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A New Approach to the Selection of Key Sectors: *Net Forward and Net Backward Linkages*

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Abstract

Traditionally key sectors for the economic development of regions and nations have been defined as sectors with above average forward and backward linkages. Early on forward linkages were defined as the row sums of the Leontief-inverse. Presently, they are defined as the row sums of the Ghosh-inverse from the supply-driven input-output model. Besides, direct input coefficients, direct output coefficients, and hypothetical extraction of sectors from the demand-driven and the supply-driven model are used to define key sectors.

In all cases, the measures look at dependency in a one-sided way, namely only at the dependency of the rest of the economy on the sector at hand. They do not look at the sector's own dependency on the rest of the economy. Put differently, if a sector is not able to generate growth impulses independently, a more than average ability to multiply these impulses does not mean very much. This paper therefore proposes to replace the traditional (gross) forward and backward linkages with net linkages that take the two-sidedness of each sector's interdependency with the rest of the economy into account.

The added value of the new method is tested by comparing its outcomes with those of the old measures. The tests use input-output tables for China, South Korea, the Netherlands and the United States. These countries were chosen to represent both small and large countries, and rich and developing countries. They show that the outcomes of the old gross measures are all strongly correlated, despite their large theoretical differences. The net backward linkages also use final output coefficients, which are shown to vary more than Leontief-multipliers, whereas net forward linkages also use the primary input coefficients, which vary less than Ghosh-multipliers. As a result, the gross and net forward linkages show a relatively strong correlation, whereas the gross and net backward linkages show no correlation at all.

Hence, net forward linkages mainly offer a new theoretical perspective, whereas the net backward linkages also offer new empirical information.

Keywords: net multipliers, linkage analysis, economic growth, input-output analysis.

1. Introduction

When doing impact analysis consultants, but also academics, often produce exaggerated estimates of the importance of a certain sector, firm or project. Aside from double counting and using improper numbers and methods, a more fundamental reason for exaggeration is the systematic one-sidedness of almost all impact studies. Phrased in modelling terms, the researchers practically always, but mostly implicitly, assume that the sector or firm at hand is exogenous to the economy at hand. Consequently, when e.g. the importance of each and every sector is measured by multiplying each sector's direct employment with its own employment multiplier, then the size of the economy at hand will be overestimated by a factor 2 if the correctly weighted average sector's employment multiplier equals 2.

In concrete impact studies, this can be remedied by correcting the gross impacts with the share of a sector's or a firm's output that is dependent on the performance of the rest of the economy. This would then result in the presentation of *net impacts* (see Oosterhaven et al. 2003). For more general purposes, the one-sidedness may also be corrected by multiplying the direct employment, value added or output of a firm or a sector with its so-called *net multiplier*, which is defined as the corresponding gross multiplier times the share of exogenous final output in the output of the firm or sector at hand (see Oosterhaven and Stelder, 2002).

The later suggestion was strongly opposed by DeMesnard (2002), who especially took offence against the use of the word multiplier and who presented an alternative *iterative net multiplier*. This led to a lively debate (Oosterhaven, 2004; Dietzenbacher, 2005, DeMesnard, 2007a, Oosterhaven, 2007; DeMesnard, 2007b). The conclusion of this debate was that iterative net multipliers, being equal to the column sums of the Leontief-inverse minus one, simply equal traditional gross multipliers for intermediate demand, and may not pass as a net multiplier as they do not satisfy the output preservation property required for real net multipliers. The original net multiplier, however, is better not labelled a multiplier because it does not equal an effect/cause ratio.

Here we start from the one conclusion of this debate that everyone definitely agrees on, namely that the original net multiplier is a new key sector indicator, and we will try to answer the question how theoretically new and how empirically different this new key sector indicator is compared to the traditional measures.

To this purpose, section 2 will give an overview of existing key sector indicators, such as gross forward and backward linkages and the use of extraction analysis as a flexible alternative. Section 3 will explain why the original net multiplier from the Leontief

model may be best viewed as a *net backward linkage* indicator. Moreover, Section 3 will introduce a new net multiplier derived from the Ghosh model, which is best viewed as a *net forward linkage* indicator. Section 4, then compares all these key sector indicators by means of input-output data for China, South Korea, the U.S.A. and the Netherlands. It shows that the outcomes of the traditional gross measures are all strongly correlated empirically, despite their important theoretical differences. Section 5 concludes that net forward linkages mainly offer a new theoretical perspective, whereas the net backward linkages also offer new empirical information.

2. Traditional gross linkage measures

- Direct linkages (Chenery & Watanabe, 1958)
- Cumulative linkages (Rasmussen, 1956)
  - column sums Leontief-inverse: backward linkages
    - change in output if **final** demand goes **up**
  - row sums Leontief-inverse: forward linkages
    - row sums Ghosh-inverse = better (Beyers, 1976)
- Hypothetical extraction (Strassert, 1968)
  - very flexible (Miller & Lahr, 2001)
    - change in output if **intermediate** demand goes **down**

3. New net linkage measures

Net multiplier Theorem 1

Multiplied with the correct sectoral totals and summed over all sectors,

the exact total for the whole economy results:

$\mathbf{v_c'}\ \mathbf{L}\ \langle \mathbf{v_c} \rangle^{-1}\ \langle \mathbf{f_c} \rangle\ \ \mathbf{v} = \boldsymbol{v}$

Net multiplier Theorem 2

The correctly weighted average of all sectoral net multipliers equals unity:
$\mathbf{v_c'}\ \mathbf{L}\ \langle \mathbf{v_c} \rangle^{-1}\ \langle \mathbf{f_c} \rangle\ (\mathbf{v}\ v^{-1}) = 1$

Net linkages = two-way dependency

- Net **backward** linkages = Leontief column sums **x** final output coefficients
  - 'gross' backward linkages **x** ability to generate own **demand-driven** growth impulses
- Net **forward** linkages = Ghosh row sums **x** primary input coefficients
  - 'gross' forward linkages **x** ability to generate own **supply-driven** growth impulses

4. Empirical outcomes

Figure 1. Rather flat: secondary 4-21 > tertiary 24-31 & primary 1-3 > quaternary 32-36

Table 1. Total backward linkages per method, per country

Averages	United States	China	Netherlands	South Korea
Hypothetical extraction	71.8	131.6	46.7	71.2
Leontief-inverse	1.80	2.54	1.53	1.73
Total intermediate inputs	0.46	0.61	0.34	0.44

Table 2. Do primary input coefficients explain the difference?

Input coefficients	United States	China	Netherlands	South Korea
foreign imports	0.04	0.05	0.17	0.11
value added	0.34	0.24	0.29	0.27
total primary inputs	0.38	0.29	0.46	0.38

Table 3. Correlation of total primary input with backward linkages

Correlation coefficients	United States	China	Netherlands	South Korea
Hypothetical extraction	-0.93	-0.77	-0.97	-0.90
Leontief-inverse	-0.99	-0.93	-0.99	-0.97
Total intermediate input	-1.00	-0.95	-1.00	-1.00

Table 4. Do different methods give different sectoral rankings?

Correlation coefficients	United States	China	Netherlands	South Korea
Hypothetical extraction vs. Leontief-inverse	0.94	0.84	0.97	0.89
Hypothetical extraction vs. Total intermediate inputs	0.93	0.80	0.97	0.92
Leontief-inverse vs. Total intermediate inputs	0.99	0.96	0.99	0.97

Hardly, despite the obvious theoretical differences!

Table 5. Do sectoral rankings differ per country?

Correlation coefficients	Hypothetical extract.	Leontief-inverse	Intermediate inputs
United States vs. China	0.38	0.40	0.59
United States vs. Netherlands	0.30	0.20	0.28
United States vs. South Korea	0.55	0.60	0.60
China vs. Netherlands	0.32	0.24	0.28
China vs. South Korea	0.63	0.69	0.61
Netherlands vs. South Korea	0.60	0.48	0.61

Yes, most for the Netherlands, a developed, small, very open economy,
next for the USA, also developed, but much, much larger and more closed

Discuss figure 2-5 here.

Preliminary statistical analysis.

Table 6. Net backward linkages vary more as final demand coefficients vary more

4 Countries	Leontief colum sums		Ghosh row sums		Coefficients	
	gross	net	gross	net	final	primary
Average	1,86	0,90	1,93	0,99	0,50	0,53
Average absolute deviation	0,35	0,42	0,56	0,28	0,24	0,13
Average % deviaton	0,19	0,47	0,29	0,28	0,48	0,24

Table 7. Rank correlation of net linkages and gross linkages

	Leontief	Ghosh
United States	-0,08	0,81
China	0,23	0,73
Netherlands	0,09	0,76
South Korea	0,21	0,76

Net backward linkages offer most new information

5. Conclusions

Traditional impact & linkage methods
- one-sided dependency on sector at hand,
- methods are theoretically rather different, but empirically not, as differences are simply explained by inverse primary input ratios

Net backward and forward linkages
- dependency of sector on rest economy added
- especially for backward linkages, not only theoretically, but also empirically new info

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Appendix: Harmonisation of the four IO tables

by Jan Oosterhaven and Peter Overbeek

The aim was to get comparable input-output tables showing each country's industry-by-industry domestic intermediate transactions. To achieve this, several problems had to be overcome. First, we describe how we dealt with the largest problem, namely the United States. After that, we describe how we dealt with the problems of China, South Korea and finally the Netherlands.

United States

For the United States two problems had to be solved. First, imports had to be deducted from total use to get the use of domestically produced commodities. Second, the use table and the make table had to be combined into an industry-by-industry table.

The following data were used:

The Use of commodities by industries after redefinitions, 2003, Benchmark, producer prices, Summary. Website:
http://www.bea.gov/bea/industry/iotables/prod/options_list.cfm?aggregations_id=0&get_results=show&goto=go_to_options&anon=175&CFID=12846&CFTOKEN=63898881

The Make of commodities by industries after redefinitions, 2003, Benchmark, producer prices, Summary. Website:
http://www.bea.gov/bea/industry/iotables/prod/options_list.cfm?aggregations_id=0&get_results=show&goto=go_to_options&anon=175&CFID=12846&CFTOKEN=63898881

The domestic Use table was derived as follows. Subscript c denotes commodities, subscript i industries and subscript f domestic final demand categories (i.e. excluding exports).

First, the total use of each commodity was calculated as: $d_c = q_c - e_c + m_c$, where q is total commodity demand, e is exports of goods and services, m is import of goods and services.

Second, the use of domestically produced commodities was calculated as a ratio of total use: $o_c = 1 - m_c/d_c$.

Third, all commodity-by-industry and commodity-by-final demand deliveries (except exports) were multiplied with this ratio to get the domestic use table:

$U_{ci} / o_c = Ud_{ci}$, where Ud_{ic} is the domestic Intermediate demand matrix, and

$F_{cf}/o_c = Fd_{cf}$, where Fd_{cf} is the domestic Final demand matrix.

Next, the market shares from the Make table were used to arrive at the domestic industry-by-industry table needed:

$(V_{ic} / q_c)\ Ud_{ci} = Z_{ii}$ (the industry-by-industry part)

$(V_{ic} / q_c)\ Fd_{cf} = F_{if}$ (the industry-by-domestic final demand part)

China

For China only one problem had to be solved. Imports by industry of origin had to be deducted from total use by industry and by final demand category.

For China the 33 sector input-output table for the year 2000 was used.

First, domestic demand by industry of origin was calculated as: $d_i = q_i - e_i + m_i$, where q is total gross output, e is exports, m is imports. Second, the ratio of domestically

produced output to total domestic demand as calculated as: $o_i = 1 - m_i/d_i$. third, this ratios is used to estimate the transactions needed:
$Z_{ii} / o_i = Zd_{ii}$ where Zd_{ii} is the domestic industry-by-industry table for China
$F_{if} /o_i = Fd_{ii}$ where Fd_{ii} is the domestic final demand-by-industry matrix where the export column e_i was excluded from the domestification.

South Korea
For South Korea the 77 sector input-output table for the year 2000 was used. Its domestification proceeded in exactly the same way as that of China.

The Netherlands
For the Netherlands a different problem was encountered. The table we had was already domestic. The problem was that there were trade margins in the final part which should be in the industry by industry part.
We had the following data for the Netherlands: a 106 sector Input-Output table for the year 2003.
To get the trade margins from the final part to the industry by industry part we made a industry by industry trade margins table which we then added to the original industry by industry table. To get the trade margins table we first did a row correction followed by a column correction followed by a row correction with the following formula's:
$Z_{ii}^{1} = Z^{0}_{ii}\hat{a}$
$Z_{ii}^{2} = Z^{1}_{ii}b\hat{}$
……
$Z_{ii}^{n} = Z^{n-1}_{ii}\hat{a}$

where $a = (r_i/x_i^{0})$, and $b = (k_i/x'^{0}_{i})$
r denotes the row total of trade margins, x is total industry output and k denotes the column total of trade margins.
We continued this until we had errors smaller than four digits behind the comma.
After that we just added the industry by industry trade margins table to the original industry by industry table and set the trade margins column in the final demand part to zero.

Aggregation
For all four countries we used the United Nations Classifications Registry ISIC Rev.3.1. (website: http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=17) to bring the number of sectors back to 37. Also, we aggregated the final demand categories and value added categories, resulting in a single column for final demand and a single row for value added. For China we had a small problem in the sense that the input-output table for China was too aggregated in some sectors. This was solved by putting blanks on positions of the sectors that were combined in the sector above the blanks.

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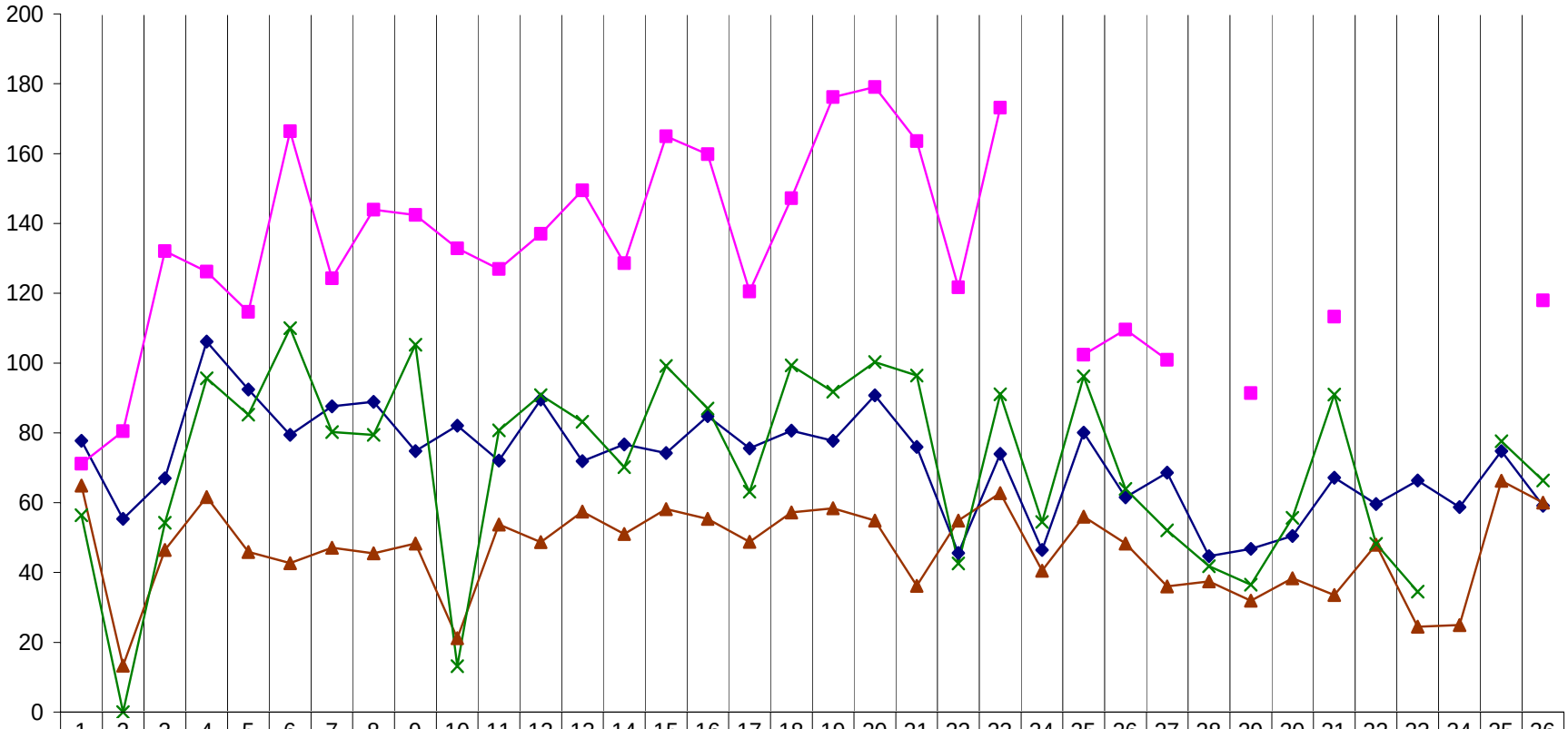
Total backward linkages with hypothetical extraction



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
US	78	55	67	106	92	79	88	89	75	82	72	90	72	77	74	85	76	81	78	91	76	46	74	46	80	61	69	45	47	50	67	60	66	59	75	59
CH	71	80	132	126	115	166	124	144	142	133	127	137	149	129	165	160	121	147	176	179	164	122	173		102	110	101		91		113					118
NL	65	13	46	62	46	43	47	45	48	21	54	49	57	51	58	55	49	57	58	55	36	55	63	41	56	48	36	37	32	38	34	48	24	25	66	60
SK	56	0	54	96	85	110	80	79	105	13	81	91	83	70	99	87	63	99	92	100	96	43	91	54	96	64	52	42	36	56	91	48	35		78	66

Figure 2. Leontief-multipliers vary more for countries than for sectors

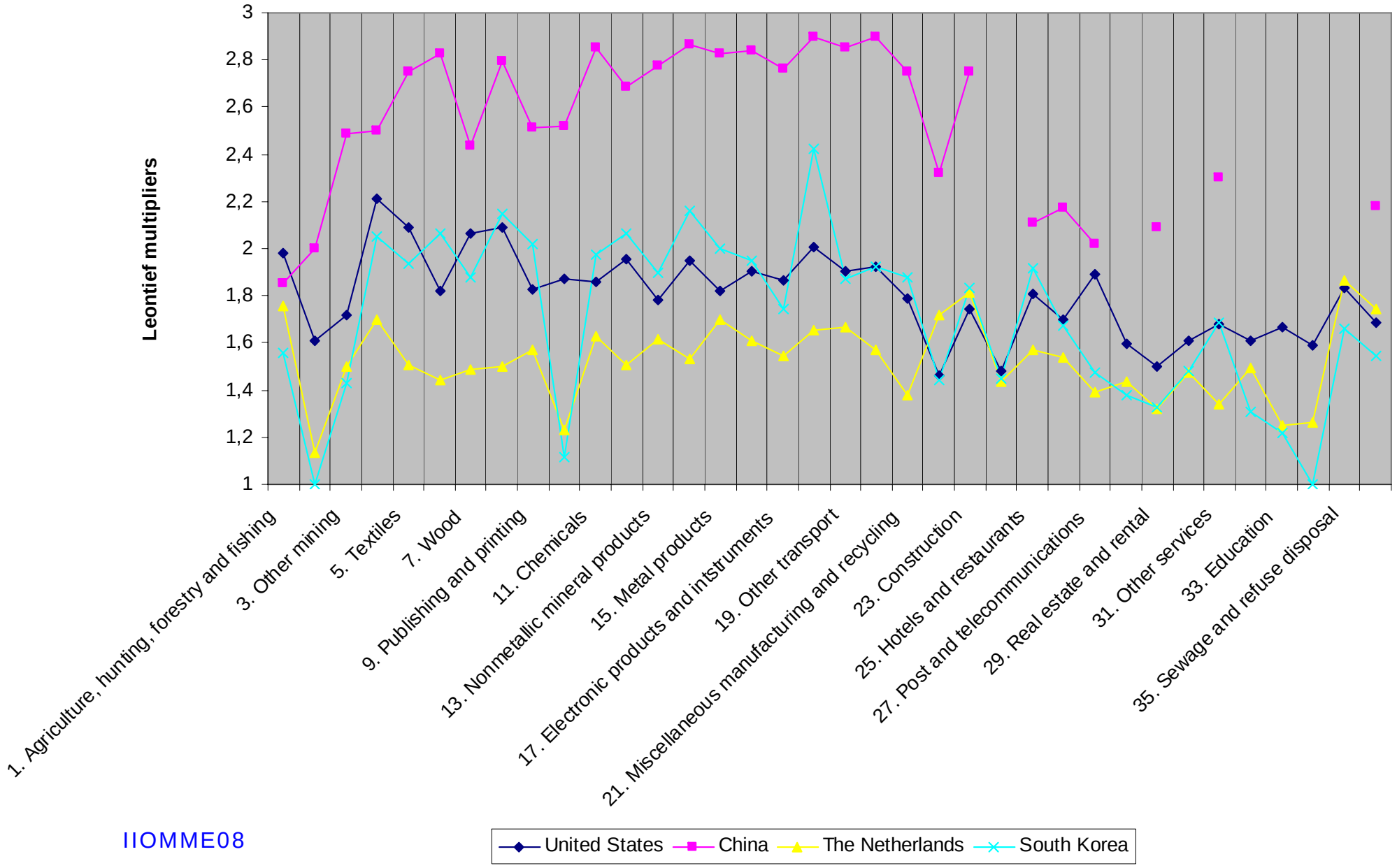


Figure 3. Final output coefficients vary much more than L-multipliers

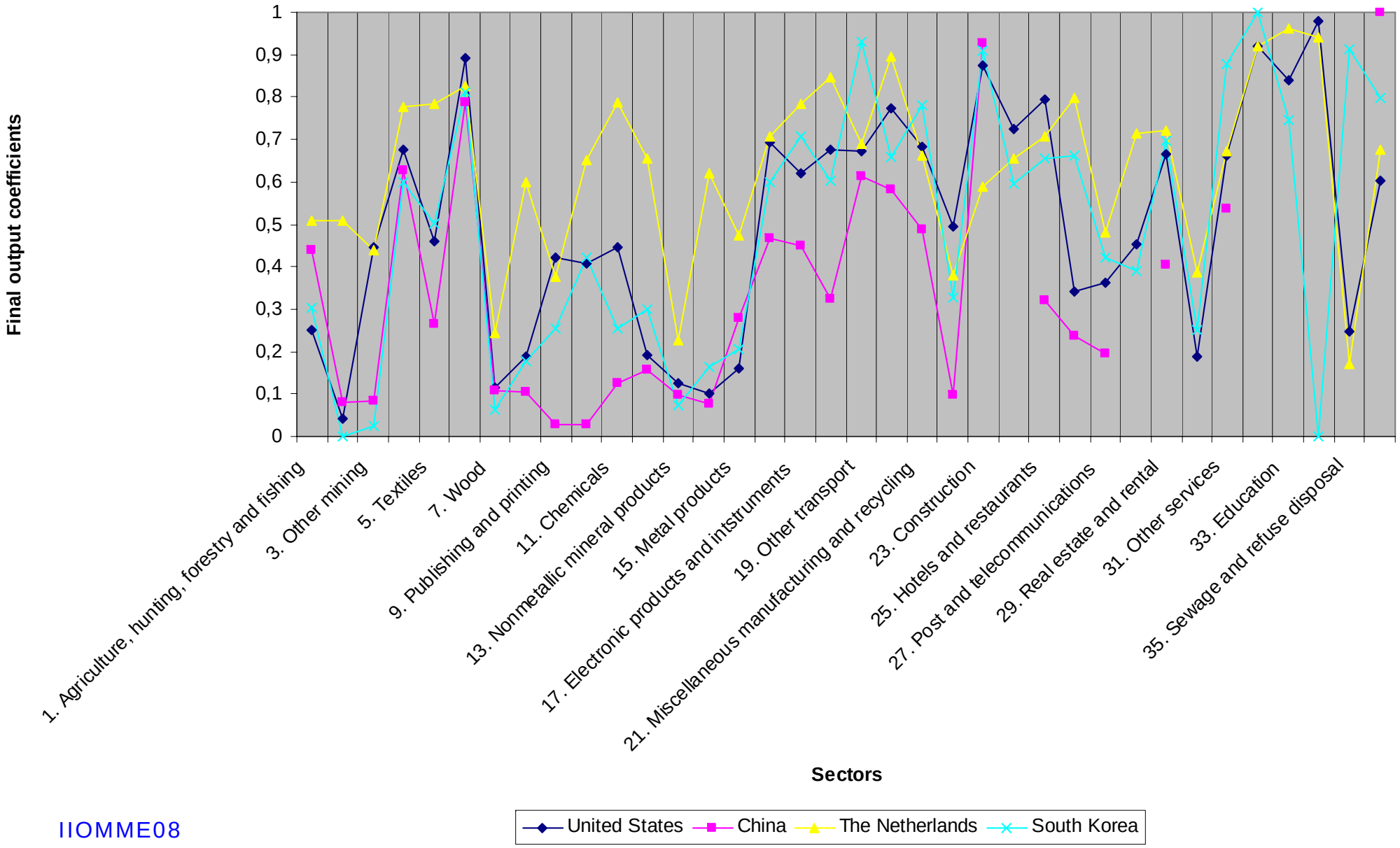


Figure 4. Ghosh-multipliers vary more for sectors and less for countries

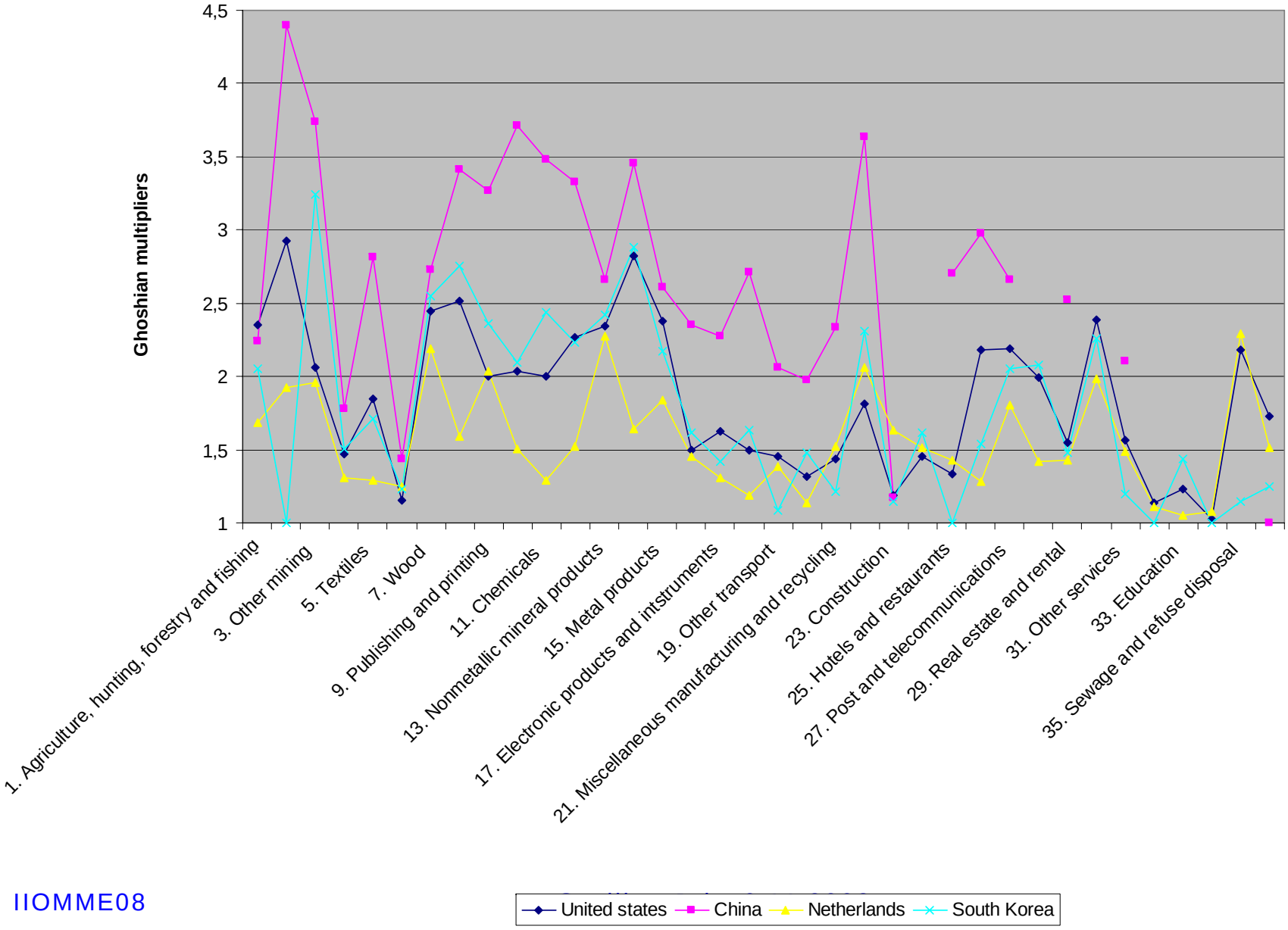


Figure 5. Primary input coefficients vary less than Ghosh-multipliers