1. (22 points) National accounts and IO tables

1.1 (14 points)

Table 2 SUTs based on product technology assumption (unit, million euros).

	USE TABLE				SUPPLY TABLE		
	AGR	MANF	FD	Total	AGR	MANF	Total
AGR products	0-8	80+8	50	**130**	130	0	**130**
MANF products	60-3	30+3	130	**220**	20-20	200+20	**220**
VA	90-9	90+9		**180**			
Total	**150-20**	**200+20**			**150-20**	**200+20**	

	USE TABLE				SUPPLY TABLE		
	AGR	MANF	FD	Total	AGR	MANF	Total
AGR products	-8	88	50	**130**	130	0	**130**
MANF products	57	33	130	**220**	0	220	**220**
VA	81	99		**180**			
Total	**130**	**220**			**130**	**220**	

Key explanations:

1) First, in the supply table, locate the secondary products that we need to treat in the SUT→IOT transformation (i.e., the 20 million euros of MANF products supplied by the AGR industry), and then move it to the main producer (i.e., MANF); adjust the rest of the supply table accordingly.

2) In the use table, reallocate the corresponding inputs from the 'AGR' industry to the 'MANF' industry according to MANF's production recipe. This is because MANF is the main producer of MANF products; adjust the rest of the table.

1.2 (2 points) Based on the tables, calculate the region's GDP (million euros): _180_.

1.3 (6 points) Knowing hybrid IOTs or SUTs use several units, e.g. kg, kWh or euro, to report transactions within economic systems. Differently, monetary IOTs just use a monetary unit, e.g. euro. What is the advantage of using several units? Please explain by indicating two examples where the hybrid IOTs or SUTs take into account flows that may be easily overlooked by the monetary IOTs.

- Undocumented wastes
- Unpriced products or wastes (e.g. packaging)
- …

2. (30 points) Supply chains and chained reactions generated by changes in final demand. Use the IOTs provided in 'Dataset'.

2.1 (14 points) Calculate the total backward linkage and direct forward linkage strengths for the 4 sector-region pairs (**12 points**). Based on the results, why sector-region pair displays the strongest interindustry linkage (**2 points**).

	Region A		Region B	
	S1	**S2**	**S1**	**S2**
i. Total backward linkage	0.9	0.9	1.0	1.2
ii. Direct forward linkage	0.9	1.0	1.0	1.0

Sector-region pair with the strongest interindustry linkage: S2-Region B

Key explanations:

1) Total backward linkages are derived from the column sums of $\boldsymbol{L}$; normalize the results so that we can better assess the strengths of the linkages
2) Direct forward linkages are derived from the row sums of $\boldsymbol{B}$; similarly, normalize for assessing the strengths. Note, $\boldsymbol{B}$ is obtained from $\boldsymbol{Z}$ and $\boldsymbol{x}$; $\mathbf{Z}=\boldsymbol{A}\bullet\text{diag}(\boldsymbol{x})$.

2.2 (**8 points**) A major economic recession this year is reflected in decreased final demands. Investments in domestic capital goods made by **S2** are expected to *decrease* by €100 in both **Region A** and **Region B**. Assuming that there is no change in the technological structure of the economy, what would be the total production of all sectors required to supply this year's final demand? Please round the results to the nearest whole number (zero decimal place).

i. (**4 points**) Find an approximate answer by using the first four terms in the power series ($I + A + A^2 + A^3 + \cdots + A^n$), i.e. one direct and three indirect production layers.

ii. (**4 points**) Find the exact answer using the Leontief inverse.

	Region A		Region B	
	S1	**S2**	**S1**	**S2**
iii. Approximation	883	3333	1699	3293
iv. Exact answer	977	3797	1945	3781

Key explanations:

1) First, create $\boldsymbol{y}_{global}$=[500;1600;800;1600], because the answers we are looking for do not concern the association of final demand; $\boldsymbol{y}_{global}$* =[500;1600-100; 500; 1500-100];
2) Then use power series expansion $\boldsymbol{y}_{global}* + \boldsymbol{A}\boldsymbol{y}_{global}* + \boldsymbol{A}^2\boldsymbol{y}_{global}* + \boldsymbol{A}^3\boldsymbol{y}_{global}*$ to obtain the approximated answer;
3) Use $\boldsymbol{L}\boldsymbol{y}_{global}*$ to obtain the exact answer.

2.3 (**8 points**) If labor costs in **Region B** increase, causing a 10 euro cents increase in value added inputs required per unit **S1** and **S2** products in the region, what are the resulting changes in relative prices of products made in **Region A**?

S1, Region A: 2%; S2, Region B: 4%.

Key explanations:

1) Create $\Delta v'$**=[0;0;0.1;0.1];** note: all monetary data in Dataset have the unit of 'euro';
2) $\Delta p = L' \Delta v'$**;** note Δp indicates relative changes, thus 0.016→2%; 0.036→4%.

3. (22 points) Footprint accounting. Use the IOTs provided in 'Dataset'.

The World Bank initiates a regional development plan. Two projects are being considered that would instigate capital investments in the regions (unit: euros/year):

		Project Expenditure	
		Project 1	***Project 2***
Region A	***S1***	*10*	*0*
	S2	*10*	*20*
Region B	***S1***	*10*	*0*
	S2	*10*	*20*

3.1 (**16 points**) Assess the projects' contributions to pollution emissions and employment in the two regions, respectively. Round the results to 1 decimal place.

		Project 1	***Project 2***
Pollution emissions (kg)	***In Region A***	176.7	207.1
	In Region B	182.4	240.5
Employment (people)	***In Region A***	0.9	0.9
	In Region B	0.9	0.8

Key explanations:

1) ***y1***=[10;10;10;10], and ***y2***=[0;20;0;20];
2) Use diag(***f***)***Ly*** to obtain the sectoral and region details on the production side;
3) Obtain the pollution and employment changes by region (by adding up the sectoral results). Pay attention to the units for pollution and employment specified in the Dataset.

3.2 (**6 points**) Which project would you recommend to the head of the World Bank? Why?

Global effects

	Project 1	*Project 2*
Pollution emissions (kg)	359.1	447.6
Employment (people)	1.8	1.7

Key points:

- Project 1 results in lower emissions and generates more jobs than Project 2 globally.
- Equality (or distribution): Project 2 adds 16% more emissions in Region B than in Region A; in comparison, Project 1's impacts are relatively equally spread between the two regions.
- *+ Other reasonable justifications*

4. (20 points) Emissions embodied in trade. Use the IOTs provided in 'Dataset'.

4.1 (**12 points**) Calculate the percentage (%) of total pollution emissions that are embodied in international trade, distinguishing the product categories of final demand and the locations where the impacts occurred directly.

Note:

- as an example, 'Final demand of Region A, Products S1' include Products S1 that were lastly made in both Region A and Region B
- Don't fill in the shaded cells in the table below – they are not part of emissions embodied in inter-regional trade.

	Final demand of Region A		**Final demand of Region B**	
	Products S1	**Products S2**	**Products S1**	**Products S2**
Impacts in Region A			4.6%	5.9%
Impacts in Region B	0.8%	14.9%		

Key explanations:

We need the sectoral details in both dimensions: final demand 'products' and producing 'industries', thus we need to diagonalize both ***f*** and ***y***.

1) Use diag(***f***)***L***diag(***y***) to calculate the impacts driven by each region's final demand, respectively.
2) Note, the question asks about emissions embodied in international trade. Hence we focus on half of the calculated results above (i.e., the last two rows for Region A and the first two rows for Region B).
3) Make sure to combine the calculated results as long as they relate to the same finished products (e.g., we typically talk about the carbon footprint of beef, rather than the carbon footprint of beef from Brazil).
4) Calculate total pollution emissions using ***f*** and ***x*** (45000 kg) to get the percentages.

4.2 (**8 points**) The government in **Region A** is interested in starting an overseas advertising and promotion campaign in an attempt to increase export sales. From the perspective of local and global pollution mitigation, respectively, which sector shall the government target to increase its export sales, why?

- Emissions multiplier related to Products S1 and S2 lastly made in Region A:

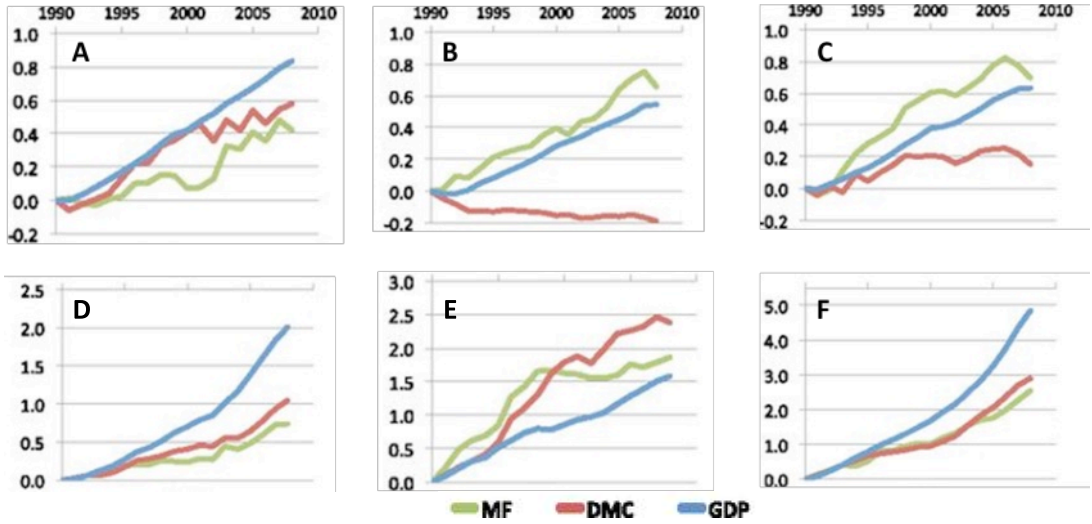
	Products S1	Products S2
Impacts in Region A	1.19	0.18
	3.54	7.96
Impacts in Region B	0.06	0.14
	0.64	1.45

- Domestic perspective: 1€ FD in S1 of region A = 1.19+3.54 = 4.7 kg, 1€ FD in S2 of region A = 0.18+7.96=8.1 kg, thus target S1

- Global perspective: 1€ FD in S1 of region A = 1.19+3.54+0.06+0.64=5.4 kg, 1€ FD in S2 of region A = 0.18+7.96+0.14+1.45=9.7 kg, thus target S1.

5 (6 points) EEIOA Semantic literature

(6 points) For six countries (A-F), the figure below shows relative changes in total resource use, measured by material footprint (MF) and domestic material consumption (DMC), respectively, and relative changes in GDP between 1990 and 2008. What is the main difference between MF and DMC? Evaluate the trends of resource productivity for each region: which one(s) have been improving resource productivities and which ones have resource productivities stagnating or declining?



- MF vs. DMC: MF enables a more comprehensive resource productivity measurement, accounting for less-visible displacements, i.e., indirect import aside from direct import
- Improving resource productivity: A, D, F
- Declining or stagnating resource productivity: B, C, E