Sustainable Logistics

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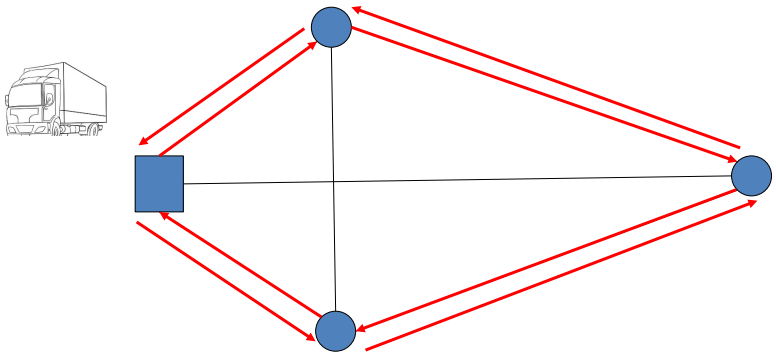
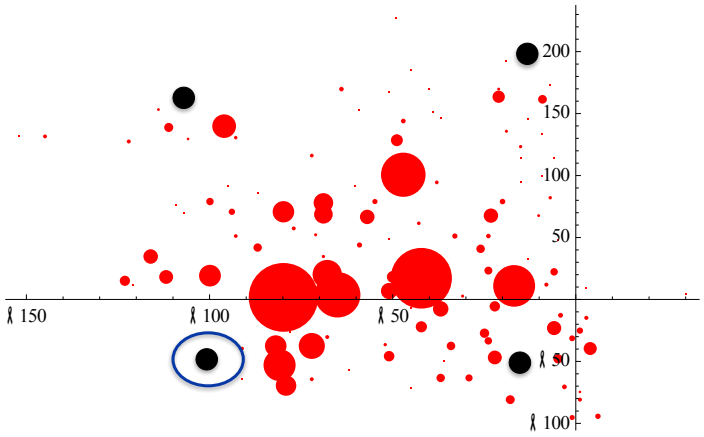
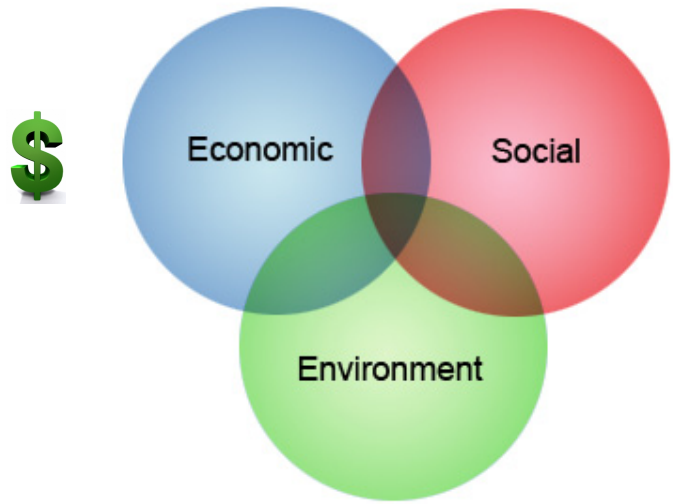
Decide the best route for this vehicle



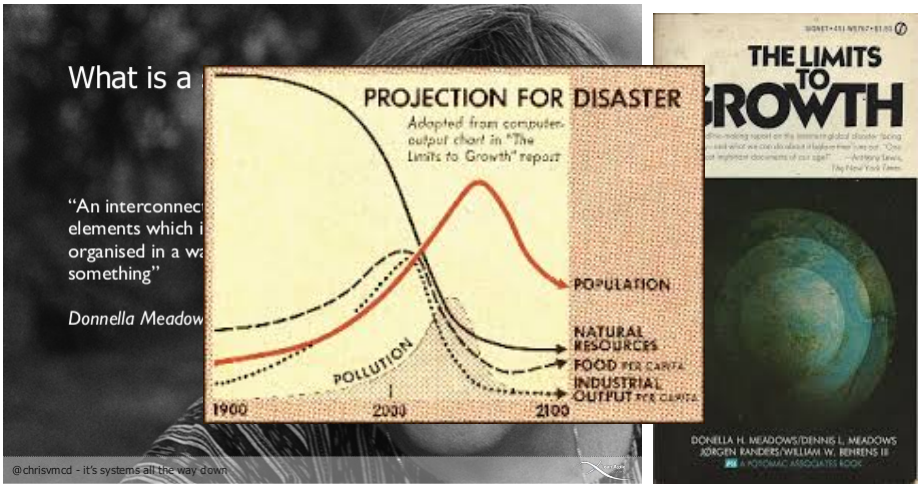
Decide the location of the DC?



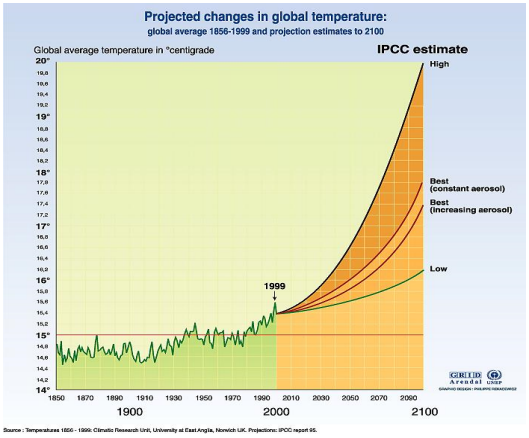
"Sustainability"



Debate regarding 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.

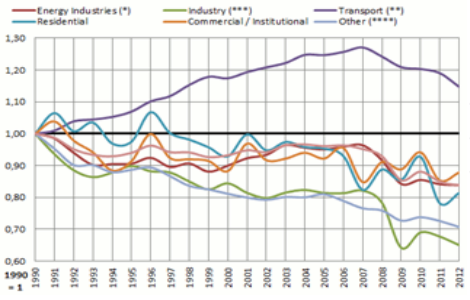
Source: Temperatures 1856 – 1999. Climatic Research Unit. Projections. IPCC report 95.

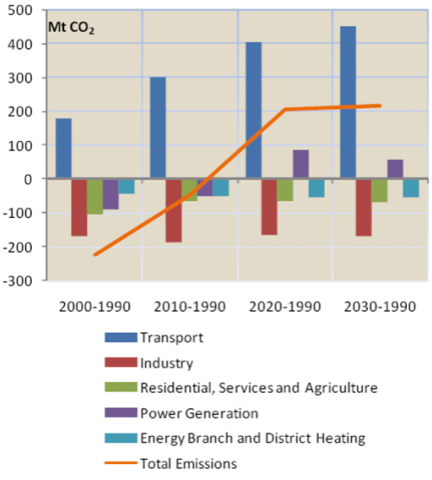
Market shift towards disclosing carbon emissions

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

Walmart DANONE Coca-Cola PEPSICO 3M FedEx DUPONT

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

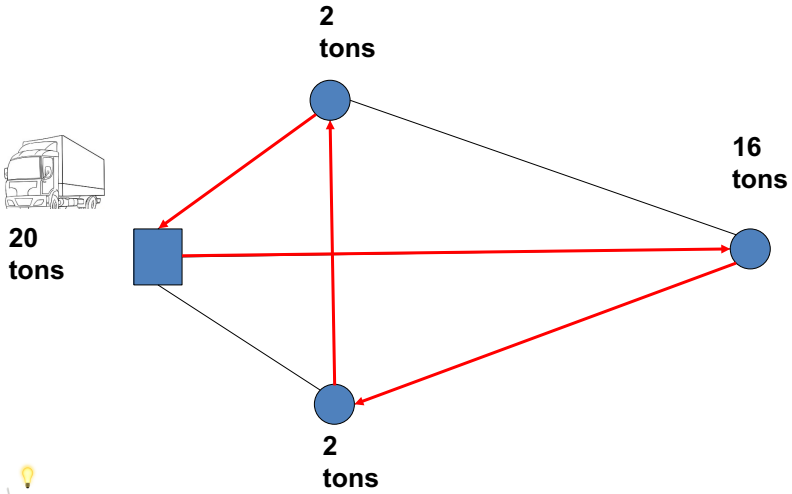




Source: European Commission (2007)

What could explain it? … Urbanization

Decide the best route for this vehicle



Insight: **It may actually happen that a reduction of fuel/cost implies an increase in mileage! ***

Example: CPG Company at Mexico City

Distance Minimization

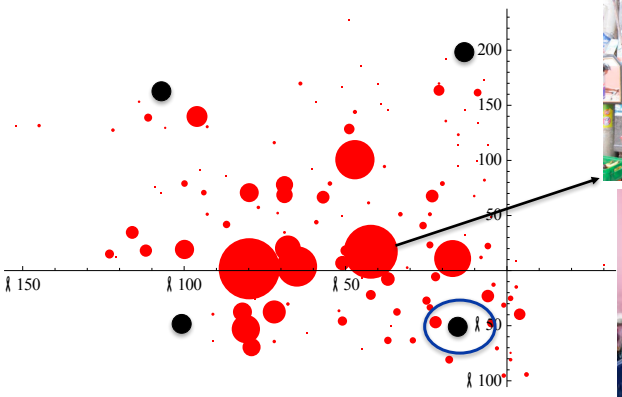
Emission Minimization

Example for a Route:

7% of CO2 emissions savings vs NO Cost

Cohen J., Velázquez-Martínez et al. (2013). "Managerial Implicatons of Considering CO2 emissions on VRPs". GCLOG Capstone Project

Decide the location of the DC



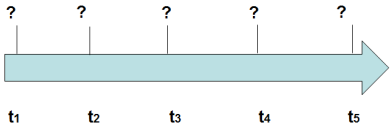
Insight: Optimal locations may be better explained by truck accessibility constraints than by demand concentration*

Velázquez-Martínez et al. (2014). "The impact of varying truck capacities in the p-Median problem in megacities". Working paper.

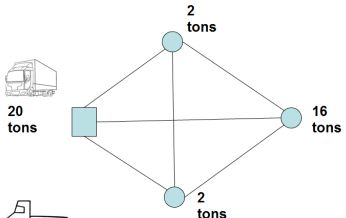
The Sustainable Logistics Initiative

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

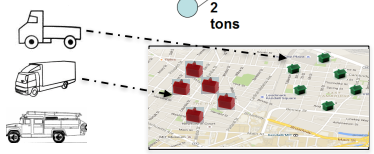
Decide how much and when to order?



Decide the best route for this vehicle



Decide the best vehicle for a region



Research Papers/Manuscripts

- Velázquez-Martínez, J.C., Fransoo (2016). **Green Facility Location**. In Sustainable Supply Chains. Edited by Y. Bouchery, T. Tan., J. Fransoo, & C. Corbett. Springer.
- Velázquez-Martínez, J.C., Fransoo, J.C., Blanco, E.E., Mora-Vargas, J. (2014). **The impact of carbon footprinting aggregation on realizing emission reduction targets**. Flexible Services and Manufacturing Journal, 1-25.
- Velázquez-Martínez, J.C., Blanco, E.E., Fransoo, J.C., Valenzuela-Ocaña, K. (2016). **A New Statistical Method of Assigning Vehicles to Delivery Areas for CO2 Emissions Reduction**. Transportation Research Part D: Transport and Environment. 43 133-144.
- Leenders, B.P.J., Velázquez-Martínez, J.C., Fransoo, J.C.(2015). **Emissions allocation in routing transportation problems**. Submitted to Transportation Research Part D: Transport and Environment.
- Velázquez-Martínez, J.C., Blanco, E.E., Fransoo, J. C., Mora-Vargas, J. (2015). **Transportation cost and CO2 emissions in location decision models**. Beta Research School for Operations Management and Logistics/ TU/e. Working Paper series 451.
- Velázquez-Martínez, J.C., Fransoo, J.C. (2016). **Managerial Implications of Considering CO2 Emissions on Vehicle Routing Problems**. Working paper.

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

ELSEVIER

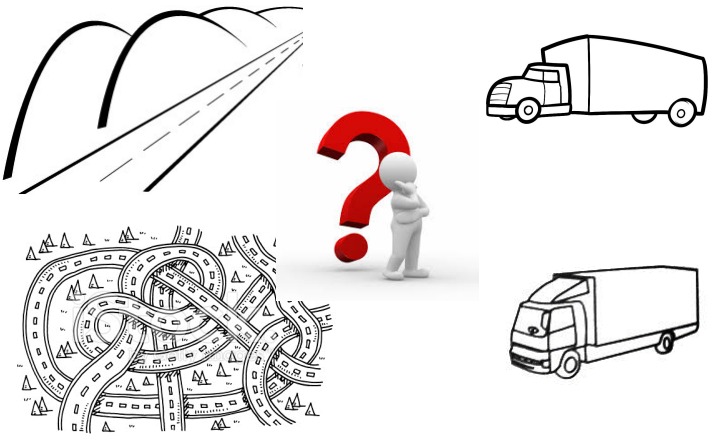
Transportation Research Part D: Transport and Environment

Volume 43, March 2016, Pages 133–144

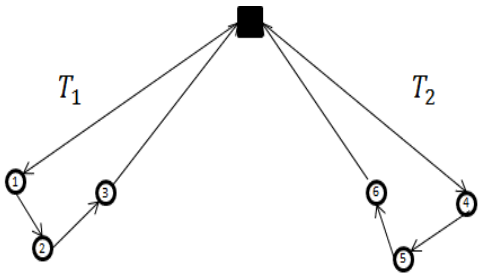
A new statistical method of assigning vehicles to delivery areas for CO_2 emissions reduction

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

Is it possible to define a single type of vehicle that outperforms the rest in terms of fuel efficiency?



Vehicle Assignment for CO2 emissions Reduction



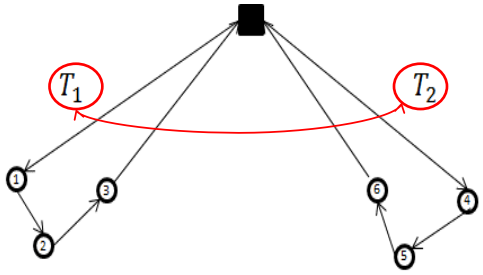
Example:

- 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)

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 statistical evidence that a type of truck T1 performs 20% better in regions with pronounced slopes and T2 performs 12% better in plane roads.



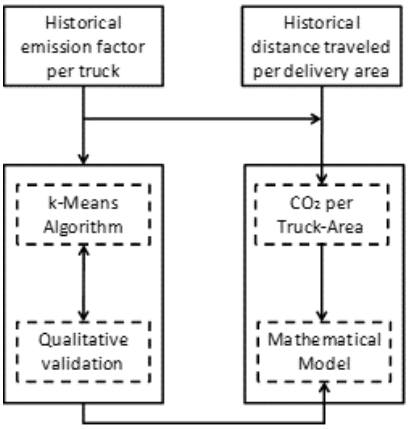
Savings of 18% in carbon emissions

Note that this result is independent on the routing

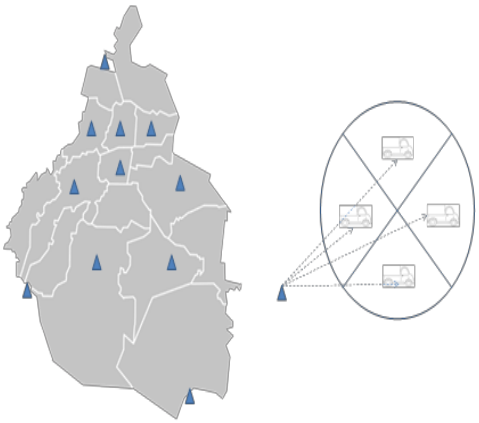
Velázquez-Martínez et al. (2016). "A new statistical method of assigning vehicles to delivery areas for CO2 emissions reduction". Transportation Research Part D

Vehicle Assignment for CO2 emissions Reduction

Conceptual Model



Case Study: Parcel Company in Mexico City



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.

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)

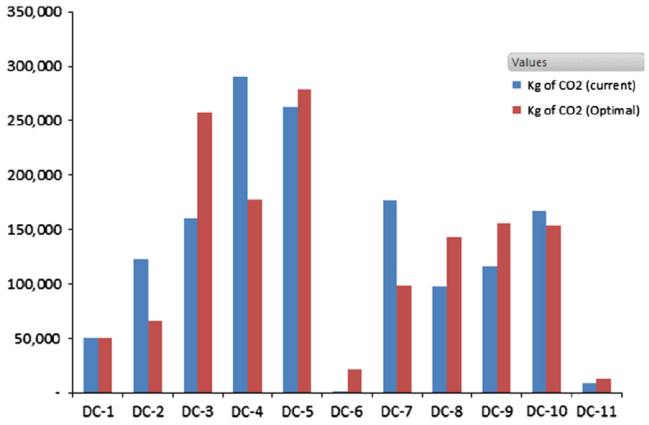


Fig. 8. Comparison between optimal and current CO_2 emissions per distribution center.

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

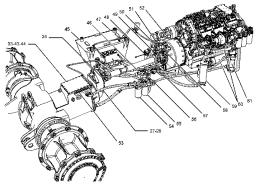
Two trucks exchange pilot (Feb 2014 vs Feb 2015). Model estimation ~19% of savings

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%

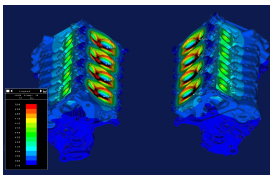
With the truck exchange, Heineken distributes **more cargo** with **less fuel** consumption (about 292 liters less ~26% of savings)

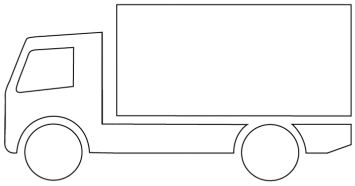
Future Research

- Optimal Fleet Composition…



$$F(\alpha_{(\theta)}, l, v, d)$$





Logistics Profile, i.e. # Stores, Density, Demand, Frequency, Congestion, Routes, etc.

Green Facility Location

- Provide alternatives for the location of DCs in Mexico City
- Recommendations for savings of ~40% of CO2 emissions
- New Methodology – Published on July 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.)

Chapter 9
Green Facility Location

Josué C. Velázquez Martínez and Jan C. Fransoo

Green Facility Location

The Multiobjective Sustainable Facility Location Model

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

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

Subject to

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

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

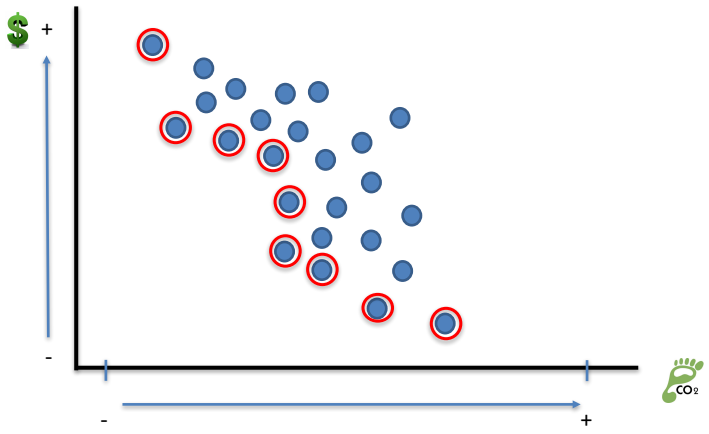
$$Y_{ij} - X_j \leq 0 \qquad \forall i \in I\ \forall j \in J$$

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

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

Solution Method

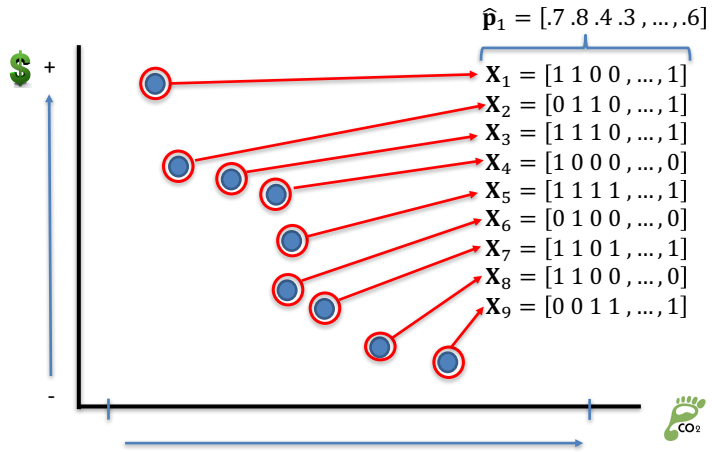
$t = 0$, Draw a sample $\mathbf{X_1}, \ldots, \mathbf{X_N}$ of Bernoulli vectors with success probability vector $\hat{\mathbf{p}}_{t-1}$.



Velázquez-Martínez et al. (2016). "Transportation cost and CO2 emissions in location decision models". Beta Research School for Operations Management and Logistics/ TU/e. Working Paper series 451.

The MOCO CEM - Algorithm

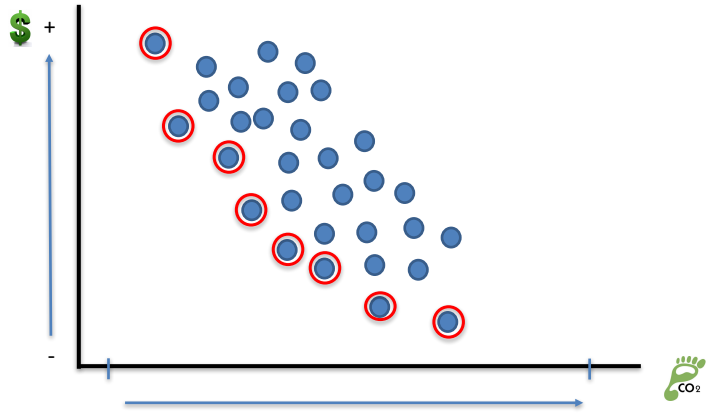
Pick the best solutions and estimate parameters



The MOCO CEM - Algorithm

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

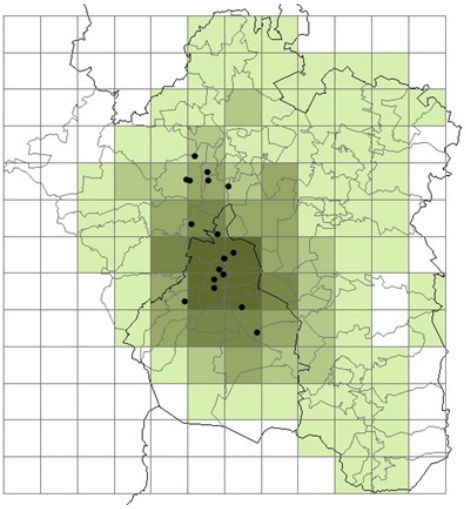
Pick the best solutions and estimate parameters…



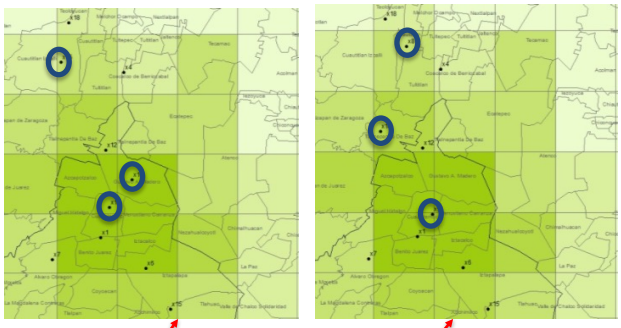
Case Study: CPG Company in Mexico City

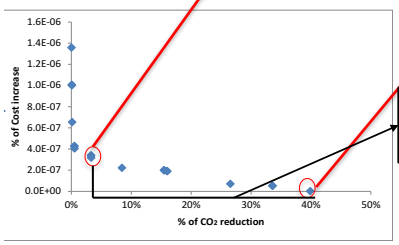
(p=10, candidate locations=18)

- The Company manages ~80,000 delivery points in Mexico City and average demand per year of 2.3 million of tons.
- The company assigns each truck to a specific zone of ~100 Km2



Some Results…





40% of CO2 reduction -> No cost increase

Some Conclusions

- There is a need to revisit decision-making models such as facility location problems that were designed under assumptions more suitable to the US and Europe environments.
- Specific characteristics of retail distribution in large urban areas may lead to structurally different logistics models.
- Companies may use the Sustainable Facility Location model to trade-off cost and CO2 when deciding facility location.
- The Multi-Objective Combinatorial Optimization Cross-Entropy Method (MOCO CEM) is an alternate algorithm to approximate the Pareto frontier for MOCO problems.


Thanks!

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