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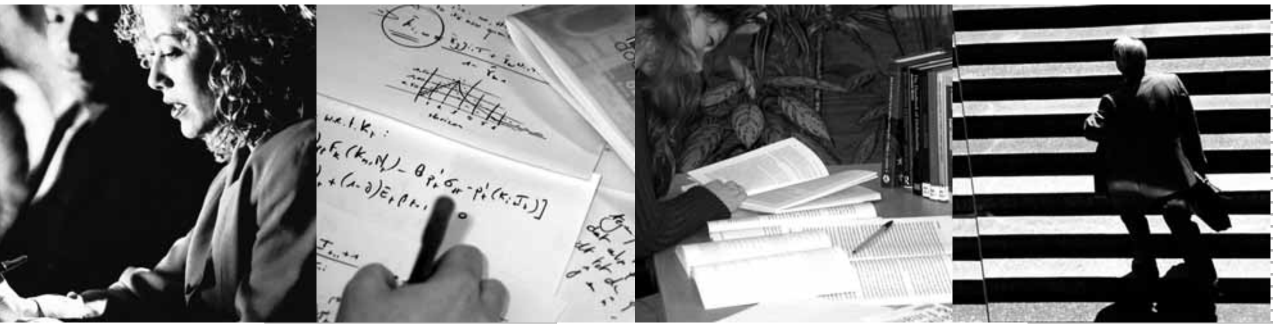
Indirect effects – A formal definition and degrees of dependency as an alternative to technical coefficients

François Coppens



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INDIRECT EFFECTS

A FORMAL DEFINITION AND DEGREES OF DEPENDENCY AS AN ALTERNATIVE TO TECHNICAL COEFFICIENTS

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Abstract

The use of input-output analysis for the computation of secondary effects of final demand changes is well-known. These 'final demand effects' can be calculated using technical coefficients and the inverse of the Leontief matrix.

This paper offers an alternative to the use of technical coefficients. Its goal is threefold.
First of all degrees of dependency are defined and it is shown how they can be used to compute secondary effects. Their definition is based on an input-output table.

Secondly the concept of secondary effects is extended to what is called indirect effects. These indirect effects are not only related to final demand but to total industry output. It is shown how these indirect effects can be calculated using technical coefficients or degrees of dependency. The method used is a variant of the so-called Hypothetical Extraction Methods. Double counting is avoided, as such the resulting multipliers are 'net multipliers'.
It is formally demonstrated that technical coefficients and degrees of dependency give the same results when a recent input-output table is available. If this is not the case then the results are different. It is impossible to say which of the two estimates is better. Since technical coefficients are already broadly accepted, some examples are given to justify the use of degrees of dependency.

Finally it is explained how the unavailability of an input-output table can be solved. Starting from the supply-use tables a 'quick and dirty method' to infer an input- output table is provided. This topic is justified by the fact that for Belgium input-output tables are only published for those years that are divisible by five, with a three year lag.

A short empirical analysis, based on currently available data, shows that technical coefficients and degrees of dependency have comparable performance, with a slight advantage for the technical coefficients. This performance is measured relative to a 'right' result, being the indirect effects for the year 2000 computed using the now available input-output table for the year 2000. This result is called 'right' because it does not make any assumptions on stability of technical coefficients nor of degrees of dependency.
The empirical analysis also compares the use of a recent supply-use table to the use of an old input-output table. Supply-use tables on average overestimate the 'right' result. They are however often closest to the 'right' result at the first level.

Since these conclusions are based on limited data further analysis is required as more data becomes available.

JEL Classification: C67, D57.

Key words: Indirect effects, Input-output analysis, degrees of dependency, technical coefficients, net multiplier.

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0. Introduction

In 2003 Coppens and van Gastel published an NBB Working Paper[1] on the importance of the car manufacturing industry for the Belgian economy. Particular interest was devoted to the estimation of the 'indirect effects', these are effects generated in the supplying sectors. The underlying reason was the increasing trend towards outsourcing (the so-called lean production system).

A well-known technique for the computation of secondary effects[2] is the use of technical coefficients computed from input-output tables. However, at that moment the most recently published input-output table for the Belgian economy was the one for 1990. Using this table to estimate indirect effects for the year 2002 seemed inappropriate to the authors, especially as the car manufacturing industry had undergone some fundamental reforms since 1990[3]. Moreover, it was known that a new methodology for the compilation of input-output tables had been introduced with effect from 1995 (European System of Accounts 1995, ESA1995[4]).

As the ESA1995 stipulated that input-output tables should be constructed from so-called supply-use tables, recent supply-use tables were used to derive, under a set of hypotheses, inter-industry relationships i.e. an input-output table.

The unavailability of a recent input-output table for the Belgian economy was only one of the problems the authors were faced with. Besides this 'lack of data' there was also a methodological problem to be solved.
Indeed, input-output analysis' goal is to study the impact of *final demand changes*. As such, it allows to compute the secondary effects of final demand. The objective however was to measure the *importance of the presence of an industry*, even when this industry only produces intermediary consumption goods. It was for instance tried to measure the importance of the chemical industry being present in a port area.
The chemical industry's output goes only partially to final demand; however, the other part is at least as important, because it also generates derived or indirect effects in other sectors. This paper describes a method to measure these 'indirect effects'.
Taking the indirect effects on employment as a specific example, it turns out that the 'indirect employment' of an industry is the employment that is potentially affected by a delocalisation of that industry.
Moreover an instrument (the degrees of dependency[5]) is defined that allows to analyse which of the other branches of the economy will be most affected by such a delocalisation.

The method and its hypotheses are described in detail in the NBB working paper 38[1]. It has also been applied to other industries (ICT, textile, ports sector ...).

In the current paper this method is formally compared to the use of technical coefficients known from input-output analysis.

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[1] Coppens F., van Gastel G., «De autonijverheid in België: Het belang van het toeleveringsnetwerk rond de assemblage van personenauto's», Working Paper 38, National Bank of Belgium, June 2003

[2] The notion of indirect effect applied is somewhat different from the one in input-output analysis as will be explained later on. The reader should therefore distinguish *primary and secondary* effects from *direct and indirect* effects.

[3] For example the introduction of the conveyor system at Ford Genk and the creation of a supplier parc at Opel Antwerp.

[4] Eurostat (1996), «European System of Accounts - ESA 1995», Office for Official Publications of the European Communities, Luxemburg, 1996

[5] The author has not been the first one to define these degrees of dependency, as they were also used in Eysackers E. (2000).

The paper consists of five parts. Technical coefficients and degrees of dependency are both derived from an input-output table, so the first chapter assumes this I-O table to be given and explains the two techniques. Primary and secondary effects are defined as well.
Moreover it is shown that, if a recent input-output table is available, both methods give the same results.

The second chapter analyses the errors made when there is no recent input-output table available. In that case the performance of each estimator depends on the underlying assumptions, i.e. the constant technical coefficients or the constant degrees of dependency. While it is generally believed that technical coefficients tend to be constant, it is argued that some recent trends such as outsourcing, globalisation and productivity increases cast doubts on this assumption, implying that there is a justification for using the degrees of dependency.

The third chapter passes from final demand to total industry output and extends the definition of primary and secondary effects to direct and indirect effects. Formulae are provided to compute them.

The fourth chapter explains how a rudimentary input-output table can be derived from the supply-use tables[6]. This is, of course, only necessary if no recent (and detailed) input-output table is available.

The final chapter is a short empirical comparison of the performance of the different estimators. It compares the performance of technical coefficients and degrees of dependency. It also compares the use of the 'quick and dirty' estimate of the input-output table to the use of a published input-output table.

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[6] It is a 'quick and dirty' method, not to be compared with the more sophisticated method used by the Federal Planning Bureau (See Federal Planning Bureau (2003)).

1. Input-output tables, some definitions

This chapter gives a brief summary of the input-output analysis. The basic concepts (the input-output table, the technical coefficients) are defined. In addition it is shown how these concepts can be used to calculate primary and secondary effects. Readers that are familiar with these concepts can skip this part and just read the conclusion 1.2.3 in order to understand the notations used.

After this brief review of input-output analysis a definition is provided of what is called degrees of dependency. It is also shown how one can use them to derive secondary effects.
Finally it is shown that technical coefficients and degrees of dependency yield the same secondary effect estimates when a recent input-output table is available.

Both concepts - technical coefficients and degrees of dependency - use the input-output table as a starting point.

1.1 Input-output table

There are in fact three input-output tables; one for domestic production, one for the imports and the (total) input-output table. In this paper the domestic input-output table is used. This is because supply from abroad does not generate any (domestic) indirect effect.

A (simplified) domestic input-output table[7] is a two-dimensional table indicating the supply from each industry of an economy to each other industry of that same economy and to final demand. Each element (i,j) in the table gives the quantity supplied by the industry in the i^{th} row to the one in the j^{th} column.

Each column thus represents the inputs of an industry. Besides the 'industry-columns' (S1, S2, ..., Sn), there are four particular columns:

- Consumption (C)
- Investments (I)
- Exports (X)
- Total output (O)

Each row indicates the outputs of an industry. There are three special rows:

- value added (VA)
- Imports (IM)
- Total output (O)

$$
IO(t)=\begin{array}{cccccccc:c}
 & \mathbf{S1} & \mathbf{....} & \mathbf{Sn} & \mathbf{C} & \mathbf{I} & \mathbf{X} & & \boldsymbol{O}\\
\mathbf{S1} & IO(1,1,t) & & IO(1,n,t) & C(1,t) & I(1,t) & X(1,t) & & O(1,t)\\
\mathbf{S2} & IO(2,1,t) & & IO(2,n,t) & C(2,t) & I(2,t) & X(2,t) & & O(2,t)\\
\mathbf{....} & & & & & & & & ...\\
\mathbf{Sn} & IO(n,1,t) & & IO(n,n,t) & C(n,t) & I(n,t) & X(n,t) & & O(n,t)\\
IM & IM(1,t) & ... & IM(n,t) & IM(C,t) & IM(I,t) & T(t) & & \\
\mathbf{VA} & VA(1,t) & \mathbf{...} & VA(n,t) & & & & & \\
\hdashline
\mathbf{O} & O(1,t) & \mathbf{...} & O(n,t) & & & & &
\end{array}
$$

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[7] For a detailed explanation, see e.g. National Accounts Institute (2004b), National Accounts Institute (2003a), National Accounts Institute (2003b), Van Straelen R.A., Virenque P.H. (1961)

Where

- IO(i,j,t) equals the (domestic) supply of industry i to industry j during period t;
- C(i,t) is consumption of products produced by industry i during period t;
- I(i,t) is investment in products produced by industry i during period t;
- X(i,t) is exports of products produced by industry i during period t;
- VA(i,t) is value added of branch i during period t, it is by definition equal to. $\sum_j IO(i,j,t)+C(i,t)+I(i,t)+X(i,t)-\sum_j IO(j,i,t)-IM(i,t)$
- IM(i,t) is imports by industry i during period t, IM(C,t) is import for consumption during t, IM(I,t) is import of investment goods during t and T(t) represents imported goods destined for exports during t.
- O(i, t) is total output from industry i during period t i.e. $O(i,t)=\sum_k IO(i,k,t)+C(i,t)+I(i,t)+X(i,t)=\sum_k IO(k,i,t)+IM(i,t)+VA(i,t)$

The nxn square in the upper left corner shows (domestic) intermediate supply. This square matrix is the core of the input-output table and shows inter-industry relations. The intermediate supply part can be read column-wise by looking at the industry inputs. It can also be read row-wise, looking at industry outputs. These two options are the basic difference between the two methods developed in the following paragraphs.

The three columns C, I, X relate to final demand F.

1.2 Technical coefficients

1.2.1 Definitions

The technical coefficient *a(i, j, t)* gives the input from industry i needed by industry j to produce one unit of output of industry j. It thus defines the input structure of a industry, or using the notations in 1.1:

$$\boxed{a(i,j,t)=\frac{IO(i,j,t)}{O(j,t)}} \qquad \textbf{\textit{(D1)}}$$

These coefficients are only defined for the nxn upper left part of the (domestic) input-output table.

The output of an industry goes to other industries or to final demand (F(i,t) = C(i,t) + I(i,t) + X(i,t)) so:

$$O(i,t)=\sum_{j=1}^{n} IO(i,j,t)+F(i,t)$$

using the above definition of the technical coefficients we have:

$$O(i,t)=\sum_j a(i,j,t).O(j,t)+F(i,t)$$

Using matrix notation this becomes

$$O(t)=A(t).O(t)+F(t) \qquad \textbf{\textit{(1)}}$$

1.2.2 Primary and secondary effects

1.2.2.1 Primary and secondary effects on output

It can now be explained how these technical coefficients can be used to compute secondary effects. Assume that final demand increases by an amount dF.

Then, from the above equation (1) it can be seen that this has a primary (or immediate) effect on industry output; O increases by an amount $dO^{(0)} = dF$.

However, there are also second order effects as can be seen from the same equation (1), because this increase in O has a new effect. Indeed, by the first term on the right-hand side of equation (1), output O increases a second time by $A(t).dO^{(0)}$.

$$dO^{(1)}=A(t).dO^{(0)} \qquad \text{(first level secondary effect)}$$

This first level increase induces, by the same mechanism, a second level secondary effect:

$$dO^{(2)}=A(t).dO^{(1)}=A(t)^2.dO^{(0)} \qquad \text{(second level secondary effect)}$$

From equation (1) it can be seen that an increase in final demand by dF increases O by an amount dO (including both immediate and secondary effects):

$$dO = \left(I - A(t)\right)^{-1}.dF$$

Where I represents the nxn unity matrix.

The same result is obtained by adding up the geometric matrix series $I + A(t) + A(t)^2 + \ldots.$

The matrix $(I-A(t))^{-1}$ is called the Leontief inverse.

So, the effects of a one million euro increase in final demand for production of industry j can be computed using a column vector dF where (the 'T' superscript means transposition)

$$dF = (\quad 0 \quad 0 \quad \ldots \quad \overset{j}{1} \quad \ldots \quad 0\quad)^T$$

resulting in

- a primary effect on industry j, $dO^{(0)} = dF$, so, a one million euro increase in output of branch j
- secondary effects at level n

$$dO^{(n)} = A(t)^n . \begin{pmatrix} 0 \\ .. \\ 1 \\ \ldots \\ 0 \end{pmatrix} = \begin{pmatrix} a^{(n)}(1, j, t) \\ \ldots \\ a^{(n)}(j, j, t) \\ \\ a^{(n)}(n, j, t) \end{pmatrix} \qquad \textbf{(2)}$$

By definition of matrix multiplication, this corresponds to the j^th column of the matrix $A(t)^n$.

It should be noted that there is a secondary effect in industry j ($a^{(n)}(j, j, t)$) as well!

1.2.2.2 Secondary effects on other variables

As regards output, the secondary effects follow immediately from the definition of technical coefficients as has been shown above. To compute secondary effects for other variables V (e.g. employment, value added) one has to make an assumption for the relation between output and the other variables. Suppose there is a variable V that is assumed to be proportional to output

$$V(i,t) = \alpha(i,t).O(i,t) \quad {}^{8} \qquad \textbf{\textit{(H1)}}$$

Defining a diagonal matrix α_d as follows

$$\alpha_d(t) = \left(\alpha_d(i,j,t)\right) \text{ with } \alpha_d(i,i,t) = \alpha \ (i,t), \alpha_d(i,j,t) = 0 \text{ when } \mathrm{i} \neq \mathrm{j}$$

This can be written as

$$V(t) = \alpha_d(t).O(t)$$

or

$$O(t) = \alpha_d(t)^{-1}.V(t)$$

Substitution into equation (1) gives

$$\alpha_d(t)^{-1}.V(t) = A(t).\alpha_d(t)^{-1}.V(t) + F(t)$$

or

$$V(t) = \alpha_d(t).A(t).\alpha_d(t)^{-1}.V(t) + \alpha_d(t).F(t)$$

The same reasoning as for output shows that a change in final demand dF induces:

- a primary effect $dV^{(0)} = \alpha_d(t).dF$
- secondary effects
    - o $dV^{(1)} = \alpha_d(t).A(t).\ \alpha_d(t)^{-1}.dV^{(0)}$
    - o $dV^{(2)} = \alpha_d(t).A(t).\ \alpha_d(t)^{-1}.dV^{(1)}$
    - o ...

So, the technical coefficient matrix has to be corrected for the proportionality between O and V. So using a matrix

$$A'(t) = \alpha_d(t).A(t).\alpha_d(t)^{-1} \qquad \textbf{\textit{(D2)}}$$

the results are similar to the ones in 1.2.2.1:

A <u>one million euro demand increase</u> for the products from industry j has an <u>immediate</u> effect on variable V given by (where dF is as in 1.2.2.1)

$$\boxed{dV^{(0)} = \alpha_d(t).dF = \begin{pmatrix} 0 \\ \ldots \\ \alpha(j,t) \\ .. \\ 0 \end{pmatrix}}$$

---

[8] In order to be correct, the formula should be $V(i,t) = \alpha^{\mathrm{V}}(i,t).O(i,t)$, since α depends on the variable V, but to avoid further complication, the 'V' superscript is dropped.

The secondary effects are obtained by multiplying this immediate effect by powers of the matrix A'(t):

$$\boxed{dV^{(n)} = A^{'}(t)^{n}.\alpha_d(t).dF = \alpha_d(t).A(t)^{n}.dF = \begin{pmatrix} \alpha(1,t).a^{(n)}(i,j,t).\alpha(j,t) \\ \ldots \\ \alpha(j,t).a^{(n)}(j,j,t).\alpha(j,t) \\ .. \\ \alpha(n,t).a^{(n)}(n,j,t).\alpha(j,t) \end{pmatrix}}$$

Cumulated primary and secondary effects are given by the matrix:

$$A^{'}(t)^{0..\infty}.\alpha_d(t).dF = \alpha_d(t).\left(I - A(t)\right)^{-1}.dF$$

1.2.3 Conclusion

If F(j, t) is total final demand (in million euro) for products of industry i, and defining a diagonal matrix $F_d(t)$, where

$$F_d(t) = \left(F_d(i,j,t)\right) \text{ with } F_d(i,i,t) = F(i,t), F_d(i,j,t) = 0 \text{ when i} \neq \text{j}$$

Then the total primary effect of a final demand F(j, t) on a variable V computed using the technical coefficients method (PV^{TC}) is found in the j'th column of the matrix:

$$\boxed{PV^{TC}(t) = \alpha_d(t).F_d(t)} \qquad \textbf{\textit{(R1a)}}$$

Where α_d is defined by (H1).

Secondary effects on variable V (SV^{TC}) are found in the j'th column of

$$\boxed{SV^{TC,(n)}(t) = A^{'}(t)^{n}.PV^{TC}(t)} \qquad \textbf{\textit{(R1b)}}$$

or, using (3) and (H1),

$$\boxed{SV^{TC,(n)}(t) = \alpha_d(t)A(t)^{n}F_d(t)} \qquad \textbf{\textit{(R1c)}}$$

A being the technical coefficients matrix.

1.3 Degrees of dependency

In the NBB working paper on the car manufacturing industry another method was used. So-called 'degrees of dependency' were defined. While technical coefficients look at the input structure of a industry, the method used focuses on the output, as will be seen below.

1.3.1 Definitions

Degrees of dependency of an industry i on an industry j are defined as[9]:

$$\boxed{d(i,j,t) = \frac{IO(i,j,t)}{O(i,t)}} \qquad \textbf{(D3)}$$

In other words, it is the proportion of output of industry i that is supplied to j. Just as for the technical coefficients, this definition holds for the intermediate consumption part of the Input-Output-table *IO(t)*. It can however be extended to the final consumption part.

In fact, in order to define primary effects, one has to define the degree of dependency of an industry vis-à-vis final demand, i.e. the primary dependency:

$$\boxed{d(i,0,t) = \frac{F(i,t)}{O(i,t)} = \frac{C(i,t) + I(i,t) + X(i,t)}{O(i,t)}} \qquad \textbf{(D3a)}$$

Using diagonal matrices F_d and O_d results in:

$$D_d(0,t) = F_d(t).O_d(t)^{-1} \qquad \textbf{(D3b)}$$

1.3.2 Primary and secondary effects

A primary (output) effect in industry j equals F(j,t) and by the foregoing it is given by:

$$PO^{DEP}(j,t) = d(j,0,t).O(j,t)$$

Pre- multiplying the left and right hand sides of this equation by $\alpha(j,t)$ and using the proportionality assumption between V and O (see (H1)) the primary effect on another variable is found:

$$PV^{DEP}(j,t) = d(j,0,t).V(j,t)$$

$$PV^{DEP}(t) = D_d(0,t).V_d(t) = F_d(t).O_d(t)^{-1}.O_d(t).\alpha_d(t) = PV^{TC}(t)$$

Secondary order effects are computed using the following rules:

$$\boxed{d^{(2)}(i,j,t) = \sum_k d(i,k,t).d(k,j,t)} \qquad \textbf{(D4)}$$

$$\boxed{d^{(n)}(i,j,t) = \sum_k d(i,k,t).d^{(n-1)}(k,j,t)} \qquad \textbf{(D4)}$$

---

[9] In the literature these are also called the technical output coefficients.

If part of an industry's output is delivered to j, then that same part of its employment is secondary employment, so:

$$SV^{DEP,(n)}(i,j,t) = V(i,t).d^{(n)}(i,j,t).d(j,0,t)$$

or using matrices:

$$SV^{DEP,(n)}(t) = V_d(t).D(t)^n.D_d(0,t)$$

Aggregated primary and secondary effects of level 1, 2, ... equals:

$$V_d(t).\left(I + D(t) + D(t)^2 + ...\right).D_d(0,t) = V_d(t).\left(I - D(t)\right)^{-1}.D_d(0,t)$$

1.3.3 Summary

Level n secondary effects of industry j on all industries can be found in column j of the matrix:

$$\boxed{PV^{DEP}(t) = V_d(t).D_d(0,t)} \qquad \textbf{\textit{(R2a)}}$$

$$\boxed{SV^{DEP,(n)}(t) = V_d(t).D(t)^n.D_d(0,t)} \qquad \textbf{\textit{(R2b)}}$$

In view of interpreting these formulae, assume for instance that V is employment. Result (R2a) means that, if x% of the output of an industry is output for final demand, then x% of the sector's employment is primary employment.

The second formula (R2b) says that, if y% of the output of an industry i is delivered to an industry j, then x%.y% of the employment of industry i is level 1 secondary employment, where x is the part of output of j that is for final demand.

1.4 The link between the two methods

Considering the definitions of technical coefficients and degrees of dependency results in

$$a(i,j,t) = d(i,j,t).\frac{O(i,t)}{O(j,t)}$$

Using the diagonal matrix O_d

$O_d(t) = \left(O_d(i,j,t)\right)$, where $O_d(i,i,t) = O(i,t)$ and $O_d(i,j,t)=0$ if $i \neq j$

results in

$$A(t) = O_d(t).D(t).O_d(t)^{-1}$$
$$A(t)^n = O_d(t).D(t)^n.O_d(t)^{-1} \qquad \textbf{\textit{(4)}}$$

This shows that the technical coefficients and the degrees of dependency are linked by the relative outputs of both sectors.

In order to compare the results of the two methods A' is rewritten using the above equation and (H1):

$$A'(t)^{n} = \alpha_{d}(t)A(t)^{n}\alpha_{d}(t)^{-1} = \alpha_{d}(t)O_{d}(t)D(t)^{n}O_{d}(t)^{-1}\alpha_{d}(t)^{-1} = V_{d}(t).D(t)^{n}.V_{d}(t)^{-1}$$

Paragraph1.2.2.2 shows that the secondary effects using technical coefficients are given by

$$\begin{aligned}
SV^{TC,(n)}(t) &= A'(t)^{n}.PV^{TC}(t) && \text{(see R1b)}\\
&= A'(t)^{n}.\alpha_{d}(t).F_{d}(t) && \text{(see R1a)}\\
&= \alpha_{d}(t).A(t)^{n}.\alpha_{d}(t)^{-1}.\alpha_{d}(t).F_{d}(t) && \text{(see D2)}\\
&= \alpha_{d}(t).O_{d}(t).D(t)^{n}.O_{d}(t)^{-1}.F_{d}(t) && \text{(see (4))}\\
&= V_{d}(t).D(t)^{n}.D_{d}(0,t) && \text{(see (H1) and (D3b))}\\
&= SV^{DEP,(n)}(t) && \text{(see R2b)}
\end{aligned}$$

Or level n secondary effects using technical coefficients are the same as level n secondary effects using the degrees of dependency method.

2. The estimation errors in the absence of a recent input-output table

In the previous chapter it was shown that technical coefficients and degrees of dependency yield the same result. However a detailed analysis of the demonstration in 1.4 shows that this is only the case when an input-output table for year t is available.

If there is no recent table available then two alternatives exist; one can assume technical coefficients to be constant and use an 'old' technical coefficient matrix, or one can use an 'old' degrees of dependency matrix and make the assumption that these are constant. This chapter analyses the errors made using these assumptions.

This could be done in matrix notations and for all levels, however to be more specific formulae are in 'number-notation' and limited to the first level.

Technical coefficients are considered relatively stable. However, recent developments such as globalisation of the economy, productivity changes and trends towards outsourcing cast doubts on this assumption. The effects these phenomena have on technical coefficients and on degrees of dependency are shown.

2.1 Comparing the estimators

If the input-output table is not up to date, an older version should be used, assuming that technical coefficients are constant. Also, degrees of dependency should be considered constant.

$$a(i, j, t+1) = a(i, j, t) \qquad \textbf{(H2a)}$$
$$d(i, j, t+1) = d(i, j, t) \qquad \textbf{(H2b)}$$

So when studying the secondary effects in year t + 1 (the calculations also hold for t+n) an input-output table for year t and data (e.g. employment) for year t+1 should be used.

This, using (R1b), results in:

$$SV^{TC,(1)}(i,j,t+1) = a'(i,j,t).PV^{TC}(j,t+1) = \frac{\alpha(i,t+1)}{\alpha(j,t+1)}a(i,j,t).\alpha(j,t+1).F(j,t+1)$$

and

$$SV^{DEP,(1)}(i,j,t+1) = V(i,t+1).d(i,j,t).\frac{F(j,t+1)}{O(j,t+1)}$$

The formulae above give a link between the two results:

$$\begin{aligned} SV^{TC,(1)}(i,j,t+1) &= \alpha(i,t+1)\frac{IO(i,j,t)}{O(j,t)}F(j,t+1) \\ &= \alpha(i,t+1)\frac{IO(i,j,t)}{O(j,t)}.\frac{O(i,t)}{O(i,t)}.\frac{O(j,t+1)}{O(j,t+1)}F(j,t+1) \\ &= \alpha(i,t+1)d(i,j,t)\frac{F(j,t+1)}{O(j,t+1)}\frac{O(j,t+1)}{O(j,t)}.\frac{O(i,t+1)}{O(i,t+1)}O(i,t). \end{aligned}$$

$$= V(i,t+1)d(i,j,t)\frac{F(j,t+1)}{O(j,t+1)}\frac{O(j,t+1)}{O(j,t)}.\frac{O(i,t)}{O(i,t+1)}.$$

$$SV^{TC,(1)}(i,j,t+1) = \frac{O(i,t)}{O(i,t+1)}\frac{O(j,t+1)}{O(j,t)}SV^{DEP,(1)}(i,j,t+1)$$

The two estimators of secondary employment give a different result. The difference depends on the relative growth of the two industries.
If industry j grows faster than industry i, then the technical coefficients estimator is higher than the degrees of dependency estimator. However, we do not have any information on which one is closer to the correct value.

The difference stems from the different assumptions made in each method. The technical coefficients method assumes the technical coefficients to be constant, while the degrees of dependency method assumes degrees of dependency to be constant.

2.2 Estimation error

Next, the error resulting from each assumption in both cases was computed.

2.2.1 Technical coefficients

Using the assumption of constant technical coefficients the estimator is:

$$SV^{TC,(1)}(i,j,t+1) = \frac{\alpha(i,t+1)}{\alpha(j,t+1)}a(i,j,t).\alpha(j,t+1).F(j,t+1)$$

while the correct result is

$$SV^{TC,(1)}(i,j,t+1) = \frac{\alpha(i,t+1)}{\alpha(j,t+1)}a(i,j,t+1).\alpha(j,t+1).F(j,t+1)$$

The error being [(real value) - (estimator)]/(real value) results in

$$Err^{TC,(1)} = 1 - \frac{a(i,j,t)}{a(i,j,t+1)}$$

The error depends on the changes in technical coefficients. When technical coefficients are constant (a(i,j,t) = a(i,j,t+1)), no error is found.

Through the definition of technical coefficients (D1), this can be rewritten as:

$$Err^{TC,(1)} = 1 - \frac{IO(i,j,t)}{IO(i,j,t+1)}\frac{O(j,t+1)}{O(j,t)}$$

or

$$Err^{TC,(1)} = 1 - \frac{1+\text{growth j}}{1+\text{growth supplies from i to j}}$$

When growth rates are relatively small Taylor approximations[10] can be used and second order terms[11] ignored , resulting in

$$Err^{TC(1)} \cong (\text{ growth supplies from i to j}) - (\text{growth j})$$

This is a rather trivial result. It indicates that the error depends on the relative growth rates of the purchases by the industry under review 'j' from the dependent industry 'i', and on the growth of the studied industry 'j'. If for example supplies from i to j grow faster than j's output (this means that the input structure is not constant), then the indirect effect is underestimated. This is e.g. the case when industry i outsources part of its activities.

2.2.2 Degrees of dependency

The author considered

$$SV^{DEP,(1)}(i, j, t+1) = d(i, j, t).V(i, t+1).\frac{F(j, t+1)}{O(j, t+1)}$$

while the correct result is

$$SV^{DEP,(1)}(i, j, t+1) = d(i, j, t+1).V(i, t+1).\frac{F(j, t+1)}{O(j, t+1)}$$

The error being [(real value) - (estimator)]/(real value), it is found

$$Err^{DEP,(1)} = 1 - \frac{d(i, j, t)}{d(i, j, t+1)}$$

The error depends on the changes in degrees of dependency. When the degrees of dependency are constant (d(i,j,t) = d(i,j,t+1)), there is no error.

This can be rewritten as:

$$Err^{DEP,(1)} = 1 - \frac{1 + \text{growth i}}{1 + \text{growth supplies from i to j}}$$

When growth rates are relatively small, Taylor approximations can be used and second-order terms ignored, resulting in

$$Err^{DEP(1)} \cong (\text{growth supplies from i to j - growth i})$$

This formulae indicates that the error depends on the relative growth rates of the purchases by the industry under review 'j' from the dependent industry 'i', and on the growth of the supplying industry 'j'. If for example the supplying industry i finds new markets then (i.e. the output structure is not constant), ceteris paribus, growth of i is positive, while supplies from i to j remain constant, and the indirect effect is overestimated.

---

[10] $\frac{1}{1+x} \approx 1 - x$, but only if x is small.

[11] The product of two growth rates comes near to zero

2.3 Some examples: Outsourcing, Globalisation, Productivity increases

It is generally accepted that technical coefficients are relatively stable. This reasoning is based on the fact that the input-structure of an industry is rather stable. In order to build a car, one for instance always needs four wheels, one dashboard, ...

In this paragraph the author tries to show that some recent economical trends question these arguments. In each of the cases below the technical coefficients are less stable than the degrees of dependency. There are certainly examples for which the contrary holds true. In fact the author believes that both technical coefficients and degrees of dependency should be considered.

Since technical coefficients are already widely used, the examples below are only meant to show that degrees of dependency can be taken into account, though they are not better than technical coefficients.

It should also be noted that technical coefficients depend on relative price levels, while degrees of dependency do not. Indeed, a technical coefficient is defined as the (monetary) supplies of an industry divided by total (monetary) output of another industry and as such it depends on the their products' relative prices.
Degrees of dependency on the other hand, equal supplies of an industry divided by the total output of the same industry and as such prices are cancelled out.

2.3.1 Outsourcing

Consider an industry j that is outsourcing part of its activities to an industry i. All other things being equal this means that:

1. output of industry j remains constant, thus its growth is zero:

   growth j = 0;

2. the output of industry i increases by the amount outsourced (Δ> 0). This means that

$$growth\ i = \frac{\Delta}{O(i,t)}$$

Supplies from i to j increase by the amount Δ. Therefore,

$$growth\ supplies\ i\ to\ j = \frac{\Delta}{IO(i,t)}$$

Using the (simplified) formulae derived in the previous paragraph, it is found that:

$$\begin{aligned} Err^{DEP,(1)} &= (growth\ supplies\ i\ to\ j\ \text{-}\ growth\ i) \\ &= \frac{\Delta}{IO(i,j,t)} - \frac{\Delta}{O(i,t)} \end{aligned}$$

Since O(i, t) is larger than IO(i, j, t), this means that:

$$Err^{DEP,(1)} < \frac{\Delta}{IO(i,j,t)}$$

$$
\begin{aligned}
Err^{TC,(1)} &= (\text{growth supplies from i to j}) - (\text{growth j}) \\
&= \frac{\Delta}{IO(i,j,t)} - 0
\end{aligned}
$$

This implies that:

$$\boxed{0 < Err^{DEP,(1)} < Err^{TC,(1)}}$$

In car manufacturing switching from Fordism to Toyotism is all about outsourcing. This outsourcing process was taken over by other industries. The reasoning above shows that the error regarding the degrees of dependency estimator is smaller.

2.3.2 Globalisation

Globalisation is another trend in our modern economy. It also has an important impact on technical coefficients. Indeed, the input structure of an industry is relatively stable, but technical coefficients relate to domestic input structure. As such, the switching from a national to a foreign supplier does not change input structure but does change technical coefficients.

Consider such a switch from a domestic to a foreign supplier. Thus, industry j does not purchase any longer from industry i, but instead purchases from abroad. *Ceteris Paribus* this means that:

1. output of industry j remains constant, thus its growth is zero:

   growth j = 0;

2. the output of industry i decreases by the amount ($\Delta > 0$). This means that

   $$\text{growth } i = -\frac{\Delta}{O(i,t)}$$

3. supplies from i to j decrease by the amount Δ. Therefore,

   $$\text{growth supplies } i \text{ to } j = -\frac{\Delta}{IO(i,t)}$$

Using the (simplified) formulae derived in the previous paragraph it is found that:

$$
\begin{aligned}
Err^{DEP,(1)} &= (\text{growth supplies } i \text{ to } j \text{ - growth } i) \\
&= -\frac{\Delta}{IO(i,j,t)} + \frac{\Delta}{O(i,t)}
\end{aligned}
$$

Since O(i, t) is larger than IO(i, j, t) this means that:

$$Err^{DEP,(1)} > -\frac{\Delta}{IO(i,j,t)}$$

$$
\begin{aligned}
Err^{TC,(1)} &= (\text{growth supplies from i to j}) - (\text{growth j}) \\
&= -\frac{\Delta}{IO(i,j,t)} - 0
\end{aligned}
$$

$$\boxed{Err^{TC,(1)} < Err^{DEP,(1)} < 0}$$

or in absolute value:

$$\boxed{\left|Err^{DEP,(1)}\right| < \left|Err^{TC,(1)}\right|}$$

2.3.3 Productivity increase

By definition, a productivity increase is an increase in output while inputs remain constant. Two cases were considered:

2.3.3.1 *A productivity increase in the industry j*

All other things being equal the result is:

1. output of industry j increases, thus its growth is positive:

   growth j = g > 0;

2. the output of industry i remains constant. This means that

   growth i = 0;

3. supplies from i to j also remain constant. Therefore,

   growth supplies from i to j = 0.

Using the (simplified) formulae derived in the previous paragraph, it is found that:

$$\begin{aligned} Err^{DEP,(1)} &= (\text{growth supplies i to j - growth i}) \\ &= 0 - 0, \end{aligned}$$

while

$$\begin{aligned} Err^{TC,(1)} &= (\text{growth supplies from i to j}) - (\text{growth j}) \\ &= -g\ . \end{aligned}$$

So, once again it is found

$$\boxed{\left|Err^{DEP,(1)}\right| < \left|Err^{TC,(1)}\right|}$$

2.3.3.2 *A productivity increase in industry i.*

This results in:

1. output of industry j remaining constant, thus its growth is zero:

   growth j = 0;

2. an increase in the output of industry i. This means that

growth i = g > 0;

3. supplies from i to j also remaining constant. Therefore,

   growth supplies from i to j = 0;

Using the (simplified) formulae derived in the previous paragraph it is found that:

$$\begin{aligned} Err^{DEP,(1)} &= (\text{growth supplies i to j - growth i}) \\ &= -g\ , \end{aligned}$$

while

$$\begin{aligned} Err^{TC,(1)} &= (\text{growth supplies from i to j}) - (\text{growth j}) \\ &= 0\,. \end{aligned}$$

So it is found that

$$\boxed{\left|Err^{DEP,(1)}\right| > \left|Err^{TC,(1)}\right|}$$

This error is however partially undone at the next level, because at that level the situation is the same as in 2.3.3.1

2.3.4 Conclusion

When no recent input-output table is available, the two methods produce different results. Which of the two estimators is better depends on whether or not the technical coefficients are more constant than the degrees of dependency. In many past studies, technical coefficients were considered relatively constant. The author believes that both methods have their advantages.

Technical coefficients assume a 'constant input structure' and that is a reasonable hypothesis. Moreover, it has been widely applied in the past.

Degrees of dependency can also be considered to be constant, if the period in question is not too long. Moreover, recent trends like outsourcing, productivity increases and globalisation are indications that input structure might not be as constant as it was in the past, and therefore degrees of dependency might be more appropriate in these cases.
There are, however, no a priori reasons to believe that one estimator is better than another.

It is also remembered that technical coefficients depend on relative price levels, while degrees of dependency do not.

3. From primary and secondary effects to direct and indirect effects

3.1 Definitions

In the preceding paragraphs *primary and secondary effects have been defined*. Primary effects in an industry are effects related to final demand for goods produced by the industry. Secondary effects are related to intermediate demands.

Working papers published by the NBB calculate 'direct' and 'indirect' effects. These are to be distinguished from the primary and secondary effects.

Primary and secondary effects are used to analyse the impact of a *change in final demand*. Changes in intermediate demand can not come about by themselves, as they are just a consequence of final demand changes. Through these primary and secondary effects the impact of for instance an increase in government expenditures may be analysed.

Direct and indirect effects serve a different purpose. It was mentioned in the introduction that the car manufacturing industry has undergone some fundamental changes, in particular the introduction of the 'lean production' system. In the lean production system car manufacturers are concentrating on their core business and are outsourcing the non-core activities. As a consequence, employment in the car manufacturing companies (direct employment) decreases, while employment in supply companies increases. It is certainly interesting to know what the combined effect is.

Car manufacturing is only one example. In many cases one wants to be able to give some *measure of importance to the presence of an industry*. Take for instance the presence of chemical plants in a harbour area. Even though only a little part of the chemical industry output is intended for final use, it seems important that this industry is present, not only because it generates 'direct' employment (i.e. employment in the chemical sector), but it also generates 'indirect employment'. In that case one would like to know what the effect is of all demands of the chemical sector on other goods, i.e. *the sector* is considered *as if its demand was final demand*.
In other words, what is the effect of the demand generated by that industry (i.e. the indirect effect) It is clear that the presence of an industry in itself is important, because, if it was not present, the 'chain' would be broken, which as such would reduce the multiplier effect of final demand.

Furthermore, if the sector was not present, some of its suppliers would most certainly not be either. Indeed, some supplier may be very 'dependent'. This notion of dependency led the author to the definition of the degrees of dependency. So, besides the computation of 'indirect' effects, *degrees of dependency can also be used for impact analysis*.
It should be possible to analyse these problems, even for sectors that have no final demand. As such, the notion of 'secondary effect' had to be generalised. Therefore, the following definition of direct and indirect effects was arrived at[12]:

Indirect effects of an industry are the secondary effects of the industry when all demand for its products is considered as final demand.
Direct effects of an industry are the primary effects of the industry when all demand for its products is considered as final demand[13]*.*

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[12] In Federal Planning Bureau (2004) (p. 41) a mixed approach is used. The definition of direct effects is the same as ours. Indirect effects of an industry are defined as the secondary effects in all the other industries..

[13] This definition is a variant of the method described in Strassert (1968).

This can be illustrated by considering an industry J. The industry generates "final demand products" and "intermediate demand products". This is shown below.

Supply	**Sector J**	**Demand**
Secondary in S1	primary effect in J	Final demand
Secondary in S2		
Secondary in Sn		
Secondary level n	secondary effect in J by S1	Intermediary demand for product J by S1
	secondary effect in J by S2	Intermediary demand for product J by S2
	secondary effect is J by Sn	Intermediary demand for product J by Sn

The final demand part of J generates a primary effect in the industry J, and (level 1) secondary effects in all industries that supply to J's final demand part.
The intermediate demand for J's products generates secondary effects in J. These are secondary with respect to the final demand part of a particular sector Si. They are also at a certain level n(i) with respect to that industry Si.
The secondary effect in J are thus level n(i), and in J's supplying sectors they generate n(i)+1 secondary effects with respect to Si.
This is well-known input-output analysis.

The above definitions state that all demand should be considered as if it were final demand. This is illustrated in the next scheme:

Supply	**Sector J**	**Demand**
Indirect effect	Direct effect	Final demand
		"as if" final
		"as if" final
		"as if" final

When all demand is considered "as if it were final demand" the primary effect is called the direct effect in industry J. The secondary effects with respect to such "as if it were final demand" for J are called indirect effects.

It should be clear that the direct effect can include primary and secondary effects, while indirect effects include only secondary effects, though not only secondary with respect to J.

Taking all demand 'as if it were final demand' implies that double counting is avoided. Indeed, it is well known that the Leontief model avoids double counting just because it starts from final demand. If all demand becomes final demand, and as a consequence the intermediary supplies from the industry J are set to zero, then double counting is thus avoided.

Considering all output of an industry "as if it were final demand" means that the following 'corrections' should be made to the technical coefficients matrix and to the matrix of the degrees of dependency:

- all intermediate demand for products from the studied industry J should become zero and thus we have to define two modified matrices

- o $\tilde{A}(t)=\left(\tilde{a}(i,j,t)\right)$ where

  $\tilde{a}(J,j,t)=0$

  $\tilde{a}(i,j,t)=a(i,j,t)$ for $i\neq J$

- o $\tilde{D}(t)=\left(\tilde{d}(i,j,t)\right)$ *where*

  $\tilde{d}(J,j,t)=0$

  $\tilde{d}(i,j,t)=d(i,j,t)$ for $i\neq J$

– the final demand diagonal matrix should be changed to:

- o $\tilde{F}_d(t)=\left(\tilde{F}_d(i,j,t)\right)$ where

  $\tilde{F}_d(i,j,t)=0 \ \text{for}\ i\neq j$

  $\tilde{F}_d(i,i,t)=F_d(i,i,t) \ \text{for}\ i\neq J$

  $\tilde{F}_d(J,J,t)=O(J,t)$

– as a consequence the final demand dependency diagonal matrix becomes

- o $\tilde{D}_d(t)=\left(\tilde{d}_d(i,j,t)\right)$ where

  $\tilde{d}_d(i,j,t)=0 \ \text{for}\ i\neq j$

  $\tilde{d}_d(i,i,t)=d_d(i,i,t) \ \text{for}\ i\neq J$

  $\tilde{d}_d(J,J,t)=1$

Using <u>technical coefficients</u>,

– the direct effect of industry J is found as the (J,J)-th element of

$DV^{TC}(t+\tau)=\alpha_d(t+\tau).\tilde{F}_d(t+\tau)$

– the indirect effect of industry J is found in the J'th column of

$IV^{TC,(n)}(t+\tau)=\alpha_d(t+\tau).\tilde{A}(t)^n.\tilde{F}_d(t+\tau)$

– Cumulated direct and indirect effects are found in the J'th column of

$IV^{TC,(0..\infty)}(t+\tau)=\alpha_d(t+\tau).\left(I-\tilde{A}(t)\right)^{-1}.\tilde{F}_d(t+\tau)$

Using <u>degrees of dependency</u>,

– the direct effect of industry J equals is found in the (J,J)-the element of

$DV^{DEP}(t+\tau)=V_d(t+\tau).\tilde{D}_d(t)$

– the indirect effect of industry J is found in the J'th column of

$IV^{DEP,(n)}(t+\tau)=V_d(t+\tau).\tilde{D}(t)^n.\tilde{D}_d(t)$

– Cumulated direct and indirect effects are found in the J'th column of

$IV^{DEP,(0..\infty)}(t+\tau)=V_d(t+\tau).\left(I-\tilde{D}(t)\right)^{-1}.\tilde{D}_d(t)$

When a recent Input-output table is available (τ = 0), both results are identical.

3.2 Intuitive meaning of indirect employment

Taking all output of a sector Si as final demand means that the-level one secondary effect can be read in the i'th column of the intermediate supply matrix. In fact it is easy to show that if a final demand change equal to this column is taken (i.e. we assume that level one suppliers deliver these amounts to final demand, e.g. exports), cumulated primary and secondary effects equal the indirect effects defined above.

A delocalisation of the industry (under the 'all other things being equal assumption') has this effect. Indeed, a delocalisation of Si means that the demand for supplies from other sectors becomes demand from abroad, and thus final demand.

Taking for instance the indirect effect on the employment variable, it may be said that:

> *the indirect employment obtained thus is all employment that is potentially affected by a delocalisation of the branch.*

This is in line with the author's intuitive understanding of indirect employment.

It is held 'potentially impacted' because dynamic effects (e.g. product and market diversification) will occur, so that only the most dependent suppliers disappear.

3.3 Aggregation and disaggregation

3.3.1 Composite industries

The formulae in 3.1 compute the indirect effects of one single *'base'* industry J, i.e. an industry corresponding to one column of an input-output table.

It should also be possible to compute indirect effects of *'composite'* industries, i.e. industries corresponding to more than one column from an input-output table. The ICT-sector[14] and the Ports sector[15] are examples of composite industries.

Assume S to be a composite sector, being built up from the two base sectors J and K (extension to composite sectors constructed from more than two base sectors is analogous).

The direct effects of sector S = {J, K} equal the sum of the direct effects of the two base sectors J and K.

One should be careful and avoid double counting when computing the indirect effects of the composite sector S.
Indeed, taking indirect employment as an example, all employment of J and K are assumed to be direct, so none of the mutual supplies between J and K should induce any indirect employment in J nor in K. If this is not the case, part of the employment is included in the direct effect, as well as in the indirect effects.
The construction of the matrices $\tilde{A}$ and $\tilde{D}$ implies that all demand for products of J and K is final demand. As a consequence, double counting is avoided when adding the indirect effects of both base industries.
The indirect effects of sector S equal the sum of the indirect effects of the base industries J and K.

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[14] See National Bank of Belgium (2004).

[15] See Lagneaux F. (2004a) and Lagneaux F. (2004b).

In conclusion, the following corrections should be made to the technical coefficients matrix and to the matrix of the degrees of dependency:

- all intermediate demand for the studied industry S should become zero and thus we have to define two modified matrices
    - $\tilde{A}(t) = (\tilde{a}(i,j,t))$ where
      $$\tilde{a}(i,j,t) = 0 \ for\ i \in \{J,K\}$$
      $$\tilde{a}(i,j,t) = a(i,j,t) \ for\ i \notin \{J,K\}$$
    - $\tilde{D}(t) = (\tilde{d}(i,j,t))$ where
      $$\tilde{d}(i,j,t) = 0 \ for\ i \in \{J,K\}$$
      $$\tilde{d}(i,j,t) = d(i,j,t) \ for\ i \notin \{J,K\}$$
- the final demand diagonal matrix should me changed to:
    - $\tilde{F}_d(t) = (\tilde{F}_d(i,j,t))$ where
      $$\tilde{F}_d(i,j,t) = 0 \ for\ i \neq j$$
      $$\tilde{F}_d(i,i,t) = F_d(i,i,t) \ for\ i \notin \{J,K\}$$
      $$\tilde{F}_d(i,i,t) = O(i,t) \ for\ i \in \{J,K\}$$
- as a consequence the final demand dependency diagonal matrix becomes
    - $\tilde{D}_d(t) = (\tilde{d}_d(i,j,t))$ where
      $$\tilde{d}_d(i,j,t) = 0 \ for\ i \neq j$$
      $$\tilde{d}_d(i,i,t) = d_d(i,i,t) \ for\ i \notin \{J,K\}$$
      $$\tilde{d}_d(i,i,t) = 1 \ for\ i \in \{J,K\}$$

Using technical coefficients,

- the direct effect of industry S equals is found as the sum of (J,J)-th and (K,K)-th element of
  $$DV^{TC}(t+\tau) = \alpha_d(t+\tau).\tilde{F}_d(t+\tau)$$
- the indirect effect of industry S is found in the J'th and K'th columns of
  $$IV^{TC,(n)}(t+\tau) = \alpha_d(t+\tau).\tilde{A}(t)^n.\tilde{F}_d(t+\tau)$$
- Cumulated direct and indirect effects are found in the J'th and K'th columns of
  $$IV^{TC,(0..\infty)}(t+\tau) = \alpha_d(t+\tau).\left(I - \tilde{A}(t)\right)^{-1}.\tilde{F}_d(t+\tau)$$

Using degrees of dependency,

- the direct effect of industry S equals is found as the sum of (J,J)-th and (K,K)-th element of
  $$DV^{DEP}(t+\tau) = V_d(t+\tau).\tilde{D}_d(t)$$
- the indirect effect of industry S is found in the J'th and K'th columns of
  $$IV^{DEP,(n)}(t+\tau) = V_d(t+\tau).\tilde{D}(t)^n.\tilde{D}_d(t)$$
- Cumulated direct and indirect effects are found in the J'th and K'th columns of
  $$IV^{DEP,(0..\infty)}(t+\tau) = V_d(t+\tau).\left(I - \tilde{D}(t)\right)^{-1}.\tilde{D}_d(t)$$

3.3.2 Disaggregation

Often one wants to compute the indirect effects of a part of an industry. The four Belgian car manufacturers for instance are only part of a 'base' industry[16].

If this is the case the base industry should be 'disaggregated', i.e. split it up using hypothesis (H1). Thus, in order to compute the indirect effects of a part p(i, t)[17] of industry i the industry was virtually split up in a part p(1, t) and a part 1 - p(1, t), resulting in a new input-output table provided in Table 1 (where i was assumed to be 1).

The same splitting-up process should be applied to the variables V (Table 2).

---

[16] See Coppens F., van Gastel G. (2003)

[17] Like for α, the 'V' superscript was dropped to avoid further complications.

Table 1: 'Disaggregated' input-output table

$$IO(t) = \left(\begin{array}{cc:ccccc} p(1,t).p(1,t).IO(1,1,t) & (1-p(1,t)).p(1,t).IO(1,1,t) & \ldots & p(1,t).IO(1,n,t) & p(1,t).C(1,t) & p(1,t).I(1,t) & p(1,t).X(1,t) \\ p(1,t).(1-p(1,t)).IO(1,1,t) & (1-p(1,t)).(1-p(1,t)).IO(1,1,t) & \ldots & (1-p(1,t)).IO(1,n,t) & (1-p(1,t)).C(1,t) & (1-p(1,t)).I(1,t) & (1-p(1,t)).X(1,t) \\ \hdashline & & \ldots & & & & \\ p(1,t).IO(2,1,t) & (1-p(1,t)).IO(2,1,t) & & IO(2,n,t) & C(2,t) & I(2,t) & X(2,t) \\ & & & & & & \\ p(1,t).IO(n,1,t) & (1-p(1,t)).IO(n,1,t) & \ldots & IO(n,n,t) & C(n,t) & I(n,t) & X(n,t) \end{array} \right)$$

Table 2: 'Disaggregated' variable V

$$V(t) = \left(\begin{array}{c} p(1,t).V(1,t) \\ (1-p(1,t)).V(1,t) \\ \hdashline V(2,t) \\ \ldots \\ V(n,t) \end{array} \right)$$

4. Supply-use tables and input-output tables[18]

If no recent input-output table is available, one can use the latest available input-output table (input-output tables are produced every five years, with a three year lag), or one can estimate an input-output table from the latest available supply-use table (supply-use tables are available for every year, with a lag of 3 years).

This chapter explains how one can estimate an input-output table starting from a supply-use table. The method is based on the more sophisticated method used by the National Accounts Institute[19] but it is a 'quick and dirty method' meaning that it is based on less detailed data.

The author starts by defining the supply-use table. Afterwards it is shown how these tables can be used to build an input-output table.

At the end of this chapter we are in a position to test the various alternatives and their combinations

- the use of an 'old' input-output table versus the 'quick and dirty' estimation of an input-output table from a more recent supply-use table
- the use of technical coefficients versus the use of degrees of dependency.

4.1 Supply-use tables

4.1.1 Supply table

The **supply table** is a product by industry table indicating each industry's supply. So

$$S(t) = (S(p,s,t))$$

where S(p,s,t) is the quantity of product p produced by industry s during period t.

One particular industry is the 'foreign' industry (Fo), its column containing the supply from abroad, in other words, the imports per product (M).

$$S(t) = \begin{array}{ccccccc} & \mathbf{S1} & \mathbf{S2} & \mathbf{.....} & \mathbf{Sn} & \mathbf{Fo} & \mathbf{MP} \\ \mathbf{P1} & S(1,1,t) & S(1,2,t)\mathbf{)} & ...... & S(1,n,t) & M(1,t) & MP(1,.,t) \\ \mathbf{P2} & S(2,1,t) & S(2,2,t) & ..... & S(2,n,t) & M(2,t) & MP(2,.,t) \\ & & & & & & \\ \mathbf{....} & & & & & & \\ \mathbf{Pm} & S(m,1,t) & S(m,2,t) & & S(m,n,t) & M(m,t) & MP(m,.,t) \\ \mathbf{MS} & MS(.,1,t) & MS(.,2,t) & & MS(.,n,t) & MS(.,f,t) & \end{array}$$

The MS and MP columns are total margins and are explained in 4.1.3.

It should be noted that, since S1 ... Sn are domestic industries, S(i,j,t) is the domestic production when $1 \le i, j \le n$

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[18] See also: Eurostat (2002), National Accounts Institute (2003), National Accounts Institute (2004a)

[19] See also National Accounts Institute (2003a), National Accounts Institute (2004b) and Federal Planning Bureau (2003).

For reasons of convenience, the following notations (and similar notations for the input-output and the use table) are introduced:

- M(i,t) = S(i, n+1, t)

4.1.2 Use table

The **use table** is very similar. In contrast to the supply table, it indicates for each industry the products used.

U(t) = (U(p,s,t))

where U(p,s,t) is the quantity of product p used by industry s in period t.

Three particular columns are

- the foreign industry; use by the foreign industry (Fo) naturally means exports (X)
- the household industry; its use equals consumption (C)
- investments (I).

$$U(t) = \begin{array}{cccccccc} & \mathbf{S1} & \mathbf{....} & \mathbf{Sn} & \mathbf{C} & \mathbf{I} & \mathbf{Fo} \\ \mathbf{P1} & U(1,1,t) & & U(1,n,t) & C(1,t) & I(1,t) & X(1,t) \\ \mathbf{P2} & U(2,1,t) & & U(2,n,t) & C(2,t) & I(2,t) & X(2,t) \\ & & & & & & \\ \mathbf{....} & & & & & & \\ \mathbf{Pm} & U(m,1,t) & & U(m,n,t) & C(m,t) & I(m,t) & X(m,t) \end{array}$$

It should be pointed out that the use table includes imported goods.

4.1.3 Margins

The two tables use different price measures. While the use table is expressed in purchase prices, the supply table is in basic prices. The differences between the two are the margins. Margins should be added to the supply table in order for total supply to be equal to total use. However, margins are not known at the same level of detail. Only the marginal totals (sum by product and sum by industry) are known.
So **Industry margins** is a row vector MS(t) = (MS(.,s,t)), while **product margins** is a column vector MP(t) = (MP(p,.,t)), where MS(.,s,t) equals the sum of the margins realised by industry s on all products s has sold, and MP(p,.,t) equals the margin sum realised on product p by all sectors that sold it.

In order to determine 'supply including margins' the author proceeds as follows. Assume that, for a particular product, the margin is constant. So, it equals

$$mp(p,t) = \frac{MP(p,.,t)}{\sum_{s \neq MP} S(p,s,t)}$$

Applying this margin to each non-trading industry for this product the author obtains the trade margins (TM) in each cell of the supply table:

$$TM(p,s,t) = S(p,s,t) * mp(p,t)$$

Summing these trade margins over all industries , it is easy to see that.

$$\sum_{s} TM(p,s,t) = MP(p,.,t)$$

The column sum of these margins does not necessarily equal MS(.,s,t), however. The next thing to do is thus to correct for these differences. The estimated industry margin for the non-trading industries s is now the sum of the elements in column s ($MS^{est}(.,s,t)$) where

$$MS^{est}(.,s,t) = \sum_{p} TM(p,s,t) = \sum_{p} S(p,s,t) * mp(p,s,t)$$

This should equal MS(.,s,t) for all s. If it does not, we should transfer this difference to the trading industry columns. However, we should remain within one product row so that row totals remain correct.

This can be done by defining a trade margin to displace (TM^{disp}) as follows:

$$TM^{Disp}(p,s,t) = TM(p,s,t).\frac{MS^{est}(.,s,t) - MS(.,s,t)}{MS^{est}(.,s,t)}$$

This is the amount to be transferred to the trading industry column. The corrected trade margin (TM^{Corr}), to be added to the supply table cells (for all but the trading industries), is:

$$TM^{corr}(p,s,t) = TM(p,s,t) - TM^{Disp}(p,s,t)$$

This method guarantees that the column sums are correct for all but the trading industries, while row totals are all correct.
The sum of all TM^{disp} should equal (approximately) the sum of the margins of the trading industries.

$$\sum_{\substack{s \\ p}} TM^{Disp}(p,s,t) \cong \sum_{trading} MS(s,t)$$

If this is the case, the total can be redistributed in the cells for the trading industries using two repartitioning keys:

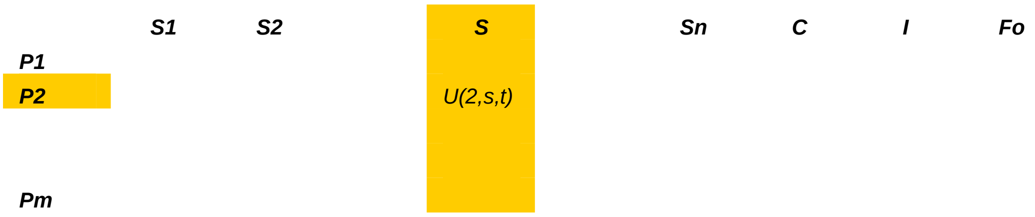
$$\mathbf{Margin}(p,s,t) = \left(\frac{\sum_{s,notrading} TM^{Disp}(p,s,t)}{\sum_{\substack{s,notrading \\ p}} TM^{Disp}(p,s,t)} \right) \left(\frac{MS(.,s,t)}{\sum_{trading} MS(.,s,t)} \right) . \sum_{trading} MS(.,s,t)$$

valid for all p and trading s

4.2 Construction of an input-output table

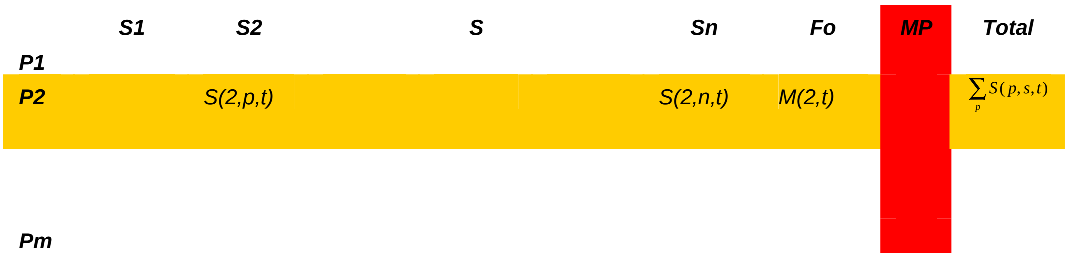
In order to construct an input-output table, it is necessary to estimate supply between each two industries. To do this the author considers an industry S. The use table provides all products used as an input.

So, in the use table all products 'p' for which U(p, S, t) ≠ 0 are looked up.



	S1	**S2**	**S**	**Sn**	**C**	**I**	**Fo**
P1							
P2			*U(2,s,t)*				
Pm							

In order to find the supply industry, each of these products used in the supply-table are looked up in order to ascertain which are the producing industries.



	S1	**S2**	**S**	**Sn**	**Fo**	**MP**	**Total**
P1							
P2		*S(2,p,t)*		*S(2,n,t)*	*M(2,t)*		$\sum_p S(p,s,t)$
Pm							

For each such 'p' industry proportions are computed from the supply table. The proportion of industry s in the supply of product p equals

$$PS(p,s,t)=\frac{S(p,s,t)}{\sum_s S(p,s,t)}$$

for the product p the industry s supplies to S

U(p,s,t)xPS(p,S,t)

It is assumed here that an industry using a product p, buys this product from all the producing industries, including the imports. ***(H3)***

Summing over all products used by S (or simply over all products, since those that are not used are shown as zero) one gets the supply from industry s to S or by definition IO(s,S,t):

$$IO(s,S,t)=\sum_p PS(p,s,t).U(p,S,t)$$

Defining a matrix PS(t)=(PS(p,s,t)) one gets in matrix notation:

$IO(t)=PS(t)^T.U(t)$, where $PS(t)^T$ is the transposed PS(t)

For this to be an input-output table, the row sum for a industry should equal the industry's total output, the column sums should equal sectoral inputs.

It is easy to show that this is the case if

$$\sum_{s} S(p,s,t) = \sum_{s} U(p,s,t)$$

This means that total supply must equal total use. This is the case when both supply and use are in the same units. This is why we described an (approximate) method for including the margins in the supply table.

The input-output table obtained is a domestic input-output table. The estimated intermediate and final consumption of the imports can be found in the last row of this input-output table for the row s = Fo:

$$IO(Fo,S,t) = \sum_{p} PS(p,Fo,t).U(p,S,t)$$

$$= \sum_{p} \frac{S(p,Fo,t)}{\sum_{s} S(p,s,t)} U(p,S,t)$$

$$= \sum_{p} S(p,Fo,t) \frac{U(p,S,t)}{\sum_{s} S(p,s,t)}$$

and, since total use equals total supply:

$$IO(Fo,S,t) = \sum_{p} S(p,Fo,t) \frac{U(p,S,t)}{\sum_{s} U(p,s,t)}$$

S(p, Fo, t) equals imports of product p, M(p,t). In other words, the import of a product is distributed in proportion to the use of the product.

In chapter 5 it will be shown that this proportional distribution is an important difference with the method used by the National Accounts Institute[20].

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[20] See also Federal Planning Bureau (2003).

5. Empirical analysis

5.1 Technical coefficients versus degrees of dependency

In chapter 2 it is shown that there are no a priori reasons to prefer technical coefficients to degrees of dependency or vice versa. In this paragraph the two estimators are compared using data available at the Belgian National Accounts Institute (NAI).

To compute indirect employment we need the following data:

- employment data for the year under review. These data are available at the National Accounts Institute (NAI). NAI has employment data for the years 1995 to 2003[21];
- input-output tables or supply-use tables
  - NAI has input-output tables for the years 1995 and 2000[22].
  - NAI has supply-use tables for the years 1995, 1997, 1999, 2000;
- the technical coefficient method requires output data (the α) for the same years as the employment data. NAI has output data for the years 1995 to 2003.

Both estimators' performance is measured by comparing their outcomes to a so-called 'right' result. This 'right' result is considered to be the indirect employment computed using the input-output table for the year 2000 and employment data for that same year[23]. It was shown before that in this case degrees of dependency and technical coefficients yield the same estimates.

The indirect effects for the year 2000 are estimated for 118 branches using the input-output table for the year 1995. For each branch the technical-coefficient method and the degrees of dependency method is applied. The results are shown in table 3. Detailed results for all branches are shown in annex 1.

Table 3: Performance of the estimators measured by the deviation from the 'right' result
(estimations using the 1995 input-output table)

	Level 1	
	Technical Coefficients	**Degrees of dependency**
Average of Absolute Value of Relative Error	36.57%	39.55%
Standard Deviation	*58.05%*	*36.55%*
Closer	67	51
Random(p-value)	*8.35%*	*94.14%*
	All Levels	
	Technical Coefficients	**Degrees of dependency**
Average of Absolute Value of Relative Error	32.54%	36.22%
Standard Deviation	*45.70%*	*34.12%*
Closer	64	54
Random(p-value)	*20.37%*	*84.44%*

---

[21] The number of wage-earners is calculated at a more detailed level (120 industries) than the number of self-employed (60 industries).

[22] Input-output tables are published for years that are a multiple of five, they are published with a three year lag (the input-output table for 2005 will for instance be published in 2008). Supply-use tables are published for every year, also with a three year lag.

[23] The author considers the input-output table for 2000, combined with the employment data for 2000, as the 'right' result, since it does not need any assumption concerning stability of either coefficients or degrees of dependency. It should be clear, however, that the 'right' result is not necessarily the 'exact' result. The 'exact' result requires that all assumptions underlying the construction of an IO-table come true.

In table 3 the two estimators are compared to the 'right' result for the first level and for all levels together.
The first row shows the average of the absolute value of the relative errors, the standard deviation appears in the second row. The row 'closer' indicates the number of times the estimate is closer to the 'right' result, i.e. the number of times the estimator has the smallest relative error in absolute value. The next row gives the probability of having the same level of 'closeness' using a complete random selection[24].

At the first level the average error of the technical coefficients estimator seems to be a little smaller than the one for the degrees of dependency. However, the t-test does not show a significant difference.

The level one technical coefficient estimator seems to be more often closer to the 'right' result.

Based on these tests it can be concluded that, for the level one indirect effects, there is a slight advantage for the technical coefficients estimator. Its more often closest to the 'right' result. On the contrary, degrees of dependency errors are less volatile.

In case all levels are considered, neither of the two approaches can be considered as 'probably better'. In that case technical coefficients seem more often closer to the 'right' result, however there is reasonable chance that this is due to randomness.

5.2 Supply-use tables versus input-output tables

In order to compare the use of a recent supply-use table to the use of the last available input-output table, estimations based on the supply-use table for the year 2000 are compared to those based on the 1995 input-output table. Again calculations were made for 118 industries.
The results are shown in table 4.

Table 4: Estimations based on a 'recent' supply-use table versus an 'old' input-output table.
(estimations using the 1995 input-output table and the 2000 supply-use table)

	Level 1		
	Input-output 1995		**Supply-use 2000**
	Technical Coefficients	**Degrees of dependency**	
Average of Absolute Value of Relative Error	36.57%	39.55%	34.72%
Standard Deviation	*58.05%*	*36.55%*	*42.99%*
Closer	38	25	55
Random(p-value)	*63.62%*	*99.87%*	*0.19%*

	All Levels		
	Input-output 1995		**Supply-use 2000**
	Technical Coefficients	**Degrees of dependency**	
Average of Absolute Value of Relative Error	32.54%	36.22%	48.28%
Standard Deviation	*45.70%*	*34.12%*	*48.95%*
Closer	48	39	31
Random(p-value)	*5.70%*	*56.04%*	*96.00%*

At the first level the average relative error's absolute value using the supply-use table seems to be lower than the average error using the input-output table. The difference is however not statistically significant.

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[24] In other words 8.35% is the probability that at least 67 guesses randomly selected from the available estimators are closest. As such a low p-value indicates that being closer is not by chance, thus the estimator might be better. The lower the p-value, the more proof we have in favour of that estimator.

The supply-use table estimation gives results that are more often closer to the 'right' result then the use of an old input-output table.

The average error increases for cumulated indirect effects for the supply-use based estimations. The technical coefficient estimator, using an 'old' input-output table is more often closer to the 'right' value.

From these observations it seems that the supply-use table estimations on average overestimate the right result.

However the data are too limited to draw final conclusions. More analysis is needed as additional input-output tables become available. It is also remembered that input-output tables are published only every five year with a three year lag, while supply-use tables are published with the same lag, but for every year.

5.3 Remark

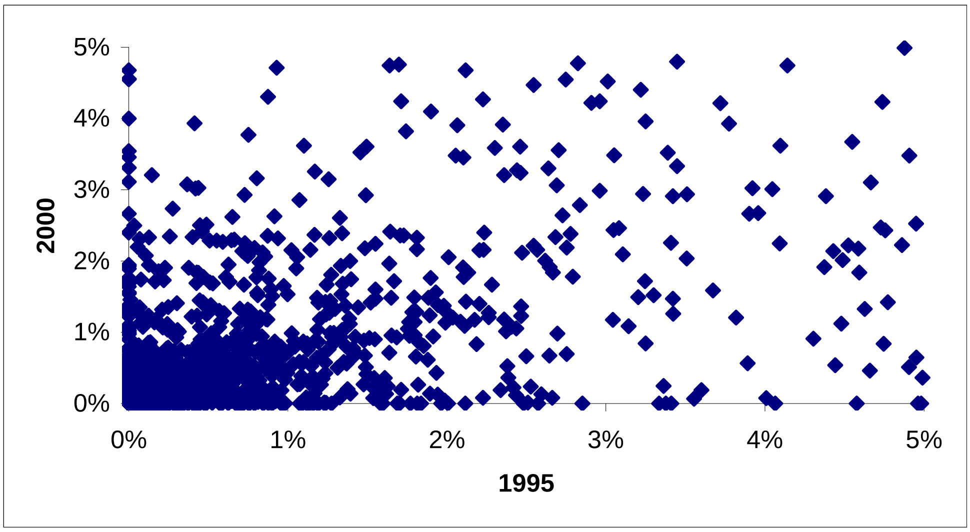
Table 4 shows the results computed using an input-output table versus the ones obtained with a supply-use table. On average the supply-use table estimations seem to overestimate the 'right' result. This seems to be due to the repartitioning of imports over the use table (see also 4.2).

Taking for example car manufacturing, it seems that car manufacturers’ imports appear to be higher in the input-output table of the Federal Planning Bureau; and as a result, domestic supplies to car manufacturers are lower. Therefore, dependency degrees and technical coefficients are also lower.

As has been pointed out before, the method applied distributes imports proportionally over the use table. This proportional distribution is applied to both intermediate use and final use. The estimated input-output table for the year 2000 assigns on average about 60% of imports to final use, whereas in the Federal Planning Bureau' s table it is only about 45%.

The Federal Planning Bureau uses a different method, based on external trade statistics. It is described in detail in ' Federal Planning Bureau (2003), "The Use Tables for Imported Goods and for Trade Margins", February 2003'.
This method is more detailed and probably based on more realistic assumptions. However, it is also more time-consuming.
As the objective was to quickly estimate an input-output table from a supply-use table, the author never intended to go into it at great length. However, since two input-output tables (for 1995 and for 2000) are now available, one might try to obtain more precise estimates.
This means that a more detailed approach was required. The only reasonable extension thus is to assume that the allocation of the imports over the cells of the use table is relatively constant. Allocation formulae can therefore be derived from the latest available use table for imported goods.
This assumption was verified using the use tables for imported goods from 1995 and 2000. The repartition of imports over the cells of the use table is far from constant, as is shown in figure 1.

Figure 1: Repartition of imports over the cells of the use table, 1995 versus 2000



Should the distributive parts be stable, these points would be aligned (the bisector). This is clearly not the case.

6. Conclusion

Technical coefficients and degrees of dependency are defined on the basis of an Input-output table. The former are well known in input-output analysis, the latter have been used in several Working Papers published by the National Bank of Belgium.
Through those definitions it is shown how these concepts can be used to compute primary and secondary effects. These primary and secondary effects should be distinguished from direct and indirect effects that are defined in chapter three.

Primary and secondary effects are used to analyse the impact of changes in final demand. Direct and indirect effects measure the importance of the presence of an industry and are not limited to final demand. They estimate the potential impact of a delocalisation of the industry.
Degrees of dependency may contribute to this kind of impact analysis.

Passing from final demand to total industry output, as is the case for indirect effects, implies double counting when no further measures are taken. This paper shows how this double counting can be avoided.

Degrees of dependency were defined elsewhere[25]. This paper for the first time compares them formally to the technical coefficients. Furthermore, the paper defines what is meant by 'indirect effect'.

As to the computation of primary and secondary effects and regarding direct and indirect effects, it is shown that technical coefficients and degrees of dependency produce the same result when an up-to-date input-output table is used.

If no updated input-output table is available, the two methods produce different results. There is no way to determine which of the two methods is more precise. This depends on the validity of the underlying assumptions. The technical coefficient method assumes constant technical coefficients; the degrees of dependency method assumes that degrees of dependency are constant.
It is not a priori possible to decide which is the more realistic assumption. It is generally assumed that technical coefficients are relatively stable, but it is argued that recent trends, such as outsourcing, globalisation and productivity increases, cast doubts on this assumption. As such, degrees of dependency are an additional instrument, also for analysing the impact of final demand changes.

Besides a formal comparison, we also compare the two methods using the data which are now available. The examples show that technical coefficients are slightly more stable.

In view of recent trends that might have a greater impact on technical coefficients (outsourcing, globalisation, productivity increases), it is recommended to use both techniques. Major differences should be analysed in detail. Degrees of dependency seem to be more intuitive.
Both methods are easily implemented in a computer program. Matrix formulae for this purpose are provided in this paper (*see chapter 3*). These formulae avoid double counting.

To overcome the lack of recent input-output tables for the Belgian economy one could estimate a 'quick and dirty' input-output table from the most recently available supply-use tables. Chapter 4 of this paper describes how this might be done.

Since no formal description of the method used by the Federal Planning Bureau is available, a formal comparison between 'quick and dirty' input-output table applied in this paper and the input-output tables compiled by the FPB was impossible. It should be pointed out, though, that the construction of input-output tables by the FPB is based on more sophisticated methods and

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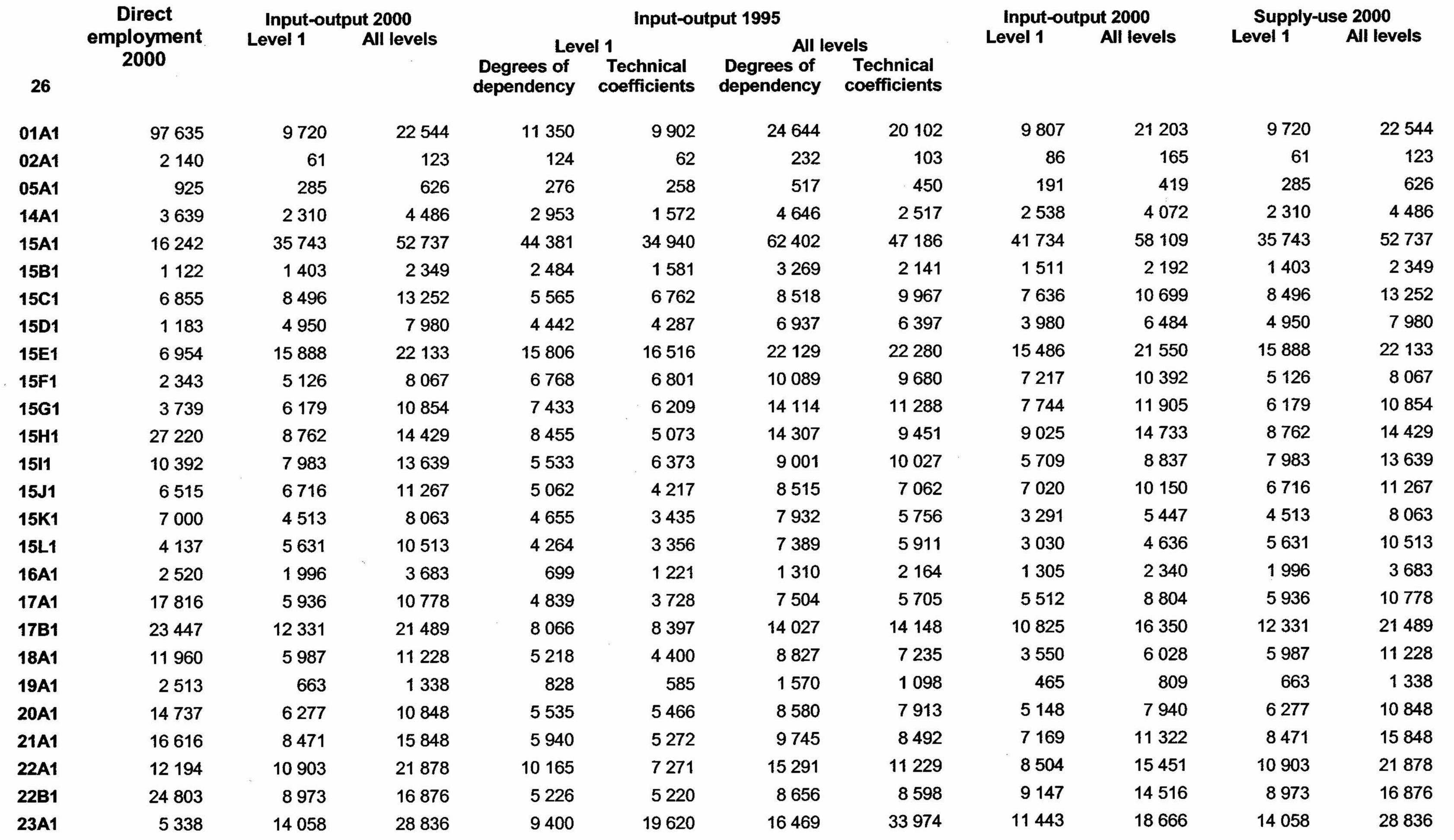
[25] They were also used in Eysackers E. (2000), Coppens F., van Gastel G. (2003).

probably on more realistic assumptions. Preference should thus be given to the FPB input-output table. The 'quick and dirty' input-output table should be used for verification purposes only or when no 'recent' input-output table is available.

Ideally, input-output tables should be constructed more frequently than every five years.

Annex 1: Indirect employment (in number of persons) estimated using different methods – results for the year 2000



26	Direct employment 2000	Input-output 2000		Input-output 1995				Input-output 2000		Supply-use 2000	
		Level 1	All levels	Level 1		All levels		Level 1	All levels	Level 1	All levels
				Degrees of dependency	Technical coefficients	Degrees of dependency	Technical coefficients				
01A1	97 635	9 720	22 544	11 350	9 902	24 644	20 102	9 807	21 203	9 720	22 544
02A1	2 140	61	123	124	62	232	103	86	165	61	123
05A1	925	285	626	276	258	517	450	191	419	285	626
14A1	3 639	2 310	4 486	2 953	1 572	4 646	2 517	2 538	4 072	2 310	4 486
15A1	16 242	35 743	52 737	44 381	34 940	62 402	47 186	41 734	58 109	35 743	52 737
15B1	1 122	1 403	2 349	2 484	1 581	3 269	2 141	1 511	2 192	1 403	2 349
15C1	6 855	8 496	13 252	5 565	6 762	8 518	9 967	7 636	10 699	8 496	13 252
15D1	1 183	4 950	7 980	4 442	4 287	6 937	6 397	3 980	6 484	4 950	7 980
15E1	6 954	15 888	22 133	15 806	16 516	22 129	22 280	15 486	21 550	15 888	22 133
15F1	2 343	5 126	8 067	6 768	6 801	10 089	9 680	7 217	10 392	5 126	8 067
15G1	3 739	6 179	10 854	7 433	6 209	14 114	11 288	7 744	11 905	6 179	10 854
15H1	27 220	8 762	14 429	8 455	5 073	14 307	9 451	9 025	14 733	8 762	14 429
15I1	10 392	7 983	13 639	5 533	6 373	9 001	10 027	5 709	8 837	7 983	13 639
15J1	6 515	6 716	11 267	5 062	4 217	8 515	7 062	7 020	10 150	6 716	11 267
15K1	7 000	4 513	8 063	4 655	3 435	7 932	5 756	3 291	5 447	4 513	8 063
15L1	4 137	5 631	10 513	4 264	3 356	7 389	5 911	3 030	4 636	5 631	10 513
16A1	2 520	1 996	3 683	699	1 221	1 310	2 164	1 305	2 340	1 996	3 683
17A1	17 816	5 936	10 778	4 839	3 728	7 504	5 705	5 512	8 804	5 936	10 778
17B1	23 447	12 331	21 489	8 066	8 397	14 027	14 148	10 825	16 350	12 331	21 489
18A1	11 960	5 987	11 228	5 218	4 400	8 827	7 235	3 550	6 028	5 987	11 228
19A1	2 513	663	1 338	828	585	1 570	1 098	465	809	663	1 338
20A1	14 737	6 277	10 848	5 535	5 466	8 580	7 913	5 148	7 940	6 277	10 848
21A1	16 616	8 471	15 848	5 940	5 272	9 745	8 492	7 169	11 322	8 471	15 848
22A1	12 194	10 903	21 878	10 165	7 271	15 291	11 229	8 504	15 451	10 903	21 878
22B1	24 803	8 973	16 876	5 226	5 220	8 656	8 598	9 147	14 516	8 973	16 876
23A1	5 338	14 058	28 836	9 400	19 620	16 469	33 974	11 443	18 666	14 058	28 836

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[26] The description of codes can be found in annex 2.

26	Direct employment 2000	Input-output 2000		Input-output 1995				Input-output 2000		Supply-use 2000	
		Level 1	All levels	Level 1		All levels		Level 1	All levels	Level 1	All levels
				Degrees of dependency	Technical coefficients	Degrees of dependency	Technical coefficients				
24A1	28 626	22 226	44 199	16 301	13 142	29 382	23 565	22 322	37 529	22 226	44 199
24B1	1 826	3 395	6 739	766	1 740	1 451	3 113	2 588	4 102	3 395	6 739
24C1	4 382	3 263	6 310	1 538	1 939	2 618	3 317	1 688	2 330	3 263	6 310
24D1	18 367	16 112	28 497	6 749	8 347	10 201	13 032	10 496	15 362	16 112	28 497
24E1	6 139	7 135	12 891	4 860	4 380	8 702	8 200	6 522	10 092	7 135	12 891
24F1	10 831	6 421	13 362	3 651	3 482	6 203	5 962	5 210	8 336	6 421	13 362
24G1	2 608	1 617	3 370	992	952	1 766	1 641	1 042	1 683	1 617	3 370
25A1	5 033	2 817	5 620	2 670	2 182	4 595	3 675	1 357	2 410	2 817	5 620
25B1	20 277	9 410	19 152	8 887	6 668	15 098	11 289	9 755	16 096	9 410	19 152
26A1	11 863	5 273	10 296	7 157	5 099	10 566	7 948	4 641	7 650	5 273	10 296
26B1	4 159	1 045	1 914	1 594	859	2 616	1 400	994	1 545	1 045	1 914
26C1	2 866	2 088	3 844	1 464	1 106	2 845	2 026	2 014	3 098	2 088	3 844
26D1	15 970	6 578	13 663	5 877	6 778	10 900	11 830	6 341	11 293	6 578	13 663
27A1	19 709	15 093	29 837	12 121	8 406	20 863	14 530	17 480	26 759	15 093	29 837
27B1	18 380	12 827	26 132	10 493	8 194	15 795	12 970	8 750	15 216	12 827	26 132
28A1	31 797	13 325	24 434	10 415	7 714	15 200	12 023	10 605	16 728	13 325	24 434
28B1	20 538	8 520	15 631	1 284	3 634	2 216	6 007	5 364	7 815	8 520	15 631
28C1	11 154	5 325	9 433	10 771	4 229	15 390	6 693	7 002	9 848	5 325	9 433
29A1	7 317	4 885	8 539	3 490	4 304	5 887	6 830	5 322	8 056	4 885	8 539
29B1	13 629	6 507	10 883	5 918	4 618	9 723	7 468	6 629	9 310	6 507	10 883
29C1	20 556	12 228	23 241	14 019	9 405	22 467	14 579	15 972	25 624	12 228	23 241
29D1	1 266	609	1 082	995	391	1 687	662	1 273	1 853	609	1 082
30A1	852	417	817	384	107	631	172	3 413	5 361	417	817
31A1	15 109	9 677	17 469	3 755	3 450	6 539	6 391	8 061	11 924	9 677	17 469
31B1	12 766	4 229	7 817	1 945	1 663	3 128	2 600	5 598	8 472	4 229	7 817
32A1	18 885	14 832	26 391	6 762	8 406	8 746	11 502	10 207	14 949	14 832	26 391
33A1	7 694	3 093	5 721	2 276	1 992	3 621	3 127	3 473	5 563	3 093	5 721
34A1	36 652	30 262	58 341	30 808	27 585	51 925	44 241	28 107	45 104	30 262	58 341
34B1	16 156	8 079	14 110	4 981	4 962	8 187	7 917	8 421	12 058	8 079	14 110
35A1	9 505	5 474	8 938	1 894	2 004	2 621	2 962	5 716	8 007	5 474	8 938

26	Direct employment 2000	Input-output 2000		Input-output 1995				Input-output 2000		Supply-use 2000	
		Level 1	All levels	Level 1		All levels		Level 1	All levels	Level 1	All levels
				Degrees of dependency	Technical coefficients	Degrees of dependency	Technical coefficients				
35B1	649	249	453	188	174	332	303	157	240	249	453
36A1	20 933	6 599	12 443	10 657	8 111	16 523	12 791	6 314	10 355	6 599	12 443
36B1	3 045	981	2 277	673	801	1 221	1 431	654	1 268	981	2 277
36C1	2 568	997	1 830	3 224	1 202	4 553	1 779	1 124	1 770	997	1 830
40A1	19 730	12 794	25 281	16 757	13 083	28 643	22 493	11 472	20 168	12 794	25 281
41A1	7 094	1 383	2 628	1 147	1 161	2 140	2 059	751	1 315	1 383	2 628
45A1	7 254	3 800	7 485	972	1 677	2 390	3 733	2 190	4 046	3 800	7 485
45B1	89 477	41 890	82 875	58 854	36 694	114 396	69 464	55 046	98 072	41 890	82 875
45C1	37 939	14 752	29 523	7 734	9 610	14 797	17 604	11 662	20 782	14 752	29 523
45D1	50 592	18 984	35 487	30 061	22 781	42 097	33 808	18 538	30 288	18 984	35 487
45E1	49 446	17 349	34 049	14 575	15 259	26 146	27 007	13 354	23 209	17 349	34 049
50A1	81 178	26 409	53 498	53 903	32 776	81 492	50 294	20 277	34 644	26 409	53 498
50B1	3 647	2 372	5 195	5 274	4 671	7 562	6 692	2 261	3 774	2 372	5 195
51A1	198 277	151 216	261 951	57 564	61 820	101 278	106 468	121 909	187 263	151 216	261 951
52A1	302 567	57 820	104 042	80 016	86 270	129 120	139 840	37 364	63 183	57 820	104 042
55A1	29 124	6 893	12 621	4 040	5 487	5 395	7 531	6 699	12 004	6 893	12 621
55B1	115 631	24 614	50 303	25 780	24 756	46 448	43 225	24 987	47 359	24 614	50 303
60A1	44 331	5 149	10 446	2 091	2 457	5 162	4 968	1 184	2 099	5 149	10 446
60B1	27 808	3 751	7 290	4 689	4 075	8 913	6 953	3 028	5 056	3 751	7 290
60C1	54 234	18 148	40 083	22 927	16 869	41 615	29 494	13 582	24 431	18 148	40 083
61A1	3 526	9 140	23 326	6 324	7 165	11 899	12 857	3 193	9 395	9 140	23 326
61B1	1 128	533	1 172	1 093	823	2 271	1 440	480	849	533	1 172
62A1	12 998	12 259	28 641	6 465	11 622	16 157	27 041	6 977	15 306	12 259	28 641
63A1	8 185	16 962	29 983	11 014	18 254	17 201	27 132	12 611	20 001	16 962	29 983
63B1	35 329	41 691	76 614	39 341	34 475	66 894	57 595	32 217	51 836	41 691	76 614
64A1	50 323	6 618	12 079	2 220	2 532	3 668	4 120	3 491	5 093	6 618	12 079
64B1	29 967	21 416	39 446	5 670	8 436	8 929	13 263	15 219	23 664	21 416	39 446
65A2	82 536	26 057	48 615	16 004	111 860	27 223	181 912	16 103	33 187	26 057	48 615
66A2	28 341	26 780	58 526	15 494	19 025	32 602	32 857	12 354	26 520	26 780	58 526
67A1	32 852	21 250	40 045	25 111	13 076	37 918	21 803	20 722	34 471	21 250	40 045

26	Direct employment 2000	Input-output 2000		Input-output 1995				Input-output 2000		Supply-use 2000	
		Level 1	All levels	Level 1		All levels		Level 1	All levels	Level 1	All levels
				Degrees of dependency	Technical coefficients	Degrees of dependency	Technical coefficients				
70A1	24 109	37 042	72 171	15 059	14 272	30 260	26 988	27 967	51 388	37 042	72 171
71A1	2 443	6 309	12 657	5 265	4 466	9 408	7 699	6 667	10 874	6 309	12 657
71B1	3 641	3 518	7 131	14 049	4 585	17 449	6 073	4 618	7 694	3 518	7 131
72A1	37 141	25 023	45 280	10 752	10 171	17 934	17 330	22 978	35 562	25 023	45 280
73A1	5 555	2 905	5 320	5 015	3 203	7 298	4 728	3 323	5 284	2 905	5 320
73A5	1 398	221	409	257	248	432	405	178	285	221	409
74A1	63 197	25 983	46 800	14 578	14 294	26 099	25 692	18 989	27 434	25 983	46 800
74B1	47 864	52 077	95 912	15 829	17 437	24 775	27 910	19 609	36 771	52 077	95 912
74C1	44 985	15 399	30 376	4 309	3 708	6 044	5 396	8 987	14 687	15 399	30 376
74D1	15 316	23 272	39 090	15 341	14 793	25 574	24 186	21 767	31 967	23 272	39 090
74E1	177 946	2 685	5 060	1 224	2 069	1 972	3 338	1 956	3 122	2 685	5 060
74F1	142 723	37 918	65 945	26 177	21 747	37 197	32 309	21 563	33 562	37 918	65 945
75A3	344 788	28 948	54 587	19 642	18 313	34 351	31 959	15 539	28 317	28 948	54 587
75B3	47 082	3 398	6 617	3 454	2 253	5 669	3 711	3 400	6 039	3 398	6 617
75C3	28 062	6 877	12 163	5 677	4 837	8 778	7 319	4 839	7 062	6 877	12 163
80A1	4 125	1 731	3 437	1 070	1 175	2 043	2 113	1 484	2 682	1 731	3 437
80A3	328 432	9 305	16 731	6 162	5 078	10 428	8 457	6 054	9 864	9 305	16 731
80A5	4 716	431	767	194	210	328	351	328	525	431	767
85A1	203 754	24 143	42 131	23 979	22 478	36 256	33 628	21 177	32 923	24 143	42 131
85B1	1 142	721	1 728	800	787	1 332	1 296	653	1 369	721	1 728
85C1	127 821	10 045	16 832	11 375	10 406	17 242	15 994	10 727	16 272	10 045	16 832
85C5	43 717	3 320	5 230	2 339	2 059	3 250	3 024	2 891	4 229	3 320	5 230
90A1	7 497	6 637	10 873	3 979	3 673	6 436	5 615	5 528	8 552	6 637	10 873
91A1	8 923	4 591	8 166	5 438	4 001	8 380	5 981	4 382	6 516	4 591	8 166
91A5	26 807	4 744	8 182	4 445	3 778	6 777	5 678	3 590	5 277	4 744	8 182
92A1	15 124	3 661	7 435	2 808	2 630	4 764	4 428	2 857	5 030	3 661	7 435
92B1	9 737	3 243	6 418	1 237	1 629	2 205	2 858	3 269	5 540	3 243	6 418
92C1	1 777	953	1 559	1 199	698	1 805	1 013	942	1 338	953	1 559
92D1	13 039	4 396	7 889	2 602	2 728	4 530	4 516	3 264	5 349	4 396	7 889
92C5	1 985	207	395	117	181	197	299	1 329	2 103	207	395

26	Direct employment 2000	Input-output 2000		Input-output 1995				Input-output 2000		Supply-use 2000	
		Level 1	All levels	Level 1		All levels		Level 1	All levels	Level 1	All levels
				Degrees of dependency	Technical coefficients	Degrees of dependency	Technical coefficients				
92D5	1 553	547	991	334	366	529	590	1 638	2 618	547	991
93A1	59 440	3 572	7 536	5 950	4 568	10 258	7 865	3 419	6 304	3 572	7 536

Annex 2: Description of industry codes

01A1	Agriculture, hunting and related service activities
02A1	Forestry, logging and related service activities
05A1	Fishing, fish farming and related service activities
14A1	Other mining and quarrying
15A1	Production, processing and preserving of meat and meat products
15B1	Processing and preserving of fish and fish products
15C1	Processing and preserving of fruit and vegetables
15D1	Manufacture of vegetable and animal oils and fats
15E1	Manufacture of dairy products
15F1	Manufacture of grain mill products, starches and starch products
15G1	Manufacture of prepared animal feeds
15H1	Manufacture of bread; manufacture of fresh pastry goods and cakes
15I1	Manufacture of sugar, chocolate and sugar confectionery
15J1	Manufacture of macaroni, noodles, couscous and similar farinaceous products, tea and coffee and other food products n.e.c.
15K1	Manufacture of beverages
15L1	Production of mineral waters and soft drinks
16A1	Manufacture of tobacco products
17A1	Preparation and spinning of textile fibres, textile weaving and finishing of textiles
17B1	Manufacture of made-up textile articles, except apparel; other textiles; knitted and crocheted fabrics
18A1	Manufacture of wearing apparel; dressing and dyeing of fur
19A1	Manufacture of leather and leather products; footwear
20A1	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
21A1	Manufacture of pulp, paper and paperboard
22A1	Publishing
22B1	Printing and service activities related to printing; Reproduction of recorded media
23A1	Manufacture of coke, refined petroleum products and nuclear fuel
24A1	Manufacture of basic chemicals
24B1	Manufacture of pesticides and other agro-chemical products
24C1	Manufacture of paints, varnishes and similar coatings, printing ink and mastics
24D1	Manufacture of pharmaceuticals, medicinal chemicals and botanical products
24E1	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations
24F1	Manufacture of other chemical products
24G1	Manufacture of man-made fibres
25A1	Manufacture of rubber products
25B1	Manufacture of plastic products
26A1	Manufacture of glass and glass products
26B1	Manufacture of non-refractory ceramic goods other than for construction purposes; manufacture of refractory ceramic products
26C1	Manufacture of cement, lime and plaster
26D1	Manufacture of articles of concrete, plaster and cement; other non-metallic mineral products
27A1	Manufacture of basic iron and steel and of ferro-alloys
27B1	First processing of iron and steel; basic precious and non-ferrous metals; casting of metals
28A1	Manufacture of structural metal products; tanks, reservoirs and containers of metal; manufacture of central heating radiators and boilers; steam generators; forging, pressing, stamping and roll forming of metal; powder metallurgy
28B1	Treatment and coating of metals; general mechanical engineering
28C1	Manufacture of cutlery, tools and general hardware; other fabricated metal products
29A1	Manufacture of machinery for the production and use of mechanical power, except aircraft, vehicle and cycle engines
29B1	Manufacture of other general purpose machinery
29C1	Manufacture of agricultural and forestry machinery; machine tools
29D1	Manufacture of domestic appliances n.e.c.
30A1	Manufacture of office machinery and computers
31A1	Manufacture of electric motors, generators and transformers; electricity distribution and control apparatus; insulated wire and cable
31B1	Manufacture of accumulators, primary cells and primary batteries; lighting equipment and electric lamps; electrical equipment n.e.c.
32A1	Manufacture of radio, television and communication equipment and apparatus
33A1	Manufacture of medical and surgical equipment and orthopaedic appliances; instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment; optical instruments and photographic equipment; watches and clocks

34A1	Manufacture of motor vehicles
34B1	Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers; parts and accessories for motor vehicles and their engines
35A1	Building and repairing of ships and boats; railway and tramway locomotives and rolling stock; aircraft and spacecraft
35B1	Manufacture of motorcycles and bicycles; other transport equipment n.e.c.
36A1	Manufacture of furniture; manufacturing n.e.c.
36B1	Manufacture of jewellery and related articles
36C1	Manufacture of musical instruments; sports goods; games and toys; other manufacturing n.e.c.
37A1	Recycling
40A1	Electricity, gas, steam and hot water supply
41A1	Collection, purification and distribution of water
45A1	Site preparation
45B1	General construction of buildings and civil engineering works; erection of roof covering and frames
45C1	Construction of motorways, roads, airfields and sport facilities; water projects; other construction work involving special trades
45D1	Building installation
45E1	Building completion; renting of construction or demolition equipment with operator
50A1	Sale of motor vehicles; maintenance and repair of motor vehicles; sale of motor vehicle parts and accessories; sale, maintenance and repair of motorcycles
50B1	Retail sale of automotive fuel
51A1	Wholesale trade and commission trade
52A1	Retail trade; repair of personal and household goods
55A1	Hotels and restaurants; other provision of short-stay accommodation
55B1	Restaurants; Bars; Canteens and catering
60A1	Transport via railways
60B1	Scheduled passenger land transport; Taxi operation; other land passenger transport
60C1	Freight transport by road; Transport via pipelines
61A1	Sea and coastal water transport
61B1	Inland water transport
62A1	Air transport
63A1	Activities of travel agencies and tour operators
63B1	Cargo handling and storage; other supporting transport activities; activities of other transport agencies
64A1	Post and courier activities
64B1	Telecommunications
65A2	Financial intermediation
66A2	Insurance
67A1	Activities auxiliary to financial intermediation, to insurance and pension funding
70A1	Real estate, renting and business activities
71A1	Renting of automobiles; of other transport equipment
71B1	Renting of other machinery and equipment
72A1	Computer and related activities
73A1	Research and experimental development on natural sciences and engineering
73A5	Research and experimental development on social sciences and humanities
74A1	Legal, accounting, book-keeping and auditing activities; tax consultancy; market research and public opinion polling
74B1	Business and management consultancy activities; management activities of holding companies
74C1	Technical testing and analysis; architectural and engineering activities and related technical consultancy
74D1	Advertising
74E1	Labour recruitment and provision of personnel
74F1	Investigation and security activities; industrial cleaning; miscellaneous business activities n.e.c.
75A3	Public administration, excluding defence and social security
75B3	Defence activities
75C3	Compulsory social security activities
80A1	Education
80A3	Education, public services
80A5	Education, other non market
85A1	Human health activities
85B1	Veterinary activities
85C1	Social work activities, market
85C5	Social work activities, non market
90A1	Collection and treatment of sewage, other waste
91A1	Activities of membership organizations, market
91A5	Activities of membership organizations, non market
92A1	Motion picture and video activities; Radio and television activities

92B1	Other entertainment activities, market
92B5	Other entertainment activities, non market
92C1	News agency activities
92C5	Other cultural activities
92D1	Sporting activities, market
92D5	Sporting activities, non market
93A1	Other service activities

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