

Center of Excellence Second-Year Progress Report

Project Number: COE-2012-01

Project Title: METROFREIGHT: the Local/Global Challenge of Urban Freight

Name and Affiliation of Main Applicant(s):

METRANS Transportation Center
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Time period that this report covers: January 2014 – December 2014

Starting date of the project: March 1, 2013

Expected end date of the project: December 31, 2017

Received Funding for Year 1: US \$324,750 SEK 2,131,253

Received Funding for Year 2: US \$673,700 SEK 4,421,325

Requested Funding for Year 3: US \$850,000 SEK 6,176,177

Date and signature of main applicants:



Genevieve Giuliano, Director

September 29, 2014

Date



Project Description

This report covers the 2014 calendar year. At this writing, 3 months remain in the calendar year. We therefore report on activities to date, meaning activities conducted during the first three quarters of 2014. For VREF, calendar year 2014 is Year 2 of the CoE grant; for MetroFreight it is a combination of years 1 and 2. The contract launching MetroFreight was finalized in late spring 2013, and establishment of all the subcontracts was not completed until summer 2013. Thus the year 1 activities have taken place from July 2013 through June 2014. Where possible we have accelerated the Year 2 schedule by launching some projects in early 2014. However, the contract revision process took some months, so most of the Year 2 activities began in early summer of 2014. We provide a status report on all the Year 2 activities.

Project Activities

The main tasks for Year 2 were: 1) Management and operation of the MetroFreight Center of Excellence; 2) Completion of Year 1 data collection and analysis; 3) Performance of the Phase 2 thematic research program; 4) Development of curriculum materials and professional training; and 5) Further development of outreach efforts.

Management and operation of the MetroFreight Center of Excellence

Hiring of MetroFreight staff was completed. Catherine Showalter, Project Manager, began employment in mid February 2014 and immediately assumed responsibilities of communication, coordination and collaboration with the MetroFreight partners. MetroFreight (MF) administration and management continue to be supported by METRANS staff members, which are funded from other sources. Staff includes Vicki Valentine, METRANS Assistant Director, Elizabeth Gatchalian, Price School contracts and grants administrator, and Janet Kleinman, METRANS Administrative Assistant.

A regularly occurring VREF team conference call is convened on the fourth Thursday of each month to share information and progress on the research tasks. The Dropbox site continues to be regularly accessed by the partners to reference all MF documents and files.

The “opportunistic meetings” policy of using major conferences as venues for in-person meetings for the MetroFreight partners has resulted in four meetings in 2014:

January 14, 2014: Transportation Research Board (TRB) Annual Meeting, Washington DC. Year 2 start-up and budget items were discussed. Attendees were Giuliano, Conway, Eickemeyer, and Dablanc.

April 18, 2014: Transportation Research Arena (TRA), Paris. Members of all four partner organizations participated in a discussion of: 1) the status of progress on Year 2 projects; 2) Jose’ Holguin-Veras’ PASI upcoming event in Colombia; and, 3) freight landscape. Attendees included Dessouky, Giuliano, O’Brien, Conway, Kamga, Rodrigue, Dablanc, Beziat, Heitz, Morganti, Ahn, J-S Lee, and Seo.

August 4 – 9, 2014: Pan-American Advanced Studies Institute on Sustainable Urban Freight Systems, Bogota and Cartagena, Columbia. MF team members met and discussed: 1) the freight landscape research, 2) MF team changes at IFSTTAR, 3) partner education activities.

October 27, 2014: Transforming Access and Mobility in Cities Workshop, New York. The team will: 1) discuss ongoing research projects, 2) continue work on Urban Freight Landscape Atlas, 3) plan for the urban freight course test offering in Spring 2015. Those who plan to attend include Giuliano, O’Brien, Rodrigue, Miller, Conway, Eickemeyer, Dablanc, Seo, and Lee.

The CoE plans include an executive committee and advisory committee. The MF executive committee is composed of the team and theme leaders. They have met monthly via conference call and in person at

special events in multiple locations. It has not proved possible to arrange a synchronous meeting of an international advisory committee across the consortium; rather, consortium members are holding local advisory board meetings.

Research

A comprehensive research program was conducted in Year 2. The Year 1 data collection and comparative analysis has led to two research activities. A total of 19 Year 2 projects were launched. Due to space constraints, we summarize research here, and include descriptions of each of the projects in Appendix 1.

Phase 1 Research: Freight flows and their impacts

The data was collected in Phase 1 and will be used in the following years for research. All data elements that were available in the four metro areas have been collected. In addition to the descriptive task of characterizing freight flows in each of our metro areas, we are working on a comparative analysis that will describe “freight landscapes”, the spatial variation in freight activity and intensity within metropolitan areas. This work builds on Dablanc and Rodrigue’s city logistics typology. We hypothesize that land use patterns and network characteristics are useful proxies for freight flows. This research will continue through year 2.

Phase 2 Research: Thematic research program

The Phase 2 research program began in Year 2 with new projects initiated in each of the MF thematic areas. Most of these individual projects have a duration period of more than one year. The research program is being carried out as described in our proposal. A few changes have been made due to changes in faculty availability. The following tables summarize research in each of our thematic areas.

Theme 1: Role of policy from industry perspective

Lead: LA/Giuliano

Project	Sub-project	Team	Status
1.1 Local government policies and freight operations	1.1a Impact of zoning regulation on location and operation of freight facilities	LA – O’Brien	Canceled; see Year 2 changes for details
	1.1b Understanding demand for curb space and access for New York City deliveries	NY – King	Replaces road pricing and port freight activity; 50% complete
	1.1c. Congestion caused by urban freight	Paris – Beziat, Koning, Dablanc	Project planned for years 2 and 3; 50% complete
	1.1d Developing a parcel freight O-D matrix	Seoul – Seo, Jeong, Ahn	85% complete; second phase to begin Feb 2015
1.2 Modeling for local impact analysis	1.2a Modeling for local impact analysis	LA – Ioannou	Project planned for years 2 and 3; 30% complete

Theme 2: Last mile strategies – parking, loading, consolidation, environmental externalities
Lead: Paris/Dablanc

Project	Sub-project	Team	Status
2.1 Central city logistics strategies	2.1a Eliminating trucks for the collection and transport of municipal solid waste	NY – Miller	Project planned for years 2 and 3; 60% complete
	2.1b Network analysis of multimodal freight transport system in NYC	NY – Wang	Project planned for years 2 and 3; 50% complete
	2.1c Feasibility of consolidated freight deliveries	Paris – Heitz	Project planned for years 2 and 3; 50% complete
	2.1d City logistics strategies for CBDs	Seoul – (Seo)	80% complete, second phase year 3
2.2 Reducing vehicle emissions	2.2a Impacts of environmental access restrictions	Paris – Dablanc, Montenon, Cruz	Planned to begin year 3; began year 2; 50% complete
2.3 Paris freight survey analysis	2.3a Diagnostics for urban goods distribution	Paris – Beziat, Dablanc, Koning	Ongoing

Theme 3: Improving freight/passenger interactions
Lead: LA/Dessouky

Project	Sub-project	Team	Status
3.1 Integrating management of truck and rail systems in Los Angeles	3.1a Integrating management of truck and rail systems in Los Angeles	LA – Dessouky	Ongoing, years 2 - 5
3.2 Improving efficiency of truck flows	3.2a Impacts of growing non-motorized infrastructure on freight operations and accessibility	NY – Conway	Year 2 and 3 project; 50% complete
	3.2b Use of bicycles and tricycles for goods movement in Paris	Paris and NY – Koning, Conway	Completed; replaces cargo tramway project
	3.2c Improving efficiency of truck flows	Seoul – J-S Lee, T. Lee, Roh	30% complete

Theme 4: Land use change dynamics, consequences, and solutions

Lead: NY/Rodrigue

Project	Sub-project	Team	Status
4.1 More efficient siting of warehouse and distribution center activity	4.1a Conceptualizing and testing the freight landscape	LA – Giuliano	80% complete; new project
	4.1b Spatial dynamics of warehousing and distribution	LA –Giuliano	Year 2-3 project, 30% complete
	4.1c The dualism of urban freight transport	NY – Rodrigue, Behrends	50% complete
	4.1d More efficient siting of warehouse and distribution center activity	Paris – Heitz, Dablanc, Bahoken	Initially planned for years 2 – 5; now 2-4; 33% complete

Theme 5: Changing production and consumption

Lead: NY/Conway

Project	Sub-project	Team	Status
5.2 Alternatives to home deliveries	5.2a Alternatives to home deliveries	Paris – Morganti	Planned for years 4-5; moved to years 2 -3; 50% complete

Education

The METROFREIGHT education strategy involves two dimensions: 1) development of curriculum materials that can be used by scholars, practitioners and the general public; 2) professional training, including formal (accredited) and informal programs to train scholars and practitioner in concepts, methods, and applications of city logistics.

Completion of Year 1 Activities

We completed the development of a dataset and curriculum guide based on an international scan of curricular materials, readings, case studies, media, exercise and examples of experiential learning. This project was designed in part to help us identify the current state of the art in urban freight education as well as gaps in the curriculum. The dataset will be updated throughout the life of the grant. It currently has 362 entries, sortable by source type and format (e.g. curriculum, YouTube video, short course, etc.), primary author or developer, title, target audience (e.g. professional training, undergraduate level course, graduate level course), and year of completion. We also indicate if the entry has any particular regional or geographic focus.

Year 2 Programs (50% complete)

Graduate course on urban freight (Years 1, 2): We are developing an interdisciplinary module-based urban freight-specific graduate course to be offered ultimately in distance format. The course has three principal areas: (1) Freight and the City (components of urban geography, urban planning, supply chain

management and urban freight distribution as well as some urban history and economics); (2) Issues and Challenges of City Logistics with a focus on urban freight transport systems, urban freight stakeholders, facilities and mitigation policies and strategies; and (3) City Logistics in Practice which includes urban freight models, data sources and collection and case studies and best practices. The curriculum will be tested first as part of a newly approved graduate level course in *Urban Freight and City Logistics* to be offered at the City University of New York in the spring semester of 2015.

Other courses: An undergraduate course in Urban Logistics and Transportation will be offered in Paris in spring 2015. A new graduate course, “Seaport Policy and Management” is being offered at USC during the fall 2014 semester.

Development of short courses (Years 2, 3): An industry-focused short course will be piloted in Los Angeles in 2015. Some of the format and content has been tested as part of other professional development trainings offered in Los Angeles.

CoE Educational Exchanges: Four educational exchanges took place in 2014: 1) **Felipe Aros**, RPI/SUFS, at IFSTTAR; 2) **Dr. Martin Koning**, IFSTTAR, at City College of New York; 3) **Dr. Laetitia Dablanc**, IFSTTAR, at USC/MF; 4) **Marco Dean**, OMEGA Centre/London, at USC/MF.

Doctoral Student Events: PhD student Sanggyun Kang (USC) was selected from our CoE to attend the PASI-SUFS conference in Bogota, Colombia from August 3 – 15, 2014. Three PhD students were selected to attend the *Transforming Access and Mobility in Cities* Workshop to be held October 27 - 30, 2014 in New York. Representing our CoE are: Adeline Heitz, (IFSTTAR), Adrien Beziat (IFFSTAR) and, Shuai (Louis) Tang, University of Buffalo, The State University of New York.

Year 2 Outreach

Collaboration with Other Centers of Excellence (CoE)

In this section we describe consortium-wide collaborations and collaborations with other CoEs.

International Dialogue on City Logistics, March 14, 2014, organized by IFSTTAR/MetroFreight including MF Paris team presentations and CoE SUFS presentations (Taniguchi, Thompson).

TRA Paris, April 2014: We organized a series of activities around the Transport Research Arena conference held at CNIT Paris in April 2014: 1) paper presentations at the TRA conference (Dablanc, Dessouky, Giuliano, Lee, O’Brien, Rodrigue) 2) MetroFreight Day, with team visits to various Paris logistics sites and a special TRA MetroFreight session.

Sustainable Urban Freight Systems (SUFS) Peer to Peer Webinar series: Dablanc presented research on Logistics Sprawl with Anne Goodchild, University of Washington, July 22, 2014. MetroFreight will participate in one or two additional SUFS webinars.

Pan-American Advanced Studies Institute on Sustainable Urban Freight Systems, August 2014: The purpose of PASI-SUFS was to promote intellectual exchange between junior and senior urban freight researchers, and hence promote more research in this emerging field. Dablanc, Giuliano and O’Brien participated as senior researchers, and Eleanora Morganti (IFSTTAR) and Sanggyun Kang (METRANS) participated as junior researchers.

VREF Workshop, Transforming Access, Mobility and Delivery in Cities, October 2014: MetroFreight is joint organizing Panel 2, “why bother about urban freight?”. Dablanc will serve as moderator, and Conway will serve as discussant in the panel discussion.

Individual Partner Efforts

This section describes outreach activities conducted by each of the MetroFreight members.

METRANS: The *METRANS seminar series* includes 2 MF urban freight seminars in fall 2014. The *METRANS Industry Outlook* brings the perspective of industry to the academic community. Dan Gardner, Trade Facilitators, Inc., presented “Making Hay: The future of US competitiveness in the age of

globalization” on April 28, 2014. METRANS sponsors the annual CITT State of the Trade and Transportation Industry Town Hall Meeting, to be held October 15, 2014. This year’s topic is global trends and their impacts on the local economy. The event draws several hundred attendees from industry, public sector, and the community.

UTRC: Conway and Rodrigue participated in panel discussion, “Where will our new freight planners come from?”, presented at the New York Metropolitan Council’s Freight Working Group, June 10, 2014.

KOTI: KOTI and Inha University held a joint seminar based on their parcel freight O-D research in June 2014. A second seminar based on their city logistics strategies research will be held November 2014. Organizers include KOTI, Inha University, Seoul Metropolitan Government, Seoul Institute, and Korean logistics companies.

Media and Communications

The MetroFreight website (www.metrotrans.org/metrofreight) was launched in July 2014. Website development continues, with all of the main sections to be completed during the 2014 calendar year. *METRANS News* is the newsletter for all METRANS centers and activities. It is issued electronically 3 times per year, and it now features a MetroFreight page in each issue. IFSTAR issues *Newsletter METROFREIGHT*, which covers the Paris MF activities.

MF team members are active contributors at conferences, professional meetings, and industry forums. Several hold influential positions on boards and committee, and several are regular contributors to public media. Due to space limitations, we do not enumerate these activities.

I-NUF 2013

The edited volume of *Research in Transportation Business and Management* (11, 2014) entitled “Managing freight in urban areas,” includes papers from the 2013 I-NUF conference and other sources. It was edited by Genevieve Giuliano and is available via Science Direct at <http://www.sciencedirect.com/science/journal/22105395/11>.

Deviations from Year 2 Plan

The following changes were made to the research program: 1) Project 1.1a cancelled due to appointment of Tom O’Brien as Interim Executive Director, Center for International Trade and Transportation, CSULB, and receipt of new Center of Excellence grant from Federal Highway Administration; 2) shift in 2.1 projects for the NY team; 3) replacement of 3.1 project on Paris Tramfret with research on cargocycles (3.2b) due to abandonment of the Tramfret demonstration; 4) addition of project 4.1a in order to extend freight landscape research; 5) launch of project 5.1 due to availability of Morganti. One change was made to education program: the test offering of the urban freight course will take place in 2015. No changes made to outreach program.

Overall evaluation of Year 2

MetroFreight has had a very productive second year of operation. We have a full complement of staff and are fully operational. We have completed almost all Year 1 activities, launched 19 Phase 2 research projects, and engaged in some major team events and collaborations. The MF research is beginning to produce scholarly products, and MF team members have been very active in public outreach and communications. MF is benefitting from extensive research programs at all of the partner institutions, allowing us to leverage funds and resources. Our decision to invest in more travel to achieve face-to-face meetings has proved valuable; these meetings provide critical support for our many ongoing collaborative activities.

List of Scientific Production

Our list of scientific production is drawn from research conducted from the four MetroFreight partners during 2014. We list publications and presentations within the area of urban freight.

Publications

Acciaro, M, T. Vanellander, C. Sys, C. Ferrari, A. Romboutsos, G. Giuliano, J. Lee-Lam, and S. Kapros (2014), "Environmental sustainability in seaports: A framework for successful innovation," *Journal of Maritime Policy and Management*, 41(5), 480-500.

Afshin A., and P.loannou, 'Optimization Strategies for Resilient Freight Transport and Sustainability' Proceedings IEEE Conference on Decision and Control, Los Angeles, Dec. 2014, accepted.

Afshin A., R. Rajabioun, P.loannou, "Traffic Flow Prediction for Transportation Networks with Limited Traffic Data," IEEE Transactions on Intelligent Transportation Systems, to appear in 2014.

Dablanc, L. (2014) "Etalement logistique" à Atlanta et Los Angeles. *Transports*, vol. 483, pp. 5-19.

Dablanc, L. (2014) Logistics Sprawl and Urban Freight Planning Issues in a Major Gateway City - The Case of Los Angeles. In J. Gonzalez-Feliu, F. Semet & J.L. Routhier (Eds.), *Sustainable Urban Logistics: Concepts, Methods and Information Systems*, pp. 49-69. Berlin Heidelberg: Springer-Verlag.

Dablanc, L., Ogilvie, S., Goodchild, A. (2014) Logistics Sprawl: Differential Warehousing Development Patterns in Los Angeles and Seattle, *Transportation Research Board 93rd Annual Meeting*, Washington DC, USA.

Dablanc, L. and Rodrigue, J-P (2014) "Urban Freight Distribution: A Global Typology", in G. Giuliano and S. Hanson (eds) *The Geography of Urban Transportation*, 4th Edition, New York: The Guilford Press. in press.

Dablanc, L. and Rodrigue, J-P (2014) City logistics: towards a global typology, *Transport Research Arena*, Paris, France April 14-17.

Fu, L. and Dessouky, M.M. (2014) "A Modelling Approach for Dynamic Headway Control," in preparation for submission for *IEEE Transactions on Intelligent Transportation Systems*.

Giuliano, G. and S. Hanson, eds., (2014) *The Geography of Urban Transportation*, fourth edition. New York: Guilford Press, forthcoming. (Third edition 2004, second edition 1996, first edition 1986)

Giuliano, G. and A. Linder (2014) "Impacts of the Clean Air Action Plan on the port trade industry," *International Journal of Shipping and Transport Logistics*, 6(2), 172 – 188.

Giuliano, G., S. Chakrabarti, and M. Rhoads (2014) "Transport geography," *International Encyclopedia of Social and Behavioral Sciences*, 2nd edition. Oxford, UK: Elsevier Science, Ltd, forthcoming.

Guerrero, D. and Rodrigue, J-P (2014) "The Waves of Containerization: Shifts in Global Maritime Transportation", *Journal of Transport Geography*, Vol. 35, pp. 151-164.

Koenig, M. and A. Conway. Biking for Goods is Good: An Assessment of CO2 Savings in Paris. In review for publication in the *Transportation Research Record* and presentation at the TRB Annual Meeting in January 2015.

Morganti, E., Dablanc, L., Fortin, F. (2014) Final deliveries for online shopping: the deployment of pickup point networks in urban and suburban areas. *Research in Transportation Business & Management*. Vol 11, pp. 23-31.

Morganti, E. Dablanc, L. (2014) Recent innovations in last mile deliveries. In Hyard, A. *Non-technological Innovations for Sustainable Transport: Four Transport Case Studies*, Springer, pp. 27-45.

Mu, S, and Dessouky, M.M. (2014) "Control Rules for Dispatching Trains on General Networks with Multiple Train Speeds," *Conference Proceedings Transport Research Arena 2014*, Paris, France.

Ng, A.K.Y., C. Ducruet, W. Jacobs, J. Monios, T. Notteboom, J-P Rodrigue, B. Slack, K.C. Tam and G. Wilmsmeier (2014) "Port geography at the crossroads with human geography: between flows and spaces", *Journal of Transport Geography*, Vol. 41, pp. 84-96.

Rodrigue, J-P Council on Advanced Manufacturing (2014) "Manufacturing Capabilities for Fostering Investments", forthcoming, World Economic Forum, Global Agenda Council.

Rodrigue, J-P (2014) Reefers in North American Cold Chain Logistics: Evidence from Western Canadian Supply Chains, in press, The Van Horne Institute, University of Calgary.

Rodrigue, J-P (2014) "The Structuring Effects of Rail Terminals", in C. Comtois and B.P.Y. Loo (eds) *Railway Renaissance: Issues and Challenges*, Ashgate, Transport and Mobility series, in press.

Rodrigue, J-P and T. Notteboom (2014) "Looking Inside the Box: Evidence from the Containerization of Commodities and the Cold Chain", in press, *Maritime Policy and Management*.

Seo, S. (2014). Visions and development directions for sustainable urban logistics system in future cities. *KOTI Logistics Brief*, 37, 6-10. (written in Korean).

Seo, S., H. Kwon, K. Kim, T. Kwon, H. Park, and C. Ahn (2014). *Planning public support policy of management, performance evaluation, and system improvement for urban and regional consolidated logistics activities*. Ministry of Land, Infrastructure and Transportation. (written in Korean)

Seo, S., H. Kwon, T. Kwon, and H. Park (2014). *Issues and policy strategies of large-scaled logistics hubs and facilities in Korea: field survey on major freight generators and its key findings*. The Korea Transport Institute, 2014-17, forthcoming. (written in Korea with an English abstract)

Yanbo Zhao, Petros Ioannou (2014) 'Positive Train Control with Dynamic Headway based on Active Communication System', *IEEE Transactions on Intelligent Transportation Systems*, accepted.

Zhou, W, X. Wang, A. Conway, and Q. Chen. Empirical Analysis of Delivery Vehicle On-Street Parking Pattern in Manhattan Area. In review for presentation at the TRB Annual Meeting in January 2015.

Zhou, W, X. Wang, A. Conway, and Q. Chen. Investigation of Freight Delivery Patterns for New York City. Conference Proceedings, TRB 93rd Annual Meeting, January 12-16, 2014. Washington, D.C.

Conference Presentations

Afshin A., and P.Ioannou "Optimization Strategies for Resilient Freight Transport and Sustainability" IEEE Conference on Decision and Control, Los Angeles, to be presented in Dec. 2014.

Dablanc, L., Ogilvie, S., Goodchild, A. (2014) Logistics Sprawl: Differential Warehousing Development Patterns in Los Angeles and Seattle, *Transportation Research Board 93rd Annual Meeting*, Washington DC, USA.

Dablanc, L. and Rodrigue, J-P (2014) "City Logistics: Towards a Global Typology", *Transport Research Arena*, Paris (France).

Fu, L. and Dessouky, M.M. "A Train Dispatching Problem under Exact Travel Time Estimation," 2014 National Meeting of INFORMS, San Francisco, CA.

Giuliano, G., (2014) "Some thoughts on the future impacts of the Panama Canal," presented at the special session 3a, 100 years of the Panama Canal: The Legacy and the Future, Transportation Research Board Annual Meeting, Washington, DC.

Giuliano, G., (2014) "Moving freight in metropolitan areas: The newest urban transportation problem," Keynote speech, International Symposium on Urban Development and Land Policy, Beijing, China.

Giuliano, G. (2014) "The urban freight landscape: A conceptual framework and preliminary tests", presented at the PASI-SUFS Workshop, Bogota, Columbia.

Morganti, E., Dablanc, L., Fortin, F., Gouvernal, E. (2014) "Final deliveries for online shopping: the deployment of pickup point networks in urban and suburban areas," *Transportation Research Board 93rd Annual Meeting*, Washington D.C., USA.

Morganti, E., Dablanc, L. (2014) Final deliveries for online shopping. *Transport Research Arena*, Paris, April 14-17.

Mu, S. and Dessouky, M. M. "Control Rules for Dispatching Trains on General Networks with Multiple Train Speeds," *Transport Research Arena 2014*, Paris, France.

Rodrigue, J-P (2014) "Hinterland Transport and Logistics", Graduate Seminar, Joint Center for Transport and Logistics, Chongqing University, Chongqing (China).

Rodrigue, J-P (2014) "Improving the Bottlenecks: the Czech Republic as a Central European Intermodal Transport and Logistics Platform", with P. Kolar, International Association of Maritime Economists (IAME), Norfolk (USA).

Rodrigue, J-P (2014) "Myths and Realities of the Panama Canal Expansion", Ohio Conference on Freight, Columbus (USA).

Rodrigue, J-P (2014) "Transshipment Hubs in the New Panamax Era: What Role for the Caribbean?", with A. Asaf, International Association of Maritime Economists (IAME), Norfolk (USA).

Rodrigue, J-P (2014) "What Does Urban Freight Data Reveals about Mega Cities? Evidence from Los Angeles, New York, Paris and Seoul", *Transport Research Arena*, Paris (France).

Rodrigue, J-P (2014) "Zonal Logistics: Supporting Global Supply Chains", *Zonal Logics of Modernity: Urban Imaginations and Economic Life*, The New School, New York University (USA).

Rodrigue, J-P (2014) "Inland Ports: Opportunities and Obstacles for Inland Distribution", Roundtable chair, *Cargo Logistics Canada*, Vancouver (Canada).

Rodrigue, J-P (2014) "Reefers in Cold Chain Logistics: Evidence from Western Canadian Supply Chains", *Cargo Logistics Canada*, Vancouver (Canada).

Rodrigue, J-P (2014) "The Panama Canal Today: Impacts on World Economy and Competition", Keynote Presentation, *One Hundred Years of the Panama Canal: Legacy and Future*, Transportation Research Board, 93rd Annual Meeting, Washington DC, (USA).

Seo, S., C. Ahn, and J-S. Lee (2014). "Developing City Logistics Policy through Identifying Parcel Freight Determinants in the City of Seoul", submitted to *Transportation Research Board 94th Annual Meeting*, Jan. 11-15, 2015, Washington DC, USA.

Seo, S., J-S. Lee, and C. Ahn (2014). "Improving the parcel service performance in the Seoul Metropolitan Area: Differentiated approaches by urban land use pattern", presented at Transport Research Arena 2014 conference, April 2014, Paris, France.

Other Presentations

Beziat A. (2014) Urban Freight Generation: impacts on the social costs of congestion, International Dialogue on city Logistics, March 14, 2014.

Conway, Alison (Panelist and Moderator). Power to the Pedals: Wenzday Jane and the Culture of Change. American Institute of Architects, New York Chapter, July 8, 2014.

Conway, Alison. Freight in a Multi-Modal City: Accommodating Goods Movement on Pedestrian and Bicycle Friendly Streets. Lectures in Planning Seminar Series (LiPS), Columbia University, February 18, 2014.

Dablanc L. (2014) UN Habitat, Sustainable Mobility, Barcelona, 23-25 April, 2014.

Dablanc L. (2014) Peer to Peer Webinar, SUFS Sustainable Urban Freight Systems, July 22, 2014.

Dablanc L. (2014) Logistics sprawl, PASI-SUFS, Bogota, Colombia, August 4-8, 2014.

Dablanc L. (2014) Chaire FRELON City Logistics, Ecole des Mines, Paris, Sept 10, 2014.

Heitz A. (2014) Logistics sprawl in metropolitan areas: the case of the Paris Region, International Dialogue on city Logistics, March 14, 2014.

Montenon A. (2014) Air quality in Europe – How does it relate to freight and logistics? International Dialogue on city Logistics, March 14, 2014.

Morganti, E. (2014) The impact of e-commerce on last mile deliveries, PASI-SUFS, Bogota, Colombia, August 4-8, 2014.

Morganti E., Seidel S., Blanquart C., Dablanc L., Lenz B. (2014) Final deliveries for online shopping in Germany and in France. Mobil- TUM, Munich (Allemagne): 19-20 May, 2014.

O'Brien, T. (2014) Impact of Streamlined Chassis Movements on Port Terminal Capacity, UC Davis ITS Seminar, Davis CA, April 2014.

O'Brien, T. (2014) Trends in Global Trade and What They Mean for Supply Chains and Policymakers, UC Berkeley, Berkeley CA, April 2014.

Reme-Harnay P. (2014) Understanding urban freight outsourcing, International Dialogue on city Logistics, March 14, 2014.

Seo, S. (2014). "Future plan and direction of public support project for consolidated logistics in Korea", presented at Briefing Session of Consolidated Logistics Support Project by Ministry of Land, Infrastructure and Transportation, Feb. 28, 2014, Seoul, Korea.

Seo, S. (2014). Seoul, Korea and Transportationistics Support Project by s in Korea, Colombia, August 4-8, 2014d in France. 014ch 14, 2014 and Future, Transportation Research Board, 93rd Annual Meetid, Infrastructure and Transportation), September 26, 2014, Seoul, Korea.

Seo, S., and S. Jeong (2014). "Development of City Logistics Strategies for the CBD and 3 land-use types in Seoul", presented at the Seminar on Green Logistics Policy in Korea (supported by World Bank), Sept. 1, 2014, Incheon, Korea.

List of Research and Management Partners

MF includes four teams. The Los Angeles team is the lead, and the CoE is housed in the METRANS Transportation Center at the University of Southern California. The overall funding allocation shares are approximately 38/15/16/17/14 for METRANS-USC, METRANS-CSULB, UTRC, IFSTTAR, and KOTI respectively. The following tables summarize management, staff, and researchers engaged in MF. Institutional affiliations are also given. Degree of funding is approximated; actual budget numbers can be provided upon request.

METRANS Team

Name and affiliation	Role in MF	MF funding
Genevieve Giuliano Professor and Director Price School of Public Policy, USC	CoE Director, theme leader, team leader, researcher	Yes, for CoE management, specific research projects; 15% of annual
Maged Dessouky, Professor Industrial and Systems Engineering, USC	Theme leader, researcher	Yes, 6% of annual (or 33% of summer months)
Geraldine Knatz, Professor, Price School of Public Policy and Engineering, USC*	Researcher	Yes, 6% of annual
Petros Ioannou, Professor Electrical Engineering-Systems, USC	Researcher	Yes, 4% of annual (or 33% of summer months)
Victoria Valentine Deguzman METRANS Administrator, USC	Center administrator	No, contribution as cost share
Catherine Showalter, Project Manager, MetroFreight Center of Excellence, METRANS, USC	Program manager (replaces Ryan Cassutt)**	Yes, 40% of annual
Sanggyun Kang, PhD student urban planning, USC	Graduate research assistant	Yes, 50% fall semester
Jack Yuan, PhD student, urban planning, USC	Graduate research assistant	Yes, 25% fall semester
Lunce Fu, PhD student, industrial and systems engineering, USC	Graduate research assistant	Yes, 25% fall semester
Thomas O'Brien, Executive Director, Center for International Trade and Transportation, CSULB	Leader, education programs, outreach programs; researcher	Yes, 15% of annual
Seiji Steimetz, Professor Economics, CSULB	Researcher	No, no project for Year 2 or 3
Alix Traver, administrative coordinator, CITT, CSULB	Administration, INUF	Yes, 9% of annual
Masters student CSULB	Graduate assistant	Yes, 19.5% of annual

* Dr. Geraldine Knatz, former CEO of the Port of Los Angeles, joined USC effective August 2014.

**Ryan Cassutt, USC graduate student, was assigned temporarily for the fall 2013 semester. Catherine Showalter was hired in mid-February 2014 as Project Manager.

IFSTTAR Team

Name and affiliation	Role in MF	MF Funding
Laetitia Dablang, Director of Research, IFSTTAR	Theme leader, team leader	No, permanent employee; 120 days spent in year 2
Francoise Bahoken, Project Engineer (geography), IFSTTAR	Cartographer	No, contribution as cost share, 14 days
Adrien Beziat, PhD student IFSTTAR	PhD student, graduate research assistant, urban freight survey	Yes, Paris survey research; 230 days
Emilie Gaubert, project engineer (statistics), IFSTTAR	Statistician	No, contribution as cost share, 25 days
Adeline Heitz, PhD student IFSTTAR	PhD student, graduate research assistant, land use and planning	Yes, 230 days
Martin Koning, Senior researcher (economics), IFSTTAR	Researcher, Paris survey	No, contribution as cost share, 40 days
Pierre Launay, PhD student IFSTTAR	PhD student, urban trucking market*	No, contribution as cost share, 20 days
Nora Marei, Post-doctoral researcher, IFSTTAR	Researcher (replaces Eleonora Morganti)*	No, contribution as cost share, 5 days
Antoine Montenon, research engineer, IFSTTAR	Junior researcher	No, contribution as cost share, 230 days
Eleonora Morganti, Post-doctoral researcher, IFSTTAR	Researcher	No, contribution as cost share, 50 days
Petronille Reme-Harnay Senior Researcher (economics), IFSTTAR	Researcher	No, contribution as cost share, 20 days

*Eleonora Morganti left IFSTTAR as of August 31, 2014, and Nora Marei will take her place. Marei is a geographer and will focus on topics about e-commerce urban deliveries, starting September 1, 2014.

*Pierre Launay has joined the Paris team as of October 1, 2014.

UTRC Team

Name and affiliation	Role in MF	MF Funding
Alison Conway, Asst. Professor, Civil Engineering, CCNY	Theme leader	No, research task begins Year 3
Penny Eickemeyer, Assoc. Director for Research, UTRC, CCNY	Research manager	No, contribution as cost share
Camille Kanga, Asst. Prof. and Director, UTRC, Civil Engineering, CCNY	Researcher	No, research task begins Year 3
David King, Asst. Prof., Urban Planning, Columbia U	Researcher	Yes, 10% of annual
Benjamin Miller, Sr. Research Associate, UTRC, CCNY	Researcher	Yes, 10% of annual
Jean-Paul Rodrigue, Prof. Global Studies and Geography, Hofstra University	Theme leader, team leader	Yes, 10% of annual
Zachary Silverman, GIS Technician, UTRC, CCNY	GIS/Geo-database specialist	No
Qian Wang, Asst. Prof., Civil Engineering, U Buffalo	Researcher	No, research task begins Year 3

KOTI Team

Name and affiliation	Role in MF	MF Funding
Sangbeom Seo, Division Director, Logistics Policy and Technology, KOTI	Team leader	Yes, 2 months
Seungju Jeong, Senior Research Fellow, Logistics Policy and Technology, KOTI	Researcher	No, contribution as cost share
Jee-Sun Lee, Assoc. Research Fellow, Logistics Policy and Technology, KOTI	Researcher	Yes, 3 months
Changjin Ahn, Researcher Logistics Policy and Technology, KOTI	Researcher, data collection and geo-statistical analysis	Yes, 12 months
Hong-Seung Roh, Director Logistics Policy and Technology, KOTI	Researcher	No, contribution as cost share
Taihyeong Lee, Division Director, Logistics Policy and Technology	Researcher	No, research task begins Year 3

Future Plans

Planned project activities

Plans to further develop the Center of Excellence (CoE)

We will further develop the CoE by continuing to recruit new researchers and students, continuing to seek funding from other sources, broadening our communications programs, publishing and disseminating our results to the industry and public sector communities, and strengthening linkages with other CoEs.

Monthly MetroFreight team meetings will continue to take place by conference call or in person at special events, such as other CoE conferences, to enhance collaboration across VREF team members. We will meet as a group at the Transportation Research Board (TRB) Annual Meeting in January 2015 in Washington DC. Research papers have been submitted to TRB in order to take advantage of the opportunity to introduce our VREF projects to other transportation professionals. The major team meeting for 2015 will take place at the next International Urban Freight (INUF) conference, October 21 – 23, 2015 in Long Beach, California, hosted by METRANS. Additional travel funding is being requested for these meetings. We have deferred the team visit to Seoul to 2016, given the timing of I-NUF. Our policy of “opportunistic” meetings will continue.

Research

For Year 3, the research program continues for the five thematic areas. Our proposal identified specific projects to be conducted in Years 3, 4 and 5 and we propose only minor changes to the proposed Year 3 work. The Year 3 research program includes 16 projects continuing from Year 2 and 8 new projects. Due to space constraints, we summarize research here, and include project descriptions in Appendix 1. All continuing projects are described in the Year 2 section; the Year 3 section includes descriptions of the new projects.

Theme 1: Role of policy from industry perspective

Lead: LA/Giuliano

Project	Sub-project	Team	Status
1.1 Local government policies and freight operations	1.1b Understanding demand for curb space and access for New York City deliveries	NY – King	Year 2-3 project; in progress
	1.1c. Congestion caused by urban freight	Paris – Koning	Year 2-3 project; in progress
	1.1d Developing a parcel freight O-D matrix	Seoul – Seo, Jeong, Ahn	Year 2-3 project; in progress
	1.1e Subcontracting in the urban freight industry	Paris – Launay, Reme	New project
1.2 Modeling for local impact analysis	1.2a Modeling for local impact analysis	LA – Ioannou	Year 2-3 project; in progress

Theme 2: Last mile strategies – parking, loading, consolidation, environmental externalities
Lead: Paris/Dablanc

Project	Sub-project	Team	Status
2.1 Central city logistics strategies	2.1a Eliminating trucks for the collection and transport of municipal solid waste	NY – Miller	Year 2-3 project; in progress
	2.1b Network analysis of multimodal freight transport systems	NY – Wang	Year 2-3 project; in progress
	2.1c Feasibility of consolidated freight deliveries	Paris -- Heitz	Year 2-3 project; in progress
	2.1d City logistics strategies for CBDs	Seoul – (Seo)	Year 2-3 project; in progress
2.2 Reducing vehicle emissions	2.2a Impacts of environmental access restrictions	Paris – Montenon, Dablanc,	planned for year 3; began in year 2; in progress
	2.2b Evaluating alternative clean fuel technologies	LA – Knatz	New project
	2.2c Alternatives to truck transport for food products	NY – Kamga	New project
2.3 Paris freight survey analysis	2.3a Diagnostic for urban goods distribution	Paris – Beziat, Koning, Dablanc	Ongoing

Theme 3: Improving freight/passenger interactions
Lead: LA/Dessouky

Project	Sub-project	Team	Status
3.1 Integrating management of truck and rail systems in LA	3.1a Integrating management of truck and rail system in LA	LA – Dessouky	Year 2-5 project; in progress
3.2 Improving efficiency of truck flows	3.2a Impacts of Growing Non-Motorized Infrastructure on Freight Operations and Accessibility	NY – (Conway)	Year 2-3 project; in progress
	3.2c Improving efficiency of truck flows	Seoul – J-S Lee, T. Lee, Roh	Year 2-3 project; in progress
	3.2d Contribution of freight to urban traffic congestion	Paris – Beziat, Koning	New project

Theme 4: Land use dynamics

Lead: NY/Rodrigue

Project	Sub-project	Team	Status
4.1 More efficient siting of warehouse and distribution center activity	4.1b Spatial dynamics of warehousing and distribution	LA – Giuliano	Year 2-3 project; in progress
	4.1d More efficient siting of warehouse and distribution activity	Paris – Heitz, Dablanc, Gaubert	Year 2-4 project; in progress
	4.1e Extending freight landscape model	LA -- Giuliano	New project
	4.1f Extending the Freight Atlas	NY – Rodrigue, Conway Paris – Gaubert, Bahoken, Beziat, Dablanc	New project; extension of Year 1 comparative analysis

Theme 5: Changing production and consumption

Lead: NY/Conway

Project	Sub-project	Team	Status
5.1 Changing patterns of home-based consumption	5.1a Freight demand from home-based shopping	NY –Rodrigue, Conway, Wang, King	New project
	5.1b Home-based shopping patterns	Seoul – Seo, J-S Lee	New project
5.2 Alternatives to home delivers	5.2a Alternatives to home deliveries	Paris – Marei	Year 2-3 project; in progress

Education

Activities in Year 3 will cover both dimensions of our education strategy, development of curriculum materials and professional training.

Completion of Year 2 activities

Graduate course on urban freight: As noted above the urban freight graduate course curriculum will be tested in spring 2015 via a new course, *Urban Freight and City Logistics*, at the City University of New York. The course will follow a three-module structure: 1) Freight and the City, 2) Issues and Challenges in City Logistics, and 3) City Logistics in Practice. At the completion of the course, students will be expected to have an understanding of: urban freight stakeholders, facilities, regulations, and data sources; the spatial distribution of urban freight activities; industry drivers of freight demand; externalities from freight operations; and recent city logistics approaches to meet freight demands and reduce freight externalities. We will also offer individual modules based on the curriculum as graduate level seminars in a distance format for graduate students at USC. Evaluations from CCNY and USC students will be used to revise the course as necessary before making the curriculum publicly available.

Year 3 Activities

We will continue urban freight curriculum development and professional training activities. In order to better manage the MF education activities, Tom O'Brien is shifting his effort from research to serving as lead for MF education. MF education activities will benefit from a new METTRANS CoE award from the US Department of Transportation to establish a Surface Transportation Workforce Development Center for an eight-state region in the Southwest US. The COE will be charged with developing a clearinghouse of transportation-related curricular materials and pilot testing Best Practice lesson plans and courses.

Urban freight curriculum (Yr 3, 4, 5): Our internal scan for the curriculum guide revealed that freight courses outside of logistics or operations research programs are quite rare. We are therefore focusing on courses or course modules that could be part of urban planning, urban geography, civil engineering, or supply chain management programs. Additional courses or course modules in urban freight will be developed. These will be specialized courses based in part on research results that can be incorporated into existing degree programs. Examples include urban freight modeling, managing freight in urban environments, and freight policy.

Professional training (Yr 2, 3): We will complete development of two short courses in urban freight, one for the goods movement industry, and one for policymakers. The first test courses will be offered in LA and Paris. The courses will be developed locally to incorporate the issues that professionals in each metro area face and to make participants more aware of current trends in urban freight and the range of possible solutions. Over the course of the grant period, training courses will be extended to New York and Seoul, and be made available to the international professional community.

For each of these, we will leverage other efforts of consortium members to test materials as well as to extend the reach of METROFREIGHT's work. These other efforts include a new train-the-trainer course on logistics, supply chain management and port operations for high school teachers being implemented in Long Beach in the spring of 2015, and an undergraduate urban freight course to be taught at University of Paris-Est.

Outreach

We will continue all of our outreach activities as described in the MetroFreight proposal and as reported on for Year 2. We highlight the following:

International Urban Freight Conference: The next I-NUF conference will take place in October, 2015, in Long Beach, CA. We plan to further expand our international outreach through the two urban freight CoEs and through the growing number of international collaborations we are developing. We will have MetroFreight and SUFS sessions to highlight the VREF funded research. As in previous conferences, we emphasize linkages with public agencies and industry, multi-disciplinary research, and dissemination of conference papers via scholarly publications.

Multimedia communications: We will continue to expand our website, media communications, newsletters, videos, and other dissemination venues.

Research Briefs series: Our research briefs will begin now that research projects are being completed.

Scholarly dissemination of research results: We will continue to seek out opportunities for special journal issues to raise the scholarly visibility of urban freight and contribute to raising its profile as a recognized field of study.

APPENDIX 1: Research Project Descriptions

APPENDIX 1

Research Project Descriptions

Year 1 Research

NY Team (Rodrigue)

The Urban Freight Landscape Atlas

The purpose of the urban freight landscape atlas is to provide a collection of maps providing a comparative perspective about key elements impacting city logistics across the four metropolitan areas of the MF project.

The first stage of the project focuses on the design of a composite map template as well as the production of three comparative maps: 1) Population density, 2) Employment density, and 3) Population density/employment density grid. The second stage will aim at producing more complex sets of maps related to the transport infrastructure, constraints and elements of the urban freight transport supply and demand.

Each metro area is providing a GIS dataset (developed in the first year) using the same units of reference (metric; km and square km) and the same scale. For the US, census tracts would be the unit of analysis. For Seoul it will be the district while for Paris municipalizes are used as the spatial unit of reference. The time unit for the datasets will be around 2010. Time series may be analyzed later on as more data is collected and made available.

Year 2 Research

This section presents summaries and progress of all research projects that were launched in Year 2.

Theme 1: Role of policy from industry perspective

Lead: LA/Giuliano

Project 1.1 Local government policies and freight operations (LA, NY, Paris, Seoul): This project conducts an analysis of the impacts of local regulations and policies on freight operations and shippers. It will focus on 1) parking, loading, zoning; and 2) vehicle performance standards (emissions, alternative fuels, vehicle size).

1.1b Understanding demand for curb space and access from deliveries in New York City **(NY – King)**

This research examines the interactions of goods movement and residential buildings. A three week (September – October) data collection effort is underway that includes field observations with traffic counters and video at several buildings in Manhattan, Queens and Brooklyn. Time of day deliveries, curb usage, off-street loading and unloading, pedestrian activities and other curbside activities are being observed. Additional data collected from building managers, Census data, New York City zoning and transportation maps, and other publicly available sources as needed. (Replaces Road Pricing and Port Freight Activity) 50% complete

1.1c Congestion caused by urban freight: tensions between the demand of freight operations and the supply of infrastructure

(Paris – Beziat, Koning, Dablanç)

The aim of this research is to quantify the social costs of congestion associated with urban freight. The computing of the supply of infrastructure is done: we created an "infrastructure index" taking into account length of roads, number of lanes and speed limits. We have also estimated the demand for passenger transportation (because we have to take it into account for a study on road congestion), using the regional Household Mobility Survey. The measure of the demand of freight operations heavily depends on the exploitation of the Urban Freight Survey (see project 2.3.

Project initially planned for years 2 and 3. 50% accomplished in year 2.

1.1d Developing a Parcel Freight O-D and Identifying Parcel Freight Determinants for Seoul Metropolitan Area

(Seoul – Seo, Jeong, Ahn)

Freight O-D has been developed using the actual number of parcels collected by one of the Korean major parcel service companies for the year of 2012. For 66 subareas of the SMA, the freight flow rate between these subareas has been analyzed. For the statistical analyses to find out the parcel freight determinants, nineteen variables were selected out of four categories of socio-economic indicators related to population, industry, housing, and income. In analyzing the effect of socio-economic attributes to each region's parcel freight, the most recent parcel movement dataset for the Year 2013 was also utilized.

Analysis results show that parcel freight inflows are highly correlated with population, housing, and income indicators, while outflows are strongly correlated to industry indicators. This study has tentatively concluded that each district (Gu) has its own socio-economic characteristics which affect the productions and attractions of parcel freight. It would imply that the approach to city logistics policy development needs not only to consider the general aspects of parcel delivery within the city but also to consider each sub-district's diverse socio-economic characteristics. For the remaining of this year, another dataset of interregional parcel freight volume will be collected. The dataset will be from other parcel service companies (Hanjin Logistics and Hyundai Logistics) which are the industry partners of the KOTI. This enrichment of the dataset is expected to make the O-D estimation and exploratory spatial analysis of the parcel freight within the SMA precise and reliable.

85-90% completed by next January, the second phase will begin from Feb. 2015.

Project 1.2 Modeling for local impact analysis (LA, Ioannou): We will develop a traffic simulation model for the Los Angeles region that will allow us to estimate impacts of existing freight flows as well as impacts of policy interventions or of land use changes. The model will have two parts: a macro-simulation model for the region, and a micro-simulation model for a small area that can be used to examine local policies such as route restrictions or parking rules. The focus of Year 2 will be the micro-simulation model.

1.2a Modeling for local impact analysis

(LA – Ioannou)

Up to date progress includes the following three parts.

1) Improvement of Previous Port Model: One of the difficulties in combining a terminal model with the road network to operate together in real time as well as interact with other modules such as the environmental model/emissions model, terminal cost model is to describe these models in a programming language that makes it easy to interface each model in a continuous manner. For this reason we developed an object-oriented, event-based terminal simulation module implemented with

the C++ programming language based on our previous terminal model. We have finished the coding of simulation part and are developing the user interface.

2) Development of the Microscopic Traffic Simulation Model for the selected area of study: The traffic simulation module models the microscopic traffic flows on the roadway network around the port area. This module is built based on the traffic simulation software VISSIM. Using VISSIM, we coded traffic detection, freeway speed control, intersection signal control, vehicle compositions, traffic demand and routing decisions to support the simulation and evaluation of the impacts of existing freight flows as well as impacts of policy interventions or of land use changes. We are currently working on tuning the model using real data and dynamic assignment. We are interacting with Professor Giuliano's student with regard to truck data and freight demand in the selected region of education.

3) Macroscopic Traffic Model for the region of study: We are currently in the process of gathering the OD matrixes where real data are available and estimating those not available via dynamic assignment. We are interacting with Professor Giuliano's group to expand the above network to the detailed and larger scale network, (converted from the ArcGIS data by Professor Giuliano's group), by focusing on what is computationally feasible by paying attention to the most important routes followed by trucks.

Theme 2: Last mile strategies – parking, loading, consolidation, environmental externalities

Lead: Paris/Dablanc

Project 2.1 Central city logistics strategies (NY, Paris, Seoul): This project will examine a) the feasibility of consolidating freight deliveries in cities; and b) alternatives for more efficient use of road and parking space in cities. Specific Year 2 research activities are as follows:

2.1a Eliminating trucks for the collection and transport of municipal solid waste on the Far West Side of Manhattan

(NY – Miller)

This research analyzes the potential benefits of modifying current and currently planned waste-collection and transfer operations in the fastest-growing area of New York City – Hudson Yards. Preliminary baseline assessments of waste quantities generated by waste fraction and by waste generator have been developed for key buildings along the High Line Corridor. A preliminary assessment of current truck-based operations (costs, truck trips, truck miles traveled, fuel use, greenhouse gas emissions) has been developed. A preliminary design of an alternative pneumatic facility for collecting refuse from key locations along the corridor has been developed based on specification, cost, and operating parameters from multiple pneumatic-equipment vendors. A preliminary concept plan for a pneumatic tube-to-rail transfer facility has been developed.

2.1b Network Analysis of the Multimodal Freight Transportation System in New York City (Wang)

The research is aimed at examining the multimodal freight transportation network in New York City (NYC) to identify the critical links, nodes and bottlenecks that affect last-mile deliveries. A two month literature review began in September 2014 on three subjects: 1) the network analysis and graph theory techniques, 2) the critical issues of freight transportation and last-mile deliveries, and 3) the freight transportation system in New York City. Data collection will take place for two months during November - December, 2014 and is categorized into three groups, including: 1) the multimodal freight transportation network data, 2) freight demand and traffic flow data, and 3) census and demographic information.

2.1c Feasibility of consolidating freight deliveries in cities; and alternatives for more efficient use of the road and parking space in cities

(Paris – Heitz)

We evaluate two small scale consolidation schemes implemented in Paris : Vert chez Vous and the Green Link. Interviews and visits have taken place with these companies and some others who have experimented with freight consolidation. Meetings were held with Chronopost in Paris (Paris 15e - Beaugrenelle) (several times), Colizen (Paris 18e) and Samada (Paris 12e). These additional companies were not chosen for a specific study but will be part of the research on this topic to understand the freight environment in Paris and make some comparisons.

50% accomplished (project planned for years 2 and 3, so 100% accomplished for year 2)

2.1d City logistics strategies for CBDs within the Seoul Metropolitan Area

(Seoul – Seo)

In June 2014, the project team conducted an on-site survey for the Dongdaemun Fashion Cluster in order to identify the main sources of freight volume within the CBD areas. The survey focuses on the regional city logistics environment and its issues relating to the conflict with pedestrians, parking, pollution, etc. In addition, the project team interviewed the public official who is charged with parking issues at Jongno-Gu in the City of Seoul. She reported that Jongno-Gu is to planning to reorganize truck parking areas and construct loading/unloading zones within the Dongdaemun Market Area. During early September 2014, an additional on-site survey is planned during one of the annual freight peak periods, *Chuseok* (Korean Full Moon). Interviews with merchants in the *Dongdaemun Fashion Cluster*, city logistics service providers, and public officials are planned for late October 2014. The interviews will concentrate on drawing solutions to the diverse city logistics activity-related issues within the CBDs of Seoul. 80% will be done by the end of this year. The extended works will be conducted next year as the second phase.

Project 2.2 Reducing vehicle emissions (LA, NY, Paris) This project will survey vehicle emissions reduction strategies and assess their effectiveness and impacts on shippers and cargo owners. Strategies include vehicle fleet retrofits, voluntary certification programs, and low emission zones. Although project 2.2 was scheduled to start in Year 3, the Paris team started in Year 2 thanks to the availability of A. Montenon, hired for Metrofreight and for another project.

2.2a Impacts of environmental access restrictions on freight delivery activities, the example of Low Emission Zones in Europe

(Paris – Dablanc, Montenon, Cruz).

Through literature review, interviews and two specific surveys in London and Berlin, we analyzed Low Emission Zone (LEZ) impacts on the urban freight industry. This research shows that the creation of a LEZ reduces the number of firms making urban deliveries, and that this reduction has probably benefited the urban freight market by compelling both public and private stakeholders to find ways to promote more efficient activities.

A second phase of this research is due to start at the end of 2014 and aims to test the impact of several LEZ scenarios on goods vehicle traffic and to appraise their potential effectiveness with regard to the socio-economic response of transport operators and the scale of pollutant emissions from this sector. 50% accomplished. Project initially planned for years 3 and 4 but started in year 2 due to the availability of Montenon. Remaining 50% will be done in year 3.

Project 2.3 Paris freight survey analysis (Paris): This is an ongoing project to analyze the Paris freight survey data in partnership with LET, APUR, and IAU.

2.3a Diagnostic for urban goods distribution: the generation factors of freight flows and their spatialization – Example from the Paris Urban Freight Survey (Paris – Béziat, Dablanc and Koning).

The aim of this research is to exploit data from the Urban Freight Survey that was implemented in Paris from 2010 to 2013. At this stage, the analysis is still in an early phase. The data was supposed to be delivered in January 2014 to MetroFreight, but was only available in July 2014. IFSTTAR and the Paris Region are in the process of signing an agreement, so that IFSTTAR will officially have access to the data in October 2014. Meanwhile, some preliminary results have been presented by the Laboratory of Transport Economics (LET), the organization that administered the survey. These are some of the results that can be obtained through the processing of the database:

- 4.1 million deliveries/pickups are carried out each week in the Paris Region. It represents 0.7 operations per job per week, which is an inferior ratio compared to the surveys made in the 1990s in smaller cities (the ratio was the same for Bordeaux, Dijon and Marseille: about one operation per employment job per week). This may be due to the higher proportion of office jobs and businesses in Paris.
- The number of operations per job per week depends very much on the type of activity. Warehousing, wholesalers and small shops have the highest ratio. On the contrary, office buildings and large retailers generate very few weekly operations per job.
- More than half of the deliveries are done using light utility vehicles (<3.5 tons). Less than 25% are done using larger vehicles (>3.5 tons). Cars and articulated trucks represent 10% each. Perhaps more surprising is the share of two wheelers (motor and non-motor). They still represent a small part (less than 5%), but it is in rapid progression, since they were not visible in the previous surveys.

Project initially planned for years 3 and 4, which will actually cover years 2, 3 and 4 (duration of Beziat PhD). One third covered in year 2.

Theme 3: Improving passenger/freight interactions, rail and highway

Project 3.1 Integrating management of truck and rail systems in Los Angeles (LA, Dessouky): This project will develop models to optimize the balance of freight demand across rail and truck modes.

3.1a Integrating management of truck and rail systems in Los Angeles (LA – Dessouky)

The purpose of this research is to further the state-of-the-art of the train scheduling and routing problem taking into consideration the new capabilities that the newly introduced technologies such as Positive Train Control (PTC) provide. Specifically, the contributions of this research are: (1) we develop a simulation framework to represent dynamic headway, (2) given the headway distance and the speed limits, we develop an algorithm to determine the optimal velocities, and (3) using these models, estimate the additional amount of freight that the rail system can handle if dynamic headway control is used to control rail movement in Southern California.

To evaluate the proposed dynamic headway model and solution procedure, we conducted simulation experiments on an actual railway network. The chosen railway network is from Downtown Los Angeles to Pomona. The railway trackage configuration in this area consists of single-, double- and triple- tracks with varying speed limits. Also two types of trains (freight train and passenger train) are tested on this

area. The simulation analysis shows that with dynamic headway control the rail capacity could be increased by 20%, allowing for a significant amount of freight flow that could shift from truck to rail. Also, the dynamic headway control also results in 40% less average delay at the rail network train count saturation point under constant headway control.

Project 3.2 Improving efficiency of truck flows (LA, NY, Paris, Seoul): This research examines freight bottlenecks associated with trade nodes (ports, airports, intermodal facilities) and develops strategies for addressing bottleneck problems, including 1) improving drayage route efficiency; and 2) increasing rail share.

3.2a Impacts of Growing Non-Motorized Infrastructure on Freight Operations and Accessibility (NY – Conway)

The purpose of this research project is to examine how freight operations in and accessibility to destinations in the Manhattan borough of New York City have been impacted by recent changes to the city's urban street infrastructure. A detailed examination of freight access on Manhattan's shared urban streets will be conducted.

To date, an extensive literature review has been conducted as well as a general examination of the basic impacts of recent infrastructure decisions on truck mobility and access through review of the NYC Street Design Manual and bicycle projects implemented in Manhattan since 2005. In the fall 2014, a comprehensive dataset will be constructed to identify and characterize high conflict areas for trucks, specifically looking to understand how the likelihood of conflict changes in areas with different types of demand and infrastructure characteristics. The dataset should be put together by the end of fall 2014 and preliminary analysis should also begin in the fall. 50% complete by 12/31/14

3.2b Use of bicycles and tricycles for goods movement in Paris and CO₂ savings (Paris and NY – Koning, Conway)

This study seeks to develop a method to evaluate the influence of Paris' efforts to promote the usage of bicycles and tricycles for goods movement, and for estimating the resulting impact on CO₂ emissions between 2001 and 2004.

To assess the evolution of commercial freight mobility in Paris performed by bikes and/or cargo-bikes, an original survey was conducted during the spring of 2014. In total, 15 relevant companies were identified; of these, nine agreed to complete a survey via email. Based on answers of individual companies, a total of 10, 816 km daily driven by bikes for freight activities has been estimated for 2014. After extrapolating our results to the 15 relevant firms, calculations suggest that the freight activities using bikes in Paris have dramatically increased since 2001. Total km traveled increased by a factor of about 10. The evolution for tkm is even more impressive, having been multiplied by a factor of 21. Thanks to the answers to the survey, km and tkm of previous modes used in Paris for freight activity were finally estimated; 5,876 km/180 tkm used to be moved by motorized two-wheels in 2001, 7,880 km/612 tkm by vans and 882 km/53 tkm by trucks.

Crossing emission parameters with the previous mode shift figures, an estimated 3.3 tons of CO₂ are found to be avoided daily due to the increased usage of bikes and cargo-bikes to move goods in Paris. The greatest change is linked to the reduced number of tkm realized with vans over 2001-2014 (-839 kg CO₂/day), and the next from motorized two-wheels (-725 kg). Savings from past trucks movements are moderate (-46 kg) due to the low share of deliveries/shipments that used this mode in 2001. The CO₂ emissions linked to the energy consumption of electric cargo-bikes is almost negligible, around 2.2 kg/day. Importantly, individuals' modal changes for shopping purposes represent 51% of the total CO₂ savings estimated. Such a result consequently highlights that commercial operators are not the sole "freight" polluters in cities and that inhabitants can also change their habits to enjoy a "greener"

environment. These calculations suffer many uncertainties and the benchmark has logically to be tested against alternative scenarios. For alternate assumptions, the decreases in CO₂ emissions range from 2.6 tons/day to 3.4 tons/day.

Project initially planned for years 2 and 3, and initially targeted at an analysis of Paris cargo tramway. As this project has been more or less abandoned by Paris authorities, cargocycle project replaced it. Project 100% accomplished in year 2.

3.2c Improving efficiency of truck flows in Gunpo-Euiwang Intermodal Logistics Park (Seoul – J-S Lee, T. Lee, Roh)

This project examines freight bottlenecks in the Seoul Metropolitan Area caused by Gunpo-Euiwang Intermodal Logistics Park. The Korean Government has implemented the freight transportation policy which focused on increasing rail share and enhancing competitiveness in terms of its service time and cost. For this reason, this project is to plan several improvement alternatives for the intermodal traffic network between main trade nodes and the rest of city areas in SMA.

A couple of site visits have been made and an extensive data collection has just been started. In order to collect reliable datasets, the project team is planning to cooperate with Korea Transport Database Center (KTDB Center) which is another research team in the KOTI. KTDB regularly conducts a transport flow survey for both passenger and freight movements. Utilizing their dataset will be the key for this project to identify the freight bottlenecks and develop improvement strategies.

20% additional field trip and data collection will be made during the rest of this year (then, the progress rate goes to 25-30%), work (remaining 70-75%) should be carried over to the next year and the project will be totally completed by the end of next year.

Theme 4: Land use change dynamics, consequences, and solutions

Project 4.1 More efficient siting of warehouse and distribution center activity (LA, NY, Paris): This project analyzes 1) spatial trends in logistics activities; 2) factors that explain logistics decentralization; 3) associated impacts on truck VMT and traffic flow; 4) develops a model for estimating impacts of alternative facility locations; and 5) assesses the potential for locating new activities in closer proximity to trade nodes.

4.1a Conceptualizing and testing the freight landscape (LA – Giuliano)

Giuliano and PhD students are conducting research on two related topics. First, we have developed a conceptual framework for the freight landscape, building on standard urban economic theory. We have tested the hypothesis that the spatial organization of population and economic activity explains freight intensity, defined as the density of truck volumes. We use population, employment, and transportation system data from the Los Angeles region and estimate two models, one with dummy variables for combinations of population and employment density, the other with population characteristics and industry sector variables. Preliminary results support the hypothesis, suggesting that spatial variables may serve as effective proxies for freight activity. (New project, 80% complete)

4.1b Spatial dynamics of warehousing and distribution (LA – Giuliano)

We are conducting research on the spatial dynamics of warehousing and distribution in the Los Angeles region. We are exploring various data sources. There is no reliable data source that provides

employment or establishment data with detailed industry sector and at small spatial scale. We are testing reliability of alternative data sources to determine trade-offs between spatial scale, industry sector detail, and accuracy. The research question is whether warehouse and distribution decentralization leads to more truck VMT in a region where such activity has a substantial import/export component. This research is ongoing; see Future Plans section for more details. (30% complete)

4.1c The Dualism of Urban Freight Transport: City vs. Suburban Logistics (NY – Rodrigue, Behrends)

In developing the concept of suburban logistics, it was recognized that the significant trend of sub-urbanization, especially in metropolitan areas, may require a new focus for urban freight transport. More and more people both in developed and developing countries are moving outside the city to suburban neighborhoods with lower densities, where accommodation is more affordable than in central areas, and which offer a better quality of life. This trend of suburbanization, including edge cities, is well documented as an element of the urban spatial structure. What is less considered are the new forms of production, distribution and consumption that suburbia has created.

The goal of this project is to identify the implications of sub-urbanization for logistics and to explore the extent to which suburban logistics deserves attention as a new field of urban freight transport research. Are we observing an emerging dualism in city logistics between the central areas and suburbia? If so, which form is this dualism taking? The composition of the project is as follows:

1. Definition of the subject: what is the difference between city logistics and sub-urban logistics? (Theoretical part)
2. Review of current trends impacting suburban logistics. (Empirical part)
3. Discussion on what extent sub-urban logistics deserves attention as a new field of urban freight transport research. 50% complete

4.1d More efficient siting of warehouse and distribution center activity (Paris – Heitz, Dablanc, Bahoken)

For the purposes of this study, we used the SIRENE database held by the French National Institute of Statistics and Economic Studies (INSEE). This database provides information about the firms present in each municipality, according to their category in the European NACE classification. Data for 2000 and 2012 was obtained. The next stage was to conduct a number of interviews with managers working in logistical hubs 129 in the parcel delivery sector (e.g. Chronopost, UPS, FedEx, and Colizen) or warehousing. These interviews confirmed that the warehouses were no longer simply used for storage but function as logistics platforms, with increasingly diversified activities which add value.

The way the distribution of spaces that are specialized in logistics warehousing has changed allows us to glimpse a specific type of multi-cluster metropolis in the case of Paris. On the one hand it is made up of low density clusters located in the inner suburban ring, and on the other hand it is spreading outwards by generating new suburban clusters which cause the conurbation to expand. What is occurring is both a process by which the center of the metropolis is expanding as a result of the contiguity of specialized logistics clusters and the emergence of new clusters in the outskirts. The Paris metropolis is characterized by the outward spread of logistics activities and the major suburban clusters which structure the Ile-de-France. This is one of the spatial dynamics which “traditionally” affects metropolises: centrifugal forces at the local level. But these centrifugal forces do not on their own fully characterize the metropolises.

We have documented a major rise in the number of warehousing and logistics facilities since the beginning of the 2000s in the Paris region and the Paris basin. Our analyses emphasize the existence of a spatial scale that is little recognized but is key to the understanding of the logistics system: the megaregional scale. We do not wish to state that the Paris basin is a megaregion in the fullest sense of

the term, as identified by recent academic studies. Our approach was limited to the study of warehousing establishments, and additional analyses about the socio-economic indicators for the Paris basin are needed. However, by identifying a megaregional logistics system, in between an international or national system and an urban one, we are led to suggest two further areas of investigation that could be of interest for the study of the 381 spatial patterns that affect freight and logistics. One relates to planning and policies.

Project initially planned for years 2, 3, 4 and 5 but will actually cover years 2, 3 and 4 (Heitz PhD duration). One third accomplished in year 2.

Theme 5: Changing production and consumption

5.2 Alternatives to home deliveries (New project) (Paris). This project examines the development of alternative delivery services to e-shoppers in large metropolitan areas.

5.2a Alternatives to home deliveries (Paris – Morganti)

We have documented the recent development of alternative parcel delivery services to e-shoppers in European large metropolitan areas, and especially in the Paris region. We have described how the operators have decided to organize their PP network, identifying main variables and constraints. We have provided an analysis of PPs spatial distribution in France. The paper shows that at the French national level, PPs are now a well established alternative to home deliveries and their presence covers urban, suburban and rural areas. While PP density in remote areas decreases faster than population density, rural e-consumers' accessibility to PP sites has reached a viable level. Furthermore, delivery services to end-consumers generate new types of B2B freight trips that are not yet included in current urban freight models. This raises important questions about the overall mobility related to e-commerce in urban regions.

This project was initially planned for years 4 and 5. Due to the availability of Morganti in Yr 2 we started then. Project will cover years 2 and 3. 50% accomplished in year 2.

Year 3 Research New Projects

This section provides summaries of new projects to be launched in Year 3. Descriptions of ongoing projects continuing from Year 2 are available in the previous section.

Theme 1: Role of policy from industry perspective

1.1e Subcontracting in the urban freight industry (Paris – Launay, Reme)

This research will examine sub-contracting in the Paris urban freight industry. This will consist in evaluating the right number of subcontractors in Paris, the number of illegal firms and workers, understanding the reasons of outsourcing, and trying to map delivery routes of sub-contractors from parcel transport hubs if possible. 100% should be accomplished in Yr 3.

Theme 2: Last mile strategies

2.2b Evaluating alternative clean fuel technologies

(LA – Knatz)

We will review the Technology Improvement Program at the Ports of Los Angeles and Long Beach to assess the effectiveness of specific technology demonstrations, such as development of CNG fuelled heavy duty trucks and to examine the process of evaluating new technology experiments and implementation.

2.2c Alternatives to truck transport for food products

(NY – Kamga)

This study will explore alternatives to the primary use of trucks for delivery and pick-up food products in NYC will begin. The alternative will be to shift these products to waterborne transportation. An analysis of the reduction of the number of vehicle miles and truck trips, fuel, pollution and congestion reduction will be estimated.

Theme 3: Improving freight/passenger interactions

3.2d Contribution of freight to urban traffic congestion

(Paris – Beziat, Koning)

This is a two part project evaluating urban freight contribution to Paris congestion. The first part is to study congestion at a macro level, by crossing data of transport infrastructure supply, household mobility, and freight flows, allowing us to estimate the share of truck traffic in the congestion of the Paris region. The second part is to study congestion caused by vehicles making deliveries while double-parked in dense city centers, in order to estimate a social cost of this congestion. Completion anticipated at end of Year 3.

Theme 4: Land use dynamics

4.1e Extending freight landscape model

(LA – Giuliano)

The freight landscape concept will be further developed. It will be tested on the San Francisco region, and when sufficient Paris survey data are available, we will extend to Paris region. We are collecting the same land use, employment, population, and network data as for Los Angeles, and will estimate similar models of truck volume intensity. The concept has been empirically tested only with simulated network flows; we are collecting actual truck data for the Los Angeles region to conduct tests based on measured truck flows.

4.1f Extending the Freight Atlas

(NY – Rodrigue, Conway; Paris – Gaubert, Bahoken, Beziat, Dablanc)

The second stage of the Urban Freight Landscape Atlas project will aim at producing more complex sets of maps related to the transport infrastructure, constraints and elements of the urban freight.

Theme 5: Changing production and consumption

5.1a Freight demand for home-based shopping

(NY – Rodrigue, Conway, Wang, King)

Steps to be taken on this project during 2015 include: 1) A detailed literature review of studies relating to residential consumer shopping behavior and the demand that it generates; 2) Outreach to local stakeholders (e.g NYCDOT) to identify broad impacts of recent changes in residential deliveries; and 3) Identification and evaluation of data collection approaches (including survey-based and observational approaches).

5.1b Home-based shopping patterns

(Seoul – Seo, J-S Lee)

There are several notable changing patterns of home-based consumption observed in Korea: online shopping at both local and global levels, grocery shopping through diverse means and media, shopping using smartphones, etc. This project focuses on the dynamics of home-based consumption and its freight movement in cities. It will explore recent changes in consumption behaviour in Korea, and how logistics companies adjust their freight transportation strategies to meet the needs produced by these new consumption patterns. For this, data collection, interview and field trip-based survey will be mainly conducted in 2015 in cooperation with Seoul team's industry partners and one of the major retailers in Korea. A case study based on these data collection and survey will provide a clue to understand the characteristics of direct-to-consumer freight flows for new home-based consumption in Korea. Ultimately, it aims at evaluating the impact of these freight flows on city logistics systems and urban environment management.

APPENDIX 2: MF Paris Newsletter



METROFREIGHT

Volvo Center of Excellence

Newsletter METROFREIGHT Paris-Ile-de-France

N° 3, Juin 2014

LE PROJET METROFREIGHT LE FRET URBAIN A PARIS, NEW YORK, LOS ANGELES ET SEOUL (2013-2017)

METROFREIGHT a démarré en juin 2013. Il s'agit d'un consortium de recherche sur le fret urbain mené par USC (*University of Southern California*, prof. Gen Giuliano) avec le KOTI (Korean Transport Institute), the University Transportation Research Center (UTRC, dont Columbia University et City College of New York) et l'IFSTAR.

Des partenaires locaux institutionnels sont associés à chacune des universités. L'IFSTAR a la chance de compter parmi ses partenaires les organismes clés que sont la Région IDF, la Ville de Paris, la DRIEA, l'IAU et l'APUR. Ils rejoignent ainsi la ville de New York, la ville de Séoul et le comté de Los Angeles dans les collectivités impliquées.

Le projet est financé par VREF, Volvo Research and Education Foundations, une fondation financée par (mais indépendante du) groupe Volvo qui a créé à travers le monde une dizaine de centres d'excellence sur le thème du transport urbain du futur.

METROFREIGHT est construit autour du thème des très grandes métropoles et s'intéresse aux enjeux économiques, environnementaux et de gouvernance du fret urbain pour ces territoires. Six axes de recherche sont menés en parallèle et dans une approche comparative :

- Données et statistiques, enquête Transports de marchandises en ville, *leader: UTRC*
- Politiques publiques et impact sur l'offre de transport de marchandises en ville, *leader: USC*
- Les derniers kilomètres, *leader: IFSTAR*
- Les interactions fret/voyageurs, *leader: USC*
- Dynamiques spatiales, urbanisme logistique, *leader: UTRC*
- Les comportements des consommateurs et producteurs, *leader: UTRC*

ACTUALITES ET AGENDA

- ▶ S'est tenu le 17 avril 2014 le **Metrofreight Day** pendant le Transport Research Arena au CNIT Paris La Défense. Une visite de sites logistiques parisiens le matin et une session spéciale l'après midi ont été organisés (voir ci-dessous). Les objectifs et premiers résultats du programme ont été présentés puis une table ronde a réuni les partenaires institutionnels de Metrofreight (Région Ile-de-France et Ville de Paris) et les chercheurs américains (Genevieve Giuliano (USC), Jean-Paul Rodrigue (Hofstra), Tom O'Brien (Cal State Long Beach), Alison Conway (City University of New York)) et coréens (Jee-Sun Lee, (KOTI)).



Un débat a réuni les chercheurs du projet Metrofreight et les représentants des collectivités locales: François Prochasson pour la Ville de Paris et Cédric Aubouin pour la Région Ile-de-France

- ▶ La **phase 1** du projet Metrofreight se poursuit, elle vise la mise au point de bases de données statistiques et cartographiques sur l'économie urbaine et le fret pour les quatre villes Paris, Séoul, Los Angeles et New York. Voir ci-dessous le point sur l'enquête Transport de marchandises en ville –Ile-de-France. Cette phase 1 a été rebaptisée **Freight Landscape** : il s'agit aujourd'hui, pour les quatre villes, de procéder à des analyses statistiques et cartographiques du fret urbain.
- ▶ Le vendredi 18 avril les chercheurs du projet se sont retrouvés pour amorcer la phase 2 du projet et définir de nouveaux objectifs pour l'année 2014/2015.

- ▶ Felipe Aros doctorant au Rensselaer Polytechnic Institute de Troy à New York, a passé deux semaines dans les locaux de SPLOTT comme chercheur invité dans le cadre d'un échange financé par la fondation VREF. Il collabore notamment avec Martin Koning et Adrien Beziat.
- ▶ L'étude sur les *Low Emission Zones* (LEZ) européennes et leur impact socio-économique sur les entreprises de livraison se poursuit (projet RETMIF/ADEME). Dans ce cadre Antoine Montonen a passé le mois de mai 2014 auprès de Michael Browne à Londres.
- ▶ Deux conférences internationales se tiendront l'année prochaine sur la logistique urbaine et le transport de marchandises, avec une forte implication prévue de METROFREIGHT:
 - **The 9th International Conference on City Logistics**, du 17 au 19 juin 2015, à Tenerife en Espagne. Elle est organisée par The Institute of City Logistics.
 - **The 6th METRANS, International Urban Freight Conference**, qui se tiendra à Long Beach en Californie du 21 au 23 octobre 2015.

COMPTE RENDU METROFREIGHT DAY 17 AVRIL 2014, TRA à PARIS

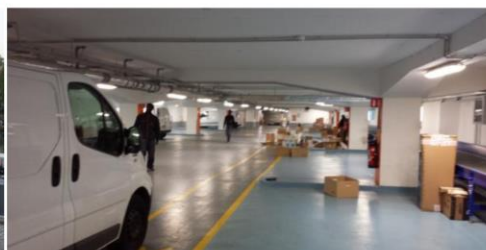
La visite de quatre sites logistiques dans Paris



Les membres du Projet Metrofreight en visite technique le 17 avril 2014



Quai de la Bourdonnais, Franprix, Paris 8^e



Chronopost Beaugrenelle, Paris 15^e



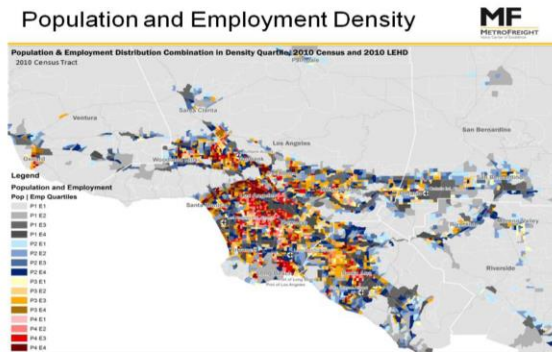
The Green Link, Paris 10^e



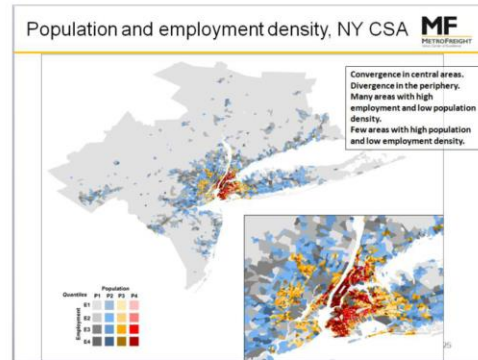
Halle Gabriel Lamé, Monoprix, Paris 12^e

Présentation des premières cartes du Freight Landscape

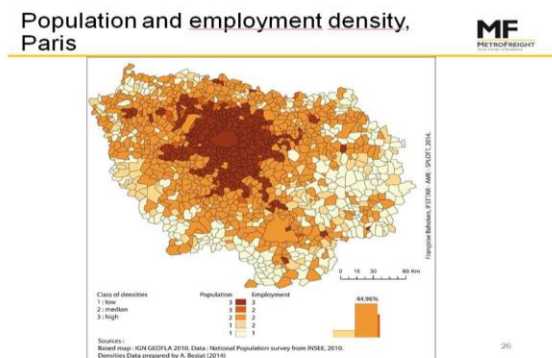
Que nous enseignent les données fret sur les « mega-cities » comme Los Angeles, New-York, Paris et Séoul ? Premiers résultats.



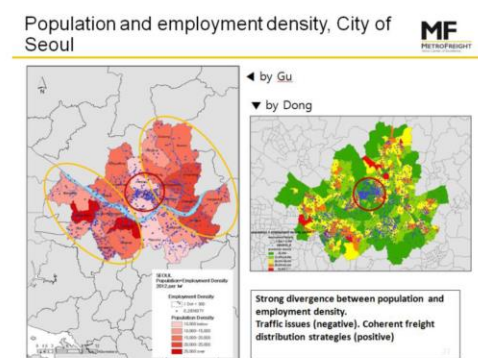
LOS ANGELES



NEW YORK



PARIS



SEOUL

Enquête Transport de marchandises en ville-IDF du Laboratoire d'Economie des Transports

Des résultats préliminaires de l'enquête ont été présentés lors du Metrofreight Day par Jean-Louis Routhier du Laboratoire d'Economie des Transports de Lyon. On apprend notamment que les établissements franciliens génèrent un peu plus de 4 millions d'opérations de livraison et enlèvement par semaine (soit 0,7 mouvements par emploi par semaine, un ratio moins élevé que celui observé dans les villes de province des précédentes enquêtes TMV). La part des deux roues motorisés et non motorisés émerge.

L'équipe METROFREIGHT à l'IFSTTAR, contacts et rôle dans le projet



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APPENDIX 3: Papers from Project

Afshin A., R. Rajabioun, P. Ioannou (2014) Traffic Flow Prediction for Transportation Networks with Limited Traffic Data. *IEEE Transactions on Intelligent Transportation Systems*, in press.

Giuliano, G. and A. Linder (2014) Impacts of the Clean Air Action Plan on the port trade industry. *International Journal of Shipping and Transport Logistics*, 6(2), 172 – 188.

Morganti, E., Dablanc, L., Fortin, F. (2014) Final deliveries for online shopping: the deployment of pickup point networks in urban and suburban areas. *Research in Transportation Business and Management*, Vol 11, pp. 23-31.

Rodrigue, J-P and T. Notteboom (2014) Looking Inside the Box: Evidence from the Containerization of Commodities and the Cold Chain. *Maritime Policy and Management*, in press.

Traffic Flow Prediction for Road Transportation Networks with Limited Traffic Data

Afshin Abadi, Tooraj Rajabioun, and Petros Ioannou, Fellow, IEEE

Abstract— Obtaining accurate information about current and near-term future traffic flows of all links in a traffic network has a wide range of applications including traffic forecasting, vehicle navigation devices, vehicle routing, congestion management etc. A major problem in getting traffic flow information in real time is that the vast majority of links are not equipped with traffic sensors. Another problem is that factors affecting traffic flows such as accidents, public events, and road closures are often unforeseen, suggesting that traffic flow forecast is a challenging task.

In this paper, we first use a dynamic traffic simulator to generate flows in all links using available traffic information, estimated demand, and historical traffic data available from links equipped with sensors. We implement an optimization methodology to adjust the origin to destination matrices driving the simulator. We then use the real-time and estimated traffic data to predict the traffic flows on each link up to 30 minutes ahead. The prediction algorithm is based on an Auto-Regressive model that adapts itself to unpredictable events.

As a case study, we predict the flows of a traffic network in San Francisco using a macroscopic traffic flow simulator. We use Monte Carlo simulations to evaluate our methodology. Our simulations demonstrate the accuracy of the proposed approach. The traffic flow prediction errors vary from an average of 2% for 5-minute prediction windows to 12% for 30-minute windows even in the presence of unpredictable events.

Index Terms— Traffic flow prediction, historical time traffic flows, optimization, least square method.

I. INTRODUCTION

Traffic flow prediction is considered as a challenging problem in transportation planning as well as in car navigation systems. Traffic flows in a network can be estimated using historical traffic flow data. However, traffic flow prediction cannot solely rely on past traffic data due to the following reasons. (1) on-road traffic events such as accidents, road closure, etc. affect the traffic flows in the network and their effect cannot be predicted a priori; (2) off-road events can have a major impact on traffic flows and may not be included in the usual historical traffic flow data; (3) traffic data are not available for all links in a traffic network simply because most links are not equipped with traffic sensors.

Traffic flow disruptions that affect the estimates of link traffic flows can be categorized as predictable and unpredictable. Predictable disruptions include traffic signals, stop signs, public

transit services, scheduled sport events, music concerts, road constructions/repairs etc. Unpredictable disruptions include automobile accidents, breakdowns, and emergency road closures etc. The impact of disruption on traffic flow depends on the location, the duration of the disruption as well as the demand during the time of the disruption. Studies regarding the impact of these types of disruption on traffic flows include [1]–[3].

The problem that arises is whether we can predict traffic flow ahead of time given the historical traffic information, information about scheduled events, and real time traffic data where available. In principle, due to unpredictable disruptions, long-term predictions may not be accurate enough for reliable practical use. However, short term traffic prediction if done properly may reach an accuracy that is useful for several applications when compared to no prediction or inaccurate prediction.

There have been many studies in the literature regarding short-term traffic flow prediction. Short-term forecasting models include non-linear models such as neural network models [4]–[8], and linear models such as Kalman filters [9]–[13], Auto-Regressive Integrated Moving Average Models (ARIMA) [14]–[17]. ARIMA models are linear estimators based on the past values of the modeled time series [18]. The nature of data and the type of application determine the modeling method used for traffic prediction. Schmitt et al. [19] investigated the limitations of linear models which are commonly used, and observed that “near-future travel times can be better predicted by a combined predictor”. A combined predictor is a linear combination of a historical mean predictor and a current real-time predictor. Gue et al. [20] compared different modeling approaches for short-term traffic prediction and concluded that using a prediction error feedback approach improves the prediction accuracy under normal and abnormal conditions. In another study, Smith et al. [21], compared parametric (seasonal ARIMA) and nonparametric (data-driven regression) models and showed that “traffic condition data are characteristically stochastic, as opposed to chaotic”. Moreover, it was argued that seasonal ARIMA models have better performance than nonparametric regression models. Furthermore, experimental studies showed that ARIMA models outperform heuristic forecast benchmarks [15]. The performance of ARIMA models can be improved by considering temporal-spatial correlations. Multivariate models are introduced to take into account these correlations. Kamarianakis et al. [22], and Min et al. [23] proposed the Space Time Auto Regressive Integrated Moving Average (STARIMA) model to satisfy inter-relations between links.

The above traffic prediction models become inaccurate under partially missing data. Missing data indicates the unavailability

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of traffic data for a certain period of time in part of transportation network due sensor malfunction or noise contaminated data. This problem occurs frequently in transportation networks [24]–[26]. Many studies address the issue of traffic prediction with partially missing traffic data. For instance, Lint et al. [4] presented a neural network for travel time prediction under missing traffic data. Sun et al. [27] introduced a Bayesian method to forecast traffic flows where a certain period of historical data is missing for some links of the transportation network. The missing portion of historical traffic data are approximated by using Gaussian Mixture Model (GMM). Also, other statistical and probabilistic methods are used to address the missing traffic data problem [28]–[34]. These approaches are not applicable to large transportation networks where historical traffic data are not available for the majority of the arterial links simply because of the lack of sensor measurements. Therefore, the problem of short-term traffic flow prediction based on completely unavailable traffic data in some links due to lack of sensors in the network is an open challenging problem.

In this paper, we propose a methodology that predicts the traffic flows for all the links in a transportation network over a short time horizon. It consists of two steps: (1) traffic flow data completion; (2) short-term traffic flow prediction. In the first step we use dynamic Origin-Destination (OD) matrices estimation with the help of a macroscopic simulator to generate traffic flow data at all links based on demand, historical data and the limited real time data available using an on line optimization methodology. In the second step we use the traffic flow data at all links generated from the first step to recursively predict future flows by adapting to changes in real time data due to unpredictable changes.

As a case study, we focus on a road network in the downtown region of San Francisco, California that we refer to as the Downtown SF sub-network. A Monte Carlo experimental method is used to evaluate the proposed algorithm under a wide range of uncertainties.

This paper is organized as follows: In section II we present the methodology for generating traffic flow data at links that have no sensors. In section III we present the short-term traffic flow prediction algorithm. We demonstrate our approach using the Downtown SF sub-network in section IV. We present our conclusions in section V.

II. TRAFFIC FLOW DATA COMPLETION

In this section, we consider a traffic network that has links with no available measurements. To address the issue of lacking traffic information for the majority of links in a transportation network, we define Link-to-Link Dividing Ratio (LLDR) as the ratio of traffic flow which propagates from a specific link to the adjacent links. These LLDRs vary for different links, and also depend on the time of the day. A transportation network consists of several elements such as links, nodes, zones, etc. Nodes are connected by links, and the links represent streets or freeways. Zones are places that considerable numbers of people visit such

as schools, stadiums, commercial buildings, and so on. One zone is defined for each residential district. The OD matrix determines the number of trips within zones in each time interval. Each OD matrix is assigned for one transportation choice. We consider two types of transportation choices personal cars and buses. There are many studies regarding OD matrix estimation. In previous efforts the OD matrices are estimated using least square techniques to minimize the difference between the measured link flows and the estimated ones [35]–[37]. Some other studies focus on dynamic OD matrix estimation [38]–[40].

In the proposed methodology, traffic flow data completion is performed in two steps: the initial OD matrices estimation, and the dynamic OD matrices estimation. Let V_{ij}^n be the i^{th} row and j^{th} column element of an OD matrix. It determines the total number of trips from zone i to zone j in the time interval $n \in \{1, \dots, T\}$. Figure 2 depicts the block diagram of the proposed methodology for traffic flow data completion. Dynamic OD matrices estimation consists of two parts: the dynamic traffic simulator, and optimization algorithm.

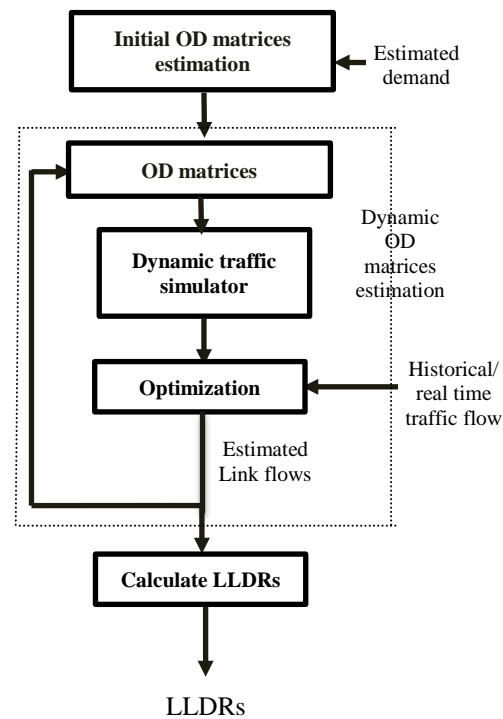


Fig. 1. Traffic flow completion methodology

A. Initial OD Matrices Estimation

The purpose of the initial OD matrices estimation is to estimate the OD matrices based on estimated demand data from the region. For instance, students go to schools at 8 AM and leave schools at 2 PM. We can roughly estimate the demand for each school in the morning based on the number of students who use the car and bus for commuting to school. There are two main methods in transportation forecasting [41]: 1- the Gravity model 2- the activity-based model. The activity based model is on the microscopic-level and requires much more information

than the Gravity model. Since in our case the data is limited, we use the Gravity model to estimate the initial OD matrices as explained below and illustrated in Fig. 3:

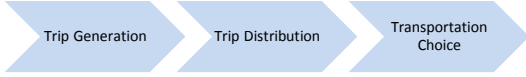


Fig. 2. The three-stage model.

The first stage in the model, referred to as trip generation, is the aggregated travel demand for each zone. Each zone has a certain production, the number of trips that begin at that zone, and a certain attraction, the number of trips that culminate at that zone. The information (i.e. production and attraction) can be obtained through surveys and information from the region. For instance, in a big sport game, the attraction includes thousands of cars and possibly hundreds of buses heading to the parking lots adjacent to the stadium before the starting of the game. The structure is the stadium and one zone is assigned for each parking lot. The production/attraction ratio of each zone (parking lot) for this specific structure (stadium) can be estimated based on the capacity of the parking lots. Also, each residential district is considered as one structure within one zone in the center of the district. Let us denote trip production of zone i and trip attraction of zone j in the time interval n , with P_i^n and A_j^n respectively. P_i^n determines total number of trips originating from zone i , and A_j^n is total number of trips ending to zone j . The production and attraction of each zone can be generated as follows:

$$P_i^n = \sum_{q \in Q} \eta_q^n(i) P_q^n \quad \forall i \in Z, \forall n \quad (1)$$

$$A_j^n = \sum_{q \in Q} \xi_q^n(j) A_q^n \quad \forall j \in Z, \forall n \quad (2)$$

where A_q^n and P_q^n are the total attraction and production for structure q in the time interval n . Structure q is a subset of Q which contains all the places in the region of study that people commute. The attraction/production of each structure is distributed to the adjacent zones. Each structure has a production/attraction ratio for each zone. $\eta_q^n(i)$ and $\xi_q^n(j)$ represent production/attraction ratios for zones i and j respectively. The parameter Z corresponds to the set of all zones in the network.

The second stage of the model referred to as, trip distribution, determines the number of trips traverse from one zone to another. The number of trips can be estimated as follows:

$$V_{ij}^n = \vartheta_{ij}^n \cdot P_i^n \cdot A_j^n \cdot e^{\psi^n d_{ij}} \quad \forall i, j \in Z, \forall n \quad (3)$$

where V_{ij}^n is the number of trips from zone i to zone j in the time interval n . The correlation between two zones can be illustrated in different formats such as exponential, linear, and so on [41]. In this paper, we choose the exponential format since it provides the best fit for the selected region which is an urban region [42]. d_{ij} is defined as the shortest distance between zones i and j . The

parameter ψ^n is a negative constant and ϑ_{ij}^n is a scaling factor to adjust the total number of trips from zone i to zone j in the time interval n in order to satisfy the following constraint equations [42].

$$\sum_{1 \leq j \leq Z} V_{ij}^n = P_i^n \quad \forall i \in Z, \forall n \quad (4)$$

$$\sum_{1 \leq i \leq Z} V_{ij}^n = A_j^n \quad \forall j \in Z, \forall n \quad (5)$$

The next step in Fig. 3, referred to as, transportation choice stage, determines the proportion of V_{ij}^n that use a specific transportation mode such as bicycles, single or multi-passenger cars, or public transit vehicles. The proportion of V_{ij}^n that uses single car and public transit are used to generate OD matrices of the trips at different intervals of time. For instance, buses represent $X\%$ of the total number of vehicles and their proportion is denoted by $V_{ij,b}^n$ where $V_{ij,b}^n = 0.01 * X * V_{ij}^n$, and the rest $(100-X)\%$ are cars ($V_{ij,c}^n = V_{ij}^n - V_{ij,b}^n$) for a pair of zones (i, j) . The ratios of buses and vehicles are variable depending on the location of zones. Buses have higher ratio in downtown region than they have in a local residential area.

B. Dynamic OD Matrices Estimation

The initial OD matrices that drive the dynamic traffic simulator are adjusted based on an optimization procedure presented below that minimizes the error between measured flows (where available) and estimated ones as well as travel times. It is assumed that trips will follow routes that minimize travel time.

1) Dynamic traffic simulator

The physical network model consists of various objects such as links, nodes, zones, etc. The OD matrix represents the aggregated number of trips from one zone to another. Traffic flows on each link can be obtained by feeding demand to a traffic flow simulator, while taking into account physical network characteristics. Figure 4 depicts the diagram for dynamic traffic flow generation.

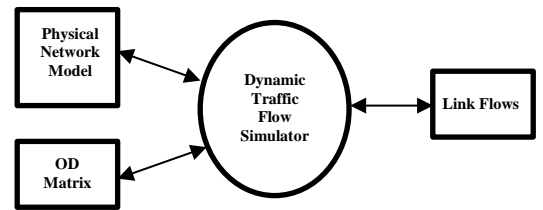


Fig. 3. Dynamic traffic flow generation

The proposed methodology evaluates the propagation of flows in the network by calculating the LLDRs based on the link flows generated by the dynamic traffic flow simulator and the optimization algorithm described below.

2) Optimization

Historical time traffic flows, derived from historical traffic

flow data, are used as one of the inputs to the optimization algorithm. They are used in both the dynamic OD matrices estimation and short-term traffic prediction models. Historical time traffic flows vary seasonally, weekday to weekend, and during a specific day. For instance, major events that occur adjacent to a road network and draw hundreds or possibly thousands of attendees can have huge impacts on network flows.

In this paper, traffic flows and information about major events are taken into account for M consecutive months. Given the major event data such as date and capacity of the venue, historical time traffic flows can also be derived for each specific event. Days are classified into three general categories: (1) regular day (2) holiday (3) major events. For regular days, the Average Hourly Traffic Flow for link l ($AHTF_l$) is expressed as follows:

$$AHTF_l(h, d, m) = \frac{\sum_{w \in W} HTF_l(h, d, w, m)}{\sum_{w \in W} 1} \quad \begin{array}{l} \forall h \in H, \\ d \in D, \\ m \in M, \\ l \in L \end{array} \quad (6)$$

where HTF_l is the hourly traffic flow for link l , h indicates the specific hour of the day, d is the day of the week, w represents the week, and m is the month of the year. For the second and third categories, (6) is also used only by taking into account historical traffic flows corresponding to the specific event or holiday. Due to the important role of recent data, a weighting factor is introduced to have a better historical time traffic flow evaluation. The weighted average hourly traffic flow for link l , ($WAHTF_l$) is calculated as:

$$WAHTF_l(h, d) = \sum_{m=1}^{|M|} \frac{(|M| - m + 1)^2}{\sum_{k=1}^{|M|} (|M| - k + 1)^2} e^{-\zeta m} AHTF_l(h, d, m) \quad \begin{array}{l} \forall h \in H, \\ d \in D \end{array} \quad (7)$$

where ζ is a constant positive coefficient and the number of members in a set is denoted by $|\cdot|$. For the sake of simplicity, in the rest of this paper, $WAHTF_l$ is denoted by $\bar{v}_{l,n}$ where n is the time interval.

A physical transportation network is defined on a set of links and nodes, i.e. $g = (N, L)$ where N and L represent nodes and links in the network respectively. Let S denote all Origin-Destination (OD) pairs and θ is the set of all routes connecting OD pair $s \in S$. Each route $r \in \theta$ consists of one or more links from L . The cost of route $r \in \theta$ for OD pair s , denoted as $c_{s,r,t}$, depends on the traffic flow of the route. We define cost as travel time of loaded route in the network. We also denote $\bar{v}_{l,n}$ the historical time traffic flow on link l , and $v_{l,n}$ represents the estimated flow of link l in the time interval n where n is an integer and $n \in \{1, \dots, T\}$ and $t \in [0, T]$, where t indicates time and T is the length of the total interval. Since traffic sensors are only available for a portion of links in the network we use the results from the three-stage model that covers all links in the network as the initial solution for the optimization algorithm. Let $v_{s,r,t}$ be the generated flow (number of vehicles per time slot) of route r for the OD pair s through the three-stage model.

Therefore, the flow of link l is calculated as follows:

$$v_{l,n} = \sum_{s \in S} \sum_{r \in \theta} \sum_{t \in T} \rho_{s,r,n}^{l,t} v_{s,r,t} \quad \begin{array}{l} \forall l \in L, \\ n \in \{1, \dots, T\} \end{array} \quad (8)$$

where $\rho_{s,r,n}^{l,t}$ is a decision variable equal to 1 if link l is on route r connecting OD pair s during time t in time slot n and 0 otherwise. Note that $c_{s,r,t}$ is the function of $\rho_{s,r,n}^{l,t} v_{s,r,t}$ [41]. Moreover, $v_{l,n}$ must satisfy the flow conservation law, thus we have:

$$v_{l,n} = \sum_{k \in A(l)} R_{l,k,n} v_{k,n} \quad \begin{array}{l} \forall l \in L, \\ n \in \{1, \dots, T\} \end{array} \quad (9)$$

where $v_{k,n}$ represents the flow of links feeding link l , and $R_{l,k,n}$ is defined as the LLDR of link k to link l . We define $\varphi^n(R)$ as a set of $v_{l,n}$ and the corresponding $v_{s,r,t}$ as well as $R_{l,n}$ that satisfies (8) and (9).

Note that $A(l) = \{j \in L | head(j) = tail(l)\}$. This contains all the links that are feeding the link l . We refer to the optimization algorithm formulated below as the master problem.

$$\begin{array}{ll} \min & g(V) \\ \text{wrt} & \\ v_{s,r,t} & = \alpha_1 \sum_{n \in \{1, \dots, T\}} \sum_{l \in L} \left[\frac{\bar{v}_{l,n} - \sum_{s \in S} \sum_{r \in \theta} \sum_{t \in T} \rho_{s,r,n}^{l,t} v_{s,r,t}}{\bar{v}_{l,n}} \right]^2 \\ & + \alpha_2 \sum_{s \in S} \sum_{r \in \theta} \sum_{t \in T} c_{s,r,t} v_{s,r,t} \end{array} \quad (10)$$

$$\text{subject to} \quad v_{s,r,t} \geq 0 \quad (11)$$

The objective function (10) minimizes the normalized variation between the historical time link flows and the simulated ones as well as the total cost (travel time) of the network. Constraint (11) imposes non-negative value for link flows. The coefficients $0 \leq \alpha_1, \alpha_2 \leq 1$ weight the relative importance of average historical count data and total travel time. The optimization (10)-(11) aim to minimize the total travel time in addition to minimizing the error between the measured flows (where available) and estimated ones by taking into account the fact that in general drivers select traffic routes that minimize travel time. The objective is to guide the solution using new efficient routes with the minimum total network cost. The column generation algorithm is one of the most common algorithms to find the efficient routes [43]. It starts with the subset of solution ($\theta_1 \subset \theta$) of (10) which can be presented as follows:

$$\begin{array}{ll} \min & g(V) \\ \text{wrt} & \\ v_{s,r,t} & = \alpha_1 \sum_{n \in \{1, \dots, T\}} \sum_{l \in L} \left[\frac{\bar{v}_{l,n} - \sum_{s \in S} \sum_{r \in \theta_1} \sum_{t \in T} \rho_{s,r,n}^{l,t} v_{s,r,t}}{\bar{v}_{l,n}} \right]^2 \\ & + \alpha_2 \sum_{s \in S} \sum_{r \in \theta_1} \sum_{t \in T} c_{s,r,t} v_{s,r,t} \end{array} \quad (12)$$

$$\text{subject to} \quad v_{s,r,t} \geq 0 \quad (13)$$

Using information from the region as well as sensor data, we would like to estimate link flows for the specified time window

on a specific link. Using an observation interval (such as a six-month period) we are able to calculate the average flow for a particular time of the day using (7).

Solution Methodology

We start with a subset of solution $\theta_1 \subset \theta$ (restricted master problem) using column generation algorithm. The restricted master problem is a way to expedite the process of finding the lowest cost route. The restricted master problem is defined as a subset of the master problem (θ_1). The initial solution of the restricted master problem is determined by the three-stage model as explained in detail in the previous subsection. Initially, the column generation algorithm begins with the restricted master problem with only a small subset of routes (initial solution). Then it adds new eligible routes to the previous routes. The restricted master problem is defined as follows:

$$\begin{aligned} \min \quad & g(V) \\ \text{wrt} \quad & v_{s,r,t} \\ v_{s,r,t} = & \alpha_1 \sum_{n \in \{1, \dots, T\}} \sum_{l \in L} \left[\frac{\bar{v}_{l,n} - \sum_{s \in S} \sum_{r \in \theta_1} \sum_{t \in T} \rho_{s,r,n}^{l,t} v_{s,r,t}}{\bar{v}_{l,n}} \right]^2 \\ & + \alpha_2 \sum_{s \in S} \sum_{r \in \theta_1} \sum_{t \in T} c_{s,r,t} v_{s,r,t} \end{aligned} \quad (14)$$

$$\text{subject to} \quad v_{s,r,t} \geq 0 \quad (15)$$

where $\theta_1 \subset \theta$. The initial solution θ_1 is derived by feeding the initial OD matrices into dynamic traffic simulator. The column generation algorithm operates as follows.

- Step 1: Apply the initial solution
- Step 2: Calculate the total cost
- Step 3: Add new eligible routes
- Step 4: Calculate new total cost, go to step 3

We take a derivative with respect to $v_{s,r,t}$ in order to find new eligible routes.

$$\begin{aligned} g_{m,p,w} = \frac{\partial g(V)}{\partial v_{m,p,w}} = & 2\alpha_1 \sum_{t \in [0,T]} \sum_{l \in L} \left[\frac{\bar{v}_{l,n} - \sum_{s \in S} \sum_{r \in \theta} \sum_{t \in T} \rho_{s,r,n}^{l,t} v_{s,r,t}}{\bar{v}_{l,n}} \right] \rho_{m,p,n}^{l,w} + \\ & \alpha_2 c_{m,p,w} \end{aligned} \quad (16)$$

The routes with the negative value of $g_{m,p,w}$ are eligible routes and are added to the previous routes. As a result, the problem of finding a new eligible route in order to add to the previous routes has changed to the dynamic shortest route problem with new link costs. Finding the minimum cost flows in this case is NP-complete. In the static case, the computation time for finding the shortest path in a graph with N nodes is $O(n)$; however, in the dynamic case, 2^{N-1} routes must be evaluated from node 1 to N. Thus, the computational time grows exponentially [44]. The LLDRs can be calculated based on the estimated link flows using (9).

III. TRAFFIC FLOW PREDICTION

In this section, the estimated LLDRs as well as current and historical traffic flows are used by the traffic prediction

algorithm to make predictions as explained in this section. Figure 5 depicts the overall structure of the prediction approach.

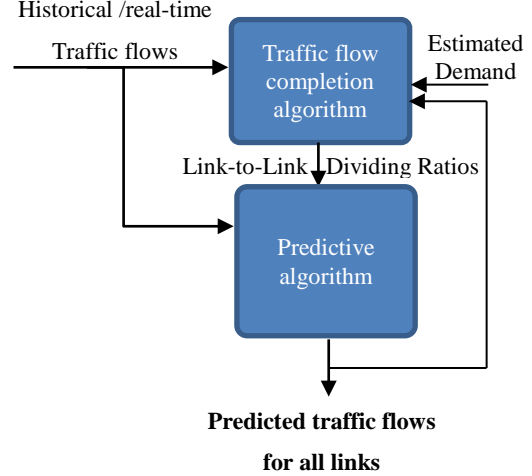


Fig. 4. Overall block diagram

The approach to be presented in detail below is summarized as follows: First, an autoregressive model of the link flows is introduced that takes into account the uncertain nature of traffic and historical traffic data including the most recent ones as well as historical time traffic flows in its coefficients. Due to the non-stationary nature of traffic flows, we detrend the traffic flow data by subtracting the corresponding long-term historical flow means $\bar{v}_{l,t}$, which are calculated in Section II, from the real-time flows $v_{l,t}$ in order to obtain a stationary process. Then, we train the autoregressive model using the most recent data in order to calculate the model parameters. Finally, we apply the least square method with the LLDRs constraints to expand the short-term prediction results to the entire network.

Let $v_{l,t}$ represent the flow for the specific link l at time t that is assumed to be generated by the autoregressive model[15]:

$$v_{l,t} = \beta_0 + \sum_{m=1}^M \beta_m v_{l,t-m} + \varepsilon_{l,t} \quad \forall l \in L, \quad \forall t \quad (17)$$

where the coefficients $\beta_s, s=0, \dots, M$ are the parameters of the autoregressive model, and $\varepsilon_{l,t}$ forms a white noise process which is the innovation process uncorrelated with $v_{l,t}$. The order M of the model is found by applying the Akaike information criterion [45]. Historical time traffic flow means, which are calculated in previous subsection, are denoted by $\bar{v}_{l,t} = \mathbf{E}\{v_{l,t}\}$. Using the autoregressive model (17), $\bar{v}_{l,t}$ is represented by:

$$\bar{v}_{l,t+1} = \beta_0 + \sum_{m=0}^{M-1} \beta_m \bar{v}_{l,t-m} \quad \forall l \in L, \quad \forall t \quad (18)$$

Then, these historical means are subtracted from real-time traffic flows. We define the error process $e_{l,t}$ as:

$$e_{l,t} = v_{l,t} - \bar{v}_{l,t} \quad \forall l \in L, \quad \forall t \quad (19)$$

Then from (17) and (18) we have:

$$e_{l,t} = \sum_{m=1}^M \beta_m e_{l,t-m} + \epsilon_{l,t} \quad \forall l \in L, \forall t \quad (20)$$

The uncertainty in the system is modeled by a white noise process, therefore $e_{l,t}$ is a stationary, mean-zero process for all the links in the network. Now, we represent this model in the matrix form as follows:

$$\mathbf{e}_{l,t} = A_l \mathbf{e}_{l,t-1} + \boldsymbol{\epsilon}_{l,t} \quad \forall l \in L, \forall t \quad (21)$$

where $\mathbf{e}_{l,t}$, A , and $\boldsymbol{\epsilon}_{l,t}$ are defined as:

$$\mathbf{e}_{l,t} = \mathbf{v}_{l,t} - \bar{\mathbf{v}}_{l,t}, \quad \boldsymbol{\epsilon}_{l,t} = \begin{bmatrix} \epsilon_{l,t} \\ 0 \\ \vdots \\ 0 \end{bmatrix}$$

$$A_l = \begin{bmatrix} \beta_1 & \beta_2 & \cdots & \cdots & \beta_M \\ 1 & 0 & \cdots & \cdots & 0 \\ 0 & 1 & 0 & \cdots & 0 \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ 0 & 0 & \cdots & 1 & 0 \end{bmatrix}, \quad \forall l \in L, \forall t \quad (22)$$

$$\mathbf{v}_{l,t} = \begin{bmatrix} v_{l,t} \\ v_{l,t-1} \\ \vdots \\ v_{l,t-M+1} \end{bmatrix}, \quad \bar{\mathbf{v}}_{l,t} = \begin{bmatrix} \bar{v}_{l,t} \\ \bar{v}_{l,t-1} \\ \vdots \\ \bar{v}_{l,t-M+1} \end{bmatrix}$$

Using the matrix form, it enables us to expand the prediction algorithm to more than one time step in the future. Let $\hat{\mathbf{e}}_{l,t}$ be the estimated value of $\mathbf{e}_{l,t}$. The following estimator minimizes the estimated value of $\mathbf{e}_{l,t+1}$ given the flow data at times $t, t-1, t-2, \dots$ [46]:

$$\hat{\mathbf{e}}_{l,t+1|t} = E\{\mathbf{e}_{l,t+1} | \mathbf{v}_{l,t}\} \forall l \in L, \forall t \\ = A_l E\{\mathbf{e}_{l,t} | \mathbf{v}_{l,t}\} + E\{\boldsymbol{\epsilon}_{l,t}\} \quad (23)$$

where $\hat{\mathbf{e}}_{l,t+1|t}$ is the estimate of $\mathbf{e}_{l,t+1}$ given the flow data at times $t, t-1, t-2, \dots$. Since $\mathbf{e}_{l,t+1}$ is calculated from (19), we have $E\{\mathbf{e}_{l,t} | \mathbf{v}_{l,t}\} = E\{\mathbf{e}_{l,t} | \mathbf{e}_{l,t}\}$. Considering the fact that the real-time $\mathbf{e}_{l,t}$ is known at time t and $\boldsymbol{\epsilon}_t$ has zero mean and is uncorrelated with $\mathbf{v}_{l,t}$, the predicted value of traffic flow error becomes:

$$\hat{\mathbf{e}}_{l,t+1|t} = A_l \mathbf{e}_{l,t} \quad \forall l \in L, \forall t \quad (24)$$

In general, the predictions need to be made for more than one time step ahead in the future. Since the real-time information is available for up to time t , $\hat{\mathbf{e}}_{l,t+1|t}, \hat{\mathbf{e}}_{l,t+2|t}, \dots, \hat{\mathbf{e}}_{l,t+p|t}$ are informationally equivalent and

$$\hat{\mathbf{e}}_{l,t+p|t} = E\{\mathbf{e}_{l,t+p} | \mathbf{e}_{l,t}\} \\ = E\{\mathbf{e}_{l,t+p} | \hat{\mathbf{e}}_{l,t+1|t}\} = \cdots \quad \forall l \in L, \forall t \quad (25) \\ = E\{\mathbf{e}_{l,t+p} | \hat{\mathbf{e}}_{l,t+p-1|t}\}$$

$$\hat{\mathbf{e}}_{l,t+p|t} = A_l^p \mathbf{e}_{l,t} \quad \forall l \in L, \forall t \quad (26)$$

The value $\hat{\mathbf{e}}_{l,t+p|t}$ is estimated after calculating β_1, \dots, β_M . The truncated error process $e_{l,k}, k \in \{t-T+1, t-T, \dots, t\}$ is used to obtain the sample auto-covariance functions:

$$C_l(j) = \frac{1}{T} \sum_{i=t-T}^{t-j} e_{l,i+j} e_{l,i} \quad \forall l \in L, \forall j \in \{0, 1, \dots, T\} \quad (27)$$

where T is the length of the short-term historical data used for fitting the model. The least square method is used to estimate the β 's parameters. Considering the expanded predicted value $\hat{v}_{l,t+1} = \sum_{m=0}^{M-1} \beta_m \bar{v}_{l,t-m}$, the mean square residuals are defined as [47]:

$$R_l(\beta) = \frac{1}{T} \sum_{t=1}^T W_t (e_{l,t} - \hat{e}_{l,t})^2 \\ = \frac{1}{T} \sum_{t=1}^T W_t \left(e_{l,t} - \sum_{m=1}^M \beta_m e_{l,t-m} \right)^2 \quad \forall l \in L \quad (28)$$

where the W 's are the positive normalizing weights. The objective is to minimize the residuals with respect to $\{\beta_m; m = 1, 2, \dots, M\}$ by assuming $e_{l,0} = e_{l,-1} = \dots = e_{l,-M+1} = 0$. The coefficients (β_m) are calculated by setting the gradient of the residual function to zero. The model contains M parameters; hence there are M equations as follows:

$$\frac{\partial R_l}{\partial \beta_i} = -2 \sum_{t=1}^T W_t e_{l,t-i} \left(e_{l,t} - \sum_{m=1}^M \beta_m e_{l,t-m} \right) = 0 \quad \forall l \in L \quad (29)$$

The coefficients ($\hat{\beta}_m$) are obtained by solving the linear equation:

$$\begin{bmatrix} C_l(0) & C_l(1) & \cdots & C_l(M-1) \\ C_l(1) & C_l(0) & \cdots & C_l(M-2) \\ \vdots & \vdots & \ddots & \vdots \\ C_l(M-1) & C_l(M-1) & \cdots & C_l(0) \end{bmatrix} \begin{bmatrix} \hat{\beta}_1 \\ \hat{\beta}_2 \\ \vdots \\ \hat{\beta}_M \end{bmatrix} \\ = \begin{bmatrix} C_l(1) \\ C_l(2) \\ \vdots \\ C_l(M) \end{bmatrix} \quad \forall l \in L \quad (30)$$

After calculation of $\hat{\mathbf{e}}_{l,t+p|t}$, $\mathbf{v}_{l,t+p|t}$ (the prediction of link flows at time $t+p$) is obtained by:

$$\mathbf{v}_{l,t+p|t} = \bar{\mathbf{v}}_{l,t+p} + \hat{\mathbf{e}}_{l,t+p|t} \quad \forall l \in L, \forall t \quad (31)$$

The short-term traffic flow prediction model is recalibrated once the new traffic data are received. However, the results from the short-term traffic prediction model includes the critical coverage gaps where the real time data is not available which can be a large portion of an urban transportation network. Therefore, we take into account both historical data and prediction results to minimize travel times with respect to the

predicted traffic flows ($\hat{v}_{l,t+p|t}$) as follows:

$$\text{minimize} \quad \left[\gamma_1 \sum_{l \in L_1} \left[\frac{v_{l,t+p|t} - \hat{v}_{l,t+p|t}}{v_{l,t+p|t}} \right]^2 + \gamma_2 \sum_{l \in L} \left[\frac{\bar{v}_{l,t+p} - \hat{v}_{l,t+p|t}}{\bar{v}_{l,t+p}} \right]^2 \right] \quad (32)$$

$$\text{s.t.} \quad \hat{v}_{l,t+p} \in \varphi^{t+p}(R) \quad (33)$$

where $0 < \gamma_2 < \gamma_1 < 1$, $v_{l,t+p|t}$ is the result from the short-term traffic prediction model. $\bar{v}_{l,t+p}$ is the historical time traffic flow at time $t+p$ for the link l and $\hat{v}_{l,t+p|t}$ is the final traffic flow prediction for link flows based on the historical data as well as the prediction model. It is worth noting that we take $\gamma_1 > \gamma_2$ because of the relative importance of the role of the results from the prediction model in computing link flows. L_1 is defined as the number of links with available real time data and L denotes the number of all the links in the transportation network. The objective is to find $\hat{v}_{l,t+p|t}$ for all the links in the network including links where data is unavailable. Constraint (33) yields link flows satisfying the LLDRs derived from the traffic flow completion model. The output of the above model is the set of link flows and updated LLDRs. The LLDRs are calculated from link flows using (8).

IV. COMPUTATIONAL EXPERIMENT

The San Francisco, California downtown region is chosen as the case study in order to perform experiments and demonstrate the effectiveness of the developed algorithm. Traffic flow and event data as well as incident data are provided by UC Berkeley PATH [48]. Clearly, the quality and quantity of data have an impact on the quality of the final solution. We use a macroscopic traffic simulator based on the commercial software VISUM for the traffic assignment [49]. The inputs of VISUM are the OD matrices and the outputs are the estimated link flows. The OD matrices are adjusted based on the available traffic volumes and the initial OD matrices using the optimization formulation introduced in section II. Figure 6 shows the traffic network in the VISUM format.

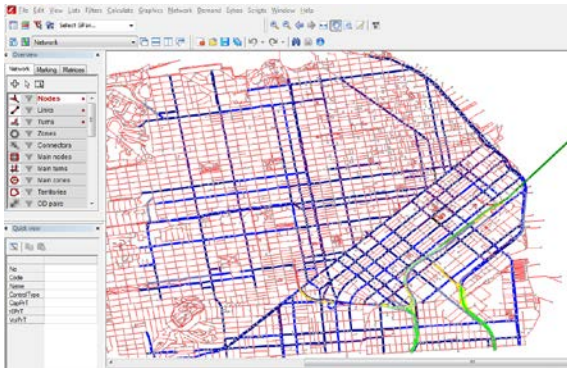


Fig. 5. Case Study Traffic Network

The traffic network under study contains more than 20,000

links and real time traffic data is only available for about 16% of the links in the network. The initial traffic flow estimation model is used to generate traffic flows based on the information from the big venues (e.g. AT&T Park stadium) which provides a benchmark for the traffic flow completion model. Traffic data are received every one minute for those 16% links and no data is available for the rest of the links.

Three scenarios are used to demonstrate the accuracy of the proposed model. The first one presents a time series scenario. At each step, traffic flows are predicted for the next 5 minutes. For instance, traffic flows for time $t+5$ are predicted based on the traffic data up to time t , and for time $t+6$ up to time $t+1$. The second scenario is defined as the comparison of the predicted and measured volumes for the 30-minute horizon prediction. Finally, the third scenario indicates the prediction of flows on the targeted links for the next 5, 10, 15, 20, 25, and 30 minutes time horizon. Note that the targeted links are chosen to be in the category of non-available data links. Therefore, the assumption is that no historical and real time traffic data are available, but in fact both are available to verify the proposed model results. Figure 7 demonstrates the time series scenario for the next five minutes. Figure 8 illustrates the scatter plot for the second scenario, and Table I presents the Root Mean Square Percentage Error (RMSPE) for the third scenario which is the prediction of targeted links every 5 minutes for the next half an hour.

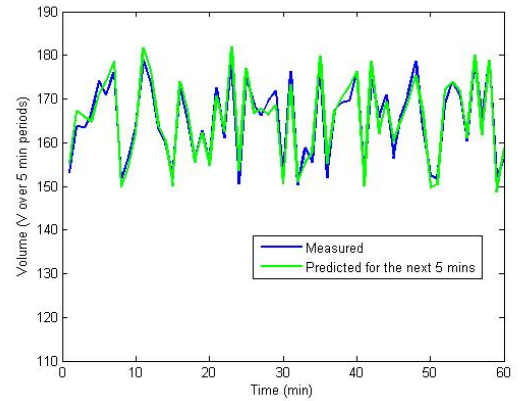


Fig. 6. Time Series Analysis (Scenario 1)

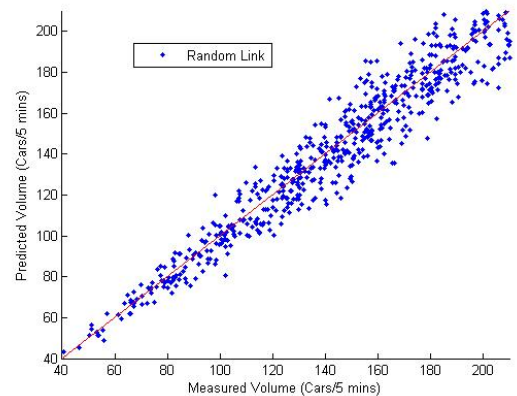


Fig. 7. Predictions Scatter Plot (Scenario 2)

TABLE I
ROOT MEAN SQUARE PERCENTAGE ERROR (SCENARIO 3)

Time (min)	RMSPE (%) [11 am]	RMSPE (%) [3pm]	RMSPE (%) [8 pm]
5	1.98	2.4	1.62
10	6.3	6.56	4.86
15	7.02	7.04	7.38
20	7.34	10.72	8.1
25	8.28	11.36	9.54
30	9.9	11.84	10.14

The first column represents the prediction timing, 5, 10, 15, ... minutes from present time. Columns 2-4 demonstrate the root mean square percentage error (RMSPE) for the targeted links at 11 am, 3 pm, and 8 pm on weekday respectively defined as:

$$RMSPE = \sqrt{\frac{1}{N} \sum_{l=1}^N \left[\frac{\hat{v}_l - v_l}{v_l} \right]^2} \quad (34)$$

where \hat{v}_l is the predicted traffic flow, and v_l indicates the measured one for the link l . Results in Figures 7, 8 and Table I present the accuracy of the proposed methodology to predict traffic flows in the urban region with the complex characteristics. Figure 8 also suggests that the proposed predictor is unbiased.

In addition to the above experiments which were performed under normal conditions, Monte Carlo experiments are carried out in order to evaluate the effects of random uncertainties due to the stochastic nature of traffic data. The most possible source of error in the proposed predictive algorithm is that the estimated LLDRs from the historical traffic data might not be valid for some links of the network at the current time due to accidents or social events. In order to measure the sensitivity of the model with respect to these variations, Monte Carlo experiments are performed. The method is as follows:

- 1) At each experiment the LLDRs are calculated.
- 2) 50% of the LLDRs are selected randomly.
- 3) Selected LLDRs are multiplied by a random variable Γ .
- 4) The new LLDR set is fed to the predictive algorithm, and the results are recorded.

These four steps are repeated 1000 times for each data sample. The coefficient Γ is assumed to be a Gaussian random variable $\Gamma \sim N(1, 0.1)$. The variance $\sigma^2 = 0.1$ is selected based on the observations from Downtown SF traffic data ($\sigma = 0.316$). In the cases that the new LLDR is bigger than 1, the fixed value of 1 is chosen for the specific LLDR. Figures 9 and 10 show the error for a specific data sample for 5-minute and 15-minute time horizons prediction. In this sample, the standard deviation of the Monte Carlo results is $\sigma = 0.09$, which indicates that the sensitivity of the predictive algorithm to be about 28% with respect to the LLDR variations. The sensitivity of traffic flow predictions to the error in LLDR calculations suggests that the prediction/simulation model is robust, and the noise does not escalate through different steps of the model.

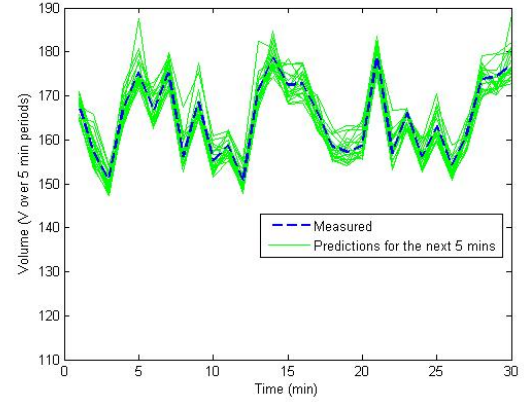


Fig. 8. Monte Carlo Experiments results for 5-minute-ahead predictions over a 30-minute period

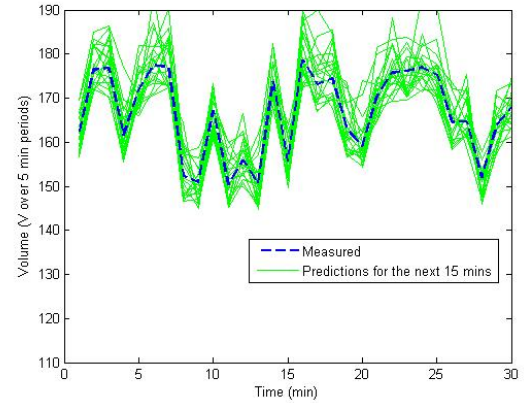


Fig. 9. Monte Carlo Experiments results for 15-minute-ahead predictions over a 30-minute period

V. CONCLUSIONS

In this paper, we estimate traffic flows in all links in a traffic network where traffic data are unavailable, and use the information to predict short-term traffic flow for the entire transportation network. A large network in the San Francisco area is used to demonstrate the efficiency and accuracy of the methodology. Monte Carlo simulations are used to account for random effects and uncertainties. The results demonstrate accurate predictions of traffic flow rates up to 30 minutes ahead of time under normal operations. In the case of events the prediction algorithm adapts to the changes and modifies its prediction outputs with good accuracy.

One of the limitations of this paper is the lack of adequate number of data during normal and incident traffic conditions to perform additional tests. Future work will involve the collection of additional real time data as they become available due to emerging traffic sensor technologies, the use of vehicles as probes and vehicle to infrastructure communications. Such data may be used to improve the accuracy of our approach as well as validate it under different traffic scenarios and different networks.

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Impacts of the clean air action plan on the port trade industry

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Abstract: The Clean Air Action Plan (CAAP), implemented by the Ports of Los Angeles and Long Beach in 2006, was an unprecedented effort to reduce air pollution emissions associated with port operations. We conduct a case study to understand why the ports developed the CAAP, how it was structured, and how it affected stakeholder relations. We identify those with the most influence in the international trade supply chain – ‘dominant actors’ – and hypothesise that they are the key participants in the CAAP development process and are least likely to be the subject of costly requirements or changes in operations. We find that the CAAP led to a restructuring of stakeholder relations, with new alliances formed between the ports and regulatory agencies and old alliances strained by what was perceived as a closed process utilised to develop the plan and as a lack of consideration of industry borne costs.

Keywords: ports; environmental regulation; environmental policy; air pollution.

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1 Introduction

In the fall of 2006 the Ports of Long Beach and Los Angeles announced the establishment of the Clean Air Action Plan (CAAP). The CAAP was unprecedented in several ways: it was a voluntary agreement between two competing ports; it was achieved with the cooperation of local, state and federal agencies; it promised large particulate emissions reductions along with continued port growth, and it had an expected price tag of \$2.1 billion. By 2010 it was evident that CAAP was a success: the ambitious emissions reduction targets were reached, generating large societal benefits to surrounding communities. An environmental mitigation plan of this magnitude merits study. How did the ports develop and implement such a plan, and how did the plan affect port and industry stakeholders? Does it provide a model for designing effective mitigation policies?

The actions of the port authorities of Los Angeles and Long Beach offer a starting point to understand how environmental changes may impact other ports throughout the US and the world, how ports can act to address environmental impacts, and how effective environmental mitigation policies might be designed. This paper presents results from a larger study of the motivations, development process, and outcomes of the CAAP (Giuliano and Linder, 2011). In this paper we explore the development of the CAAP and its impacts on port and industry stakeholders using a political economy framework. Our approach is a qualitative case study, using data from multiple sources. The remainder of this paper is organised as follows. Section 2 reviews the literature on environmental policy and practices related to ports and international trade. Section 3 describes the Southern California context and the conditions under which the CAAP emerged, and summarises the CAAP and its provisions. In Section 4 we present a conceptual framework of stakeholder relationships and present our expectations on how these relationships explain the CAAP. We then present our analysis of the CAAP and discuss results. We close with some conclusions and suggestions for further research.

2 Literature review

The combination of dramatic increases in freight traffic and concentration of trade activities in large metropolitan areas has motivated an emerging literature in urban freight. While freight is essential to urban life, it is a substantial contributor to environmental externalities; it accounts for 30% to 40% of global urban transport-related CO₂ emissions and nearly 50% of particulate emissions (BESTUFS II, 2006). Urban freight contributes to congestion, competes with passengers for scarce road and rail space, and negatively affects the livability of metro areas.

There is a growing literature on urban freight policy, much of it focused on environmental impacts and regulation (Danielis et al., 2010; Melo and Macharis, 2011). Studies of specific policy examples include off-hours deliveries in New York (Holguín-Veras et al., 2006), clean vehicle certification programmes (Dablanc, 2008), port operational policies, such as gate appointment systems (Giuliano and O'Brien, 2006; Namboothiri and Erera, 2008; Yahalom, 2001), extended gate hours (Giuliano and O'Brien, 2008), and vessel speed reduction (VSR) programmes (Linder, 2010). This work has not reached a point of synthesis or general understanding of what policies are

effective, and what conditions are required for effective implementation (Giuliano et al., 2013).

Most relevant to our examination of CAAP are studies that examine motivations for strategy choices or seek to explain policy outcomes. Doig's (2001) historical study of the Port Authority of New York and New Jersey notes the critical role of organisational structure and public entrepreneurs. Erie's comprehensive study (2004) argues that development of the Los Angeles and Long Beach ports was part of a larger regional development strategy based on infrastructure investment. More recently, Erie and MacKenzie (2010) use a governance framework to examine trends in infrastructure investment and management in Southern California. They argue that while municipal agencies and joint powers authorities have operated effectively in the past, this is no longer the case. Explanations include lack of consensus on how to solve externality problems and politicisation of municipal agencies, in turn explained by term limits, fiscal problems, and super majority voting requirements in a fragmented governance structure.

Woudsma et al. (2009) explore the role of stakeholder collaboration in the adoption of environmental innovations in port gateways. Their research suggests that successful implementation requires the leadership of key public and private organisations, collaboration among stakeholders, as well as effective mediating factors (e.g., incentives, information, trust among stakeholders). Giuliano (2010) examines programmes to reduce landside congestion at two US west coast port complexes. Differences in outcomes are explained by both institutional and contextual factors.

Giuliano and O'Brien have offered explanations for both the results of state legislation, AB 2650, which led to a gate appointment system, and the PierPass programme, which imposes a fee for peak period deliveries (Giuliano and O'Brien, 2008; Giuliano et al., 2008). Outcomes of AB 2650 were explained in the context of the economic and institutional structure of the international trade supply chain. They interpret Pier Pass as an example of self-regulation that originated in response to a regulatory threat. In both cases, Giuliano and O'Brien argue that institutional relationships and market power play a significant role. Our analysis of the CAAP builds on the Giuliano and O'Brien conceptual framework.

3 Background

3.1 The ports of Los Angeles and Long Beach

The Ports of Los Angeles and Long Beach grew rapidly as a result of the surge of US – Asia trade in the 1990s. In 1990 the two ports had an annual TEU¹ volume of 3.7 million; by 2000 volume had risen to 9.5 million, and the ports were the undisputed leaders of Pacific Coast trade, with a market share of nearly 60% (and 46% of all North America waterborne trade). In 2006 volume reached nearly 16 million TEUs.² This rapid growth had significant impacts on local communities. It contributed to rapid economic growth of the region, but also generated congestion and contributed to air pollution and other environmental externalities. From the public's perspective, trucks on the road became symbolic of the negative impacts of international trade (Giuliano and Linder, 2011).

The Los Angeles region also has the nation's worst air quality problem. Ships use cheaper grades of diesel fuel, generating high emissions of sulphur oxides, volatile organic compounds, and particulates. Diesel trucks and trains are major sources of

particulates. The region is subject to strict emissions regulations, but the regional air quality authority (South Coast Air Quality Management District, SCAQMD) does not have jurisdiction over ships, trucks or trains. The growth in trade increased the share of emissions coming from these sources, making it more difficult to meet stringent emissions reductions goals. For example, NO_x emissions from regional trucks as a share of on road emissions rose from 68% in 2002 to 75% in 2008. NO_x emissions from trains and vessels as a share of 'other mobile' sources rose from 28% to 33% over the same time period.³

During the same period, the health impacts of diesel particulates on surrounding communities were documented in a group of longitudinal studies (Coussens, 2004). Growing public awareness and the engagement of the environmental community led to pressures on local officials to address the problem. The result was a series of legislative efforts to manage truck traffic and reduce port-related emissions, and a series of lawsuits that prevented the ports from any further expansion of capacity or facilities. It is in this contentious context that the CAAP was developed (Giuliano and Linder, 2011).

Table 1 CAAP provisions

<i>Mode</i>	<i>Control measures</i>	<i>CAAP cost (\$M)</i>	<i>Comments</i>
HDVs	All trucks meet 2007 EPA standards by 2011 Alternative fuel station	\$1,808	CTP: licensed trucking companies, employee drivers, costs to be paid by state bonds, ports, fees on cargo owners
OGVs	VSR Electric shore power Auxiliary engine fuel standards Main engine fuel standards Engine emissions control devices	202	Incentives for VSR, cleaner fuels; ports pay for landside shore power improvements
Cargo handling equipment (CHE)	Cleanest available technologies All CHE meet 2007 EPA standards by 2010	0	Accelerated equipment replacement by terminal operators
Harbor craft	Gradual shift to highest EPA standards	0	Retrofits, engine replacements
Railroad	Switch engine replacement for local rail line Increased emissions control on Class 1 RRs Cleanest available technology for new rail yards	21	Switch engine replacement part of existing agreement; Class 1 RR compliance by 2011; no new rail yards developed
Other	Technology advancement programme Infrastructure and operational efficiency Administrative costs	36	TAP for development of clean vehicle technology
Total		\$2,067	

3.2 *Overview of the CAAP*

The CAAP provisions are summarised in Table 1. Costs are those deemed by the ports to be part of the ports' 'future budget planning', not the full costs of implementing the plan [Port of Los Angeles and Port of Long Beach, (2006), p.19]. By far the most costly measure is the Clean Truck Program (CTP); it called for the replacement of the entire drayage vehicle fleet. It had four elements:

- 1 gradual phase out of older trucks
- 2 registry system for enforcement
- 3 \$35/TEU charge to the beneficial cargo owner (BCO) for deliveries with non-compliant trucks
- 4 concessions with licensed motor carriers, which would effectively prohibit owner-operators from access to the docks.

The ports expected the bulk of the costs of CTP to be funded by a combination of state bonds and container fees. There are two notable features of CAAP:

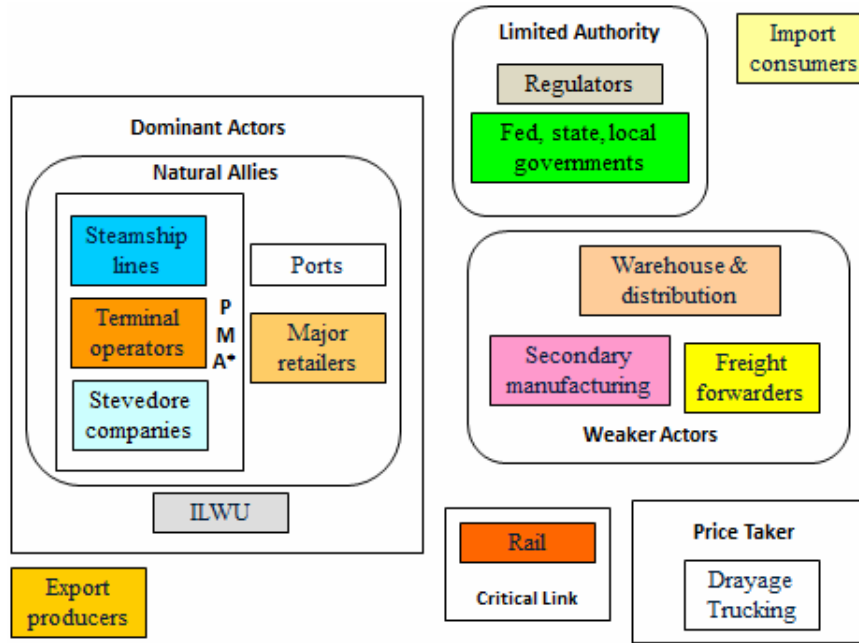
- 1 there is no complete accounting of the costs or benefits of the Plan
- 2 the emphasis of the plan on heavy duty diesel trucks (HDVs) is not consistent with the greatest sources of pollution, ocean going vessels (OGVs).

4 **Conceptual framework: relationships and market power**

Following Giuliano and O'Brien (2008), we use a political economy framework to explain CAAP outcomes. Giuliano and O'Brien argue that institutional relationships and market power play a significant role in port-related trade. Figure 1 is a stylised model of international trade supply chain relationships. A set of 'dominant actors' – ports, terminal operators, steamship lines, major retailers, and the International Longshore and Warehouse Union (ILWU) – influence port operations, labour relations, and responses to regulatory and other threats. All but the ILWU are 'natural allies', given their common interest in growing their businesses, which means efficient operations, profits and price competitiveness. The ILWU has the same interest in expanding port business, but also seeks to protect jobs and benefits. By virtue of its control of the longshore labour force, the ILWU has significant influence on port operations. There are many linkages between these allies (most terminal operators and steamship lines are part of the same conglomerates), and they collaborate via trade associations and advocacy groups. In addition, US federal maritime regulatory policy allows for cooperation among terminal operators for certain purposes, and for cooperation among ocean carriers within trade lanes. Major retailers are prime clients because of the volume of their business. They have influence on operations, as they can threaten to move elsewhere should prices rise or service quality decline.

The Class 1 railroads are a 'critical link', because the volume of discretionary trade (imports and exports out of the Southern California region) is critically dependent upon the national freight rail network. The Class 1 railroads tend to operate as independent agents, collaborating with the natural allies only when in their interest to do so.

Figure 1 Stylised model of international trade supply chain relationships (see online version for colours)



Note: Pacific Maritime Association (PMA), represents steamship lines, terminal operators and stevedore companies in negotiations with the International Longshore and Warehouse Union (ILWU).

Until the past decade, governments and local regulatory authorities have had limited influence, in part because of limited jurisdiction, and in part because ports and international trade have historically been perceived as economic development engines. Warehousing, secondary manufacturing, and all the indirect activities associated with international trade are termed ‘weaker actors’ because these industries are fragmented and have little influence on supply chain dynamics. The fortunes of these industries depend on port trade, so they are linked with the dominant actors via trade associations, chambers of commerce, and social organisations.

The drayage trucking industry is at the end of the spectrum. Drayage trucking is a price taker; it has no ability to influence pricing and hence income or wages. Its owner operators – mainly non-English speaking immigrants -- are among the lowest paid in the trucking industry, in stark contrast to the wages of ILWU workers (Monaco and Grobar, 2004; Monaco and Burks, 2011). Prior to the CAAP, drayage truckers operated the oldest and therefore most polluting trucks. Unlike the terminal operators, drayage truckers are subject to anti-trust prohibitions and have been unsuccessful in organising for better working conditions or higher pay.

Figure 1 also includes the local community, which historically has supported port activities as a major source of jobs and economic growth. City council members have been supportive of port growth and prominent proponents of port expansions and infrastructure projects. Neighbourhoods surrounding the port areas are poor, minority, and often immigrant populations with little capacity for political participation or community organisation. Many residents are dependent upon the jobs provided in

secondary industries (including drayage trucking) and hence not inclined to object to the negative impacts port-related activities. This changed with the growing recognition of health impacts on local residents and environmental justice implications of poor and minority communities suffering disproportionately from port-related air pollution. Political leaders shifted to a position of environmental mitigation plus growth.

Given these differences in market power and potential to cooperate, we expect differences in both the extent to which these stakeholders participated in the process, and in how they were affected by the CAAP provisions. With regard to participation, we expect that the dominant actors participated more than weaker actors. The ports would be less inclined to include stakeholders who had little ability to influence port business or garner political support, and more inclined to include those who did. Similarly, the ports would likely be more sensitive to costs of the CAAP that are imposed on the dominant actors, and less sensitive to those imposed on weaker actors. Thus, we would expect the most stringent and costly measures imposed on the weakest actors, namely the drayage truckers. The role of the community is uncertain, given the potentially conflicting objectives of reducing air pollution impacts and maintaining economic growth.

SCAQMD and the California Air Resources Board (CARB), the local and state regulatory agencies, are expected to have a dominant role. Both agencies have plans that identify emissions reduction targets in future years, and one logical strategy for the CAAP is to simply accelerate reaching these targets. Also, if in fact regulatory pressure is a motivating factor, then the ports would want to negotiate with these agencies to assure receiving credit for achieving emissions reductions beyond the standards and preempt more stringent regulations. The agencies have motivation to be actively involved, given their responsibility for compliance enforcement.

The regulatory framework also plays a role in CAAP and may compliment market power motivations. Regulatory authority differs across pollution source. Ocean vessels are exempt from US emissions laws, hence OGV emission reductions take place only by voluntary compliance. The ports would have a strong incentive to include steamship lines in the process in order to negotiate the desired reduction strategies. Railroads are subject to national regulation, so emissions reductions from these sources beyond national requirements must also rely on voluntary compliance. Finally, we might expect that sources already under control of local and state regulators would not be targeted in the plan, because emissions reductions from these sources are already strictly regulated and largely achieved. The ports were facing the challenge of which sources had the highest potential for short-term emissions reductions versus which sources could be incentivised to take the required actions to achieve these reductions.

Our discussion so far has focused on motivations and outcomes based on political and power relationships. There is an alternative hypothesis: the CAAP was the result of an objective analysis of alternative strategies, and selection of the strategies was based on technical merit. This would involve some form of cost-effectiveness analysis of each alternative measure to generate a dollar value per ton of pollutant removed. Strategies would be ranked based on cost-effectiveness. While estimated costs and emissions reductions are documented for some of the measures, no comparison or ranking of strategies is provided, and we were unable to obtain documentation of such analysis. Furthermore, only the cost to the ports was considered, rather than the total cost of implementing each measure. We therefore do not expect that cost-effectiveness analysis played a significant role in development of CAAP.

5 Methods, data and results

We conduct a qualitative case study using data from many sources: data collected and interviews conducted in several prior studies (Giuliano et al., 2005; Giuliano and O'Brien, 2006, 2008; Linder, 2010), an events history, media review, a review of documents surrounding the plan, and stakeholder interviews. See Giuliano and Linder (2011) for details. We examine stakeholder participation and perceptions, development of the CAAP measures, and impacts on supply chain actors.

5.1 Stakeholder participation

The CAAP was created by the ports in cooperation with the SCAQMD, CARB and the Environmental Protection Administration (EPA), then released to the public for comment on June 26, 2006. The final plan was released and approved on November 20, 2006. Our interviews indicated that CAAP development was largely a closed process. The ports chose to restrict the process to themselves and regulatory agencies for two reasons. First, if one stakeholder were included, all stakeholders would expect to be included. Second, because of the diversity of interests among stakeholders, it would be difficult to get consensus on what would be included in the plan. It was assumed that the business community would argue for less stringent measures, while the local community would want more stringent measures. When the plan was released, reactions were consistent with this assumption. The ports also emphasised a concern with the 'technical merit' of each mitigation measure, and the need to negotiate with the regulatory agencies on that basis. Potential measures were evaluated internally.

Informal networks among key stakeholders (e.g., our dominant actors) allowed for some input and participation, despite the closed nature of the process. Terminal operators had indirect input into the plan based on relationships with the ports. Operators were consulted informally to test feasibility of different possible mitigation strategies. Interactions took place over the phone or during a golf game. Operators also attended meetings held by regulatory agencies where the CAAP mitigation strategies were discussed. The ILWU was kept in the loop through relationships with port management. Environmental advocates had the opportunity testify at public meetings and provide public comments.

Not all key stakeholders were included, even informally. The Pacific Merchant Shipping Association (PMSA, which represents terminal operators and global shipping companies) claimed to have been completely excluded from the process, and saw this as leading to an adversarial relationship with the ports. Public comments received by the ports document that most stakeholders were excluded and dissatisfied with the extent of their ability to influence CAAP development. Examples include:

From an ocean shipping line: [We] "were not included in any portion of its drafting, policy making, or in the development or discussion of any of the technical appendices." [POLA and POLB, (2006), p.290].

From Union Pacific railroad: "the specific rail control measures proposed in the CAAP, while building on work done in NNI and GMAP, are still in a conceptual state and were formulated without input from the Railroads" [POLA and POLB, (2006), p.292].

From California Trucking Association: “The failure by the San Pedro Ports to include private stakeholders in the development of the Plan has resulted in a plan that in its current form can never be implemented” [POLA and POLB, (2006), p.194].

5.2 *Who could be targeted?*

The ports were facing a daunting challenge: how to develop a set of mitigation strategies that would have significant results in the short-term and that could be implemented, given legal, technological and funding limitations. The ports settled on two strategies: determine what is feasible to do that would have a large impact in a short time period, and work with regulators to align CAAP measures with future regulatory targets.

In considering the options the ports had, it becomes obvious that drayage trucking was the most promising target for significant and visible change. OGVs were the most obvious target from the perspective of emissions contributions. However, the steamship lines are critical to port business, and they could not simply be told that ships could not dock unless they switched to low sulphur fuels in US waters or used electric power while at dock. There are substantial costs to retrofitting engines and adding auxiliary units to be able to use electric power; estimates from CARB work are \$1.1 million per container vessel for retrofit and about \$5 million per berth for dock electrification (CARB, 2007). The ports would be able to achieve these measures only with incentives and subsidies, and there was no obvious source of funds other than the ports themselves.

The Class 1 railroads were not a promising target. Locomotive engines are subject to EPA standards. The ports lobbied EPA to accelerate the standards, but EPA refused. Thus the ports were left with incentives and persuasion with unwilling partners.

The ports have more control over terminal operators via the long-term lease agreements under which the terminals operate, but terminal operators and steamship lines are tightly linked, and the ports had to be more careful imposing demands on the lines' business partners. The ports took a moderate approach, requiring accelerated replacement of CHE (which would generate only modest emissions reductions) and providing the funds themselves for berth electrification.

Options for heavy duty trucks were quite different. First, the drayage industry was vulnerable due to its weakness within the supply chain. Second, the technology was already available in the form of 2007 EPA approved engines, and if the entire fleet were replaced, emissions reductions would be large. Third, drayage trucks were publicly visible and perceived as unsafe and polluting. The ports could argue that they were not only cleaning the air, but getting unsafe trucks off the road. Fourth, a recently approved state bond measure, Proposition 1B, held promise as a source of funds for purchasing replacement trucks. Fifth, the CAAP provided an opportunity for labour advocates to unionise drayage trucking. Accordingly, the ports took the position that they had the authority to control entry and exit of all vehicles on port property, including authority on vehicle ownership and attributes. They used that authority to structure the CTP around a concession system, completely restructuring the industry. This effort, with almost no participation by those to be affected, is consistent with the market power relationships we described in Section 4 above.

5.3 *Working with regulators*

The second strategy employed in the CAAP was to work with the regulators (particularly CARB) to adopt more stringent standards, and to make sure that the CAAP provisions fed into future standards. In most cases, the control measures were coordinated closely with regulations for each source. In some cases, the measure was written to accelerate implementation of an existing regulation, or the measure had requirements that exceeded a regulation. One intended outcome of this coordination is referred to as a backstop process, where the incentives offered for particular measures could sunset into a required implementation of a CARB regulation. One port representative said that one of the most beneficial results of the plan was that the “[C]ARB has aligned their regulatory strategies with the CAAP,”..... “when the industry agreed to do something for the CAAP, the [C]ARB saw that the industry thought this was feasible and built this into the rules.” The state-wide vessel fuel rule and the shore side power rule implemented by CARB were identified by this respondent as stemming from the CAAP. A respondent from the SCAQMD agreed and felt that the shore power and truck rule were “at least informed in not based upon actions of the ports.” The ports were not as successful at the federal level. There was particular disappointment regarding the rail measures and EPA’s unwillingness to accelerate locomotive emissions requirements.

The backstop strategy had some potentially significant benefits for the ports. First, it may help the ports’ competitive position, at least within California. All ports in the state must follow the same rules. Second, having in effect designed the regulations, the ports have the advantage of regulations most appropriate to their circumstances, while other ports in different circumstances may find the regulations more difficult or costly. Finally, by integrating CAAP into the regulatory system, CAAP can be seen as a temporary measure, with regulatory agencies ultimately returning to their role as primary enforcer.

5.4 *Stakeholder reactions*

Once the draft CAAP was made available for review, response was quick. Comments focused on the ports’ strategies, methods of collecting fees, the aggressiveness of the plan, and the plan’s relationship to current regulation. The PMSA, shippers and terminal operators criticised the plan as being inflexible and overly aggressive. Costs were a great concern for many. These groups, together with the railroads, noted that most of the costs would be borne by industry, yet there was no cost analysis to justify such expenses. Because they were excluded from the process, some groups were not convinced that all costs were justified. A stevedore company wrote: “Requiring extraordinary investment in questionable technology and purchases of millions of dollars of equipment within an unreasonable timeframe based upon the arbitrary timing and nature of lease negotiations may appease some vocal activists but will have potentially devastating financial impact on some businesses” [POLA and POLB, (2006), p.260].

Interestingly, the ports offered a fixed set of responses that included,

“The Ports did not quantify: 1) new equipment, infrastructure, or increased operational and maintenance costs that the industry may incur or 2) air pollution related health impacts and cost to the public. The CAAP was developed primarily as a tool for the Ports to identify measures to be implemented for reducing air quality impacts from port operations. Therefore, in the context of a planning document for the Ports, only the costs that needed

to be considered for the Ports' future budget planning were estimated.... However, it is important to keep in mind that it is ultimately the shipping industry and the cargo owners that will bear the burden of reducing emissions from the goods movement sources" [POLA and POLB, (2006), p.19].

Several comments addressed the relationship of proposed measures with regulatory requirements. They included questions of preemption as well as the aggressiveness of the proposed measures. One terminal operator argued that CARB described its own regulation on CHE as aggressive even though it resulted from an established process that included public input and analysis, and was vetted for cost-effectiveness, financial impact and legality. How then could targets beyond these regulations be considered feasible? Industry representatives also argued that regional targets create problems. With uncertainty on whether these targets would be adopted outside of Southern California, technology suppliers have little incentive to serve a small market.

Comments from the Class 1 railroads reflected their market positions. They argued that the ports had no legal jurisdiction, and any attempt to impose standards not consistent with EPA standards would cause problems. Creating different standards would in effect create different locomotive technology markets, reducing scale economies in engine production, and generating operational problems for national railroads. Lease negotiations leading to different operating requirements across terminals would add to difficulties. Ultimately, overly ambitious emissions standards could lead to reduced rail mode share, having the unintended consequence of pushing even more cargo to the less efficient truck mode. The California Trucking Association took the position that the ports had no legal authority to impose the proposed changes; the plan would be unenforceable due to anti-trust and federal preemption under interstate commerce law.

5.5 Impacts on stakeholder relationships

Development of the CAAP represents a break with the dominant actors model. Unlike previous mitigation efforts, the ports elected to create the CAAP independently. The 'natural allies' were included only to provide input on the feasibility of a particular strategy. The breakdown in relationships is further indicated by the treatment of CAAP costs. Industry representatives were clearly dissatisfied with the lack of consideration of the costs that would be imposed on terminal operators, steamship lines, railroads and others. Yet the ports simply responded that these costs were not within their scope of analysis.

Excluding the ports' natural allies and business partners was a big risk. Ultimately, major customers determine the route of discretionary cargo. If a WalMart decides that the LA/LB ports are too costly or unreliable, there are other options for getting goods to markets. It is possible that the ports considered their competitive position to be so dominant that losing business was unlikely. It is also possible that the ports felt there was no option but to ameliorate the effects of emissions as demanded by environmental and community leaders. The only other alternative was to forego any future growth of the ports. This perspective was voiced by a port representative:

"Unless we can clean the air, we're not going to move forward with any of these projects. The community won't allow it. In fact, I expect every one of the environmental impact documents for these projects will be challenged and end up in court" (R. Kanter, POLB, quoted in *Los Angeles Times*, Sahagun, 2007).

On the other hand, alliances with the regulatory agencies and political leadership had many advantages. Alignment with regulatory agencies provided the ‘backstop’ and a long-term structure for future emissions reductions. The ports took the initiative, but would be able to withdraw from self-regulation by working with regulatory agencies to formalise their programmes. Strategically, working together and formalising air quality efforts into an action plan helped attract some of the positive publicity the ports desired. The negative publicity and litigation that the plan attracted (focused mainly on CTP) may have helped to convey the message that the ports were serious.

Alliance with political leadership was essential, given that the ports’ boards are appointed by their respective mayors, who were in turn responding to local political pressures. In addition, the ports needed access to funds, with the most promising source the Proposition 1B state infrastructure bond programme. Gaining access to bond financing required the endorsement of state elected officials.

By far the most radical part of the CAAP is the CTP. True to our dominant actors model, the drayage industry had no part in the development of the CTP. Rather, the evidence suggests that the CTP was the result of external influences: the Los Angeles City mayor’s well-known ties to labour; the Teamsters Union seeing an opportunity for additional members, the Natural Resources Defense Council and others arguing that independent owner operators did not have the means to either purchase new trucks or maintain them properly, and that restructuring the drayage industry would lead to better jobs and increased safety. Eventually the CTP led to a break between the two ports. The Port of Los Angeles (POLA) has continued to push for the original programme that requires approved trucking firms and employee drivers, while the Port of Long Beach (POLB) has shifted to acceptance of independent operators.

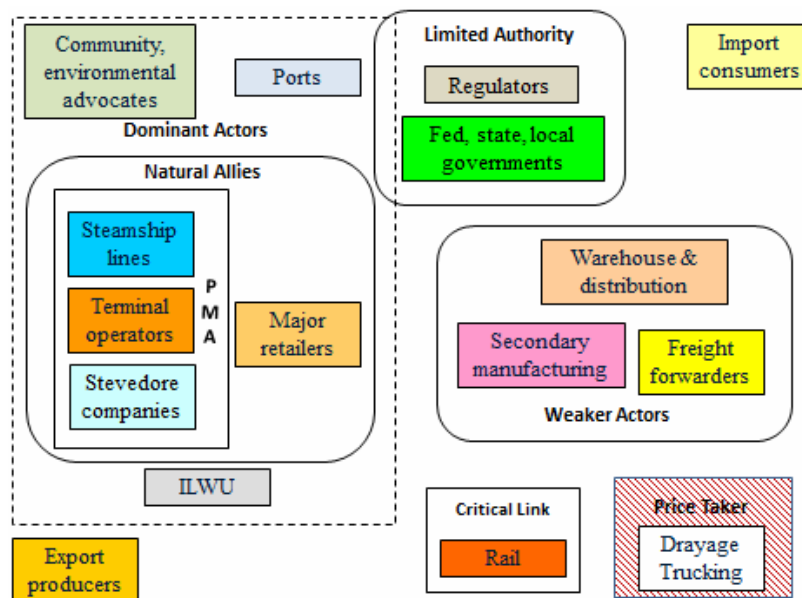
Our interviews provide evidence of the breakdown in alliances among the dominant actors. There was extensive dissatisfaction with the CAAP development process and what was perceived as the ports’ almost dismissive treatment of their concerns about costs. PMSA alluded to an adversarial relationship with the ports, and noted a sentiment among shippers that they were not getting the level of service they were paying for. Although relationships had soured, there were still some signs that the ports were responding to shipper concerns. For example, the proposed infrastructure fee was postponed to 2012, POLA discounted berthing rates, and both ports continue to provide the financial incentives associated with the VSR programme despite the already high participation rates.

The break between the two ports over the CTP provides further evidence. Although the ports have historically been in strong competition with one another, they also have a long history of cooperating when it is in their interest to do so. Clearly the CAAP was something that required cooperation; neither port could have imposed such a plan independently. Since they compete for the same market, additional costs of any sort would simply cause them to lose business. But the two ports face somewhat different political environments. The Port of Long Beach and its associated business comprise a much larger share of the city’s total economic activity than is the case for Los Angeles. In addition, the Long Beach City Hall is located a short distance from the ports. Physical proximity likely reinforces the interdependence of the city and its port. In contrast, the Los Angeles City Hall is 20 miles north of the ports, and port-related activity is not the only important economic engine in the city. With regard to the CTP, the Los Angeles mayor is well known as a staunch labour supporter, and was willing to take a risk.

Ultimately the stakes became too high for Long Beach to continue to fight for a restructured drayage industry.

Our model of stakeholder relationships as illustrated in Figure 1 no longer holds. Although the logic of much of the CAAP reflects the power relationships among the various actors, the ports' position shifted. Figure 2 shows our revised model. The ports are no longer part of the natural allies; they are positioned between government and regulators, and community and environmental advocates. They are responding to community concerns and collaborating with the regulators. The dominant actor box is now permeable, with governments, regulators, and community all having much greater impact on port-related trade. Rail remains an independent critical link, and drayage trucking remains a price taker, albeit under a very different operating structure.

Figure 2 Revised model (see online version for colours)



5.6 Impacts of CAAP

In a previous paper we analysed motivations for the CAAP and concluded that it was a response to social and political pressures that had built up over several years. From the release of a key air pollution health impacts study in 2000 and the first NRDC lawsuit in 2001 to the build-up of legislative regulatory efforts and repeated challenges to new projects, the ports were facing an increasingly untenable situation. The CAAP was an effort to regain legitimacy and protect the long term fortunes of the ports (Giuliano and Linder, 2013). Did it work? Are the ports in a better position to expand and avoid further lawsuits? Have the ports been able to protect their competitive position?

As an air quality improvement programme, the CAAP was an unqualified success. Emissions reductions by 2009 were 61% for SOX, 48% for NOX, and 58% for PM, compared to the no CAAP baseline, and 75% of all drayage truck trips were 2007 EPA compliant (POLA and POLB, 2010). The CAAP also had some success in internalising externalities: steamship lines, terminal operators, shippers, truckers, and cargo owners all

paid towards reducing emissions. No analysis has been done to determine whether charges were in proportion to damages imposed, or whether the costs of CAAP were exceeded by the social benefits of improved air quality and associated health impacts. The POLA cites a consultant study that suggests a positive cost/benefit ratio for the CTP by 2010.⁴

The objective of CAAP to allow the ports to grow and avoid further lawsuits has yet to be demonstrated. Disputes over CTP continue, including the NRDC lawsuit against POLB for eliminating the concession programme. Environmental and community opposition continues on several projects that remain in the queue, including the Southern California International Gateway (SCIG), a near-dock intermodal yard for which the first environmental review document was released in 2005, and at the time of this writing is pending review by the Los Angeles City Council.

The extent to which CAAP has affected the ports' competitiveness is unknown. The CAAP was launched on the eve of a severe recession that resulted in a drop of port traffic of 25%. Within the Pacific Coast market, the LA/LB share peaked in 2006 at 60% and has declined since then; as of 2011, the share is 54%, with the loss mainly due to faster growth of Mexico and Canada ports. The loss of market share could be the result of many factors: the uncertainties and higher costs associated with CAAP, or faster economic growth in Canada and Mexico, or changes in pricing and services at other ports.

6 Conclusions

Our results suggest that the CAAP was unprecedented not only as an air quality mitigation plan, but also as a collaborative effort of two competing port authorities. CAAP is a demonstration of the potential power of port authorities in determining the conditions of port trade. The ports were influential in getting many of the state bills that would have imposed various regulations and fees on the industry rejected, and in persuading the Governor to veto bills that would impose new fees on port trade. They are also active participants in international forums aimed at reducing emissions of ships. They have used their large financial resources to fund dock electrification, alternative fuel facilities, and even development of new technologies. The ports also had the power to impose new costs on even their close allies. Port authorities historically have been recognised as particularly powerful public organisations; it would appear this remains the case. Perhaps the best example was the ability of the POLA to have their concession model upheld in court. Even if this case is appealed and reversed, their influence is demonstrated by the ability to change the fundamental business model of a key part of the supply chain.

Our results also show that the structure of CAAP is largely consistent with our dominant actors model. The Class 1 railroads remained largely independent of the process, and successfully avoided the imposition of beyond-compliance mandates. The steamship lines continued to receive berthing discounts from the VSR programme, and the transition to at berth vessel electrification has progressed slowly. Terminal operators accelerated the replacement of CHE. Although costs were imposed on all port industry segments, the greatest costs were imposed on the weakest actors, the drayage truckers. Drayage trucking was portrayed as unsafe, polluting, and without the resources to maintain new trucks, even if the trucks were given to them. Thus the concession model was deemed necessary to preserve the air quality gains of using new trucks. It is notable

that there was little public discussion of the impacts on the truckers themselves. The drayage trucking fleet was estimated to be in the range of 10,000-12,000, the vast majority operated by owner-drivers; these drivers may or may not have been hired as employees by the firms that entered the market under concession agreements.

Finally, the CAAP restructured stakeholder relationships within the international trade industry. The port authorities are no longer part of the group of natural allies, operating independently from the regulators and the influence of local leaders. They found themselves in a far more complex environment, seeking to continue to expand their business on the one hand, but having to respond to political and legal pressures that were so severe as to impede any further expansion on the other. Our model of international supply chain relationships worked well in explaining outcomes of previous environmental mitigation strategies at the LA/LB ports. The stability of these relationships over several years speaks to the revolutionary nature of the CAAP. Whether the strained relationships with the natural allies that resulted from the CAAP are temporary remains to be seen, and may hinge on whether the ports are successful in expanding and regaining their competitive position.

We close with some comments on the larger implications of our work. First, our model of international supply chain relationships has not been applied to other ports. Given that the international trade industry is global and port-related activity is composed of the same set of actors everywhere (ports, steamship lines, terminal operators, longshore labour, etc.), we suspect that the model would be applicable in the US, and perhaps in other countries. Comparative research of other large ports would be helpful in determining whether the model provides a valid framework for understanding industry behaviour.

Second, we do not know whether conditions in Southern California are so unique that the shifting of long-term relationships and practices that we observed in the case of CAAP are unlikely to happen anywhere else in response to a major business threat. Although environmental concerns continue to grow and the stringency and extent of regulation increases (for example the growth in greenhouse gas emissions regulation), we have no examples of environmental programmes implemented elsewhere that are comparable to the Southern California case.

Third, environmental problems and policies to solve them continue to evolve. The port trade industry, like industry more generally, faces rising expectations on the part of the public for 'environmentally friendly' business practices. It is possible that the Southern California ports are leading the way to new forms of environmental mitigation that involve closer public/private alliances and a recalibration of who should pay. The Southern California example merits continued monitoring and study.

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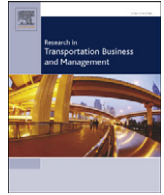
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Notes

- 1 TEU is 20 feet equivalent unit, the accepted volume measure for container flows. The standard container size today is 40 feet, so TEU volume is approximately twice the volume of containers.
- 2 All figures are from Association of American Port Authorities data, calculated by the authors.
- 3 Calculated by authors from data in the 2007 Air Quality Management Plan Appendix, published by AQMD and available online at <http://www.aqmd.gov/aqmp/07aqmp/draft/AppIII.pdf> (SCAQMD, 2007).
- 4 See http://www.portoflosangeles.org/ctp/CTP_O&B.pdf.



Final deliveries for online shopping: The deployment of pickup point networks in urban and suburban areas



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Pickup point

ABSTRACT

In France, e-commerce has experienced steady growth over the past decade. A striking aspect is that it is now widespread among different segments of the population, including suburban and rural households. This growth has generated significant demand for dedicated delivery services to end consumers. Pickup points (PP) represent a fast-growing alternative to home delivery, accounting for about 20% of parcel deliveries to households. The article focuses on the strategy of PP network operators. Our results are threefold. We have documented the recent development of alternative parcel delivery services to e-shoppers in Europe, and especially in France. We have described how the operators have decided to organize their PP network, identifying main variables and constraints. We have provided an analysis of the spatial distribution of PPs in France. The paper shows that at the French national level, PPs are now a well established alternative to home deliveries and their presence covers urban, suburban and rural areas. While PP density in remote areas decreases faster than population density, rural e-consumers' accessibility to PP sites has reached a viable level. Furthermore, PP delivery services generate new types of B2B freight trips that are not yet included in current urban freight models.

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1. Introduction

As in many European countries, shopping habits in France are changing fast. E-commerce is becoming increasingly common due to the spread of IT systems such as laptops, tablets and smartphones. In 2012 e-commerce accounted for 7% of the French retail market (excluding food), i.e. €45 billion, with revenue up by 19% compared with 2011 (FEVAD, 2012). Interestingly, a few authors (Moati, 2009) have reported that online shopping has become widespread among the different segments of the population whether they live in central, suburban or even rural areas, although this change has not been documented in a comprehensive manner. Over the past 10 years, the spread of online shopping has generated significant demand for dedicated delivery services to the end consumer. This has resulted in the increasing fragmentation of shipments in the “last mile” as the final segment of the supply chain is known (Esser, 2006; Schewel & Schipper, 2012). Currently, in France, the vast majority of the 300 million parcels generated annually by distance selling result from online shopping (ARCEP, 2013).

Consequently, e-commerce increases the challenges facing product distribution, with direct effects on logistics systems in urban and suburban areas where traffic congestion and accessibility are crucial factors. In the case of the business to consumer market (B2C), home deliveries constitute the most problematic solution in terms of service costs and organization (Song, Cherrett, McLeod, & Wei, 2009). Although home deliveries are usually preferred by online shoppers (CREDOC, 2010), we are seeing the development of alternatives which satisfy both consumer demand for flexibility and firms' need to optimize parcel distribution through consolidated shipments. In Europe, automated parcel stations (APS) equipped with lockers, and pick-up points (PP), which are stores providing parcel drop-off and pick up services, are fast-growing solutions. These two end-delivery options are playing a decisive role in the reorganization of commercial and logistics activities (Augereau & Dablanc, 2008) and are becoming key features of the strategy of e-commerce and transport players. In the US, the online giants Amazon and Google (Google has opened an internet sales platform based on Amazon's market place) recently decided to invest in their own branded locker box solutions and are in the process of deploying pilot pickup/drop off sites. Similarly, in France new players are constantly emerging and new partnerships being set up, such as the takeover of the Kiala PP network by UPS in February 2012, and the takeover of the Pickup Services PP network by the French company La Poste, via its subsidiary GeoPost in 2009.

Currently, in Europe, the largest APS network is the Packstation network operated by DHL/Deutsche Post in Germany (2500 locations

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around the country). Locker box networks have a limited presence in France, as witnessed by the very small network of 33 kiosks run by La Poste under the name of Cityssimo. New operators such as ByBox (originally from the UK) are likely to extend these services in Europe in the coming years. The second alternative, which forms the focus of this paper, is PP networks. In France, four competing providers are growing rapidly and managing increasingly large volumes of parcels. These operators – Mondial Relay, Relais Colis, Kiala and Pickup Services – have developed standardized delivery solutions for the whole country and in 2013 each of the networks provides access to a pickup point in under 10 min by car or on foot (depending on the area) to 90% of the French population. Today in France, more than 20% of online shopping shipments are delivered through a PP instead of to home.

According to the [European Commission Green Paper on the parcel delivery market for e-commerce \(2012\)](#), the growth potential of reception point delivery systems in the European Union is strong. It is probable that in the near future, drop-off and collection schemes will account for a significant share of parcel volume and will evolve into a more structured distribution channel, affecting urban logistics practices and enhancing competitiveness. The rapid development of alternative solutions for parcel distribution is confirmed by reports and studies dealing with trends affecting the internet economy and consumer shopping behaviors ([Bourdin, 2012](#); [Nemoto, Visser, & Yoshimoto, 2001](#); [Rallet & Perrin Boulonne, 2010](#)).

Previous research on end-delivery movements for e-commerce has mostly focused on describing and modeling household shopping trips ([Gonzalez-Feliu, Ambrosini, & Routhier, 2012](#)). In particular home delivery, the core business for shippers and couriers, has been thoroughly investigated during the last decade ([Browne, 2001](#); [Punakivi & Saranen, 2001](#); [Taniguchi and Kakimoto, 2003](#); [Visser, Nemoto, & Browne, 2013](#)), as has grocery shopping ([Cairns, 1996](#); [Wygonik & Goodchild, 2012](#)). However, with regard to e-commerce delivery schemes, little is known about proximity reception points and site location criteria, trip chain patterns, and tracking and tracing ICT tools. [Song et al. \(2009\)](#) investigated the effect of failed deliveries, estimating customer traveling costs and the environmental costs of home delivery against potential PP networks based on post offices, supermarkets and railway stations across West Sussex in the United Kingdom. In France, the topic has barely been studied.

The aim of this paper is to provide a better understanding of recent developments in urban freight logistics for alternative parcel delivery services to e-shoppers. Our work is part of a broader research program (2012–2015) that looks at disparities in access to e-commerce and home deliveries among urban, suburban and rural residents in France ([Motte-Baumvol & Belton-Chevallier, 2012](#)). We focused our research on PP service providers. It depicts the structure of French PP networks and the strategy of operators when designing PP networks. It provides an analysis of the locational patterns of PP networks and assesses disparities of access to PPs in urban, suburban and rural areas. We have conducted a case study on the Seine-et-Marne Department, a large area to the East of the city of Paris. Seine-et-Marne is partially integrated within the Paris metropolitan area, with urban and suburban settings, but it also has some rural areas, providing an interesting example of diverse residential environments and enabling comparisons. A final objective of this work is to provide directions for future research looking at the impacts of e-commerce on mobility and city logistics. Identifying some of the variables related to parcel flows within PP networks can help us better understand and plan for the traffic generated by city logistics.

Section two of the article describes recent changes and the main PP networks in the current European and French contexts. Section three presents the conceptual framework and methodology applied to the research. Section four describes the strategy of PP network operators. Section five provides a spatial analysis of PP deployment in Seine-et-Marne. Section six draws conclusions and opens up discussion for further research.

2. The development of PP networks in the end-delivery sector

2.1. Alternatives to home delivery services

Our analysis is structured on the basis of the two categories identified by [Augereau and Dablanc \(2008\)](#): (i) pickup points (PP) and (ii) automated lockers. PP networks operate through local shops where packages generated by the distance selling market are dropped off for collection by their individual recipients. In general, PPs are attended 6 days a week, during the opening hours of their host business (dry cleaners, florists, etc.). The second category refers to networks of APS, where people can withdraw packages 24 h a day from locker boxes usually located in shopping centers, gas stations, train stations or on the street. The strength of both systems is the flexibility of opening times compared with post offices, giving consumers the option to withdraw their packages at the time that suits them, as well as the lower costs for transport providers compared with home delivery. Moreover PP and APS networks make use of powerful IT tools for tracking parcels and managing returns, and international partnerships are set up for cross-border deliveries.

In spite of the major investment costs they entail, locker networks seem to be a promising solution, reducing missed deliveries and allowing for off-hour logistics operations ([Augereau & Dablanc, 2008](#)), the main focus of this analysis is on the PP solution, due to the fact that limited number of parcels is handled by APS schemes in France.

2.2. Main drop off networks in Europe today

Alternative delivery networks have recently developed in all European countries, especially in northern Europe (the Swedish operator PostNord provides about 5000 distribution points to the end consumer in Sweden, Norway, Finland and Denmark), the UK, France and Germany, where e-commerce and delivery services are more mature than in the rest of Europe. The United Kingdom, Germany and France have Europe's largest online markets, which together represent 71% of e-commerce with revenues amounting to €143.2 billion in 2011 ([Kelkoo, 2012](#)). Between 10 and 20% of shipments are delivered through a PP or locker solution. [Table 1](#) gives a glimpse of the recent progress of selected European PP/APS networks in these three countries, with growth rates ranging from 5% to 150% since 2008.

This trend towards an intensification of the networks has been confirmed in France, where the aggregate number of ventures serving as PP rose from 10,900 in 2008 to 18,200 in 2012, i.e. an increase of 67%. The French system of *point relais* (reception points) has atypical features, such as its early development, which began 30 years ago to manage mail-order deliveries, and the large number of players, with different shareholding structures ([Patier, Alligier, Bossin, & Perdrix, 2002](#)). As presented in the introduction, there are four competing PP network operators in France (Mondial Relay, Kiala, Relais Colis and Pickup Services), and the development of their networks is fairly similar (see below). These providers are medium-sized, whereas in most other countries, the market is dominated by one or two large operators (e.g. Hermes in Germany, which is almost the country's only PP network operator, in parallel with DHL Packstations providing APS).

2.3. The French PP model

The initial rise of PP operators in France derives from the development of mail-order selling during the 1980s ([Augereau, Curien, & Dablanc, 2009](#)). Sogep – known as Relais Colis – and Mondial Relay were created by two mail-order companies, respectively La Redoute and 3Suisses, with the aim of improving the efficiency of their shipping services. These operators expanded their networks during the 1990s, driven by a sequence of postal strikes, and are now among the biggest players on the French market. The spread of e-commerce opened the way for two additional PP companies, the Belgian firm Kiala and Pickup Services, a French start-up created in 2004. The rise of these companies

Table 1
Trends for reception point networks in Europe.

Company	Service type*	Country	No. sites 2008	No. sites 2012	Growth rate 08–12	Parcel volumes 2012
ByBox	APS	UK	1000	1300	+30%	N.A.
Collect Plus	PP	UK	Not available	5000	N.A.	N.A.
PackStation	APS	Ger.	1000	2500	+150%	N.A.
Paketshop (Hermes)	PP	Ger.	13,000	14,000	+7.7%	N.A.
ByBox	APS	F	Not implemented	170	N.A.	N.A.
Cityssimo	APS	F	20	33	+55%	N.A.
Kiala	PP	F	3800 (with M.R.)	4500	+18%	15 million
Pickup Services	PP	F	3100 (à2pas)	5200	+68%	9 million
Mondial Relay (Point Relais)	PP	F	3800 (with Kiala)	4300	+13%	12 million
Relais Colis (Sogep)	PP	F	4000	4200	+5%	23 million

Source: the authors with company data from various sources

* APS = automated pack station; PP = pickup point

has not gone unnoticed by the major delivery and transport players, such as UPS and La Poste, which have shown particular interest in the IT system and e-logistics data networks set up by the two firms. As mentioned earlier, UPS and La Poste have bought Kiala and Pickup Services respectively.

Fig. 1 shows that the four current networks primarily rely on small independent local shops, such as florists, bars, tobacco shops and press kiosks. These networks have a quite similar spatial deployment and standard of service across France. Each of the operators provides online shoppers with between 4000 and 5500 pickup points across the country, i.e. a network which is almost a quarter the size of the network of post offices. In 2010, about 60 million parcels were delivered in France via PPs, i.e. approximately 20% of the total volume of parcels generated by distance selling.

Table 2 presents changes in the density of PPs for each network, showing the increase that took place for the whole French population between 2008 and 2012. However, due to the constant growth of e-commerce, it is important to point out that each PP site is now serving a larger number of online shoppers.

The continuing influx of newcomers to the end-delivery sector shows that the market has not reached saturation. In 2012, for example, the retailing chain Casino Group created an ad hoc reception service for CDiscount, a household appliance e-retailer. This network is hosted by the convenience stores belonging to the group and benefits from flows that are integrated into the inventory management system used by Casino outlets. Other retailers provide a PP option in their own outlets, such as Darty and most of the main retailing chains (Carrefour, Auchan, Monoprix, etc.). In particular grocery retailers, increasingly provide “Drive” services, which are in-store pickup services for online grocery shoppers.

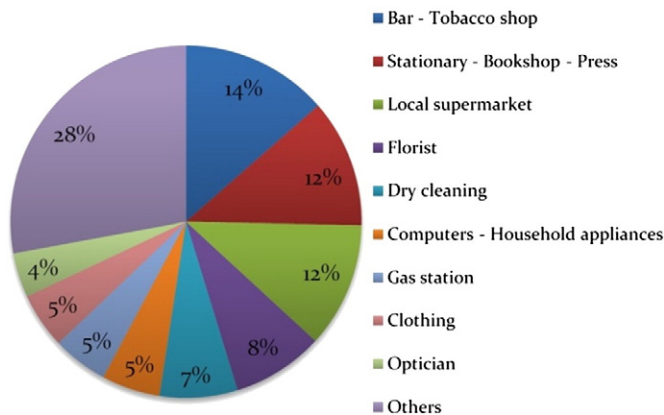


Fig. 1. Type of partner store in the pickup points network, Seine-et-Marne.

3. Definitions and methodology

3.1. Defining the conceptual framework

Our exploratory research took place in 2012–2013. We began by drafting a conceptual framework (Verschuren & Doorewaard, 1999) to outline the main factors which guided our investigation of the features and spatial patterns of PP networks, from the operator's point of view. A graphic representation of the conceptual framework is presented in Fig. 2. The model consists of six elements. The central circle (*Pickup Point Networks*) represents the process of deployment led by the operator, which tends to enlarge the network by adding more sites. The main hypothesis is that PP network growth is influenced by external and internal factors such as population density, proximity to transportation nodes and socio-economic centers, and the distribution of parcel flows throughout the network. These factors, which are identified as the key elements of PP strategies, are represented by circles connected by two directional arrows due to their strong interactions. The *Demographic indicators* circle represents the concentration of consumers, as it is assumed that a higher population density generates greater demand for delivery services. One of the variables that represent the demographic context is thus population density. Similar variables that represent employment rate, computer ownership, Internet access and level of use are usually included in the assessment process. The *Centers and nodes for city users* circle represents parameters related to end-consumers' mobility and accessibility to socio-economic activities, in particular end-consumers' use of both public transport and private cars, and the density of retail outlets and commercial services, business and employment sites, cultural and leisure centers and public transportation nodes, i.e. bus stops and regional railway stations. The third circle, *Parcel flow within the network*, represents the volumes of parcels passing through each site and provides information on the preferences of receivers throughout the selected geographical zone. This factor is useful for evaluating the strategic value of locations and preventing saturation of the local PP network. Although it provides important insights into their performance, the data relating to this indicator is held by the PP network operators who consider it to be confidential.

The deployment of PPs is subject to two main constraints, pertaining to the retail and transport systems, represented by two semi-circles. With regard to the design of a PP network, retail activities play key logistics functions as they permit the reception, storage and delivery of parcels. The availability of retail activities and the willingness of shop-owners to enter a PP network are therefore vital for successful network design. Indeed, as there is a risk of a PP becoming overloaded, in very busy areas PP operators are already competing with each other to find new shops to add to their networks. If the volume of parcels increases further, networks could reach saturation point. Additional constraints relate to the transport system, and affect the urban freight system as a whole. Roads, parking lots and public transport networks and services

Table 2
Pick-up point density over population and e-shoppers, France 2008–2012.

PP network	PP per 100,000 inhabitants 2008	PP per 100,000 inhabitants 2012	PP per 10,000 e-shoppers 2008	PP per 10,000 e-shoppers 2012
Kiala	6.1	7	1.7*	1.4
Pickup Services	5	8.1	1.4	1.7
Point Relais (Mondial Relais)	6.1	6.3	1.7*	1.3
Relais Colis	6.4	6.6	1.8	1.4
Average	5.9	7	1.6	1.5

Source of data: interviews and FEVAD and INSEE 2013.

* Mondial Relay and Kiala shared the network until 2012.

directly influence the development and performance of delivery services that use PPs, therefore the transport system and the available infrastructure are indicated as a potential constraint that affects the strategy of network operators.

3.2. Phases of investigation

Our investigation combined a qualitative approach, based on a literature review and survey activities, with a spatial analysis of PP localization. These two methods provided complementary but converging results. They provided a more comprehensive picture of the variables affecting PP delivery schemes and allowed us to verify intermediate findings.

The qualitative research set out to collect data on the existing e-commerce parcel delivery system from the various stakeholders in the transport and retail systems, including web-retailers, shippers, the French public postal operator, logistics providers, PP network operators and PP partnering shop-owners. It included an analysis of official documents, academic and consulting studies, articles in the trade press and reports on postal activities and e-commerce. Data on PPs was collected from the literature and PP network operators' websites, as the official statistics are limited.

As reported in Table 3, seventeen individual face-to-face interviews were conducted by using semi-structured questions (dealing with the nature of delivery services, ICT tools and operational processes, and delivery demand/supply in urban, suburban, exurban and rural areas). The respondents were selected from among the largest transport and retail operators providing home delivery and alternative delivery services in France. The survey also involved administering questionnaires to a small sample of PP partnering shops—four for each PP network operating country-wide. The purpose of the questionnaires was to collect information on the last part of the delivery process, and to identify

the mechanisms of last mile operations for PP services, in particular from small retailers.

The second phase of the investigation focused on a geospatial analysis of the four PP networks and an assessment of population accessibility within Seine-et-Marne, comparing urban, suburban and rural areas, using the categories defined by the French National Institute for Statistics and Economic Studies (INSEE). The selected areas were defined as follows:

- An *urban area* is a set of municipalities made up of an urban center with more than 10,000 jobs, where the distance between buildings is equal to or less than 200 m.
- A *suburban area* is a residential area within commuting distance of an urban center and connected to it by public transportation and main roads.
- A *rural area* is any of the small urban units and rural municipalities outside urban and suburban areas.

The approach we adopted in order to analyze locational factors and strategies were to use spatial data and descriptive statistical variables, including nearest neighbor statistics. We used the digital spatial database for Seine-et-Marne (August 2012) provided by the Ile-de-France Institute of Planning and Urbanism (IAU). The accessibility measure took account of access distance and time for the population, where *access distance* was calculated by using the Euclidean distance from the centroid of each municipal zone to the nearest PP site in the four networks, and *access time* was calculated by using the shortest journey by car on non-congested routes from the centroid of each municipal zone to the nearest PP site in the networks. Once travel time had been computed for each relationship, we compared the access time for urban, suburban and rural municipalities, weighted by population using the data for 2009.

4. Strategy of pickup point network operators

4.1. Characterization of pickup points

According to the interviews, the main difficulty involved in running a PP service lies in the capacity to reduce delay (for many shipments, a maximum of 48 h from an online order to its delivery) and provide competitive prices throughout France. To meet the requirements of consumers and online retailers, PP delivery systems must guarantee coverage not only of urban areas but also less dense areas such as suburban and rural areas where delivery volumes, and therefore economic benefits, are often smaller. In addition to spatial constraints, reception points are subject to seasonal peaks of activity, for example, before Christmas and during seasonal sales.

Deciding on the location for PP sites is a two-stage process. The first is to divide the area into macro-zones on the basis of administrative criteria (post code and Department boundaries). The second is to conduct zoning on the basis of "catchment areas," in order to estimate the potential flow of parcels, on which basis, a certain number of PPs has to be integrated into the network. Surprisingly, the network operators do not specify an optimum or maximum number of parcels for a local

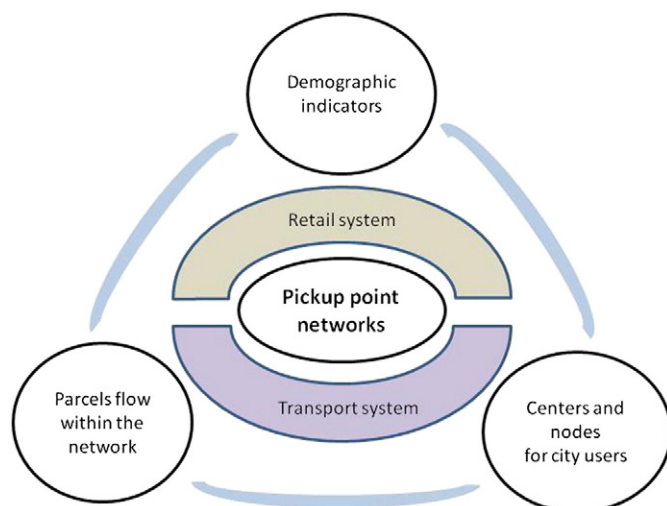


Fig. 2. The conceptual framework for a PP network, from operator's point of view.

Table 3
E-commerce parcel delivery system survey.

Sector	Service	Activity	Type of survey	#
Transport system	Reception points delivery services	Companies managing PP and APS networks	Interview	4
	Home delivery services	Shippers, carriers, postal operator, logistics providers	Interview	6
Retail system	Commercial activities	Shop-owners hosting PP	Questionnaire	16
	E-commerce	Web-retailers, brick and mortar retailers, trade associations	Interview	7
			Total	33

store to handle per day. However, the data we obtained situate the optimal flow at between 10 and 30 parcels per host outlet, even if during peak seasons this level is often exceeded. The average fee paid to participating shop-owners is €0.50 per parcel and ranges from €0.15 to 1.50 depending on the network and the type of service provided (reception, payment, returns management, recycling, etc.).

In general, parcel operators do not surcharge when delivering to remote areas, or, conversely, very central and dense areas, despite the high costs involved. According to the interviewees, standardized rates for a PP network are made possible by hidden cross-subsidies from consumers. Standard rates for domestic parcel deliveries are based on weight and size, however one of our respondents mentioned that their company is considering the possibility of also basing delivery fees on distances and deadlines.

4.2. IT tools and operational process

A characteristic shared by all the interviewed PP providers is the use of a technological platform designed to manage the entire distribution system. IT tools process a complex system of information flows: parcel origin and destination, transport legs, location of transshipment warehouses, location of hubs, agencies and pickup points, business opening hours and holiday times, etc. The IT platform is used to organize all this data then to apply algorithms in order to optimize flows. Data on a parcel's progress is automatically uploaded to the central system which distributes it to the different links in the chain, tracking parcels throughout the delivery process and informing supply chain operators about various matters, namely inventory management, packaging, order preparation, packing, dispatch, transport information outsourcing, consumer services and returns.

PP operators seem to be very responsive as regards adapting their network to fluctuations in parcel traffic, particularly when they detect a rising trend in the volumes to be delivered in a given area. In this situation, they attempt to recruit a new PP partner to cope with the increased demand. Network stability (maintaining a low turnover of local partner outlets) is an essential factor in order to satisfy consumer expectations.

4.3. Network implementation criteria

The respondents all recognized the importance of population density factors and transportation nodes, i.e. the main train and subway stations and the main road intersections. However, their site selection criteria for the four PP networks vary considerably. One PP provider said that data on internet penetration and/or household ownership of ICT equipment was taken into account when modeling the network. Another mentioned the use of trip generation models, i.e. a purchasing trip model, and also stated the importance of urban geography, housing patterns and land use classification. In some cases a distinction between areas with high rise buildings and areas with single homes is made. Delivery operations in these two types of residential areas follow different patterns, mostly because single-home areas seem to accommodate home deliveries more easily. One reason may be that a family member (such as a stay-at-home mother) may be present for more time during the day than in apartments. Another reason, mentioned several times during our interviews, is that a single home provides more potential

for informal arrangements when nobody is at home (parcels can be left by the door, or hidden in the courtyard, or left at a neighbor's, etc.). Thus home delivery is preferred to use of a PP.

The respondents also underlined that once an area is covered by a certain number of points, the volume of parcels passing through each local site is closely monitored. Future development of the networks is forecast on the basis of trends in daily flows. Two respondents stressed that "response time" has to be short and that when volumes are increasing on one site, another PP has to be recruited in order to maintain a balance between all the PPs.

4.4. Constraints on network implementation

The respondents identified two main categories of challenges when building a PP network. The first constraint mentioned by all the respondents is the availability of a dynamic base of retail activities. Convenience stores, florists, news kiosks, etc. have become logistics players in the last mile distribution chain and play a decisive role in activating and maintaining the PP network. Shop-owners decide to provide parcel reception services both for additional revenue and in the hope of generating more in-store traffic, but the possibility of entering a network also depends on the features of their business, physical factors and site location. Some explanatory comments from PP network operators are given below.

"We cannot set up a reception point if there are no stores in the area, or if a store's manager refuses to make it a hosting site."

"In some cases, it is hard to recruit new shops. For example, in dense areas, where real estate is expensive, shop-owners are not at all interested in joining the network and sharing limited storage space."

Predictably, the interviews confirmed the high dependency of PP network design on good accessibility and the provision of good transport infrastructure, for both delivery carriers and end-consumers. Traffic congestion and mobility constraints, therefore, are among the top challenges when implementing a PP network. According to our interviews of transport operators, PP delivery operations are most efficient when they are consolidated in a medium to heavy truck able to serve 15 to 17 outlets. However in very dense areas, where only light commercial vehicles are allowed, consolidation is reduced and per parcel delivery costs increase.

5. Identifying the spatial patterns of PP networks

5.1. Location as a strategic issue for efficient PP networks

To illustrate the mechanisms that determine the location of PP networks, it is useful to identify the firms' business model. Their economic viability depends on the capacity of the network to attract and manage a sufficient volume of goods, in order to achieve economies of scale and thereby reduce the unit cost of delivering parcels and the proportion of fixed costs generated by the structure.

The increase in flows, which constitutes a primary target, must be backed up by a capillary network large enough to serve online shoppers in each area. In fact, there is a risk that distribution concentrates at certain PPs to the detriment of others that are less strategically located or less easily accessible. So while delivery consolidation helps to increase

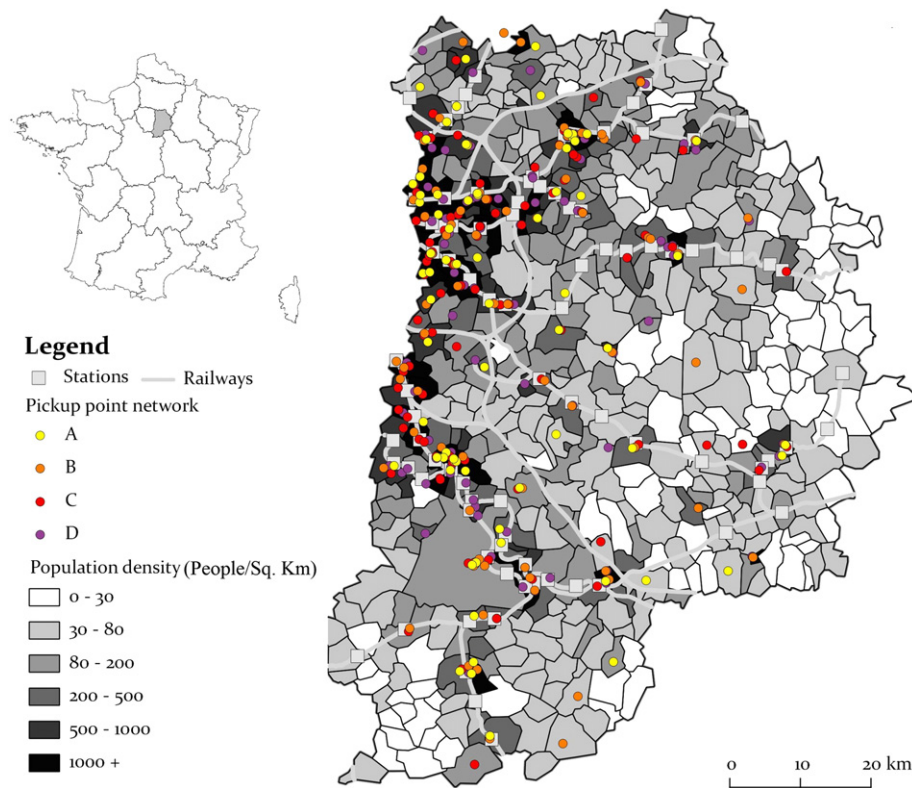


Fig. 3. Pick-up points network in Seine-et-Marne, 2012.

the productivity of a pickup point, the flow of parcels must be appropriate to the size of the business hosting the reception point in terms of storage space and time taken up by parcel handover. Therefore the location scheme adopted by the provider must have the scope to maintain a balanced flow and achieve uniform performance in a network that must remain as stable as possible.

5.2. PP location and distances

In order to assess the deployment of PPs in different types of urban, suburban and rural environments in France, we took the Seine-et-Marne Department as a case study. It is located in the Eastern part of the Paris region, with a population of 1.3 million and 440,000 jobs. Seine-et-Marne covers 6000 km², of which farmland accounts for 56%. The population has tripled over the past 50 years and its density across the area tends to vary substantially. Urban sprawl from Paris means the western parts of Seine-et-Marne are far more densely populated than the eastern and southern parts, where significant rural areas still remain. Densities are also higher along the three main regional railway lines.

The Paris region, which has the highest demand for parcel deliveries in the country, has high standards for delivery services (24 h and even “same day” deliveries). The demand for shipping services has generated dense PP coverage in Seine-et-Marne: the four French PP companies cover the Department with an aggregate of 391 parcel reception points. Each network offers a wide range of PPs, between 70 and 134 sites each. As shown in Fig. 3, there are a large number of PPs in the west of the Department, which is part of the Paris conurbation, where population densities exceed 1000 per square km. More precisely, within the whole Department, PP distribution patterns show a significant positive correlation with population density, with a predictable decline in PP densities in rural areas.

At the aggregate level, all the PP networks present similar locational patterns and tend to target the same areas, i.e. those with the highest population, where there is a very large number of potential partnering

shops. The clustering trend is further evidenced by the dispersion index which ranges between 0.56 and 0.93 for the four PP networks. As expected, distances to the nearest PPs vary significantly: on average, the population is located 1.6 km from the nearest PP in urban areas, and 6 km in rural areas. No major differences are observed between the four networks. Discrepancies between urban and rural areas confirm the importance of car dependency issues for the rural population, while urban consumers are more likely to reside within walking distance of the nearest PP.

It is also noteworthy that a large number of PP sites are located near commuter railway stations: half the stations in Seine-et-Marne are within 300 m of a PP. As shown in Fig. 3, 51% of PPs are located within 400 m of a station and there is a PP within 600 m of each regional railway station. Therefore, railway stations, which serve as functional nodes and a transit point for commuters in the Paris conurbation, are targeted as priority sites for recruiting stores to be added to the network.

5.3. Access time

At the aggregate level, the four networks offer widespread coverage of Seine-et-Marne, securing very short access times by car in almost the whole Department. Our calculation shown in Fig. 4 shows that PP access times in most municipalities range from 1 to 7 min by car and that 91% of the population is less than 10 min by car from the nearest PP.³ On average, each network provides an access time by car of between 4 min in urban areas and 8 min in exurban/rural areas.

5.4. Location of the PP in the built-up and exurban/rural areas

Population density patterns around PPs were examined to ascertain whether the PP densities in different zones differ, and if they do, in what way. For this purpose three zones (one urban, one suburban and one

³ One drawback of this is that PPs which are located just outside the mapped area (institutional borders of Seine-et-Marne) are absent from the analysis.

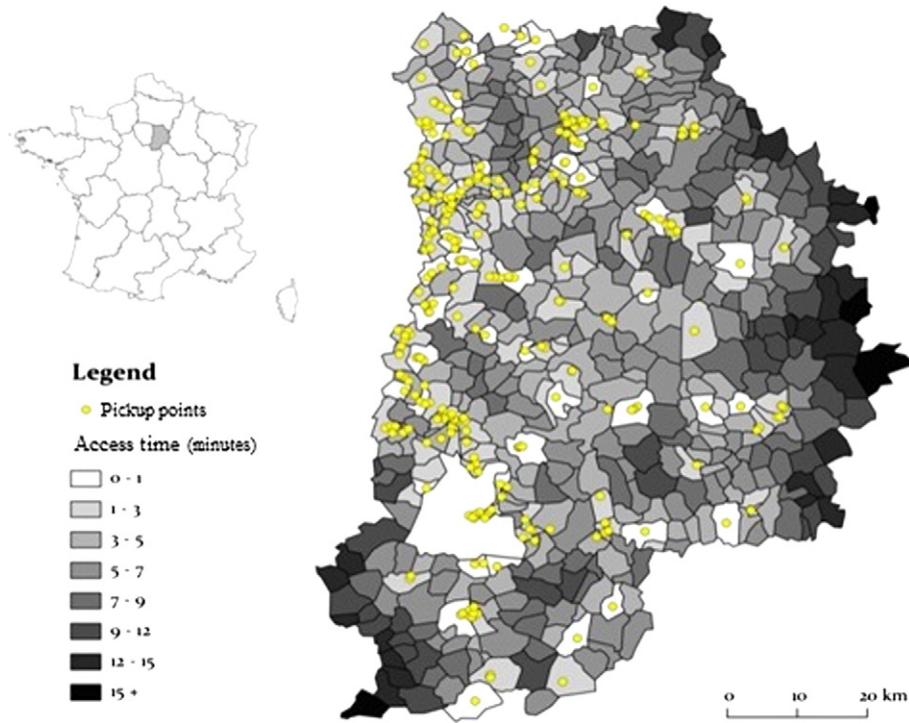


Fig. 4. Access time to PPs in Seine-et-Marne, 2012.

rural) were selected. Some interesting patterns in the distribution of PPs across different areas were noted. Fig. 5 (top) shows the inner center of Meaux, an urban area with 50,000 inhabitants and 10,000 jobs. Fig. 6 (middle) also shows PP network location for two suburban municipalities, Ozoir (population 20,000) and Gretz (population 8000) which are served by a regional railway (RER D). Fig. 7 (bottom) shows a rural area in the north of the Department, which has four small municipalities (on average 2800 inhab. each).

The first thing to emerge is that PP networks are implemented not only in cities but also in small villages of less than 3000 inhabitants. Although dense urban areas remain better served, PPs are tending to become ubiquitous, with good accessibility even in rural areas, as shown

by our findings concerning PP accessibility in terms of both time and distance.

In Meaux, an urban area, we observe a concentration of PPs in the main commercial street, where there are large flows of passers-by. In suburban and rural areas, the siting of PPs reflects the structure of villages or hamlets, where amenities are usually concentrated in the “urban core”. Thus it can be observed that in small settlements, PPs are more often located in the most “urban” areas than on the road intersections at the entrance of the settlements. Whenever present, regional and local train stations are the preferred targets for siting PPs.

Finally, as expected, PP density is high in the urban area and tends to be lower in low-density residential areas and rural regions, where there

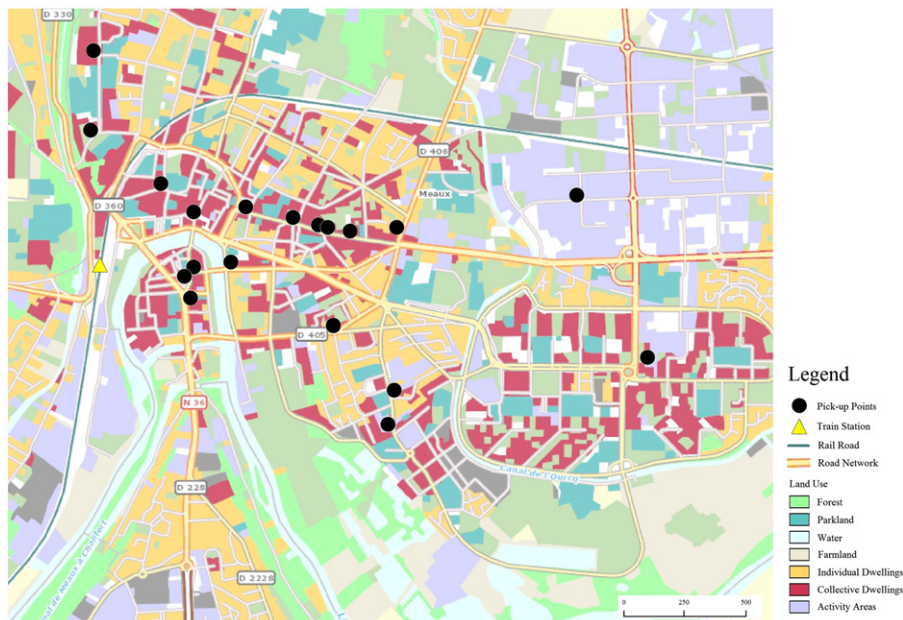


Fig. 5. Pickup point location in urban (top), suburban (middle) and rural areas (bottom).

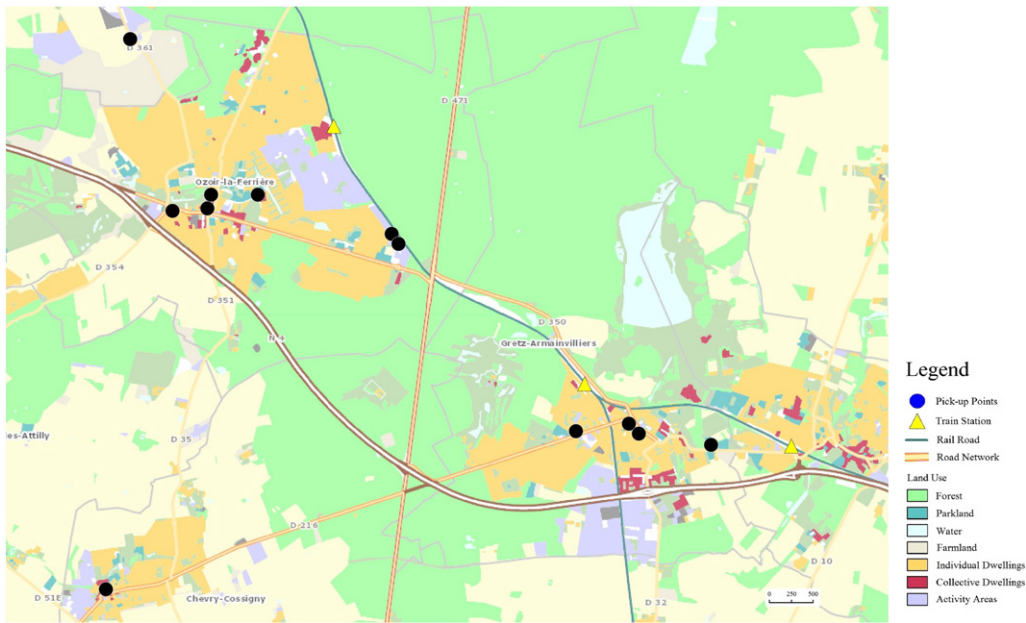


Fig. 6. Pickup point location in urban (top), suburban (middle) and rural areas (bottom).

are fewer services and amenities. However the decrease in PP coverage is more than proportional to the population decrease. As shown in Fig. 8, PPs are over-represented in urban areas (93%) in comparison with their share of the population (83%). This results in lower accessibility to the PP delivery option for the rural population, and may help explain the markedly higher preference for home deliveries in rural areas.

6. Conclusion

In this paper, by focusing on the strategy implemented by PP network operators, we have provided a description of pickup point networks and discussed the rapid growth of end-consumer deliveries in metropolitan areas and their adjacent near-rural environments. We have defined a conceptual framework that identifies the main variables and constraints that may affect the design of a PP network, and confirmed the hypotheses that underlie this framework with the results

from a survey conducted among the main stakeholders (PP operators and shop-owners). The paper then presents the spatial relationships of PPs located throughout the Department of Seine-et-Marne. We have investigated the main locational patterns of PP networks, comparing urban, suburban and rural settings and examined the correlation with population density, activities and transport systems. We have measured accessibility in terms of time and distance.

Our results are threefold. First, we have documented the recent development of alternative parcel delivery services to e-shoppers in Europe, and especially in France, which has the highest rate of PP use among the main European countries. Secondly, we have described how the operators have decided to organize their PP network and assessed the relevance of population density and proximity to public transportation nodes when designing a network.

Finally, and quite importantly, our research shows that at the French national level, PPs are now a well-established alternative to

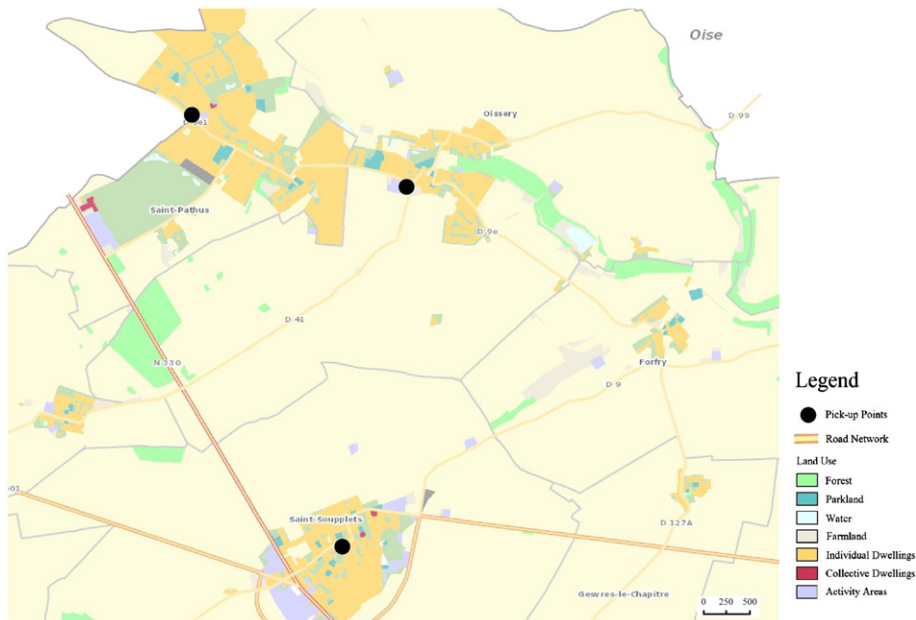


Fig. 7. Pickup point location in urban (top), suburban (middle) and rural areas (bottom).

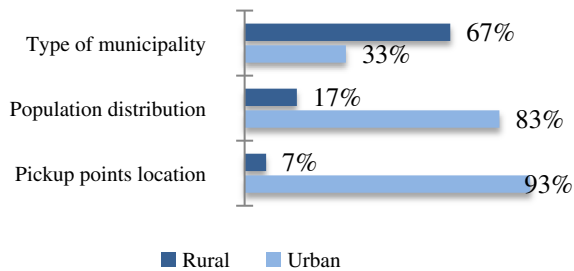


Fig. 8. Disparities between urban and rural areas.

home deliveries and their presence covers urban, suburban and rural areas. While PP density in remote areas decreases faster than population density, rural e-consumers' accessibility to PP sites has reached a viable level. This raises important questions about the overall mobility (commercial + private) related to e-commerce in urban regions.

Deliveries to end-consumers for B2C operations present many challenges, such as missed and highly fragmented deliveries. The example of France as discussed in this paper shows that PP networks make it possible to change from B2C deliveries to less costly B2B deliveries: PPs reduce the risk of missed deliveries and improve shipment consolidation. This explains their very considerable increase in France and Europe during the past 5 years. However, PP delivery services generate new types of B2B freight trips, that are not yet included in current urban freight models.

This paper lays the basis for further research focused on the identification of explanatory factors for freight and passenger trip generation in urban and metropolitan areas. It could also help those modeling city logistics traffic to better integrate the effects of e-commerce. More precisely, we suggest that PP parcel flows should be included when the next version of the urban freight FRETURB model is designed. This new version will benefit from recent quantitative survey results on urban freight patterns in the Paris region (Routhier, 2013) which do not include any specific focus on PP networks. Similarly, efforts to identify the net impacts of e-commerce deliveries on overall mobility from delivery operators' commercial trips and end-consumers' pickup trips could benefit from a detailed understanding of PP network configuration. The potential gains, in terms of reduced vehicle-kilometers, on the commercial side of truck and van movements may well be lost due to increased private car trips, especially as suburban and rural residents gain access to PP services. Finally, we consider that it would be interesting to investigate how home deliveries vary according to the type of housing. Households living in high rise buildings may have a very different pattern for home deliveries (increased use of PPs) from households in single-family homes, as some of our respondents and certain aspects of our spatial analyses have suggested. This type of research could provide interesting information for urban planners and residential developers when considering new developments by helping to quantify the demand for home delivery services that these developments may generate.

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Looking inside the box: evidence from the containerization of commodities and the cold chain

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Looking inside the box: evidence from the containerization of commodities and the cold chain

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Conventional investigations about containerized transportation tend to overlook the goods being carried to focus upon the associated modes and terminals. Containerization is entering a new phase in its global diffusion and adoption by freight distribution systems. The emerging phase of containerization encompasses a complementarity with the commodity sector and the extraction of niche market opportunities to satisfy new demands. This phase is driven by a commodity-wise approach, which inherently creates an array of challenges. For instance, niche markets develop or disappear based on temporary market conditions, the balance of flows on trade routes, and the need for market size. Still, the nature of the commodities being carried is a fundamental element in the emerging containerization of commodities. This article aims at analyzing this emerging niche in the containerization process by 'looking inside the box'. It particularly unravels the dynamics for a number of commodities and demonstrates which role the container fulfills in these commodity markets. The underlying factors that enable the growth or decline of commodity-based niche markets in containerization are discussed. It also looks at the dynamics of the specialized reefer market of cold chain logistics.

1. Introduction

The launching of the first containership *Ideal X* by Malcolm McLean in 1956 is often considered as the beginning of containerization. In the early years of container shipping, vessel capacity remained very limited in scale and geographical deployment, and the ships used were simply converted general cargo ships or tankers. Shipping companies and other logistics players hesitated to embrace the new technology as it required large capital investments in ships, terminals, and inland transport. The first transatlantic container service between the US East Coast and Northern Europe in 1966 marked the start of long-distance containerized trade. The first specialized cellular containerships were delivered in 1968, and soon, the containerization process expanded over maritime and inland freight transport systems (Rodrigue and Notteboom 2009; Levinson 2006).

Container shipping developed rapidly due to the adoption of standard container sizes in the mid-1960s and the awareness of industry players about the advantages and cost savings resulting from faster vessel turnaround times in ports, the reduction in the level of damages and associated insurance fees, and the integration with inland transport modes such as trucks, barges, and trains. The large-scale adoption of the container in combination with the globalization process drove worldwide container port throughput from

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Table 1. Composition of worldwide container port throughput.

	Total port handling million TEU	Full container handling million TEU	Empty container handling million TEU	Transshipment handling million TEU	Gateway handling million TEU	Empty incidence (%)	Transshipment incidence (%)
1990	88.0	70.2	17.8	15.5	72.5	20.2	17.6
1995	145.5	118.7	26.8	31.2	114.3	18.4	21.4
2000	236.6	186.4	50.2	59.2	177.4	21.2	25.0
2005	399.0	316.3	82.6	106.5	292.5	20.7	26.7
2006	442.8	349.9	92.9	120.3	322.5	21.0	27.2
2007	497.0	392.5	104.5	138.0	359.0	21.0	27.8
2008	525.3	416.7	108.6	149.4	375.9	20.7	28.4
2009	476.1	376.2	99.9	136.0	340.1	21.0	28.6
H1–2010*	260.4	206.0	54.4	74.4	186.0	20.9	28.6
Annual growth							
1990–2009	9.3%	9.2%	9.5%	12.1%	8.5%		
2000–2009	8.1%	8.1%	7.9%	9.7%	7.5%		
2005–2009	4.5%	4.4%	4.9%	6.3%	3.8%		

Note: *First half of 2010.

Source: Based on Drewry Shipping Consultants (2009).

36 million TEU in 1980 to 237 million TEU in 2000 and 545 million TEU in 2010. Around 79% of the worldwide container port throughput involved laden containers, and about 21% are empty containers (Table 1).

The container and the associated maritime and inland transport systems proved to be very instrumental to the consecutive waves of globalization. Hence, emerging worldwide container shipping networks allowed changes in the economic and transport geography as they significantly shortened the maritime cost distances between production and consumption centers around the world. Container shipping also became an essential driver in reshaping global supply chain practices allowing global sourcing strategies of multinational enterprises, pull logistics solutions, and the development of global production networks. New supply chain practices in turn increased the requirements on container shipping in terms of frequency, schedule reliability/integrity, global coverage of services, rate setting, and environmental performance.¹

While the dynamics of containerization is a well-researched theme by academics, consultants, and the wider business community, the investigation of cargo being carried by containers appears to be underrepresented, particularly for commodities and the cold chain. The perception of the container as a transport unit must be expanded to consider the container as a supply or commodity chain unit as well. This article will demonstrate that the emerging phase of containerization encompasses a complementarity with the commodity sector and the extraction of niche market opportunities to satisfy new demands. This phase is driven by a commodity-wise approach, which inherently creates an array of challenges. This article aims at analyzing this emerging niche in the containerization process by ‘looking inside the box’. The underlying factors that enable the growth or decline of commodity-based niche markets in containerization are discussed. It also looks at the dynamics of the specialized reefer market of cold chain logistics.

2. The growth of containerization

Containerized freight is commonly characterized by the movement of manufactured goods and parts from manufacturing facilities to retail activities with the whole range of distribution activities in between, such as terminals and distribution centers. This process has substantially benefited from the mobility containerization provided in terms of spatial flexibility and distribution efficiency. The outcome has been the emergence of global production and distribution networks. This underlines that containerization has mainly been investigated from the principle of flow, particularly in light of the development of maritime and inland logistics. Issues such as shipping networks and service configurations as well as the setting and operation of maritime terminals and inland ports have received attention to explain the structure of global supply chains (Fremont 2007; Slack 1998).

The conventional growth dynamics of containerization have mainly relied on an array of drivers, which include:

- *Substitution-based growth.* Initially, substitution was the main factor behind the growth of containerization with the gradual capture of the break bulk cargo market. This process has been particularly visible in many ports as illustrated by rising containerization degrees (i.e., the ratio between containerized throughput of the port and the total general cargo volumes handled in the port). The container penetration in world general cargo traffic increased from 21% in 1980 to a rather stable 65% in the past five years (Figure 1). The evolution of the containerization degrees in the ports of the Hamburg–Le Havre range in Europe in Figure 2 shows that, except for Zeebrugge and Dunkirk, all large container ports in the range (i.e., Rotterdam, Antwerp, Hamburg, Bremerhaven, and Le Havre) have reached containerization degrees above 80%. Since almost all break bulk cargo that could be containerized (i.e., in terms of dimensions, weights, etc.) has been containerized, this substitution process is essentially near to completion in developed economies. It is also rising rapidly in emerging economies and developing countries. Particularly for developed economies, this leaves the possible containerization of niche markets, namely commodities and temperature-sensitive cargo (cold chain).

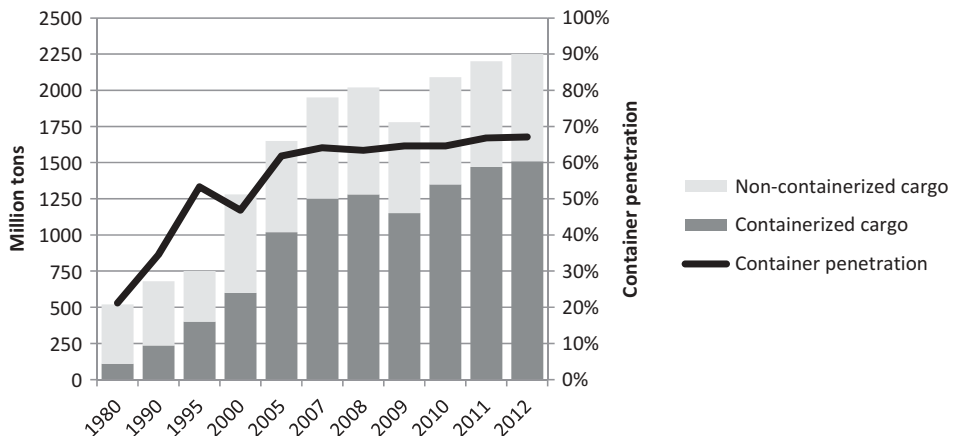


Figure 1. World general cargo traffic and container penetration.

Source: Own compilation based on world maritime traffic data.

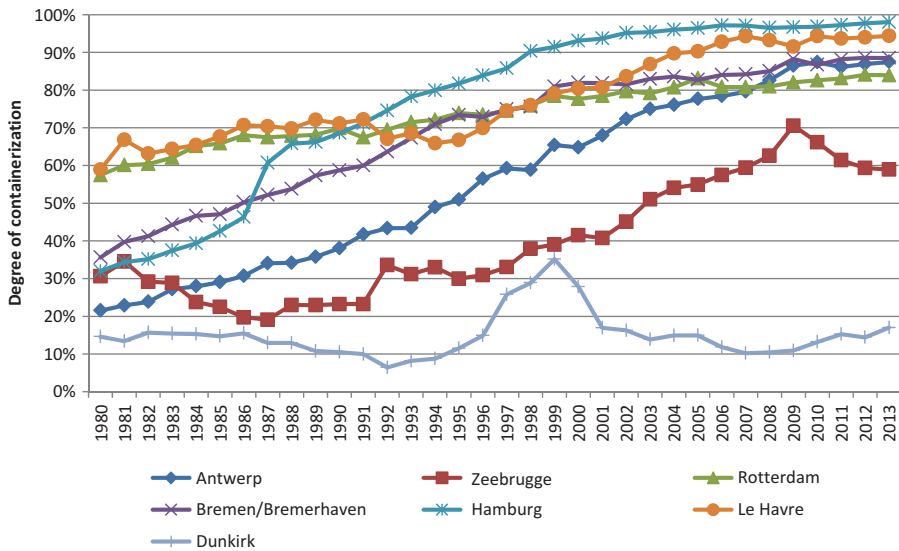


Figure 2. Evolution of the containerization degree in seaports of the Hamburg–Le Havre range in Europe (in %).

Note: The degree of containerization is defined as the container traffic in tons as percentage of total general cargo traffic in tons (excluding dry and liquid bulk traffic).

Source: Own compilation based on data of respective port authorities.

- Incidental growth.* Production and trade imbalances in the global economy are reflected in physical flows and transport rates (Darmon and Drewnowski 2008; Theofanis and Boile 2009) and lead to specific container repositioning strategies and arrangements as discussed by Lopez (2003) and Song Dong-Ping (2009). Containerized flows are almost never balanced, implying that empty containers must be repositioned to locations where export cargo is available (Table 2). For North America, the imbalance with the Far East peaked to about 8.5 million TEU in 2006 with containerized freight flows between the Far East and North America almost three times as voluminous as containerized flows between North America and the Far East. Imbalances in the Europe–Far East trade are also substantial with eastbound traffic only reaching 38% of westbound flows in 2007. In the years 2008 and 2009, the traffic imbalances slightly improved. Despite observed imbalances, the empty incidence in port throughput on a global scale has remained rather stable at 20–21% (Table 1). The more imbalanced the traffic is, the more containerized capacities are required. This also leaves opportunities to take advantage of empty backhauls and the lower freight rates they imply.
- Induced growth.* Global freight distribution implies a transport chain where several modes are used to move cargo between its origin and destination. On the maritime segment, this has led to the emergence of intermediary hubs connecting different systems of circulation. This requires transshipment and consequently additional containerized capacities. Intermediary hubs emerge in places where the hub-and-spoke and interlining/relay solutions offer clear advantages over direct port

Table 2. Evolution of container imbalances on major trade routes (container volumes expressed in 1000 TEU).

Year	Far East–N.Am. eastbound	N.Am.–Far East westbound	EB/WB* imbalance	Far East–Europe westbound	Europe–Far East eastbound	EB/WB* imbalance	N.Am.–Europe eastbound	Europe–N.Am. westbound	EB/WB* imbalance
1995	3974	3536	1.12	2401	2022	0.84	1692	1679	1.01
1996	3990	3650	1.09	2607	2207	0.85	1603	1705	0.94
1997	4565	3455	1.32	2959	2323	0.79	1719	2055	0.84
1998	5387	2857	1.89	3577	2097	0.59	1663	2348	0.71
1999	6109	2923	2.09	3898	2342	0.60	1503	2423	0.62
2000	7309	3526	2.07	4651	2462	0.53	1707	2695	0.63
2001	7429	3396	2.19	4708	2465	0.52	1554	2577	0.60
2002	8354	3370	2.48	5105	2639	0.52	1432	2634	0.54
2003	8998	3608	2.49	6869	3763	0.55	1636	3029	0.54
2004	10 580	4086	2.59	8167	4302	0.53	1883	3525	0.53
2005	11 894	4479	2.66	9326	4417	0.47	1986	3719	0.53
2006	13 164	4708	2.80	11 215	4457	0.40	2054	3735	0.55
2007	13 540	5300	2.55	12 983	4969	0.38	2414	3510	0.69
2008	12 897	6375	2.02	13 312	5235	0.39	2618	3394	0.77
2009	10 621	6117	1.74	11 362	5458	0.48	2047	2738	0.75

Note: *Eastbound traffic compared to westbound traffic (a value of 1 implies a perfectly balanced trade).

Source: Based on data of UNCTAD (2011).

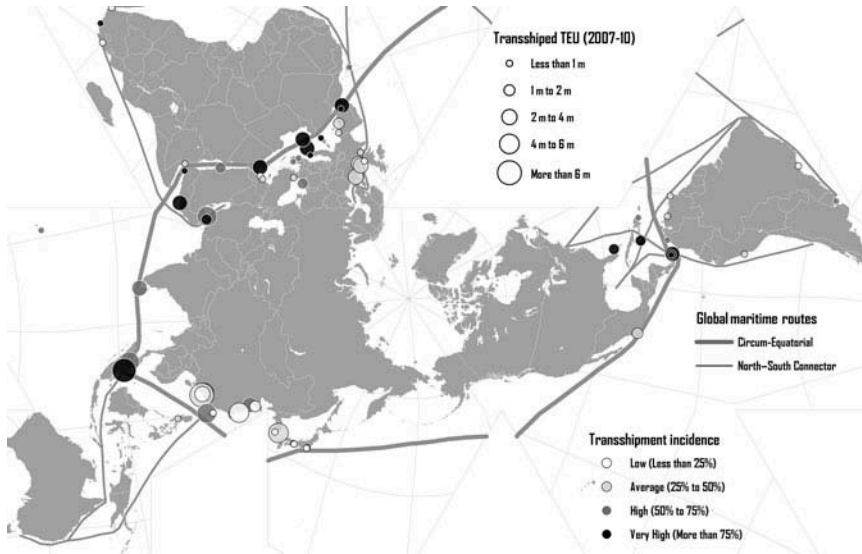


Figure 3. The global transshipment market.

calls at mainland ports. They are particularly located along the equatorial round-the-world route (Figure 3). The creation of intermediate hubs does not occur in all port systems, but around specific regions ideally suited for maritime hub-and-spoke distribution patterns, thanks to geographical, nautical, and market-related advantages (see Rodrigue and Notteboom 2010 for a more comprehensive discussion). Transshipment has proven to be a major driver for the growth of worldwide container port throughput, with substantially higher growth rates than observed for gateway traffic (Table 1). The worldwide transshipment incidence has steadily increased from around 18% in 1990 to over 28% in 2010.

- *Derived growth* (often labeled as organic growth). It is an outcome of economic and income growth where there is a growing quantity of freight in circulation. Additionally, globalization has relied through the exploitation of comparative advantages on a fragmentation of production that implied a growth of the average distance over which containerized freight is being carried. In both cases, greater containerized capacities are required, average voyage days per vessel increase, and the number of vessel round-trips per year decreases (Figure 4). The dynamics based on derived demand may have reached maturity in terms of its containerization potential as many global supply chains are now fully containerized. For the conventional containerized market, this implies that changes are derived from the ebb and flows of commercial activity and much less from the geographical and functional diffusion of the container.

Given that the derived growth function of containerization is becoming less dynamic, that the substitution effect is getting weaker in developed economies, and that empty incidence has remained rather stable, an increasing share of the growth will (have to) come from increased transshipment volumes and the development of niche markets and opportunities that were initially bypassed. For the latter, it is thus important to consider commodity and cold chains as components of containerization.

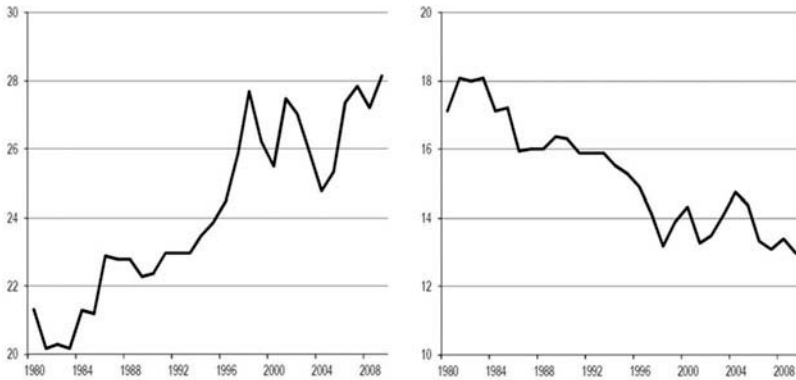


Figure 4. Evolution of the average number of voyage days (left) and the average number of round-trips per year per vessel (right)—container services only—period 1980–2008.

Source: Kim (2010) based on data Clarksons.

Commodities, from grain, chemicals, to wood products, are among a large array of goods being traded in the global economy. Temperature-sensitive products, particularly food, also represent a niche for containerization. It can thus be argued that a subsequent phase in the geographical and functional diffusion of containerization will relate to commodities and the cold chain, which represent a notable market potential being realized. Both transport systems—bulk and containerized—have a role to play, implying that the containerization of commodity chains is more likely to be a process based on a complementarity rather than on competition since each transport chain has its own advantages.

It is clear that for several commodities such as grain, iron ore, and coal, containerization will at best perform a niche role in the total volume handled. Both are likely to benefit since containerization offers speed and flexibility, while bulk offers the lowest transport cost possible. Because of vested interests, in terms of accumulated infrastructure investment and long-standing practices, many opportunities could be captured by commodity producers, large and small alike, over niche markets (high-quality grains, organics, etc.).

The emerging phase of containerization encompasses a complementarity with the commodity sector and the extraction of niche market opportunities to satisfy new demands. This phase is driven by a commodity-wise approach, which inherently creates an array of challenges. For instance, niche markets develop or disappear based on temporary market conditions, the balance of flows on trade routes, and the need for market size. Still, the nature of the commodities being carried is a fundamental element in the emerging containerization of commodities.

3. Market potential

The degree of market penetration of containerization remains to be assessed, and there is a wide variety of levels to which the container can be embedded within various commodity and cold chains. Some commodities are already fully containerized, while for others containerization is still in its infancy. For instance, 95% of all European coffee imports are containerized since coffee is a commodity of high value and its consumption rather ubiquitous. The demand structure of coffee is thus well suited for the benefits of

Table 3. International shipping—containerization of some major commodities by Canadian region.

	Containerized in %	
	2008	2009
<i>Atlantic region</i>		
Stone, sand, gravel, and crushed stone	0.1	0.0
Non-metallic minerals	2.3	3.8
Other refined petroleum and coal products	0.5	0.4
<i>St Lawrence Region</i>		
Wheat	0.4	0.2
Oil seeds, nuts, and agricultural products	7.5	7.1
Metallic waste and scrap	1.5	4.5
<i>Pacific region</i>		
Wheat	1	0.4
Colza seeds (canola)	1.1	0.2
Wood pulp	53.2	53.7
Sulfur	1.6	0.1

Source: Statistics Canada (2009).

containerization. Many segments of raw materials and food commodity chains are in the process of being containerized, which is starting to account for a notable share of international trade. Table 3 provides a Canadian example that even traditional bulk commodities such as wheat, oil seeds, and wood pulp are affected by containerization. This process is supported by several factors:

- A growing number and availability of containers in transport markets around the world are making it a rather ubiquitous transport product. Yet, this ubiquity is challenged by temporal shortages of containers (as for example reported by market players in mid-2010²) and of specific container sizes in some markets. Since 2000, the global inventory of containers grew 6.9% annually while the container ship fleet increased 11.1% per year. The box-inventory-to-vessel capacity ratio reached 1.99 at the end of 2011 compared to 2.03 in 2010 (figures Alphaliner). This is the lowest ratio on record and compares with the capacity ratio of 2.99 boxes per slot in 2000. The lower ratio is partly the result of a more efficient asset management by shipping lines, but also reflects increased pressures on container availability;
- A general rise in commodity prices and growing demand in new markets have made many commodities more prone to be containerized from a value proposition standpoint;
- Fluctuations and rises in bulk shipping rates have incited the search of options to bulk shipping. The increased volatility in bulk shipping (as illustrated by the Baltic Dry Index in Figure 5) also makes long-term planning for bulk shipping complex and subject to risks;
- Relatively stable and even declining container shipping costs, particularly in light of rising commodity prices, rendered the container even more attractive since shippers can be more confident about shipping rates (Figure 6);

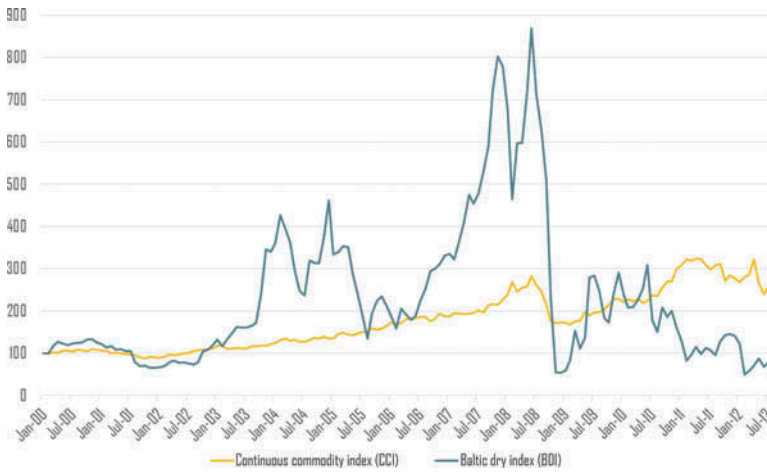


Figure 5. Continuous Commodity Index and Baltic Dry Index, 2000–2012 (2000 = 100).

- Global trade imbalances are transcribed in imbalanced container shipping rates, which represent a notable export subsidy for return (backhaul) cargo. For markets having notable imbalances, such as China (exports) and the United States (imports), incentives are acute. Empty container repositioning has created opportunities by making available pools of empty containers that can be filled for backhauls. Cargo flows that are attracted by low backhaul rates include waste paper, metal scrap, and lower value agricultural and chemical bulk commodities.

Containerization has benefited substantially from economies of scale, particularly for maritime shipping. The container confers few differences in scale economies for a producer as each

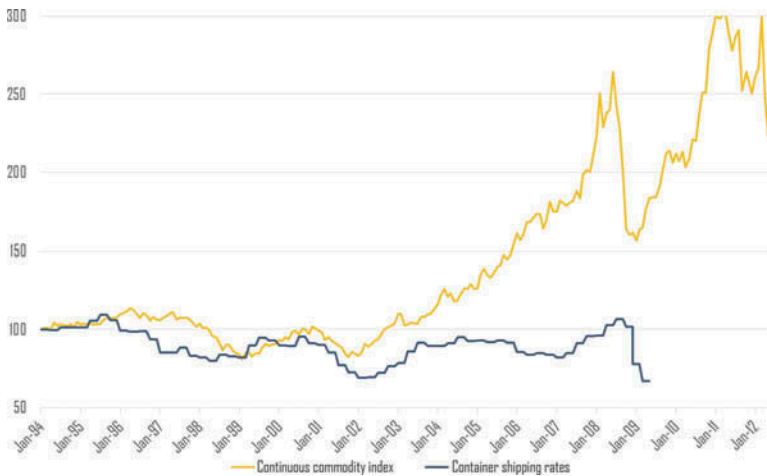


Figure 6. Continuous Commodity Index and average container shipping rates, 1994–2012 (1994 = 100).

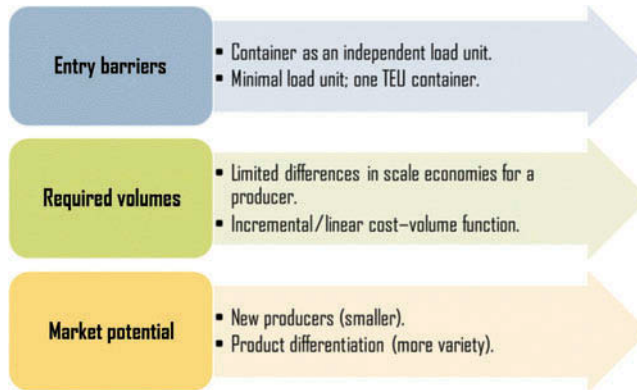


Figure 7. From bulk to containers: breaking economies of scale.

container is a unique transport unit and since containerized shipping networks are fairly ubiquitous (Figure 7). Barriers to entry are thus quite small as each container is an independent load unit that can accommodate lower volumes without much drawbacks as long as other containerized volumes are present (economies of scale are very important for terminal operators and maritime shipping). For instance, farmers (or cooperatives) may develop their own markets by sending small agricultural commodity loads through regular containerized supply chains. Thus, containerization can provide the double benefit of permitting the development of global niche markets where numerous small exporters may compete as well as offering new economic development venues in commodity sectors, which could not previously access foreign markets.

The growth of China as an export-oriented economy has been accompanied by an impressive growth in the consumption of key commodities (Figure 8). The consumption of 53% of the world's cement production is reflective of massive capital investment and the related construction activity. It must be considered that a share of the national commodity consumption is used in the manufacturing of goods that will be exported to foreign markets. Thus, a share of China's commodity consumption is attributed to consumption taking place elsewhere, such as in the United States and Western Europe.

Yet, more attention should be placed on analyzing the potential, particularly the time and flexibility benefits, for the containerization of commodity markets. For instance, the opportunity created by transpacific trade imbalances has yet to be better captured by the North American commodity sector, particularly in light of expected Chinese demand. The same applies for the European commodity sector in terms of the imbalanced Pacific–Indian–Mediterranean routes.

Temperature control in the shipment of foodstuffs is a component of containerization that has continued to rise in necessity with international trade. As a growing number of countries focus their export economy around food and produce production, the need to keep these products fresh for extended periods of time has gained in importance. Increasing income levels create a change in diet with among others a growing appetite for fresh fruit and higher value foodstuffs such as meat and fish. Persons with higher socioeconomic status and of more economic means are more likely to consume vegetables and fruit, particularly fresh, not only in higher quantities but also in greater variety (Darmon and Drewnowski 2008). Consumers with increasing purchase power have

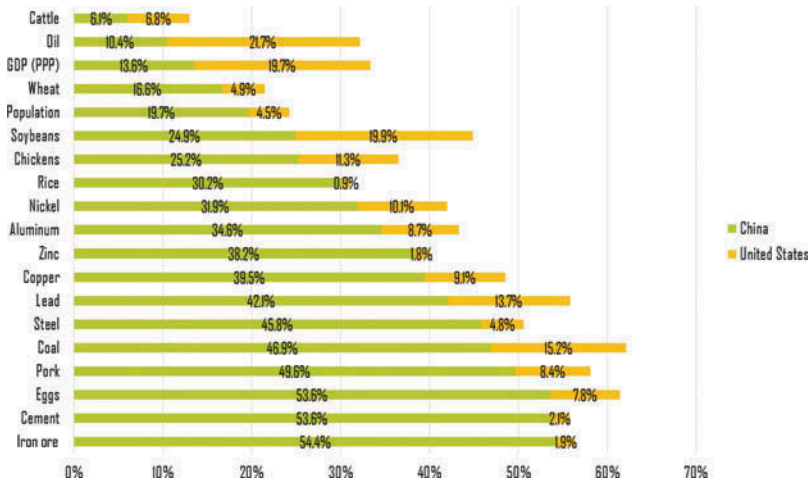


Figure 8. The share of China and the United States in the world commodity consumption, c2009/2010.

Source: United States Geological Survey (2009), BP Statistical Review of World Energy (2009), Food and Agriculture Organization of the United Nations (2008), International Monetary Fund (2010), United States Department of Agriculture (2010).

become preoccupied with healthy eating; therefore, producers and retailers have responded with an array of exotic fresh fruits originating from around the world. Any major grocery store around the world is likely to carry tangerines from South Africa, apples from New Zealand, bananas from Costa Rica, and asparagus from Mexico.

A cold chain industry has emerged to service these commodity chains. In 2002, an estimated 1200 billion dollars' worth of food was transported by a fleet of 400 000 refrigerated containers (reefers). Alone, the United States imports about 30% of its fruits and vegetables and 20% of its food exports can be considered perishables. Figure 9 shows the percentage of seaborne trade in relation to the total worldwide trade for eight different reefer commodity groups. These eight clusters are further divided into: (a) during transport living cargo and (b) during transport non-living cargo. Bananas, exotics (pineapples, kiwifruit, avocados), deciduous (apples, grapes, pears), and citrus (oranges, lemons/limes, grapefruit, others) are a part of the living group. The non-living commodities exist out of fish/seafood and meat (poultry, pork, beef/veal, offal, sheep meat). The dairy (cheese/curd, butter) and other groups (tomatoes, frozen potatoes, stone fruit, berries, melons, frozen vegetables, fresh vegetables) contain living and non-living commodities. Making the distinction between the living and the non-living is of vital importance for the transport mode because of the distinction in temperature setup and atmosphere control. Living commodities will be transported under refrigerated conditions with a limited life span, and non-living commodities can be frozen, resulting in a longer life span. Out of the 156.9 million tons of worldwide reefer trade in 2009, it is estimated that 54% was seaborne, although the percentage varies significantly by commodity, as shown in Figure 9.

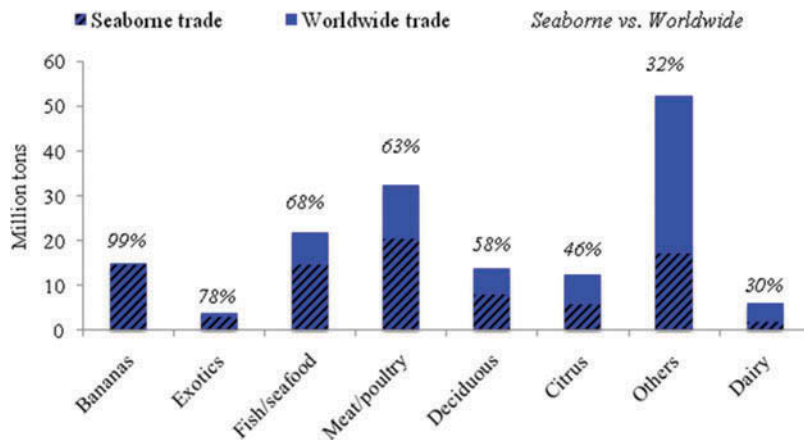


Figure 9. Total worldwide and seaborne trade of perishable reefer cargo by commodity, 2009.

Note: The difference between seaborne and worldwide trade is the result of two major reasons: (a) transportation via air and (b) international trade via truck and/or rail.

Source: Own compilation based on data of Drewry Shipping Consultants (2010).

4. Commodities in containers

Because of the nature of the freight it handles, the containerization of commodities and the cold chain create a unique set of challenges. There are several problems related to placing commodities in and removing those from containers.

4.1. Location and load unit

The location and load unit availability of containers imply that containers must be available in proximity, in sufficient quantities, and be of a suitable load unit. While for light commodities the load unit is secondary, for ponderous commodities the twenty-foot container is the most suitable. For hinterland transportation, this is an issue as maritime shipping companies own the majority of the global container assets and prefer these containers to be within the maritime system where they generate income for the carriers as opposed to the inland system where they generate income for truck, rail, and barge companies. Table 4 reveals that the share of standard dry containers in the total world container box fleet is very high and still rising (from 88% in 2003 to 90% in 2009). Forty foot containers represent just over half of all units.

Perishable or temperature-sensitive items are carried in refrigerated containers or reefers that account for a growing share of the refrigerated cargo being transported around the world. While in 1980 33% of the refrigerated transport capacity in maritime shipping was containerized, this share rapidly climbed to 47% in 1990, 68% in 2000, and 90% in 2010. About 1.7 million TEU of reefers were being used by 2009. The dominant size is 40 high-cube footers (45R1 being the size and type code) as confirmed in Table 4 by the high share of 40 footers in the total reefer container fleet. All reefers are painted white to increase the albedo (share of the incident light being reflected; high albedo implies less solar energy absorbed by the surface). For instance, a low albedo container can have its internal temperature increase to 50°C when the external temperature reaches 25°C on a

Table 4. Change in the world container box fleet for the period 2003–2009.

	Mid-2003	Mid-2004	Mid-2005	Mid-2006	Mid-2007	Mid-2008	Mid-2009	Average annual growth (in %) 2003–2009	Share 2003	Share 2009
Dry freight standard										
TEU (thousands)	14 588	15 946	17 826	18 936	21 302	23 999	23 523	8.3%	87.7%	89.7%
Units (thousands)	9682	10 522	11 721	12 447	14 010	15 769	15 468	8.1%		
<i>FEU share</i>	50.7%	51.6%	52.1%	52.1%	52.0%	52.2%	52.1%			
Dry freight special										
TEU (thousands)	801	787	796	817	868	922	949	2.9%	5.3%	3.8%
Units (thousands)	587	575	580	593	623	653	662	2.0%		
<i>FEU share</i>	36.5%	36.9%	37.2%	37.8%	39.4%	41.3%	43.3%			
Integral reefer and insulated										
TEU (thousands)	1057	1153	1252	1326	1445	1631	1689	8.1%	5.6%	5.3%
Units (thousands)	616	662	710	742	799	893	918	6.9%		
<i>FEU share</i>	71.6%	74.0%	76.5%	78.6%	80.8%	82.5%	83.9%			
Tank										
TEU (thousands)	156	163	172	179	192	199	204	4.6%	1.4%	1.2%
Units (thousands)	153	160	169	176	188	196	201	4.7%		
<i>FEU share</i>	1.8%	1.8%	1.8%	1.8%	1.7%	1.7%	1.7%			
Total										
TEU (thousands)	16 601	18 049	20 045	21 258	23 806	26 751	26 365	8.0%	100%	100%
Units (thousands)	11 038	11 920	13 179	13 958	15 621	17 511	17 250	7.7%		
<i>FEU share</i>	50.4%	51.4%	52.1%	52.3%	52.4%	52.8%	52.8%			

Source: Own compilation based on data from Containerisation International, Market Analysis: World Container Census 2010.

sunny day, while a high albedo container can have its internal temperature increase to only 38°C under the same conditions.

4.2. *Container handling*

Another issue involves container preparation. Containers are well adapted to handle packaged freight either directly ('floor loaded') or on pallets. This is another matter for commodities, particularly bulks. Some, like grains, would require a container to be thoroughly cleaned before being loaded to avoid any form of shipment contamination. In many cases, container liners will be used to protect the products being carried. The most common liners are made of polyethylene to protect common dry bulk products such as chemicals and minerals. For commodities that require a level of air circulation, such as coffee or cacao, polypropylene liners are used. Another form of lining concerns thermal protection so that goods can be shielded against temperature spikes that could degrade or damage them. It is often required that containers to be cleaned once unloaded, so they can be used for other purposes without contaminating other shipments. The usage of dedicated containers is also a possibility as it would reduce preparation costs, but would likely imply empty movements and high repositioning costs, which tends to defeat the purpose of containerization (a ubiquitous load and transport unit). Still, specialized containers exist for liquids (i.e., a tank container fleet of over 200 000 units in 2009, [Table 4](#)) and for refrigerated cargo.

The next issue is related to container loading, unloading, and transloading. Containers carrying manufactured goods are dominantly loaded horizontally either manually or with forklifts. Loading a container horizontally with bulk cargo is a complex task often requiring a panel to block the back door and hold the loose cargo. Alternatively, containers can be flipped vertically to be loaded or unloaded, but this requires specialized handling equipment. Still, this is an attractive option in situations of constant volume. The usage of different modes to reach the load center (such as rail hopper cars) or the switch from domestic (53 footer) to maritime (40 footer) containers requires a transloading operation, which represents additional costs. Some commodity chains, such as grains, also benefit if the integrity is maintained from the origin to the destination as it guarantees the quality of the shipment and product differentiation. This requires the source loading of containers.

The refrigeration unit of a reefer requires an electric power source during transportation and at a container yard. It is important to underline that the refrigeration units are designed to maintain the temperature within a prefixed range, not to cool it down. This implies that the shipment must be brought to the required temperature before being loaded into a reefer, which requires specialized warehousing and loading/unloading facilities. A new generation of reefers is coming online, which are equipped with an array of sensors monitoring effectively the temperature and shutting the cooling plant when unnecessary. This enables to improve the reliability of temperature control as well as extend the autonomy of the reefer.

4.3. *Weight*

Weight is also a major issue as container loads are much lighter for conventional (mainly retail) freight than for commodities. The shipping industry has adapted to this characteristic and prefers using larger containers (40 footers, high cube when possible) as they offer more volume for the same handling costs. Retail goods tend to have a higher volume to mass ratio than commodities. Shipping commodities such as grain tend to rely on 20

footers (one TEU) for the simple reason that they can each load around 26–28 tons, while a 40 footer, because of structural integrity issues, has a loading capacity of about 30 tons, but this load is occupying twice the shipping volume. Consequently, the commodity sector mostly relies on a load unit (20 footer), which is different than many containerized supply chains, such as retail, that are relying on the 40 footer, particularly the high cube. This results in a problem of load unit mismatch between inbound and outbound logistics. The need to reposition empty 40 footers, which carried import cargo, can seriously hamper the commodities sector to benefit from traffic imbalances and associated lower backhaul rates.

Weight distribution is also a related problem as containerships are designed to accommodate a specific weight load and distribution. Figures of 10–14 tons per loaded TEU are common in operational considerations when allocating containers on a containership. It has been noted that in North America, export containers tend to be twice as heavy as import containers. If a ship is presented with a significant container volume of more than 20 tons per TEU, adjustments in the distribution of this load must be made and shipping lines might start imposing heavy load surcharges. Under normal circumstances where there is an equilibrium between inbound and outbound traffic, a containership presented with a full load of heavy containers could only be filled to 75% of its capacity. This can be mitigated by considering the current structure of trade imbalances in North America with much of the containers leaving West Coast ports being empty. A scenario implying a full distribution of containers loaded with commodities and empties is thus applicable.

5. Current issues on containerized commodities and cold chains

5.1. *Competition or an emerging complementarity?*

There is limited evidence underlining that the containerization of commodities is competing with existing bulk commodity chains. The process is more one of an emerging complementary between bulk and containerized commodity chains within global freight distribution, each having its own characteristics:

- *Bulk commodity chains.* These chains are commonly based on the specialization of terminals; often by specific commodity since each requires specialized handling and storage facilities. There is also the issue of empty return movements as modes carrying commodities do so in only one direction with backhaul cargo opportunities almost nonexistent. For instance, a crude oil tanker comes back empty after unloading its cargo. Thus, from a transportation perspective, this distribution system is prone to inefficiencies and has a level of usage which is in theory 50%, but lower in reality because of the seasonality of some commodity markets, notably agricultural production.
- *Containerized commodity chains.* They are increasingly being used and it is becoming a matter of embedding commodity flows within the containerized freight distribution system. This would mainly concern niche markets where product separation (e.g., different grades of grain), smaller batches, delivery time, and accessibility are more important. The containerized commodity chain, like its bulk counterpart, also faces the empty movement challenge. However, considering the current structure of international trade, a higher integration of commodities in containerized freight distribution would actually play a positive role in mitigating imbalances.

The transport of commodities is already characterized by substantial investment in bulk handling equipment, for both modes and terminals. There is thus a lot of accumulated inertia in existing distribution channels making stakeholders such as freight forwarders reluctant to change practices. In light of these powerful stakeholders, it remains to be seen how containerized commodity chains can take shape. The most likely processes involve the capture of niche markets, accommodating seasonal and regional demand surges, servicing new or expanding markets where bulk infrastructures are not adequate, or accommodating low volume situations where economies of scale are difficult to achieve.

The situation is very different in the reefer business as the increasing containerization of reefer cargo is undermining the future development of the niche reefer ship markets, particularly for the shipments of fruits such as bananas. Between 1999 and 2010, the number of reefer vessels declined from about 900 to 727. The ‘Big Six’ specialized reefer operators (i.e., Seatrade, Hamburg Reefer Charter, Star Reefer, NYKCool, Green Reefers, and Fresh Carriers Company) controlled 51.8% of the total cubic capacity of the specialized reefer fleet in June 2010 (Drewry Shipping Consultants 2010). Reefer containers are competing with reefer ships, and the former are rapidly gaining market share. The world’s refrigerated ship fleet is fast shrinking as a new generation of container ships with a large reefer capacity³ transforms how fruit, meat, and other perishable foods move around the globe. Traditional systems built around reefer ships, where food sits on pallets in a refrigerated hold and is delivered to a cold store on arrival, are shifting to systems to handle goods in containers with refrigeration units, sometimes bypassing cold stores on arrival. This process is accelerated by a lack in investments in new reefer vessels: 33% of the fleet is aged above 26 years and only 3% is aged below 5 years. Moreover, the use of containers speeds up the terminal operating process as illustrated in the cargo handling productivity figures in Table 5.

The shift to reefer containers is further supported by the commercial efforts of major container lines to further strengthen their relations with large supermarkets. The dominance of supermarkets in the North American and European fresh products market is high. These largely vertical integrated supermarkets are creating their own in-house sourcing teams, so as to cut out the international distributors. By buying directly at the producers, the cold chain can be shortened, resulting in cost savings. Within the larger AP Moller–Maersk entity, there is ‘Dansk Supermarked’, which operates a chain of supermarkets throughout Denmark, resulting in a direct working knowledge of the perishable

Table 5. Comparative table for the typical handling speed for the discharging of bananas (in number of banana boxes handled per minute per crane).

	Reefer vessel	Reefer container
Spiral conveyer system*	50	
Pallet cage spreader**	385	
Container crane***		480

Notes: *Loose boxes are stacked in the ship. In the port of discharge dock workers place the boxes one by one on a conveyer system directly connected to a warehouse where after a quality check the boxes are palletized.

**Pallet cages that can hold 4 up to 8 pallets are attached to a mobile crane. Figures are based on a cage for 8 pallets.

***Based on an average of 30 moves per hour per crane. The banana boxes in the container are palletized.

Source: Own compilation based on expert information from a specialized terminal operator

goods supply chain. International distributors such as Chiquita and Del Monte invented the reefer market and thus have a long history of working with the reefer specialists. The supermarkets favor the services of container carriers due to the manageable shipped quantities and the existing business relationships.

5.2. *Mismatches and seasonality*

In spite of the presence of substantial imbalances, the empty container backhauls cannot be fully exploited because of demand mismatches. It is common for commodity trade that import regions are not the same as exports regions. While imports regions tend to be consumption related and correspond to large metropolitan areas, exports regions are mainly rural areas or resource extraction areas with low population densities. One thus attracts a large quantity of full containers but may not necessarily provide a similar volume of exports, while the other could generate a substantial export volume, but does not have a significant import volume. The setting of a cargo rotation would permit repositioning opportunities and help mitigate the availability of containers for exports. Sometimes, due to time and cost issues, a repositioning is not performed and the empty container goes straight back to the port instead of being loaded for the backhaul.

Many commodities such as agricultural products have a seasonality. This implies that for a region there will be a surge in demand at specific times of the year, while at other times demand would be considerably less. Additionally, seasonality has a geography since harvesting time varies between different regions of the world, which implies temporal and geographical fluctuations in the repositioning of empty containers. Seasonality is also linked with commodity price fluctuations, implying that as one gets closer to the delivery time of a futures contract, the market price tends to reflect better the real physical relationship between supply and demand. It is common in the agricultural sector that commodity prices will drop during the harvest season as real output is finally known and that uncertainties are removed. If the output is higher than the expected, then prices drop, making containerization a less appealing alternative.

The further developments of containerized niche markets lean on supply chain integration since containerized commodity movements are particularly suitable where there is a significant backhaul movement of empty containers. Since the inbound flows relate to a very different supply chain (mostly retail), an effective use of backhaul containerized assets requires concerted efforts between major commodity producers, rail operators, container owners (shipping and container leasing companies), and terminal operators.

5.3. *Cold chain integrity*

A chain is as strong as its weakest link. This is of particular relevance for a cold chain that preserves the integrity of a product by maintaining its temperature within a specific temperature range (2–8°C is common ranging to 13°C for bananas; [Figure 10](#)). Many products, such as food, pharmaceuticals, and some chemicals, can be damaged when not kept within a specific temperature range. Thus, supply chain integrity for temperature-sensitive products includes the additional requirements of proper packaging, temperature protection, and monitoring, which is fueling the growth of in-transit temperature monitoring. Attaching monitoring devices to the freight ensures the recipient that the product integrity was maintained during transportation, and whenever a breach occurs, it helps identify the location along the supply chain where the breach of integrity took place (identification of the liability).

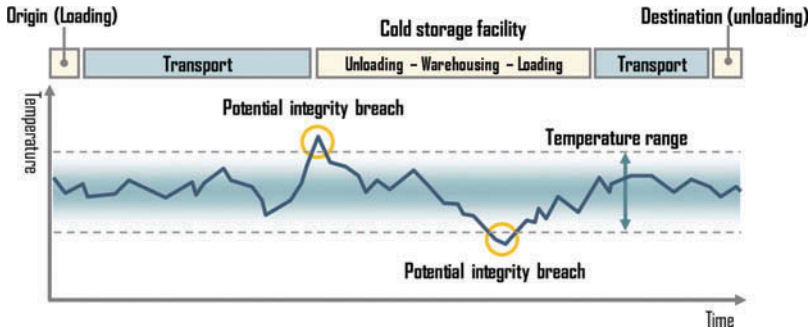


Figure 10. Temperature integrity along a cold chain.

Reefer containers have become a crucial element of the cold chain as they offer a temperature-controlled transport and storage unit, but are often too large for many types of cold chain shipments such as pharmaceuticals. A cold chain can be maintained over several transport activities, but with two potential breaches in its integrity. In the first case, it could involve the cargo being left exposed during the unloading process (or a reefer not connected to a power source during transshipment or the door left open for a too long time). In the second case, the product could have been stored in a refrigerated warehouse at a temperature below the product's storage specifications.

Due to the growth of temperature-controlled shipments, a particular attention must be placed at identifying the locations, the equipment, and the circumstances in which a breach in integrity can take place:

- *Transportation issues.* During transport, a malfunction (or an involuntary interruption of power) of the refrigeration equipment can in a couple of hours compromise the cold chain. Since the refrigeration equipment is designed to maintain a specific temperature level, a batch that was not previously cooled may place an undue stress on the equipment to the point that the temperature cannot be brought to the specified range. The reefer, due to wear and tear or defective equipment, may offer an improper cold storage environment, namely poor air circulation and defective insulation at seals (such as doors). Drivers may also voluntarily shut down the refrigeration unit to save on fuel costs, leave doors open for too long time during deliveries, or may be forced by local legislations to cut idling time.
- *Transshipment and warehousing issues.* During the loading, unloading, or warehousing of a product, there are many potential situations where a cold chain can be compromised. For instance, a product can be left on the loading dock for an extended period or the refrigeration unit can be turned off during transshipment. Some warehouses can have poor temperature maintenance and control, while others do not have different temperature storage facilities so all freight is stored at the same temperature. Due to the limited economies of scale of the cooling unit inside a reefer container, if compared to the central cooling unit of specialized reefer vessel, the quality of cooling is lower and the costs are higher. If looking at the banana trade, a specialized reefer vessel's bulk holds can cool down the banana boxes to a level of 13.3°C in 24 hours, a reefer container needs four days to reduce the temperature to

15.6°C. Due to the restricted cooling capacity of reefer containers, a pre-cooling warehouse is needed to cool down the bananas before transport, introducing an extra segment in the banana supply chain.

5.4. Terminal and transloading issues

Considering that most commodities extracting regions tend to be located inland, while manufacturing and consumption tend to take place more in coastal regions, the containerization of commodities relies on a closer dynamics between gateway ports and inland terminals. A fair amount of containerized freight is transloaded once they reach a gateway. For the North American West Coast, this amounts to about 20–25% of all containers. Maritime shipping companies are reluctant to have their containers moving inland as they prefer to keep them within their networks. There is thus a preference at major gateways to transload maritime containers (mainly 40 footers) into domestic containers (mainly 53 footers) in addition to the significant unit advantage it confers as the contents of three maritime containers are transshipped into two domestic containers. However, domestic containers are not well adapted for shipping commodities (less structural integrity and weight limitations) and cannot be forwarded on export markets. Transloading also results in less maritime containers available inland to be used for exports.

Bulk and containers rely on very different terminal characteristics and dynamics. Many bulk terminals were built to handle specific commodities and cannot readily be converted to other uses. Bulk commodities can be stored at port terminals in a relatively compact manner, such as grain into grain elevators or coal and iron ore in simple large piles. The same volume of containerized commodities can consume as much as four times the terminal space. Still, this could be mitigated if the loading process takes place inland, either at a load center, at a satellite terminal, or even at the exporter's premises. Additionally, the intermodal velocity of containerized freight tends to reduce its spatial imprint since a container spends much less time at a terminal. A container port that is experiencing a growing role as a platform to export containerized commodities is expected to see a notable increase in the demand for storage space and pressures on dwell time. Since containerized commodities tend to be heavier than regular container loads, it may require adaptations in terminal management and operations (stacking and equipment usage). With volumes large enough, terminals could start to have dedicated sections for containerized commodities, as they already have to accommodate reefers.

The growth of the intermodal transportation of reefers has increasingly required transport terminals, namely ports, to dedicate a part of their storage yards to reefers. This accounts between 1% and 5% of the total terminal capacity, but can be higher for transshipment hubs. The stacking requirements simply involve having an adjacent power outlet, but the task is more labor intensive as each container must be plugged and unplugged manually and the temperature to be monitored regularly as it is the responsibility of the terminal operator to ensure that the reefers keep their temperature within preset ranges. This may also forbid the usage of an overhead gantry crane implying that the reefer stacking area can be serviced by different equipment. Even if reefers involve higher terminal costs, they are very profitable due to the high-value commodities they transport.

6. Conclusions

The first phase of containerization was mainly fuelled by a process of substitution, mostly in the form of the containerization of conventional general cargo. This also led to the development of a global containerized freight distribution system supporting a wide array of supply chains, particularly for manufacturing and retailing. As derived growth of containerization becomes less dynamic, the substitution effect is becoming weak in developed economies, and as empty incidence has remained rather stable, an increasing share of the growth will (have to) come from the development of niche markets and opportunities that were initially bypassed. In this context, we argued it is important to consider commodity and cold chains as a key component in a new phase in the global diffusion of containerization and its adoption by freight distribution systems.

The emerging phase of containerization encompasses a complementarity with the commodity sector and the extraction of niche market opportunities to satisfy new demands. This phase is driven by a commodity-wise approach which inherently creates an array of challenges. For instance, niche markets develop or disappear based on temporary market conditions, the balance of flows on trade routes, and the need for market size. Other challenges emerge from more operational considerations linked to the availability, specialization, and use of boxes.

Integrating the movements of commodities and the cold chain within containerized distribution systems thus involves a new set of challenges as their dynamics differ. Still, there is substantial potential for growth in the usage of containers to carry various commodities on global markets. With the continuing growth of the global population, the agricultural sector and its commodity chains have much to gain from the velocity, ubiquity, and flexibility of containerized freight distribution.

This article sets the scene for more detailed research that links supply chain challenges in specific commodity chains to containerization, a link that has been largely ignored in the existing literature.

Notes

1. During the TOC Europe (Terminal Operators Conference) in Antwerp in early June 2011, Eivind Kolding—CEO of Maersk Line—unveiled the new mission for container shipping. Based on an investigation of customer's requirements, the liner shipping industry should, according to Maersk, focus on three key factors: (a) on time performance/reliability; (b) ease of business (i.e., avoid complexity, increase transparency); and (c) environmental performance. These three aspects should be considered in a supply chain perspective.
2. Container shipping demand in 2010 was rebounding so fast after the crisis year 2009 that there were not enough containers available for Asia's exporters during the peak season that runs from June to October (Wright 2010). During 2009, shipping lines and container leasing companies hardly ordered any new containers as market expectations were weak. Neither the shipping lines nor their customers had anticipated the unprecedented surge in demand in most trades. The container shortage was further exacerbated by labor shortages in Chinese container factories and slow steaming practices, which lower container round-trip time. Also in 2011, the problem of container shortages reemerged as the production of boxes lagged growing cargo capacity.
3. Many container lines have introduced new services on the routes between the southern and northern hemispheres that have traditionally been reefer vessel markets. In June 2009, the reefer TEU capacity on full container vessels was 16.7% of the total containership TEU capacity or equal to 2.19 million TEU. Maersk Line is operating ships on north–south services with up to 1700 plugs for refrigerated containers per vessel.

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