tool is also useful for exploratory disconfirmation. In recent years, there has been a strong geographical shift in the location of manufacturing plants in North America. Specifically, major assembly plants (and their suppliers) have been relocating to the Southeast due to the availability of a trained, efficient and lower cost (non-union) workforce, proximity to major logistics hubs, as well as state support and financial incentives in the form of lower taxes. From a research standpoint, one would anticipate greatly increased volumes of commercial traffic along the major corridors linking vendors and manufacturers. One would expect that this might lead to increased accident rates and reduced transportation efficiencies. Because the ADoT provided traffic volume reports since 2005, the comparison of traffic volumes before and after automotive plants arriving was possible. However, this has not been shown to be the case with traditional analytical methods. The use of the tool by the investigators revealed a potential explanation for the lack of evidence. The economic crisis also hit the automotive industry hard in 2008, and this moderating factor could have suppressed any expectation of increased activity. While it is quite possible that other tools could have been used to uncover and explore the influence of counter-balanced factors (economic activities), we found it particularly useful in guiding our investigation into this hypothesis.

TABLE 2
TRAFFIC VOLUME, 5 CLUSTER MEANS, TABULAR

S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
January							February							March						
						1			5	5	5	4	1			5	5	5	4	3
2	5	5	5	5	5	1	2	5	5	5	5	4	1	2	5	5	5	5	4	1
2	5	5	5	5	4	1	2	5	5	5	5	4	3	2	5	5	5	5	4	3
1	2	5	5	5	5	1	2	5	5	5	5	4	1	2	5	5	5	5	4	1
1	5	5	5	5	5	1	2	5						1	5	5	5	5		
2	5																			
April							May							June						
					4	2	2	5	5	5	5	4	3				5	5	4	3
2	5	5	5	5	4	2	4	5	5	5	5	4	3	2	5	5	5	5	4	1
2	5	5	5	5	4	1	2	5	5	5	5	4	3	1	5	5	5	5	4	3
2	5	5	5	5	4	1	2	5	5	5	5	4	3	2	5	5	5	5	4	3
2	5	5	5	5	4	1	1	2	5					2	5	5	5	4		
July							August							September						
					4	3		5	5	5	5	4	3					5	4	2
1	4	4	5	4	4	4	2	5	5	5	5	4	3	1	1	5	5	5	4	3
1	1	5	5	5	4	3	2	5	5	5	5	4	3	1	5	5	5	5	4	3
2	5	5	5	5	4	3	2	5	5	5	5	4	3	1	5	5	5	5	4	3
2	5	5	5	5	4	3	4	1	5	5				1	5	5	5	5	4	
2																				
October							November							December						
						2			5	5	5	4	3					5	4	1
2	5	5	5	5	4	3	2	5	5	5	5	4	1	1	5	5	5	5	4	1
2	5	5	5	5	4	3	2	5	5	5	5	4	3	1	5	5	5	5	4	3
2	5	5	5	5	4	1	1	5	4	4	3	2	2	1	5	5	5	4	4	1
2	5	5	5	5	4	3	4	5	5	5				1	2	2	2	4	4	3
1	5																			

FIGURE 2
TRAFFIC VOLUME, 5 CLUSTER MEANS, GRAPHICAL



Visualizing Spatiotemporal Transportation Safety Data

Compared to the relatively expensive commercially available GIS analytical software systems, the researchers developed a low cost VBA-based interactive visualization tool that can transform accident data into an animated map. In addition to displaying location and time on the map, the tool is able to show three other variables dynamically denoted by symbols, shapes, and colors selected by the user. Also, the built-in information (such as population per state) can be displayed on the map. This multidimensional visualization tool is proposed as a potentially informative and flexible way to provide an effective overview for users to analyze the data. While this is impossible to replicate in grayscale, it is hoped that Figure 4 can provide a reduced fidelity version of what is possible.

In Figure 4, the map layer is shaded by population size for each state. The darkest hue of the states represents a population size greater than 30 million. The shade of the symbols show the accidents that have occurred on the different days of the week. It should be noted that the user can select the number of days that will be shown on the map, which allows for visualizing different hypotheses and research questions. The symbols (on the right side of Figure 4) indicate the number of fatalities per traffic accident. Additional relevant information can be depicted with the histogram, line chart, bar chart and/or pie chart, which we provide as a part of the toolkit. In Figure 4, we summarize the counts of types of routes where fatal accidents occurred in 2011. State highways show the highest occurrences of accidents. We believe that this snapshot view of the data can be very informative, especially with the ability of the user to query and select specific ranges (or values) for the variables he/she would want to depict.

This visualization tool provides a complete accident monitoring system, seeing different accident-related variables associated with the location and time in the same graph. The users can now know the frequency of accidents based off of location, time, weather conditions, type of vehicle or any other variable of interest they select. Researchers or public policy decision makers can get precise information on how to interpret the data in the data preparation stage and then move forward to analyze the data.

DEVELOPING A DATA VISUALIZATION TOOLKIT TO EVALUATE SAFETY POLICY CHANGES

In this last section, we use our data visualization toolkit to demonstrate the hidden patterns from the traffic flows and examine the animated transformation from spatiotemporal traffic accidents onto a map. In this section, a new data visualization form from the toolkit is introduced. A statistical analysis is performed initially to catch the potential impact of policy changes. The conclusions are displayed on a heat map where different colors shade the significance of policy adoption and symbols simply represent the results of interest.

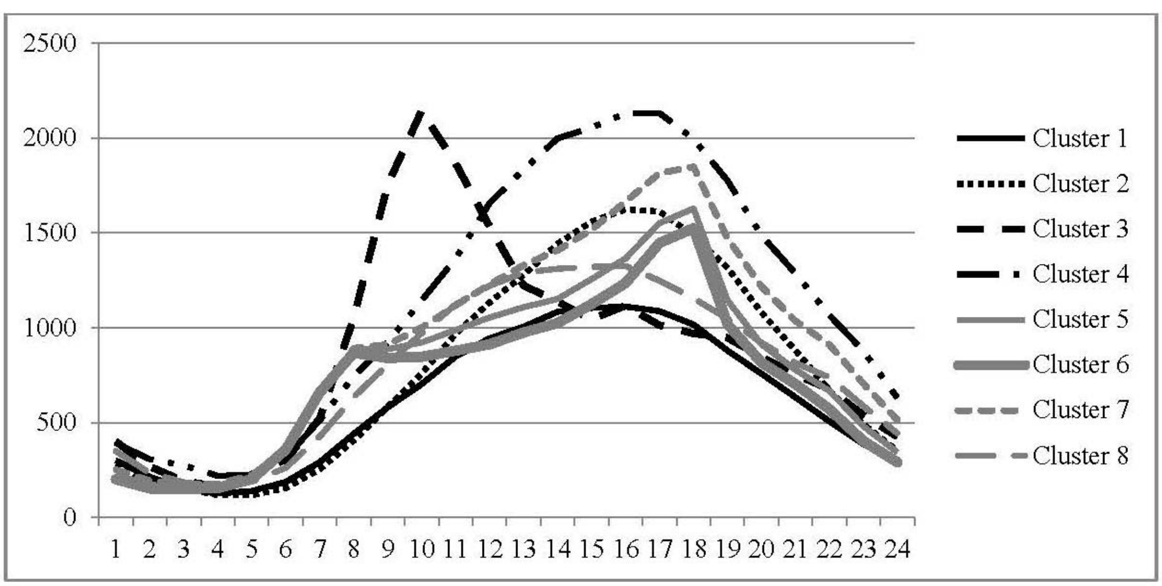
Examining the Potential Impact of Safety Policy on Accidents

The example used for this demonstration is the effectiveness of “Distracted Driving Laws” which have been enacted in recent years. Within the 12 southeastern states, seven have banned texting while driving including Arkansas, Georgia, Kentucky, Louisiana, North Carolina, Tennessee, and Virginia before January 2012. The laws apply to all vehicle drivers including CMV drivers. There are two accident measures within southeastern states for the time periods before and after text messaging ban laws were enacted. These two measures are fatal injury rate and non-fatal injury rate standardized by 100 million vehicle miles traveled by all vehicles as a measure of overall highway safety. Based on the state size, there are four different indicators:

TABLE 3
TRAFFIC VOLUME, 8 CLUSTER MEANS, TABULAR

S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
January							**February**							**March**						
						1			6	6	6	7	8			6	6	5	7	8
2	5	5	6	6	5	1	2	5	6	5	5	7	8	2	6	6	6	5	7	8
2	6	6	6	6	7	8	2	6	6	6	5	7	8	2	6	6	6	5	7	8
1	2	6	6	6	5	1	2	5	6	6	5	7	8	2	6	6	5	5	7	1
1	6	6	6	6	5	1	2	6						2	5	6	5	6		
2	6																			
April							**May**							**June**						
					7	8	2	5	6	5	5	7	8				5	5	7	8
2	5	5	5	5	7	2	7	5	6	5	5	7	8	2	6	5	5	5	7	1
2	6	6	6	5	7	8	2	6	5	5	5	7	8	2	6	6	5	5	7	8
2	6	6	6	5	5	8	2	6	6	5	5	7	8	2	5	5	5	5	7	8
2	6	6	6	5	7	1	1	4	5					2	5	5	5	7		
July							**August**							**September**						
					7	8		5	5	5	5	7	8					6	7	8
8	4	7	5	5	4	4	2	5	6	5	5	7	8	1	2	6	6	6	7	3
1	1	6	5	5	7	8	2	5	6	6	5	7	8	2	6	6	6	6	7	3
2	5	6	5	5	7	8	2	6	6	6	6	7	8	2	6	6	6	5	7	3
2	5	5	5	6	7	8	4	1	6	6				1	6	6	6	5	7	
2																				
October							**November**							**December**						
						8			6	6	5	7	8					5	7	8
2	6	6	6	5	7	8	2	6	6	6	5	7	1	1	6	6	6	5	7	8
2	5	6	6	5	7	8	2	6	6	6	5	4	3	1	6	6	6	5	7	8
2	6	6	6	5	7	8	1	6	7	4	5	2	4	8	5	5	5	7	7	1
2	6	6	6	5	7	3	4	6	6	6				1	4	7	2	7	4	8
2	6																			

FIGURE 3
TRAFFIC VOLUME, 8 CLUSTER MEANS, GRAPHICAL



100 million vehicle miles traveled, 100,000 population, 100,000 registered vehicles, and 100,000 licensed drivers, for calculating the fatality rate as well as injury rate. Nevertheless, 100 million vehicle miles traveled is more accurate for measurement. The main target is to test the efficiency of those states that have adopted the distracted driving law, and to transform the results into a graphical pattern. In other words, better efficiency means there is significant evidence to show that the fatality rate after embracing the distracted driving law is lower than before.

The first step of the analysis is conducted at a 5% significance level by testing the hypothesis that the text messaging ban law had a positive influence on reducing fatal and non-fatal injury rates (Table 4). The F-test is applied first to determine if equal variances are used to compare two populations in the given time frame from 2002 to 2011, which are pre-law periods and post-law periods. Four out of seven states have a p-value lower than 0.05 in the t-test. Considering compound effects such as other policies deployed, the result can only provide relatively sufficient evidence that the distracted driving law may reduce the fatal injury rate in these four states. The hypothesis to test the impact of policy change for the non-fatal injury rates led to different results. Georgia did not have significant results for reducing non-fatal injury rates while Arkansas joined the group with a low p-value. Meanwhile, North Carolina and Tennessee are the only two states to have high p-values demonstrating the influence of the distracted driving law.

Visualizing the Statistical Results of Policy Changes

In order to improve the understanding of the impact of policy changes, we visualized the outcomes by plotting the results on the U.S. map according to the p-values (Figures 5 and 6). Three categories are classified for the potential impact of policy making by symbols: the smiley face, mad face, and stop sign. A "smiley face" indicates where the policy has had significant impact in reducing fatality and injury rates, the "mad face" shows the opposite result, and the "no sign" means the state has not adopted the selected policy. In addition, the gradient of the grayscale specifies the significance of each state's results. A stronger result or higher degree of statistical significance is represented by clear or no shading; less strong results are indicated by a darker shading as indicated in the legend on the left lower panel. In this case, North Carolina, which is painted dark gray, is affected most positively by the policy. Virginia, which shows "mad face" and darkest color, indicates a lack of evidence that there was any reduction in either fatal or non-fatal accidents.

For policy makers who do not have a statistical background, graphical information would attract their attention and provide clearer results. Therefore, they are able to have quick responses for the effectiveness of traffic policies and are able to ultimately make better decisions. For those audiences who know how to read statistical reports, they may not be willing to focus on understanding the complicated tables due to busy work or other issues; the graphical results can provide clear directions in less time. The example is only to provide one single policy evaluation with 12 southeastern states; however, once the results correspond to the multiple policy evaluation in the entire U.S., the complexity of reading and interpreting the reports increase. It is suggested that transforming p-values into a colored map could improve clarity and understanding.

This easy-to-use and straightforward visualization tool can also show the impact of any policy making after gaining the results from statistical analysis. Although discussing a single traffic policy may ignore the compound effects with other policies, this tool shows a potential way to present how policies impact the drivers' behavior in easy to understand visual form.

CONCLUDING REMARKS

To effectively learn from the ever-increasing volume and complexity of traffic data collected,

FIGURE 4
SPATIOTEMPORAL DATA MAPPING TOOL INTERFACE

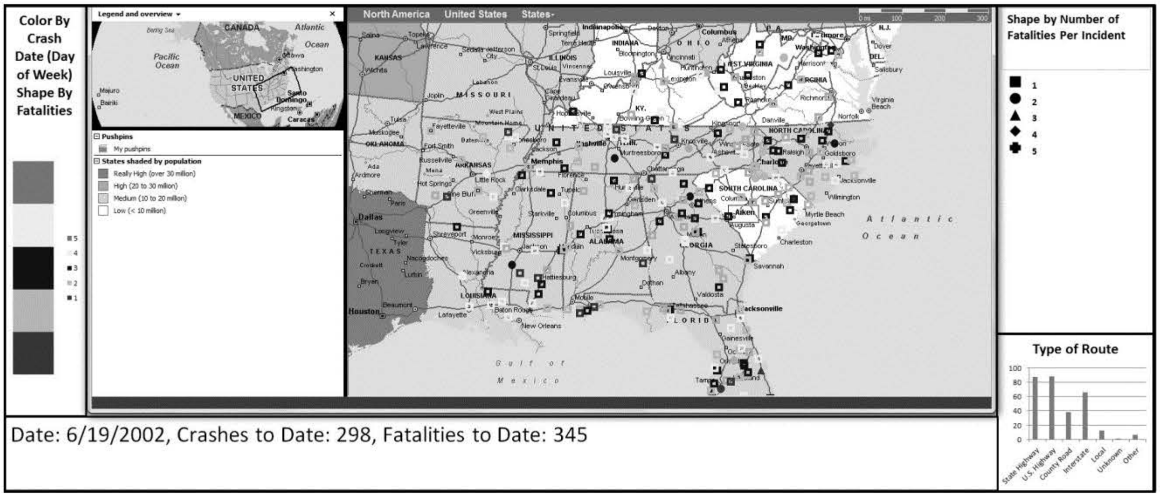


TABLE 4
PRE AND POST LAW COMPARISON FOR FATAL AND NON FATAL INJURY RATES

	Fatal			Non-Fatal		
	F test	Test type	T test	F test	Test type	T test
Alabama		NA			NA	
Arkansas	0.0643	Pooled	0.1413	<0.0001	Not Pooled	<0.0001
Florida		NA			NA	
Georgia	0.0850	Pooled	0.0306	0.0730	Pooled	0.0748
Kentucky	0.3056	Pooled	0.0729	0.1706	Pooled	0.3795
Louisiana	0.8000	Pooled	0.0786	0.1950	Pooled	0.1784
Mississippi		NA			NA	
North Carolina	0.1058	Pooled	<0.0001	0.02512	Not Pooled	<0.0001
South Carolina		NA			NA	
Tennessee	0.0612	Pooled	0.0029	0.0001	Not Pooled	<0.0001
Virginia	0.7328	Pooled	0.7542	<0.0001	Not Pooled	0.318
West Virginia		NA			NA	

this research effort explored how visualization techniques can be used to extract trends and to gain further understanding about factors of interest affecting transportation safety. Traffic safety is a critical issue to the trucking industry and is also very relevant to highway funding decisions. First, we examined how existing visual data mining tools can assist in theory development and policy making. The focus was on presenting some of the tools that have not been heavily used in the exploratory data analysis of transportation datasets. Some of these tools have been used for exploring similar traffic datasets (e.g. the work of N. Yau (2013)), while others have been applied outside the transportation field.

Using the insights from these methods and some fundamentals of visual data mining, we developed a new and potentially useful "visualization toolkit" that can be used to uncover unknown relationships in traffic volume; primarily in the clustering of traffic flows and visualizing the patterns associated with each cluster. We also provided a spatiotemporal multi-characteristic plot that allows practitioners and researchers to simultaneously visualize up to five variables of interest on a map; the model used included time and space variables. Such a tool can be useful when studying a dataset for the first time and in evaluating the validity of modeling assumptions.

Our third proposed contribution is based on the development and use of a “p--value heat map” that assists policy-makers, researchers and the general public to succinctly see the potential impact of public policy on the reduction of nonfatal and fatal crashes. This tool helps policy-makers who may not have a strong statistical background to understand statistical outputs of policy-analysis models.

FIGURE 5
P-VALUE MAP: FATAL INJURY

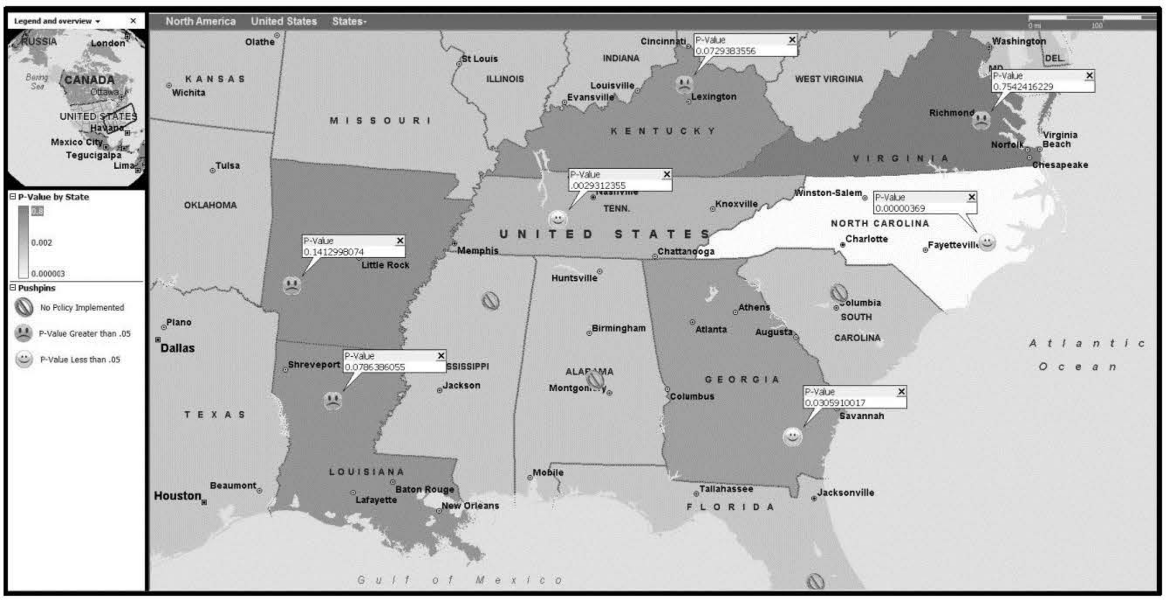
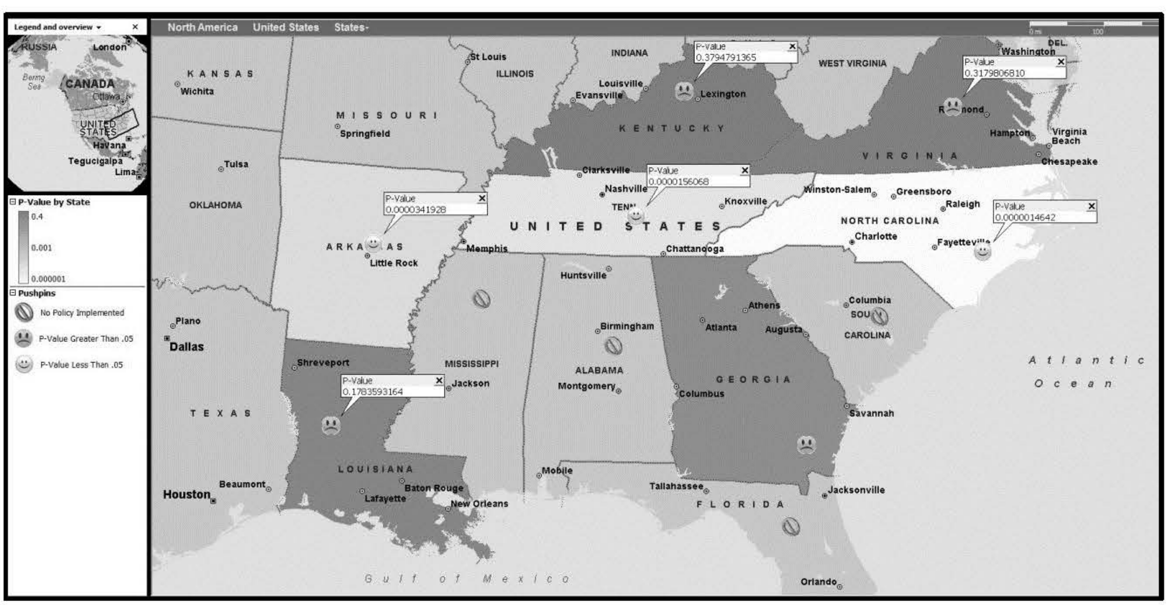


FIGURE 6
P-VALUE MAP: NON-FATAL INJURY



The results from this paper attempted to demonstrate the power of visualization and how they can assist with both theory development and explaining the results of statistical models. There remains significant work to be done in this area, including integrating visualization methods with traffic databases for real-time visualization of emerging trends, better understanding of the limitations of these approaches, and ensuring that these tools can be generalized to multiple application domains.

Supplemental Material - The clustering tool is located at: https://www.dropbox.com/s/lyq1tqhaquipjq3/CA2005.xlsm. The other tools are in the process of being revised for public use. Upon publication, we will provide the most up-to-date version at the corresponding author's website.

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IDENTIFYING THE DIMENSIONS OF LOGISTICS SERVICE QUALITY IN AN ONLINE B2C CONTEXT

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ABSTRACT

There is theoretical and practical evidence indicating the existence of significant differences between the needs and wants of firms and end consumers, as well as the existence of significantly different needs between offline and online environments. Therefore, it is not clear how effectively measures of logistics service quality developed in an offline, B2B context can be applied to an online, B2C environment. This manuscript explores the elements of logistics service quality that end consumers value in an online context. The literature on logistics service quality in B2B and the literature on online consumer satisfaction are integrated. This results in the development of a set of dimensions for measuring online logistics service quality in online, B2C environments. Specifically, the dimensions of a new scale for measuring online logistics service quality (labeled oLSQ) were identified and defined. Managers can use the dimensions of logistics service quality identified in the oLSQ scale as a guide when designing and managing online retail stores.

INTRODUCTION

Research, corroborated by industry data, suggests the existence of significant business growth potential for the provision of products and services via the Internet (Bauer *et al*., 2006). Online retail sales reached $231 billion in 2012 representing eight percent of total retail revenues. Online sales outpace sales growth at traditional stores and are expected to grow at a compound annual rate of 9% between 2012 and 2017 (Mulpuru et al., 2013). The opportunity to exploit this potential is a function of the Internet retailer's ability to meet customers' expectations in the virtual shopping environment (Zeithaml *et al*., 2002). Studies highlight the presence of a significant number of dissatisfied online customers as a result of service breakdowns (including stock-outs), lost orders, or inadequate order handling (Meuter *et al*., 2000). As a result, dissatisfied consumers lead to online sales losses of several billion dollars per year (Rust & Lemon, 2001).

The quality of logistics service performance is a key marketing component that helps create customer satisfaction (Bienstock *et al*., 1997; Mentzer *et al*., 1998) and has been recognized accordingly for some time (Perrault & Russ, 1974). Research suggests many interpretations of how logistics creates customer satisfaction, with the most traditional being based on the creation of time and place utility (Perreault & Russ, 1974). The so-called seven Rs describe the firm's ability to deliver the right amount of the right product at the right place at the right time in the right condition at the right price with the right information (Ackerman, 1996).

While logistics researchers have developed an important body of literature on the various ways that logistics can contribute to customer satisfaction, the majority of the work has been done in a B2B context, with the customer being a firm, not the end consumer. Furthermore, very few studies explore customers' perception of logistics services in an online context (for exceptions please see Esper *et al*., 2003; Rabinovich & Bailey, 2004; Rabinovich, 2007; Xiang et al., 2010). There is theoretical evidence indicating the existence of significant differences between the needs of firms and end consumers, as well as the existence of significanty different needs across offline and online environments

(Esper *et al.*, 2003). Therefore, it is not clear how effectively measures of logistics service quality developed in an offline, B2B context can be applied to an online, B2C environment. This manuscript begins to address this gap by exploring the elements of logistics service quality that end consumers value in an online context. Specifically, the dimensions of a new scale for measuring online logistics service quality (labeled oLSQ) were identified and defined.

The rest of this paper is organized as follows. A literature review of physical distribution and logistics service quality in B2B is first conducted in order to identify the dimensions of logistics service quality that can be adapted to an online, B2C context. Second, the literature on contributors to online consumer satisfaction is examined in order to establish what shoppers value and what logistics service elements lead to satisfaction. Third, these two distinct bodies of literature are integrated, which culminates in the development of a set of relevant dimensions for measuring logistics service quality in online, B2C environments. Finally, the implications for both managers and consumers are put forth and directions for future research are discussed.

LITERATURE REVIEW

The following sections review first the logistics service quality literature, and then the online customer satisfaction literature.

Exploring the Concept of Logistics Service Quality

As early as the twentieth century Shaw (1915) acknowledged the role of physical distribution by classifying business activities into "three great divisions": activities of production (which change the form of materials), activities of distribution (which change the place and ownership of the commodities produced) and facilitating activities (which aid and supplement the operations of production and distribution). Clark (1922) further separated the activity of physical distribution into its transportation and storage functions reflecting the various ways that physical distribution creates value. While the domain of physical distribution was not clearly defined yet, Stewart (1965) reported the importance of minimizing out-of-stock occurrences, gaining effective advantage with shorter customer order cycles, and reduced prices through distribution efficiencies as potential contributors to additional sales volumes. Similarly, LeKashman and Stolle (1965) argued that stockouts, excess delivery time, or excess variability of delivery time can result in lost sales. These studies provide the first logistics service quality criteria.

Perreault and Russ (1976) explored the role of physical distribution service (PDS) in industrial purchase decisions (the importance of PDS, the determinants of its importance and the determinants of purchaser satisfaction with it). In their seminal work the authors went on to further investigate PDS by asking respondents to indicate their satisfaction with several aspects of PDS provided by their suppliers such as billing procedures, order methods, accuracy in filling orders, delivery time, and delivery time variation. Gilmour (1977) investigated the service provided by major suppliers in the scientific instrument and supplies industry in Australia. Respondents were shown a list of 17 customer service elements and asked to rank order the five most important for their industry. The emergent five most important purchasing elements for all customers were: availability, after-sales service, delivery reliability, delivery time, and technical competence of the representatives.

Anderson *et al.* (1978) examined the relative importance of physical distribution elements. Their results revealed the following rankings: order cycle time reliability, percent orders filled, minimum PDS cost, minimum order cycle time, and minimum damage in transit. Luce (1982) surveyed purchasing managers on the subject of physical distribution service. Respondents were asked to rank order the five PDS elements which they perceived as most important. The five PDS elements most often cited were: accuracy in filling orders, average delivery time, rush services and billing, action on complaints, and order status information. Jackson *et al.* (1986) explored the perceived importance of six physical distribution service components and how the importance varied across five product types and three buy classes. The physical distribution service components ranked in the following order (most to least important): consistent delivery, in-stock, lead time, cooperation, and order processing information. At this point, it would seem that most of the traditional measures of logistics service quality have emerged.

A seminal work in the arena of physical distribution quality is the comprehensive literature review by Mentzer *et al.* (1989) that reveals the existence of three major dimensions of PDS: *availability, timeliness,* and *quality*. The *availability* dimension is represented by in-stock rate and percent orders, units, and lines filled. Consistent delivery, lead time, average delivery time, order cycle time reliability, and minimum order cycle time form the *timeliness* dimension. Finally, the *quality* dimension is represented by minimum damage in transit and order-filling accuracy. The authors further suggest that these PDS dimensions and indicators are somewhat robust across products and firms.

While the importance of various elements of PDS has been considered before, the first scale for physical distribution service quality (PDSQ) was developed by Bienstock and Mentzer (1997). To develop an instrument for measuring PDSQ an initial set of 23 items was generated by reviewing prior research on physical distribution service. The further refined instrument through exploratory factor analyses contained 15 items. Mentzer *et al.* (1989) argue that two elements exist in service delivery: marketing customer service and physical distribution service (PDS). In this view PDSQ is considered a component of logistics service quality (LSQ). Building on the previous work on PDSQ, Mentzer *et al.* (2001) developed the most comprehensive scale for LSQ, which in fact provides the building blocks for the development of oLSQ in this study. A review of extant literature combined with depth interviews and focus groups yielded nine dimensions for the concept of LSQ. The dimensions were subsequently tested via surveys. Another contribution of the study by Mentzer *et al.* (2001) is the conceptualization of LSQ as a process. The following nine dimensions were identified: personnel contact quality, order release quantities, information quality, ordering procedures, order accuracy, order condition, order quality, order discrepancy handling, and timeliness.

Personnel contact quality refers to the customer orientation of the supplier's logistics contact people. Specifically, it is a measure of whether customer service personnel are knowledgeable, empathize with their situation, and help them resolve their problems (Bitner *et al.*, 1994; Parasuraman *et al.*, 1985). Order release quantities refer to the concept of product availability. It measures whether the product the customer desires is available. The importance of product availability has long been considered a key component of logistics excellence (Mentzer *et al.*, 1989; Novack *et al.*, 1994). Customers are expected to be most satisfied when they are able to obtain the desired quantity, therefore stockouts are believed to have a significant impact on customer satisfaction and loyalty. Information quality is related to customers' perception of the information provided by the supplier regarding products from which customers may choose (Mentzer *et al.*, 1999; Rinehart *et al.*, 1989). Customers should be able to make better decisions when information is available and of adequate quality.

Ordering procedures refer to the efficiency and effectiveness of the procedures followed by the supplier (Bienstock *et al.*, 1997; Mentzer *et al.*, 1999). Specifically, order placement procedures need to be both effective and easy to use. Order accuracy refers to how closely shipments match customers' orders upon arrival (Bienstock *et al.*, 1997; Mentzer *et al.*, 1997). This measure includes having the right items in the order, the correct number of items, and no substitutions for items ordered.

Order condition is a measure of the lack of damage to orders (Bienstock *et al.*, 1997; Mentzer *et al.*, 1989). Damaged orders is suggested to lower the customers' level of satisfaction with the firm's logistics service. Order quality refers to how well products work (Novack *et al.*, 1994). This measure includes how well products conform to specifications and customers' needs. Order discrepancy handling refers to how well the firm addresses any discrepancies in orders after the orders arrive (Novack *et al.*, 1994; Rinehart *et al.*, 1989). If customers receive orders that fall short of their expectations they will seek corrections, and how well these issues are handled will impact the customers' perception of the quality of the firm's services.

Finally, timeliness refers to whether orders arrive at the customer's location when promised. In a broader sense, it also refers to the length of time between order placement and receipt (Hult, 1998; Hult *et al.*, 2000). The delivery time can be affected by transportation time, as well as back-order time when products are unavailable (Bienstock *et al.*, 1997; Mentzer *et al.*, 1999).

To summarize, this section provides a comprehensive review of the various dimensions of logistics service quality previously suggested in the B2B, offline research. It further shows the chronologic progression of the logistics service quality dimensions and culminates with the introduction of the traditional LSQ scale on which this paper builds.

Exploring the Determinants of Consumer Satisfaction With E-Commerce Services

In this section the literature on online consumer satisfaction is explored chronologically in order to establish what online shoppers value and what the elements of logistics service are that lead to consumer satisfaction. Particular emphasis is placed on studies that actually provide a scale for measuring consumers' satisfaction with online retail experiences, also referred to as e-commerce. Consistent with Oliver (1999) in this study satisfaction is defined as the perception of pleasurable fulfillment of a service.

The seminal work on quality by Juran and Gryna (1970) suggests four quality dimensions: capability (does the product perform as expected), availability (is the product usable when needed), reliability (is the product free from failure) and maintainability (is the product easy to repair when broken). Parasuraman *et al.* (1988, 1991) conducted empirical studies in several industry sectors to develop and refine SERVQUAL. This scale measures service quality along five dimensions: reliability, responsiveness, assurance, empathy, and tangibles. The generic dimensions of quality developed in these two studies are at least partially reflected in the majority of subsequently suggested quality scales.

Using a survey of web site visitors Rice (1997) attempted to determine the factors that would induce revisit. Good content/information and having and enjoyable experience were found to be the most important drivers. Their examination of the top 100 U.S. retailers (Griffith & Krampf, 1998) revealed that access and responsiveness of the web site were key indicators of service quality delivered through the web. Ho and Wu (1999) also explored the antecedents of online customer satisfaction using an empirical study.

Five antecedents were identified in this study: logistical support, technological characteristics, information characteristics, homepage presentation, and product characteristics. Of the five antecedents, logistical support emerged as the most significant antecedent for electronic commerce.

Liu and Arnett (2000) surveyed Webmasters for Fortune 1000 companies to assess the factors critical to web site success with consumers. Five dimensions were found to be most salient to consumers: quality of information (relevant, accurate, timely, customized and complete information presentation), service (quick response, assurance, empathy, and follow-up), system-use (security correct transaction, customer control on transaction, order-tracing facility, and privacy), playfulness (customers' sense of enjoyment, interactivity, attractive features, and enabling customer concentration), and design of web site system/interface (involved organized hyperlinks, customized search functions, speed of access, and ease of correcting errors).

In an attempt to adapt the SERVQUAL dimensions to online services, Kaynama and Black (2000) evaluated the online services of 23 travel agencies on seven dimensions derived from SERQUAL: responsiveness, content and purpose (derived from reliability), accessibility, navigation, design and presentation (derived from tangibles), background (assurance), and personalization and customization (derived from empathy). One of the most cited scales on online consumer satisfaction was developed by Szymanski and Hise (2000) who evaluated the impact on customer satisfaction of customer perceptions of online convenience, merchandising (product offerings and product information), site design, and financial security.

Lociacono *et al.* (2000) also developed a scale called WEBQUAL with 12 dimensions: information fit to task, interaction, trust, response time, design, intuitiveness, visual appeal, innovativeness, flow (emotional appeal), integrated communication, business processes, and substitutability. Informational fit to task refers to appropriateness of information, quality of information and presentation of information. Interactivity refers to the extent to which web site users can: communicate with the people behind the web site, interactively search for information, and conduct transactions through the web site. Trust is determined by the privacy of information offered by the web site. Response time refers to the time it takes for the web page to load in a user's browser and also the required time to complete various transactions. Design refers the aesthetics of the web site such as information organization and navigability. Intuitiveness refers to the ability of the shoppers to easily navigate the web site. Visual appeal refers to the graphics and text on the site. Innovativeness is conceptualized as the "aha" or surprise element associated with the web site, including its creativity and uniqueness. The flow dimension is addressed by the level of enjoyment and engrossing associated with the site. Integrated communication refers to the seamlessness of communication with users through multiple channels. The business process dimension measures the fit of the web strategy with the general business strategy. Lastly, substitutability is a measure of the effectiveness of the web site interaction compared to other means such as physical stores. Overall, WEBQUAL is created to guide web site designers and help them better create web sites. One of the drawbacks of this scale is that it involved students visiting web sites to evaluate them rather than actual online consumers reporting their experiences. As a result, the authors excluded a dimension called customer service because it could not be measured. The dimension of fulfillment was also not included in WEBQUAL for the same reason.

In their highly referenced study on Web site quality Zeithaml *et al.* (2000) identified a large number of web site features at the perceptual-attribute level and categorized them into 11 service quality dimensions: (1) reliability refers to the correct technical functioning of the site and the accuracy of service promises, such as having items in stock, delivering what is ordered, delivering when promised, accurate billing and accurate product information, (2) responsiveness refers to quick response and the ability to get help if there is a problem or question, (3) access refers to the ability to get online quickly and contact the company when needed, (4) flexibility refers to having choice of ways to pay, ship, buy, search for, and return items, (5) ease of navigation refers to whether the site contains functions that helps shoppers find what they need without difficulty, has good search functionality, and allows shoppers to maneuver easily and quickly back and forth through the pages, (6) Efficiency refers to whether the site is simple to use, has a proper structure, and whether it requires a minimum of information to be input by customer, (7) assurance/trust refers to whether the customer has confidence in dealing with the site as a result of the reputation of the site and the products and services it sells, as well as whether clear and truthful information is presented, (8) security/ privacy refers to the degree to which customers believe the site to be safe from intrusion and personal information is protected, (9) price knowledge refers to the extent to which customers can determine shipping price, total price, and comparative prices during the shopping process, (10) site aesthetics refers to the appearance of the site, (11) and customization - personalization refers to how much and how easily the site can be tailored to individual customers' preferences, histories, and ways of shopping.

Also building on the SERVQUAL model, Barnes and Vidgen (2001) created a scale also called WebQual. In their study in the field of online book trade, the authors identified five key dimensions each of which encompasses two subdimensions: tangibles (aesthetics, navigation), reliability (reliability, competence), responsiveness (responsiveness, access), assurance (credibility, security), and empathy (communication, understanding the individual). As conceptualized in WebQual: aesthetics refers to the appearance of the web site including style and audiovisual impact; navigation refers to the ease of finding a site and getting around it to find specific items; reliability, refers to the provision of reliable information and reliable service; competence refers to the right knowledge and capability to provide the good or service; responsiveness refers to prompt service and timeliness via the site; access refers to approachability and ease of access; credibility refers to the trustworthiness of the site; security refers to freedom from risk or doubt in transacting with the site to purchase a good; communication refers to provision of the correct information in an appropriate format; and, understanding the individual refers to empathy with the customer to provide the right products, prices, and content.

Overall, the main focus of WebQual is on the technical aspects of the online shopping experience.

Yoo and Donthu (2001) created a nine-item SITEQUAL scale for measuring site quality. Four quality dimensions are suggested in this scale: ease of use, aesthetic design, processing speed, and security. Similar to the WebQual, SITEQUAL was developed and tested using a convenience sample therefore it doesn't constitute a comprehensive assessment of a site's service quality. In their study examining Internet pharmacies, Yang *et al.* (2001) identified and evaluated six dimensions of consumer perceptions of service quality: ease of use (user friendliness, loading/transaction speed, search capability, and easy navigation), web site content (information that matches the needs of the consumer), accuracy of content, timeliness of response, aesthetics (attractiveness of the site and catalog pictures), and privacy. Heim and Sinha (2002) developed a taxonomy of the e-service process. Their study suggested that website navigation, product information and representation, order processing, and fulfillment are the major dimensions of an e-service process.

Zeithaml *et al.* (2002) synthesized the previous literature on online service quality by conducting a comprehensive literature review. Five broad sets of criteria for evaluating service quality in an online context are suggested: information availability and content, ease of use or usability, privacy/security, graphic style, and reliability/ fulfillment. Research suggests that availability and depth of information is important because when users can control the content, order and duration of exposure to information their ability to integrate, remember and use information improves (Ariely 2000). Ease of use has been considered relevant because Internet-based transactions can be complex and intimidating to some customers. Privacy (the protection of personal information) and security (the protection of users from the risk of fraud and financial loss) have been empirically proven to have a strong impact on attitude toward use of online financial services (Montoya-Weiss *et al.*, 2003). Graphic style refers to issues such as color, layout, print size and type, graphics and animations, and has been suggested to affect customer perceptions of online shopping (Hoffman & Novak, 1996; Hoque & Lohse, 1999). Lastly, reliability/fulfillment has been argued to be an important aspect of online service quality (Wolfinbarger & Gilly, 2003). Furthermore, Wolfinbarger and Gilly (2003) found that reliability/fulfillment was the strongest predictor of customer satisfaction and quality.

Wolfinbarger and Gilly (2003) examined the dimensions of service quality in internet retailing through the use of online and offline focus groups, a sorting task and an online survey. Four quality dimensions emerged in their study: fulfillment/reliability (involving accurate representation of the product, on-time delivery, and accurate orders), web site design (involving some attributes associated with design as well as an item dealing with personalization and another dealing with product selection), customer service (combining interest in solving problems, willingness of personnel to help, and prompt answers to inquiries) and security/privacy (feeling safe and trusting of the site). The resulting quality scale labeled eTailQ was represented by 14 items.

Montoya-Weiss *et al.* (2003) conducted two large-scale studies in different service contexts to explore antecedents to online service quality. Research on technology adoption shows that user perception of usefulness and ease of use determine the adoption of a new information system (Venkatesh & Davis, 2000). Furthermore, consistent with information search theory and human-computer interaction research (Hoque & Lohse, 1999) the authors propose that customers' assessment of three web site design characteristics will influence their evaluations of online channel service quality. The three suggested characteristics are: navigation structure, information content, and graphic style. Navigation structure refers to the organization and hierarchical layout of the content and pages in a web site.

Web site information content is defined as the material that appears on a web site. Finally, graphic style is defined as the tangible aspect of the online environment that reflects the perceived attractiveness of a web site.

Kim *et al.* (2004) developed an index of customer satisfaction using a Korean sample. His study revealed ten antecedents to customer satisfaction which in turn was linked to repurchase intentions. The ten antecedents were: delivery and after sales service, purchase result and price attractiveness, product information, customer service, site design, process convenience, product attractiveness, payment method, site information, and log-on convenience. In a subsequent study, Schaupp and Belanger (2005) proposed that three categories of factors impact online consumer satisfaction: technology factors (security, usability and side design), shopping factors (convenience, trust and trustworthiness, and delivery), and product factors (merchandising, product value, and product customization). Convenience is often found to be the most important determinant of online shopping (Jiang et al., 2013). Online shopping allows individuals to save time and effort by making it easy to locate items and purchase products (Peterson *et al.*, 1997).

Using Zeithaml *et al.*'s (2002) explorative study as a starting point, Parasuraman *et al.* (2005) developed one of the most comprehensive works on e-service quality. The result of their empirical test suggested the need for two different scales to accurately measure electronic service quality: E-S-QUAL and E-RecS-QUAL. The first scale, E-S-QUAL measures core service quality aspects and consists of four quality dimensions:

efficiency, fulfillment, system availability and privacy. The second scale, E-RecS-QUAL is suggested to be relevant when consumers face "nonroutine encounters" (e.g. product returns, problems) during the online-shopping process. This scale is composed of three quality dimensions: responsiveness, compensation and contact.

Bauer *et al.* (2006) argued that affective reactions are of crucial importance for the evaluation of e-services, as fun and enjoyment are major determinants of Internet usage behavior (Van Riel *et al.*, 2001). Their study suggested that transferring this quality criterion to online shopping is essential. The perceived fun of using the web site along with personalization of content features appear to be an important quality criteria (Zeithaml *et al.*, 2002). Bauer *et al.* (2006) considered a four-stage transaction model in their investigation of electronic service quality: information phase, agreement phase, fulfillment phase, and the after-sales phase. The resulting scale, eTransQual, had five quality dimensions: functionality/design, enjoyment, process, reliability, and responsiveness.

To summarize, this section provides an extensive review of the various determinants of consumer satisfaction with e-commerce services. It further shows the variety of dimensions and subdimensions of quality that previous authors have introduced in a B2C context. While different authors have suggested different, and arguably contradictive interpretations of the dimensions of service quality, this comprehensive review provides the basis for identifying what aspects of the logistics service that online consumers value.

IDENTIFYING THE DIMENSIONS OF ONLINE LOGISTICS SERVICE QUALITY (OLSQ)

In this section the literature reviewed is integrated, and this results in the identification of the dimensions of online logistics service quality (oLSQ). Specifically, we adopt the quality dimensions from the traditional LSQ that we believe would apply to an online B2C context, and further combine those dimensions with the quality dimensions suggested by the review of the online consumer satisfaction literature that we believe apply to logistics services.

Similar to Mentzer *et al.*'s (2001) conceptualization of logistics service quality, oLSQ was examined as a process consisting of two distinct stages: order placement and order receipt.. The idea of improving the measurement of service quality by grouping user activities into a set of discrete stages is supported by the task completion approach (Sismeiro & Bucklin, 2004). Considering that web site users are able to separate their evaluations of the online shopping experience according to discrete stages, a process-based approach provides richer diagnostic information and managerial implications for improving service quality (Bauer *et al.*, 2006).

Order Placement Stage Dimensions

The first dimension of oLSQ is *customer service* and it represents a combination of elements from the traditional LSQ and the literature on online satisfaction. Specifically, we draw upon the personnel quality dimension from LSQ which refers to the customer orientation of the supplier's logistics contact people (Bitner *et al.*, 1994; Parasuraman *et al.*, 1985). However, in an online setting consumers interact with websites and personnel, therefore the dimension of customer service is conceptualized here as prompt answers to inquiries, online retailer's interest in solving consumer problems, willingness of personnel to help, as well as the ability of website functions/features to automatically assist with consumer problems (Wolfinbarger & Gilly, 2003).

The second dimension of oLSQ, *ordering procedure* is adopted from the traditional LSQ scale. It refers to the efficiency and effectiveness of the procedures established by the online retailer (Bienstock *et al.*, 1997; Mentzer *et al.*, 1999). This dimension also includes ease of use which emerged as an important criteria in the review of online consumer satisfaction literature (Yoo & Donthu, 2001; Zeithaml, Parasuraman & Malhotra, 2002; Yang *et al.*, 2001).

The third dimension, *hedonic aspect* emerged from the literature on consumer satisfaction. It is argued that affective reactions are of crucial importance in the evaluation of e-services, as fun and enjoyment are major determinants of Internet usage behavior (Van Riel *et al.*, 2001). Specifically, this measure refers to customers' sense of enjoyment with the shopping experience.

Website design is the fourth dimension that has emerged from the literature on consumer satisfaction (Yoo & Donthu, 2001; Szymanski & Hise, 2000; Montoya-Weiss *et al.*, 2003; Liu & Arnett, 2000). It is conceptualized here as a measure of the web site's navigation structure and graphic style. Navigation structure refers to the organization and hierarchical layout of the content and pages in a web site. Finally, graphic style is defined as the tangible aspect of the online environment that reflects the perceived attractiveness of a web site (Montoya-Weiss *et al.*, 2003).

Order Release Quantity/Availability is a measure adopted from the traditional LSQ scale. It measures whether the product the customer desires is available. The importance of product availability has long been considered a key component of logistics excellence (Mentzer *et al.*, 1989; Novack *et al.*, 1994). It is expected that product availability and stockouts will have a significant impact on customer satisfaction.

Flexibility is the sixth dimension of oLSQ. As defined here it refers to having choice in ways to pay, ship, buy, search for, and return items (Zeithaml *et al.*, 2000). This dimension emerged as important in the review of online consumer satisfaction. To some extent, it overlaps with what's referred to as customization in the consumer satisfaction literature (Srinivasan *et al.*, 2002; Schaupp & Belanger, 2005; Kaynama & Black, 2000). The ability to return items is a critical component of this dimension.

Information quality is a measure adopted from the traditional LSQ scale. It is related to customers' perception of the information provided by the supplier regarding products from which customers may choose (Mentzer *et al.*, 1999; Rinehart, Cooper, & Wagenheim, 1989). Customers should be able to make better decisions if information is available and of adequate quality. While the measure is adopted from the traditional LSQ, research on online consumer satisfaction emphasizes the importance of information quality as well (Bauer *et al.*, 2006; Barnes and Vidgen, 2001; Yoo & Donthu, 2001; Zeithaml *et al.*, 2002; Zeithaml *et al.*, 2000; Ho & Wu, 1999; Montoya *et al.*, 2003; Rice, 1997; Liu & Arnett, 2000; Lociacono *et al.*, 2000; Ariely, 2000). An important aspect of information quality is the availability of accurate tracking information.

Merchandising is the eighth measure for oLSQ and it refers to the depth and breadth of the retailer's product offering. Sometimes referred to as selection, this dimension has been found important to online shoppers' satisfaction in a number of studies (Yoo & Donthu, 2001; Schaupp & Belanger, 2005; Wolfinbarger & Gilly, 2003).

Order Value is the ninth measure for oLSQ . It captures the dimensions of product value (Schaupp & Belanger, 2005) and delivery value (Heim & Sinha, 2002; Ba & Johansson, 2008). Both aspects of order value are important contributors to online shoppers' satisfaction.

Assurance/Trust has emerged as an important dimension of oLSQ. It refers to whether the customer has confidence in dealing with the site as a result of the reputation of the site and the products and services it sells (Zeithaml *et al.*, 2000). Since customers have to disclose personal financial information when shopping online, assurance/trust is a critical component of oLSQ (Liu & Arnett, 2000; Zeithaml *et al.*, 2000; Zeithaml *et al.*, 2002; Kaynama & Black, 2000; Barnes & Vidgen, 2001).

System availability/Reliability is the last dimension in the order placement stage. This measure refers to whether the website is available for use and whether it can consistently be used without technical problems (Zeithaml *et al.*, 2002; Parasuraman *et al.*, 2005; Zeithaml *et al.*, 2002; Bauer *et al.*, 2006).

Order Receipt Stage Dimensions

Order accuracy refers to how closely shipments match customers' orders upon arrival (Bienstock *et al.*,1997; Mentzer *et al.*, 1997). This measure includes having the right items in the order, the correct number of items, and no substitutions for items ordered. Its importance has been recognized for online transactions considering it can be time consuming for shoppers to have errors corrected (Zeithaml *et al.*,2000; Zeithaml *et al.*, 2002).

Order condition is a measure of the lack of damage to orders (Bienstock *et al.*, 1997; Mentzer *et al.*, 1989). Damaged orders has been found to significantly lower the customers' level of satisfaction with the firm's logistics service. *Order quality* refers to how well products work (Novack *et al.*, 1994). This measure includes how well products conform to specifications and customers' needs.

Timeliness refers to whether orders arrive at the customer's location when promised. In a broader sense, it also refers to the length of time between order placement and receipt (Hult, 1998; Hult *et al.*, 2000). Its importance has been recognized in the consumer satisfaction literature as well (Yang *et al.*, 2001; Barnes & Vidgen, 2001).

Order discrepancy handling is the last dimension in the order receipt stage of oLSQ. It refers to how well the firm addresses any discrepancies in orders after the orders arrive (Novack *et al.*, 1994; Rinehart *et al.*, 1989). If customers receive orders that fall short of their expectations they will seek corrections, and how well these issues are handled will impact the customers' perception of the quality of the firm's services.

Table 1 identifies and summarizes the dimensions for a new scale of online logistics service quality, or oLSQ.

CONCLUSIONS AND FUTURE RESEARCH

The quality of logistics service performance is a key marketing component that helps create customer satisfaction and has been recognized accordingly for some time (Perrault & Russ, 1974). Although extensive academic research has examined the various dimensions of logistics service quality it has done so primarily in an offline B2B environment. Very few studies explored facets of logistics service in an online B2C environment and even fewer explored how online retailers can use logistics services to create consumer satisfaction. This study acknowledges the limitations in the literature and takes a first step towards building theory in this area.

Specifically, dimensions for a new scale for logistics service quality labeled oLSQ were identified to capture the logistics elements that contribute to the creation of satisfaction for online shoppers. A comprehensive review of the literature on logistics service quality and online consumer satisfaction was conducted. The two distinct areas of literature were then integrated in order to determine the appropriate dimensions of oLSQ. This research contributes to the body of knowledge in a number of ways. The results of the comprehensive literature review suggests that logistics service paradigms that worked well in offlline B2B contexts are not always applicable,, in online B2C environments. End consumers have different expectations as compared to business customers, and online environments present different logistics requirements as compared to offline contexts.

TABLE 1
ORIGIN OF THE OLSQ DIMENSIONS

Dimensions suggested by the online consumer satisfaction literature	oLSQ Dimensions	Dimensions of the traditional LSQ scale
Customer Service Wolfinbarger and Gilly 2003	Customer Service	**Personnel Contact Quality** Mentzer *et al* 2001
Ease of Use Yoo and Donthu 2001; Zeithaml *et al.* 2002; Yang, *et al.* 2001	Ordering Procedure	**Ordering Procedure** Bienstock *et al.* 1997; Mentzer *et al.* 1999
Hedonic Aspect Van Riel et al. 2001	Hedonic Aspect	
Website Design Yoo and Donthu 2001; Szymanski and Hise 2000;; Liu and Arnett 2000	Website Design	
	Order Release	**Order Release Quantity** Mentzer *et al.* 1989; Novack *et al.* 1994
Flexibility Srinvasan *et al.* 2002; Schaupp and Belanger 2005; Kaynama and Black 2000	Flexibility	
Information Quality Bauer *et al.* 2006; Barnes and Vidgen 2001; Zeithaml *et al.* 2002	Information Qual.	**Information Quality** Mentzer *et al.* 1999; Rinehart *et al.* 1989
Merchandising Yoo and Donthu 2001; Schaupp and Belanger 2005	Merchandising	
Order Value Schaupp and Belanger 2005; Heim and Sinha 2002; Ba and Johansson 2008	Order Value	
Assurance/Trust Liu and Arnett 2000; Zeithaml *et al.*2000; Zeithaml *et al.* 2002;	Assurance/Trust	
System Availability Zeithaml *et al.* 2002; Parasuraman *et al.* 2005; Zeithaml *et al.* 2002	System Avail.	
	Order Accuracy	**Order Accuracy** Bienstock *et al.* 1997; Mentzer *et al.* 1997
	Order Condition	**Order Condition** Bienstock *et al.* 1997; Mentzeret *et al.* 1989
	Order Quality	**Order Quality** Novack *et al.* 1994
	Timeliness	**Timeliness** Yang *et al.* 2001; Barnes and Vidgen 2001
	Order Dis. Han.	**Order Discrepancy Handling** Novack *et al.* 1994; Rinehart *et al.*1989

Another contribution of this research is the identification of the specific aspects of logistics services that contribute to online shopper's satisfaction - these are the dimensions of the oLSQ scale.

This study has managerial implications as well. Managers can use the dimensions of logistics service quality identified in the oLSQ scale as a guide when designing their online retail stores. It is possible that some managers might have exceeded customer expectations according to traditional LSQ guidelines, and despite that sales revenues are still not what the firm would expect/desire, and customers are not coming back for return purchases. Perhaps such firms completely ignored "non-traditional" aspects of oLSQ such as the *hedonic* dimension. The service provided might have been as efficient and effective as possible, but a lack of fun, playfulness, and enjoyment of the ordering process might have driven some shoppers away from the online outlet.

The purpose of this paper was to identify the dimensions of the online logistics service quality scale. What is required next is the development and adoption of scale items. Qualitative interviews should first be conducted in order to confirm the dimensions of oLSQ, as well as potentially add new ones that didn't emerge through this integrative literature review. Next, the resulting scale should be tested. Future research can address other aspects of logistics services in an online B2C context as well. For instance it would be interesting to explore whether the experience of the delivery service itself can influence consumer satisfaction and loyalty. This would carry significant implications. Currently, most firms deliver items in an impersonal manner, usually by leaving the package in front of the customer's door. If the delivery process has the potential to influence consumer's loyalty and satisfaction, would firms invest in innovative ways to make the delivery process more personal? Considering the significant lack of logistics research in the area of online retailing to consumers, we conclude by emphasizing the need for more studies to analyze logistics services from the end consumer's perspective.

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Coyle, John J., Bardi, Edward J., and Novack, RobertA. (2004), *Transportation*, 6th ed., Cincinnati, OH: South-Western College Publishing.

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MANUSCRIPT SAMPLE

A FRAMEWORK FOR EVALUATING SUPPLY CHAIN PERFORMANCE

Terrance L. Pohlen, University of North Texas

ABSTRACT

Managers require measures spanning multiple enterprises to increase supply chain competitiveness and to increase the value delivered to the end-customer. Despite the need for supply chain metrics, there is little evidence that any firms are successfully measuring and evaluating inter-firm performance. Existing measures continue to capture intrafirm performance and focus on traditional measures. The lack of a framework to simultaneously measure and translate inter-firm performance into value creation has largely contributed to this situation. This article presents a framework that overcomes these shortcomings by measuring performance across multiple firms and translating supply chain performance into shareholder value.

INTRODUCTION

The ability to measure supply chain performance remains an elusive goal for managers in most companies. Few have implemented supply chain management or have visibility of performance across multiple companies (Supply Chain Solutions, 1998; Keeler et al., 1999; Simatupang and Sridharan, 2002). Supply chain management itself lacks a widely accepted definition (Akkermans, 1999), and many managers substitute the term for logistics or supplier management (Lambert and Pohlen, 2001). As a result, performance measurement tends to be functionally or internally focused and does not capture supply chain performance (Gilmour, 1999; *Supply Chain Management*, 200 I) . At best, existing measures only capture how immediate upstream suppliers and downstream customers drive performance within a single firm.

Table 1 about here

Developing and Costing Performance Measures

ABC is a technique for assigning the direct and indirect resources of a firm to the activities consuming the resources and subsequently tracing the cost of performing these activities to the products, customers, or supply chains consuming the activities (La Londe and Pohlen, 1996). An activity-based approach increases costing accuracy by using multiple drivers to assign costs whereas traditional cost accounting frequently relies on a very limited number of allocation bases.

$$y = a^2 - 2ax + x^2$$

REFERENCES

Manrodt, Karl (2003), "Drivers of Logistics Excellence: Implications for Carriers," In 1. W. Wilson (Ed.), *Logistics and Transportation Yearbook 2003* (pp. 126-154) Englewood Cliffs, NJ: Prentice-Hall, Inc.

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