Sustainable Logistics

MIT SCALE
Latin America

June 9, 2016
MIT Center for Transportation & Logistics
Cambridge, Massachusetts

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The SCALE LatAm - Mission

To lead impactful & applied research in logistics and supply chain management relevant to Latin America

- Lead & support academic partners
- “Push” an innovative research agenda
- “Push” an innovative education agenda

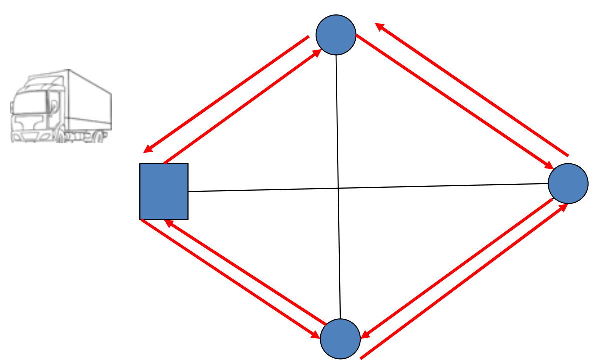
MIT SCALE
Latin America

Research Agenda

- Sustainability
- International Trade & Logistics
- Urban Logistics
- Applied Operations Research
- Innovative Case Studies in Logistics & SCM
- Logistics Efficiency in SMEs *

~80 Researchers from all over Latin America
~20 Practitioners
~20 Students

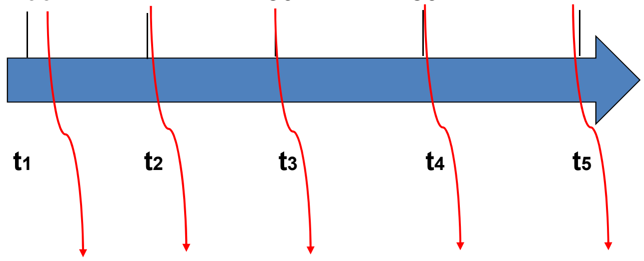
Decide the best route for this vehicle



Decide how much and when to order?

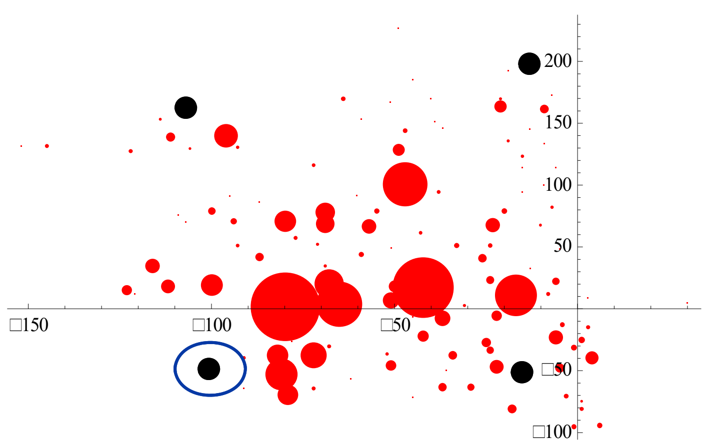
Setup cost = $5   **Inventory cost = $0.50**

Demand (Kg)	**100**	**100**	**50**	**50**	**210**
Period (weeks)	**t_1**	**t_2**	**t_3**	**t_4**	**t_5**

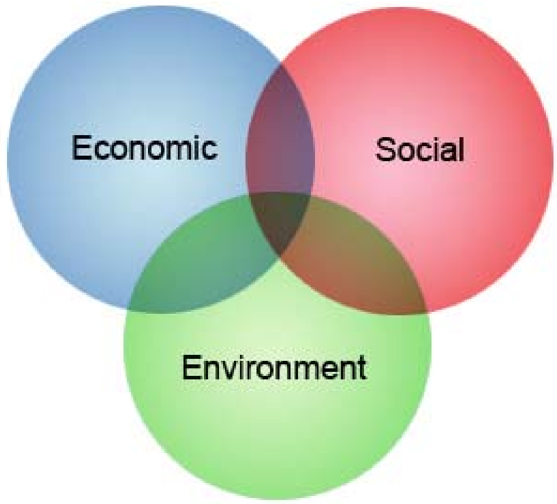


When to order? **Q_1 = 100, Q_2 = 100, Q_3 = 50, Q_4 = 50, Q_5 = 210**

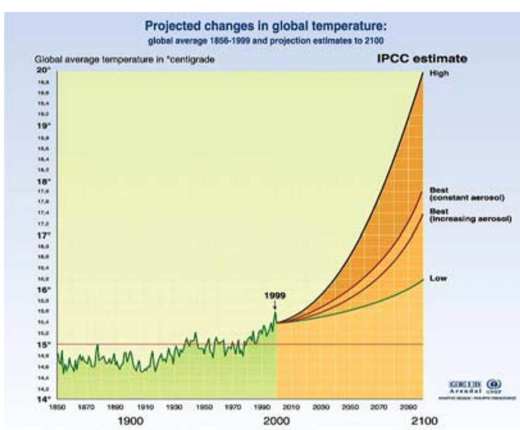
Decide the location of the DC?



"Sustainability"



Sustainability…?



The latest IPCC report is calling for a reduction of Greenhouse gases compared to 2000 by 24-40% till 2020 and 80-95% till 2050.

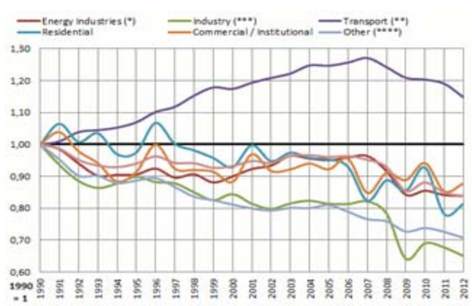
The market is changing towards green consumers and technologies.

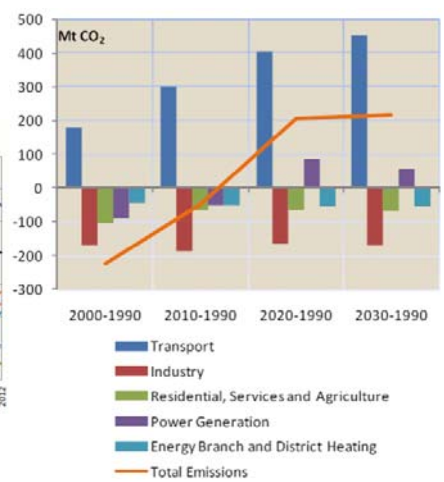
Source: Temperatures 1856 – 1999. Climatic Research Unit. Projections. IPCC report 95.

Market shift towards disclosing carbon emissions

1525 companies in 2010 & ~1000 commit to a self-imposed carbon target (CDP, 2011).

Transport emissions are by far the main contributor to emissions growth…

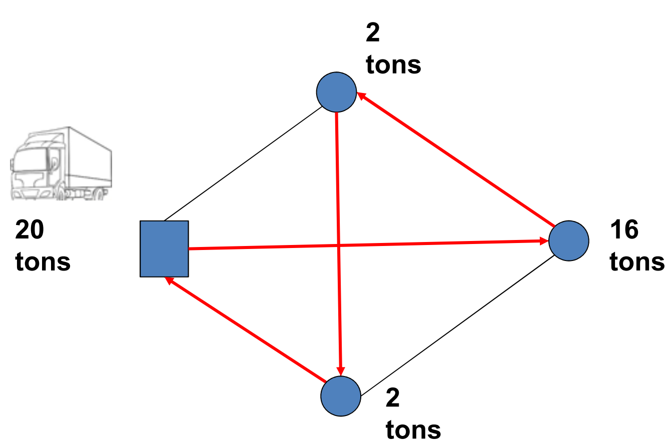




Source: European Commission (2007)

What could explain it? … Urbanization

Decide the best route for this vehicle



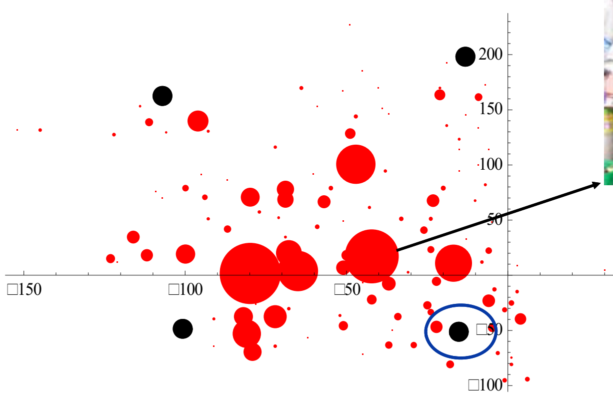
Decide how much and when to order?

Setup cost = $5 Inventory cost = $0.50

Transport EF = 1,850 Kg of CO2/kg

Demand (Kg)	**100**	**100**	**50**	**50**	**210**
Period (weeks)	t_1	t_2	t_3	t_4	t_5
When to order?	$Q_1 = 510$				

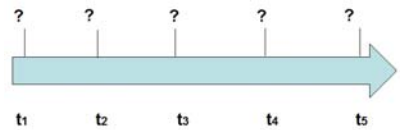
Decide the location of the DC



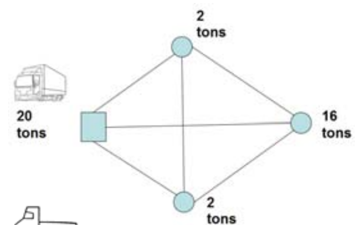
The Sustainable Logistics Initiative

How do companies can look for alternatives to reduce CO2 emissions by making smarter logistics decisions? Examples:

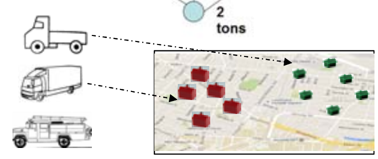
Decide how much and when to order?



Decide the best route for this vehicle



Decide the best vehicle for a region



Carbon Footprinting Aggregation?

- Support Measurement of CO2 emissions
- Identify potential savings during the logistics operations
- Impact of carbon footprinting aggregation– Published on 2014

Article
Flexible Services and Manufacturing Journal
June 2014, Volume 26, Issue 1, pp 196-220

First online: 05 January 2013

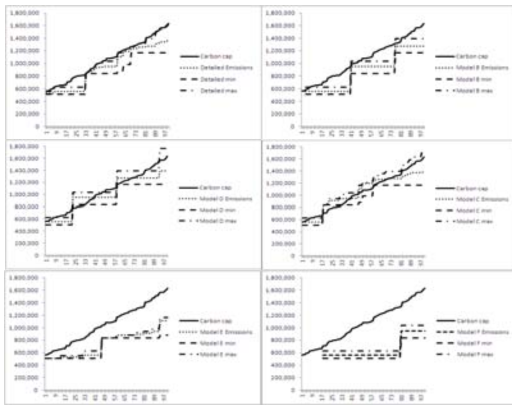
The impact of carbon footprinting aggregation on realizing emission reduction targets

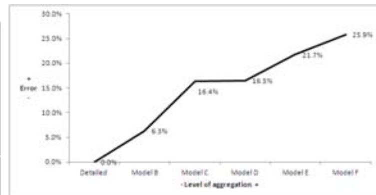
Josué C. Velázquez-Martínez, Jan C. Fransoo, Edgar E. Blanco, Jaime Mora-Vargas

Impact of aggregation

Dynamic Lot-Sizing Problem (Wagner and Whitin, 1958) with backorder assumption.

	Lot size per shipment	Average demand	FTL
EF per truck	Model A	Model C	Model E
Standard EF	Model B	Model D	Model F





The analytical results show the limitations of aggregate models on achieving emission reduction targets.
The numerical experimentation showed that the magnitude of errors can be substantial (16% & 25%).

Source: Velázquez-Martínez et al. (2014). "The impact of Carbon Footprinting Aggregation on Realizing Emission Reduction Targets". Flex Serv Manuf J

Truck assignment for fuel savings

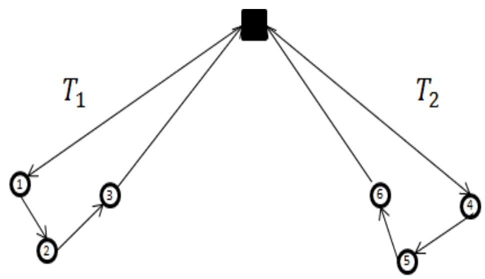
- Overall assignment of trucks for a DC in Mexico City
- Recommendations for fuel savings of ~3% & 26%
- 1st part of the Methodology –Published on 2016

Transportation Research Part D: Transport and Environment
Volume 43, March 2016, Pages 133–144

A new statistical method of assigning vehicles to delivery areas for CO_2 emissions reduction

Josué C. Velázquez-Martínez[a], Jan C. Fransoo[b, 1], Edgar E. Blanco[a, 2], Karla B. Valenzuela-Ocaña[c, 3]

Vehicle Assignment for CO2 emissions Reduction



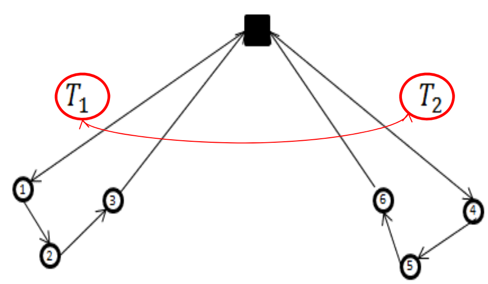
Example:

- Two trucks (T_1 & T_2) with same capacity
- Both travel same distance
- T_1 delivers in a flat area & regular (Av Speed 25 m/s)
- T_2 delivers in a pronounced area, congested, etc. (Av Speed 5.5 m/s)

Source: Velázquez-Martínez et al. (2016). "A new statistical method of assigning vehicles to delivery areas for CO2 emissions reduction". Transportation Research Part D

Vehicle Assignment for CO2 emissions Reduction

Suppose that by studying the historical performance of the trucks over time, we observe <u>*statistical evidence*</u> *that a type of truck $T1$ performs 20% better in regions with pronounced slopes and $T2$ performs 12% better in plane roads.*



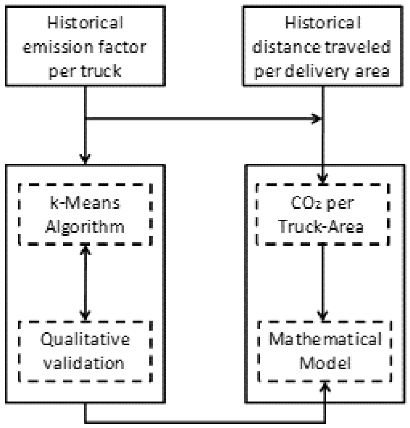
Savings of 18% in carbon emissions

Note that this result is independent on the routing

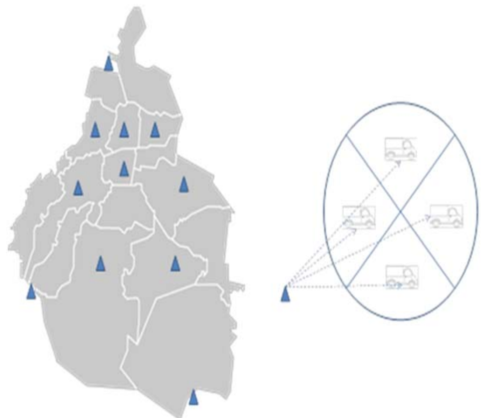
Source: Velázquez-Martínez et al. (2016). "A new statistical method of assigning vehicles to delivery areas for CO2 emissions reduction". Transportation Research Part D

Vehicle Assignment for CO2 emissions Reduction

Conceptual Model



Case Study: Parcel Company in Mexico City



Source: Velázquez-Martínez et al. (2016). "A new statistical method of assigning vehicles to delivery areas for CO2 emissions reduction". Transportation Research Part D

Av emission factor analysis

Fig. 7. Average emission factors per type of truck per cluster.

Source: Velázquez-Martínez et al. (2016). "A new statistical method of assigning vehicles to delivery areas for CO2 emissions reduction". Transportation Research Part D

CO2 vehicle assignment comparison (-3% = 40 tons of CO2 = 12 vehicles)

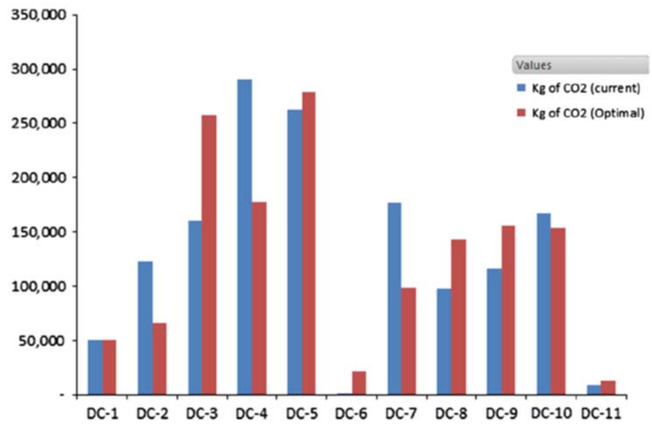


Fig. 8. Comparison between optimal and current CO_2 emissions per distribution center.

Source: Velázquez-Martínez et al. (2016). "A new statistical method of assigning vehicles to delivery areas for CO2 emissions reduction". Transportation Research Part D

Practical application

Heineken study: Two trucks exchange pilot (Feb 2014 vs Feb 2015)

Route	Demand increase	Fuel efficiency (Km/l)		CO_2 emissions (Tons)		CO_2 Savings
		Feb 2014	Feb 2015	Feb 2014	Feb 2015	
RF1404	44%	3.25	3.26	1.47	1.12	25%
RF1407	42%	3.1	3.23	1. 45	1.05	27%

With the truck exchange, Heineken distributes **more cargo** with **less fuel** consumption (about 292 liters less ~26% of savings)

Green Facility Location

- Provide alternatives for the location of DCs in Mexico City
- Recommendations for savings of ~40% of CO2 emissions
- New Methodology – To be Published on 2016

Springer Series in Supply Chain Management

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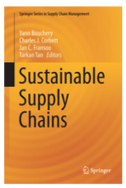
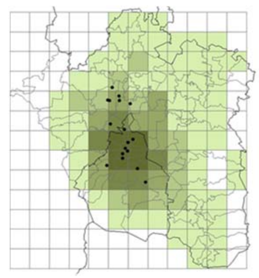


Sustainable Supply Chains

Editors: **Bouchery**, Y., **Corbett**, C.J., **Fransoo**, J.C., **Tan**, T. (Eds.)



Green Facility Location

The Multiobjective Sustainable Facility Location Model

$$Min \rightarrow OF1 = \sum_{j\in J}\sum_{i\in I}\left(A_{ij}\frac{h_i}{W_i} + v_{ij}d_{ij}\left\lceil\frac{h_i}{W_i}\right\rceil\right)Y_{ij}$$

$$Min \rightarrow OF2 = \sum_{j\in J}\sum_{i\in I} d_{ij}\left\lceil\frac{h_i}{W_i}\right\rceil\left[f_i^e + (f_i^f - f_i^e)\frac{h_i}{W_i}\right]Y_{ij}$$

Subject to

$$\sum_{j\in J} Y_{ij} = 1 \qquad \forall i \in I$$

$$\sum_{j\in J} X_j = p$$

$$Y_{ij} - X_j \leq 0 \qquad \forall i \in I\ \forall j \in J$$

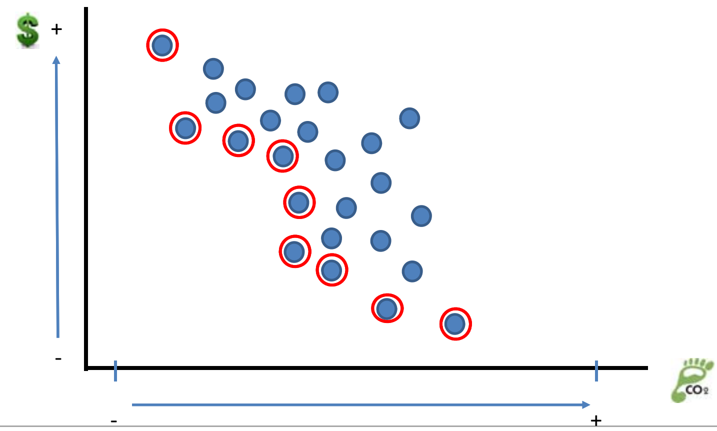
$$X_j \in \{0,1\} \qquad \forall j \in J$$

$$Y_{ij} \geq 0 \qquad \forall i \in I, \forall j \in J$$

Solution Method

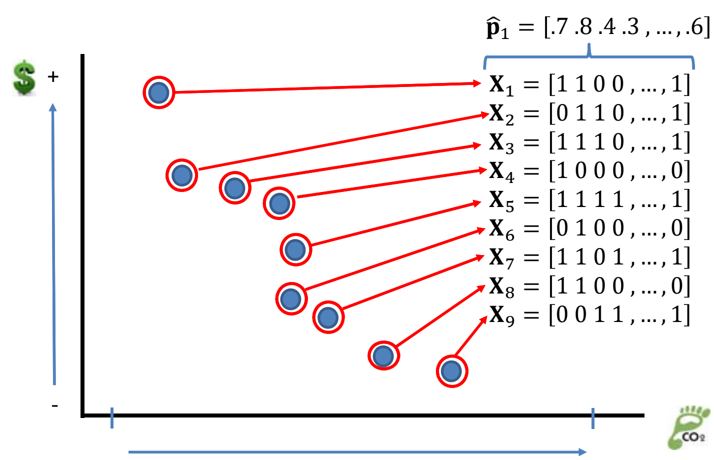
The Multiobjective Combinatorial Optimization CE Method (MOCO CEM)

$t = 0$, Draw a sample $\mathbf{X_1}, \ldots, \mathbf{X_N}$ of Bernoulli vectors with success probability vector $\widehat{\mathbf{p}}_{t-1}$.



The MOCO CEM - Algorithm

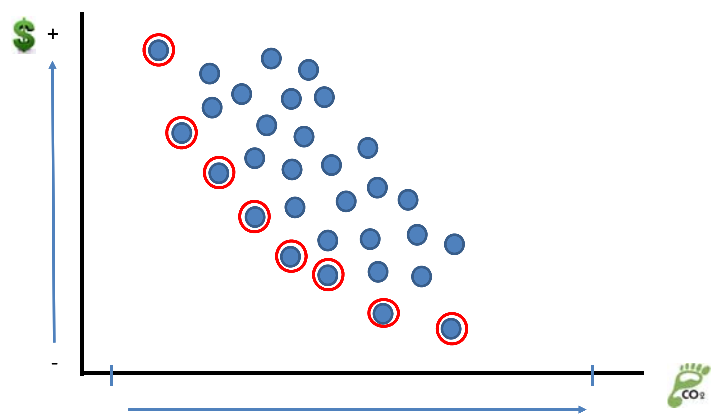
Pick the best solutions and estimate parameters



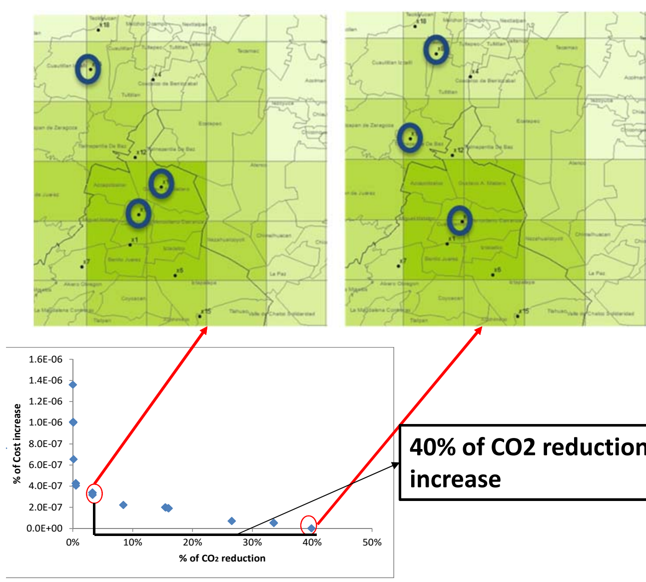
The MOCO CEM - Algorithm

$t = 1$, Draw a sample $\mathbf{X_1}, \ldots, \mathbf{X_N}$ of Bernoulli vectors with success probability vector $\widehat{\mathbf{p}}_{t-1}$

Pick the best solutions and estimate parameters…



Some Results…



40% of CO2 reduction -> No cost increase

Thanks!

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