

Flows of domestic knowledge and innovation clusters in the
Polish economy.
An analysis with input-output methods.

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Main object of the study and methods

- Main object of this study:

An attempt to identifying innovation clusters at the industry level in the Polish economy.

- Methods :

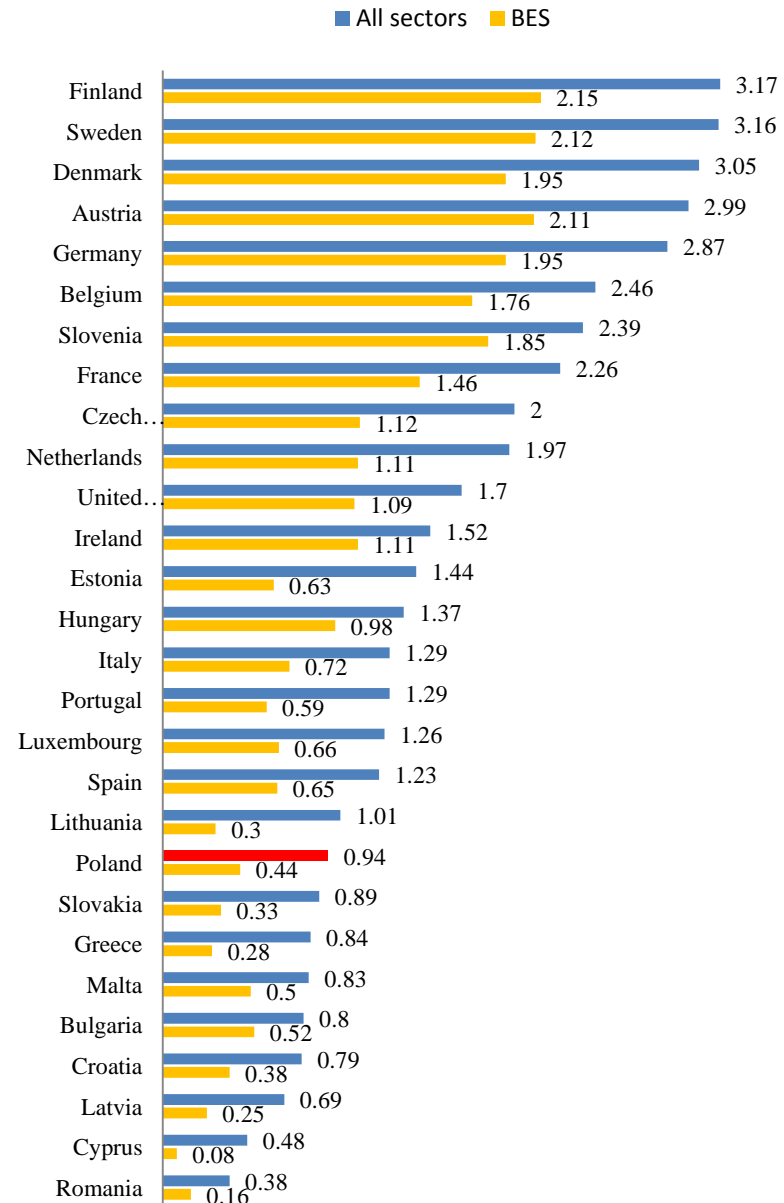
Minimal Flows Analysis (MFA) – a tool of Qualitative Input-Output Analysis (QIOA). It has been applied for domestic R&D flows matrix.

Innovation Clusters

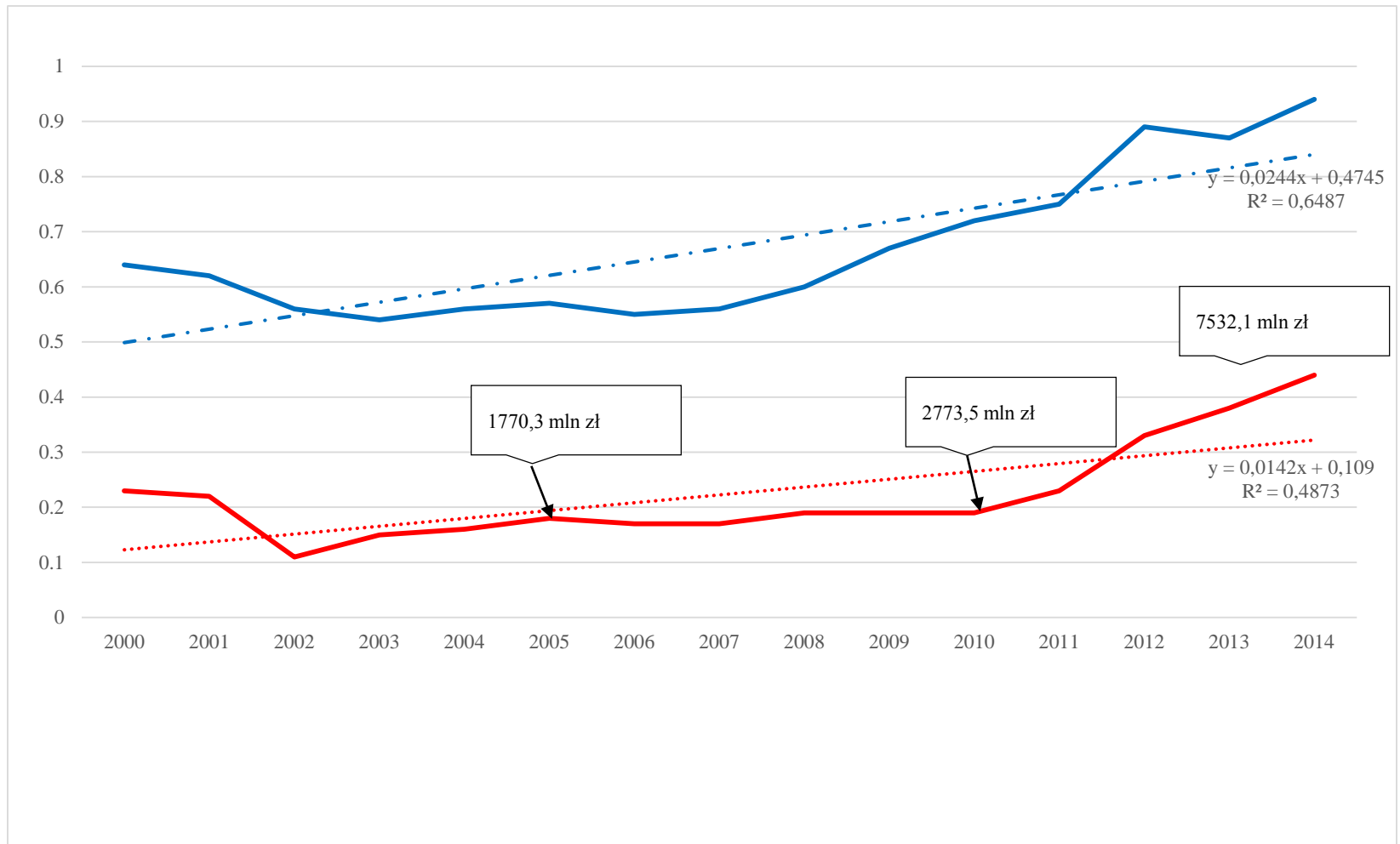
- M.E. Porter cluster concept – geographical grouping of interacting firms, specialized suppliers, providers of services, cooperating institutions that compete but also cooperate (Porter, 2001);
- Innovation cluster – group of different entities (enterprises, organizations, institutions, research institutes) that cooperate for the purpose of innovation. This cooperation expedites the diffusion of knowledge (codified and tacit) among the cluster members.
- For the purposes of the analysis, an innovation cluster was defined as a group of industries that gain the most (directly or indirectly) from knowledge and technology transfers created by its centre.

- R&D expenditures— main indicator of innovative potential of the economy;
- Leaders on world R&D activity: USA, China, Japan, Germany;
- For innovative leader countries R&D expenditures related to GDP is around 3% (excluding China);
- Leaders in UE: Finland, Sweden, Denmark, Germany

R&D expenditures as % of GDP



R&D expenditures as % of GDP in Poland (all sectors and BES)



Domestic R&D flows matrix

Main assumptions:

- R&D expenditures are the main indicator of knowledge creation and innovation capacity of the particular industry;
- Knowledge (and innovations) is embodied in domestic intermediate products and spill over between industries;
- The size of the domestic knowledge transfer between the two sectors is proportional to the strength of the linkages (direct and indirect) between them;

Domestic R&D flows matrix

Domestic R&D flows matrix is described by formula:

$$F_{R\&D}^d = [f_{ij}^d] = \langle R \& D \rangle \langle \mathbf{x}^d \rangle (\mathbf{I} - \mathbf{A}^d)^{-1} \langle \mathbf{y}^d \rangle = \langle \mathbf{r} \rangle (\mathbf{I} - \mathbf{A}^d)^{-1} \langle \mathbf{y}^d \rangle$$

where:

$\langle R \& D \rangle$ - the diagonal matrix with the main diagonal elements **representing the amounts of R&D expenditures of respective industries;**

$\langle \mathbf{x}^k \rangle$ - the diagonal matrix of **industries' total output;**

$\langle \mathbf{y}^k \rangle$ - the diagonal matrix of final demand for domestic products;

$(\mathbf{I} - \mathbf{A}^k)^{-1}$ - the Leontief inverse matrix;

$\langle \mathbf{r} \rangle = \left\langle \frac{R \& D_i^k}{x_i^k} \right\rangle$ - the diagonal matrix of R&D **intensities.**

Domestic R&D flows matrix

Interpretation of elements of R&D flows matrix:

f_{ij}^k - portion of R&D expenditures originating in i-th industry that are used to produce final products by j-th industry;

The elements in the i-th row show what portion of R&D expenditures of the i-th industry is used by all industries – directly and indirectly (sum of these elements is equal of R&D expenditures of i-th industry).

Minimal Flow Analysis (Schnabl, 1994, 1995)

- MFA is one of the QIOA methods used for analysis of important (the strongest) inter-industry linkages ;
- MFA performs of binarisation of inter-industry linkages;
- This procedure simplifies the transaction matrix by filtering out all irrelevant elements;
- The assignment of elements of transaction matrix 0s or 1s depends on the value of threshold;
- The transaction matrix is described by elements of $F_{R\&D}^d$ matrix.

MFA – main assumptions

The Leontief inverse matrix can be approximated by the same of geometric sequence of the direct coefficients matrix \mathbf{A} , then:

$$F_{R\&D}^d = \langle r \rangle (\mathbf{I} - \mathbf{A}^d)^{-1} \langle y^k \rangle = \langle r \rangle (\mathbf{I} + \mathbf{A}^d + (\mathbf{A}^d)^2 + (\mathbf{A}^d)^3 + \dots) \langle y^d \rangle =$$

$$= \underbrace{\mathbf{Z}_0 + \mathbf{Z}_1 + \mathbf{Z}_2 + \mathbf{Z}_3 + \dots}_{\text{layer matrices}}$$

$\mathbf{Z}_0 = \langle r \rangle \mathbf{I} \langle y^d \rangle$ a diagonal matrix of R&D expenditures of the i -th industry incurred to make its domestic final products;

$$\mathbf{Z}_1 = \langle r \rangle \mathbf{A}^d \langle y \rangle, \quad \mathbf{Z}_2 = \langle r \rangle \mathbf{A}^d \langle \mathbf{A}^d y \rangle, \dots \textit{etc.}$$

MFA – main assumptions

Converting Z_i matrices into binary matrices W_i :

$$w_{kl(i)} = \begin{cases} 1 & \text{when } z_{kl(i)} > T \\ 0 & \text{when } z_{kl(i)} \leq T \end{cases}$$

Building adjacency matrix W^k using the recursive formula:

$$\mathbf{W}^k = \begin{cases} \mathbf{W}_{k-1} \cdot \mathbf{W}^{(k-1)} & \text{for } k = 1, 2, \dots \\ \mathbf{I} & \text{for } k = 0 \end{cases}$$

The adjacency matrix points to all inter-industry linkages in the innovation flows matrices that are significant with respect to the threshold value.

MFA – main assumptions

Dependence matrix \mathbf{D} is a Boolean sum of the all adjacency matrices (the elements of this matrix are only 0s and 1s).

Connectivity matrix $H = [h_{ij}] = D + D'$

$$h_{ij} = \begin{cases} 0 & \text{no significant linkages between sectors } i \text{ and } j \\ 1 & \text{sector } i \text{ is linked to } j, \text{ but not vice versa} \\ 2 & \text{a bilateral linkage between sectors } i \text{ and } j \end{cases}$$

How to determine the threshold value?

- Repeat MFA procedure for different threshold values (started from $T=0$) and increase it by some constant value;
- About 50 iterations (last threshold value could be at the level of 95th percentile of the off-diagonal elements of matrix \mathbf{F}) are recommended;
- Observe the changes in the number of significant linkages between sectors (described by elements of connectivity matrix);
- Determine the threshold value at the level which stabilizes the number of significant linkages (it's around 20th threshold value in this research).

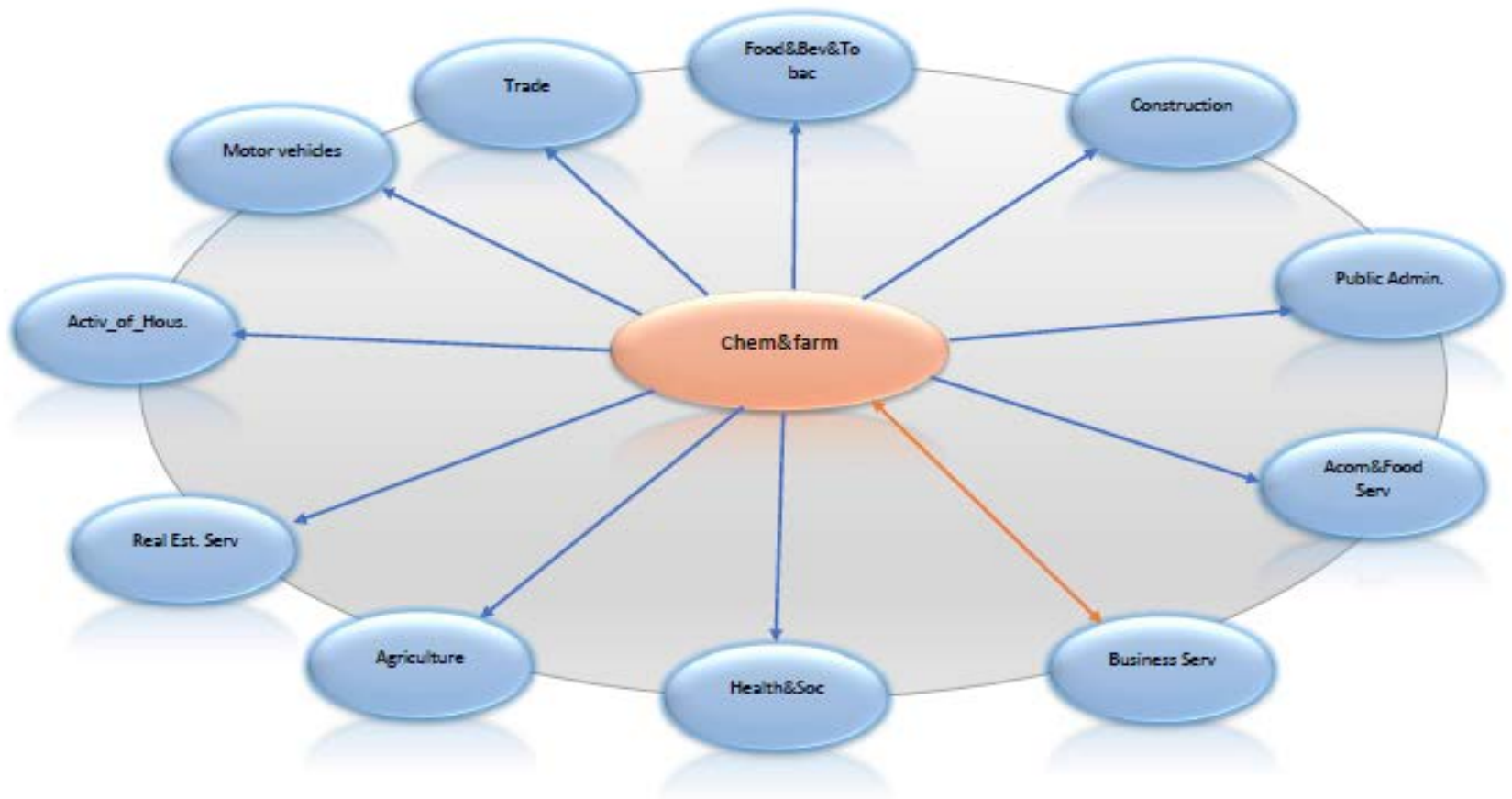
Data

- Analyzed years: 2000, 2005, 2010;
- R&D expenditures by industries (NACE 2) come from OECD database (STAN Database); The data was converted into the product-based systems (supply/make matrices);
- I-O table with domestic goods disaggregated into 42 product groups (product-by-product).

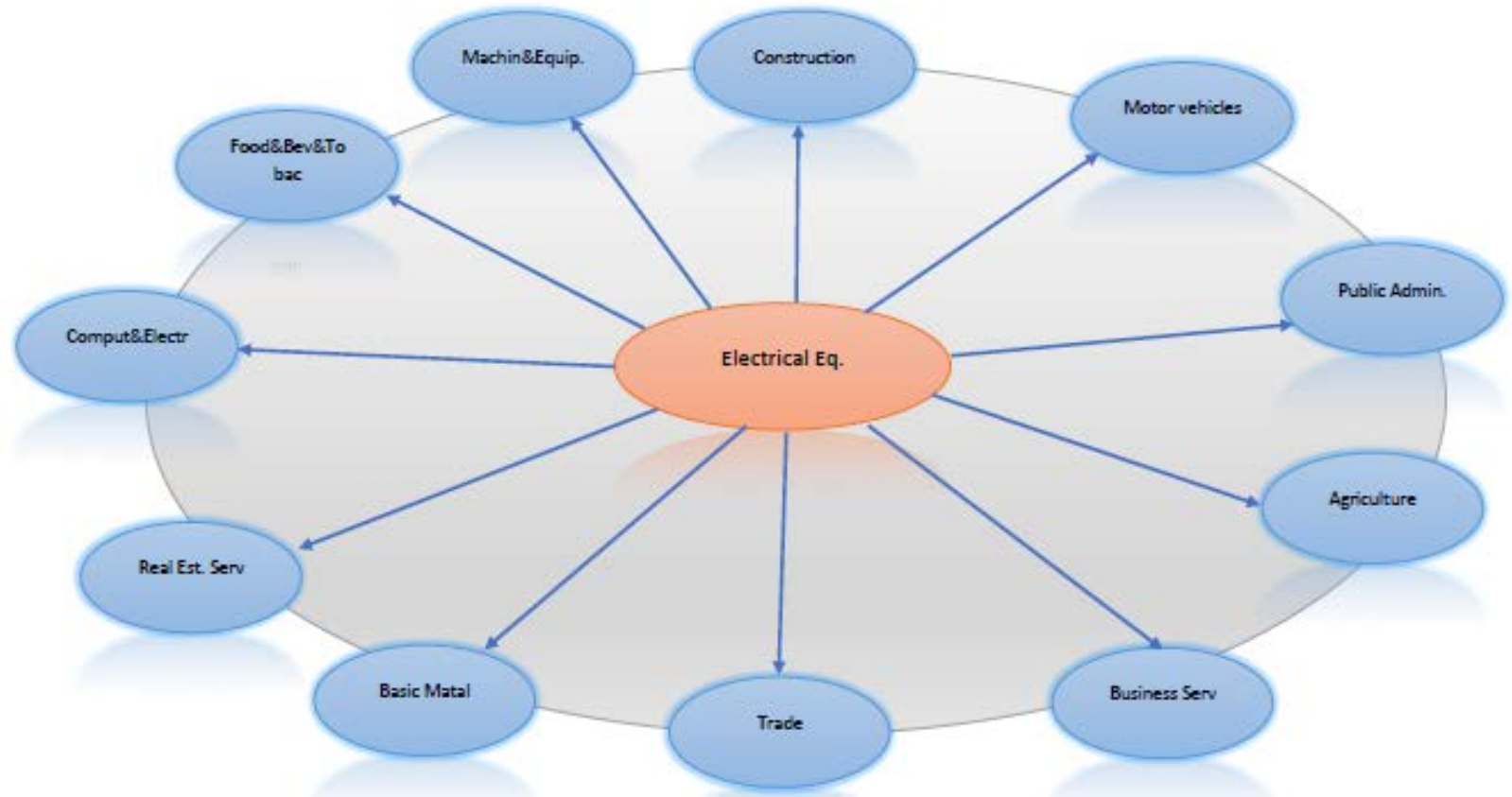
Results:

- In 2000 four innovation clusters were identified:
 - Chemical&pharmaceutical cluster;
 - Electrical equipment cluster;
 - Machinery cluster;
 - Metal industry cluster.
- Above industries are the centres of these clusters (the sum of elements in row of D matrix for these industries divided by the sum of elements in suitable column is much more than 1). There are industries with relatively high R&D expenditures.
- The surrounding of each cluster's centre consisted of both manufacturing and service industries (beneficiaries).

Chemical&farmaceutical cluster in 2000



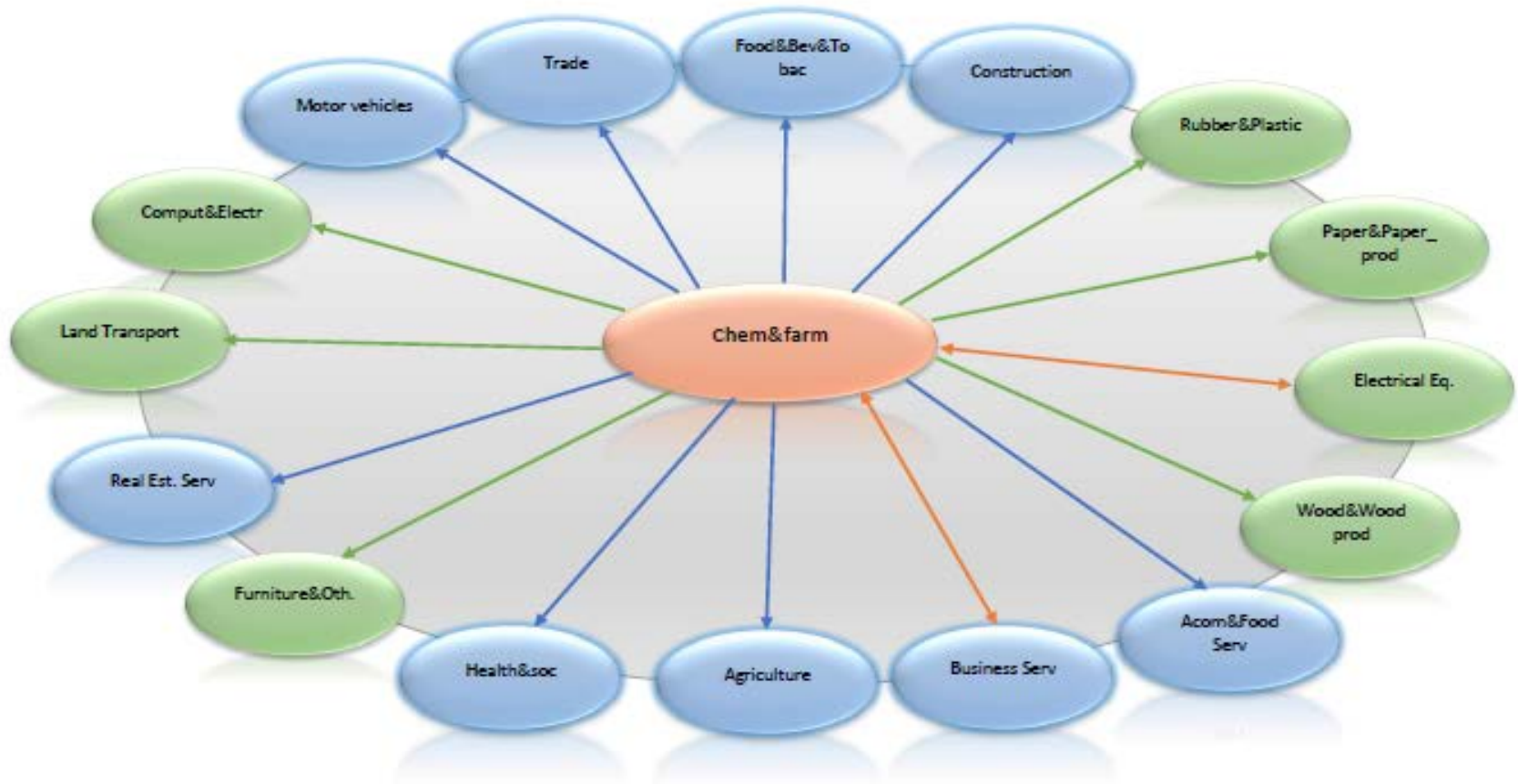
Electrical equipment cluster in 2000



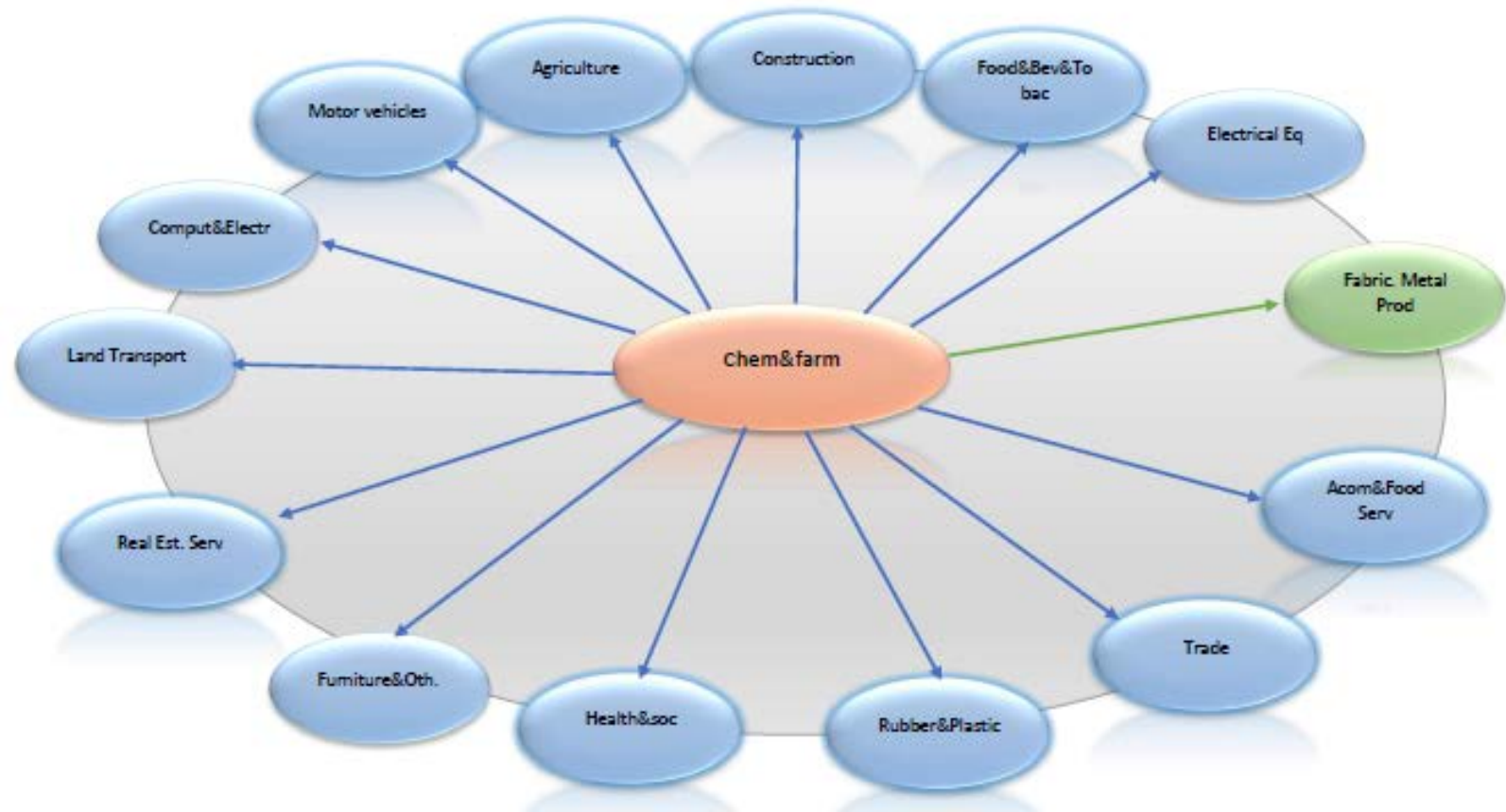
Results

- The chemical&pharmaceutical cluster existed in all analysed years;
- The numbers of beneficiare industries increased (mainly in 2005). In the surrounding of this cluster new manufacturing industries appeared: (1) rubber and plastic products, (2) computers, electronic and optical products, (3) electrical equipment, (4) paper and paper products, and (5) furniture;
- In 2010 the chemical&farmaceutical cluster was unchanged in general, even though the number of industries surroundings of its centre slightly decreased.

Chemical&farmaceutical cluster in 2005



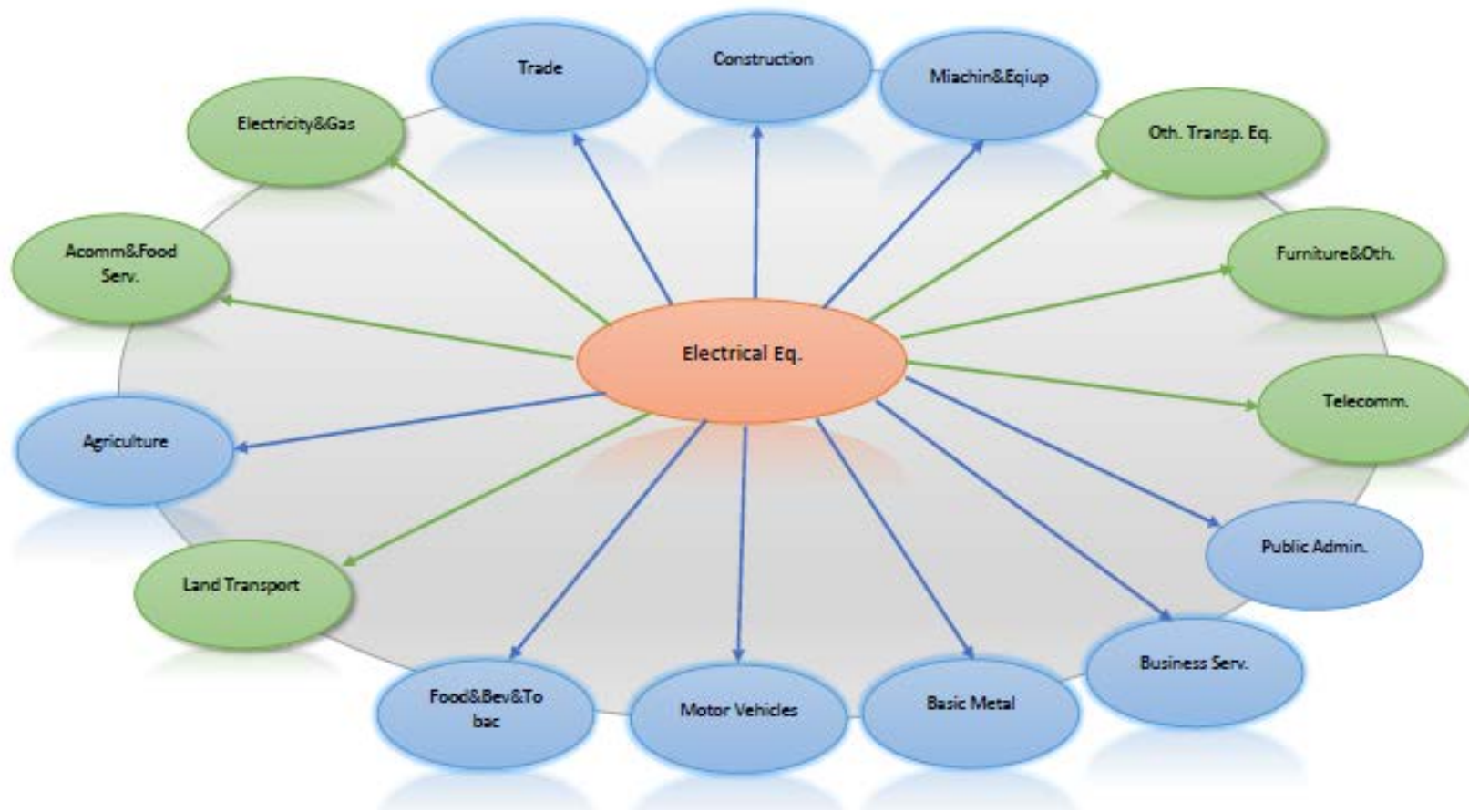
Chemical&farmaceutical cluster in 2010



Results

- The electrical equipment manufacturing cluster was identified only in 2000 and 2005;
- As in the case of the chemical and pharmaceutical cluster, in 2005 the number of significant linkages was higher than in 2000. The main recipients of knowledge and innovations created by the electrical equipment manufacturing industry (the core of the cluster) were the manufacturers of motor vehicles, metals, machinery and equipment, food industry, construction and agriculture;
- In 2005, the range of its beneficiaries included also the producers of other transport equipment, furniture and other products, and the energy sector. The flows of knowledge and innovations to business support services were also significant.

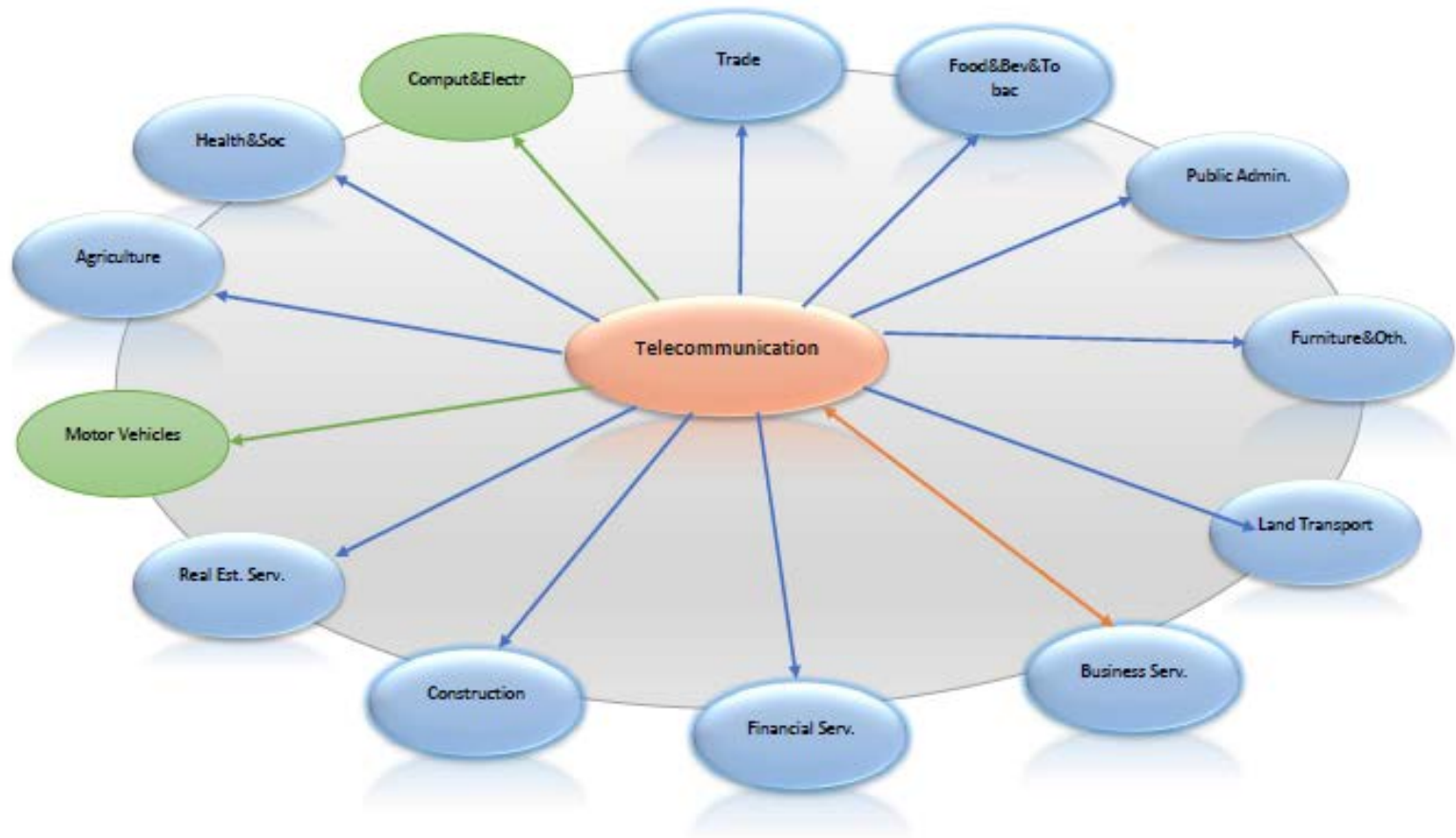
Electrical equipment cluster in 2005



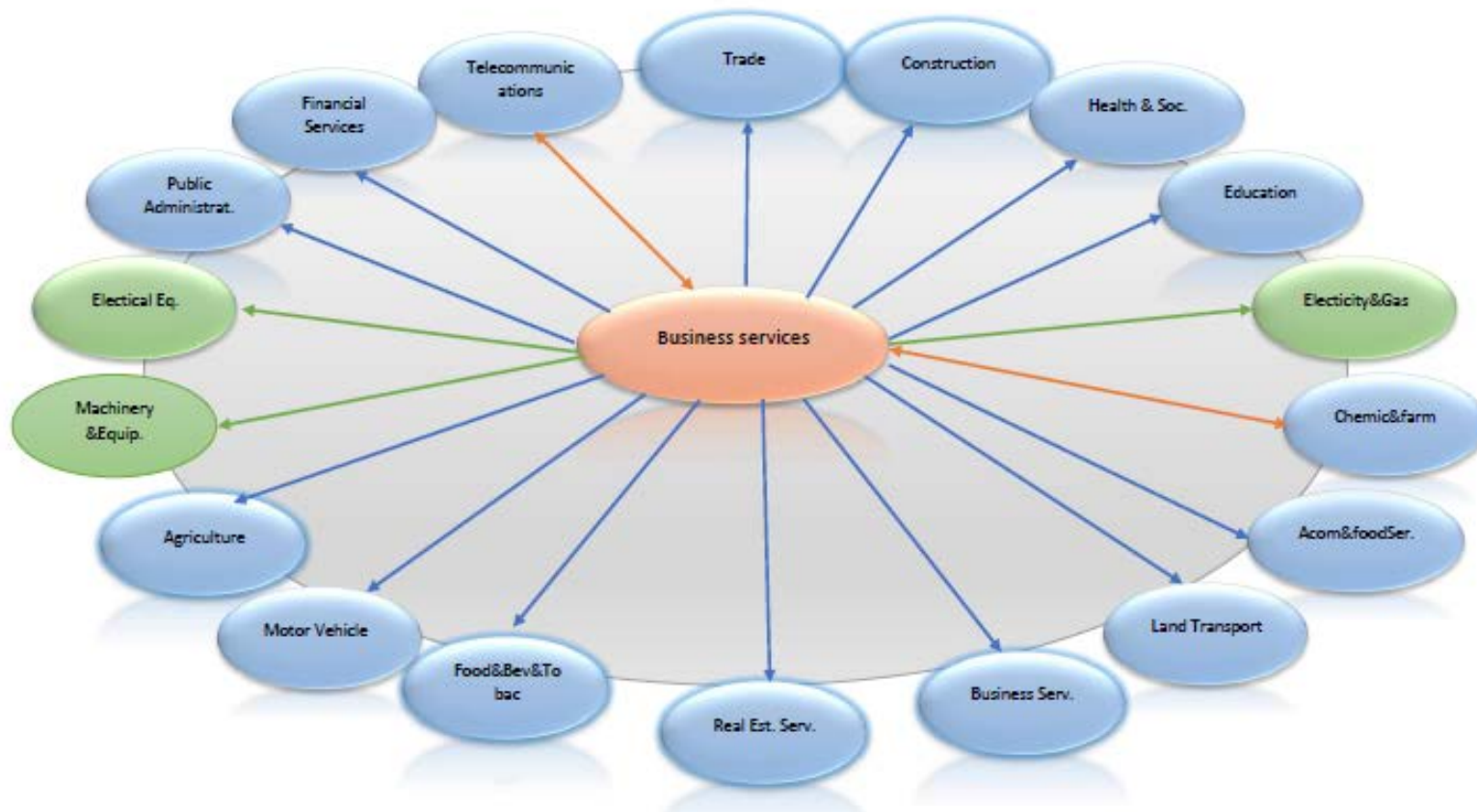
Results

- In the years 2005 and 2010, innovation clusters based on the machinery and metal industries were not identified;
- In these years, two new service-based clusters were identified: telecommunication cluster and business support services cluster;
- Beneficiaries of these clusters are mainly services industries;
- In the case of the telecommunications cluster these were mainly financial and insurance services, business support services (a feedback), real estate services, transportation and storage services, as well as food industry and manufacture of machinery and equipment.
- The business support services cluster included also some manufacturing industries, e.g. the chemical and pharmaceutical industry, the food industry, automotive industry and agriculture.

Telecommunication cluster in 2010



Business support services cluster in 2010



Conclusions

- The research was an attempt to identify the innovation clusters in the Polish economy determined by the flows of domestic knowledge;
- The assumption underlying the research was that knowledge and technology diffuse with the flows of domestic intermediate goods, so input-output methods were applied for this purpose;
- In 2000 four clusters were identified. The beneficiaries of knowledge transfers in these clusters were both manufacturing industries and services industries;
- In 2005 and 2010, the role of cluster centres was performed by the services industries. In 2005, a telecommunications cluster and a business support services cluster appeared.

Thank you for attention!