INVESTMENT NEEDS FOR TRANSPORT INFRASTRUCTURES ALONG LOW CARBON PATHWAYS

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A role to play for sustainable development

Population and economic growth → Higher freight and passenger activity (Dulac, 2013; Schafer, 2009)

- 23 % of energy-related CO2-emissions (IEA, 2012a)
- Highest GHG emissions growth since 1970 (IEA, 2012)

Balancing mobility demand

Mitigation

Increasing stocks and maintenance

Infrastructures

Modal shift (Henao, 2015)

Lock-in effect (Davis, 2014; Guivarch, 2011)

Chronic underinvestments ?

"The engineers estimated the cost of bringing America's infrastructure to a state of good by 2020 at $3.6 trillion, **of which only about 55 percent has been committed**." (ASCE, 2013)

"…the transport infrastructure gap in Latin America will once again increase, which could seriously limit the total volume traded" (Campos & Gaya, 2009)

"**Years of chronic underinvestment in critical areas such as transportation** […]are now catching up with countries around the world." (McKinsey, 2013)

→ Tension exacerbated or released ?

Research questions and gaps addressed

Investment needs under low carbon pathways

Impact of climate policy ? Regional heterogeneity ? Levers ?

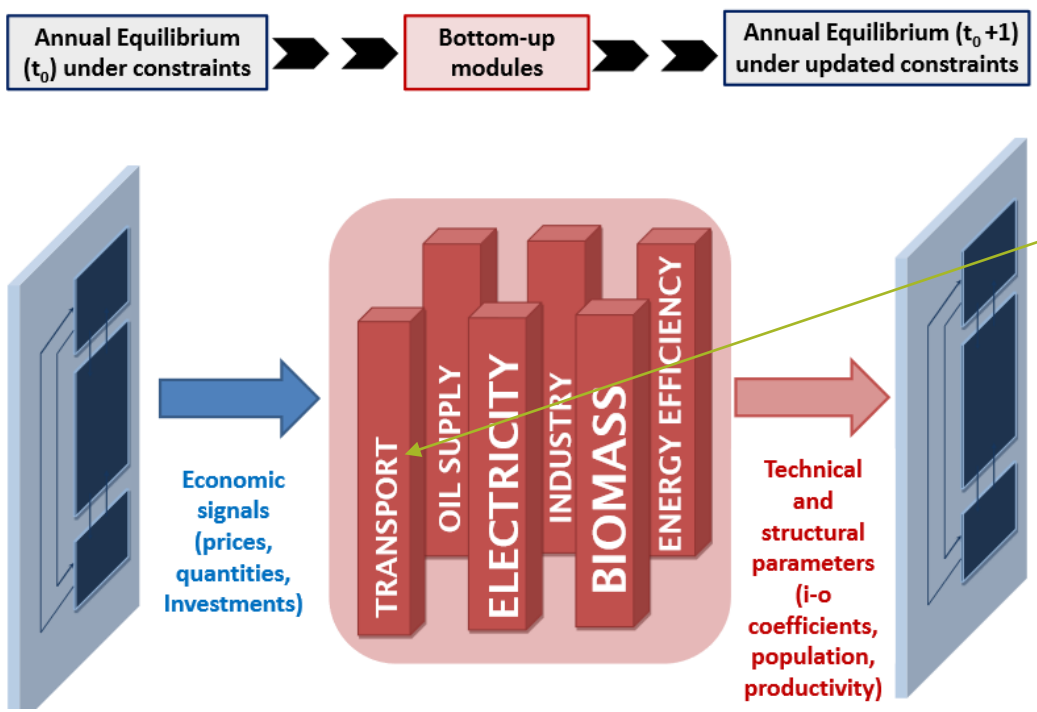
- Geographical scope
- Time horizon
- Results in cumulative terms and relative to GDP
- Costs considered
- Robustness of results
- Sensitivity analysis

METHODOLOGY

1. Construction of socio-economic scenarios
2. Quantifying 'ex-post' investments needs

The IMACLIM-R model (Waisman et al, 2013)

- Hybrid model : CGE + bottom up modules
- Second best worlds: myopic, imperfections
- 12 sectors, 12 regions→5 regions (ASIA, CIS, LAM, OECD, MAF)



Recursive dynamic architecture of Imaclim-R

Passenger :

- Mobility services in utility function of households
- Time and budget constraints
- Modes : Personal vehicles, Air, Public transport, Non motorized

Freight:

- Leontief I/O coefficients
- Terrestrial, maritime, air

Exploring uncertainties

Uncertainties considered (parameters set)	Alternatives	
Growth drivers : demography, productivity	SSP1, SSP2, SSP3	3
Mitigation challenges : FF reserves, energy intensity, low carbon-tech development	Low (SSP1) or High (SSP3)	2
Transport activity : mobility needs	Past trend or decrease	2
Transport structure: mode speeds/congestion, car occupancy	Individual or Shared-Mobility	2
Transport intensity : energy efficiency	Low or High	2
Transport Fuel : availability of alternatives	Low or High	2

→ **96 baselines scenarios**

→ **3 climates policies studied : Baselines, Low mitigation ambitions (Representative Concentration Pathway 4.5), High mitigation ambitions (between RCP2.6 and RCP4.5)**

→ **288 transport activity scenarios with outputs : GDP, CO_2 emissions, pkm, tkm**

METHODOLOGY

1. Construction socio-economic scenarios
2. Quantifying 'ex-post' the investments needs

Investments needs module

+ Dissagregation of mobility scenarios
  - public transport->Bus Rapid Transport (BRT), train, high speed rail (HSR)
  - Land freight-> train and truck
+ Aggregation on the different infrastructures
  - Calibration of initial stocks (2015)
+ Calculation of infrastructure needs (inspired by Dulac, 2013)
  - Target of infrastructure occupancy on the long term. Linear evolution
  - Difference between existing stock and necessary stock→new builts or increase of infrastructure occupancy
  - Constraints on infrastructures density (Dulac,2013)
+ Associated costs
  - Construction, upgrade, O&M
  - Airports : fixed cost per passenger kilometer

Uncertainties on parameters

Parameters considered	Alternatives	
Mode shares (land freight and public transport)	Constant, Modal shift	2
Target of road occupancy (thousand vkm/lane.km)	600, 900	2
Target of rail occupancy (millions pkm+tkm/track.km)	5, 30	2

Litterature for the year 2011

Road : from 200 (India) to 1100 (Latin America) according to Dulac (2013) ;

Rail : from 3 (EU27) to 35 (China)

Model calibration in 2015

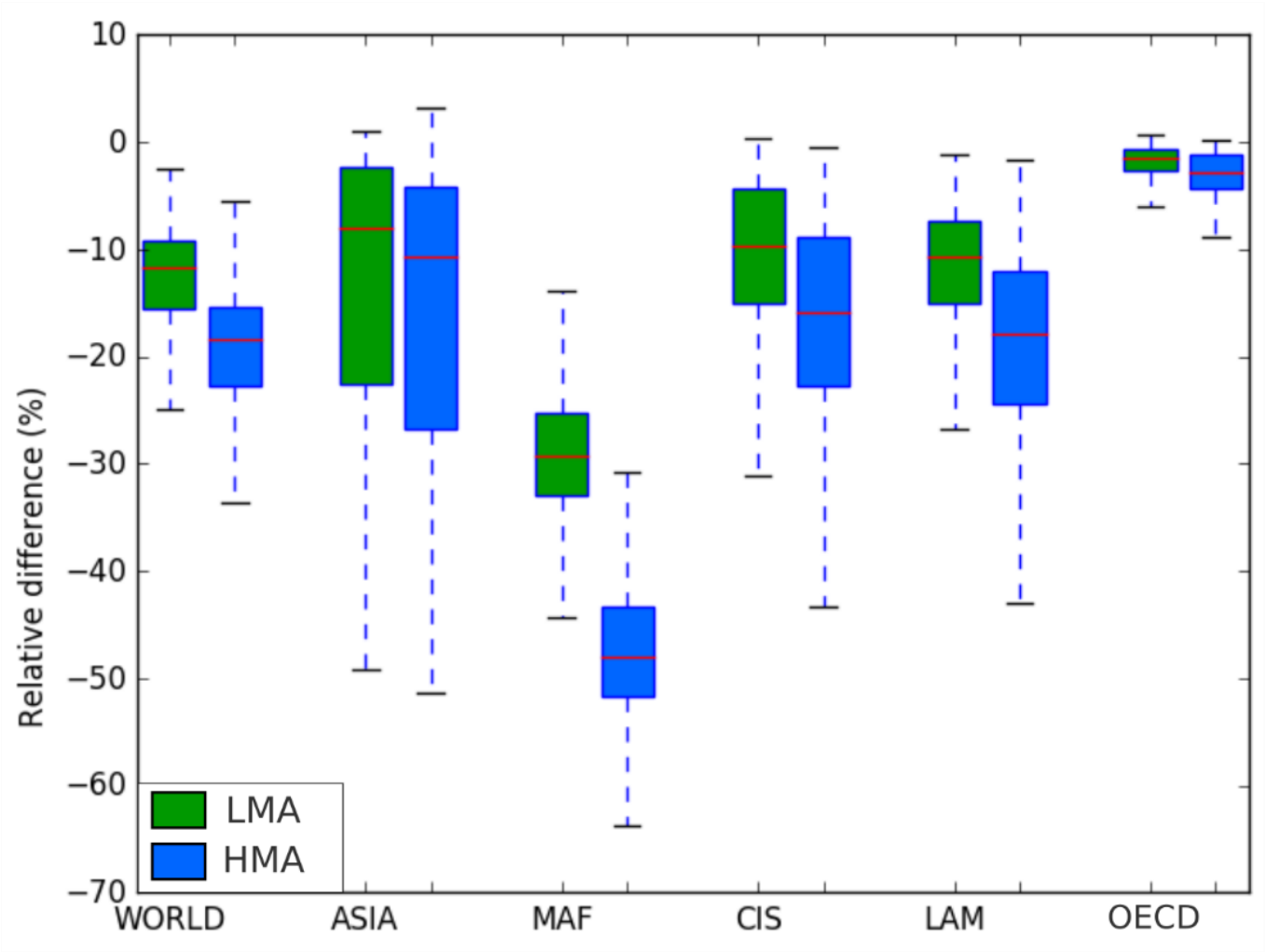
	ASIA	CIS	LAM	MAF	OECD
Road occupancy	200	300	1500	900	550
Rail occupancy	20	25	6	10	6

Uncertainties on parameters

Parameters considered	Alternatives	
Mode shares (land freight and public transport)	Constant, Modal shift	2
Target of road occupancy (thousand vkm/lane.km)	600, 900	2
Target of rail occupancy (millions pkm+tkm/track.km)	5, 30	2
Year to reach occupancy target	2050, 2080	2
Road unit costs : evolution until 2080	Constant, +50%, -50%	3
Rail unit costs : evolution until 2080	Constant, +50%, -50%	3

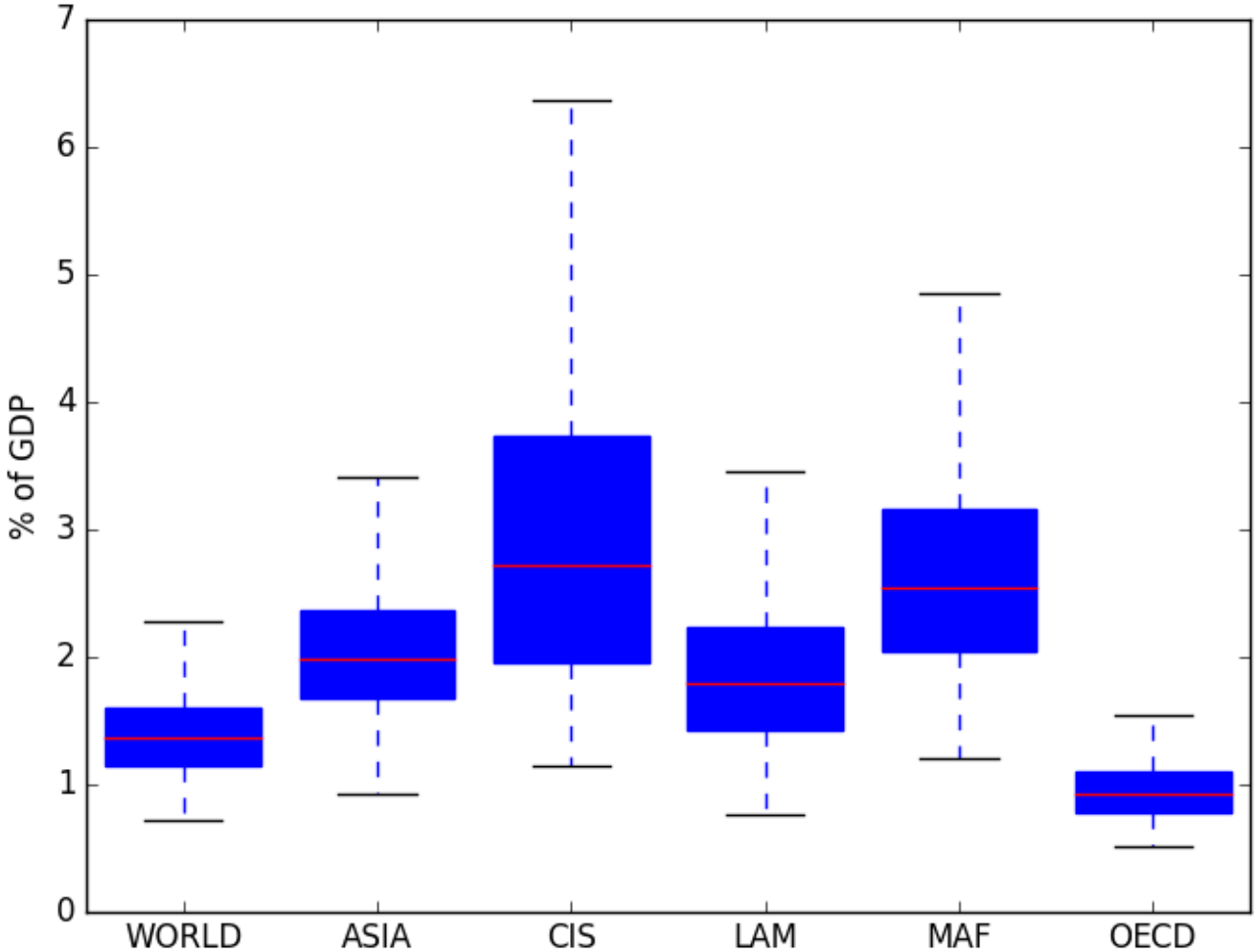
288 transport activity scenarios X 144 -> 41472 investments needs quantifications

Effects of LC policy on investments



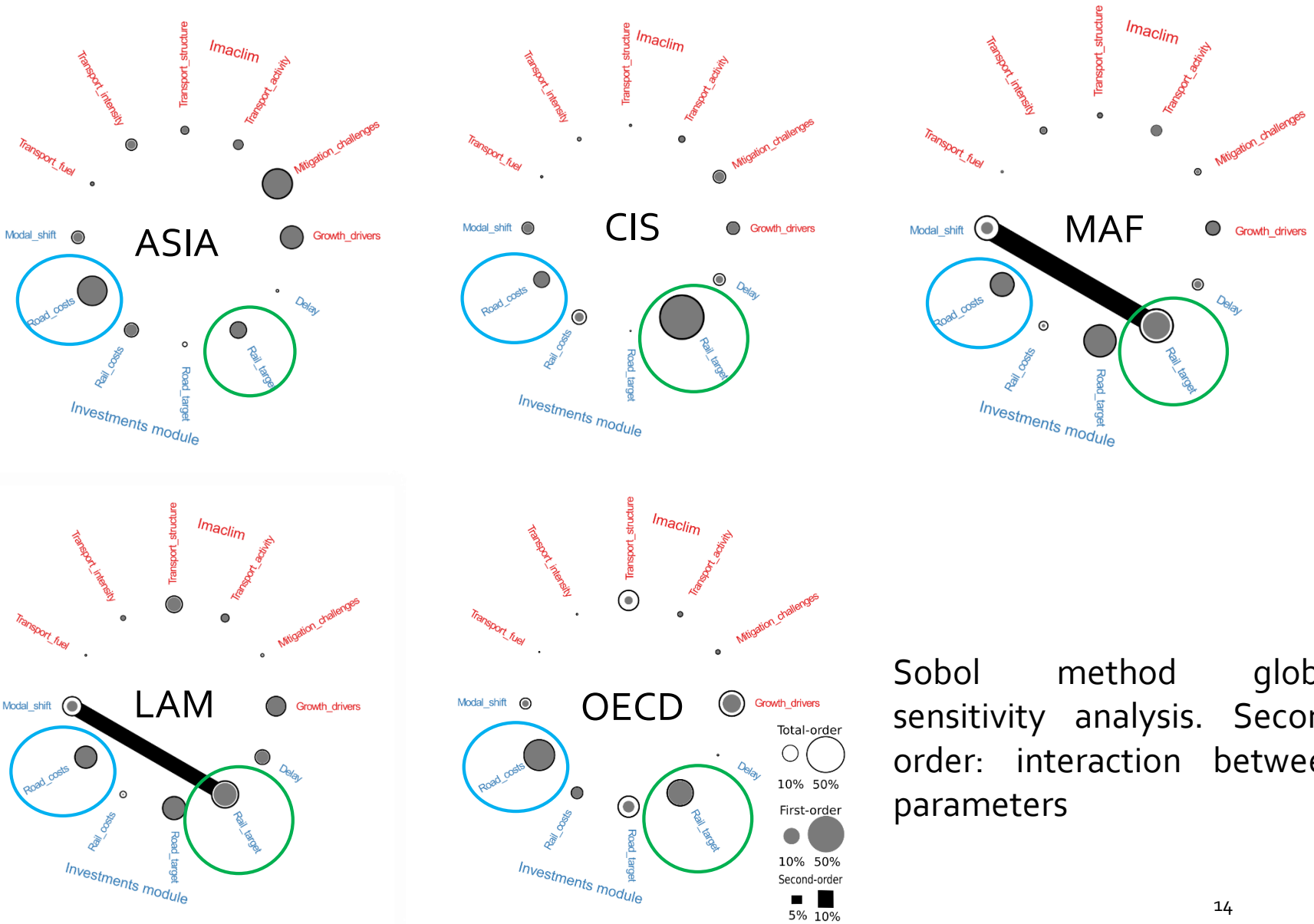
Comparison of cumulative investment needs between mitigation scenarios and their corresponding baselines

Regional investments under 'high mitigation ambitions' scenarios



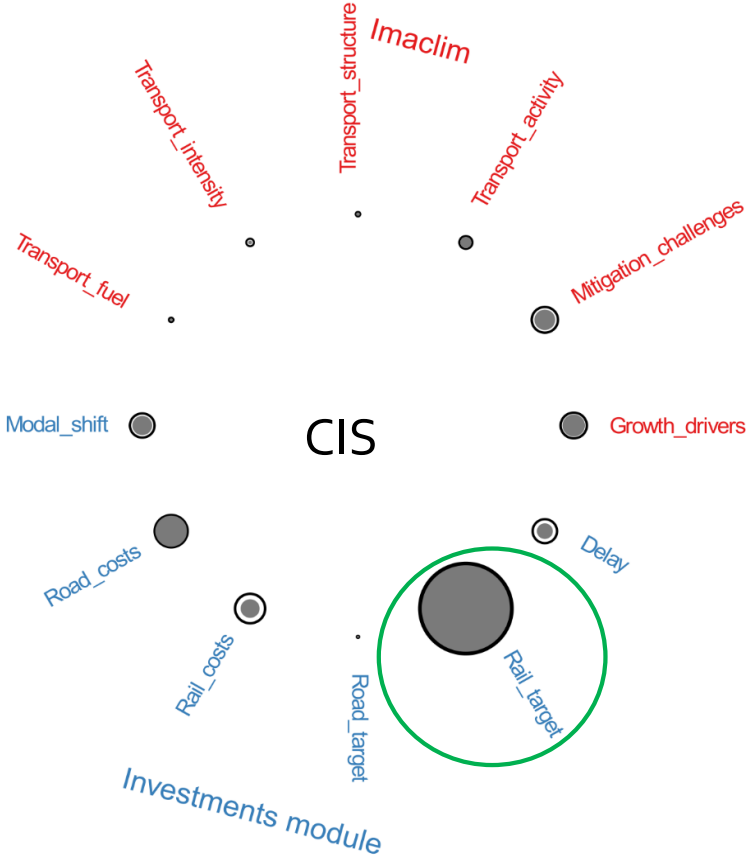
Average over time of annual investments needs relative to GDP for each scenario

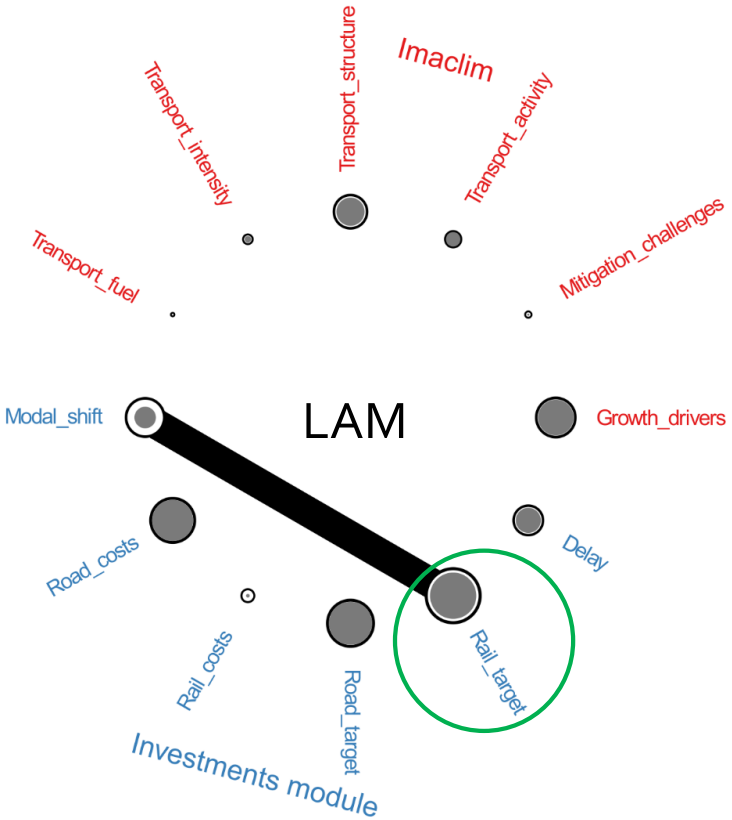
Determinants of the investments needs relative to GDP



Sobol method global sensitivity analysis. Second order: interaction between parameters

Determinants of the investments needs relative to GDP



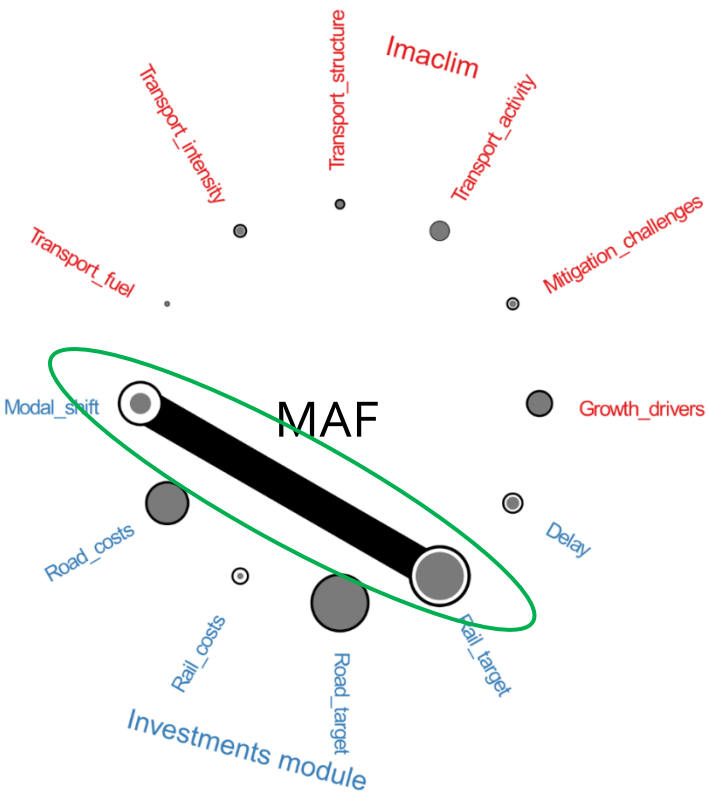


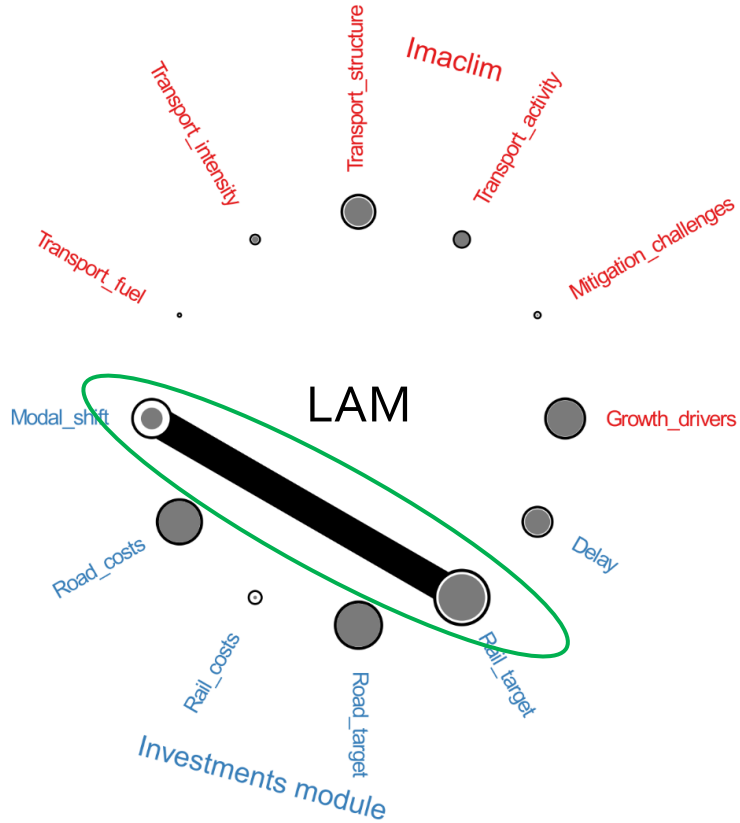
Rail occupancy in 2015	**25 millions tkm+pkm/track.km**	**6 millions tkm +pkm/track.km**

Low target : 5 millions tkm + pkm/track.km

High target : 30 millions tkm + pkm/track.km

Determinants of the investments needs relative to GDP





Scenarios considered	MAF	LAM
Low rail occupancy target + no modal shift	2.6%	1.8%
Low rail occupancy target + modal shift	3.4%	2.4%
High rail occupancy target + no modal shift	2.3%	1.6%
High rail occupancy target + modal shift	2.2%	1.5%

Average annual investments needs on the scenarios considered

Conclusions and policy implications

- Climate policies tend to reduce cumulative investments needs in transport infrastructures : reduction of transport activity + mode shift to low carbon modes

-->*Reorientation of investments*

- Rail occupancy and road buildings costs are influencing determinants

-->*Road costs : R&D ? Availability of raw materials ?*

-->*Optimization of rail occupancy : local conditions , type of levers…*

- Mode shift sought for different reasons (CO_2, air quality, congestion). Lever for investments only if combined with action on rail occupancy

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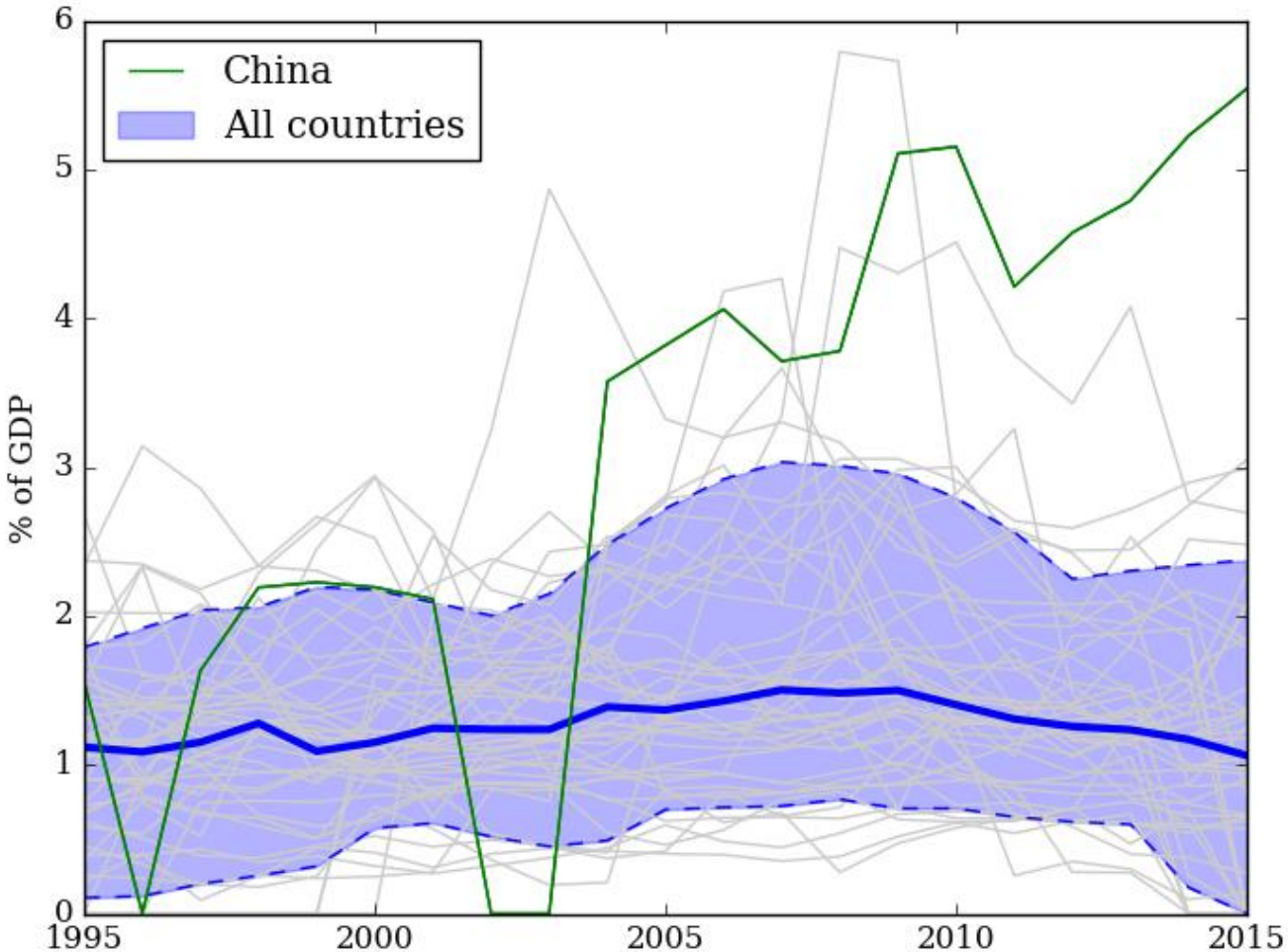
Limitations

- Results depend on model structure and parameters alternatives
- Calibration of initial infrastructures→ lack of data, inconsistency
- Feedback effect of investments on GDP
- Effect of infrastructures on mobility demand
- Benefits as damages avoided not included

Historical values of investments



Historical annual investments on transport infrastructures (rail, road and airports) - median(solid line) and 10th and 90th percentile (dashed lines) - Data aggregated by the authors from OECD (2017) and World Bank (2017) for 45 countries

Uncertainties on parameters

Parameters considered	Alternatives	
Mode shares (land freight and public transport)	Constant, Modal shift	2

- **5% of bus mobility as BRT (Dulac, 2013)**
- **Freight in 2050 : 60% rail and 40% road (UIC,2016)**
- **Passenger in 2050 : 40% rail of public transport in 2050 (IEA,2012)**