Week Six

EPA143A

INPUT-OUTPUT ECONOMICS

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ANSWERS

EXERCISE W-6.1

1. The A-matrix is:

$$\begin{matrix} 0.09091 & 0.00000 & 0.11667 & 0.08333 \\ 0.00909 & 0.02500 & 0.20000 & 0.02333 \\ 0.45455 & 0.35000 & 0.26667 & 0.14000 \\ 0.22727 & 0.12500 & 0.11667 & 0.18667 \end{matrix}$$

Coefficient $a_{32} = 0.35$. The coefficient indicates that mining requires €0.35 billion of inputs from manufacturing to produce €1 billion of gross output of mining goods.

2. $\mathbf{L} = [\mathbf{I} - \mathbf{A}]^{-1}$ is:

$$\begin{matrix} 1.27817 & 0.11785 & 0.26409 & 0.17980 \\ 0.23091 & 1.17670 & 0.37711 & 0.12233 \\ 1.00494 & 0.69449 & 1.78125 & 0.42950 \\ 0.53680 & 0.31340 & 0.38726 & 1.36016 \end{matrix}$$

3. $l_{11} = 1.27817$. This means that agricultural gross output will (directly + indirectly) increase by €1.28 billion in response to an increase in final demand for agricultural goods of €1 billion. Coefficient $l_{24} = 0.12233$. This means that gross output of mining will (directly + indirectly) increase by €0.12 billion in response to an increase in final demand for services of €1 billion.

4. The backward production linkages are calculated as the column sums of the Leontief inverse. This gives:

   3.05083 2.30243 2.80972 2.09179

   Agriculture has a backward production linkage of 3.05; mining of 2.30; manufacturing of 2.81; and services of 2.09. Agriculture has the strongest backward production linkages, mostly because it is heavily dependent on intermediate inputs produced by manufacturing (fertilizers; gasoline; plastics). In the Leontief-inverse, coefficient $l_{31} = 1.00494$. This means that gross output of <u>manufacturing</u> will (directly + indirectly) increase by €1.0 billion in response to an increase in final demand for <u>agriculture</u> of €1 billion.

5. $\mathbf{E} = \boldsymbol{\ell} \times [\mathbf{I} - \mathbf{A}]^{-1}$ gives: 0.662 0.398 0.634 0.926

   In response to an increase in final demand for agricultural goods of €1 billion, gross output in agriculture will increase by €3.06 billion; this will generate 0.662 million new jobs.

6. The indirect employment creation in response to an increase in final demand of €1 billion is highest for agriculture. An increase in final demand of €1 billion for agriculture generates 0.1 million jobs directly (in agriculture itself), but 0.562 million jobs indirectly (*i.e.* in all industries including agriculture). The main reason is the very strong backward production linkage of agriculture with manufacturing ($l_{31} = 1.00494$).

	Agriculture	Mining	Manufacturing	Services
total job creation	0.662	0.398	0.634	0.926
direct job creation	0.100	0.050	0.200	0.600
indirect job creation	0.562	0.348	0.434	0.326

EXERCISE W-6.2

1. $\mathbf{L} = [\mathbf{I} - \mathbf{A}]^{-1}$ is:

1.78584	0.17650	0.48141	0.29918	0.30561
0.97328	2.45289	0.86247	0.83350	0.38931
0.29200	0.30428	1.52957	0.39233	0.41817
0.26170	0.20246	0.25183	1.21973	0.24186
0.27246	0.15857	0.23640	0.30341	1.36165

The backward production linkages are the columns sums of the Leontief inverse. Hence, we have: 3.58529 3.29469 3.36168 3.04815 2.71660

For example, the backward production linkage of heavy industry (sector 2) is 3.29469. This means that an increase in final demand for (capital) goods produced by heavy industry of €1 billion will generate €3.29 billion extra gross output in the economy as a whole. It can be seen from column 2 of the Leontief inverse that heavy industry is having the strongest backward linkage with itself – for instance: shipbuilding (which is part of 'heavy industry') requires steel from the steel industry (which is also part of 'heavy industry').

2. Using $\mathbf{F} = \mathbf{f} \times [\mathbf{I} - \mathbf{A}]^{-1}$ we obtain:

	agriculture	heavy industry	consumer goods industry	WRT	other services
total GHG emissions	1.89	2.25	1.64	1.37	0.84
direct GHG emissions	0.50	0.80	0.40	0.30	0.10
indirect GHG emissions	1.39	1.45	1.24	1.07	0.74

For agriculture, the direct emission intensity f_1 = 0.50, which means that agriculture is emitting 0.5 million tonnes of CO_{2eq} per €1 billion of final demand. The total emission intensity F_1 = 1.89, which means that the economy as a whole is emitting 1.89 million tonnes of CO_{2eq} per €1 billion of final demand for agricultural goods.

EXERCISE W-6.3

1. The Leontief inverse $\mathbf{L} = [\mathbf{I} - \mathbf{A}]^{-1}$:

1.1636	0.0146	0.0803	0.0121	0.0218	0.0080	0.0056	0.0032	0.0074	0.0137
0.0188	1.0635	0.0511	0.1011	0.0242	0.0078	0.0055	0.0041	0.0062	0.0072
0.3738	0.2543	1.4605	0.1926	0.3664	0.1273	0.0770	0.0478	0.0908	0.1090
0.0548	0.0989	0.0744	1.3160	0.0416	0.0406	0.0305	0.0270	0.0355	0.0371
0.0129	0.0223	0.0131	0.0283	1.0904	0.0141	0.0184	0.0224	0.0160	0.0088
0.2892	0.2297	0.2894	0.1642	0.2078	1.2408	0.0809	0.0468	0.0916	0.0911
0.1452	0.2125	0.2129	0.2346	0.2468	0.2343	1.2828	0.1540	0.3065	0.1242
0.0985	0.1076	0.1033	0.1141	0.1052	0.1373	0.1145	1.2432	0.1080	0.0677
0.0066	0.0077	0.0095	0.0243	0.0082	0.0072	0.0066	0.0050	1.0080	0.0048
0.0281	0.0369	0.0450	0.0510	0.0408	0.0542	0.0522	0.0465	0.0610	1.0662

The vector of backward production linkages is:

2.1915	2.0483	2.3395	2.2383	2.1530	1.8717	1.6740	1.5999	1.7311	1.5297

French manufacturing has the strongest (highest) backward production linkages. Its backward production linkage 2.3395. This means that an increase in final demand for goods produced by manufacturing of €1 billion will generate €2.34 billion extra gross output in the economy as a whole.

2. The vector of (direct) value-added intensities is:

Agric.	Mining	Manufact.	EGW	Constr.	WRT	Info	FIRE	Govt	OthServ
0.4321	0.4734	0.3556	0.3885	0.4309	0.5235	0.6160	0.6467	0.5859	0.7156

3. The vector of value-added multipliers for French industries in 2015 is:

Agric.	Mining	Manufact.	EGW	Constr.	WRT	Info	FIRE	Govt	OthServ
2.314	2.113	2.812	2.574	2.321	1.910	1.623	1.546	1.707	1.398
For Germany									
2.772	1.945	2.534	2.344	2.124	1.876	1.567	1.585	1.613	1.425

The value-added multipliers by industry are quite similar for France and Germany. Germany's agriculture and manufacturing have higher value-added multipliers than French agriculture and manufacturing.

4. The vector of total employment effects for French industries in 2015 is:

Agric.	Mining	Manufact.	EGW	Constr.	WRT	Info	FIRE	Govt	OthServ
15.58	9.44	10.89	7.82	12.86	13.16	8.37	4.91	7.44	18.74
For Germany									
19.80	12.87	11.78	9.49	16.20	15.37	6.54	5.71	7.62	22.91

The employment multipliers in German industries are considerably higher than those in French industries. The difference is large in, for example, construction. In Germany, the total job multiplier for construction is 16.2 jobs per €1 million of final demand, whereas in France it is 12.86 jobs per €1 million of final demand. Differences in total job multipliers are large in agriculture (15.58 jobs per €1 million of final demand in France versus 19.8 jobs per €1 million of final demand in Germany) and in other services (18.74 jobs per €1 million of final demand in France versus 22.91 jobs per €1 million of final demand in Germany). Direct and indirect labour intensity of gross output is lower in French than in German industries.

5. The vector of total GHG intensities for French industries in 2015 is:

Agric.	Mining	Manufact.	EGW	Constr.	WRT	Info	FIRE	Govt	OthServ
1341.8	381.6	342.5	565.3	152.1	159.4	51.8	31.9	52.3	90.8
For Germany									
1881.3	874.4	353.3	2428.6	202.5	261.4	92.3	84.1	100.2	121.5

It can be seen that the total GHG intensities are lower in all French industries relative to German industries. The difference is most pronounced in the case of 'Electricity, gas & water supply' (EGW): in France, the total (direct + indirect) carbon emissions associated with an increase in final demand for / gross output of EGW by €1 million are 565.3 tonnes of CO_{2eq} compared to 2429 tonnes of CO_{2eq} in Germany. The cause of this difference is that more than 70% of French electricity is generated by nuclear power plants, which have very low carbon emissions per MWh. The low GHG intensity of electricity in France helps to keep GHG emission intensities relatively low in all industries (because these industries have backward production linkages with EGW). There exists a clear structural difference in (direct and total) GHG emission intensities between (nuclear) France and Germany.

6. The reclassified, production-chain based GHG quantities by industry for France in 2015 is derived using $\mathbf{P} = \hat{\mathbf{F}} \times \mathbf{y}$.

GHG emissions (million tonnes of CO_{2eq}): France (2015)

	recorded at geographical location	reclassified according to responsible (using) industry	difference
Total	330.7	330.7	
Agriculture	90.7	46.4	-44.3
Mining	1.1	-11.5	-12.7
Manufacturing	91.2	104.4	13.3
EGW	49.6	15.3	-34.3
Construction	9.0	31.4	22.4
WRT	55.3	41.6	-13.6
Inform. & oth.bus. services	10.5	21.4	10.9
FIRE	1.4	7.5	6.1
Public administration	2.7	36.7	34.0
Other services	19.1	37.4	18.3

Which industries have high indirect GHG emissions (embodied in intermediate input use)? Manufacturing (+ 13.3 million tonnes of CO_{2eq}), construction (+22 million tonnes of CO_{2eq}), information & other business services (+11 million tonnes of CO_{2eq}), public administration (+34 million tonnes of CO_{2eq}) and other services 9+18 million tonnes of CO_{2eq}). These industries use carbon-intensive intermediate inputs produced by other industries.