Institut Mines-Télécom

Large-Scale Allocation of Personalized Incentives

Partner Institution

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Conference paper

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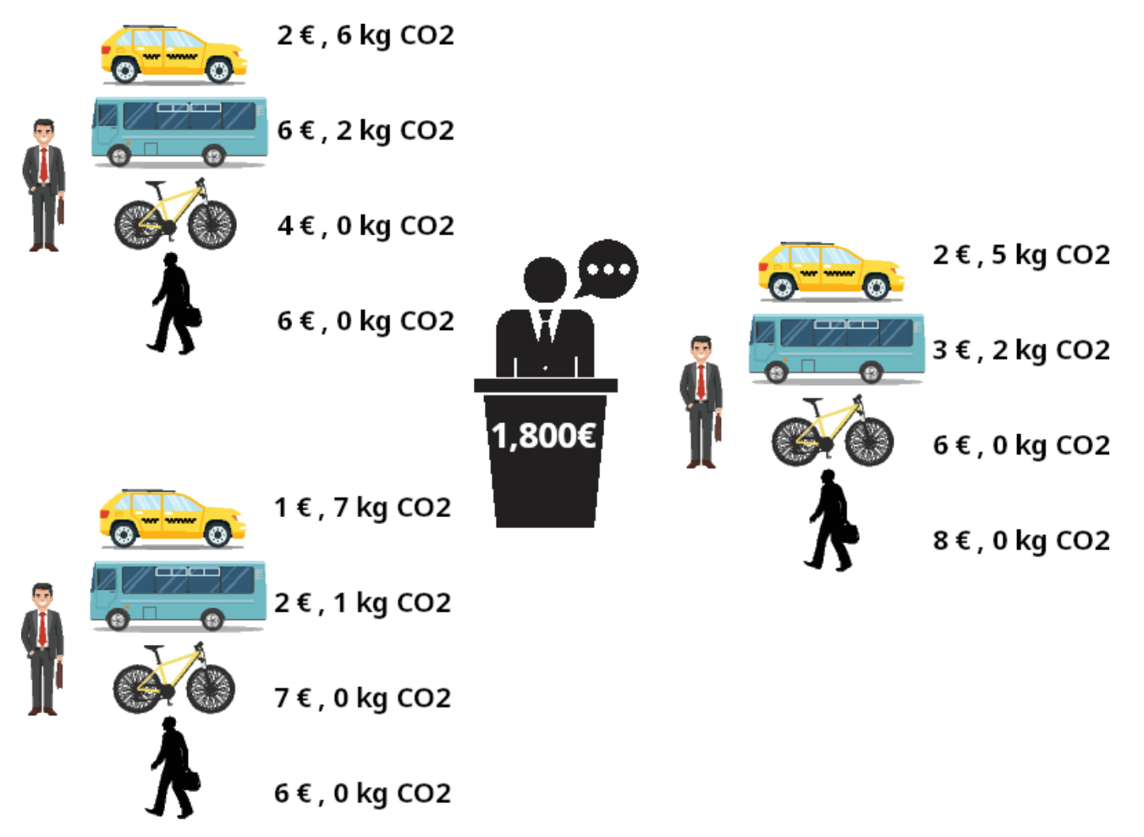
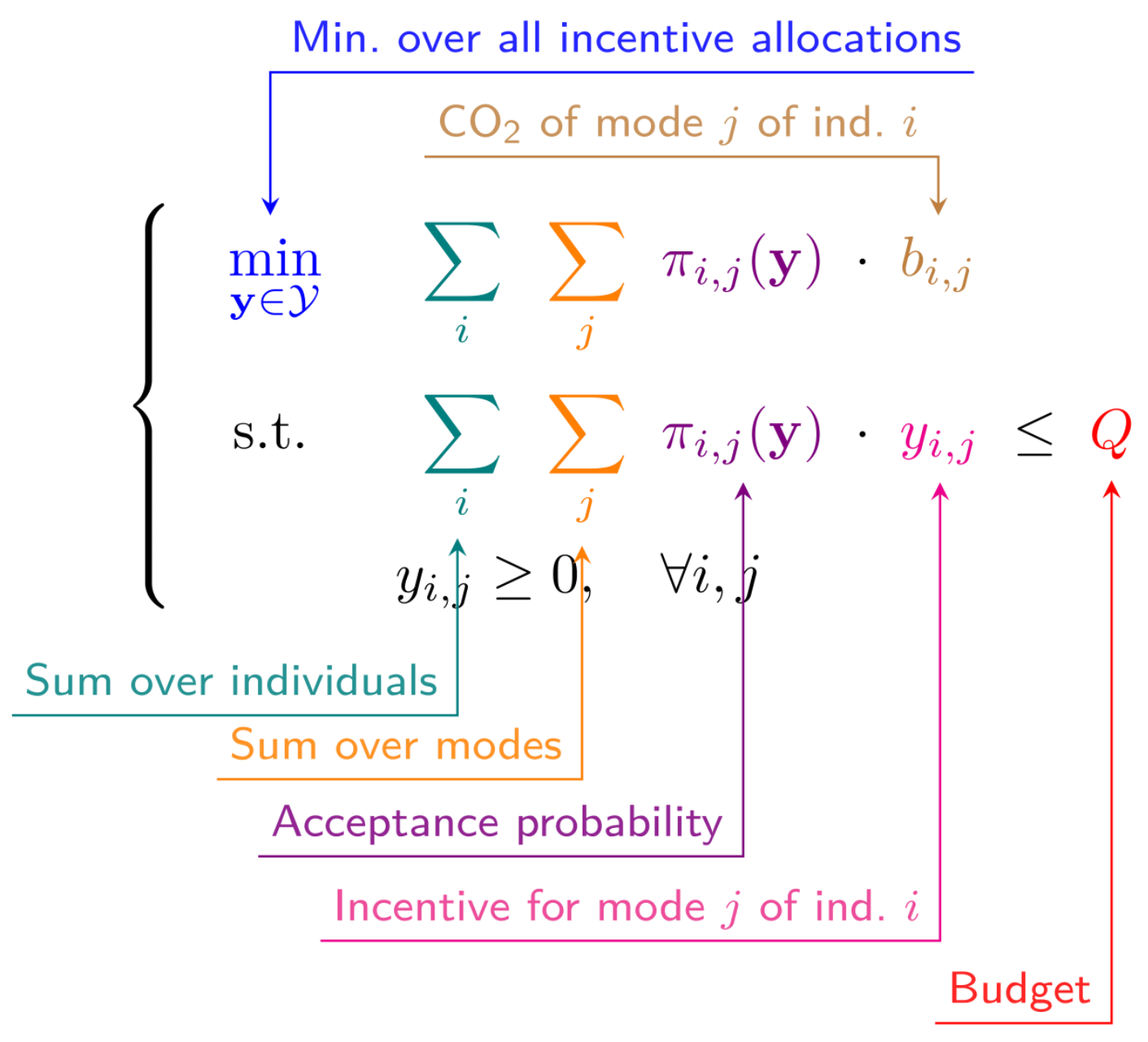
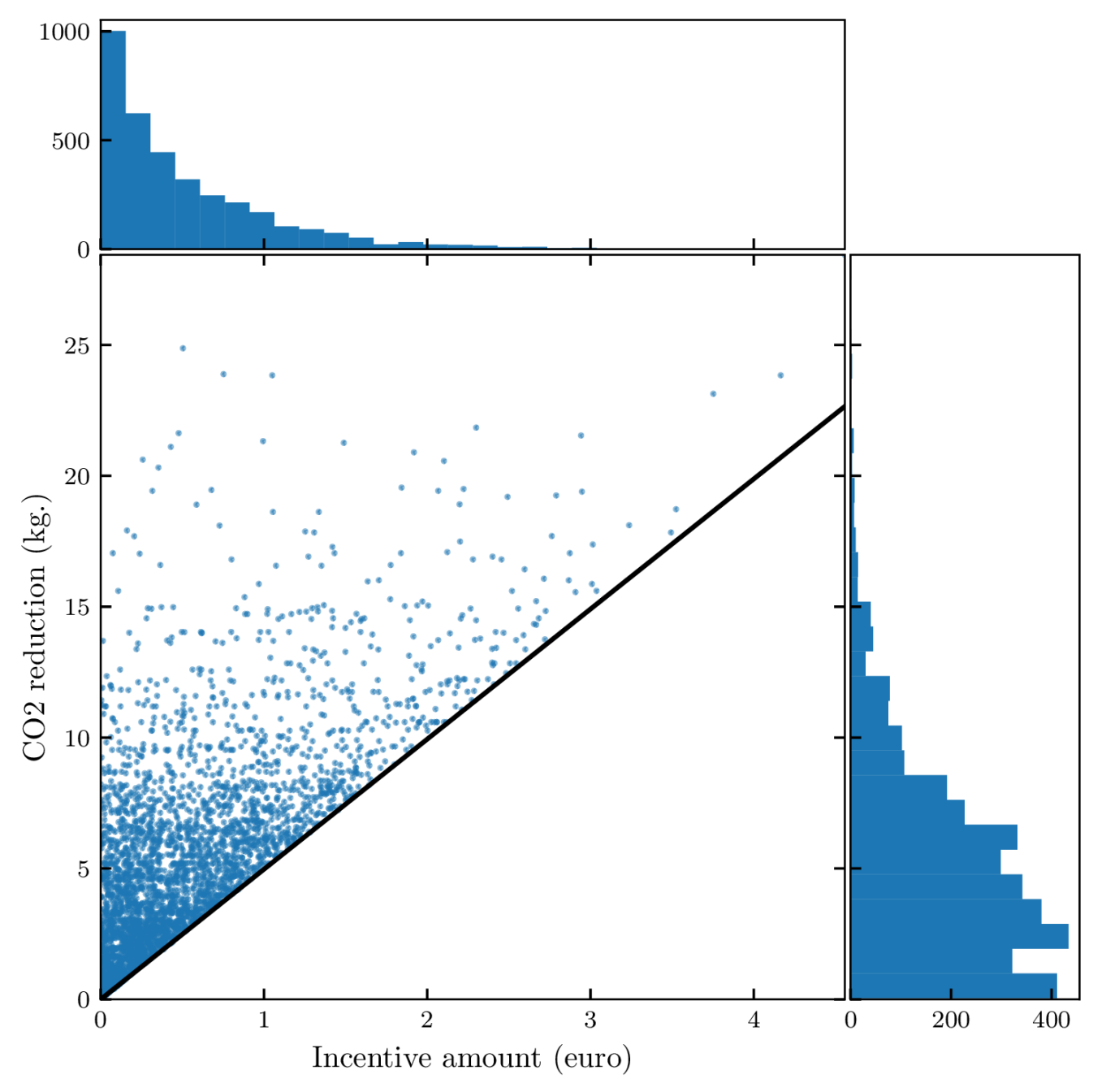


Simplified representation of the framework

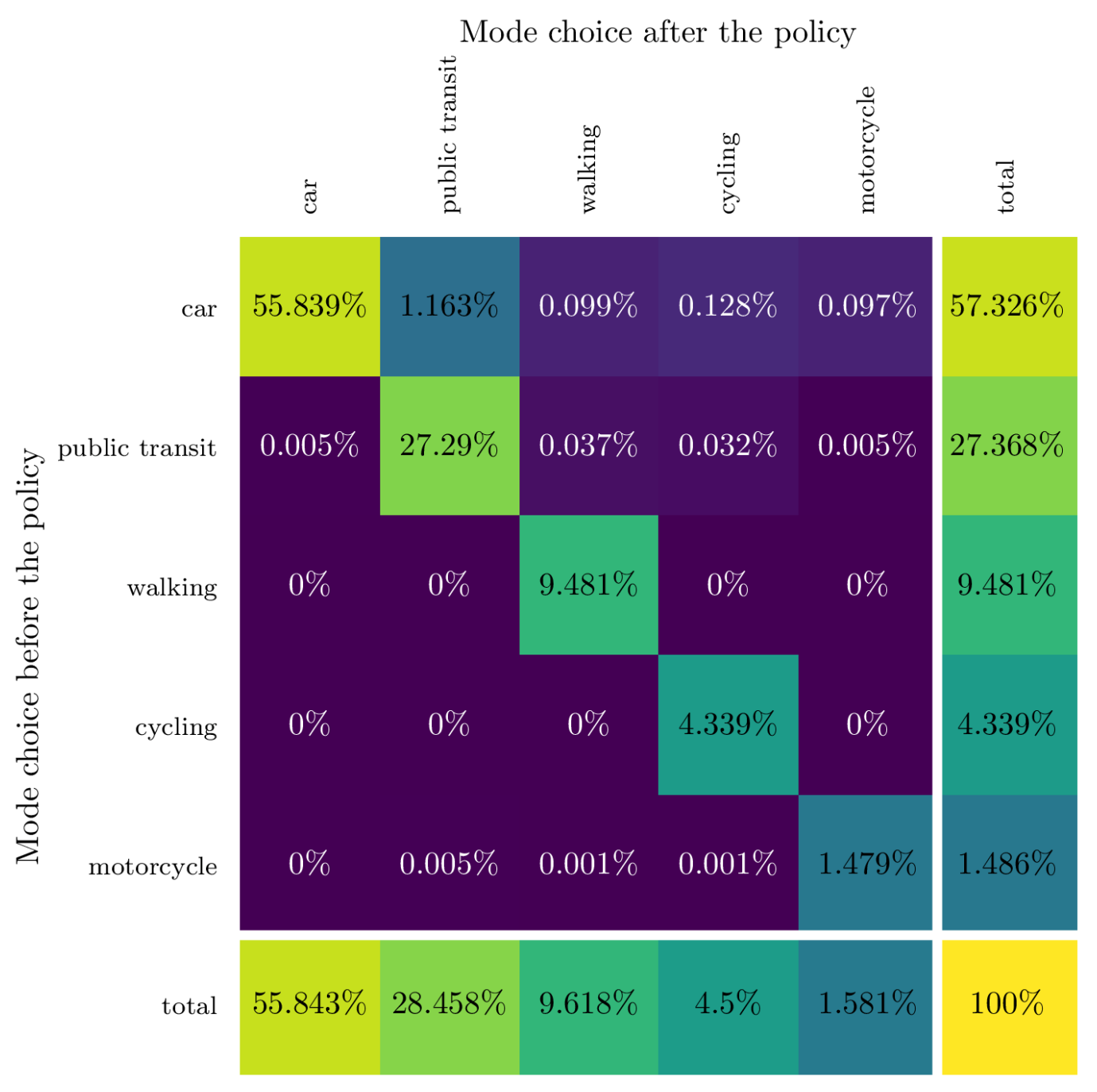


$$\begin{cases} \min\limits_{\mathbf{y}\in\mathcal{Y}} & \sum\limits_i \sum\limits_j \pi_{i,j}(\mathbf{y}) \cdot b_{i,j} \\ \text{s.t.} & \sum\limits_i \sum\limits_j \pi_{i,j}(\mathbf{y}) \cdot y_{i,j} \leq Q \\ & y_{i,j} \geq 0, \quad \forall i,j \end{cases}$$

Optimization problem of the regulator



Distribution of incentive amount and CO_2 reduction (Scenario 3)



Mode choice after the policy

Mode choice before the policy	car	public transit	walking	cycling	motorcycle	total
car	55.839%	1.163%	0.099%	0.128%	0.097%	57.326%
public transit	0.005%	27.29%	0.037%	0.032%	0.005%	27.368%
walking	0%	0%	9.481%	0%	0%	9.481%
cycling	0%	0%	0%	4.339%	0%	4.339%
motorcycle	0%	0.005%	0.001%	0.001%	1.479%	1.486%
total	55.843%	28.458%	9.618%	4.5%	1.581%	100%

Evolution of modes shares before and after the policy (Scenario 3)

Expected CO_2 emissions reduction in the 4 scenarios

Definitions and Framework

Personalized-Incentive Policy

- **Topic:** Mode choice for the commute to work of many individuals
- Each mode of transportation is characterized by an individual value (or *utility*) and a level of CO_2 emissions
- A regulator proposes incentives to induce individual to switch to another transportation mode
- **Goal of the regulator:** Minimize CO_2 emissions, subject to the budget constraint
- **Assumptions:** Fixed congestion; independent CO_2 emissions

Solution under Perfect Information

Multiple-Choice Knapsack Problem and Greedy Algorithm

- **Perfect information:** The regulator knows exactly the individual values for each mode of each commuter
- The regulator optimization problem reduces to a multiple-choice knapsack problem
- A near-optimal incentive allocation can be found in polynomial time, using a greedy algorithm from Kellerer et al. (2004)
- **Properties:** Anytime algorithm, diminishing returns on budget spent

Solution under Imperfect Information

Choice Probabilities and a Novel Algorithm

- **Imperfect information:** The regulator knows the distribution of the individual values
- A novel polynomial-time algorithm can be used to find a near-optimal incentive allocation
- The algorithm uses acceptance probabilities (probability that the individual accepts the incentive)

Large-Scale Application

Mode Choice in Lyon Metropolitan Area

- Over 200 thousands individuals and over 1 million alternatives
- 5 modes of transportation: car, public transit, walking, cycling and motorcycle
- **Four scenarios:**
  1. imperfect information with default unobserved,
  2. imperfect information with default observed,
  3. perfect information,
  4. proportional subsidy
- With a daily budget of 25k euros, CO_2 emissions can be reduced by 25 tons (scenario 1), 50 tons (scenario 2), 67 tons (scenario 3) or 15 tons (scenario 4)
- The average incentive amount is 3.99 euros in scenario 1, 1.56 euros in scenario 2 and 1.92 euros in scenario 3
- The mode share of car decreases from 57.3 % to 57.1 % (scenario 1), 52.6 % (scenario 2) or 51.8 % (scenario 3)

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