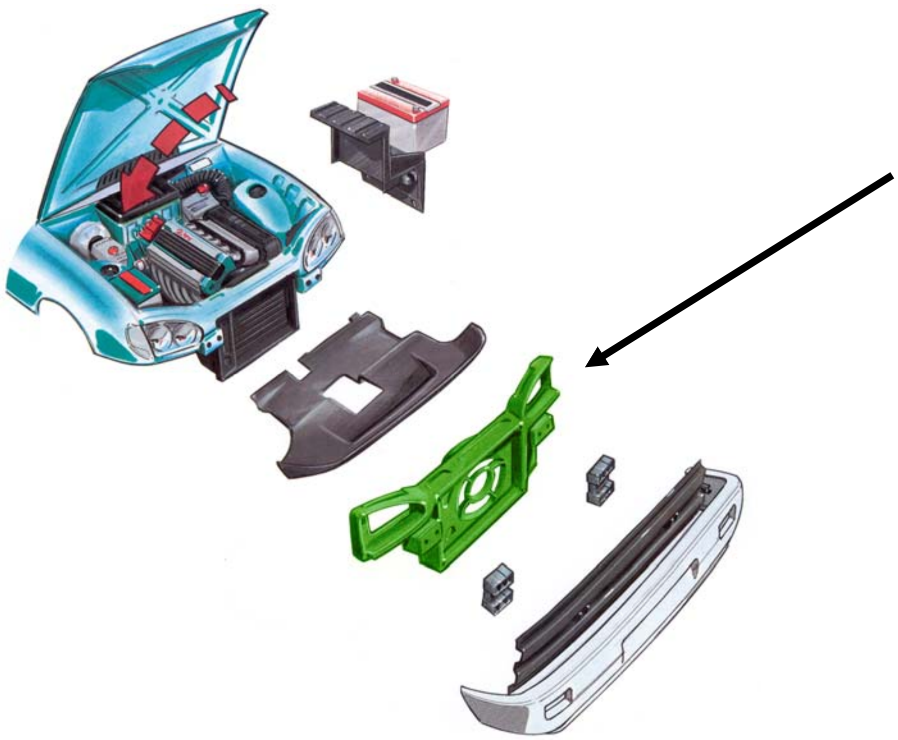
Short course on Input-Output: Groupwork I
Case study on automobile materials

Olivier Jolliet, Ecointesys – Life Cycle Systems
Yves Letterrier, LTC-EPFL

A. Introduction and objectives

The aim of this exercise is to evaluate the environmental impacts associate with one part of a car. The front panel is a static piece, which is used to keep other parts together. It does not have any other mechanical function. A supplier to the automotive industry faces a decision regarding the choice of material for this new structural part. The development department of the company has selected three materials that could satisfy the functional and production requirements. The three materials selected are steel, aluminum and a thermoset composite (polyester-based SMC, for sheet molding compound), as specified in Table 1. In a first step we study in details the case of aluminium.



The exercise aims to determine the life cycle energy use and the CO_2 emissions of the aluminium front panel using a simplified Input-Output matrix. Emphasis is set on the understanding and interpretation, performing simple calculation by hand.

Table 1: LCA data

Products	Main function	Secondary functions
scenario 1, 2, 3 automobile component	Transport of persons	Ensure required stiffness

Product or system	Functional unit		Reference flows	Key environmental parameters
scenario 1 Steel	1 front end panel over 200'000 km		Steel raw material(kg):15.4 Required gasoline (l): 80	Production: kg/funct. Unit Emission+energy use at production Use phase: Weight Motor efficiency
scenario 2 SMC composite			SMC raw material(kg): 7 Required gasoline (l): 56	
scenario 3 Aluminum			Alu raw material(kg): 5.9 Required gasoline (l): 30.4	

B. Data collection and interpretation

Input-Output and economical data

Input-Output tables are normally available at governmental bureau of statistics (for example the BEA (Bureau of Economy Analysis) in the US). Table 2 present a small extract of the money flows between the main sectors involved in the aluminium front panel production.

Table 2: Transaction matrix [M$] and total output [M$]

Column: supplying sector purchasing sector

	Aluminium	**Coal and Petroleum**	**Electricity**	**Total output [M$]**
Aluminium	976	0	0	5688
Coal and Petroleum	0.50	5877	13240	109680
Electricity	1518	1243	27	132400

1.) Interpret the term 13240 of the transaction matrix (table 1). What are the most important suppliers and customers for the aluminium sector (in monetary terms)?

2.) Starting from the transaction matrix and the total output, complete the matrix of direct coefficients ("A") and give the interpretation of the term designated by an arrow.

Equation to use: ……

$$\text{The transaction matrix } Z = \begin{pmatrix} 976 & 0 & 0 \\ 0.50 & 5877 & 13240 \\ 1518 & 1243 & 27 \end{pmatrix} \text{ and the total output } x = \begin{pmatrix} 5688 \\ 109680 \\ 132400 \end{pmatrix}$$

$$A = \begin{pmatrix} 0.17 & 0 & 0 \\ 0.000088 & 0.054 & 0.1 \\ & & \end{pmatrix}$$

Environmental data

Table 3: Total primary non-renewable energy consumption and CO_2 emission per sector per year

Sector	Energy consumption [MJ/year]	CO_2 emissions [kg/year]
Aluminium	0	1.1E9
Coal and Petroleum	6.26E13	76E9
Electricity	0	1.5E12

3.) Using tables 2 and 3, calculate the environmental matrices for the primary energy consumption and for the CO_2 emissions.

Determine the environmental matrix for non-renewable primary energy [MJ/$]:

$$F_{energy} = \left(\qquad\qquad\qquad\qquad \right)$$

Determine the environmental matrix [kg CO_2/$]:

$$F_{CO_2} = \left(\qquad\qquad\qquad\qquad \right)$$

Explain why the value of F_{energy} for aluminium and electricity are zero whereas the values of F_{CO2} are not null:

Case specific data:

4.) To be able to evaluate the embodied energy and the CO_2 emissions, case specific data have to be collected. Calculate the final demand.

Table 4: Aluminium front panel data and related prices

Goods	Required amounts	Price	Final demand
Aluminium	5.9 [kg/panel]	2.5 [$/kg]	
Oil for manufacturing	2.14 [l/panel]	0.32 [$/l]	
Electricity for manufacturing	15.2 [kWh/panel]	0.07 [$/kWh]	
Gasoline during use phase	30.4 [l/panel]	0.036 [$/l]	

C. Calculating of the manufacturing primary energy and CO_2 emissions

5.) Using the data provided in table 4, determine the necessary final output (in monetary units) in each sector in order to manufacture one front panel.

The environmental Input-Output equation: ……

Complete:

$$I\text{-}A = \begin{pmatrix} & & \\ -0.000088 & 0.95 & -0.1 \\ -0.27 & -0.011 & 0.1 \end{pmatrix}$$

$$(I\text{-}A)^{-1} = \begin{pmatrix} 1.2 & 0 & 0 \\ 0.034 & 1.1 & 0.11 \\ 0.32 & 0.012 & 1.00 \end{pmatrix}$$

(Can be calculated with Excel)

The Input-Output equation: …..

Complete the final demand and the final output:

$$\begin{pmatrix} 1.2 & 0 & 0 \\ 0.034 & 1.1 & 0.11 \\ 0.32 & 0.012 & 1.00 \end{pmatrix} \cdot \begin{pmatrix} \\ 0.69 \\ 1.06 \end{pmatrix} = \begin{pmatrix} 17.7 \\ 1.4 \\ \end{pmatrix}$$

In this example, identify the sector that generates the most important contribution to the final output of the electricity sector:

6.) Estimate the total non-renewable primary energy consumption induced by this manufacturing.

Calculate the non-renewable primary energy consumption:

$$\left(\qquad\qquad\qquad\qquad\qquad\qquad \right) \cdot \begin{pmatrix} 17.7 \\ 1.4 \\ \; \end{pmatrix} = \qquad \text{MJ}$$

7.) Calculate the contribution of tier 0, 1, 2 and 3 to the non-renewable primary energy consumption.

tier 0: $I \cdot \vec{y} = \vec{x}_0 = \begin{pmatrix} 14.75 \\ 0.69 \\ 1.06 \end{pmatrix}$ contribution of tier 0 = $\left(\qquad\qquad\qquad\qquad\qquad \right) \cdot \begin{pmatrix} 14.75 \\ 0.69 \\ 1.06 \end{pmatrix} = \qquad \text{MJ}$

tier 1: $A \cdot \vec{y} = \vec{x}_1 = \begin{pmatrix} 2.5 \\ 0.14 \\ 4.0 \end{pmatrix}$ contribution of tier 1 = $\left(\qquad\qquad\qquad\qquad\qquad \right) \cdot \begin{pmatrix} 2.5 \\ 0.14 \\ 4.0 \end{pmatrix} = \qquad \text{MJ}$

tier 2: $A^2 \cdot \vec{y} = \vec{x}_2 = \begin{pmatrix} 0.43 \\ 0.41 \\ 0.68 \end{pmatrix}$ contribution of tier 2 = 232 MJ

tier 3: $A^3 \cdot \vec{y} = \vec{x}_y = \begin{pmatrix} 0.072 \\ 0.090 \\ 0.12 \end{pmatrix}$ contribution of tier 3 = 51 MJ

Explain the high value found in tier 2:

Are the contributions of the second and third tiers significant? Verify the convergence (decrease in the contributions when considering higher tiers) of the value of the non-renewable energy consumption towards the value calculated under 5.

8.) Calculate the primary embodied energy of the gasoline necessary to perform 200'000 km during the product life.

Write the equation to use to find the final output:……

complete:

$$\begin{pmatrix} 1.2 & 0 & 0 \\ 0.034 & 1.1 & 0.11 \\ 0.32 & 0.012 & 1.00 \end{pmatrix} \cdot \begin{pmatrix} 0 \\ \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ 12.1 \\ \end{pmatrix}$$

What sector shows the biggest difference in final output when considering the necessary gasoline for the use phase?

Write the equation to estimate the non-renewable primary energy consumed: …..

Complete:

$$\begin{pmatrix} 0 & 5.71E2 & 0 \end{pmatrix} \cdot \begin{pmatrix} 0 \\ 12.1 \\ \end{pmatrix} = \qquad \text{MJ}$$

9.) Calculate the total CO_2 emission taking into account the gasoline needed for 200'000 km travel during the product life.

The final demand:

y_1 =14.75 [$]
y_2 = 11.69 [$]
y_3 = 1.06 [$]

From the final demand, we can calculate the final output, write the equation: ……

$$\begin{pmatrix} 1.2 & 0 & 0 \\ 0.034 & 1.1 & 0.11 \\ 0.32 & 0.012 & 1.0 \end{pmatrix} \cdot \begin{pmatrix} 14.75 \\ 11.69 \\ 1.06 \end{pmatrix} = \begin{pmatrix} 17.7 \\ 13.5 \\ 5.9 \end{pmatrix}$$

And calculate the CO_2 emissions:

$$\left(\qquad\qquad\qquad\qquad\qquad\qquad \right) \cdot \begin{pmatrix} 17.7 \\ 13.5 \\ 5.9 \end{pmatrix} = \qquad\quad kgCO_2$$

Calculated with the process LCA, one found 179 kg for the aluminium front panel, explain the potential difference with the value found above:

Correction Groupwork I

1.) Interpret the term 13240 of the transaction matrix (table 1). What are the most important suppliers and customers for the aluminium sector (in monetary terms)?

Each term of the transaction matrix represents the monetary value of the amount of goods that flow from one sector to another. The row i summarised the flow of goods from the sector i to all the other (the outputs of sector i). The column j shows the flow of goods from the economy to the sector j (the inputs to sector j). Thus, for example, 13240 is the monetary value of the goods that flows from the coal and petroleum sector to the electricity sector.

The most important suppliers (in monetary terms):

For the aluminium, it is the electric sector since it supplies electricity for an amount of 1518 M$.
For the coal and petroleum, it is itself.
For the electricity sector, it is the coal and petroleum sector.

The most important customers (in monetary terms):

For the aluminium, it is itself.
For the coal and petroleum, it is the electricity sector.
For the electricity, it is the aluminium sector.

2.) Starting from the transaction matrix and the total output, complete the matrix of direct coefficients ("A") and give the interpretation of the term designated by an arrow.

Equation to use: $a_{ij} = z_{ij}/x_j$

a_{ij} = monetary value of the flow of goods from sector i to sector j divided by the total output of sector j
z_{ij} is the value of the goods sold by sector i to sector j.
x_j is the total output of sector j.

$$\text{The transaction matrix } Z = \begin{pmatrix} 976 & 0 & 0 \\ 0.50 & 5877 & 13240 \\ 1518 & 1243 & 27 \end{pmatrix} \text{ and the total output } x = \begin{pmatrix} 5688 \\ 109680 \\ 132400 \end{pmatrix}$$

$$\text{And therefore } A = (z_{ij}/x_j) = \begin{pmatrix} \frac{976}{5688} & \frac{0}{109680} & \frac{0}{132400} \\ \frac{0.50}{5688} & \frac{5877}{109680} & \frac{13240}{132400} \\ \frac{1518}{5688} & \frac{1243}{109680} & \frac{27}{132400} \end{pmatrix} = \begin{pmatrix} 0.17 & 0 & 0 \\ 0.000088 & 0.054 & 0.1 \\ 0.27 & 0.011 & 0.0002 \end{pmatrix}$$

The term a_{ij} represents the flow from sector i to sector j normalised by the total output of sector j. The term 0.27, for example, represents the necessary input from the electricity sector in order to produce 1 $ of aluminium.

3.) Using tables 1 and 2, calculate the environmental matrices for the primary energy consumption and for the CO_2 emissions.

Determine the environmental matrix for non-renewable primary energy [MJ/$]:

$F_{energy,1}$ = 0/5688 = 0
$F_{energy,2} = 6.26 \cdot 10^{13} / 109680 = 5.71 \cdot 10^{8}$ [MJ/M$] $= 5.71 \cdot 10^{2}$ [MJ/$]
$F_{energy,3}$ = 0/132400 = 0

$$F_{energy} = \begin{pmatrix} 0 & 5.71 \cdot 10^{2} & 0 \end{pmatrix}$$

Determine the environmental matrix [kg CO_2/$]:

$F_{CO2,1} = 1.1 \cdot 10^{6}/5688 = 1.93 \cdot 10^{2}$ [t/M$] = 0.193 [kg CO_2/$]
$F_{CO2,2} = 76 \cdot 10^{6}/109680 = 6.93 \cdot 10^{2}$ [t/M$] = 0.693 [kg CO_2/$]
$F_{CO2,3} = 1.5 \cdot 10^{9}/132400 = 1.13 \cdot 10^{4}$ [t/M$] = 11.3 [kg CO_2/$]

$$F_{CO_2} = \begin{pmatrix} 0.193 & 0.693 & 11.3 \end{pmatrix}$$

Explain the results:

It can seem weird that the F_1 and F_3 values are zero. Although the aluminium and the electricity sector use some energy, they buy this energy from another sector. These two sectors don't extract directly some non-renewable energy. And actually, the only sector that extracts some non-renewable energy (if the nuclear energy is not considered) is the coal and petroleum sector. It will be different for the CO_2 emissions since the production of electricity, for instance, releases directly some CO_2.

4.) To be able to evaluate the embodied energy and the CO_2 emissions, case specific data have to be collected.

Table 3: Aluminium front panel data and related prices

Goods	Required amounts	Price	Final demand
Aluminium	5.9 [kg/panel]	2.5 [$/kg]	14.75 [$]
Oil for manufacturing	2.14 [l/panel]	0.32 [$/l]	0.69 [$]
Electricity for manufacturing	15.2 [kWh/panel]	0.07 [$/kWh]	1.06 [$]
Gasoline during use phase	30.4 [l/panel]	0.36 [$/l]	11 [$]

C. Calculating of the manufacturing primary energy and CO_2 emissions

5.) Using the data provided above, determine the necessary final output (in monetary units) in each sector in order to manufacture one front panel.

The environmental Input-Output equation: $\vec{f} = F \cdot \vec{x} = F(I - A)^{-1}\vec{y}$

$\vec{f}$ is the vector of total pollutant emissions or energy consumption
F is the matrix of pollutant emissions and energy consumption per unit of output of sector
A is the technical coefficient matrix
$\vec{y}$ is the vector of final demand
$\vec{x}$ is the vector of final output

$$I\text{-}A = \begin{pmatrix} 0.083 & 0 & 0 \\ -0.000088 & 0.95 & -0.1 \\ -0.27 & -0.011 & 0.1 \end{pmatrix}$$

$$(I\text{-}A)^{-1} = \begin{pmatrix} 1.2 & 0 & 0 \\ 0.034 & 1.1 & 0.11 \\ 0.32 & 0.012 & 1.00 \end{pmatrix}$$

***Facultative**: determination of (I-A)$^{-1}$*

In order to calculate (I-A)$^{-1}$ one can use the following general formula:

$B^{-1} = \frac{1}{|\det B|}\,\mathrm{adj}(B)$ *where $(adj(B))_{ij}$ = cofactor(b_{ij}) = $(-1)^{i+j}$·(det(B without row i and column j))*

*det (I-A) = 0.8284 · (0.946419*0.999797- (-0.1)*(-0.011332)) = 0.782916*

*$(I\text{-}A)^{-1}_{11}$ = (1/0.782916) ·(0.946419*0.999797- (-0.1)*(-0.011332)) = 1.2071*

Applying this formula we find (I-A)$^{-1}$

$$(I\text{-}A)^{-1} = \begin{pmatrix} 1.2 & 0 & 0 \\ 0.034 & 1.1 & 0.11 \\ 0.32 & 0.012 & 1.00 \end{pmatrix}$$

The Input-Output equation: $\vec{x} = (I - A)^{-1}\vec{y}$

$$\begin{pmatrix} 1.2 & 0 & 0 \\ 0.034 & 1.1 & 0.11 \\ 0.32 & 0.012 & 1.0 \end{pmatrix} \cdot \begin{pmatrix} 14.75 \\ 0.69 \\ 1.06 \end{pmatrix} = \begin{pmatrix} 17.7 \\ 1.4 \\ 5.8 \end{pmatrix}$$

Identify the sector that gives the most important contribution to the output of the electricity sector:

$$5.8 = 14.75 \cdot 0.32 + 0.69 \cdot 0.012 + 1.06 \cdot 1.0 = 4.7 + 0.083 + 1.06 = 5.8$$

And the most important contribution comes from the aluminium sector.

6.) Estimate the total non-renewable primary energy consumption induced by this manufacturing.

$$\begin{pmatrix} 0 & 5.71 \cdot 10^2 & 0 \end{pmatrix} \cdot \begin{pmatrix} 17.7 \\ 1.4 \\ 5.8 \end{pmatrix} = 787 \text{ MJ}$$

7.) Calculate the contribution of tier 0, 1, 2 and 3 to the non-renewable primary energy consumption.

tier 0: $I \cdot \vec{y} = \vec{x}_0 = \begin{pmatrix} 14.75 \\ 0.69 \\ 1.064 \end{pmatrix}$ contribution of tier 0 = $\begin{pmatrix} 0 & 5.71 \cdot 10^2 & 0 \end{pmatrix} \cdot \begin{pmatrix} 14.75 \\ 0.69 \\ 1.064 \end{pmatrix} = 394 \text{ MJ}$

tier 1: $A \cdot \vec{y} = \vec{x}_1 = \begin{pmatrix} 2.5 \\ 0.67 \\ 4.1 \end{pmatrix}$ contribution of tier 1 = $\begin{pmatrix} 0 & 5.71 \cdot 10^2 & 0 \end{pmatrix} \cdot \begin{pmatrix} 2.5 \\ 0.14 \\ 4.0 \end{pmatrix} = 83 \text{ MJ}$

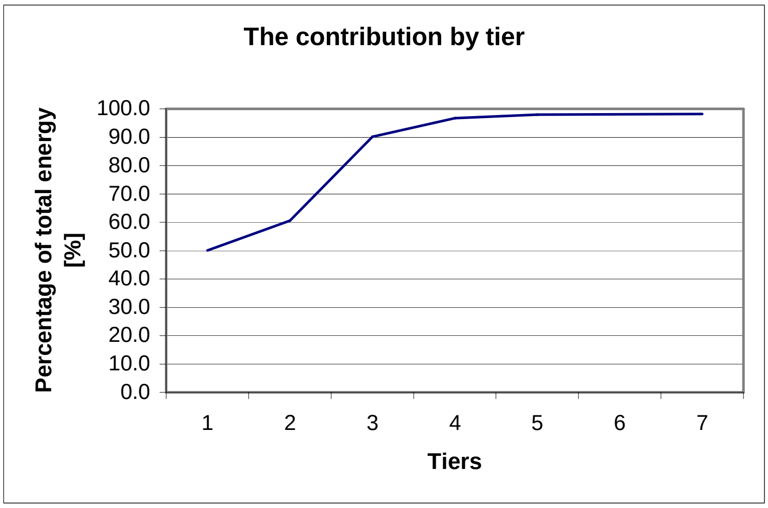
tier 2: $A^2 \cdot \vec{y} = \vec{x}_2 = \begin{pmatrix} 0.43 \\ 0.41 \\ 0.68 \end{pmatrix}$ contribution of tier 2 = 232 MJ

tier 3: $A^3 \cdot \vec{y} = \vec{x}_y = \begin{pmatrix} 0.072 \\ 0.090 \\ 0.12 \end{pmatrix}$ contribution of tier 3 = 51 MJ

Are the contributions of the second and third tiers significant? Verify the convergence (decrease in the contributions when considering higher tiers) of the value of the non-renewable energy consumption.

In the following table are presented the contribution of the different tiers:

tier	Contribution of the tier [MJ]	Cumulative contribution [MJ]	Percentage of the total [5]
0	394	394	50.1
1	83	477	60.6
2	232	709	90.2
3	51	761	96.7
4	10	770	97.9
5	1.7	771.9	98.1
6	0.3	772.2	98.2



We see that the contributions of the tiers 2 and 3 are important. We have to wait until the third or the fourth tier to have an acceptable value.

The high value for tier 2 can be explained in the following way. The aluminium sector buys a lot from the electricity sector which itself buys a lot from the coal and petroleum sector. Therefore, one needs to wait until the second tier to see this contribution appearing.

8.) Calculate the primary embodied energy of the gasoline necessary to perform 200'000 km during the product life.

Write the equation to use to find the final output: $\vec{x} = (I - A)^{-1}\vec{y}$

$$\begin{pmatrix} 1.2 & 0 & 0 \\ 0.034 & 1.1 & 0.11 \\ 0.32 & 0.012 & 1.00 \end{pmatrix} \cdot \begin{pmatrix} 0 \\ 11 \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ 12.1 \\ 0.1 \end{pmatrix}$$

As expected, it is the coal and petroleum sector that is dominant for the production of the gasoline for the use phase.

Write the equation to estimate the non-renewable primary energy consumed: $\vec{f} = F \cdot \vec{x} = F(I - A)^{-1}\vec{y}$

$$\begin{pmatrix} 0 & 5.71E2 & 0 \end{pmatrix} \cdot \begin{pmatrix} 0 \\ 12.1 \\ 0.1 \end{pmatrix} = 6910 \text{ MJ}$$

9.) Calculate the total CO_2 emission taking into account the gasoline needed for 200'000 km travel during the product life.

The final demand:

y_1 =14.75 [$]
y_2 = 11.69 [$]
y_3 = 1.06 [$]

From the final demand, we can calculate the final output.

$$\begin{pmatrix} 1.2 & 0 & 0 \\ 0.034 & 1.1 & 0.11 \\ 0.32 & 0.012 & 1.0 \end{pmatrix} \cdot \begin{pmatrix} 14.75 \\ 11.69 \\ 1.06 \end{pmatrix} = \begin{pmatrix} 17.7 \\ 13.5 \\ 5.9 \end{pmatrix}$$

And calculate the CO_2 emissions:

$$\begin{pmatrix} 0.193 & 0.693 & 11.3 \end{pmatrix} \cdot \begin{pmatrix} 17.7 \\ 13.5 \\ 5.9 \end{pmatrix} = 80 \text{ kgCO}_2$$

Calculated with the process LCA, one found 179 kg for the aluminium front panel, explain the difference with the value found above:

The differences can arise from the fact that we take into account only three sectors and from the fact that the emissions during the use phase are not taken into account. Considering 0.00020168 kg CO_2/kgkm one finds that the emissions for 200'000 km and for the aluminium front panel is 153 kg. Thus, the total CO_2 emissions would be 233 kg.

Annex 1: Contributions to the aluminium sector (for 1 M$ of primary aluminium)

Sector name	Contribution [%]	Contribution [M$]
Nonferr. Metal ores except cooper	1.966	0.01298
Other non farm buildings	0.652	4.31E-03
Distilled and blended liquors	0.005	3.52E-05
envelopes	0.003	1.76E-05
sanitary paper products	0.011	7.03E-05
paperboard container and boxes	0.019	1.23E-04
periodicals	0.003	1.76E-05
manifolds business form	0.029	1.93E-04
industrial inorganic and organic chemicals	5.427	0.03583
chemicals and chemical prepration	0.099	6.51E-04
petroleum refining	0.141	9.32E-04
lubricating oil and greases	0.045	2.99E-04
product of petroleum and coal	5.159	0.03406
tires and inner tube	0.008	5.27E-05
miscellaneous plastic products	0.530	3.50E-03
gaskets, packing and sealing devices	0.072	4.75E-04
glass and glass product, except container	0.021	1.41E-04
lime	0.538	3.55E-03
abrasive products	0.051	3.34E-04
metal heat treating	0.072	4.75E-04
primary smelting and refining of petroleum	0.413	2.73E-03
primary aluminium	25.990	0.1716
primary non ferrous metals	0.857	5.66E-03
non ferrous wire drawing and insulating	0.093	6.15E-04
hand and edge tools, except machine tools and handsaws	0.003	1.76E-05
miscellaneous fabricated wire products	0.005	3.52E-05
pipe, valves and pipe fitting	0.120	7.91E-04
fabricated metal products	0.043	2.81E-04
industrial trucks and tractors	0.043	2.81E-04
special dies and tools and machine tool accessories	0.072	4.75E-04
metalworking machinery	0.008	5.27E-05
pumps and compressors	0.157	1.04E-03
general industrial machinery and equipment	0.037	2.46E-04
fluid power equipment	0.037	2.46E-04
industrial and commercial machinery and equipment	0.101	6.68E-04
carbon and graphite products	1.100	7.26E-03
motor vehicles parts and accessories	0.019	1.23E-04
mechanical measuring devices	0.003	1.76E-05
Environmental controls	0.008	5.27E-05
ophtalmic goods	0.003	1.76E-05
photographic equipment and supplies	0.008	5.27E-05
railroad and related services	2.969	0.0196
Local and suburban transit and interurban highway passenger transport	0.011	7.03E-05
motor freight transportation and wharehousing	3.864	0.02551
water transportation	0.354	2.34E-03
air transportation	0.242	1.60E-03

pipelines except natural gases	0.008	5.27E-05
arrangement of passenger transportation	0.003	1.76E-05
communication, except radio and TV	0.120	7.91E-04
electric services	40.424	0.2669
gas production and distribution	1.472	9.72E-03
water supply and sewerage system	0.192	1.27E-03
sanitary services, steam supply and irrigation systems	0.048	3.17E-04
wholesale trade	1.251	8.26E-03
retail trade, except eating and drinking	0.024	1.58E-04
banking	1.225	8.09E-03
credit agencies other than banks	0.011	7.03E-05
security and commodity brokers	0.126	8.29E-04
insurance carriers	0.144	9.49E-04
insurance agents, brokers and services	0.096	6.33E-04
royalties	0.083	5.45E-04
hotels and lodging places	0.101	6.68E-04
laundry, cleaning, garments services and shoe repair	0.032	2.11E-04
electrical repair shop	0.013	8.79E-05
miscellaneous repair shop	0.242	1.60E-03
services to dwelling and other buildings	0.008	5.27E-05
personal supply services	0.138	9.14E-04
computer and data processing services	0.032	2.11E-04
management and consulting services	0.091	5.98E-04
detective and protective services	0.011	7.03E-05
miscellaneous equipment rental and leasing	0.261	1.72E-03
other business services	1.239	8.18E-03
advertising	0.123	8.09E-04
legal services	0.192	1.27E-03
engineering, architectural and surveying services	0.269	1.78E-03
accounting, auditing and bookeeping,…	0.040	2.64E-04
eating and drinking places	0.141	9.32E-04
automotive rentals and leasing, without driver	0.325	2.15E-03
automotive repair shops and services	0.051	3.34E-04
theatrical producers, band, etc…	0.008	5.27E-05
physical fitness facilities and member fees….	0.003	1.76E-05
colleges, universities and professional schools	0.003	1.76E-05
business associations and professional membership	0.008	5.27E-05
U.S. postal service	0.024	1.58E-04
other state and local governement enterprise	0.013	8.79E-05