# Sensitivity Analysis of a Large Scale Integrated Land Use and Transportation System


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## Introduction

Why uncertainty quantification (UQ) for integrated land use and transportation models (ILUTMs)?

- UQ helps us characterize and reduce uncertainty.
- Little work done to quantify uncertainty [2].
- Important for accurate forecasting of land use and transportation demands.

Impact of sensitivity analysis

- Ranks parameters according to their impact on output uncertainty.
- Helps in calibration and model validation.

Focus of this work

- Sensitivity analysis of land use part TRANUS [1], Grenoble, France.
- Total number of uncertain parameters were 100.
- *Total effect* [3] of each uncertain input parameters on the $QoI$ . Given calculated $(X)$ and observed $(X^o)$ land use assignments.

$$Q = ||X - X_o||_2^2$$

where, $||\cdot||_2$ is the $\mathcal{L}_2$ norm.

- Use of high performance computing for faster computation.

Table 1: Description of the sectors.

| Sector number | Description | Sector Type |
|---|---|---|
| 1 | Industrial employment | Employment |
| 2 | Public employment | Employment |
| 3 | Offices, research& development employment | Employment |
| 4 | Retail employment | Employment |
| 5 | School employment | Employment |
| 6 | Household income (rich) | Income |
| 7 | Household income (above average) | Income |
| 8 | Household income (below average) | Income |
| 9 | Household income (poor) | Income |
| 10 | Students | Income |
| 11 | Individual housing | Real estate |
| 12 | Apartment Housing | Real estate |
| 13 | Land for economic activities | Employment |
| 14 | Land for shops in urban area | Employment |
| 15 | Social housing | Real estate |
| 16 | University | Employment |
| 17 | Retail employment (less frequent) | Real estate |
| 18 | Supermarket employment | Real estate |
| 19 | Retired income (rich) | Income |
| 20 | Retired income (poor) | Income |
| 21 | Other commercial ventures | Employment |
| 22 | Other land use | Real estate |

## Total effect

Tells us the impact of a parameter on the $QoI$ if only and only that parameter is allowed to vary, or is uncertain. (More information in Saltelli *et al.* [3])

## Methodology

Description of TRANUS land use model.

- Consists of 20 nonlinear equations and inequalities.
- Population divided into economic *sectors* and land divided into geographical *zones*.
- Solution reached when supply and demand of land to the population, equilibrates.

Description of TRANUS Grenoble model, and uncertain parameters

- 22 economic sectors and 225 geographical zones

## Uncertain parameters

$$\Psi = [\min^{mn}, \max^{mn}, \delta^{mn}, \bar{\omega}^{mn}, \delta, \theta^n]^\top,$$

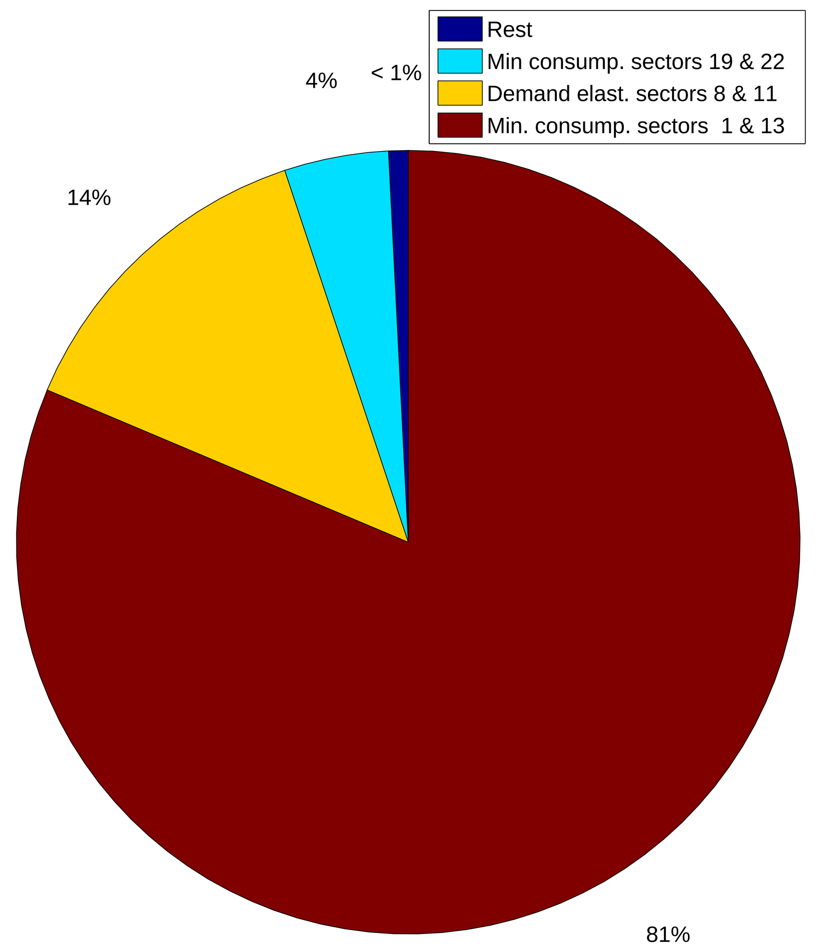
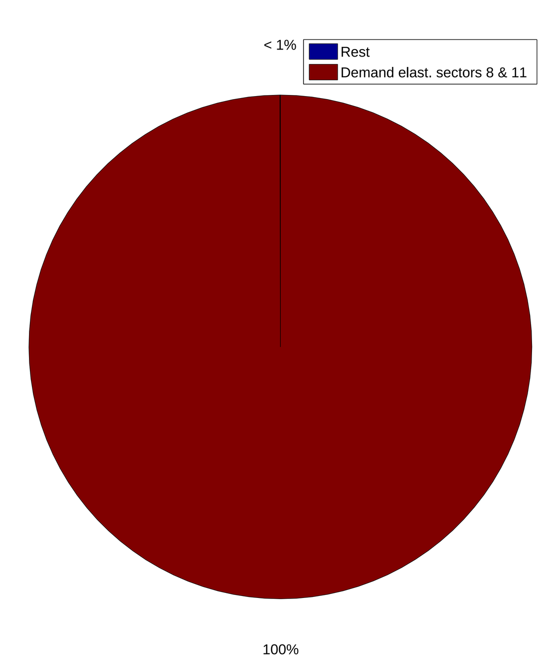
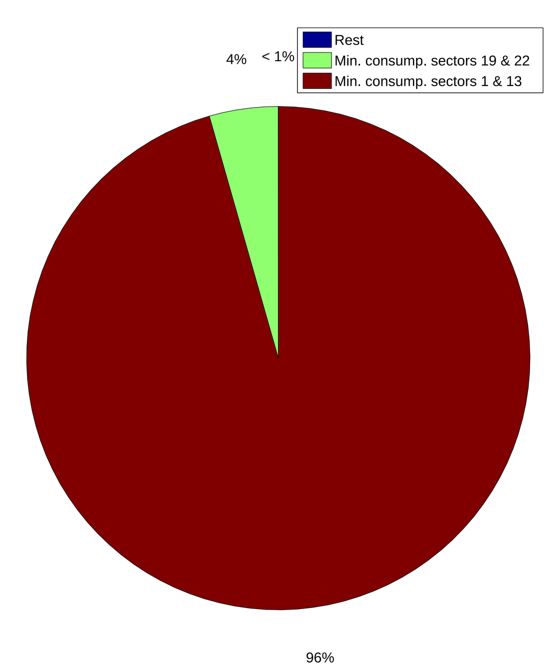


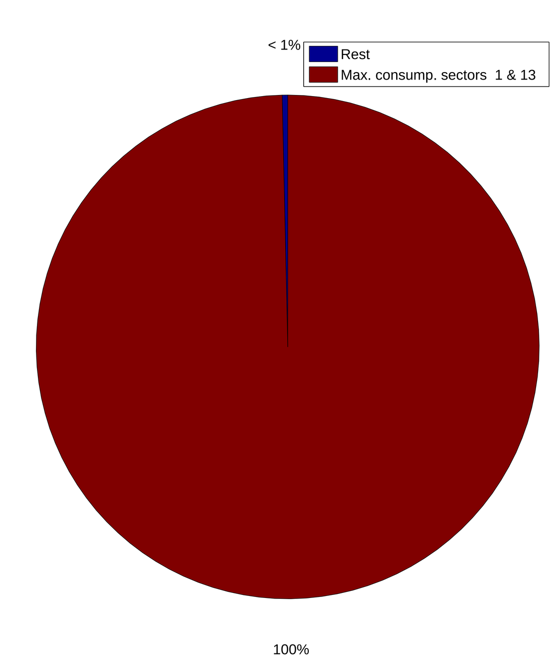

Figure 1: Total effect of the variables on the $QoI$



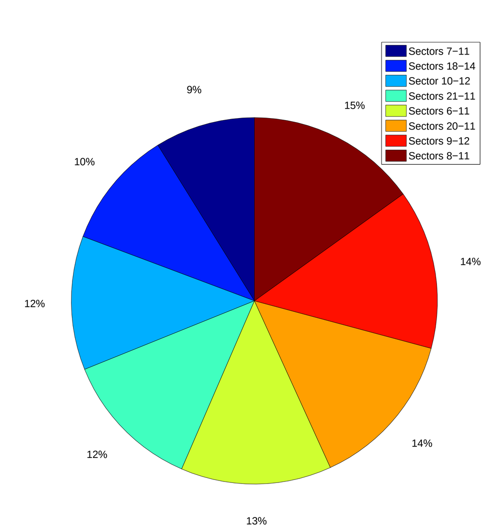

(a) Demand elasticity $\delta^{mn}$.



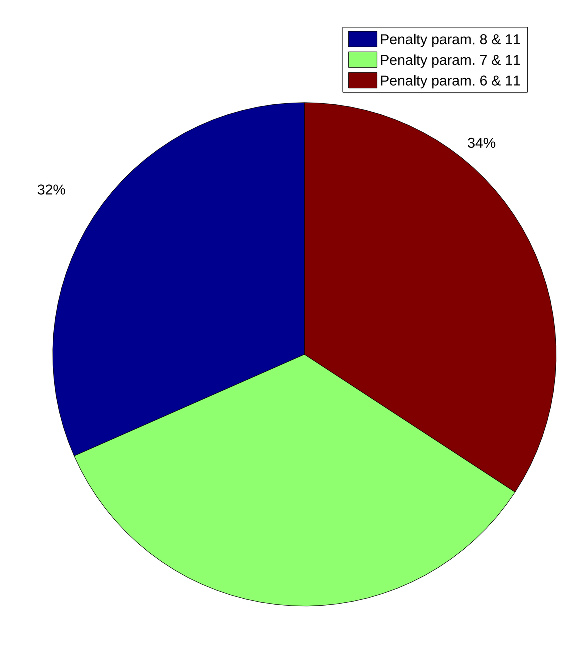

(b) Minimum consumption $\min^{mn}$.



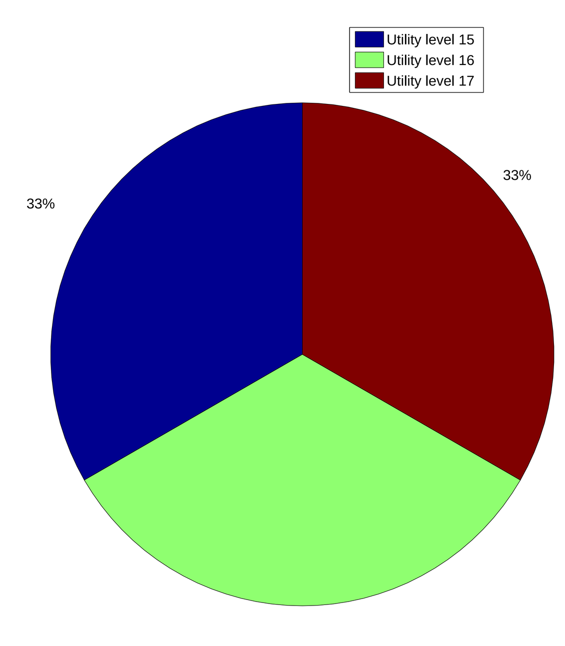

(c) Maximum Consumption $\max^{mn}$.




(d) Demand substitution elasticity $\bar{\omega}^{mn}$.




(e) Penalty parameter $\delta$.




(f) Utility level $\theta^n$

Figure 2: Total effect when only certain type of variable is uncertain

## Conclusions

While estimating the parameters, at least calibrate the variables that have significant impact towards $QoI$ .

## References


[1] T. de la Barra, B. Pérez, and N. Vera. Tranus-j: putting large models into small computers. *Environment and Planning B: Planning and Design*, 11(1):87–101, 1984.

[2] P. Dutta, M. Saujot, E. Arnaud, B. Lefévre, and E. Prados. Uncertainty propagation and sensitivity analysis during calibration of an integrated land use and transport model. In *Proceedings of the 32nd International Conference on Urban, Regional Planning and Transportation, Amsterdam*, volume 65.

[3] A. Saltelli, K. Chan, E.M. Scott, et al. *Sensitivity analysis*, volume 134. Wiley New York, 2000.

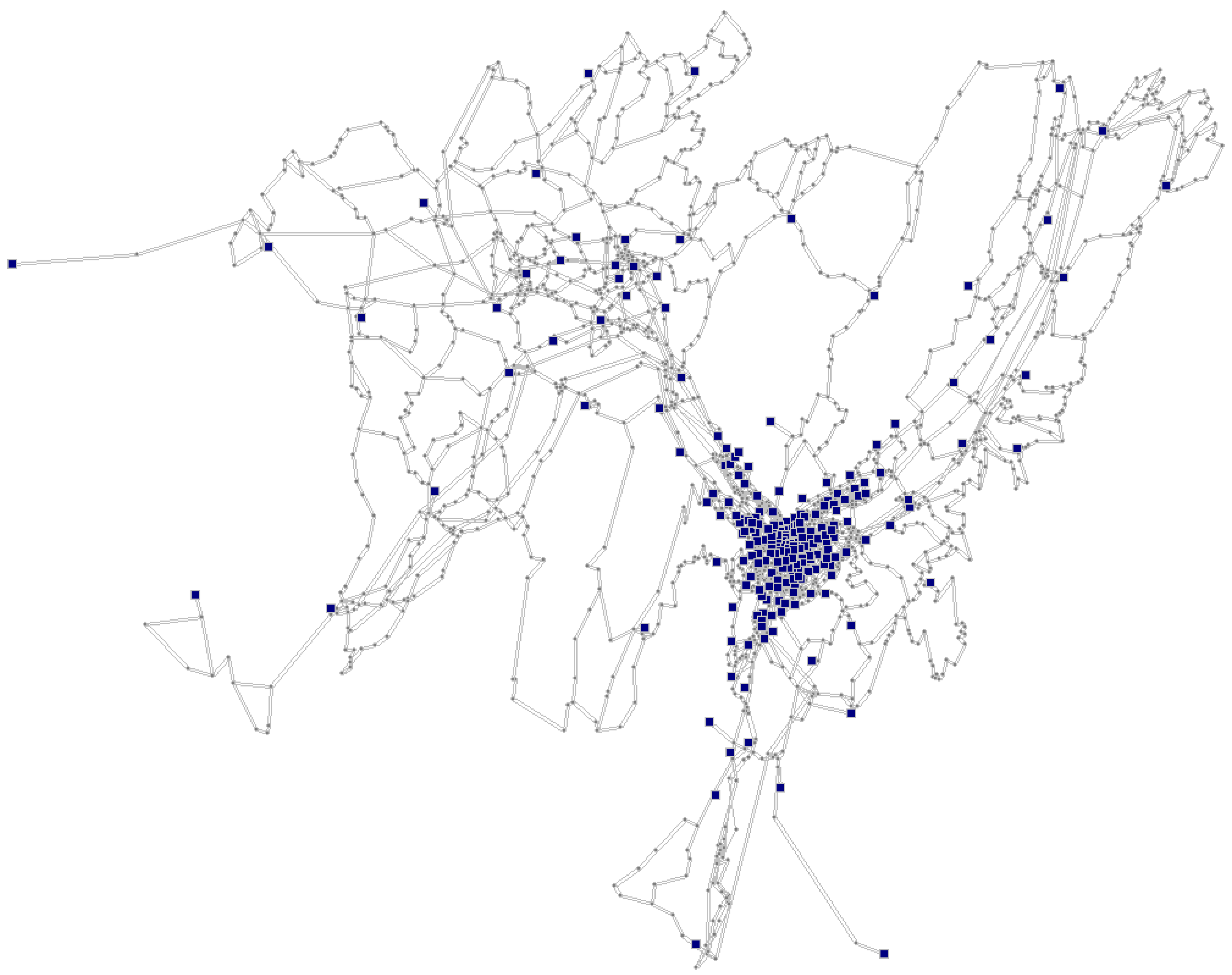



Figure 3: TRANUS Grenoble model.

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