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Sectoral demand-driven and supply-driven input-output multipliers in Cyprus

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Abstract

This paper aims to analyse the inter-industry linkages and interdependencies in the economy of Cyprus. Demand-driven and supply-driven sectoral multipliers are estimated to assess the economy-wide effects of sectors' expansion or contraction. The demand-side multiplier analysis indicates that construction and shipping create the highest backward linkages in the Cypriot economy in terms of output generation. Real estate creates the largest direct and indirect effects in the economy in terms of value-added generation, while wholesale and retail trade create the highest economy-wide impacts in terms of employment generation. The supply-side multiplier analysis confirms the significant backward linkages of shipping in the Cypriot economy. The demand-side multiplier analysis can provide guidance to decision makers regarding the economy-wide impacts of investing in certain production sectors, while the supply-driven multiplier analysis can provide insights on how negative sectoral shocks propagate in the economy through supply chains.

Keywords: inter-industry linkages, mixed input-output model, construction, shipping, Cyprus

1. Introduction

The Cypriot economy has experienced great volatility and uncertainty during the last decade. The severe impacts of the recent 2013 financial crisis and the current COVID-19 pandemic outbreak were not homogeneous across the economic sectors, highlighting the capacity of some industries to better withstand and recover from the recessionary impact. In the 2013 financial crisis, the banking and financial sector and the construction industry bore the brunt of GDP and job losses, while sectors such as the food manufacturing industry were more resilient to economic downturn (Giannakis and Mamuneas, 2018). The outbreak of the coronavirus pandemic caused an unprecedented shock to tourism industry. The economy's dependence on tourism made it especially vulnerable to the pandemic crisis, which is currently struggling to return to pre-crisis economic growth paths.

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The European Commission coordinated a common European response to the coronavirus outbreak, that is, a European-wide COVID-19 Recovery and Resilience Facility, to mitigate the socioeconomic impact of the pandemic and support the recovery. Cyprus is expected to draw significant funds from the Recovery and Resilience Plan totalling around 1.2 billion euro over the period 2021-2026 to support the implementation of critical investment and reform measures and enhance the growth potential of the country (Republic of Cyprus, 2021). An important challenge in this effort is the identification of the priority domains (Trippl et al., 2020). The Smart Specialization Strategy, i.e., the place-based territorial policy currently adopted by the European Union (EU), emphasizes the need for greater investments in production activities that maximise the impact on the wider economy (Barca, 2009). The compelling need for targeted programs to enhance the competitiveness and the growth potential of the economy is clearly perceived.

The sectoral composition of the economy including the mix of industries and their interrelationships is important for better understanding the economic performance in growth and recession times (Boschma, 2015). The magnitude of sectoral multiplier effects is a key criterion in understanding sectors' potential to invigorate economic growth. The aim of this paper is to analyse the inter-industry linkages and interdependencies in the economy of Cyprus. To do so, we estimate demand-driven and supply-driven input-output multipliers to explore the channels through which sectoral output growth or contraction propagates in the economy through supply chain linkages. The demand-driven multiplier analysis indicates that construction and shipping create the highest backward linkages in the Cypriot economy in terms of output generation. Real estate creates the largest direct and indirect effects in the economy in terms of value-added generation, while wholesale and retail trade create the highest economy-wide impacts in terms of employment generation. The supply-side multiplier analysis confirms the significant backward linkages of shipping in the Cypriot economy.

The paper is organized as follows: Section 2 outlines the methodological framework of the study and the available data. Section 3 presents the results, while the paper ends with the conclusions drawn from the analysis.

2. Methodology and Data

Input-output (IO) analysis is a modelling technique for analysing the interdependence of the production sectors in an economy (Leontief, 1966). An IO model, which consists of a system of linear equations, records the financial flows among economic sectors. The rows of an IO table show the distribution of the output of a certain sector to all sectors of the economy, while the columns show the purchases of intermediate inputs, labour and other, made by each sector.

Input-output modelling has been widely applied for policy impact analysis, technological change and forecasting (Rose, 1984; Giannakis and Bruggeman, 2017). IO models, although their well-known limitations, such as fixed prices, constant return to scale, no supply constraints (Miller and Blair, 2009), have been used to analyse how the effects of exogenous economic shocks or fiscal stimulus propagate in the economic system through the linkages and interdependences between the production sectors (Acemoglu et al., 2016; Taliotis et al., 2020).

A key output from the IO modelling framework is the estimation of multipliers that allow for the disaggregation of the effect of exogenous changes in the economic system. Standard demand-side IO models estimate the economy-wide effects of changes in the final demand elements

(consumption, investment, exports) that are exogenously determined, i.e., outside of the model (e.g., changes in consumer preferences, government purchases). In certain circumstances in which the gross outputs of some sectors are exogenously specified, e.g., due to a policy, natural disaster or a strike of a major supplier, the use of demand-driven multipliers can induce bias and inflate the results (Johnson and Kulshreshtha, 1982; Papadas and Dahl, 1999); thus, a mixed type of IO model is appropriate to capture the economy-wide effects of such changes (Miller and Blair, 2009). The methodology of the demand-driven and supply-driven multiplier analysis is briefly reviewed in the Appendix I and Appendix II, respectively.

The structure of the Cypriot economy is assessed on the basis of the latest available national symmetric IO table for the year 2017 (Eurostat, 2021). The scheme of the IO table consists of 65 sectors of economic activity (Table 1).

3. Results

The IO multiplier analysis identified the most important sectors of economic activity with regards to their capacity to enhance output, value added and employment generation. Table 1 reports the results of the demand-driven multiplier analysis. The highest output multipliers, which indicate the significance of the backward linkages of each sector, are observed for construction (2.33), water treatment and supply services (2.31) and shipping (2.21). The meaning of the output multiplier of the construction sector is that an increase in the final demand for the products and services of the sector by 1-million-euro induces an increase in the total output of 2.33 million euro. Finance (1.75), accommodation and food services (1.74) and wholesale and retail trade (1.72) sectors also create strong backward linkages within Cypriot economy. On the contrary, sectors such as coke and refined petroleum products, motor vehicles, transport equipment and computer and electronic products exhibit low output multipliers.

The value-added multipliers indicate the direct and indirect increase in the value added of economy generated by a 1-million-euro increase in the final demand of the products and services of the individual sectors. Forestry (0.85), education (0.82), real estate (0.80) and public administration (0.80) exhibit the highest direct value-added multipliers in Cyprus, while water treatment and supply services (0.41), shipping (0.40) and construction (0.39) create the highest indirect effects on the value added of the Cypriot economy (Table 1). Real estate (0.94), education (0.93) and public administration (0.92), due to their high direct value-added multipliers, create the largest (direct and indirect) effects on the national economy.

The most labour intensive sectors, i.e., those with high direct employment multipliers, are security and investigation services (35.7), residential services (31.9) and retail trade services (25.2). As such, for every 1-million-euro increase in the final demand for the products and services of the security and investigation services sector, 35.7 jobs are created within the sector but only 5.3 jobs in the rest economic sectors, i.e., in total 41 new jobs are created in the economy. Construction (11.3), food industry (7) and shipping (7) create the highest indirect effects on national employment. For every 1-million-euro increase in the final demand for the products and services of the construction sector, 21.8 jobs are created in the economy of which 10.5 are directly created within the sector and 11.3 are indirectly generated in the interrelated sectors. It is worth mentioning that the employment multiplier effects of shipping are solely indirect. Coke and refined petroleum products, transport equipment and computer and electronic products, similar to output generation, create low employment multiplier effects.

Table 2 depicts the results of the supply-driven multiplier analysis. The results of the mixed IO model reveal that shipping has the highest supply driven multiplier (1.18), that is, a contraction (growth) in the output of the sector by 1-million-euro will decrease (increase) the output of the remaining sectors by 1.18 million euro. The highest effects are observed for the warehousing services for transportation (0.519), the legal and accounting services (0.248) and the financial services (0.153). The accommodation and food services (0.725) and the wholesale and retail trade (0.675) sectors have also high supply-driven multipliers.

TABLE 1

Demand-driven gross output, value added and employment multipliers for Cypriot sectors of economic activity (2017)

	Gross Output	Employment		Value Added	
		Direct effects	Indirect effects	Direct effects	Indirect effects
CPA_A01 - Products of agriculture, hunting and related services	1.66	16.2	5.8	0.36	0.19
CPA_A02 - Products of forestry, logging and related services	1.15	14.2	1.4	0.85	0.05
CPA_A03 - Fish and other fishing products; aquaculture products; support services to fishing	1.54	8.2	4.3	0.54	0.16
CPA_B - Mining and quarrying	1.46	2.7	4.2	0.07	0.17
CPA_C10-12 - Food, beverages and tobacco products	1.69	5.8	7.0	0.14	0.22
CPA_C13-15 - Textiles, wearing apparel, leather and related products	1.06	2.0	0.5	0.03	0.02
CPA_C16 - Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials	1.65	13.4	6.7	0.25	0.20
CPA_C17 - Paper and paper products	1.29	3.7	1.8	0.10	0.07
CPA_C18 - Printing and recording services	1.79	14.9	5.1	0.39	0.22
CPA_C19 - Coke and refined petroleum products	1.00	0.0	0.0	0.00	0.00
CPA_C20 - Chemicals and chemical products	1.10	1.3	0.7	0.05	0.03
CPA_C21 - Basic pharmaceutical products and pharmaceutical preparations	1.27	3.0	1.6	0.21	0.07
CPA_C22 - Rubber and plastic products	1.27	3.3	1.7	0.09	0.07
CPA_C23 - Other non-metallic mineral products	1.71	4.5	4.5	0.24	0.20
CPA_C24 - Basic metals	1.22	1.5	1.4	0.08	0.06
CPA_C25 - Fabricated metal products, except machinery and equipment	1.63	7.9	4.0	0.26	0.17
CPA_C26 - Computer, electronic and optical products	1.04	0.1	0.2	0.03	0.01
CPA_C27 - Electrical equipment	1.12	1.7	0.8	0.05	0.03
CPA_C28 - Machinery and equipment n.e.c.	1.13	1.8	0.8	0.07	0.04
CPA_C29 - Motor vehicles, trailers and semi-trailers	1.01	0.3	0.1	0.01	0.00
CPA_C30 - Other transport equipment	1.01	0.0	0.1	0.01	0.00
CPA_C31_32 - Furniture and other manufactured goods	1.21	5.2	1.5	0.12	0.07
CPA_C33 - Repair and installation services of machinery and equipment	1.63	12.7	4.3	0.51	0.18
CPA_D - Electricity, gas, steam and air conditioning	1.68	3.3	3.9	0.33	0.16
CPA_E36 - Natural water; water treatment and supply services	2.31	1.8	6.9	0.32	0.41
CPA_E37-39 - Sewerage services; sewage sludge; waste collection, treatment and disposal services; materials recovery services; remediation services and other waste management services	1.71	9.0	6.0	0.55	0.30
CPA_F - Constructions and construction works	2.33	10.5	11.3	0.30	0.39
CPA_G45 - Wholesale and retail trade and repair services of motor vehicles and motorcycles	1.72	23.5	4.7	0.46	0.21
CPA_G46 - Wholesale trade services, except of motor vehicles and motorcycles	1.53	17.0	3.9	0.64	0.19

CPA_G47 - Retail trade services, except of motor vehicles and motorcycles	1.60	25.2	3.5	0.61	0.25
CPA_H49 - Land transport services and transport services via pipelines	1.59	12.2	4.5	0.46	0.17
CPA_H50 - Water transport services	2.21	0.1	7.0	0.29	0.40
CPA_H51 - Air transport services	1.21	0.8	1.4	-0.05	0.05
CPA_H52 - Warehousing and support services for transportation	2.07	2.6	4.8	0.16	0.25
CPA_H53 - Postal and courier services	1.62	18.3	5.2	0.50	0.24
CPA_I - Accommodation and food services	1.74	18.4	5.8	0.49	0.26
CPA_J58 - Publishing services	2.08	1.4	4.4	0.22	0.27
CPA_J59_60 - Motion picture, video and television programme production services, sound recording and music publishing; programming and broadcasting services	1.50	10.0	3.5	0.38	0.18
CPA_J61 - Telecommunications services	1.66	4.5	3.5	0.44	0.26
CPA_J62_63 - Computer programming, consultancy and related services; Information services	1.77	1.7	2.2	0.17	0.17
CPA_K64 - Financial services, except insurance and pension funding	1.75	2.9	5.2	0.30	0.35
CPA_K65 - Insurance, reinsurance and pension funding services, except compulsory social security	1.78	3.9	5.4	0.23	0.25
CPA_K66 - Services auxiliary to financial services and insurance services	1.92	2.9	3.2	0.19	0.20
CPA_L68B - Real estate services excluding imputed rents	1.30	1.0	1.8	0.80	0.14
CPA_L68A - Imputed rents of owner-occupied dwellings	1.56	1.0	3.7	0.69	0.21
CPA_M69_70 - Legal and accounting services; services of head offices; management consultancy services	1.42	9.6	3.4	0.65	0.19
CPA_M71 - Architectural and engineering services; technical testing and analysis services	1.40	21.6	4.2	0.59	0.17
CPA_M72 - Scientific research and development services	1.16	0.8	1.4	0.57	0.06
CPA_M73 - Advertising and market research services	1.49	3.4	3.5	0.11	0.14
CPA_M74_75 - Other professional, scientific and technical services and veterinary services	1.97	14.4	6.5	0.33	0.30
CPA_N77 - Rental and leasing services	1.34	4.9	3.1	0.42	0.13
CPA_N78 - Employment services	1.56	19.8	5.7	0.62	0.22
CPA_N79 - Travel agency, tour operator and other reservation services and related services	1.52	18.5	4.2	0.66	0.21
CPA_N80-82 - Security and investigation services; services to buildings and landscape; office administrative, office support and other business support services	1.55	35.7	5.3	0.58	0.20
CPA_O - Public administration and defence services; compulsory social security services	1.24	19.2	2.4	0.80	0.12
CPA_P - Education services	1.27	24.0	2.5	0.82	0.11
CPA_Q86 - Human health services	1.53	15.5	4.3	0.63	0.18
CPA_Q87_88 - Residential care services; social work services without accommodation	1.57	31.9	6.2	0.62	0.21
CPA_R90-92 - Creative, arts, entertainment, library, archive, museum, other cultural services; gambling and betting services	1.37	8.6	2.5	0.50	0.13
CPA_R93 - Sporting services and amusement and recreation services	1.72	13.7	6.4	0.51	0.27
CPA_S94 - Services furnished by membership organisations	1.62	24.9	6.4	0.60	0.24
CPA_S95 - Repair services of computers and personal and household goods	1.45	6.4	2.7	0.39	0.15
CPA_S96 - Other personal services	1.38	25.4	2.7	0.73	0.16

TABLE 2

Supply-driven gross output multipliers for Cypriot sectors of economic activity (2017)

	Gross Output	Sectoral Output Shares
A01. Products of agriculture, hunting and related services	0.476	1.72%
A02. Products of forestry, logging and related services	0.146	0.05%
A03. Fish and other fishing products; aquaculture products; support services to fishing	0.510	0.12%
B. Mining and quarrying	0.459	0.35%
C10-12. Food, beverages and tobacco products	0.486	4.44%
C13-15. Textiles, wearing apparel, leather and related products	0.042	0.92%
C16. Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials	0.312	0.30%
C17. Paper and paper products	0.163	0.31%
C18. Printing and recording services	0.723	0.13%
C19. Coke and refined petroleum products	0.001	2.57%
C20. Chemicals and chemical products	0.083	0.87%
C21. Basic pharmaceutical products and pharmaceutical preparations	0.248	1.05%
C22. Rubber and plastic products	0.249	0.51%
C23. Other non-metallic mineral products	0.579	0.87%
C24. Basic metals	0.148	0.43%
C25. Fabricated metal products, except machinery and equipment	0.555	0.94%
C26. Computer, electronic and optical products	0.025	0.88%
C27. Electrical equipment	0.106	0.46%
C28. Machinery and equipment	0.124	0.61%
C29. Motor vehicles, trailers and semi-trailers	0.529	1.12%
C30. Other transport equipment	0.009	4.13%
C31-32. Furniture and other manufactured goods	0.197	0.68%
C33. Repair and installation services of machinery and equipment	0.609	0.36%
D. Electricity, gas, steam and air conditioning	0.673	1.25%
E36. Natural water; water treatment and supply services	0.654	0.42%
E37-39. Sewerage services; sewage sludge; waste collection, treatment and disposal services; materials recovery services; remediation services and other waste management services	0.360	0.51%
F. Constructions and construction works	0.534	5.59%
G45. Wholesale and retail trade and repair services of motor vehicles and motorcycles	0.675	0.72%
G46. Wholesale trade services, except of motor vehicles and motorcycles	0.509	2.34%
G47. Retail trade services, except of motor vehicles and motorcycles	0.591	2.95%
H49. Land transport services and transport services via pipelines	0.528	0.84%
H50. Water transport services	1.179	3.40%
H51. Air transport services	0.210	1.08%
H52. Warehousing and support services for transportation	0.174	6.77%
H53. Postal and courier services	0.574	0.17%
I. Accommodation and food services	0.725	5.00%
J58. Publishing services	0.941	1.84%

J59-60. Motion picture, video and television programme production services, sound recording and music publishing; programming and broadcasting services	0.356	0.35%
J61. Telecommunications services	0.239	1.55%
J62-63. Computer programming, consultancy and related services; Information services	0.132	5.20%
K64. Financial services, except insurance and pension funding	0.393	8.77%
K65. Insurance, reinsurance and pension funding services, except compulsory social security	0.536	1.04%
K66. Services auxiliary to financial services and insurance services	0.124	3.90%
L68A. Imputed rents of owner-occupied dwellings	0.561	2.12%
L68B. Real estate services excluding imputed rents	0.184	2.56%
M69-70. Legal and accounting services; services of head offices; management consultancy services	0.256	3.83%
M71. Architectural and engineering services; technical testing and analysis services	0.293	0.33%
M72. Scientific research and development services	0.161	0.51%
M73. Advertising and market research services	0.310	1.07%
M74-75. Other professional, scientific and technical services and veterinary services	0.944	0.36%
N77. Rental and leasing services	0.315	0.58%
N78. Employment services	0.391	0.16%
N79. Travel agency, tour operator and other reservation services and related services	0.512	0.20%
N80-82. Security and investigation services; services to buildings and landscape; office administrative, office support and other business support services	0.484	0.39%
O. Public administration and defence services; compulsory social security services	0.161	3.38%
P. Education services	0.266	2.35%
Q86. Human health services	0.524	1.90%
Q87-88. Residential care services; social work services without accommodation	0.495	0.23%
R90-92. Creative, arts, entertainment, library, archive, museum, other cultural services; gambling and betting services	0.362	0.69%
R93. Sporting services and amusement and recreation services	0.644	0.51%
S94. Services furnished by membership organisations	0.608	0.24%
S95. Repair services of computers and personal and household goods	0.452	0.22%
S96. Other personal services	0.362	0.53%

4. Conclusions

Our study provides a macroeconomic snapshot of the Cyprus economy using the IO modelling framework. Demand-driven and supply-driven IO multipliers are estimated to assess the economy-wide effects of changes in the demand and supply of individual sectors. The estimated demand-driven multipliers indicate that construction and shipping create the highest backward linkages in the Cypriot economy in terms of output generation. With regards to the value-added generation, real estate creates the largest total (direct and indirect) effects in economy, while construction and shipping create the largest indirect effects. Wholesale and retail trade, education and accommodation and food services sectors create the highest economy-wide impacts in terms of employment generation. The largest indirect employment multiplier effects are reported for construction, food industry and shipping. Finally, the estimated supply-side multipliers highlight the strong effect of shipping on the output of the economy.

The demand-side multiplier analysis can provide guidance to decision makers regarding the economy-wide effects of investing in certain production sectors. Investments in new technologies and innovations are necessary for achieving high growth rates in the long run. The size of sectoral multiplier effects is a key criterion in judging the ability of a sector to invigorate economic growth. On the other hand, the supply-driven multiplier analysis can provide insights on how negative sectoral shocks propagate in economy through supply chain linkages.

Appendix I

Demand-driven input-output multiplier analysis

The matrix of technical coefficients A $\left(A = \{a_{ij}\}, \forall\, i,j = 1, \dots, n\right)$ determines the needs of the n economic sectors for intermediate inputs. The technical coefficients (a_{ij}) relate the intermediate inputs of sector j from sectors i (x_{ij}) to the j's sector total inputs (x_j), that is, the sum of intermediate inputs and value added as follows:

$$a_{ij} = \frac{x_{ij}}{x_j} \tag{I1}$$

The traditional equations of the standard demand-side IO model in matrix notation can be formulated as follows:

$$X = AX + F \tag{I2}$$

$$(I - A)X = F \tag{I3}$$

$$X = (I - A)^{-1}F \tag{I4}$$

where X is a $n \times 1$ vector of sectors' output; F is a $n \times 1$ vector of exogenous final demand for each sector's products and services; $(I - A)^{-1}$ is the Leontief inverse matrix (L).

The L matrix, which comprises of the interdependency coefficients (z_{ij}), quantifies the round-by-round direct and indirect effects exerted by a change in final demand of sector i (ΔF_i) on the output of all sectors (ΔX).

The demand-driven output multiplier of sector j (O_j) equals to the column sums of the L matrix:

$$O_j = \sum_{i=1}^{n} z_{ij} \tag{I5}$$

The demand-driven value added multiplier of sector j $(DIVA_j)$ is estimated as follows:

$$DIVA_j = \sum_{i=1}^{n} z_{ij} * \frac{VA_j}{X_j} \tag{I6}$$

where $\frac{VA_j}{X_j}$ is the direct value added/output ratio.

The demand-driven employment multiplier of sector j (DIE_j) is estimated as follows:

$$DIE_j = \sum_{i=1}^{n} z_{ij} * \frac{E_j}{X_j} \tag{I7}$$

where $\frac{E_j}{X_j}$ is the direct employment/output ratio.

Appendix II

Supply-driven input-output multiplier analysis

In the demand-driven IO models (Appendix I), the changes in final demand (ΔF) are exogenously determined and their effects on output (ΔX) are endogenously estimated. As we mention in the Introduction Section, the output of certain sectors can also be exogenously specified, due to policies or exogenous shocks, and the effect on the output of the remaining sectors can be estimated endogenously.

Using the subscript 1 to denote the sectors whose outputs are exogenously specified and the subscript 2 for the remaining sectors, i.e., those sectors whose outputs are endogenously determined, the equation ($I3$) can be expressed as a system of two matrix equations as follows:

$$(1 - a_{11})X_1 - a_{12}X_2 = F_1$$
$$-a_{21}X_1 + (1 - a_{22})X_2 = F_2 \quad \text{(II1)}$$

Rearranging eq. ($II1$) so that to have the endogenous variables (X_2, F_1) on the left-hand side and the exogenously determined variables (X_1, F_2) on the right, we have:

$$\begin{bmatrix} -a_{12} & -1 \\ (1 - a_{22}) & 0 \end{bmatrix} \begin{bmatrix} X_2 \\ F_1 \end{bmatrix} = \begin{bmatrix} -(1 - a_{11}) & 0 \\ a_{21} & 1 \end{bmatrix} \begin{bmatrix} X_1 \\ F_2 \end{bmatrix} \quad \text{(II2)}$$

Denoting $M = \begin{bmatrix} -a_{12} & -1 \\ (1 - a_{22}) & 0 \end{bmatrix}$ and $N = \begin{bmatrix} -(1 - a_{11}) & 0 \\ a_{21} & 1 \end{bmatrix}$, eq. (II2) can become:

$$\begin{bmatrix} X_2 \\ F_1 \end{bmatrix} = M^{-1}N \begin{bmatrix} X_1 \\ F_2 \end{bmatrix} \quad \text{(II3)}$$

Considering that our analysis focus on the impact of exogenous changes of the output of a certain sector on the output of the remaining sectors of the economy, we can assume zero changes in exogenously determined final demand ($\Delta F_2 = 0$) (Papadas and Dahl, 1999). The suggested multiplier matrix from equation ($II3$) denotes the changes in the endogenous outputs (X_2) derived from a unitary change in the exogenous output (X_1).

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