

# The Effects of ICT on Environmental Sustainability

## Revisiting a System Dynamics Model Developed for the European Commission

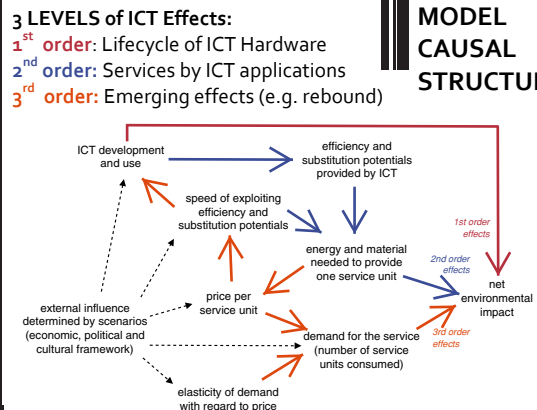
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## AIM

In 2014, we revisit a 2002 model commissioned by the European Commission's Institute for Prospective Technological Studies (IPTS), to explore the future impacts of information & communication technology (ICT) on environmental sustainability in the EU-15 for the time horizon of 2000-2020.

We analyze the results in light of empirical data available for 2000-2012.

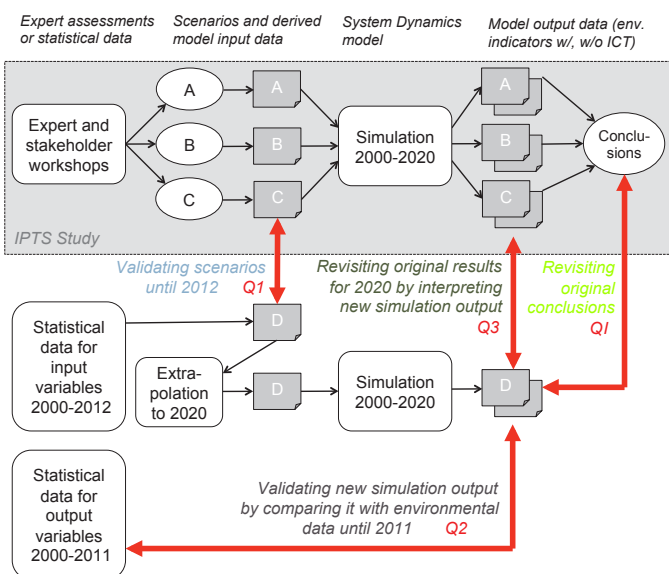
MODEL  
CAUSAL  
STRUCTURE



### 3 SCENARIOS

- |   |                                                                                                                                                                          |
|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A | TECHNOCRACY: strong economic growth and employment driven by large companies in the service sector and is enabled by low regulation.                                     |
| B | GOVERNMENT FIRST: strong environmental regulation, resulting in only moderate growth, no progress in employment, but good conditions for small/medium-sized enterprises. |
| C | STAKEHOLDER DEMOCRACY: steady economic growth, leading to an increase in the number of households, desk workers, and total labor force.                                  |

## RESEARCH QUESTIONS



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**NONE** of the 3 scenarios dominantly represents reality during the period 2000-2012.

Scenarios **A** and **B** come closest to the real-world data in **7 cases each**, and Scenario **C** in **5 cases**.

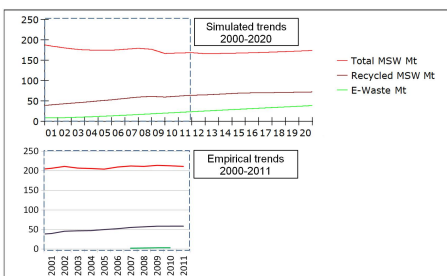
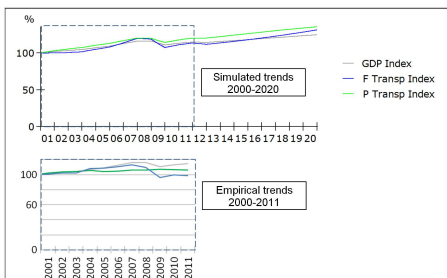
Q2.  $\mathbb{C}^n \times \mathbb{C}^n \rightarrow \mathbb{C}^n \times \mathbb{C}^n$  သို့  $\mathbb{C}^n \times \mathbb{C}^n \rightarrow \mathbb{C}^n \times \mathbb{C}^n$  [  $\mathbb{C}^n \times \mathbb{C}^n \rightarrow \mathbb{C}^n \times \mathbb{C}^n$  ]  
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 $\mathbb{C}^n \times \mathbb{C}^n \rightarrow \mathbb{C}^n \times \mathbb{C}^n$  [  $\mathbb{C}^n \times \mathbb{C}^n \rightarrow \mathbb{C}^n \times \mathbb{C}^n$  ]

[illegible]

We defined a **NEW** scenario, **Scenario D** based on the empirical data available today.

The predictions were roughly plausible, but cannot be taken as precise predictions. The purpose of the model was **NOT** to predict the development of the environmental indicators in absolute terms, but the relative impact of ICT on these indicators. (simulation tool: *PowerSim*)

No	External variable	Scenario assumptions used as simulation input, 2000-2015			Empirical data for EU15 2000-2015	Scenario closest to reality
		A	B	C		
161	GDP Annual Growth Rate	+ 0.5%	+ 1.1%	+ 3%	+ 1.1% (14.1% increase over 2000-2015)	B
164	Labor Demand Annual Growth Rate	+ 0.4%	+ 0.5%	+ 0.7%	+ 0.6% (8.1% increase over 2000-2015)	A
167	Population Annual Growth Rate	+ 0.0%	+ 0.0%	0%	+ 0.4% (5.5% increase over 2000-2015)	A,B,B
169	Number of Households Annual Growth Rate	+ 0.5%	+ 0.8%	+ 2%	+ 1.5% for 2003-15 (14.1% increase over 2000-2015)	A
165	Number of SMEs Annual Growth Rate	+ 0.1%	+ 0.4%	+ 0.4%	+ 0.48% for 2003-15 (5.4% increase over 2000-2015)	A
166	Office Work Demand Annual Growth Rate	+ 0.4%	+ 0.6%	+ 0.7%	+ 1.1% for 2003-2015	A
E100	Fossil Energy Price Annual Change Rate	+ 35%	3%	+ 35%	+ 3.8% Automotive gas oil price as proxy	B
L100	Shift to Energy Efficient ICT Half-life	15.4	15.9	7.5.4	- 7.5.4	C
T100	ICT-induced Spatial Structural Dispersion	0	+ 0.5%	+ 0.5%	+ 0% increase in average commuting distance over the period 2000-2015 in Finland as proxy	B & C
E11	DET Electricity Use Efficiency Potential		+ 50%		- 30%	
E12	DET Electricity Use Efficiency Half-life	15.4	7.5.4	15.4	(2.9% increase in efficiency over 9 years 2000-2015 in EU-15)	A & C
E13	DET Electricity Price Annual Growth Rate	+ 45%	0%	+ 45%	+ 3.9% (22% increase over 2000-2015)	B
E14	Electricity Supply Efficiency Potential		+ 0.5%		- 30%	
E15	Electricity Supply Efficiency Half-life	20.4	10.4	20.4	(2.5% increase in efficiency over 10 years 2000-2015)	A & C
G101	Average Useful Life of ICT Annual Change Rate	- 0.1%	0%	- 0.1%	- 0.1% over 8 years 2000-2015	A & C
W10	MSW Recycling Potential		55%		- 30%	B
W11	MSW Recycling Half-life	20.4	8.4	20.4	(48% recycling rate in 2015)	



See \* for more comparisons

**ICT Impact Index** =  $\frac{\text{the value for the reference simulation run}}{\text{the value for the corresponding "ICT freeze" run}}$   
 = 1 means that ICT has no influence  
 > 1 means that ICT increases the environmental burden  
 < 1 means that ICT reduces the environmental burden

ICT impact index	A			B			C			D		
	worst	mean	best	worst	mean	best	worst	mean	best	worst	mean	best
Freight Transport	1.04	1.01	0.90	1.32	1.27	1.11	1.03	0.98	0.83	0.99	0.95	0.81
Passenger Transport	1.03	1.02	1.01	1.04	1.04	1.02	1.03	1.02	1.00	1.03	1.05	1.04
Energy	0.98	0.95	0.89	1.03	0.99	0.92	0.97	0.93	0.85	0.94	0.90	0.82
GHG	0.97	0.93	0.87	1.03	0.98	0.90	0.97	0.92	0.83	0.81	0.89	0.79
Materials	0.90	0.88	0.79	1.00	0.97	0.87	0.90	0.86	0.74	0.85	0.83	0.71

Revisiting the main conclusions of the IPTS study

- ICT applications supporting a product-to-service shift (virtual goods)
  - ✓ Reducing influence on total material demand (dematerialization effect)

- ICT applications for heating management (intelligent heating)
  - ✓ reducing effect on energy consumption in the domestic/tertiary sector (mainly heating)

ICT applications for passenger transport efficiency

- ✓ Stimulating influence on total passenger transport. more cost / time efficient (rebound)

✓ Time utilization. Advantage for public transport compared to private car transport

✗ ICT now slightly inhibits growth of freight transport. This ICT effect is mainly due to its dematerialization effect, which is stronger than in the original study.

## CONCLUSIONS

**None of the three scenarios** that were developed by experts to specify the external factors needed to run the model were **realistic** from today's point of view.

If the model is re-run with more realistic input data for the first half of the simulation period, the **main results regarding the impact of ICT remain qualitatively the same**; they seem to be relatively robust implications of the causal system structure, as it is represented in the model.

Overall, the impacts of ICT for mitigating greenhouse gas emissions and other environmental burdens for 2020 tend to be **slightly stronger** if the simulation is based on the empirical data now available.

\* Read more in the book chapter:

Modeling the Impacts of ICT on Environmental Sustainability: Revisiting a System Dynamics Model Developed for the European Commission, *ICT Innovations for Sustainability* (L. M. Hilty & B. Aebischer, eds.) Springer 2015



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