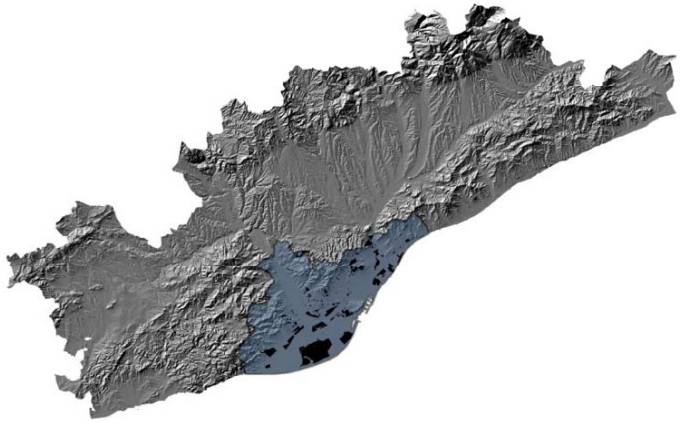

A MODEL TO EVALUATE THE ENVIRONMENTAL AND ENERGETIC EFFICIENCY OF THE TERRITORIAL FUNCTIONALITY (TRANSPORT AND ACTIVITY LOCATION) OF THE METROPOLITAN AREA OF BARCELONA

FUNCIONAL DESIGN AND PRELIMINARY RESULTS

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OUTLLINE

- RESEARCH PROBLEM
- OBJECTIVES AND STRUCTURE
- THE MATHEMATICAL PROCEDURE AND MODEL
- SOME RESULTS
- CONCLUSIONS

THE RESEARCH PROBLEM

- In recent decades, Southwest Europe metropolises have undergone a process of **territorial dispersion**.

- Traditional **view of sustainability** in transport is strong focuses in **technological** factors

- **Transportation plans** (infrastructure) have been evaluated with the classic transport model (four stages). The **optimization** is mainly on private efficiency (of operators and users) of **generalized costs**, with an **assessment of environmental** indicators (GEI emissions, accidents, etc).

- The transport model considers as **exogenous** the structure of urban activities for the base situation, and for different periods of evaluation (scenarios).

- **Urban planning** applied mainly the strategic environmental assessment method, who is focuses in the incorporation of good environmental practices in the different planning stages, **without a quantity evaluation of impacts**.

- **It is not usual the simulation of environmental relation of transport projects and land urban plan, in a systemic approach over a metropolitan scale.**

OBJECTIVES AND STRUCTURE

- Today the **decision makers** required the **assessment, monitoring, and prediction of the externalities generated by transport and urban plans, under a comprehensive approach to the phenomenon**.

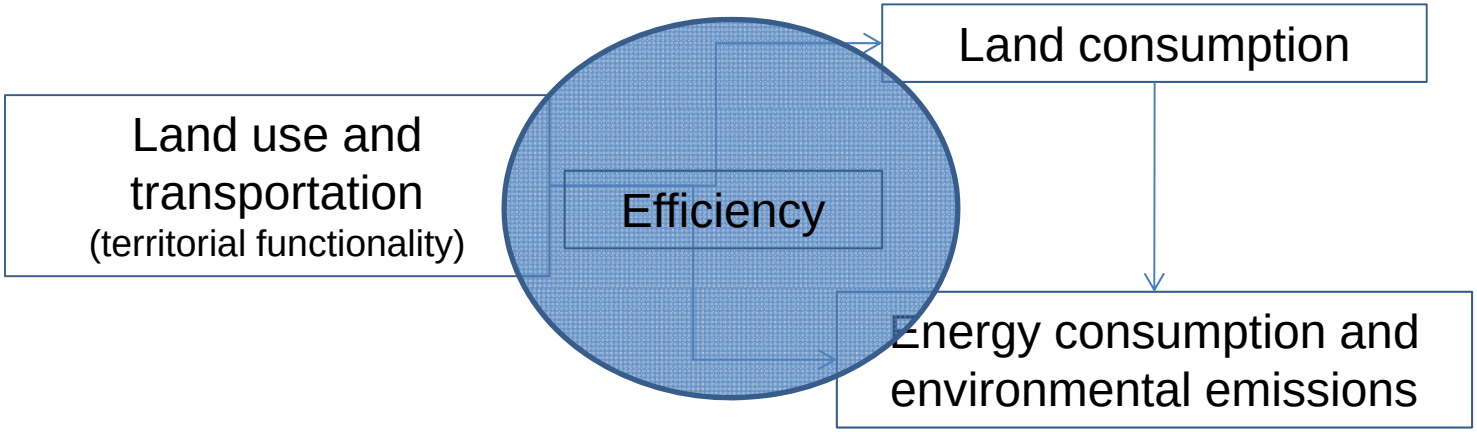
- **Only with this approach can be identify the trade-off between the different elements of the territorial system**.

- The objective of this work is to build a mathematical model for the metropolitan area of Barcelona (164 municipalities), based on an integrated transport and land use model, to assess the social and environmental efficiency of urban functionality in relation to flows and activities in the territories

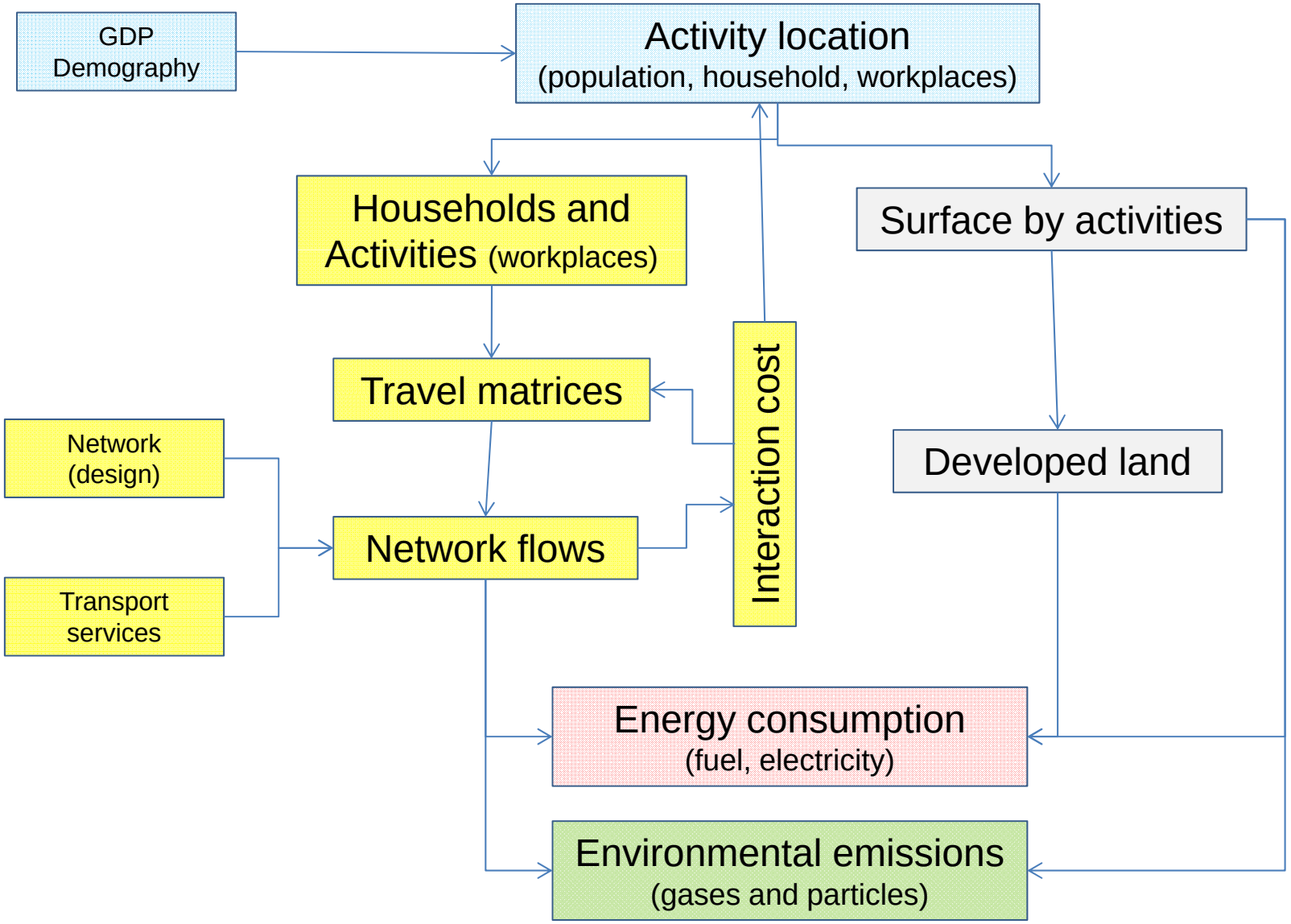
In particular there are four points that underpin the model:

OBJECTIVES AND STRUCTURE

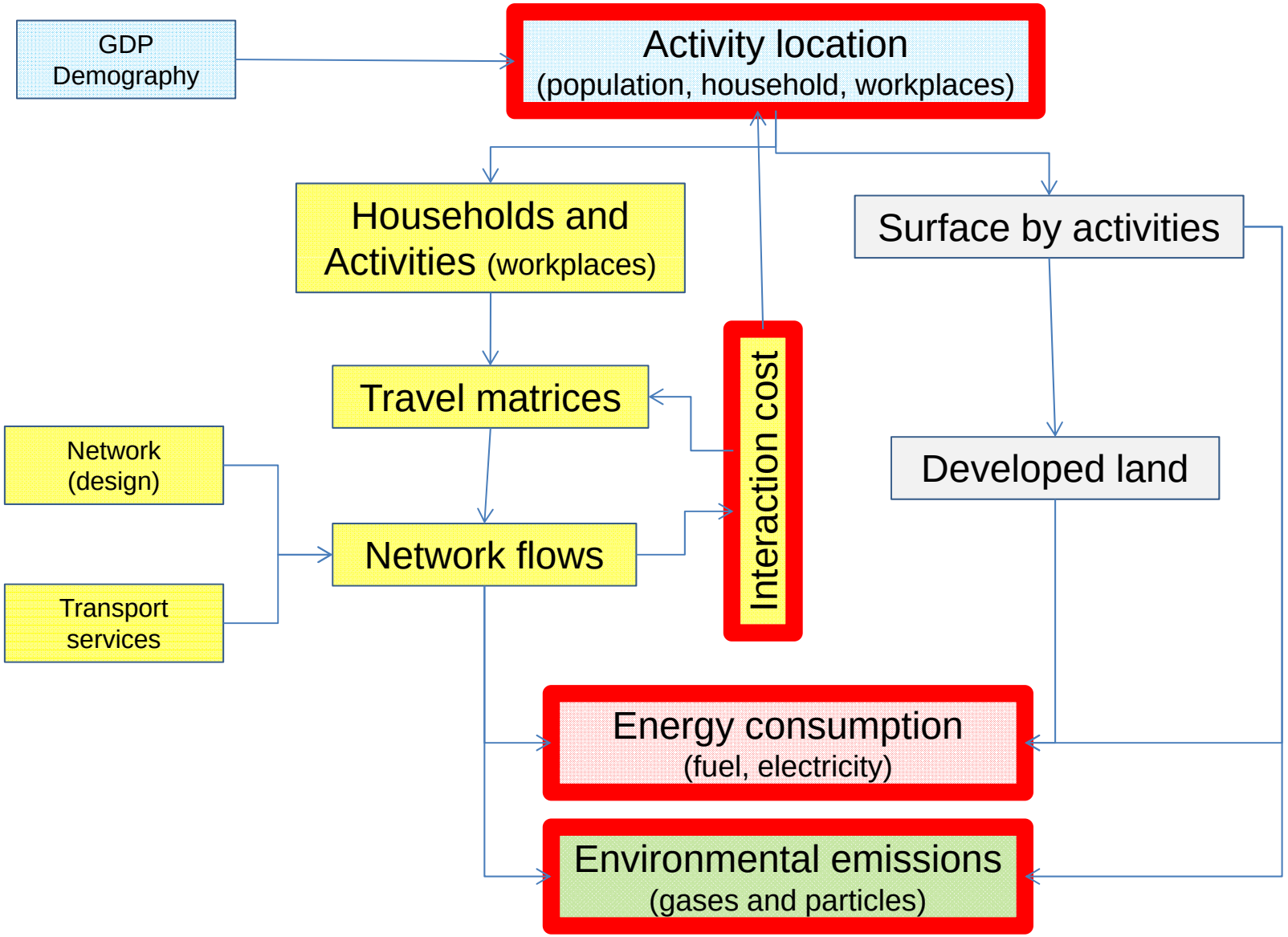
a) A basic land use-transportation model (LUTM)
b) An energy consumption and environmental emissions model (produced by the territorial functionality)
c) A land consumption model (developed land produced by the territorial functionality), and
d) The assessment of social equity (in access to urban activities, and in there exposure to environmental effects) as and indicator of efficiency of the system.



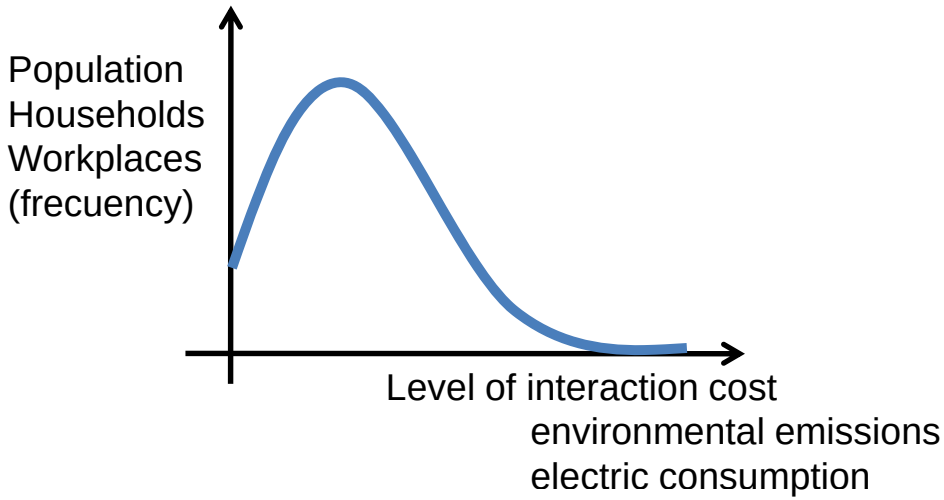
THE MATHEMATICAL PROCEDURE



THE EFFICIENCY ASSESMENT



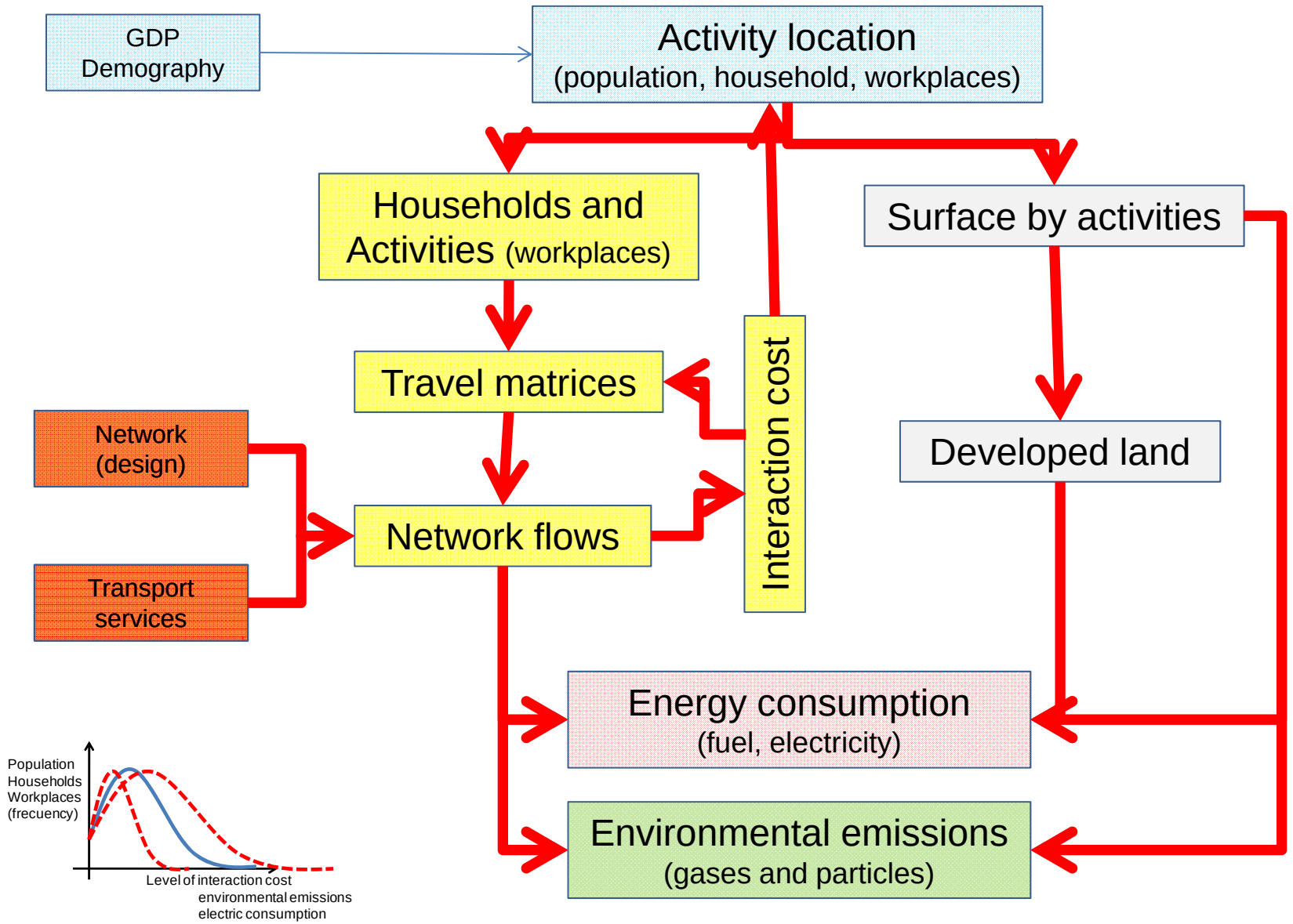
EFFICIENCY INDICATORS



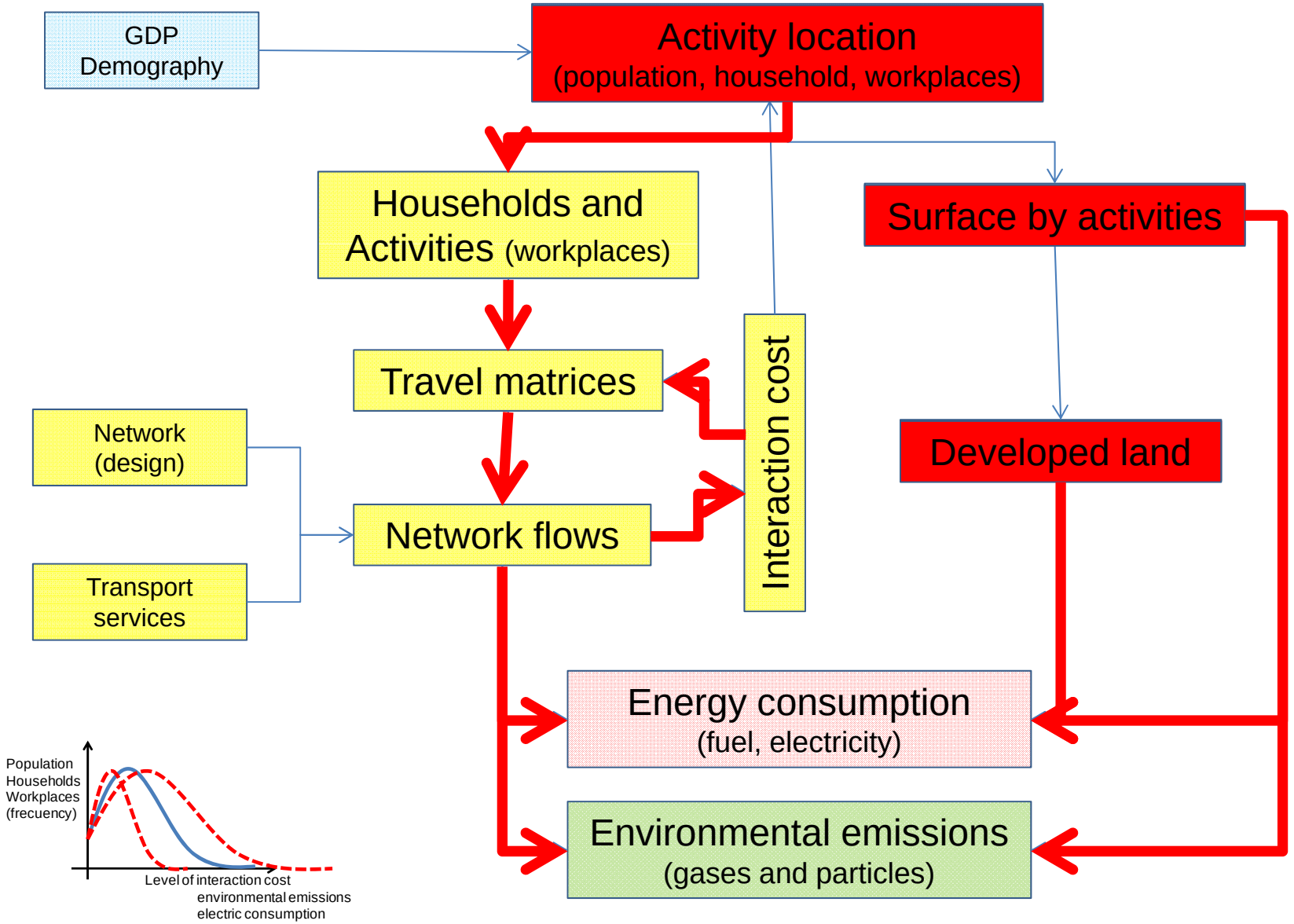
Cuantitative indicators of efficiency

Mean value
Median value
Dispersion of values
Disimilarity – GINI
Disimilarity – Duncan
Exposure

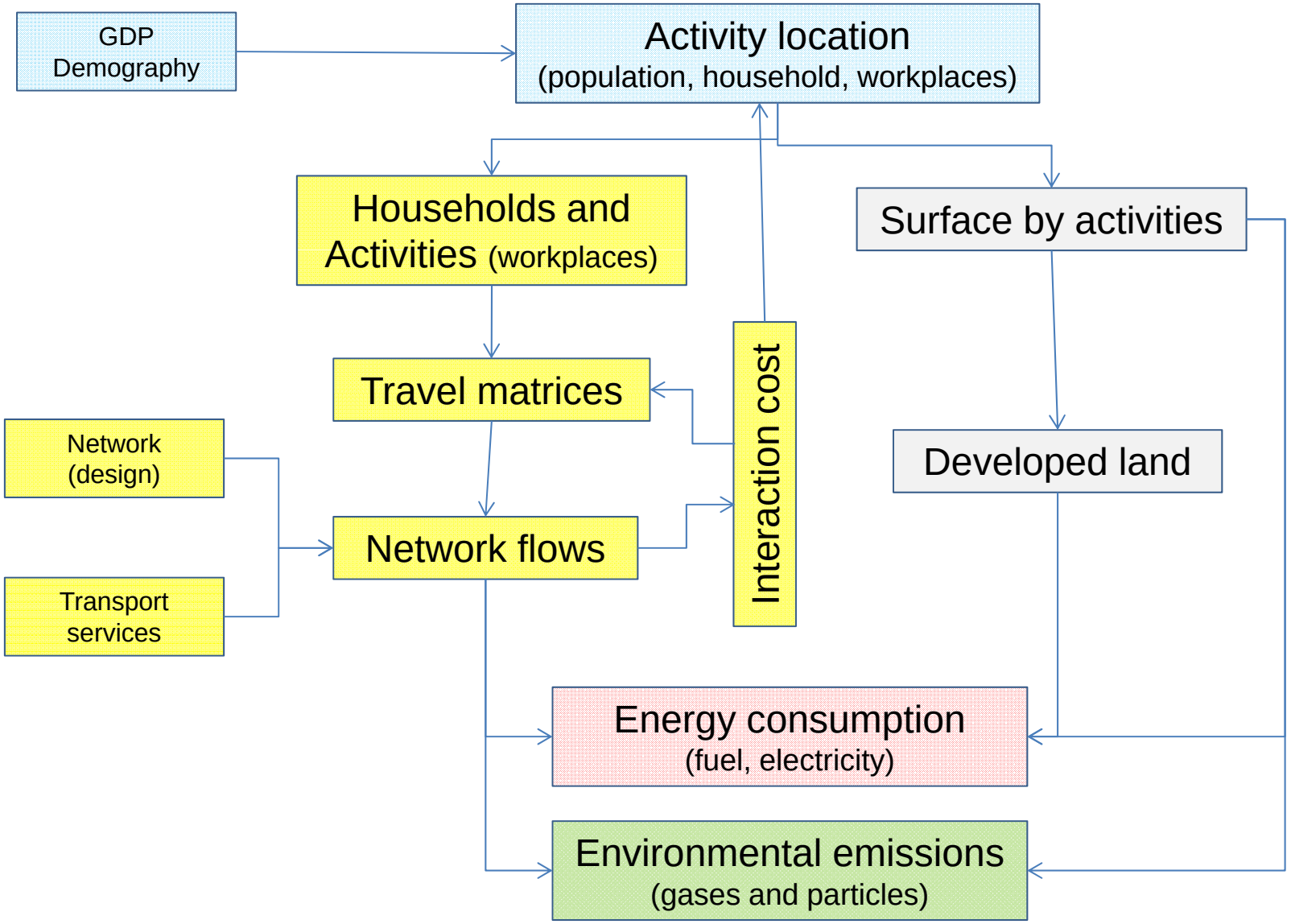
EVALUATION PROCESS : Assessment the effects of A TRANSPORT PROJECT



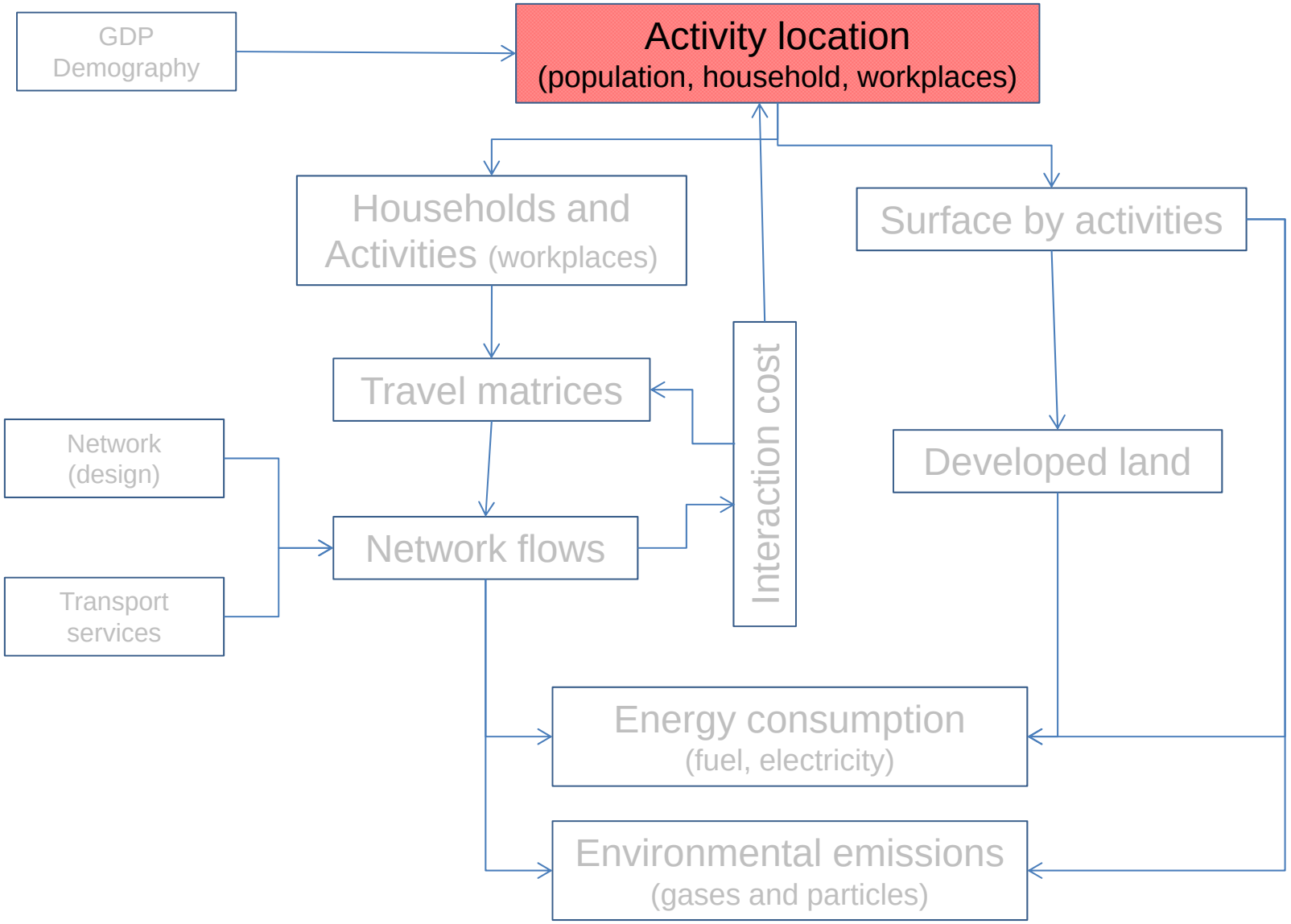
EVALUATION PROCESS : Assessment the effects of **AN URBAN PLAN PROJECT**



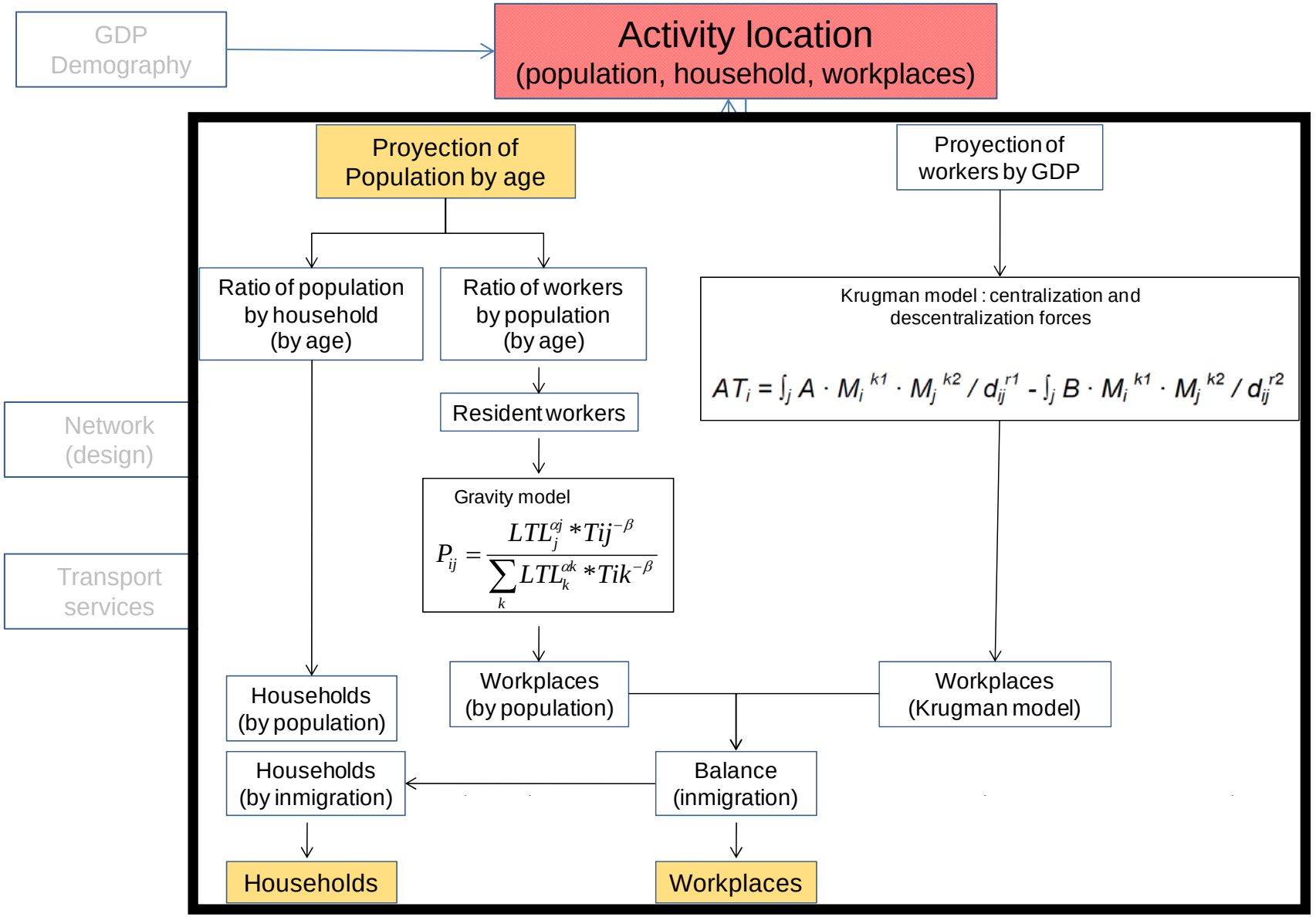
THE MATHEMATICAL MODEL

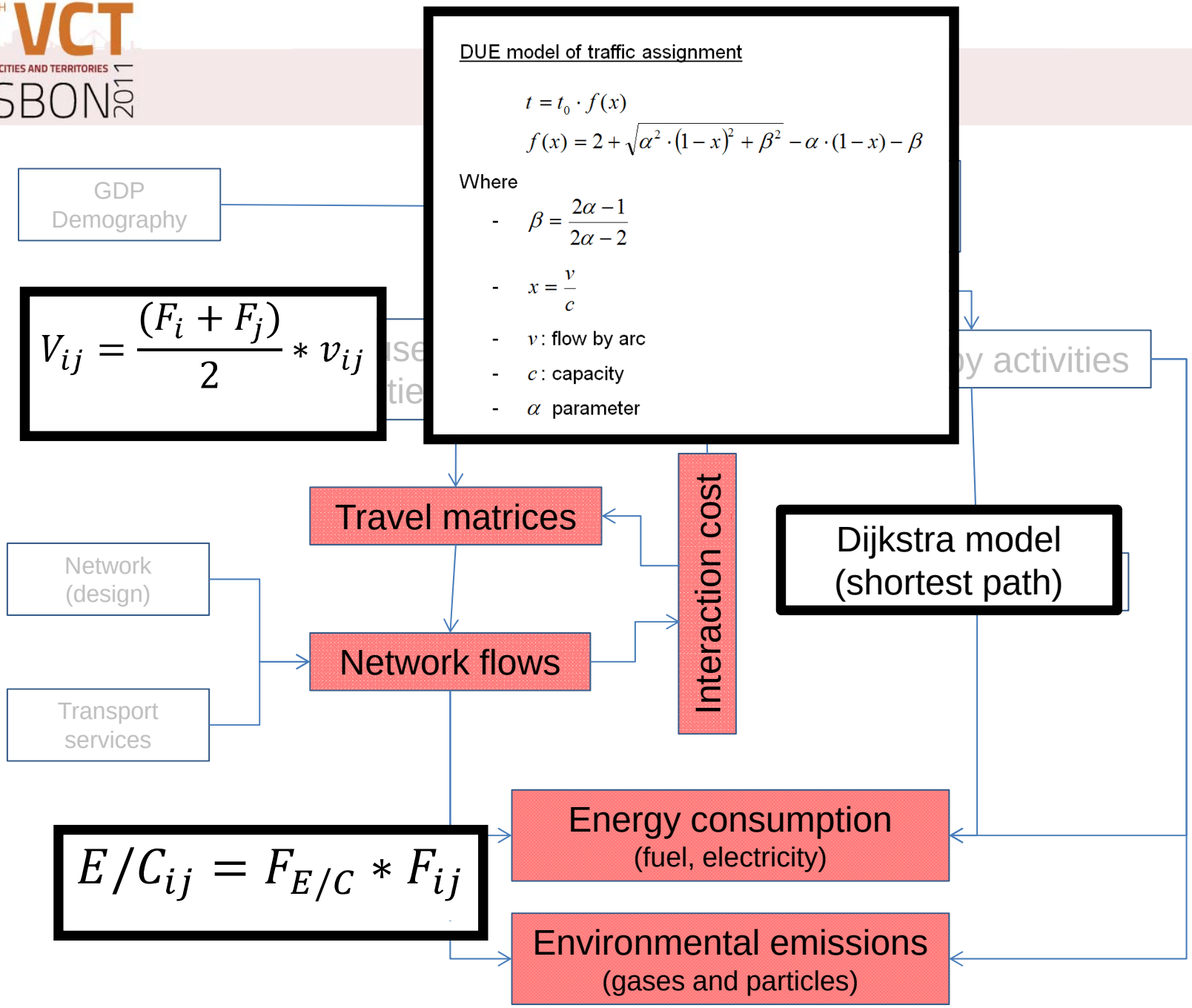


THE MATHEMATICAL MODEL

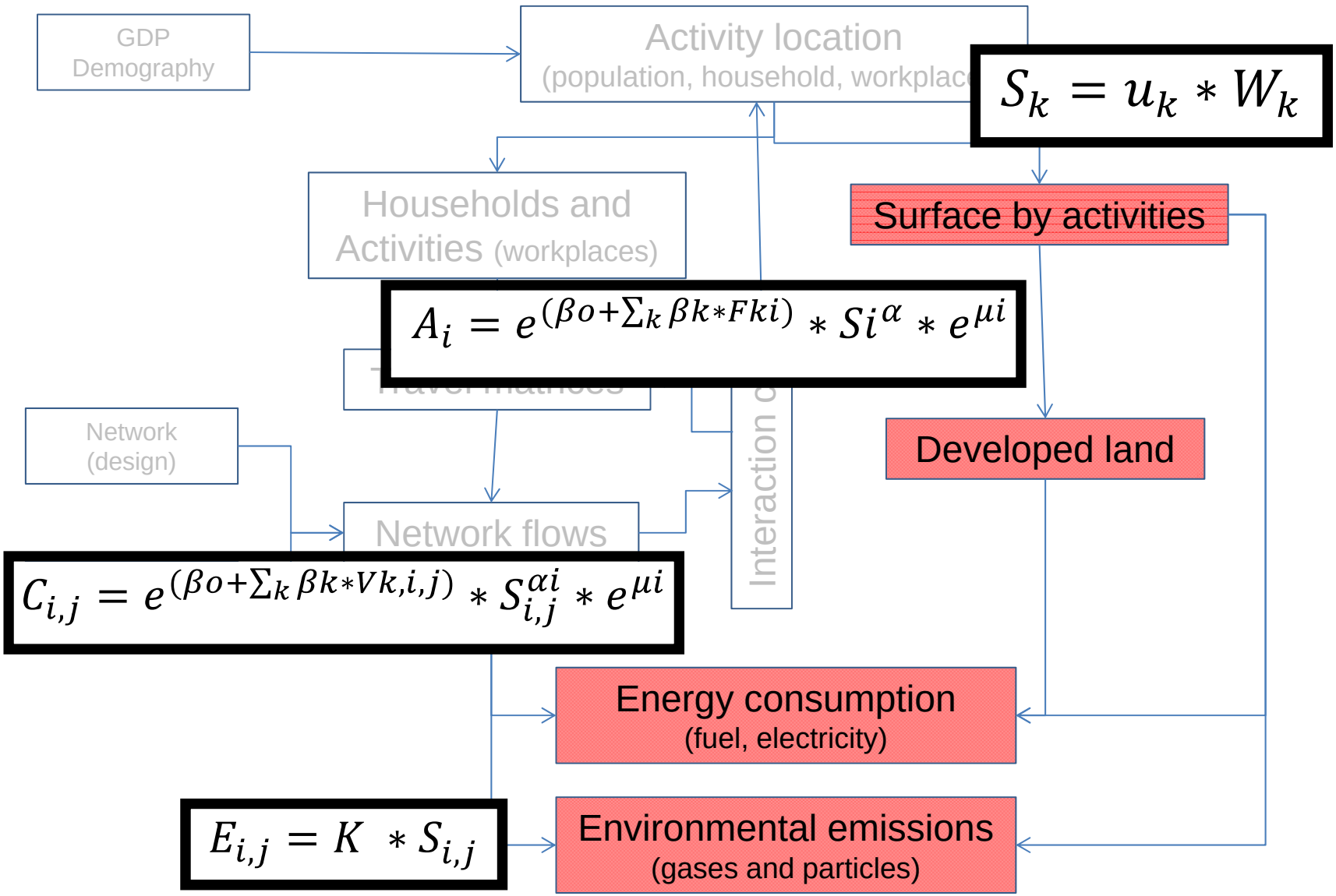


THE MATHEMATICAL MODEL




DUE model of traffic assignment
$t = t_0 \cdot f(x)$
$f(x) = 2 + \sqrt{\alpha^2 \cdot (1-x)^2 + \beta^2} - \alpha \cdot (1-x) - \beta$
Where
- $\beta = \frac{2\alpha - 1}{2\alpha - 2}$
- $x = \frac{v}{c}$
- v: flow by arc
- c: capacity
- α parameter
GDP
Demography
$V_{ij} = \frac{(F_i + F_j)}{2} * v_{ij}$
y activities
Travel matrices
Interaction cost
Dijkstra model
(shortest path)
Network
(design)
Network flows
Transport
services
$E/C_{ij} = F_{E/C} * F_{ij}$
Energy consumption
(fuel, electricity)
Environmental emissions
(gases and particles)

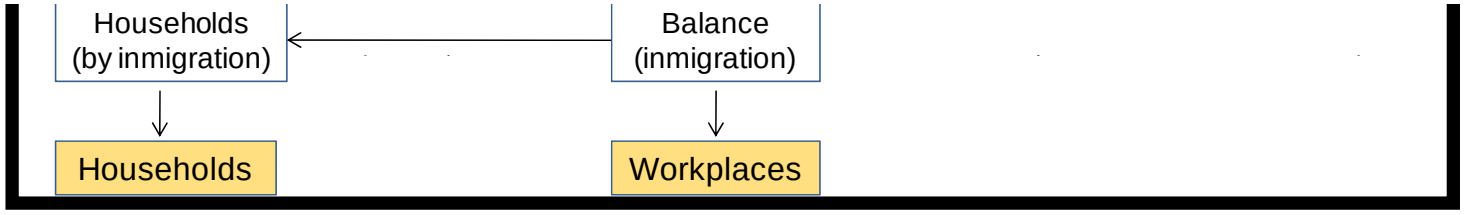
THE MATHEMATICAL MODEL



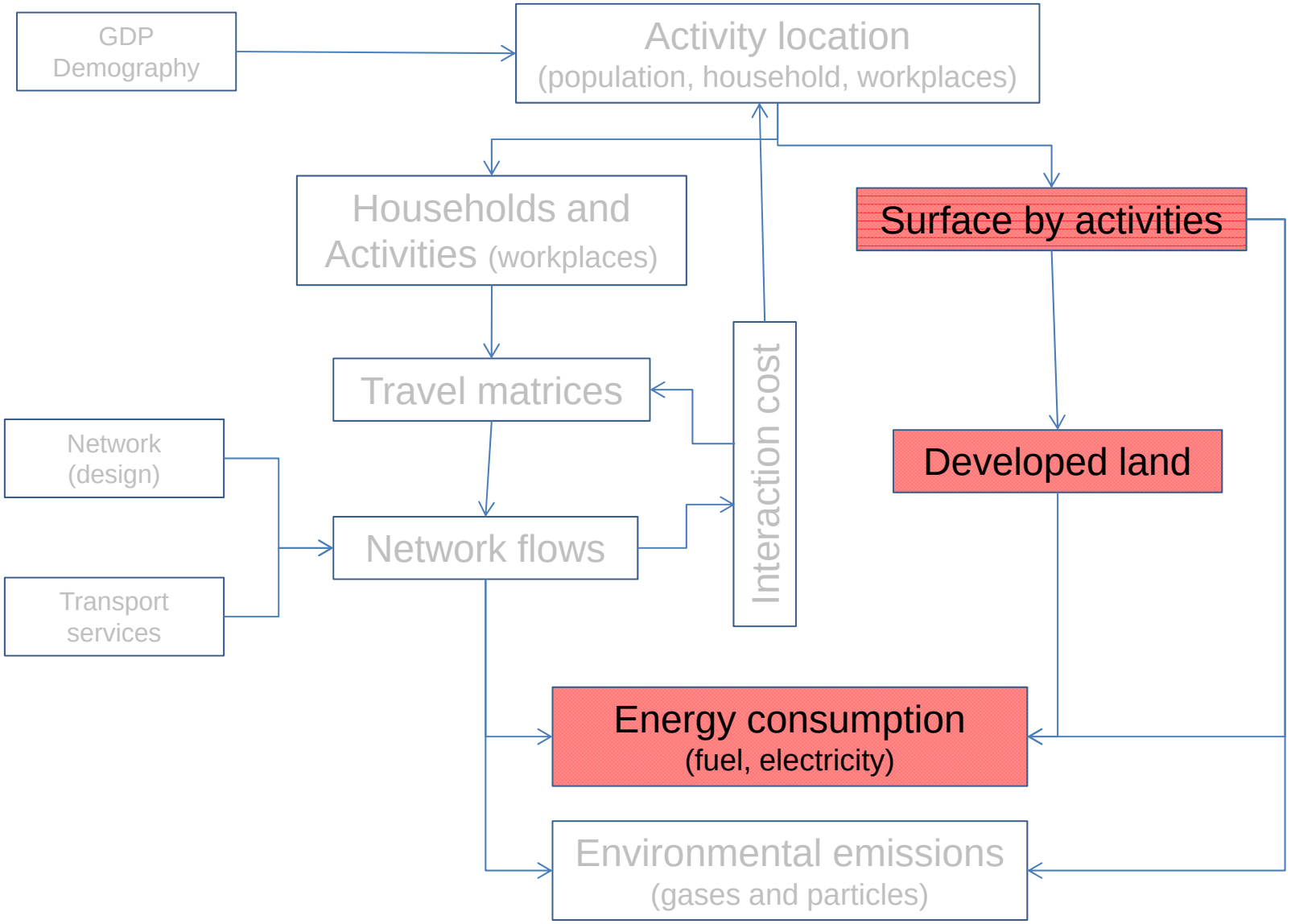
7TH VCT VIRTUAL CITIES AND TERRITORIES LISBON 2011

PRELIMINARY RESULTS

	Auditório A	Auditório B
	P Session 1.4	P Session 2.4
11:30	**Fernandes et al** – *"Micro-simulação de veículos e peões"*	**Schmeidler** – *"Role of urban planning in creation of more sustainable transport networks in user friendlier cities"*
11.45	**Cantergiani** – *"Identificación de componentes espaciales en un MBA"*	**Verones** – *"A Decision Support Tool for Urban Energy Policy"*
12:00	**Marmolejo et al** – *Modelo demográfico-usos de suelo Barcelona*	**Sarralde et al** – *"Urban form, resource intensity & renewable energy potential*
12:15	**Minoura et al** – *"Form and Performance: Urban Territorial Analysis"*	**Delponte et al** – *"The Role of Spatial Planning towards Energy Saving Policies"*
12:30	**Fitch-Osuna et al** – *"Valuación de la producción y organización territorial"*	**Chair: Ilaria Delponte**
12.45	**Chair: Alexandre Peimbert**	

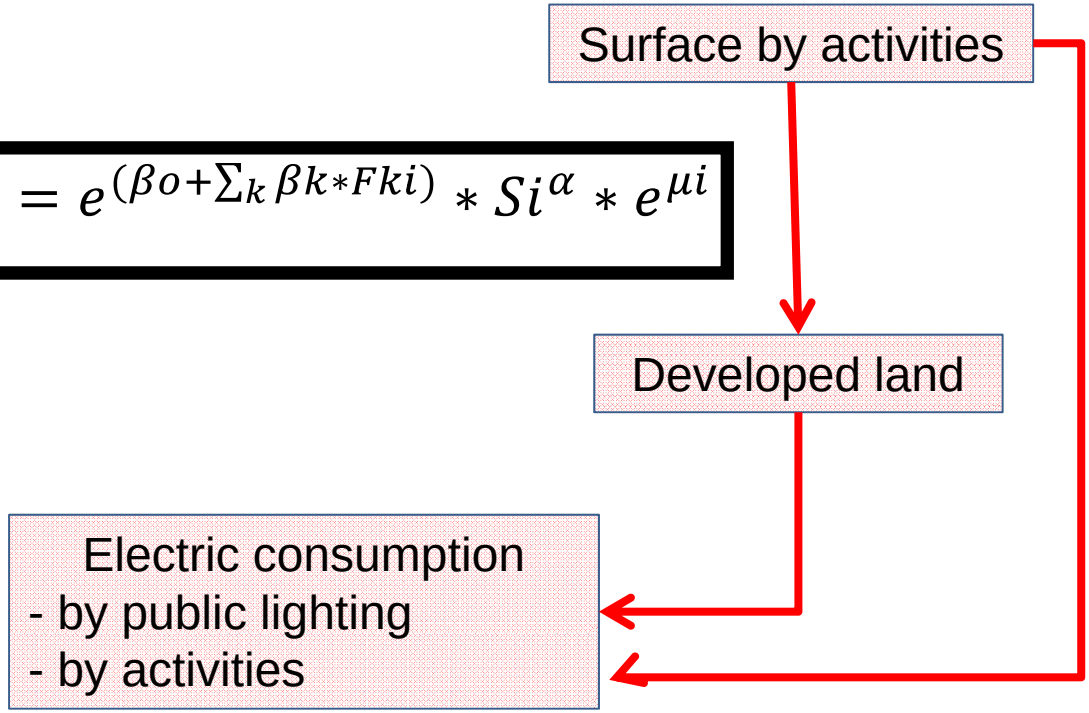


PRELIMINARY RESULTS



PRELIMINARY RESULTS

$$A_i = e^{(\beta o + \sum_k \beta k * Fki)} * Si^{\alpha} * e^{\mu i}$$



PRELIMINARY RESULTS

$$A_i = e^{(-13{,}473 - 0{,}527 * DFi)} * Si^{1{,}058}$$

Where

Ai : developed land produced in the municipality i

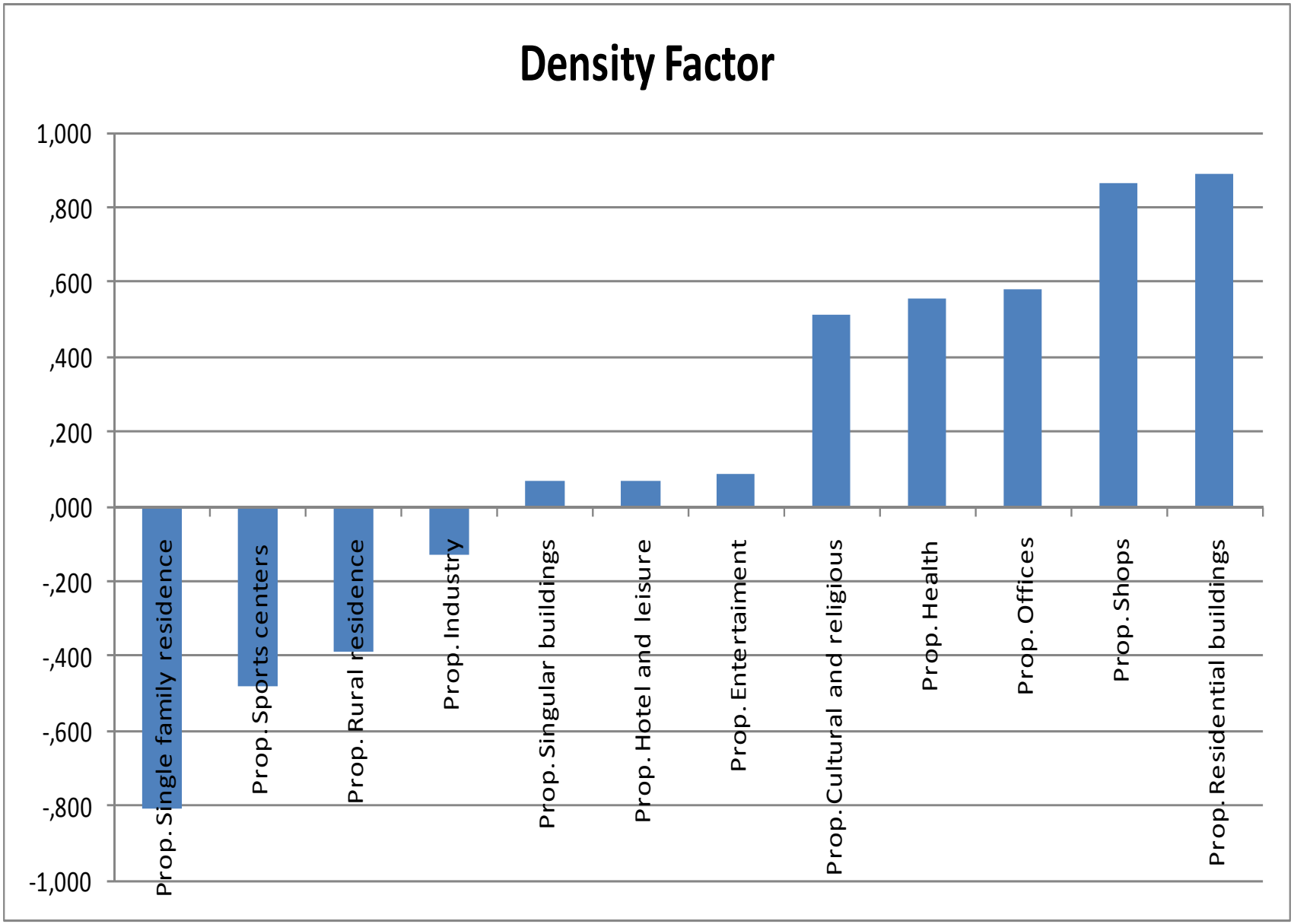
Si : total activity surface in the municipality i

DFi : density factor of municipality i

PRELIMINARY RESULTS

	Main factors				
Original variables	**F1**	**F2**	**F3**	**F4**	**F5**
Prop. Residential buildings	**,890**	,238	-,078	,028	-,142
Prop. Single family residence	**-,808**	**,412**	,118	-,126	,012
Prop. Rural residence	**-,389**	-,148	-,169	**,605**	,151
Prop. Industry	-,126	**-,912**	,039	,026	,069
Prop. Offices	**,580**	**-,488**	**,332**	-,065	,005
Prop. Shops	**,864**	,073	-,170	-,105	-,007
Prop. Sports centers	**-,479**	**,546**	,287	-,071	-,041
Prop. Entertaiment	,085	,131	-,295	,185	**,830**
Prop. Hotel and leisure	,069	,118	**-,597**	**-,592**	,117
Prop. Health	**,557**	**,381**	,252	,116	,241
Prop. Cultural and religious	**,511**	**,397**	,149	**,374**	-,110
Prop. Singular buildings	,068	-,071	**,657**	**-,368**	**,441**

PRELIMINARY RESULTS



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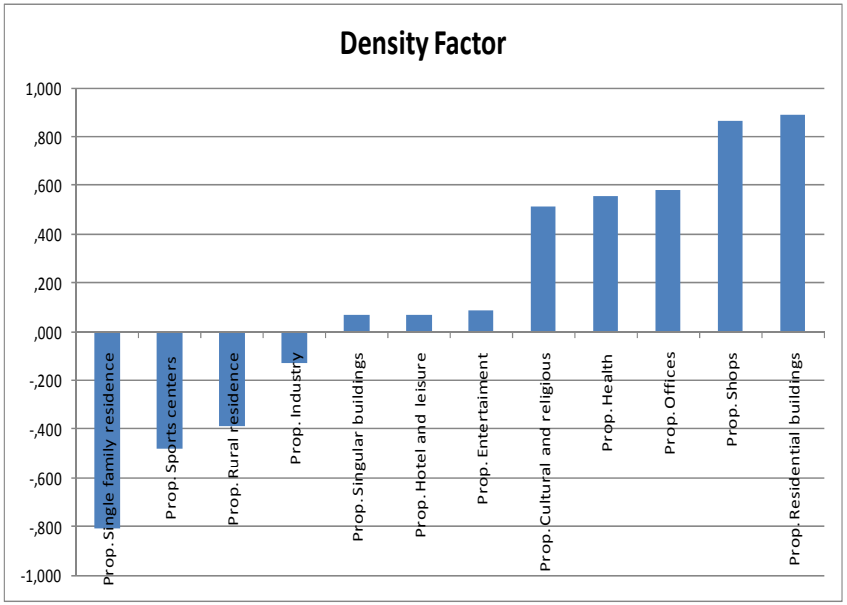
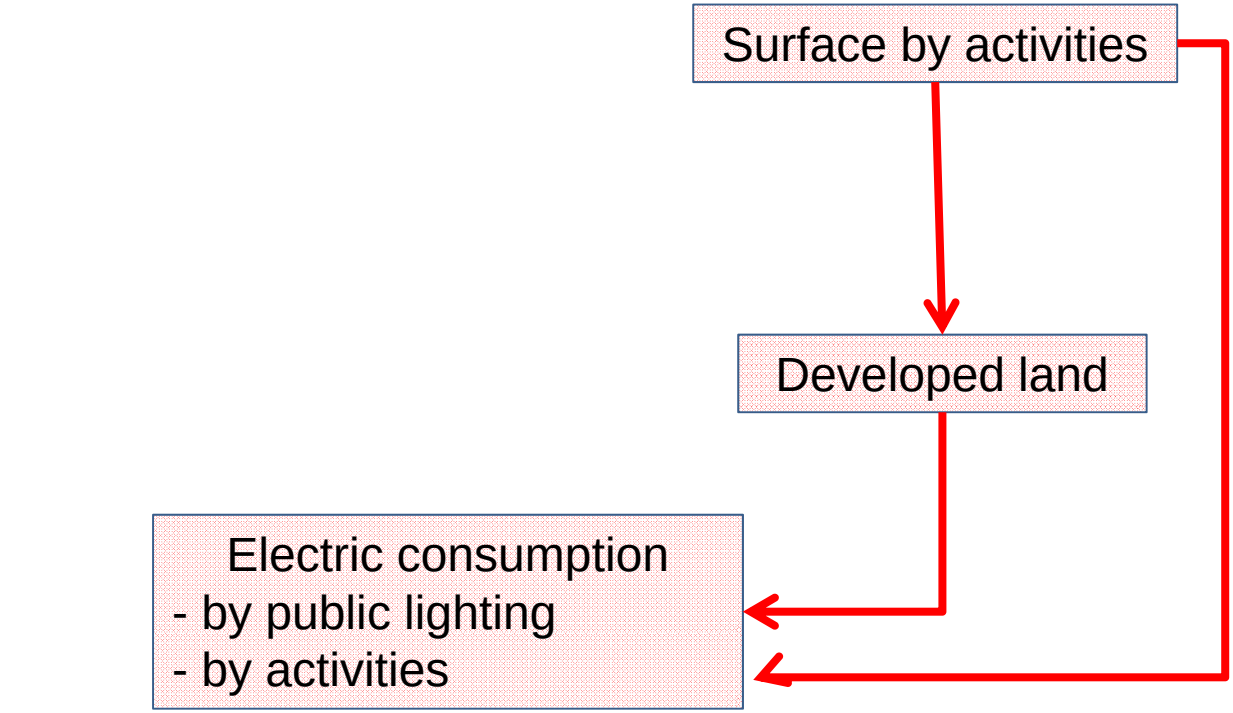


PRELIMINARY RESULTS



$$C_{i,j} = e^{(\beta o + \sum_k \beta k * Vk,i,j)} * S_{i,j}^{\alpha i} * e^{\mu i}$$

PRELIMINARY RESULTS

Activity	Annual electric consuption (Kwh 2005)	%	Built surface (m2 2005)	%
Industry	7.030.724.574	**38,0**	57.126.766	14,2
Residence	5.792.747.971	31,3	257.597.812	**64,2**
Shops	2.159.251.967	11,7	23.469.345	5,9
Transport and comunication	764.144.468	4,1	21.190.966	5,3
Health	666.538.743	3,6	3.500.726	0,9
Hotels	426.138.862	2,3	4.843.349	1,2
Personal services	415.165.810	2,2	22.553.418	5,6
Public administration	218.896.512	1,2	1.399.358	0,3
Financial services	217.414.542	1,2	1.504.748	0,4
Education	101.702.346	0,5	7.909.588	2,0
Public lighting system	705.920.396	3,8		
Total	**18.498.646.190**	**100,0**	**401.096.076**	**100,0**

$$C_{i,j} = e^{(\beta o + \sum_k \beta k * Vk,i,j)} * S_{i,j}^{\alpha i} * e^{\mu i}$$

	Electric consumption models										
Variables	**Residence**	**Public administration**	**Shops**	**Education**	**Financial services**	**Hotels**	**Industry**	**Health**	**Personal services**	**Transport and comunication**	**Public lighting system**
Constant	1,207	-7,763	2,718	4,489	6,221	3,335	-5,965	7,722	-7,698	-8,388	10,496
Ln (residence surface)	**1,001**										
Ln (Public administration surface)		**,764**									
Ln (Shops surface)			**,921**								
Ln (Education surface)				**,847**							
Ln (Financial services surface)					**,868**						
Ln (Hotels surface)						**,377**					
Ln (Industry surface)							**1,138**				
Ln (Health surface)								**,793**			
Ln (Personal services surface)									**1,200**		
Ln (Transport and comunication surface)										**,514**	
Summer minimum temperature	**,106**		**,161**			**,477**			**,427**		
Summer average temperature		**,686**					**,346**			**,814**	
Average working time							**,158**				
Average time of personal engagement					**,164**						
Ln(Total developed land)											**1,326**
% developed land between cadastral areas											**10,454**
Adjust R square	**,909**	**,531**	**,725**	**,696**	**,773**	**,448**	**,638**	**,705**	**,543**	**,511**	**,546**

FINAL REMARKS

- The model is currently under construction, joining the calibrated models of consumption and environmental emissions to an existing transport model in the metropolitan area of Barcelona (SIMCAT).

- The functional design of the process has been adapted to the availability of information for the different sub-models and procedures.

- An important learning is that it is necessary to maintain consistency throughout the procedures, in scale and complexity of the different models/analysis. This means that it must integrate appropriate techniques in each dimension, but not the more complex developments, because the global model requires consistent inputs and outputs between dimensions.

- The current calibrated models shows good performance (adjust, significance, etc). Although the errors are significant

- The use under a differential approach (difference of the situation with and without project), subtracts the absolute estimation error, giving validity to the measure of the effect of a project or plan.

This research was funded by…

THANKS FOR YOUR ATTENTION