VILNIUS GEDIMINAS
TECHNICAL UNIVERSITY
FACULTY OF CIVIL ENGINEERING

TECHNOLOGY FORESIGHT AND SCENARIO PLANNING IN ENGINEERING

Professor Joanicjusz Nazarko, DSc, PhD, Eng

Łukasz Nazarko, PhD

Bialystok University of Technology, Poland

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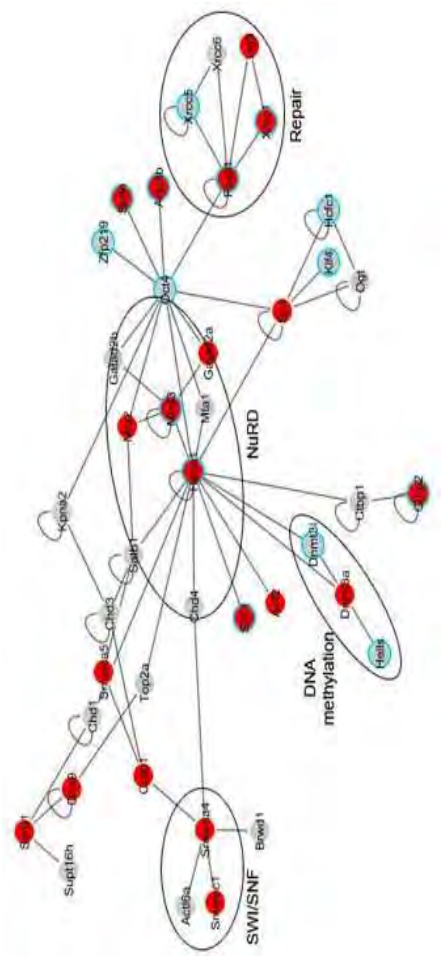
PART IV

- ✓ Description and Explanation of Selected Foresight Methods: Structural Analysis

Structural Analysis (Cross-Impact Analysis)

http://www.sanger.ac.uk/about/press/2010/100401-stemcells.html



Structural analysis is a tool enabling its user to sort out and analyze sets involving a large number of factors influencing one another. By examining relationships between seemingly unrelated factors, this method allows to determine their mutual interactions and relationships, and based on these relationships to extract the key factors.

Source: Nazarko J. (ed.), Wnorowski H. (ed.), Kononiuk A. (ed.), *Analiza strukturalna czynników rozwoju nanotechnologii w województwie podlaskim*. Oficyna Wydawnicza Politechniki Białostockiej, Białystok 2011.

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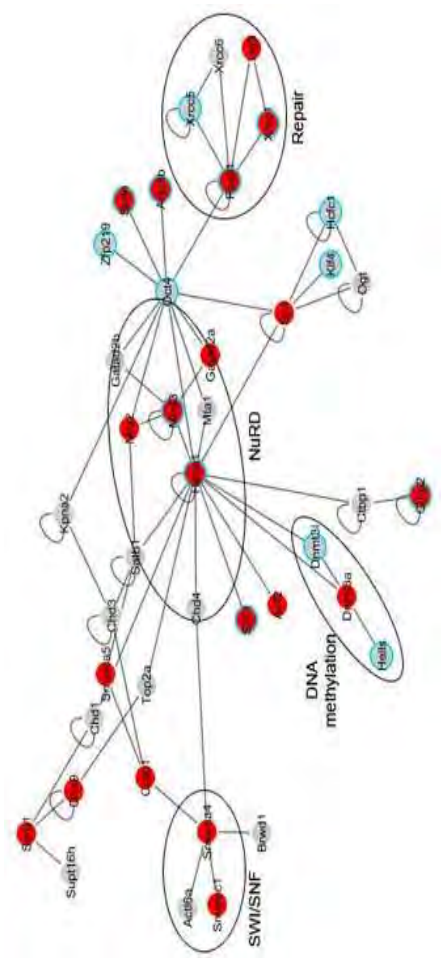

http://www.sanger.ac.uk/about/press/2010/100401-stemcells.html

Structural analysis is a tool that structures the **pooling of ideas**. This form of analysis describes a system using a matrix which combines the constituent components of the system.

This method identifies the main variables which are both **influential** and **dependent** : those which are essential to the **evolution of the system**.

The **advantage** of structural analysis is that it stimulates thought and generates ideas among group members, thus encouraging them to think about many aspects of how a system works.

The **limitations** concern the subjective nature of the list of variables drawn up during the first phase.

Source: Nazarko J. (ed.), Wnorowski H. (ed.), Kononiuk A. (ed.), *Analiza strukturalna czynników rozwoju nanotechnologii w województwie podlaskim*. Oficyna Wydawnicza Politechniki Białostockiej, Białystok 2011.

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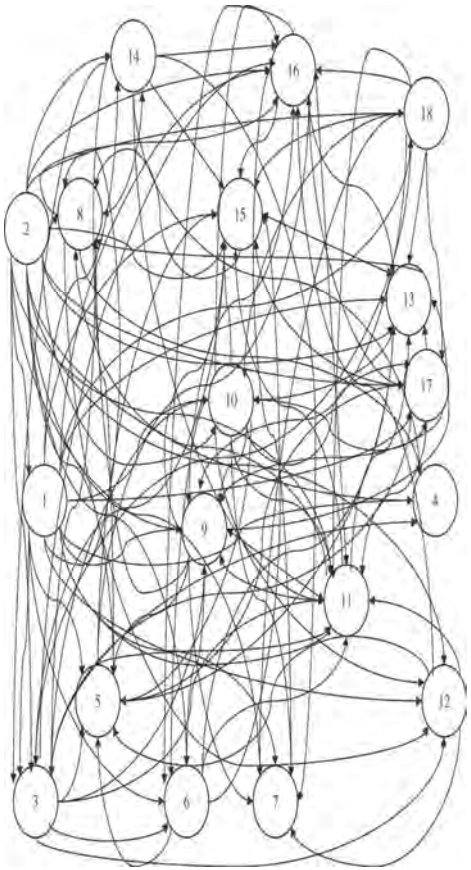


http://www.informaworld.com/smpp/section?content=a781526935&fulltext=713240928

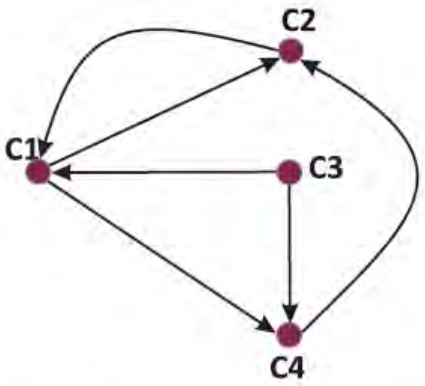
Stages of the analysis:

1. Creation of the inventory of variables/factors that may turn out to be the stake (key) factors - STEEPVL
2. Grouping of the variables/factors into the STEEPVL categoriers
3. Description of relationships between variables – creation of the Structural Matrix
4. Processing the Structural Matrix in MICMAC software
5. Identification of essential groups of variables: stake (key), target, result, autonomous, determinant, external, secondary, regulating

Źródło : J. M. Wójcicki (red.), P. Ładażyński (red.), *System monitorowania i scenariusze rozwoju technologii medycznych w Polsce*, Konsorcjum ROTMED, Warszawa 2008, s. 207.

Structural Analysis (Cross-Impact Analysis)

Graph of system **A**



Structural matrix of system A (of direct influences)

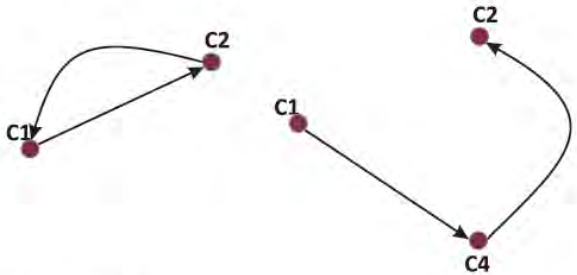
A

	C1	C2	C3	C4	Influence
C1	0	1	0	1	**2**
C2	1	0	0	0	**1**
C3	1	0	0	1	**2**
C4	0	1	0	0	**1**
Dependence	**2**	**2**	**0**	**2**	

Source: Nazarko J. (ed.), Wnorowski H. (ed.), Kononiuk A. (ed.), *Analiza strukturalna czynników rozwoju nanotechnologii w województwie podlaskim.* Oficyna Wydawnicza Politechniki Białostockiej, Białystok 2011.

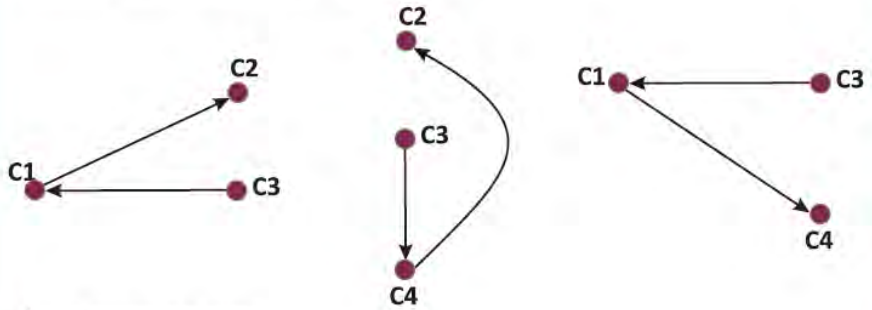
Structural Analysis (Cross-Impact Analysis)

Ścieżki wpływu czynnika C1 o długości 2



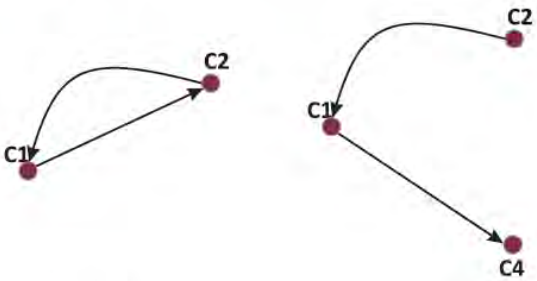
Źródło: opracowanie własne.

Ścieżki wpływu czynnika C3 o długości 2



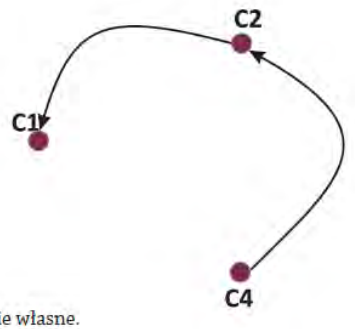
Źródło: opracowanie własne.

Ścieżki wpływu czynnika C2 o długości 2



Źródło: opracowanie własne.

Ścieżka wpływu czynnika C4 o długości 2



Źródło: opracowanie własne.

Źródło: Nazarko J. (red.), Wnorowski H. (red.), Kononiuk A. (red.), *Analiza strukturalna czynników rozwoju nanotechnologii w województwie podlaskim.* Oficyna Wydawnicza Politechniki Białostockiej, Białystok 2011.

Structural Analysis (Cross-Impact Analysis)

A^2	C1	C2	C3	C4	Influence
C1	1	1	0	0	**2**
C2	0	1	0	1	**2**
C3	0	2	0	1	**3**
C4	1	0	0	0	**1**
Dependence	**2**	**4**	**0**	**2**	

Source: Nazarko J. (red.), Wnorowski H. (red.), Kononiuk A. (red.), *Analiza strukturalna czynników rozwoju nanotechnologii w województwie podlaskim.* Oficyna Wydawnicza Politechniki Białostockiej, Białystok 2011.

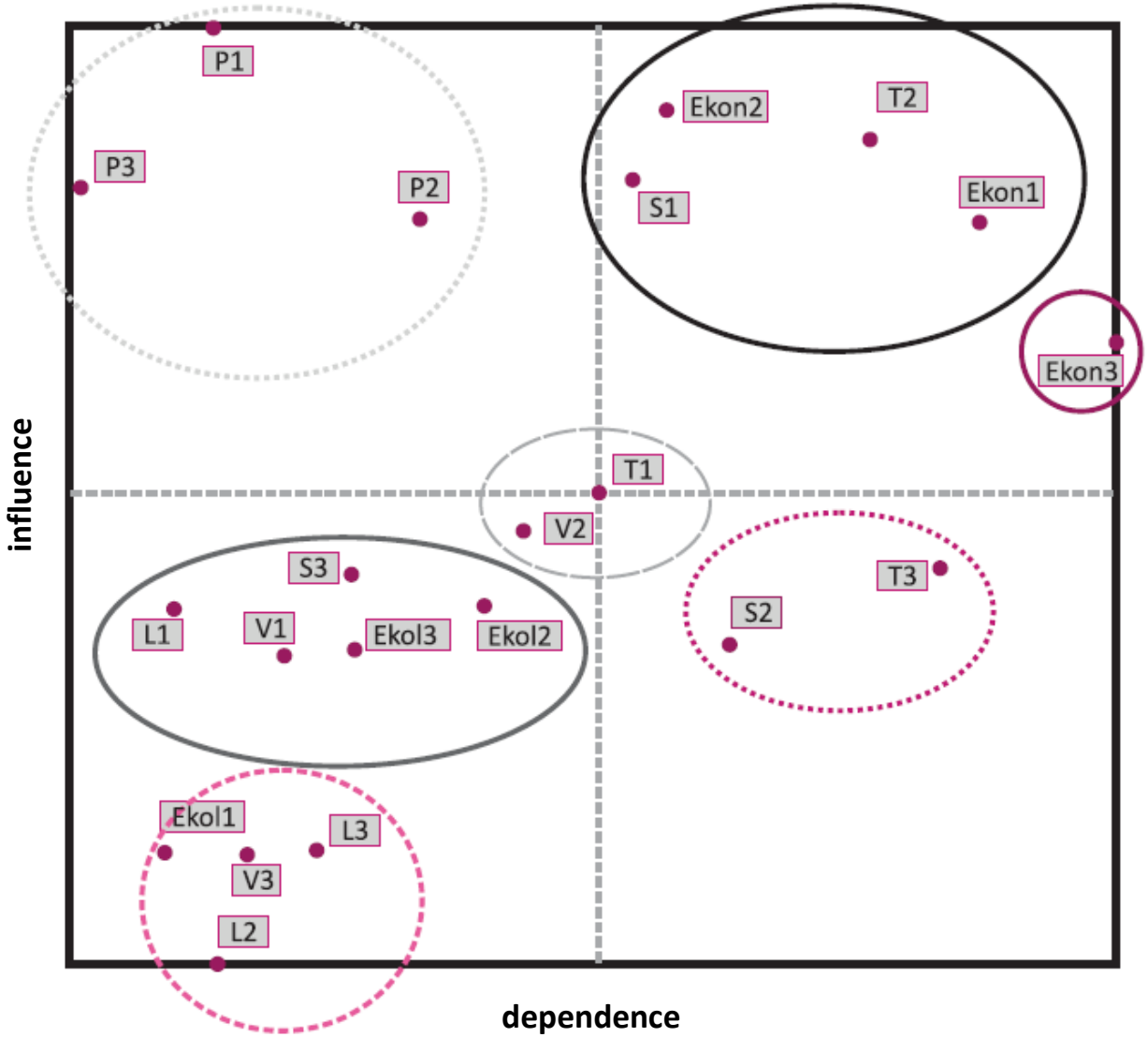
Structural Analysis (Cross-Impact Analysis)

A^3

	C1	C2	C3	C4	Influence
C1	1	1	0	1	3
C2	1	1	0	0	2
C3	2	1	0	0	3
C4	0	1	0	1	2
Dependence	4	4	0	2	

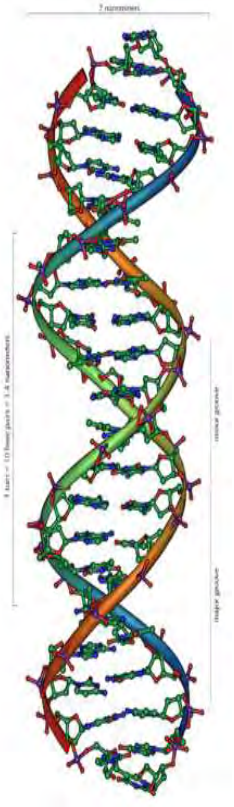
Source: Nazarko J. (red.), Wnorowski H. (red.), Kononiuk A. (red.), *Analiza strukturalna czynników rozwoju nanotechnologii w województwie podlaskim.* Oficyna Wydawnicza Politechniki Białostockiej, Białystok 2011.

Structural Analysis



- *stake* factors
- *target* factors
- *result* factors
- *autonomous* factors
- *determinant* factors
- *external* factors
- *secondary* factors
- *regulating* factors

Types of facors (variables) in structural analysis (1)



http://www.thehealthcareblog.com/photos/uncategorized/2008/10/21/dna.png

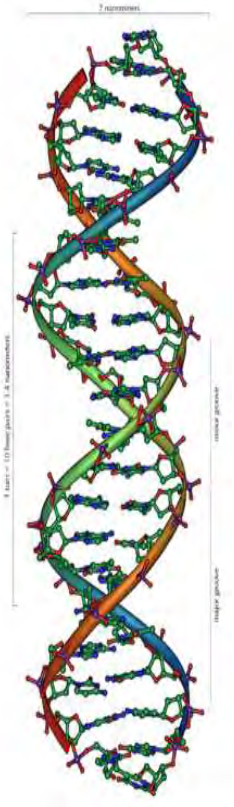
1. **Stake (key) variables** (strategic) – have high influence on other variables and at the same time they strongly depend on other variables. They generally have a great impact on the system and are the factors of instability.

2. **Target variables** – are more dependent that influent. They can be considered as resulting from the system's evolution and they represent possible objectives for the system.

3. **Determinant variables** – are very influent and little dependent. Most of the system depends on these variables. They are also considered as entry variables in the system. They may be a driving force or factors of inertia for the system.

Źródło : J. M. Wójcicki (red.), P. Ładażyński (red.), *System monitorowania i scenariusze rozwoju technologii medycznych w Polsce*, Konsorcjum ROTMED, Warszawa 2008, s. 198.

Types of facors (variables) in structural analysis (2)



http://www.thehealthcareblog.com/photos/uncategorized/2008/10/21/dna.png

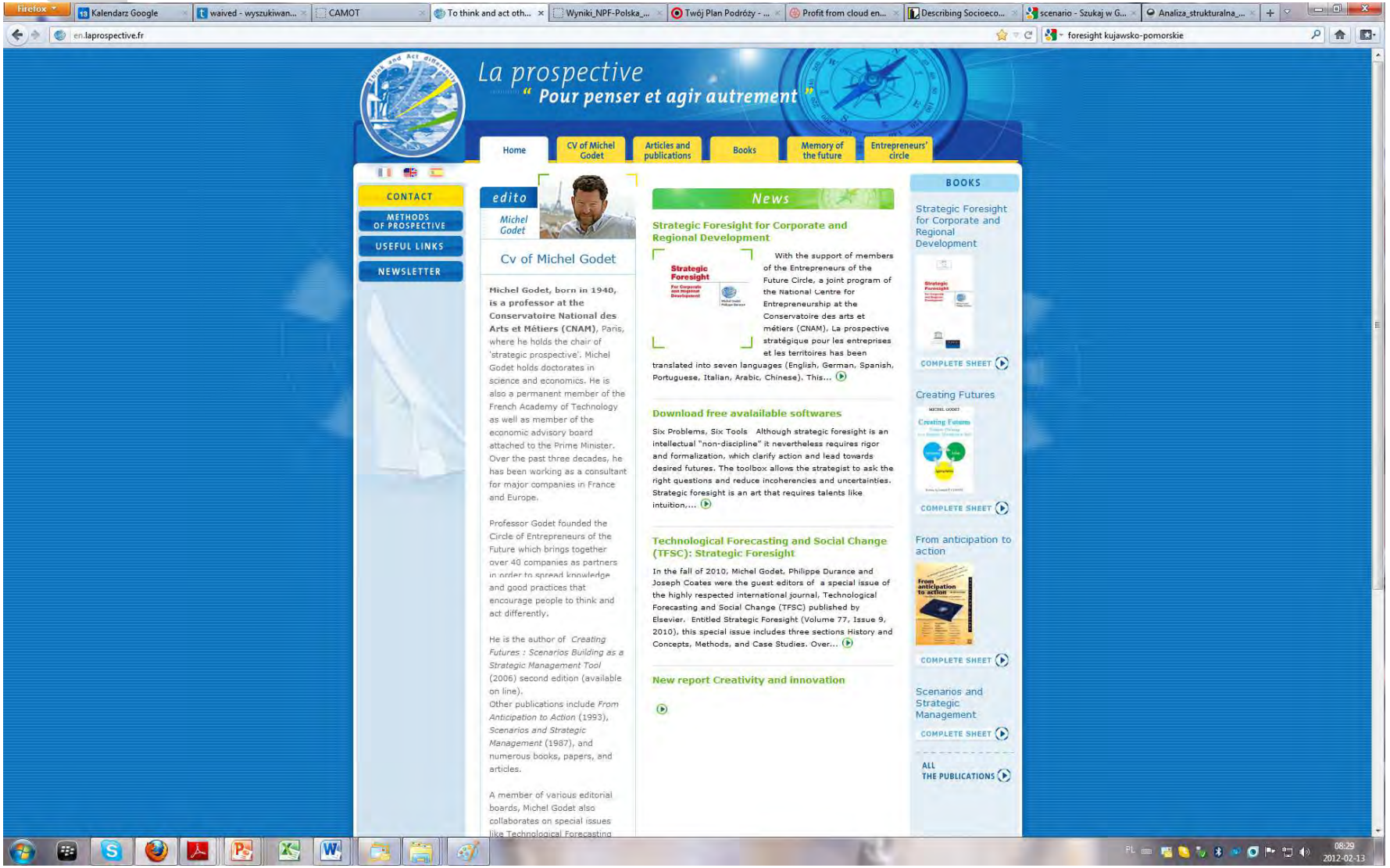
4. **Regulating and Secondary variables** – not decisive for the system but they may act as secondary objectives or secondary stakes that help achieve the main objectives.

5. **Result variables** – are little influent and very dependent. They are especially sensitive to the evolution of influent variables. They are exit variables from the system.

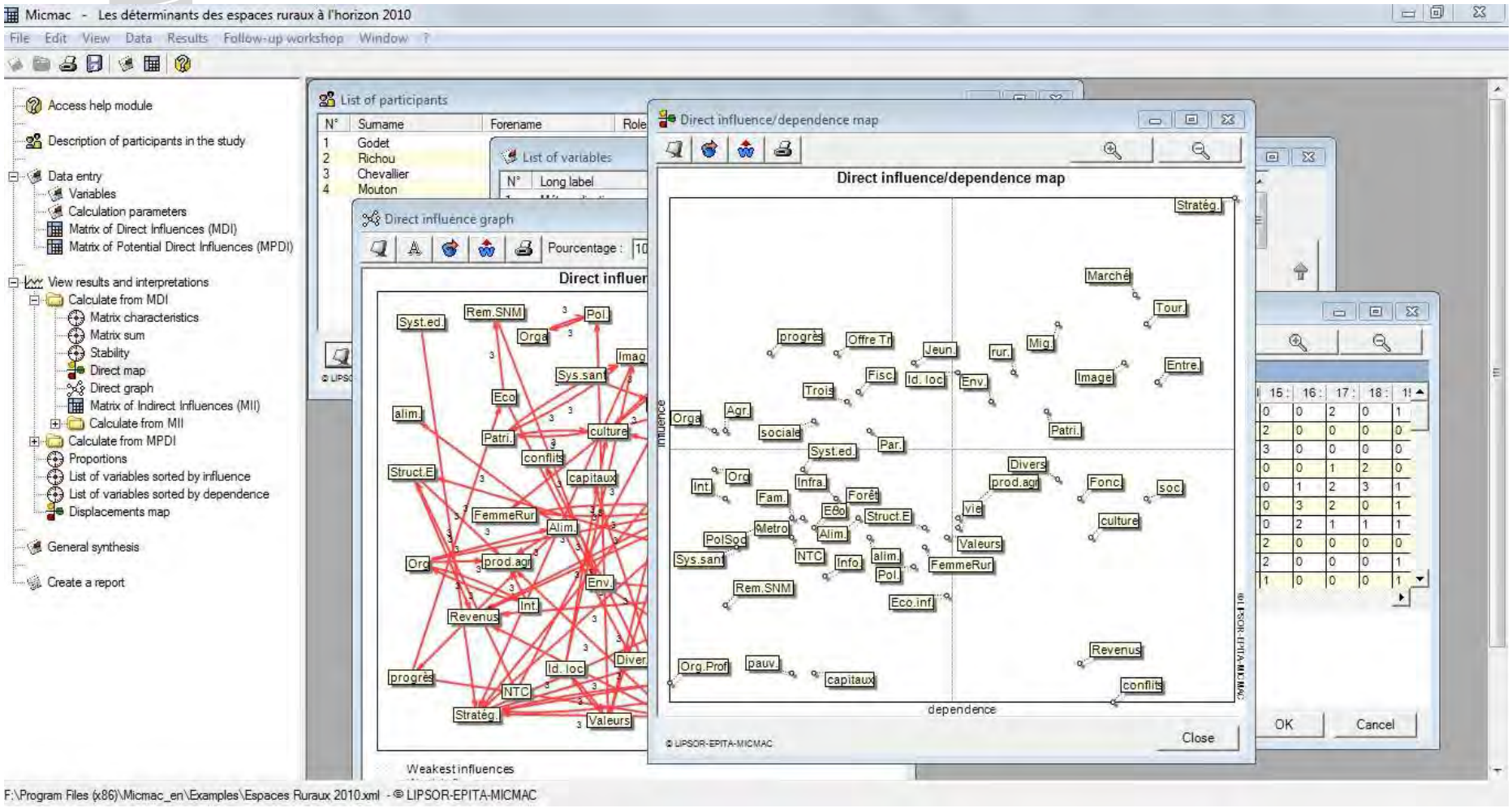
6. **Autonomous and external variables** – are little influent and little dependent. Their evolution is excluded from the system's global dynamics.

Źródło : J. M. Wójcicki (red.), P. Ładażyński (red.), *System monitorowania i scenariusze rozwoju technologii medycznych w Polsce*, Konsorcjum ROTMED, Warszawa 2008, s. 198.

MicMac Software



MicMac Software



An Example of Structural Analysis
Innovation-Oriented Development of Mazovian Enterprises

	Social Factors (S)
S1	Readiness to cooperate in a triad comprising business, government, and research institutions
S2	Propensity toward entrepreneurship in the society
S3	Preparedness of the government cadres in regard to industrial innovation support
	Technology Factors (T)
T1	System effectiveness of technology assessment and transfer
T2	Supply of innovative techologies
T3	Level of innovation of technological solutions in new enterprises
	Economic Factors (Econ)
Econ1	Availability of funds for innovation-related activities
Econ2	Effectiveness of institutions devoted to business support
Econ3	Strength of the relationship between government financial support for R&D and cooperation by R&D centers with industry
	Ecological Factors (Ecol)
Ecol1	Barriers to development resulting from environmental protection
Ecol2	Level of public support for implementation of environmental technologies
Ecol3	Development of green economy
	Political Factors (P)
P1	Preferences for extending credit to innovative SME's
P2	Compliance with EU regulations
P3	Promoting innovation in policies by provincial self-governance bodies
	Personal values-related Factors (V)
V1	Degree of readiness to cooperate
V2	Education
V3	Desire for personal development and for participation in new initiatives
	Legal Factors (L)
L1	Speed of legal procedures
L2	Legal definition of innovation
L3	Legal support for innovative solutions

An Example of Structural Analysis
Innovation-Oriented Development of Mazovian Enterprises

Matrix of direct influences (including potential influenes)

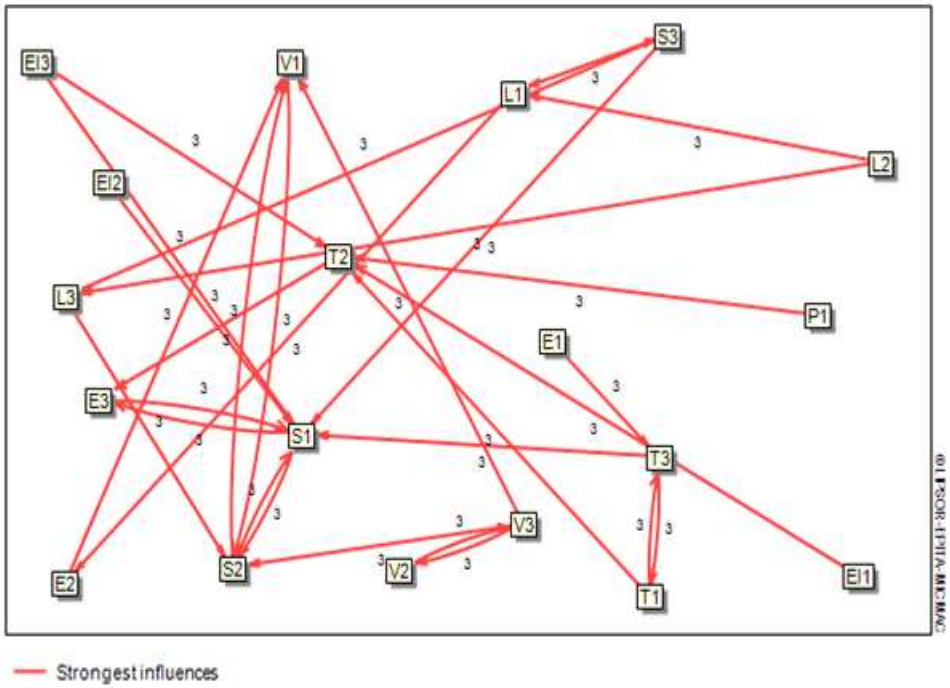
	S1	S2	S3	T1	T2	T3	Ekon 1	Ekon 2	Ekon 3	Ekol 1	Ekol 2	Ekol 3	P1	P2	P3	V1	V2	V3	L1	L2	L3
S1	0	1	1	2	3	2	2	1	2	0	2	0	0	2	0	1	1	0	0	0	0
S2	2	0	0	0	1	0	1	1	2	0	0	0	0	0	0	0	1	0	0	0	0
S3	0	0	0	0	0	1	2	1	1	0	0	2	0	0	0	2	1	0	0	0	0
T1	0	0	1	0	2	1	1	1	2	0	1	1	1	0	0	0	1	0	0	0	0
T2	2	1	0	2	0	3	1	1	3	3	2	0	0	1	0	0	1	0	0	0	1
T3	1	3	0	0	2	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Ekon1	2	2	2	1	1	2	0	2	3	0	1	0	0	1	0	0	1	1	0	0	0
Ekon2	3	3	0	3	3	3	2	0	2	0	0	0	1	1	0	0	1	0	0	0	0
Ekon3	1	2	0	1	2	3	1	2	0	0	0	0	0	2	0	1	1	0	0	0	0
Ekol 1	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0
Ekol 2	0	0	1	0	0	3	0	0	1	0	0	2	0	0	0	0	1	0	0	0	1
Ekol 3	0	0	1	0	0	1	2	0	1	0	1	0	0	0	0	1	0	0	0	0	1
P1	1	1	0	3	2	1	2	3	2	0	1	0	0	2	0	0	1	0	2	1	2
P2	2	3	0	1	2	2	2	2	3	0	0	0	0	0	0	0	2	0	0	0	0
P3	1	0	0	2	2	0	1	2	1	0	2	0	2	1	0	0	0	0	1	3	2
V1	0	1	1	0	0	1	1	0	1	0	0	1	0	0	0	0	1	1	0	0	0
V2	1	2	1	0	0	1	2	0	2	0	0	0	0	0	0	1	0	1	0	0	0
V3	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0
L1	0	0	0	0	2	0	2	1	1	0	0	0	0	0	0	0	0	3	0	0	0
L2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L3	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

MicMac Analysis of STEEPVL Factors

Innovation-Oriented Development of Mazovian Enterprises

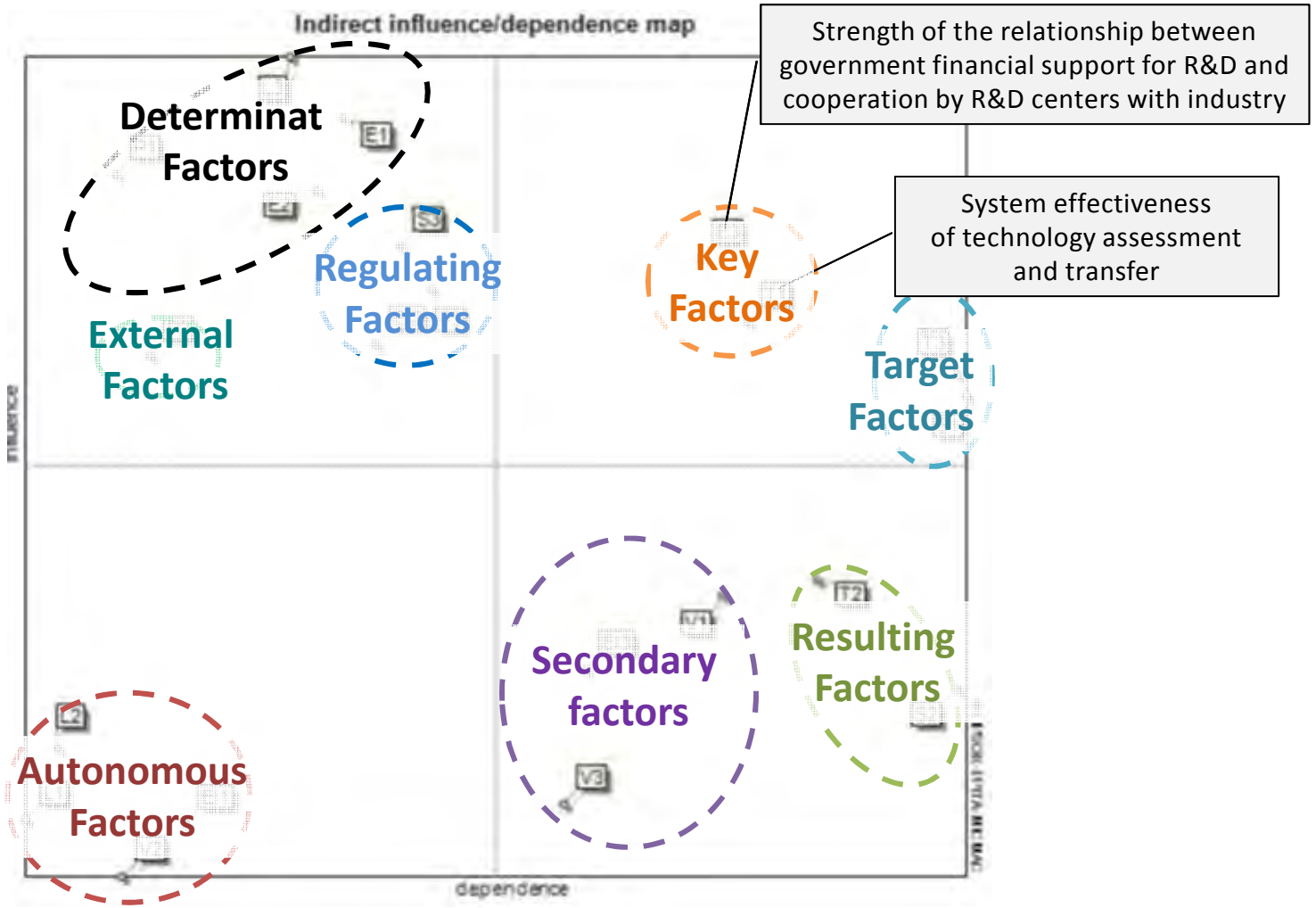
	1 : S1	2 : S2	3 : S3	4 : T1	5 : T2	6 : T3	7 : E1	8 : E2	9 : E3	10 : EI1	11 : EI2	12 : EI3	13 : P1	14 : P2	15 : P3	16 : V1	17 : V2	18 : V3	19 : L1	20 : L2	21 : L3
1 : S1	0	3	1	3	2	2	1	2	3	0	1	2	0	0	2	3	0	1	0	0	1
2 : S2	3	0	0	1	2	3	0	1	1	0	0	2	0	0	1	3	0	2	0	1	1
3 : S3	3	1	0	3	0	1	1	3	2	0	2	1	1	1	2	2	0	1	3	1	2
4 : T1	2	2	1	0	3	3	1	1	3	1	1	1	2	0	1	3	0	1	0	0	1
5 : T2	2	2	1	2	0	3	1	0	3	1	1	2	0	0	1	1	1	1	0	0	1
6 : T3	3	3	1	3	3	0	0	0	2	0	2	2	0	2	2	1	1	2	0	1	1
7 : E1	3	3	2	2	3	3	0	1	2	0	3	2	1	1	1	3	1	3	0	0	1
8 : E2	3	3	3	3	2	3	3	0	1	0	1	1	1	1	0	3	0	1	1	1	1
9 : E3	3	3	1	3	3	3	2	1	0	0	1	1	1	1	1	3	0	3	0	0	1
10 : EI1	1	0	0	1	3	2	0	0	0	0	3	3	0	1	1	1	0	2	0	0	0
11 : EI2	3	3	0	2	2	3	2	2	2	3	0	3	0	0	1	3	0	1	0	0	0
12 : EI3	3	3	0	0	3	3	0	0	2	3	1	0	0	2	1	0	0	1	0	0	0
13 : P1	3	3	1	3	3	3	3	1	2	0	1	2	0	1	1	0	0	1	0	0	3
14 : P2	1	2	2	2	1	2	2	1	1	3	1	2	2	0	2	0	1	1	1	2	1
15 : P3	3	2	2	2	2	3	3	1	2	1	1	2	1	1	0	1	2	1	0	0	0
16 : V1	3	3	2	1	1	1	1	2	2	1	0	0	0	0	2	0	0	2	0	0	1
17 : V2	1	2	1	2	1	2	0	0	1	0	0	1	0	0	0	1	0	3	1	0	1
18 : V3	2	3	1	1	2	3	0	0	0	0	0	1	0	0	0	3	3	0	0	0	0
19 : L1	2	2	0	2	2	1	0	3	0	0	0	1	1	0	0	0	0	1	0	1	1
20 : L2	1	1	2	0	1	1	0	0	1	0	1	1	1	0	2	0	0	0	3	0	3
21 : L3	2	3	3	3	2	3	3	1	2	0	3	2	1	1	1	2	0	1	1	1	0

Matrix of Direct Influences
(Structural Matrix)



Direct Influece Graph

Influence/Dependence Map of STEEPVL Factors
Innovation-Oriented Development of Mazovian Enterprises



Exercise

Task:

Structural analysis of STEEPVL factors in the fields of:

1. Development of Construction Sector in Lithuania
2. The Future of Civil Engineering Education in Lithuania

http://www.deliveredinnovation.com/cloud-process-system-design-enterprise-architecture/business-process-redesign-cloud-enablement

Exercise

- *Create the Structural Matrix of the STEEPVL factors in the area of the Future of Civil Engineering Education in Lithuania*

STEEPVL Factors

The FUTURE of CIVIL ENGINEERING EDUCATION in LITHUANIA		
Category		**Factors**
Econ ECONOMIC	Econ1	Government spending on Civil Engineering education
	Econ2	Public support for research in Civil Engineering
	Econ2	Construction companies' funding for Civil Engineering education
P POLITICAL	P1	Government's promotion of technological studies
	P2	Government's prioritization of engineering studies
L LEGAL	L2	Regulations allowing study and work at the same time ("sandwich studies")
	L3	Guarantees of getting a job after graduation

Structural Matrix (Direct Influence)

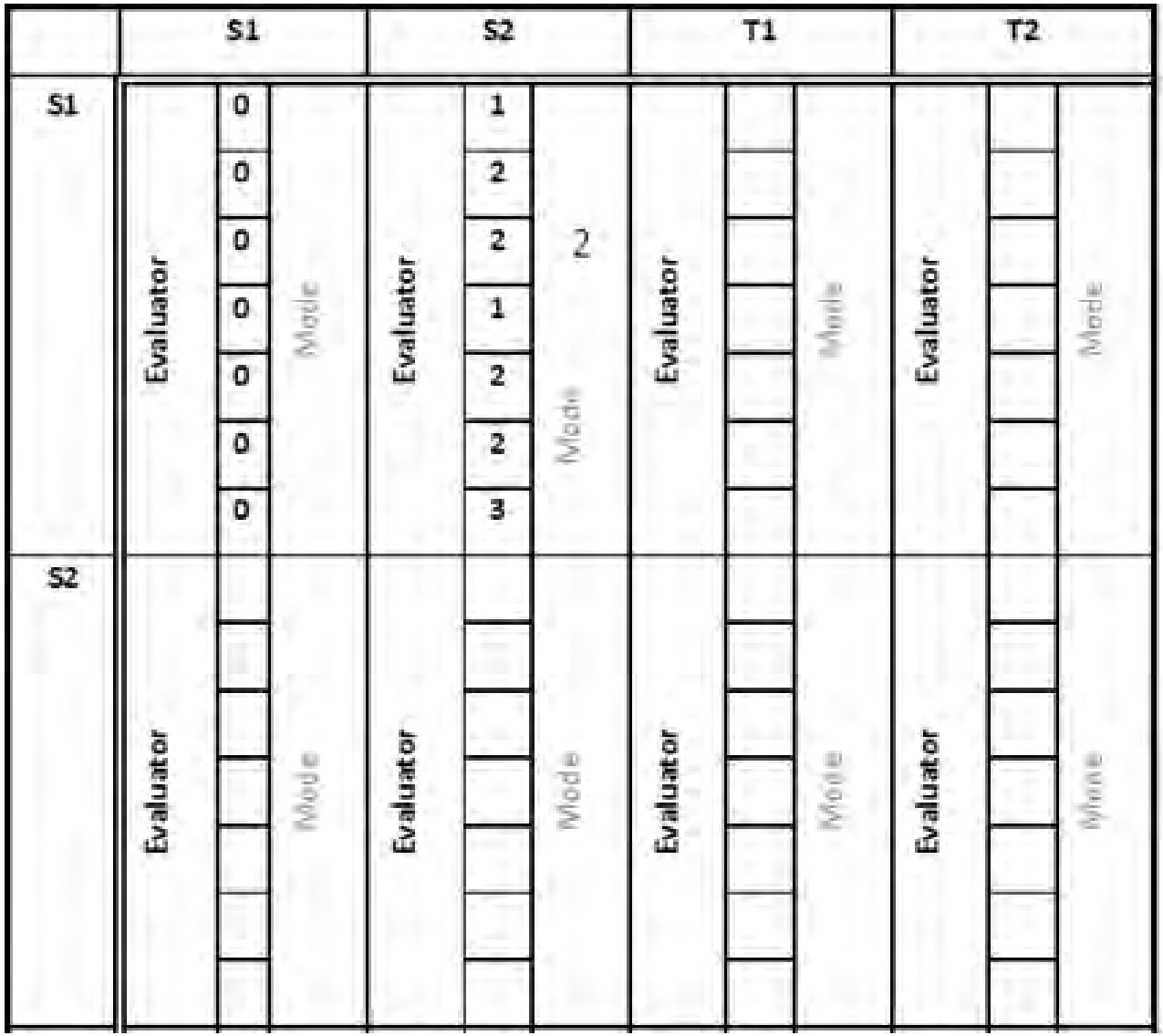
	Econ1	Econ2	Econ3	P1	P2	L2	L3
Econ1							
Econ2							
Econ3							
P1							
P2							
L2							
L3							

0 – no direct influence
1 – low direct influence
2 – medium direct influence
3 – strong direct influence

Exercise

- *Create the Aggregated Structural Matrix of the STEEPVL factors in the area of the Future of Civil Engineering Education in Lithuania*

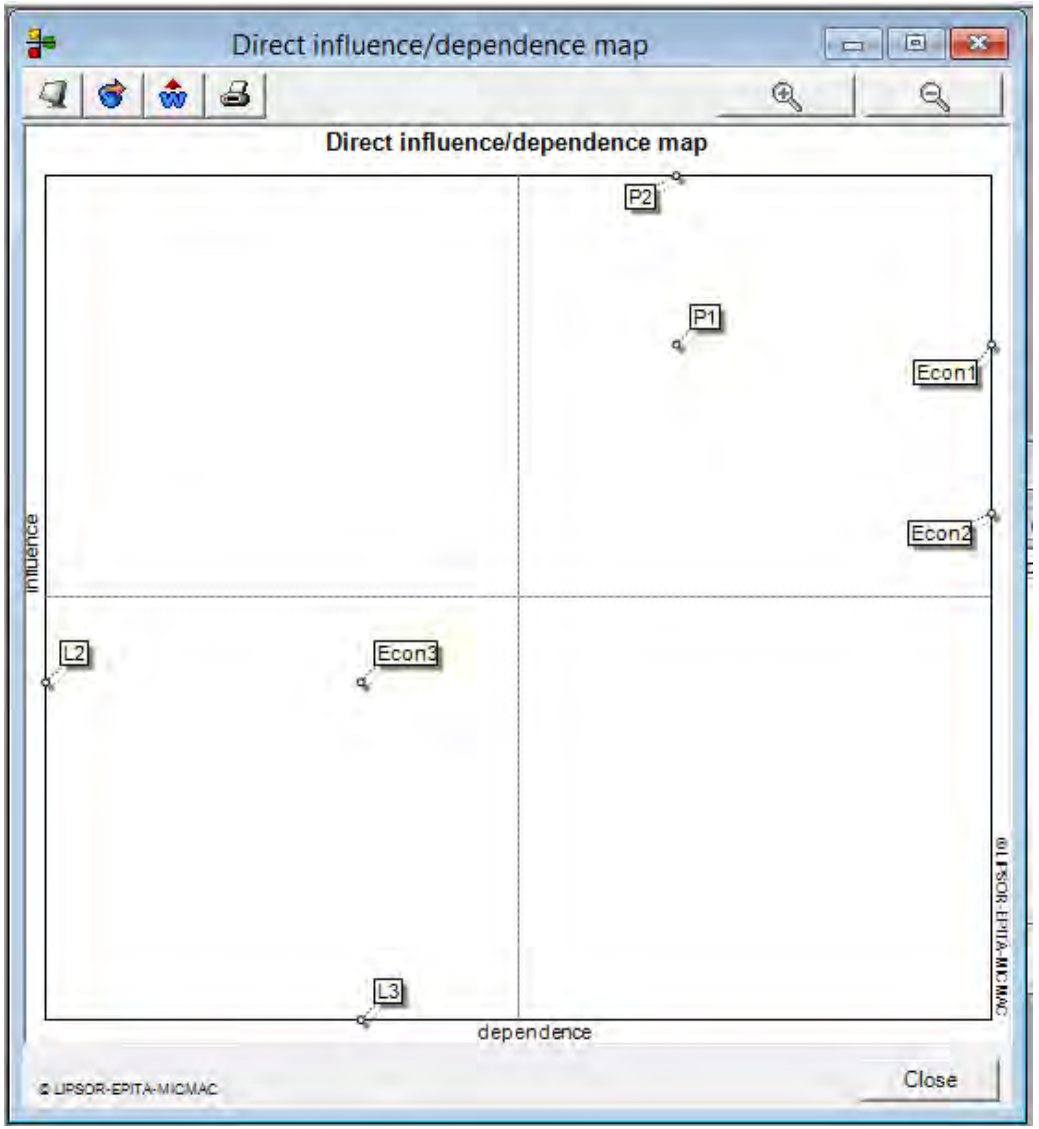
Aggregated Structural Matrix



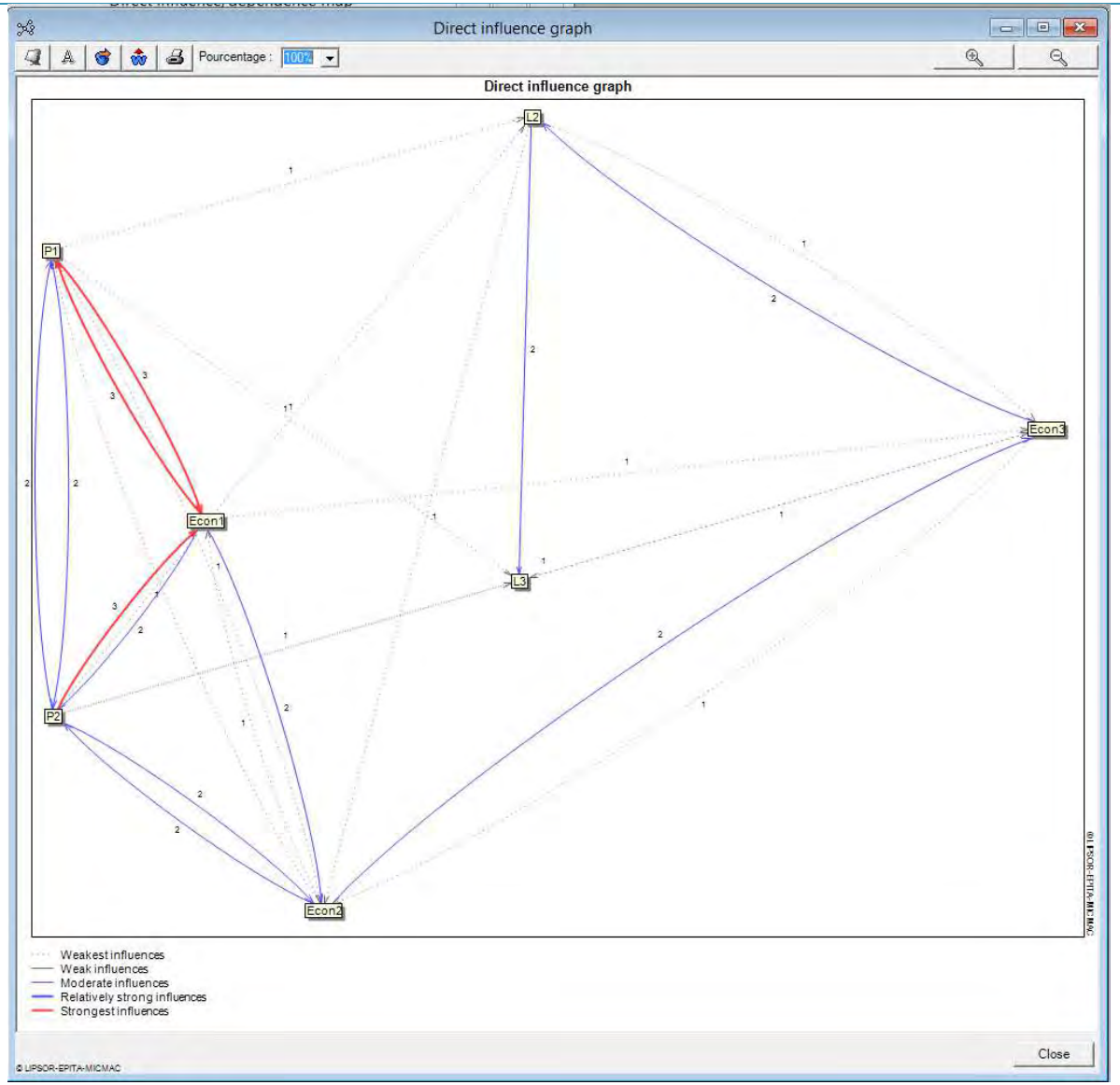
Aggregated Structural Matrix

		Government spending on Civil Engineering education	Public support for research in Civil Engineering	Construction companies' funding for Civil Engineering education	Government's promotion of technological studies	Government's prioritization of engineering studies	Regulations allowing study and work at the same time("sandwich studies")	Guarantees of getting a job after graduation
		Econ1	Econ2	Econ3	P1	P2	L2	L3
Government spending on Civil Engineering education	Econ1	**0**	**2**	**1**	**3**	**2**	**0**	**0**
Public support for research in Civil Engineering	Econ2	**1**	**0**	**2**	**1**	**2**	**0**	**0**
Construction companies' funding for Civil Engineering education	Econ3	**0**	**1**	**0**	**0**	**0**	**2**	**1**
Government's promotion of technological studies	P1	**3**	**1**	**0**	**0**	**2**	**1**	**1**
Government's prioritization of engineering studies	P2	**3**	**2**	**1**	**2**	**0**	**1**	**1**
Regulations allowing study and work at the same time ("sandwich studies")	L2	**0**	**1**	**0**	**0**	**0**	**0**	**2**
Guarantees of getting a job after graduation	L3	**0**	**0**	**0**	**0**	**0**	**0**	**0**

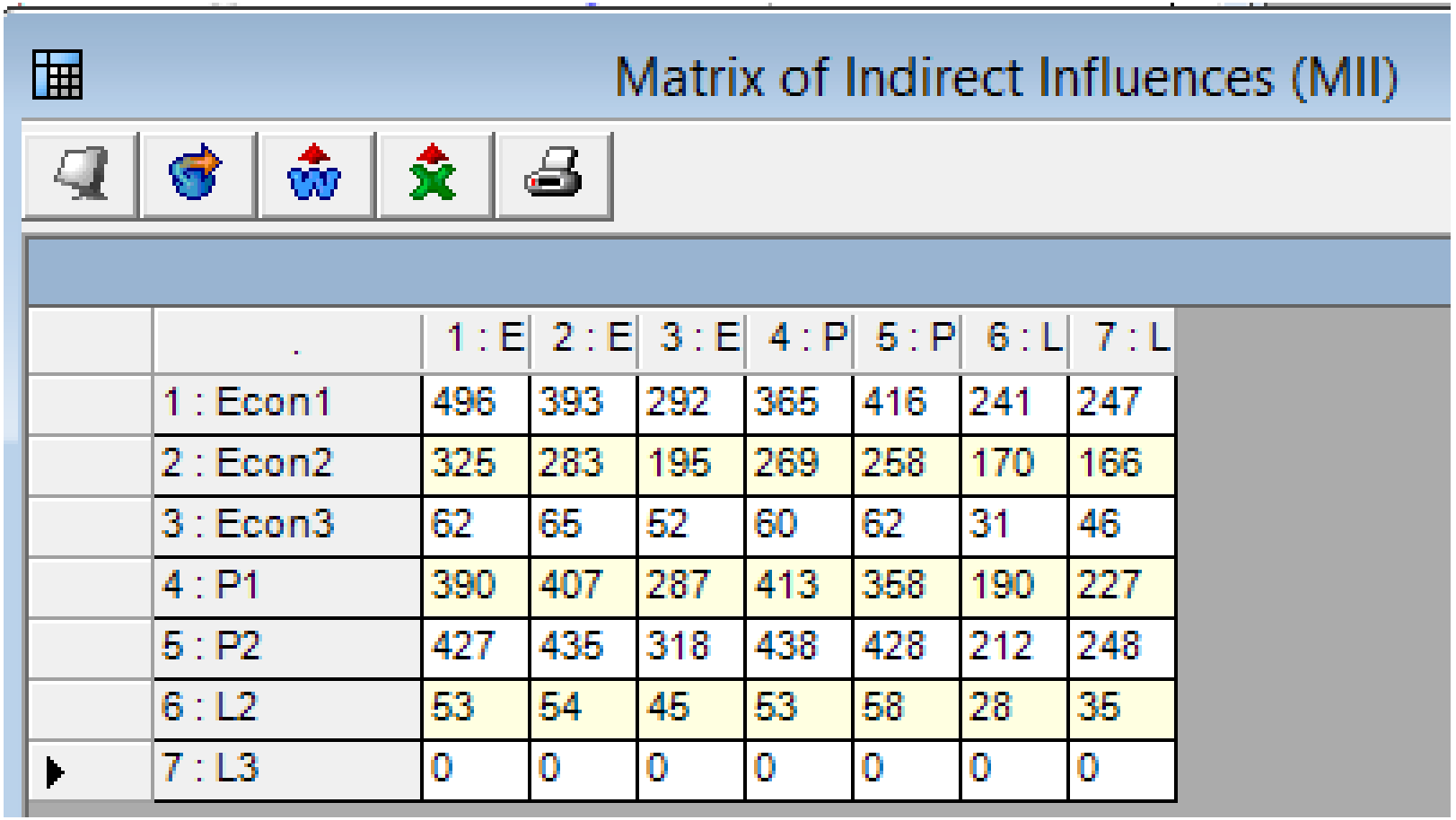
Direct Influence/Dependence Map



Direct Influence Graph

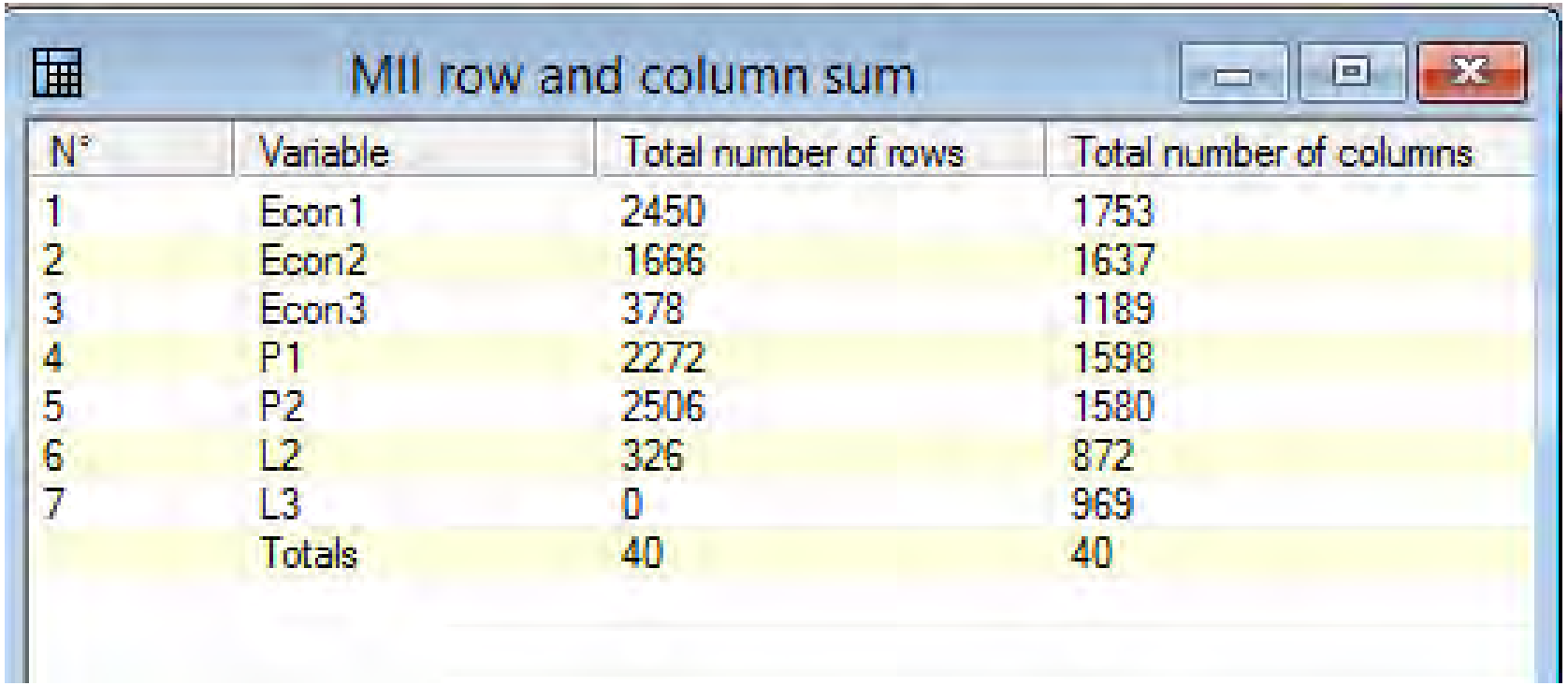


Matrix of Indirect Influence (MII)



.	1 : E	2 : E	3 : E	4 : P	5 : P	6 : L	7 : L
1 : Econ1	496	393	292	365	416	241	247
2 : Econ2	325	283	195	269	258	170	166
3 : Econ3	62	65	52	60	62	31	46
4 : P1	390	407	287	413	358	190	227
5 : P2	427	435	318	438	428	212	248
6 : L2	53	54	45	53	58	28	35
7 : L3	0	0	0	0	0	0	0

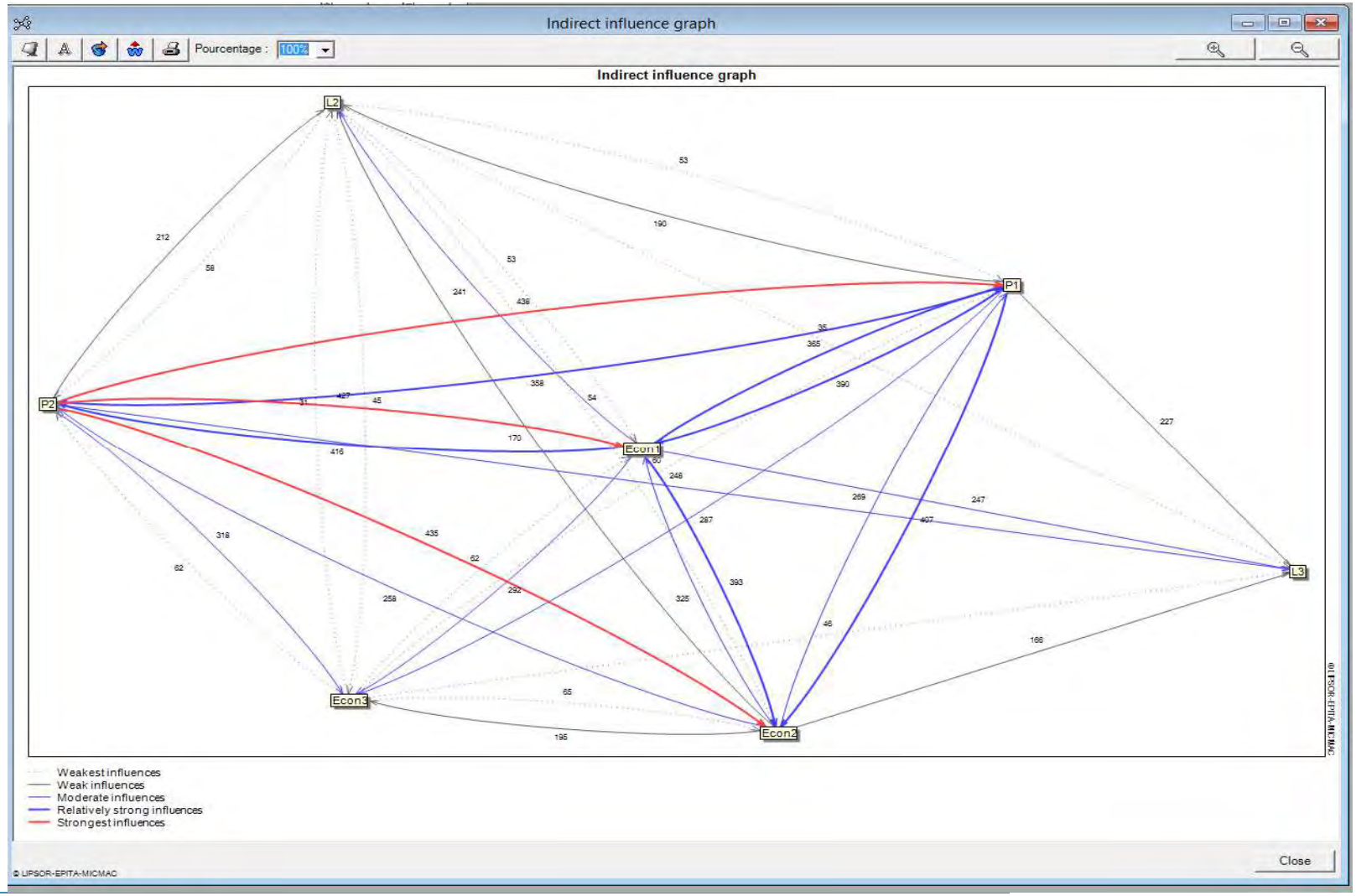
MII row and column sum



MII row and column sum

N°	Variable	Total number of rows	Total number of columns
1	Econ1	2450	1753
2	Econ2	1666	1637
3	Econ3	378	1189
4	P1	2272	1598
5	P2	2506	1580
6	L2	326	872
7	L3	0	969
	Totals	40	40

Indirect Influence Graph

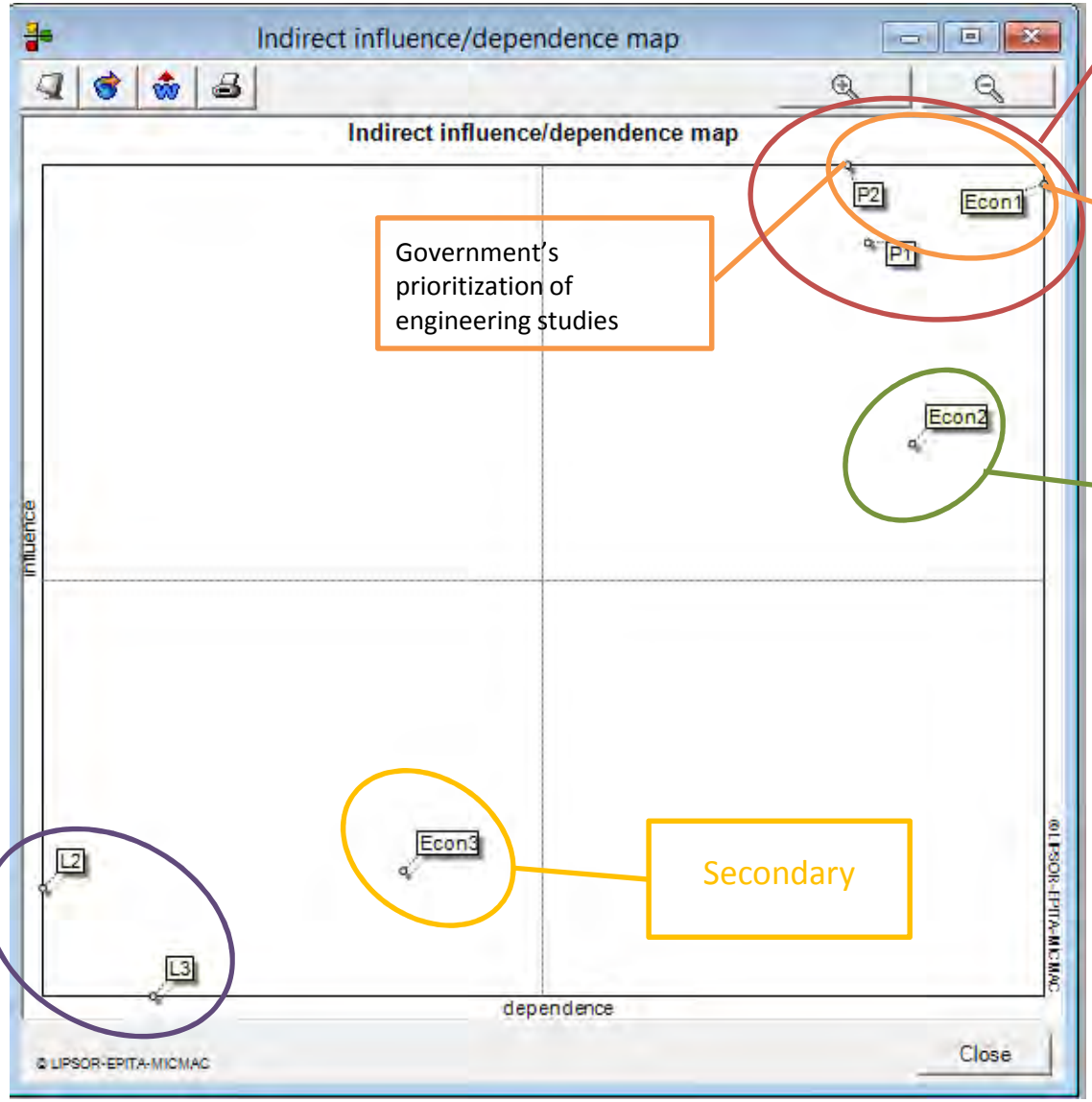


Exercise - continued

Factor classification:

- *stake (key) factors*
- *target factors*
- *result factors*
- *autonomous factors*
- *determinant factors*
- *external factors*
- *secondary factors*
- *regulating factors*

Indirect Influence/Dependence Map



Key (stake)

Government spending on Civil Engineering education

Government's prioritization of engineering studies

Target

Autonomous

Secondary