INVESTMENTS NEEDS FOR TRANSPORT INFRASTRUCTURES ALONG LOW CARBON PATHWAYS

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Third International Workshop : the energy transition in land transportation

09th November 2017

CONTEXT

Transport sector and infrastructures

- ‘Immobile capital (Prud’homme 2004)
- Long lifetime (Prud’homme 2004)
- ‘Lumpy’ investments (Lecocq et al, 2014)
- Increasing returns (Driscoll, 2014)

A role to play in the sustainable development

Population and economic growth → Higher freight and passenger activity

- 23 % of energy-related CO_2-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 (Guivarch et al, 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 adressed

Investments needs under low carbon pathway ?

Impact of climate policy ? Regional heterogeneity ? Determinants ?

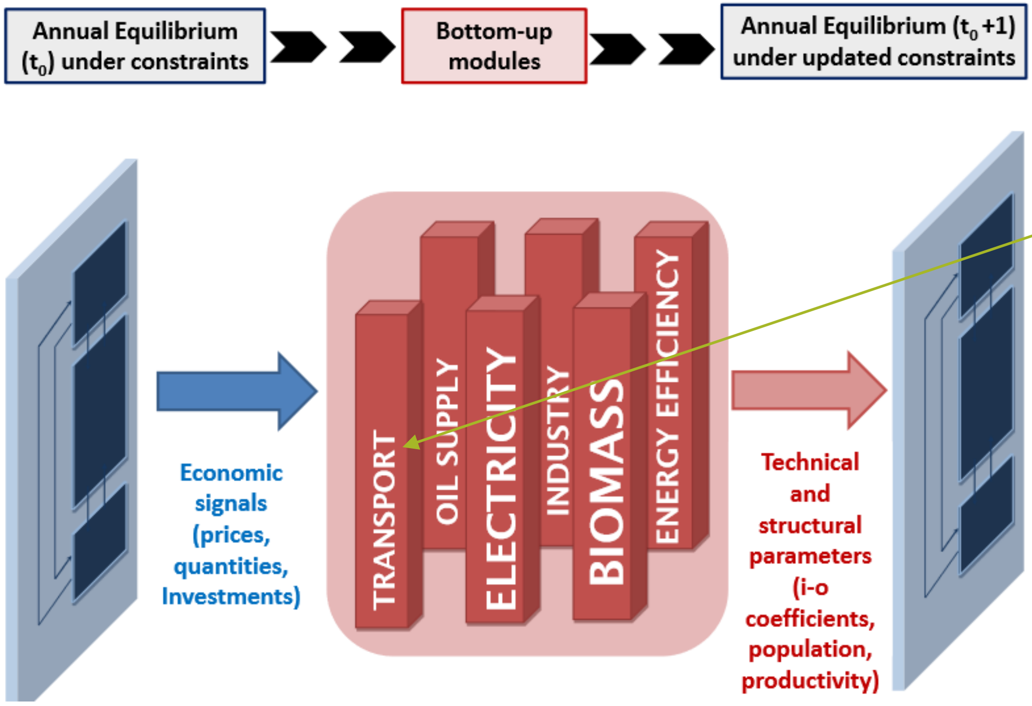
- Geographical scope
- Horizon term
- Only construction costs -> Underestimation ?
- Climate policies
- Figures in cumulative terms + relative to GDP
- Exploring uncertainties
- Determinants ? → sensitivity analysis

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
- Recursive dynamic architecture
- 12 sectors, 12 regions→5 regions (ASIA, CIS, LAM, OECD, MAF)
- Second best worlds: myopic, imperfections



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

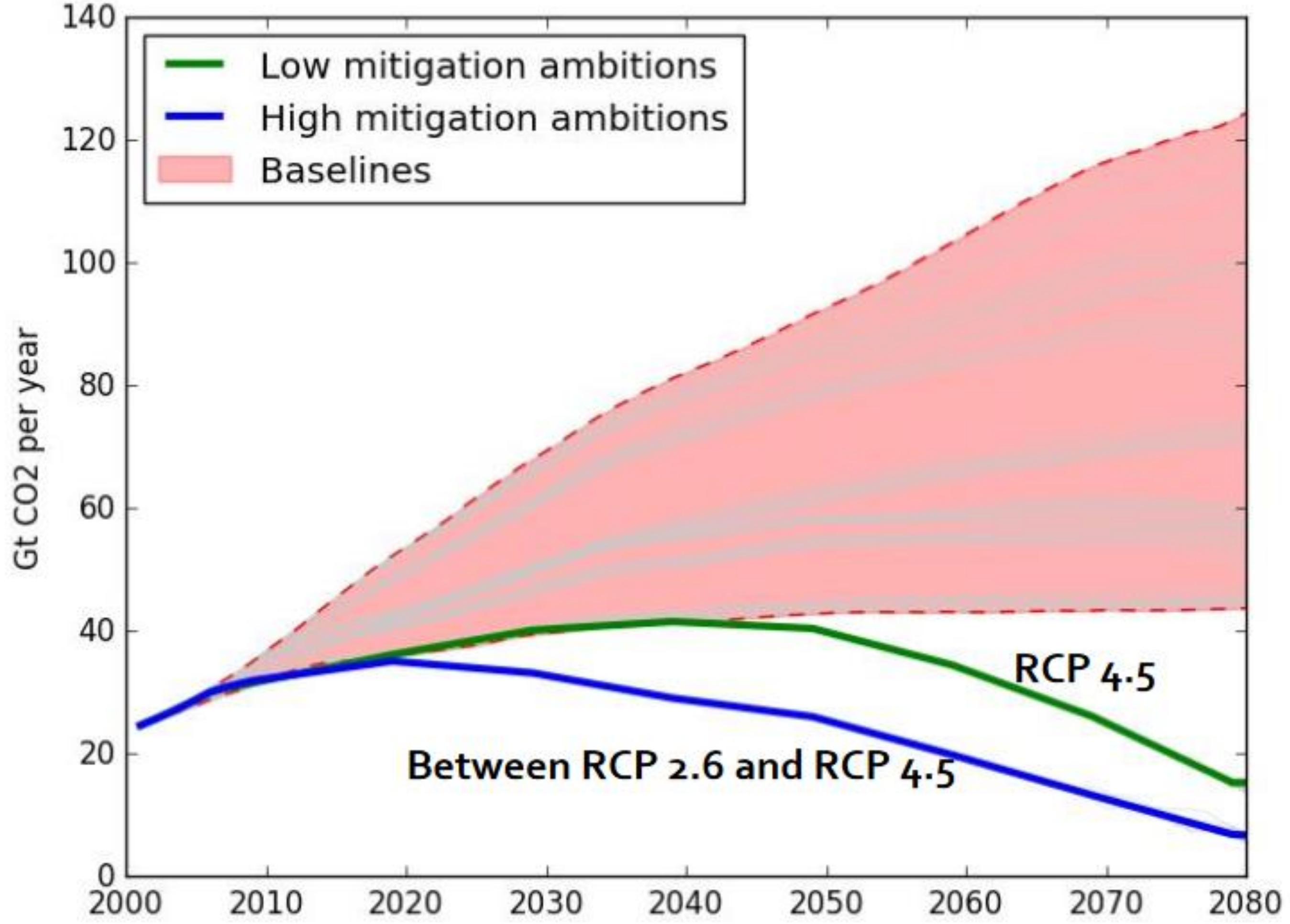
Exploring uncertainties

Uncertainties considered (parameters set)	Alternatives	
Growth drivers	SSP1, SSP2, SSP3	3
Mitigation challenges : FF reserves, energy intensity, low carbon-tech development	SSP1 (Low)or SSP3 (High)	2
Transport activity (affluence) : mobility needs	Past trend or decrease	2
Transport structure: mode shares, 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, High mitigation ambitions**

→ **288 transport activity scenarios with outputs : GDP, CO2 emissions, pkm, tkm**

Climate policies in Imaclim-R



METHODOLOGY

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

Investments needs module

- Dissagregation of mobility scenarios
- Aggregation on the different infrastructures
- Calculation of infrastructure needs
- Associated costs

Investments needs module

- Dissagregation of mobility scenarios
  - *Passenger* : car, air, public transport->(BRT, train, bus, HSR)
  - Freight : terrestrial -> (train and truck)
- Aggregation on the different infrastructures
- Calculation of infrastructure needs Associated costs

Investments needs module

+Dissagregation of mobility scenarios

+Aggregation on the different infrastructures

- Calibration of initial stocks
- Rail : pkm+tkm per track.km
- Road : vkm per paved lane.km
- BRT lanes : pkm per trunk.km
- HSR: pkm on track.km

- Calculation of infrastructure needs
- Associated costs

Investments needs module

+Dissagregation of mobility scenarios

+Aggregation on the different infrastructures

+Calculation of infrastructure needs

- Target of infrastructure occupancy on the long term (2050 or 2080). Linear evolution
- Difference between existing stock and necessary capacity
- Constraints on infrastructures density

- Associated costs

Investments needs module

+Dissagregation of mobility scenarios

+Aggregation on the different infrastructures

+Calculation of infrastructure needs

+Associated costs

- New builts, upgrade, O&M (Dulac, 2013)
- Airports : fixed cost per passenger unit

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)**

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 in 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

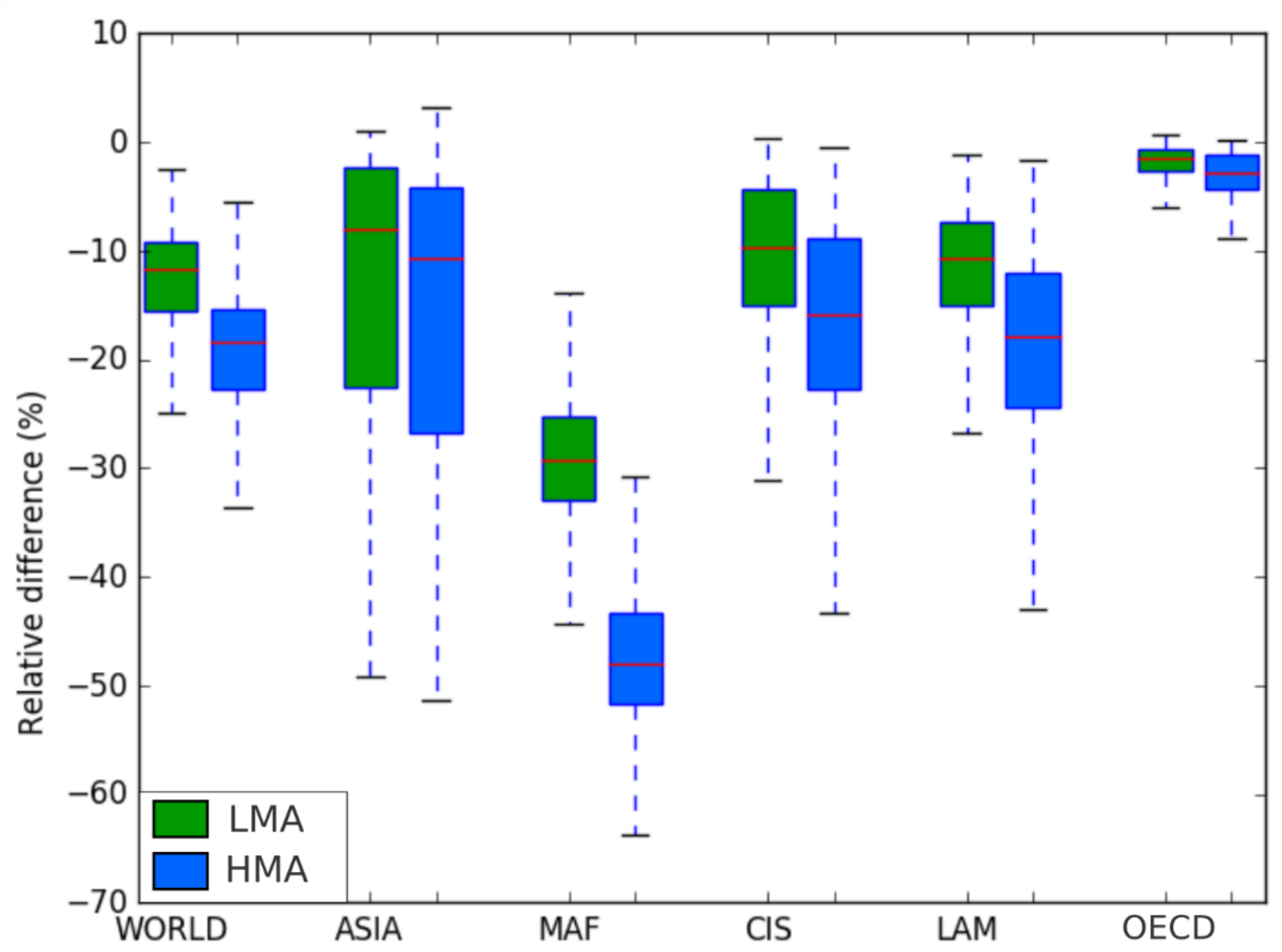
Uncertainties on parameters

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

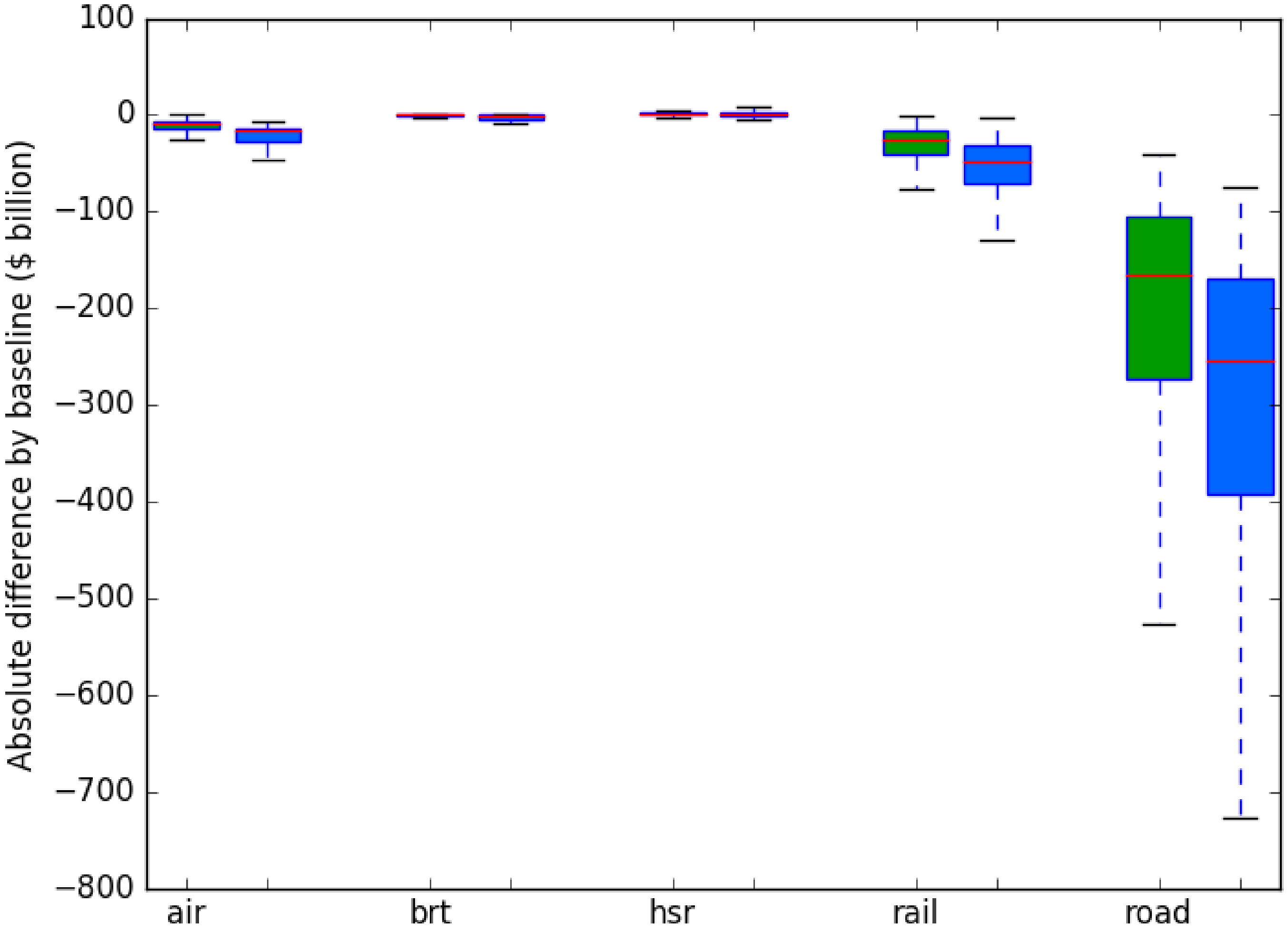
RESULTS

Effects of LC policy on investments

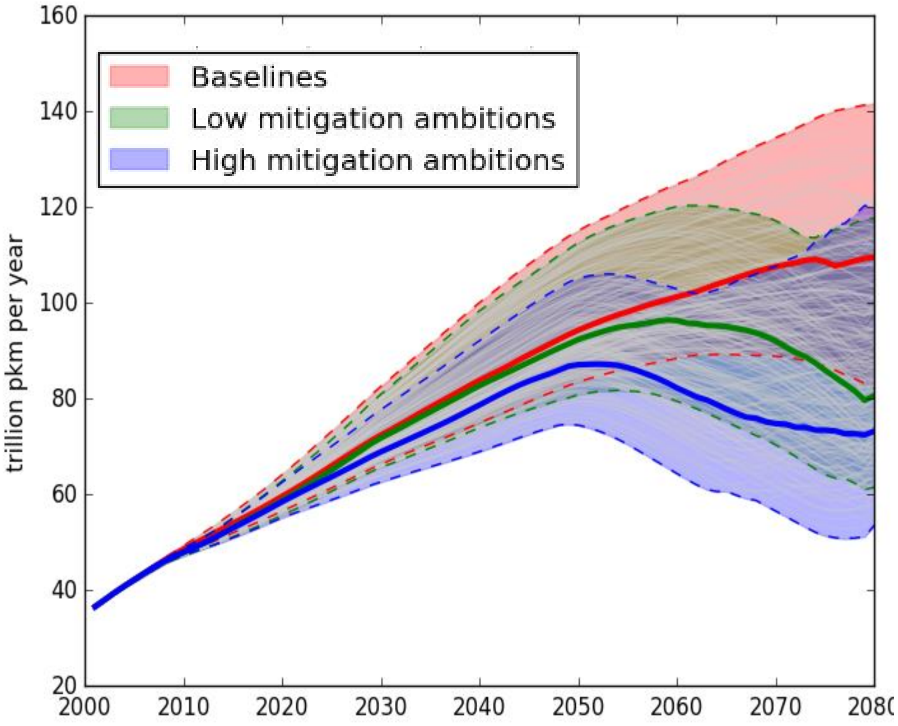


Comparison of cumulative investment needs between mitigation scenarios and their corresponding baselines

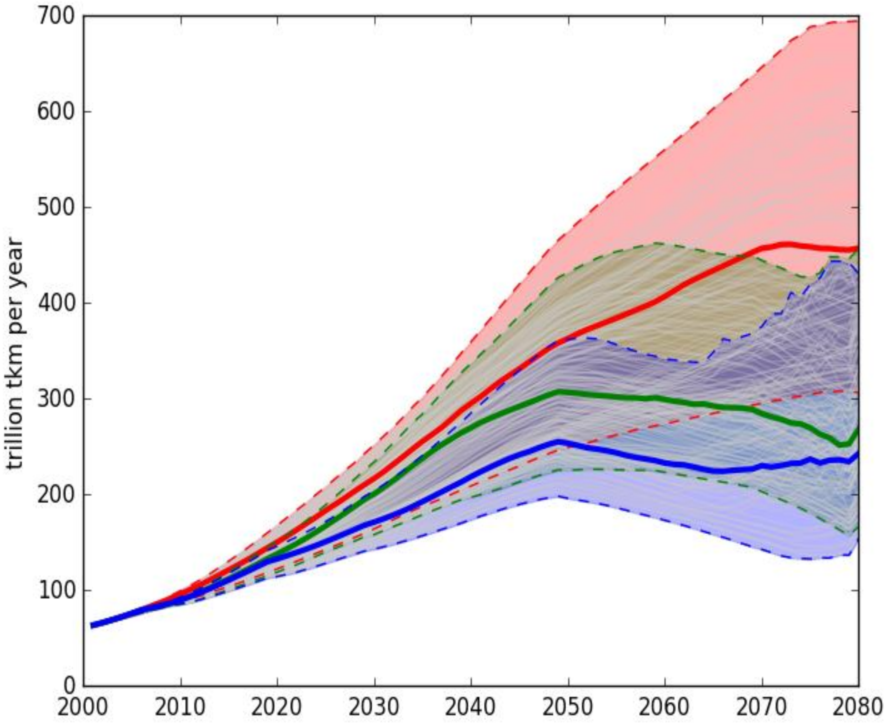
Contribution of each infrastructure type



Drivers of investments reduction



Global passenger activity over time



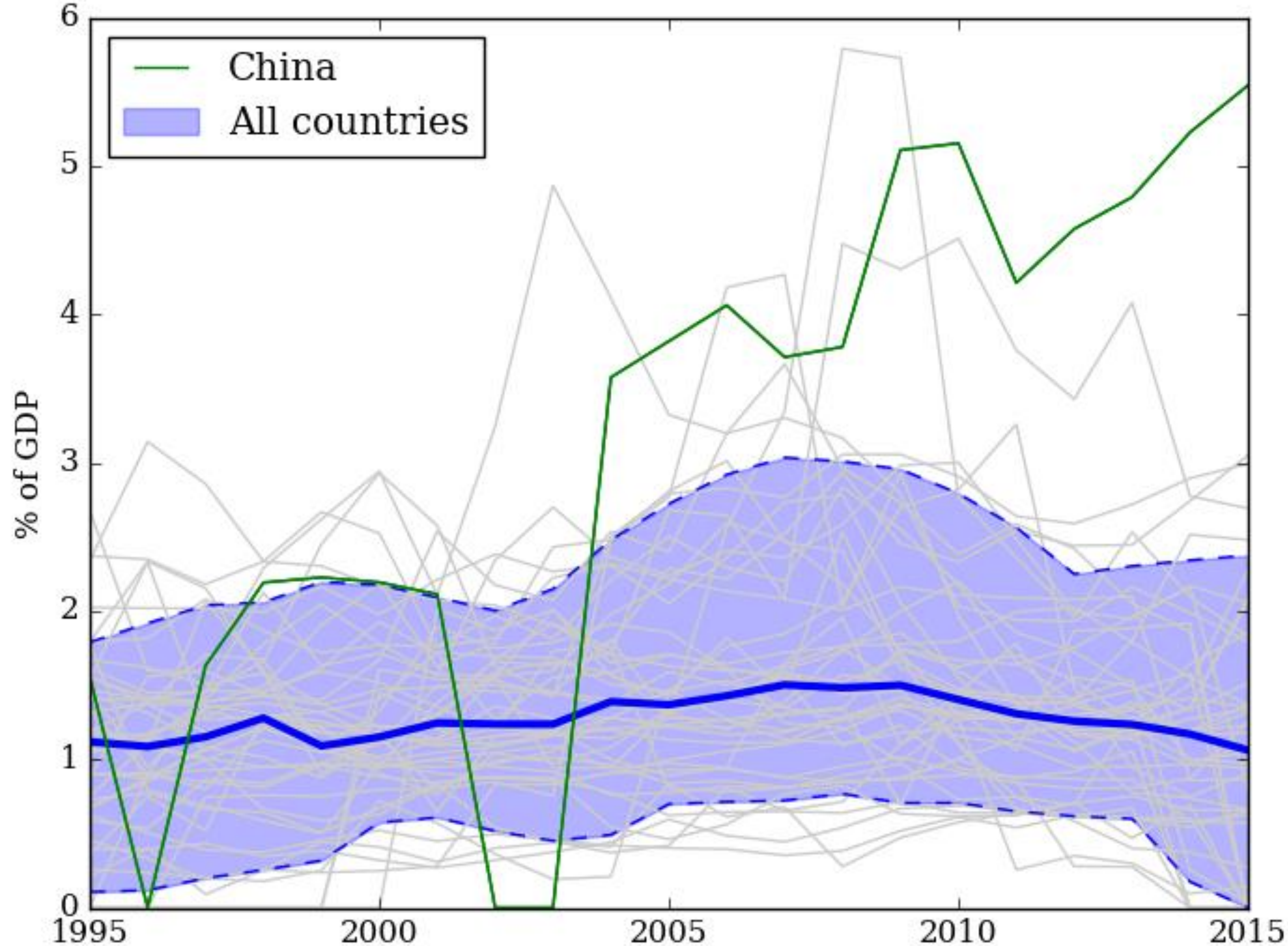
Global freight activity over time

Drivers of investments reduction

- **Transport activity decrease (freight and passenger)**
- **Mode shift to lower carbon modes**

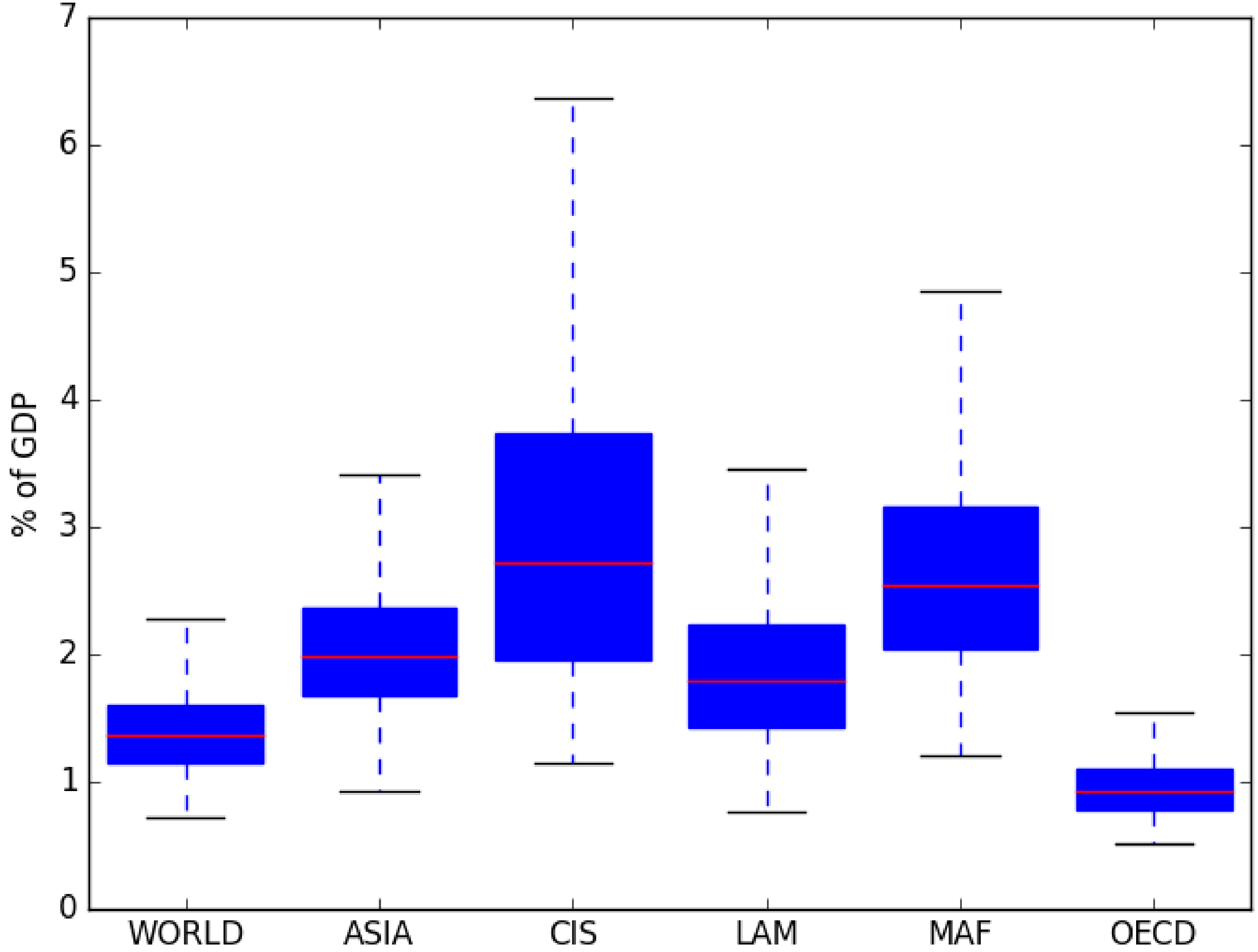
		2015	2050		
			Baseline	LMA	HMA
ASIA	Personal Vehicle	24%	37%	34%	30%
	Air	1%	3%	3%	3%
	Public transport	40%	49%	50%	51%
	Non Motorized	35%	11%	13%	17%
CIS	Personal Vehicle	64%	68%	66%	61%
	Air	2%	8%	8%	8%
	Public transport	23%	20%	22%	24%
	Non Motorized	11%	4%	4%	7%
MAF	Personal Vehicle	31%	43%	41%	38%
	Air	2%	5%	3%	3%
	Public transport	42%	40%	42%	40%
	Non Motorized	25%	12%	13%	19%

Historical values of investments

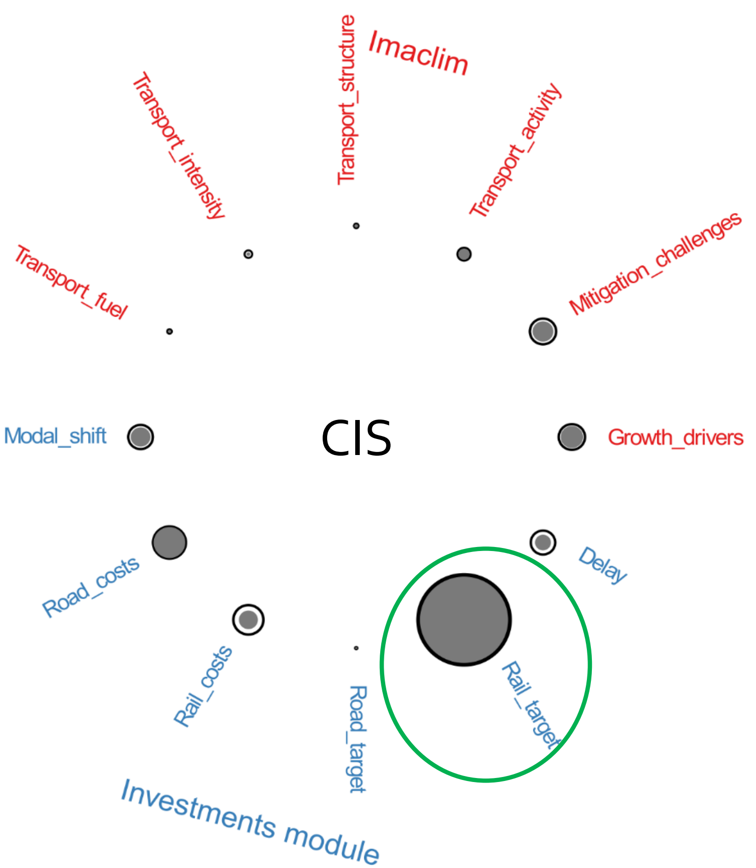


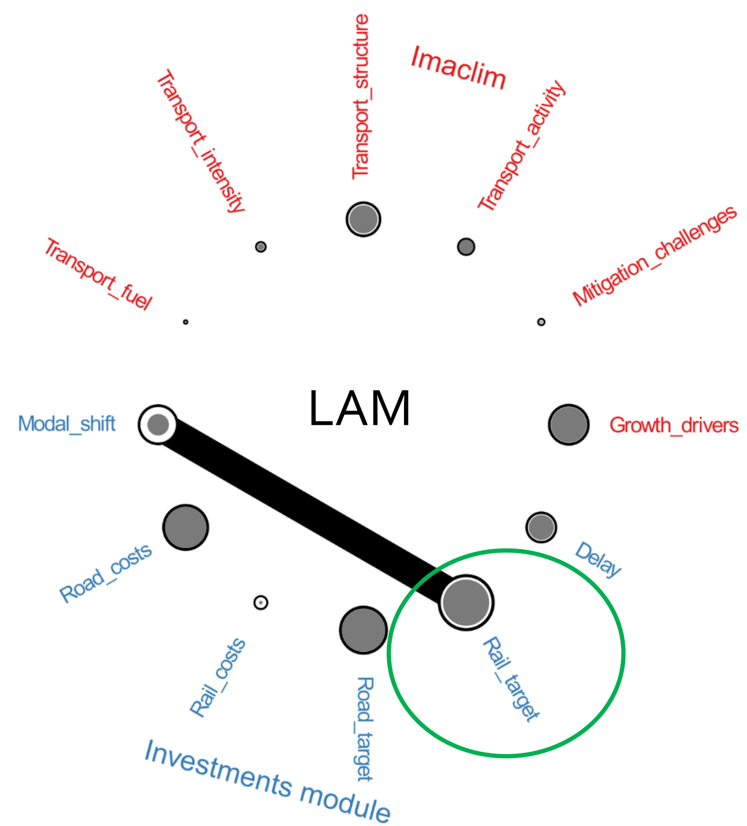
Historical annual investments on transport infrastructures (rail, road and airports) - median(solid line) and 10th and 90th percentile (dashed lines) - Data aggregated by the authors from OECD (2017) and World Bank (2017) for 45 countries

Regional investments under HMA scenarios



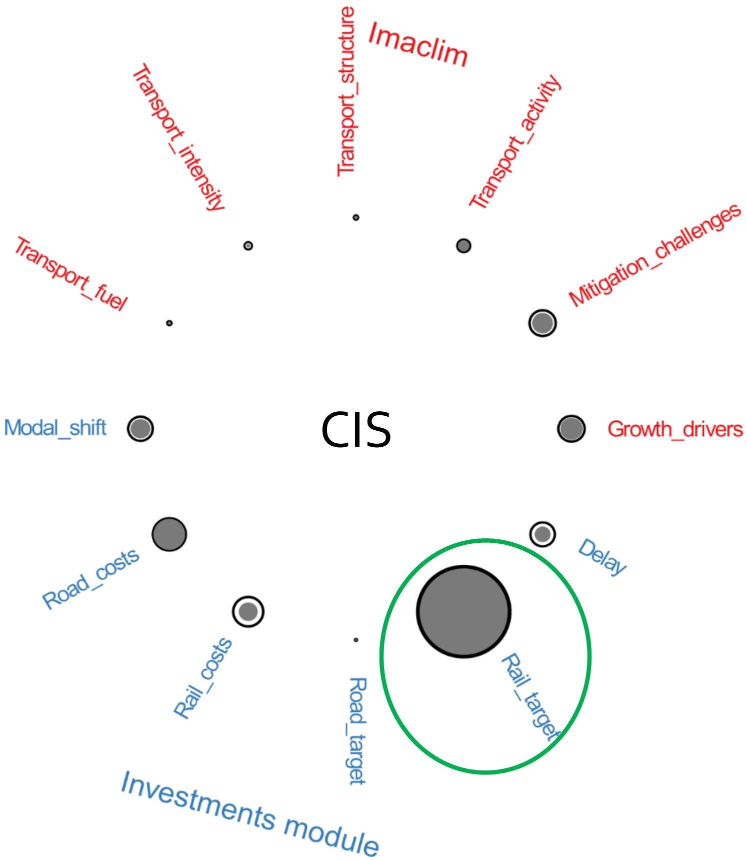
Global sensitivity analysis with Sobol Method

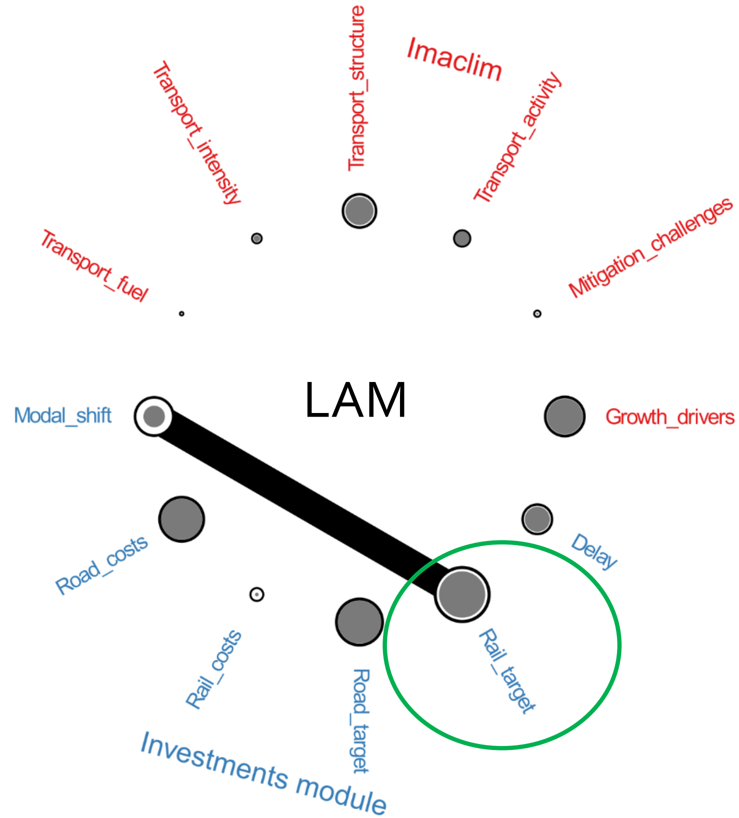




Sobol method global sensitivity (Saltelli, 2008) analysis for the investments needs relative to GDP. Filled nodes represent the first-order indices and rings the total-order indices. Lines representsecond-order indices arising from interactions between inputs. Width of lines indicates the second-order indices. Only the second-order indices greater than 5% of total variance are represented.

Global sensitivity analysis (Sobol)





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

Sobol method global sensitivity analysis for the investments needs relative to GDP.

Main Conclusions

- Cumulative investments needs in transport infrastructures reduced under climate policies compared to BAU

->Global, Regional, Robust to uncertainties

->Induced by transport activity reductions and modal shift

- Heterogeneity between regions under LC pathways
- Rail occupancy target is a influencing determinant

→irrealism vs strategy to avoid high investments

Limitations

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

Implications

- Decrease could compensate additional investments along LC pathway
- Optimization of rail infrastructure as a strategy ?
  - Local conditions
  - Types of levers

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