Regional Input-Output Tables for Poland

Łucja Tomaszewicz, Joanna Trębska
University of Łódź

Why we decided to investigate interregional i/o models for Poland

- Practically there are hardly any investigations into regional interrelationships.
- Our analysis can be a useful resource in the present discussion of the development strategy for the region of Łódź (LORIS project).
- By using regional and interregional input-output matrices it becomes possible to focus on relationships within regional output and final demand.
- Analyses built on the input-output multipliers help identify how an additional final demand affects not only the output of a given region, but also outputs of other regions, through intermediate demand transactions.

Main task of the study

- Presentation of linkages between two areas – one is the Łódź region economy and the other region is „the rest of the Polish economy” – in the context of the following relationships: final demand – gross output.

- Calculations of error measures for the case of neglecting interregional linkages (feedback effects).

Regional and interregional matrices

Matrix of I/O coefficients for a two-region system has a form:

$$\mathbf{A} = \left[\begin{array}{c|c} \mathbf{A_{11}} & \mathbf{A_{12}} \\ \hline \mathbf{A_{21}} & \mathbf{A_{22}} \end{array}\right]$$

Matrices $\mathbf{A_{11}}$ $\mathbf{(A_{22})}$, $\mathbf{A_{12}}$ $\mathbf{(A_{21})}$ provide regional input coefficients and interregional flows coefficients, respectively.

Regional and interregional multipliers

Following Round [2001] Leontief inverse can be presented also in the form:

$$\mathbf{M} = \begin{bmatrix} \mathbf{M}_{11} & \mathbf{M}_{12} \\ \mathbf{M}_{21} & \mathbf{M}_{22} \end{bmatrix} = \left[\begin{array}{c|c} \mathbf{F}_{11}\mathbf{L}_{11} & \mathbf{F}_{11}\mathbf{S}_{12}\mathbf{L}_{22} \\ \hline \mathbf{F}_{22}\mathbf{S}_{21}\mathbf{L}_{11} & \mathbf{F}_{22}\mathbf{L}_{22} \end{array}\right]$$

By substituting

- $\mathbf{F}_{11} = [\mathbf{I} - (\mathbf{I} - \mathbf{A}_{11})^{-1}\mathbf{A}_{12}(\mathbf{I} - \mathbf{A}_{22})^{-1}\mathbf{A}_{21} = \mathbf{I} - \mathbf{S}_{12}\mathbf{S}_{21}$ - interregional feedback effects that include the effect of both Leontief inverse and interregional spillover,
- $\mathbf{L}_{11} = (\mathbf{I} - \mathbf{A}_{11})^{-1}$ - interregional (Leontief) multipliers effects,
- $\mathbf{S}_{12} = \mathbf{L}_{11}\mathbf{A}_{12} = (\mathbf{I} - \mathbf{A}_{11})^{-1}\mathbf{A}_{12}$ - interregional spillover effects, that is spillovers in region (1) from the final demand stimulus generated in region (2).

Column sums of particular blocks of matrix **M** are the output multipliers.

Decomposition of multipliers

Blocks of multiplier matrix **M** can be decomposed into the feedback, spillover and Leontief effects.

Using Round's definition of the feedback effect, the gross output equation can be presented in a form (see Round [2001], p. 58):

$$\begin{bmatrix} \mathbf{X}_1 \\ \mathbf{X}_2 \end{bmatrix} = \begin{bmatrix} \mathbf{F}_{11} & \mathbf{0} \\ \mathbf{0} & \mathbf{F}_{22} \end{bmatrix} \begin{bmatrix} \mathbf{I} & \mathbf{S}_{12} \\ \mathbf{S}_{22} & \mathbf{I} \end{bmatrix} \begin{bmatrix} \mathbf{L}_{11} & \mathbf{0} \\ \mathbf{0} & \mathbf{I}_{22} \end{bmatrix} \begin{bmatrix} \mathbf{Y}_1 \\ \mathbf{Y}_2 \end{bmatrix} \quad \text{or} \quad \mathbf{X} = \mathbf{M}_F \mathbf{M}_S \mathbf{M}_L \mathbf{Y}$$

where $\mathbf{M}_F, \mathbf{M}_S$ and $\mathbf{M}_L$ are multiplier matrices representing the feedback, spillover and Leontief effects, respectively.

The additive decomposition of the above equation is similar to that proposed by Pyatt and Round [1979] and Round [1985] for the case of SAM:

$$\mathbf{X} = [\mathbf{I} + (\mathbf{M}_L - \mathbf{I}) + (\mathbf{M}_S - \mathbf{I})\mathbf{M}_L + (\mathbf{M}_F - \mathbf{I})\mathbf{M}_S\mathbf{M}]\mathbf{Y}$$

(a) (b) (c) (d)

where (a) - an initial injection,

(b) - Leontief inverse multipliers,

(c) – spillover multipliers,

(d) – feedback multipliers.

Error measures

The problem is how strong impact the feedback effect has on the gross output of a particular region. This problem is directly connected with the question of efficacy against the costs of constructing multiregional input-output models. It has been concluded from various investigations that the feedback effect is rather small.

- Original measure proposed by Miller [1966]:

$$OPE = \frac{\mathbf{i}^{\mathrm{T}}\left[\mathbf{I} - \mathbf{A}_{11} - \mathbf{A}_{12}(\mathbf{I} - \mathbf{A}_{22})\mathbf{A}_{21}\right]^{-1}\mathbf{Y}_1 - \left(\mathbf{I} - \mathbf{A}_{11}\right)^{-1}\mathbf{Y}_1}{\mathbf{i}^{\mathrm{T}}\left[\mathbf{I} - \mathbf{A}_{11} - \mathbf{A}_{12}(\mathbf{I} - \mathbf{A}_{22})\mathbf{A}_{21}\right]^{-1}\mathbf{Y}_1}$$

(overall percentage error)

- Measures proposed by Gillen and Guccione [1980], [1988]:

$$MPE = \frac{\|\mathbf{A}_{12}\|\,\|\mathbf{A}_{21}\|}{(1-\|\mathbf{A}_{11}\|)(1-\|\mathbf{A}_{22}\|)} \qquad LUB = \left\|(\mathbf{I} - \mathbf{A}_{11})^{-1}\mathbf{A}_{12}(\mathbf{I} - \mathbf{A}_{22})^{-1}\mathbf{A}_{21}\right\| \qquad IFI = \frac{\mathbf{i}^{\mathrm{T}}\widetilde{\mathbf{F}}_{11}\mathbf{i}}{\mathbf{i}^{\mathrm{T}}\mathbf{F}_{11}\mathbf{L}_{11}\mathbf{i}}$$

(maximum percentage error) *(least upper bound)* *(interregional feedback index)*

- *MPE* increases together with decreasing self-sufficiency of a region and decreases with growing aggregation over the regions and sectors,

- *LUB* represents the lowest *MPE* estimates generated from all possible final demand vectors; is independent of final demand and decreases with growing self-sufficiency of the regions,

- *IFI* is a percentage difference between unweighted average output multipliers from $\mathbf{F}_{11}\mathbf{L}_{11}$ and those from $\mathbf{L}_{11}$.

Existing data

- To date, the system of national accounts for the whole economy has been an indirect source of information about the regions in Poland.
- The most difficult part is capturing interregional flows generated by the free movement of goods and services, when economic borders between regions are conventional and thus the flows are not subject to registration.
- Because statistical data necessary for the research are incomplete, estimation methods that regionalise national accounts are used rather than methods requiring to construct an independent system of regional accounts.

Estimation of regional input coefficients

Estimates of intraregional and interregional flows of intermediate output follow Miller's specification ([1985], [1986]), so

$$\mathbf{A_{11}} = \hat{\mathbf{c}}_1 \mathbf{A_1} \quad \mathbf{A_{12}} = (\mathbf{I} - \hat{\mathbf{c}}_2)\mathbf{A_2}$$

$$\mathbf{A}_{22} = \hat{\mathbf{c}}_2 \mathbf{A_2} \quad \mathbf{A_{21}} = (\mathbf{I} - \hat{\mathbf{c}}_1)\mathbf{A_1}$$

A matrix for the whole economy (in 2000) was taken as the background for calculations, as there was no data on regional technology coefficients ($\mathbf{A_1}, \mathbf{A_2}$).

Diagonal matrices $\hat{\mathbf{c}}_1$ and $\hat{\mathbf{c}}_2$ were calculated on the basis of location quotients representing some kind of self-sufficiency measures of regions:

$$\hat{\mathbf{c}}_1 = \begin{cases} 1 \text{ if } (LQ_{i(1)}) > 1 \\ LQ_i \text{ if } (LQ_{i(1)}) < 1 \end{cases} \qquad LQ_{i(1)} = \frac{X_{i(1)}}{X_{(1)}} / \frac{X_i}{X}$$

where $LQ_{i(1)}$ describes the share of gross output of industry *i* in the region of Łódź in total gross output of that region in relation to corresponding ratio for the whole national economy.

Assumptions

- When $LQ_{i(1)} > 1 \quad a_{ij(11)} = a_{ij}$ and $a_{ij(21)} = 0$

  (parallel when $LQ_{i(2)} > 1 \quad a_{ij(22)} = a_{ij}$ and $a_{ij(12)}) = 0$

- $a_{ij(21)} = (1 - LQ_{i(1)})a_{ij}$ when $LQ_{i(1)} < 1$

  $a_{ij(12)} = (1 - LQ_{i(2)})a_{ij}$ when $LQ_{i(2)} < 1$

Table 1. Location quotients for regions (1) and (2) in 2000

Sections and divisions	Section symbol	Number	Region (1)	Region (2)
Agriculture, hunting and forestry	A	1	1.244	0.985
Fishing	B	2	0.194	1.049
Mining and quarrying	C	3	0.784	1.013
Manufacture of food products and beverages	D1	4	1.141	0.991
Manufacture of tobacco products	D2	5	1.719	0.957
Manufacture of textiles	D3	6	5.550	0.725
Manufacture of wearing apparel and furriery	D4	7	1.538	0.968
Processing of leather and manufacture of leather products	D5	8	1.217	0.987
Manufacture of wood and wood straw and wicker products	D6	9	0.889	1.007
Manufacture of pulp and paper	D7	10	0.708	1.018
Publishing. painting and reproduction of recorded media	D8	11	0.944	1.003
Manufacture of coke, refined petroleum products	D9	12	0.710	1.018
Manufacture of chemicals and chemical products	D10	13	0.723	1.017
Manufacture of rubber and plastic products	D11	14	1.164	0.990
Manufacture of other non-metallic mineral products	D12	15	1.782	0.953
Manufacture of basic metals	D13	16	0.256	1.045
Manufacture of metal products	D14	17	0.899	1.006
Manufacture of machinery and equipment n.e.c	D15	18	0.786	1.013
Manufacture of office machinery and computers	D16	19	1.089	0.995
Manufacture of electrical machinery and apparatus n.e.c	D17	20	1.264	0.984
Manufacture of radio, television and communication equipment and apparatus	D18	21	0.367	1.038
Manufacture of medical. precision and optical instruments, watches and clocks	D19	22	0.649	1.021

Table 1. Location quotients for regions (1) and (2) in 2000 (cont.)

Sections and divisions	Section symbol	Number	Region (1)	Region (2)
Manufacture of motor vehicles, trailers and semi-trailers	D20	23	0.243	1.046
Manufacture of other transport equipments	D21	24	0.171	1.050
Manufacture of furniture; manufacturing n.e.c.	D22	25	0.823	1.011
Recycling	D23	26	0.706	1.018
Electricity, gas and water supply	E	27	1.389	0.977
Construction	F	28	0.743	1.016
Trade and repair	G	29	1.173	0.990
Hotels and restaurant	H	30	0.793	1.013
Transport, storage and communication	I	31	0.859	1.008
Financial intermediation	J	32	0.661	1.020
Real estate, renting and business activities	K	33	0.931	1.004
Public administration and defence; compulsory social security	L	34	1.071	0.996
Education	M	35	1.047	0.997
Health and social work	N	36	1.210	0.987
Other community, social and personal service activities	O+P	37	0.877	1.007

Location quotients

Location quotients calculated for the two analysed regions and presented in Table 1 are an interesting analytical material in themselves.

- Location quotients turn out particularly high for the manufacture of textiles, wearing apparel and furriery.
- Agriculture still remains regional specialisation.
- For modern branches such as manufacture of radio, television and communication equipment and apparatus, medical and optical instruments location quotients are below 0.65.
- The proportion of manufacture of office machinery and equipment in the Łódź region is similar to its share in the national economy.
- Location quotients for education and healthcare are higher than 1.

I/O multipliers

- The calculated multipliers provide a wealth of analytical opportunities.
- They show how effective it would be to increase final demand for products of particular branches in a given region for increasing output inside that region –$\mathbf{M}_{11}$ ($\mathbf{M}_{22}$) and in its surroundings -$\mathbf{M}_{12}$ ($\mathbf{M}_{21}$)
- Distinct variations in the multipliers' $\mathbf{M}_{12}$ and $\mathbf{M}_{21}$ result from the fact that our study focuses on linkages between the small region of Łódź and the rest of the economy.

Table 2. Input-output multipliers in 2000

Sections and divisions	Section symbol	No.	M_{11}			M_{21}	M_{12}	M_{22}
			Direct effect	Indirect effect	Total multiplier	Total multiplier		
Agriculture, hunting and forestry	A	1	1.654	0.964	2.618	0.489	0.003	2.874
Fishing	B	2	1.015	0.978	1.994	0.764	0.003	2.979
Mining and quarrying	C	3	1.071	0.691	1.763	0.441	0.001	1.997
Manufacture of food products and beverages	D1	4	1.485	1.466	2.951	0.464	0.004	3.312
Manufacture of tobacco products	D2	5	1.410	1.116	2.526	0.401	0.007	2.709
Manufacture of textiles	D3	6	1.391	1.040	2.431	0.529	0.106	2.597
Manufacture of wearing and furriery	D4	7	1.022	1.136	2.159	0.297	0.067	2.511
Processing of leather and manufacture of leather products	D5	8	1.244	0.996	2.240	0.347	0.010	2.723
Manufacture of wood and wood, straw and wicker products	D6	9	1.206	0.874	2.080	0.464	0.002	2.800
Manufacture of pulp and paper	D7	10	1.422	0.832	2.254	0.896	0.002	3.090
Publishing, painting and reproduction of recorded media	D8	11	1.121	0.816	1.937	0.532	0.001	2.470
Manufacture of coke, refined petroleum products	D9	12	1.129	1.157	2.286	0.787	0.001	2.919
Manufacture of chemicals and chemical products	D10	13	1.278	0.703	1.981	0.609	0.002	2.846
Manufacture of rubber and plastic products	D11	14	1.243	0.950	2.194	0.646	0.006	2.867
Manufacture of other non-metallic mineral products	D12	15	1.172	0.805	1.977	0.506	0.003	2.408
Manufacture of basic metals	D13	16	1.111	0.768	1.879	1.223	0.001	2.869
Manufacture of metal products	D14	17	1.110	0.589	1.699	0.982	0.001	2.715
Manufacture of machinery and equipment n.e.c	D15	18	1.070	0.656	1.726	0.672	0.002	2.591
Manufacture of office machinery and computers	D16	19	1.255	0.589	1.844	0.386	0.001	2.053
Manufacture of electrical machinery and apparatus n.e.c	D17	20	1.134	0.865	1.999	0.793	0.003	2.883
Manufacture of radio, television and communication equipment and apparatus	D18	21	1.176	0.431	1.607	1.424	0.002	3.970
Manufacture of medical, precision and optical instruments, watches and clocks	D19	22	1.033	0.669	1.701	0.454	0.001	2.232

Table 2. Input-output multipliers in 2000 (cont.)

Sections and divisions	Section symbol	No.	M_{11}			M_{21}	M_{12}	M_{22}
			Direct effect	Indirect effect	Total multiplier	Total multiplier		
Manufacture of motor vehicles, trailers and semi-trailers	D20	23	1.082	0.732	1.814	1.168	0.004	2.749
Manufacture of other transport equipments	D21	24	1.028	0.496	1.524	0.766	0.002	2.899
Manufacture of furniture; manufacturing n.e.c.	D22	25	1.067	1.061	2.128	0.532	0.012	2.887
Recycling	D23	26	1.094	0.703	1.797	1.364	0.002	2.763
Electricity, gas and water supply	E	27	1.113	0.873	1.986	0.514	0.001	2.345
Construction	F	28	1.148	0.847	1.995	0.535	0.002	2.639
Trade and repair	G	29	1.036	0.792	1.828	0.342	0.002	2.223
Hotels and restaurant	H	30	1.006	1.397	2.403	0.332	0.004	3.108
Transport, storage and communication	I	31	1.181	0.581	1.761	0.443	0.001	2.359
Financial intermediation	J	32	1.301	0.574	1.875	0.660	0.001	2.461
Real estate, renting and business activities	K	33	1.139	0.541	1.680	0.294	0.001	1.949
Public administration and defence; compulsory social security	L	34	1.000	0.438	1.438	0.218	0.002	1.666
Education	M	35	1.013	0.291	1.304	0.120	0.001	1.454
Health and social work	N	36	1.047	0.406	1.452	0.209	0.001	1.718
Other community, social and personal service activities	O+P	37	1.047	0.732	1.779	0.370	0.002	2.201

Additive decomposition of multipliers

- The spillover effects observed only in the blocks beyond the main diagonal of $(\mathbf{M}_S - \mathbf{I})\mathbf{M}_L$ are considerably larger in block (2,1) than (1,2), which stems from the fact that subject to analysis are relationships between a small region and the rest of the economy.
- When block (2,1) elements are considered, the spillover effects are the higher, the lower specialisation of region (1) in making specific products.
- Feedback multipliers are almost non-significant. However, they are the higher, the higher region's specialisation in particular products.

For the sake of example, let us discuss the following elements of multipliers matrix **M**. It gives some insight into the size of feedback effects in absolute terms.

- $m_{66(11)} = 1 + 0{,}39119 + 0 + 0{,}00012 = 1{,}39131$

  (a) (b) (c) (d),

  which equals to the direct multiplier effect in the textile industry shown in presented above table.

From calculations it follows that:

- $m_{13,6(21)} = 0 + 0 + 0{,}13333 + 2 \cdot 10^{-5} = 0{,}13335$
- $m_{66(12)} = 0 + 0 + 0{,}05846 + 5 \cdot 10^{-6} = 0{,}05847.$

Calculation of error measures

- In absolute terms the feedback effects are very small in the Polish two-regional models. We compare our results with those achieved by Guccione *et al.* [1988] for the USA and by Dietzenbacher, van der Linden and Steenge [1993] for the EC countries.
- Our research produced definitely lower measures than those arrived at by above mentioned authors.
- A simulation, introducing the intermediate use of imported goods (10% of a given regional technological coefficient) also in branches being the region's specialization confirms the sensitivity of our measures to changes in the I/O structures.

Table 3. Size of feedback effects

Measure	Value (percent) for Polish two-regional model		Mean (percent)	
	I/O table built according to the presented estimation method	Introduction of 10% changes in coefficients a_{ij}	For USA	For EC
Overall percentage error *(OPE)*	0.016	0.181		1.78 (1970) 1.58 (1980)
Maximum percentage error *(MPE)*	36.21	38.45		
Least upper bound *(LUB)*	0.113	0.494		
Interregional feedback index *(IFI)*	0.02	0.184	0.99 (1963) 1.32 (1977)	