

**NEREUS**

Núcleo de Economia Regional e Urbana  
da Universidade de São Paulo  
The University of São Paulo  
Regional and Urban Economics Lab

**ESTIMATION OF NUTS2 INTERREGIONAL INPUT-OUTPUT  
SYSTEMS FOR GREECE, 2010 AND 2013**

Eduardo A. Haddad  
Natália Cotarelli  
Thiago C. Simonato  
Vinicius A. Vale  
Jaqueline C. Visentin

**TD Nereus 03-2018**  
São Paulo  
2018

# Estimation of NUTS2 Interregional Input-Output Systems for Greece, 2010 and 2013

E. Haddad, N. Cotarelli, T. C. Simonato, V. A. Vale and J. C. Visentin

**Abstract.** The aim of this paper is to describe in details the process of estimation of two interregional input-output systems for Greece, for the years 2010 and 2013. Further understanding of the changing structure of the Greek regional economies during the crisis, within an integrated interregional system, is one of the main goals of a broader project underway at the University of São Paulo Regional and Urban Economics Lab (NEREUS). With this paper, we make available not only the details of the methodological procedures adopted to generate the interregional systems, but also the database itself to be used by other researchers and practitioners.

## 1. Introduction

We have witnessed considerable advances in the estimation of regional and interregional extensions of input-output models since the pioneering incursions of Isard (1951) and Leontief et al. (1953). Despite those efforts, the scarcity of information associated with the high cost of obtaining interregional trade flows based on survey data remains as one of the main obstacles to the estimation of interregional input-output systems. This has made the so-called non-survey estimation methods of interregional systems gain popularity among academic researchers and practitioners (Round, 1983).

Round (1983) recalls that the use of the terms survey and non-survey methods suggests the existence of two exclusive and well-defined research techniques. However, interregional input-output systems are often constructed under hybrid approaches, combining various techniques according to the quantity and quality of primary data available. This paper describes the process of estimation of two interregional input-output systems for Greece, for the years 2010 and 2013, using the method known as Interregional Input-Output Adjustment System (IIOAS), based on Haddad *et al.* (2016a). Both systems are estimated under the very same methodological procedure and consider the 13 NUTS2 regions in Greece whose economies are disaggregated in 44 sectors.

The IIOAS is a hybrid method that combines data made available by official agencies, such as the Hellenic Statistical Authority (HSA) and EUROSTAT, with non-survey techniques for the

estimation of unavailable information. The main advantages of the IIOAS are its consistency with information from the National Accounts Statistics and the flexibility of its regionalization process, which can be applied to any country that: (i) publishes standard make and use tables; and (ii) provides a regional information system at the sectorial level. Such flexibility can be attested by recent applications for distinct interregional systems: interisland model for the Azores (Haddad et al., 2015), interregional models for Colombia (Haddad et al., 2016a), Egypt (Haddad et al., 2016b), Lebanon (Haddad, 2014), Morocco (Haddad et al., 2017a), and Brazil (Haddad et al., 2017b).

The estimated systems are expected to be able to capture the existing specificities in the productive structure of each Greek region and, in addition, contribute to the methodological debate on the estimation of interregional input-output systems under conditions of limited information (Hulu and Hewings, 1993; Riddington, Gibson and Anderson, 2006; Zhang, Shi and Zhao, 2015; Tobben and Kronenberg, 2015; Flegg et al., 2016).

The paper is organized as follows: section 2 describes in detail the methodological procedure used in the construction of the interregional systems for Greece based on the IIOAS method. Section 3 presents an illustrative analysis using different indicators from the estimated databases, revealing some of the main structural features of the economy of Greece. Final remarks follow.

## **2. Interregional Input-Output Matrix for Greece**

### **2.1. Initial Data Treatment**

The estimation of the Interregional Input-Output Matrix for Greece (IIOM-Greece) is based on the Interregional Input-Output Adjustment System (IIOAS) method. The IIOAS method was developed to estimate interregional input-output systems under conditions of limited information. In the case of Greece, we have used data from national and regional accounts provided by the Hellenic Statistical Authority (HSA) and EUROSTAT for the years 2010 and 2013. The data consist mainly of the Supply and Use Tables (SUT) at the national level, and regional data on gross fixed capital formation, disposable income, gross value-added by sectors, total nights spent by non-residents, and wages and salaries by sectors.

The first step in data treatment was to estimate a national input-output matrix for Greece from the SUT. We have adapted the methodology proposed by Guilhoto and Sesso Filho (2005, 2010) to transform the economic flows valued at market prices into flows valued at basic prices. The procedure consists mainly in following steps:

1. Allocation of margins and indirect taxes for all users (intermediate consumption, investment demand, household consumption, government consumption, and exports) which was estimated based on shares calculated from the sales structure of the Use Table. The underlying hypothesis is that margins coefficients and tax rates on products are the same for all users.
2. Allocation of imports for all users (except exports) which was also estimated based on shares calculated from the sales structure of the Use Table.
3. The values from (1) and (2) were then deducted from the Use Table, originally evaluated at market prices, to obtain a new Use Table at basic prices.
4. The structure of the Make Table was then used to transform the new Use Table from a commodity by sector into a sector by sector system of information. The auxiliary matrix generated by the structure of the Make Table is often called the market share matrix.
5. Finally, in the Greek case, the national structure of 64 sectors was aggregated into 44 sectors to match the auxiliary data available at the regional level.

The next step was to disaggregate the national data into the 13 regions of Greece. The details of such procedure are described in Sections 2.2 and 2.3.

## **2.2. Estimation of the Interregional Trade Matrices**

In order to estimate the interregional system, it has been necessary to estimate the trade matrices among the 13 regions of Greece. This procedure has been made by calculating three components: (i) the regional demand for domestic products; (ii) the regional demand for

imported products; and (iii) the total supply of each region to the domestic and foreign markets, by sector.

We have assumed that regional demands for domestic and import products follow the national pattern for all users. In other words, economic agents share the same technology and preferences. However, it is important to note that we have estimated different trade matrices for each sector, which has allowed us to have different regional sourcing for intermediate inputs and final products.

The regional demand for domestic products is calculated, for each user, using the information provided in the matrix of demand-generating coefficients (DOMGEN). These coefficients are defined as the ratio of each element of the national use matrix to its respective column total.

For intermediate consumption, the ratio is defined as follows:

$$cic_{ij}^{dom} = \frac{z_{ij}^{dom}}{x_j}, \forall i, j = 1, \dots, 44 \quad (1)$$

where  $cic_{ij}^{dom}$  is the national coefficient of intermediate consumption of domestic inputs;  $z_{ij}^{dom}$  is the intermediate consumption of domestic inputs by sector, and  $x_j$  is the total sectoral output. From Equation (1), we can have a matrix of size  $44 \times 44$  (*sector x sector*),  $\mathbf{CIC}^{dom}$ , with all the intermediate consumption ratios ( $cic_{ij}^{dom}$ ).

Regarding the domestic absorption components (investment, household consumption, and government expenditure), we have used the ratio of each  $i$ -element to its respective column sum:

$$cinv_i^{dom} = \frac{inv_i^{dom}}{invt}, \forall i = 1, \dots, 44 \quad (2)$$

$$chou_i^{dom} = \frac{hou_i^{dom}}{hout}, \forall i = 1, \dots, 44 \quad (3)$$

$$cgov_i^{dom} = \frac{gov_i^{dom}}{govt}, \forall i = 1, \dots, 44 \quad (4)$$

where  $inv_i^{dom}$ ,  $hou_i^{dom}$ , and  $gov_i^{dom}$  are the investment demand, household consumption, and government expenditure of each  $i$ -element in the national use matrix; and  $invt$ ,  $hout$ , and  $govt$  are the respective column sums, including tax. Thus, from Equation (2) to (4), we may have vectors of size  $44 \times 1$ ,  $\mathbf{cinv}^{dom}$ ,  $\mathbf{chou}^{dom}$ , and  $\mathbf{cgov}^{dom}$ , with all the investment demand, household consumption and government expenditure ratios, respectively.

The gross regional demand for domestic products is obtained by multiplying these coefficients – Equations (1) to (4) – by (i) a matrix with the total sectoral output of each region in the main diagonal and zero elsewhere,  $\mathbf{X}^r$ ; (ii) the total investment demand of each region,  $invt^r$ ; (iii) the total household consumption of each region,  $hout^r$ ; and (iv) the total government expenditure of each region,  $govt^r$ :

$$\mathbf{IC}^{r,dom} = \mathbf{CIC}^{dom} * \mathbf{X}^r, \forall r = 1, \dots, 13 \quad (5)$$

$$\mathbf{inv}^{r,dom} = \mathbf{cinv}^{dom} * invt^r, \forall r = 1, \dots, 13 \quad (6)$$

$$\mathbf{hou}^{r,dom} = \mathbf{chou}^{dom} * hout^r, \forall r = 1, \dots, 13 \quad (7)$$

$$\mathbf{gov}^{r,dom} = \mathbf{cgov}^{dom} * govt^r, \forall r = 1, \dots, 13 \quad (8)$$

where  $\mathbf{IC}^{r,dom}$  is a matrix of intermediate consumption of domestic products;  $\mathbf{inv}^{r,dom}$  is the consumption vector of capital goods produced domestically;  $\mathbf{hou}^{r,dom}$  is the household consumption vector of domestic products; and  $\mathbf{gov}^{r,dom}$  is the vector of government expenditure on domestic products; all for each region  $r$ .

Therefore, the (gross) total demand for domestic products in each region is given by

$$\mathbf{demdom}^r = \sum_{j=1}^{44} \mathbf{IC}^{r,dom} + \mathbf{inv}^{r,dom} + \mathbf{hou}^{r,dom} + \mathbf{gov}^{r,dom}, \forall r = 1, \dots, 13 \quad (9)$$

where  $\mathbf{demdom}^r$  is the total demand vector for domestic products of size  $44 \times 1$  for each region  $r$ .

The procedure to estimate the demand for imported products is similar. Analogously, we have created a matrix of demand-generating coefficients for imported products (IMPGEN) defined to be the ratio of each element of the national matrix of imports over the respective column sum in the use matrix.

For intermediate consumption, the coefficient represents the share of imports in terms of national production as follows:

$$cic_{ij}^{imp} = \frac{z_{ij}^{imp}}{x_j}, \forall i, j = 1, \dots, 44 \quad (10)$$

where  $cic_{ij}^{imp}$  is the intermediate consumption coefficient of imported inputs;  $z_{ij}^{imp}$  is the intermediate consumption of imported inputs, and  $x_j$  is the total sectoral output.

Analogously to domestic ratios, from Equation (10) we can have a matrix of size  $44 \times 44$  (*sector x sector*),  $\mathbf{CIC}^{imp}$ , with all the intermediate consumption ratios related to imported inputs.

Further, the coefficients for the final demand elements are given by

$$cinv_i^{imp} = \frac{inv_i^{imp}}{invt}, \forall r = 1, \dots, 13 \quad (11)$$

$$chou_i^{imp} = \frac{hou_i^{imp}}{hout}, \forall r = 1, \dots, 13 \quad (12)$$

$$cgov_i^{imp} = \frac{gov_i^{imp}}{govt}, \forall r = 1, \dots, 13 \quad (13)$$

where  $inv_i^{imp}$ ,  $hou_i^{imp}$ , and  $gov_i^{imp}$  are the investment demand, household consumption, and government expenditure of each  $i$ -element in the national imported matrix. Thus,  $cinv_i^{imp}$ ,  $chou_i^{imp}$ , and  $cgov_i^{imp}$  are the demand shares of imported products related to investment demand, household consumption, and government expenditure, respectively. From Equation

(11) to (13), we can have vectors of size  $44 \times 1$ ,  $\mathbf{cinv}^{imp}$ ,  $\mathbf{chou}^{imp}$ , and  $\mathbf{cgov}^{imp}$ , with all the investment demand, household consumption and government expenditure ratios, respectively.

Therefore, the demands for imported products, by region, are defined as

$$\mathbf{IC}^{r,imp} = \mathbf{CIC}^{imp} * \mathbf{X}^r, \forall r = 1, \dots, 13 \quad (14)$$

$$\mathbf{inv}^{r,imp} = \mathbf{cinv}^{imp} * \mathbf{inv}^r, \forall r = 1, \dots, 13 \quad (15)$$

$$\mathbf{hou}^{r,imp} = \mathbf{chou}^{imp} * \mathbf{hou}^r, \forall r = 1, \dots, 13 \quad (16)$$

$$\mathbf{gov}^{r,imp} = \mathbf{cgov}^{imp} * \mathbf{gov}^r, \forall r = 1, \dots, 13 \quad (17)$$

where  $\mathbf{IC}^{r,imp}$  is a matrix with imports of intermediate inputs;  $\mathbf{inv}^{r,imp}$  is the imports vector of capital goods;  $\mathbf{hou}^{r,imp}$  is the vector of imports by household; and  $\mathbf{gov}^{r,imp}$  is the vector of government expenditure on imports; all for each region  $r$ .

The total demand for imported products by region is given by

$$\mathbf{demimp}^r = \sum_{j=1}^{44} \mathbf{IC}^{r,imp} + \mathbf{inv}^{r,imp} + \mathbf{hou}^{r,imp} + \mathbf{gov}^{r,imp}, \forall r = 1, \dots, 13 \quad (18)$$

In order to generate a matrix of regional demands for domestic products, we have placed all demand vectors for domestic products ( $\mathbf{demdom}^r, \forall r = 1, \dots, 13$ ) side by side, which has allowed us to have a matrix of size  $44 \times 13$  (sector x region) –  $\mathbf{DEMDOM}$ , where each row represents the domestic demand for sector  $i$  by each region  $r$ . Similarly, we have made the same procedure with the demand vectors for imported products ( $\mathbf{demimp}^r, \forall r = 1, \dots, 13$ ), which has also allowed us to have a matrix of size  $44 \times 13$  (sector x region) –  $\mathbf{DEMIMP}$ , where each row represents the sectoral imports by each region  $r$ .

The next step was to estimate the sectoral domestic supply (**supdom<sup>r</sup>**) in each region, which has been done by taking the difference between the sectoral total output (**x<sup>r</sup>**) and the sectoral exports (**exp<sup>r</sup>**) in each region.

$$\mathbf{supdom}^r = \mathbf{x}^r - \mathbf{exp}^r, \forall r = 1, \dots, 13 \quad (19)$$

Similarly, placing all regional vectors side by side, we have created a matrix of size  $44 \times 13$  (sector  $\times$  region) – **SUPDOM**, where each row represents the total regional domestic supply of sector  $i$ .

Thus, having the sectoral domestic demand and supply by region (**DEMDOM** and **SUPDOM**), we have to ensure the equilibrium between them, in aggregate terms. We have thus adjusted the aggregate value of (gross) total domestic demand for each sector in order to have total domestic demand equivalent to total domestic supply.

The next step has been to construct, for each sector, matrices with regional trade shares (**SHIN<sup>i</sup>**). In other words, we have created matrices for each sector that represent the regional share on the total domestic trade. Considering  $s$  origin regions and  $d$  destination regions, we have estimated 44 matrices (one for each sector) of size  $13 \times 13$  (origin  $\times$  destination).

These shares have been estimated using Equations, (20) and (21), based on previous work by Dixon and Rimmer (2004). Equation (20) has been used to calculate the initial ratio of the intra-regional trade (main diagonal of the trade matrix) while Equation (21) has been used to estimate the interregional trade flows.

Thus, the intra-regional trade share is given by

$$shin_{s,d}^i = \text{Min} \left\{ \frac{supdom_s^i}{demdom_d^i}, 1 \right\} * f, \forall i = 1, \dots, 44; s, d = 1, \dots, 13 \text{ and } s = d \quad (20)$$

where  $shin_{s,d}^i$  is the share of sector  $i$  in the national trade within each region. The intra-regional trade flow is defined to be the ratio of supply to demand of sector  $i$  within the region. If supply is greater than demand, we have assumed that all demand is met internally. However, based on

Haddad et al. (2016a), we have multiplied the result by a factor ( $f$ ) which gives us the extent of tradability of a given commodity. For non-tradable sectors, usually services, we have assumed that they are typically provided by the local economy. Thus, we have used initial  $f$  values close to unity (0.9) for non-tradable and 0.5 for tradable sectors.

Otherwise, the interregional trade is given by

$$shin_{s,d}^i = \left\{ \frac{1}{imped_{s,d}} * \frac{supdom_s^i}{\sum_{k=1}^{13} supdom_k^i} \right\} * \left\{ \frac{1 - shin_{s,v}^i}{\sum_{g=1, g \neq d}^{13} \left[ \frac{1}{imped_{g,d}} * \frac{supdom_g^i}{\sum_{k=1}^{13} supdom_k^i} \right]} \right\}, \quad (21)$$

$$\forall i = 1, \dots, 44; s, d = 1, \dots, 13; k = s; v = s; g = s \text{ and } s \neq d$$

where  $shin_{s,d}^i$  is the share of trade flows of sector  $i$  with origin in region  $s$  and destination on region  $d$ ; and  $imped_{s,d}$  is given by the average travel time between two trading regions.

From Equations (20) and (21), we generate matrices of size  $13 \times 13$  (region x region) for each sector – **SHIN** <sup>$i$</sup> , where the intra-regional trade shares are placed on the main diagonal and the interregional trade shares off-diagonal. Note that the column values add to one.

Using the **SHIN** <sup>$i$</sup>  matrices, we have estimated initial values for the trade matrices by multiplying each **SHIN** <sup>$i$</sup>  by its respective reference value in **DEMDOM** :

$$\mathbf{TRADE}^i = \mathbf{SHIN}^i * \mathbf{DEMDOM}^{*i}, \forall i = 1, \dots, 44 \text{ and } s, d = 1, \dots, 13 \quad (22)$$

where  $\mathbf{TRADE}^i$  is the trade matrix for sector  $i$  with origin in region  $s$  and destination in region  $d$ ; and  $\mathbf{DEMDOM}^{*i}$  is a diagonal matrix where values related to sector  $i$  from  $\mathbf{DEMDOM}$  have been placed on the main diagonal and zero elsewhere.

This procedure ensures that the column sums of each  $\mathbf{TRADE}_{s,d}^i$  matrix is equivalent to the demand of the respective region  $d$  for the products of region  $s$  (for each sector  $i$ ). However, the row sum is not necessarily equivalent to the supply of each sector  $i$  from region  $s$  to region  $d$ . Thus, we have used a RAS procedure<sup>1</sup> to make sure that supply and demand balance out.

After the RAS procedure, we have included in each  $\mathbf{TRADE}_{s,d}^i$  matrix the respective row from  $\mathbf{DEMIMP}$ . In other words, we added the Rest of the World as one of the origins. Thus, now  $s$  is equal to 14 since it represents the 13 Greek regions plus the Rest of the World.

### 2.3. Regionalization Procedure

The 44 trade matrices estimated are consistent with the national supply and demand in each sector. The trade matrices, after the inclusion of the import row,  $\mathbf{TRADE}_{s,d}^{*i}$ , consider the sales of each Greek region to the other Greek regions and the purchases of each of them both from domestic and of the foreign supplying regions. However, from these matrices, we are not able to know if the sales were purchased by industries (intermediate consumption) or by final users in the other regions.

In order to deal with this issue, we have used a hypothesis proposed originally by Chenery (1956) and Moses (1955). We have applied the same regional proportion in the acquisition of inputs for all sectors and final products by all final users within a given region. In other words, we have used the same trade coefficient for all sectors or final users in the destination.

The regionalization procedure may be described by the following steps. The first step is given by the calculation of a new matrix for each sector with the trade shares,  $\mathbf{SHIN}_N^i$ . This matrix is estimated based on the  $\mathbf{TRADE}_{s,d}^{*i}$  matrices as follows:

---

<sup>1</sup> For more details of this method, see Miller and Blair (2009).

$$\mathbf{SHIN\_N}^i = \mathbf{TRADE}_{s,d}^{*i} * [\mathbf{TRADE}^{*i}]^{-1}, \forall i = 1, \dots, 44; s = 1, \dots, 14; \text{ and } d = 1, \dots, 13 \quad (23)$$

where  $\mathbf{TRADE}^{*i}$  is a matrix diagonal whose  $(\sum_{s=1}^{14} trade_{s,d}^i)$  are placed on the main diagonal and zero elsewhere, being  $trade_{s,d}^i$  each element of  $\mathbf{TRADE}_{s,d}^{*i}$  matrix;  $s$  represents the 14 origin regions (13 regions of Greece plus Rest of the World) and  $d$  represents the 13 destination regions (regions of Greece).

Subsequently, we have used elements from the national use matrix to estimate the national coefficients (domestic plus imports) of intermediate consumption, investment demand, household consumption, and government expenditure.

For intermediate consumption, the matrix of coefficients is given by

$$\mathbf{CIC}^N = \mathbf{Z}^{\text{DOM+IMP}} * (\mathbf{ICT}^{*N})^{-1} \quad (24)$$

where  $\mathbf{Z}^{\text{DOM+IMP}}$  is the intermediate consumption matrix (domestic + imported); and  $\mathbf{ICT}^{*N}$  is a diagonal matrix with the values from the vector of total intermediate consumption for each sector of destination  $j$  ( $\mathbf{ict}^N$ ) in the main diagonal. This vector,  $\mathbf{ict}^N$ , is defined as

$$\mathbf{ict}^N = \mathbf{x}^N - \mathbf{va}^N \quad (25)$$

where  $\mathbf{x}^N$  is the vector with all national total sectoral output; and  $\mathbf{va}^N$  is the vector with all national sectoral value-added.

For the final demand elements, we have taken each element of each vector over its respective total (including also indirect taxes). Thus, the investment demand, household consumption, and government expenditure coefficients are defined as follows:

$$cinv_i^N = \frac{inv_i^{DOM+IMP}}{invt^N}, \forall i = 1, \dots, 44 \quad (26)$$

$$chou_i^N = \frac{hou_i^{DOM+IMP}}{hout^N}, \forall i = 1, \dots, 44 \quad (27)$$

$$cgov_i^N = \frac{gov_i^{DOM+IMP}}{govt^N}, \forall i = 1, \dots, 44 \quad (28)$$

where  $inv_i^{DOM+IMP}$ ,  $hou_i^{DOM+IMP}$ , and  $gov_i^{DOM+IMP}$  represent each element in the investment demand, household consumption and government expenditure vectors, respectively (including domestic and imported sources);  $invt^N$ ,  $hout^N$ , and  $govt^N$  are the respective column sum, including also indirect taxes.

From Equations (26) to (28), we can generate vectors with coefficients of investment demand ( $\mathbf{cinv}^N$ ), household consumption ( $\mathbf{chou}^N$ ), and government expenditure ( $\mathbf{cgov}^N$ ).

The next step has been to estimate the regional coefficients. In order to obtain the intermediate consumption shares, **RICC**, we have transformed the 44 **SHIN\_N** matrices into 14 **SHIN\_S** matrices of size  $44 \times 13$ , which represent, for each origin, foreign region inclusive, the consumption share of each sector in each destination region. Thus, each **SHIN\_S** matrix represents one origin trade region, where rows show the sectors and columns the destination regions.

Therefore, using Attica (the first region) as an example, the **SHIN\_S** for this region is composed of all the first rows of each of the 44 **SHIN\_N**. For the second region, North Aegean, the **SHIN\_S** includes all the second rows of each of the 44 **SHIN\_N**, and so on. Further, in order to estimate **RICC**, each column of each **SHIN\_S** matrix is diagonalized and multiplied by  $\mathbf{CIC}^N$ :

$$\mathbf{RICC}^{sd} = \mathbf{SHIN\_S}^* * \mathbf{CIC}^N \quad (29)$$

where  $\mathbf{SHIN\_S}^*$  is a diagonal matrix whose non-zero elements come from the **SHIN\_S**;  $s$  represents the 14 origin regions, and  $d$  represents the 13 destination regions.

From Equation (29), we estimated, for each origin region, 13 destination matrices of size  $44 \times 44$  (*sector x sector*). These matrices contain the shares of each sector in the intermediate consumption in each destination region.

Similarly, for each of the final demand components, we estimated, for each origin region, 13 vectors of size  $44 \times 1$ , **shin\_s**, which represents the shares of each destination region  $d$  in the acquisition of the output from each of the 44 sectors.

The final demand for capital goods (investment demand) for each region is given by

$$\mathbf{rcinv}^{sd} = \mathbf{SHIN\_S}^{**} * \mathbf{cinv}^N, \forall s = 1, \dots, 14; \text{ and } d = 1, \dots, 13 \quad (30)$$

where  $\mathbf{SHIN\_S}^{**}$  is a diagonal matrix of the vector **shin\_s**.

For household consumption:

$$\mathbf{rchou}^{sd} = \mathbf{SHIN\_S}^{**} * \mathbf{chou}^N, \forall s = 1, \dots, 14; \text{ and } d = 1, \dots, 13 \quad (31)$$

and for government expenditure:

$$\mathbf{rcgov}^{sd} = \mathbf{SHIN\_S}^{**} * \mathbf{cgov}^N, \forall s = 1, \dots, 14; \text{ and } d = 1, \dots, 13 \quad (32)$$

In order to obtain the regional share for the indirect tax paid by each user, we have calculated some coefficients from the national tax matrix. These coefficients are calculated for intermediate consumption, investment, household consumption, and government expenditure as follows.

The matrix with the national indirect tax coefficients related to intermediate consumption ( $\mathbf{TCIC}^N$ ) is given by

$$\mathbf{TCIC}^N = \mathbf{TIC}^N * (\mathbf{ICT}^N)^{-1} \quad (33)$$

where  $\mathbf{TIC}^N$  is a matrix of size  $44 \times 44$  (*sector x sector*) with the indirect taxes related to intermediate consumption in the national tax matrix; and  $\mathbf{ICT}^N$  is a diagonal matrix with the sectorial total intermediate consumption.

The vector with national indirect tax coefficients related to investment ( $\mathbf{tcinv}^N$ ) is

$$\mathbf{tcinv}^N = \mathbf{tinv}^N * (\mathbf{inv}^N)^{-1} \quad (34)$$

where  $\mathbf{tinv}^N$  is the vector with tax related to investment, and  $\mathbf{inv}^N$  is the total demand for investment from the national use matrix.

The vector with national tax coefficients related to household consumption ( $\mathbf{tchou}^N$ ) is given by

$$\mathbf{tchou}^N = \mathbf{thou}^N * (\mathbf{hou}^N)^{-1} \quad (35)$$

where  $\mathbf{thou}^N$  is the vector with tax related to household consumption, and  $\mathbf{hou}^N$  is the total demand for household from the national use matrix.

Finally, the vector with national tax related to government expenditure ( $\mathbf{tcgov}^N$ ) is

$$\mathbf{tcgov}^N = \mathbf{tgv}^N * (\mathbf{gov}^N)^{-1} \quad (36)$$

where  $\mathbf{tgv}^N$  is the vector with tax related to government consumption, and  $\mathbf{gov}^N$  is the total demand for government from the national use matrix.

The regional coefficients are obtained by multiplying each column of  $\mathbf{SHIN\_S}$  by the national tax coefficient. Thus, the regional coefficient for indirect tax related to intermediate consumption is given by

$$\mathbf{RTCIC}^{sd} = \mathbf{SHIN\_S}^* * \mathbf{TCIC}^N, \forall s = 1, \dots, 14; \text{ and } d = 1, \dots, 13 \quad (37)$$

which generates 182 matrices of size  $44 \times 44$  (*sector x sector*). These matrices represent the regional indirect tax coefficients for each pair of regions  $s \times d$  (*origin x destination*).

For investment demand:

$$\mathbf{rtcin}^{sd} = \mathbf{SHIN\_S}^* * \mathbf{tcinv}^N, \forall s = 1, \dots, 14; \text{ and } d = 1, \dots, 13 \quad (38)$$

which gives us 182 vectors of size  $44 \times 1$  that represents the proportion paid in tax related to the acquisition of products for investment in each pair of regions  $s \times d$ .

Similarly, we have the regional coefficient for household consumption:

$$\mathbf{rtchou}^{sd} = \mathbf{SHIN\_S}^* * \mathbf{tchou}^N, \forall s = 1, \dots, 14; \text{ and } d = 1, \dots, 13 \quad (39)$$

and for government expenditure:

$$\mathbf{rtcgov}^{sd} = \mathbf{SHIN\_S}^* * \mathbf{tcgov}^N, \forall s = 1, \dots, 14; \text{ and } d = 1, \dots, 13 \quad (40)$$

In order to have all regional coefficients in monetary flows, we have multiplied the coefficients defined above by the regional values presented in Section 2.2.

Intermediate consumption:

$$\mathbf{RIC}^{sd} = \mathbf{RICC}^{sd} * \mathbf{RICT}^d, \forall s = 1, \dots, 14; \text{ and } d = 1, \dots, 13 \quad (41)$$

where  $\mathbf{RIC}^{sd}$  is the regional intermediate consumption matrix for each pair of region ( $s \times d$ ), and  $\mathbf{RICT}^d$  is a matrix with the total regional intermediate consumption in the main diagonal and zero elsewhere.

Investment demand:

$$\mathbf{rinv}^{sd} = \mathbf{rcinv}^{sd} * rinv^d, \forall s = 1, \dots, 14; \text{ and } d = 1, \dots, 13 \quad (42)$$

where  $\mathbf{rinv}^{sd}$  is the vector of demand for regional investment for each pair of region ( $s \times d$ ), and  $rinv^d$  is the total regional for investment.

Household consumption:

$$\mathbf{rhou}^{sd} = \mathbf{rchou}^{sd} * rhout^d, \forall s = 1, \dots, 14; \text{ and } d = 1, \dots, 13 \quad (43)$$

where  $\mathbf{rhou}^{sd}$  is the vector of regional household consumption for each pair of region ( $s \times d$ ), and  $rhout^d$  is the total regional household consumption.

Government expenditure:

$$\mathbf{rgov}^{sd} = \mathbf{rcgov}^{sd} * rgov^d, \forall s = 1, \dots, 14; \text{ and } d = 1, \dots, 13 \quad (44)$$

where  $\mathbf{rgov}^{sd}$  is the vector of regional government expenditures for each pair of region ( $s \times d$ ), and  $rgov^d$  is the total regional government expenditures.

Given the estimates of sectoral foreign exports by region, ( $\mathbf{exp}^r$ ), the values are allocated directed in the relevant column of the inter-regional system.<sup>2</sup>

Similar procedure has been used to transform indirect tax coefficients in monetary flows as follows:

For tax related to intermediate consumption:

$$\mathbf{RTIC}^{sd} = \mathbf{RTCIC}^{sd} * \mathbf{RICT}^d, \forall s = 1, \dots, 14; \text{ and } d = 1, \dots, 13 \quad (44)$$

Investment:

$$\mathbf{rtinv}^{sd} = \mathbf{rtcinv}^{sd} * \mathbf{rinv}^d, \forall s = 1, \dots, 14; \text{ and } d = 1, \dots, 13 \quad (45)$$

Household consumption:

$$\mathbf{rthou}^{sd} = \mathbf{rtchou}^{sd} * \mathbf{rhout}^d, \forall s = 1, \dots, 14; \text{ and } d = 1, \dots, 13 \quad (46)$$

and government expenditure:

$$\mathbf{rtgov}^{sd} = \mathbf{rtcgov}^{sd} * \mathbf{rgov}^d, \forall s = 1, \dots, 14; \text{ and } d = 1, \dots, 13 \quad (47)$$

In order to have the completed inter-regional system, we need the regional value-added components ( $VA^R$ ). In the interregional input-output system, the total regional output ( $x^R$ ) should be equivalent to the total demand of each region ( $DT^R$ ). This balance checking can be done using the following identities.

---

<sup>2</sup> We have assumed the same ratio of foreign exports to gross output to allocate foreign exports across regions.

Total regional output:

$$\mathbf{x}^R = \sum_{i=1}^{44} \mathbf{RIC}^{sd} + \sum_{i=1}^{44} \mathbf{RTIC}^{sd} + \mathbf{rva}^{sd} \quad (48)$$

where  $\mathbf{x}^R$  is the vector of sectorial regional total output;  $\mathbf{RIC}^{sd}$  is the regional intermediate consumption matrix;  $\mathbf{RTIC}^{sd}$  is the indirect tax matrix related to intermediate consumption, and  $\mathbf{rva}^{sd}$  is the vector of regional value-added.

Total demand:

$$\mathbf{dt}^R = \sum_{j=1}^{44} \mathbf{RIC}^{sd} + \mathbf{rinv}^{sd} + \mathbf{rhou}^{sd} + \mathbf{expr}^{sd} + \mathbf{rgov}^{sd} \quad (49)$$

where  $\mathbf{dt}^R$  is the total demand vector;  $\mathbf{rinv}^{sd}$  is the demand for investment;  $\mathbf{rhou}^{sd}$  is the household consumption;  $\mathbf{expr}^{sd}$  is the export vector; and  $\mathbf{rgov}^{sd}$  is the government expenditure.

Finally, an adjustment in Stocks ( $\mathbf{stock}^R$ ) has to be done to complete the interregional system:

$$\mathbf{stock}^R = \mathbf{x}^{R'} - \mathbf{dt}^R \quad (50)$$

### 3. Structural Analysis

#### 3.1. Interregional linkages

In this section, a brief comparative analysis of regional economic structures is carried out to illustrate some of the features of the system. Production linkages between sectors are considered through the analysis of the intermediate inputs portion of the interregional input-output

database. Both the direct and indirect production linkage effects of the economy are captured by the adoption of different methods based on the evaluation of the Leontief inverse matrix.

The conventional input-output model is given by

$$\mathbf{x} = \mathbf{Ax} + \mathbf{f} \quad (51)$$

and

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} = \mathbf{Bf} \quad (52)$$

where  $\mathbf{x}$  and  $\mathbf{f}$  are respectively the vectors of gross output and final demand;  $\mathbf{A}$  is a matrix with the input-output coefficients  $a_{ij}$  defined as the amount of product  $i$  required per unit of product  $j$  (in monetary terms) -  $i, j = 1, \dots, n$ ; and  $\mathbf{B}$  is known as the Leontief inverse.

Let us consider systems Equations (51) and (52) in an interregional context, with  $r$  different regions, so that:

$$\mathbf{x} = \begin{bmatrix} \mathbf{x}^1 \\ \vdots \\ \mathbf{x}^R \end{bmatrix}; \mathbf{A} = \begin{bmatrix} \mathbf{A}^{11} & \dots & \mathbf{A}^{1R} \\ \vdots & \ddots & \vdots \\ \mathbf{A}^{R1} & \dots & \mathbf{A}^{RR} \end{bmatrix}; \mathbf{f} = \begin{bmatrix} \mathbf{f}^1 \\ \vdots \\ \mathbf{f}^R \end{bmatrix}; \text{ and } \mathbf{B} = \begin{bmatrix} \mathbf{B}^{11} & \dots & \mathbf{B}^{1R} \\ \vdots & \ddots & \vdots \\ \mathbf{B}^{R1} & \dots & \mathbf{B}^{RR} \end{bmatrix} \quad (53)$$

and

$$\begin{aligned} \mathbf{x}^1 &= \mathbf{B}^{11}\mathbf{f}^1 + \dots + \mathbf{B}^{1R}\mathbf{f}^R \\ &\quad \vdots \\ \mathbf{x}^R &= \mathbf{B}^{R1}\mathbf{f}^1 + \dots + \mathbf{B}^{RR}\mathbf{f}^R \end{aligned} \quad (54)$$

Furthermore, we may consider different components of  $\mathbf{f}$ , which includes demands originating in the specific regions,  $V$ , and abroad,  $e$ . We obtain information of final demand from origin  $s$  in the IOM-Greece, allowing us to treat  $\mathbf{V}$  as a matrix which provides the monetary values of final demand expenditures from the domestic regions in Greece and from the foreign region.

$$\mathbf{V} = \begin{bmatrix} \mathbf{V}^{11} & \dots & \mathbf{V}^{1R} \\ \vdots & \ddots & \vdots \\ \mathbf{V}^{R1} & \dots & \mathbf{V}^{RR} \end{bmatrix}; \text{ and } \mathbf{e} = \begin{bmatrix} \mathbf{e}^1 \\ \vdots \\ \mathbf{e}^R \end{bmatrix} \quad (55)$$

Thus, we can re-write Equation (54) as:

$$\begin{aligned} \mathbf{x}^1 &= \mathbf{B}^{11}(\mathbf{V}^{11} + \dots + \mathbf{V}^{R1} + \mathbf{e}^1) + \dots + \mathbf{B}^{1R}(\mathbf{V}^{1R} + \dots + \mathbf{V}^{RR} + \mathbf{e}^R) \\ &\quad \vdots \\ \mathbf{x}^R &= \mathbf{B}^{R1}(\mathbf{V}^{11} + \dots + \mathbf{V}^{R1} + \mathbf{e}^1) + \dots + \mathbf{B}^{RR}(\mathbf{V}^{1R} + \dots + \mathbf{V}^{RR} + \mathbf{e}^R) \end{aligned} \quad (56)$$

From Equation (56), we can then compute the contribution of final demand from different origins on regional output. It is clear from (56) that regional output depends, among others, on demand originating in the region and on the degree of interregional integration, also on demand from outside the region.

In what follows, interdependence among sectors in different regions is considered through the analysis of the complete intermediate input portion of the interregional input-output table. The Leontief inverse matrix, based on the system (54), will be considered, and some summary interpretations of the structure of the economy derived from it will be provided. To illustrate the nature of interregional linkages in Greece, we provide analysis of the structure of the Greek economy derived from the Leontief inverse (multipliers) matrix, focusing on the database for 2013.

### 3.2.1. Multiplier Analysis

The column multipliers derived from  $\mathbf{B}$  were computed<sup>3</sup>. An output multiplier is defined for each sector  $j$ , in each region  $r$ , as the total value of production in all sectors and in all regions of the economy that is necessary to satisfy a euro's worth of final demand for sector  $j$ 's output.

Further, the multiplier effect can be decomposed into intraregional (internal multiplier) and interregional (external multiplier) effects, the former representing the impacts on the outputs of sectors within the region where the final demand change was generated, and the latter showing the impacts on the other regions of the system (interregional spillover effects).

---

<sup>3</sup> See Miller and Blair (2009) for more details.

Table 1 shows the intraregional and interregional shares for the average total output multipliers of the 13 regions of Greece as well as the equivalent shares for the direct and indirect effects of a unit change in final demand in each sector in each region net of the initial injection (the total output multiplier effect net of the initial change). The entries are shown in percentage terms, providing insights into the degree of dependence of each region on the other regions.

Attica, Crete and South Aegean are the most self-sufficient regions, the average flow-on effects from a unit change in sectoral final demand is among the highest. The average net effect exceeds 50% for those regions (it exceeds almost 70% for Attica). For some regions, such as Central Macedonia, Ionian Islands, North Aegean, Western Greece, Eastern Macedonia and Thrace, Peloponnese, Epirus, Central Greece, Thessaly and Western Macedonia, the degree of regional self-sufficiency is lower, and the intraregional flow-on effects, on the average, are lower than the total interregional effects.

**Table 1. Regional Percentage Distribution of the Average Total and Net Output Multipliers: Greece, 2013**

		Total output multiplier		Net output multiplier	
		Intra-regional share	Interregional share	Intra-regional share	Interregional share
R1	Attica	0.89	0.11	0.69	0.31
R2	North Aegean	0.80	0.20	0.42	0.58
R3	South Aegean	0.84	0.16	0.52	0.48
R4	Crete	0.85	0.15	0.57	0.43
R5	Eastern Macedonia and Thrace	0.77	0.23	0.35	0.65
R6	Central Macedonia	0.80	0.20	0.47	0.53
R7	Western Macedonia	0.74	0.26	0.26	0.74
R8	Epirus	0.74	0.26	0.32	0.68
R9	Thessaly	0.75	0.25	0.31	0.69
R10	Ionian Islands	0.81	0.19	0.43	0.57
R11	Western Greece	0.78	0.22	0.38	0.62
R12	Central Greece	0.75	0.25	0.31	0.69
R13	Peloponnese	0.76	0.24	0.35	0.65

Source: Calculations by the authors.

### 3.2.2. Output Decomposition

In order to complement the multiplier analysis, the regional output decomposition is carried out in this section. We considered not only the multiplier structure but also the structure of final demand in the 13 domestic and the foreign regions.

Following Equation (56), regional output (for each region) was decomposed, and the contributions of the components of final demand from different areas were calculated. The results are presented in Table 2. As expected, the main contributions to the final demand of a region are given by itself, so the highest values in table are on the diagonal. In addition, the importance of Attica (R1) and Central Macedonia (R6) for the Greek economy is verified, with the final demand of these regions generating the greatest contribution to the output of the others. The final demand for Attica (R1) contributes 35% of the Greek output, mainly through the regions South Aegean (R3), Ionian Islands (R10), Crete (R4), Central Greece (R12), Peloponnese (R13) and Western Macedonia (R7). The second major region, Central Macedonia (R6), contributes with 13% of Greece's final output. It is worth noting the importance of the rest of the world's demand for the Greek product, with a contribution of 21%.

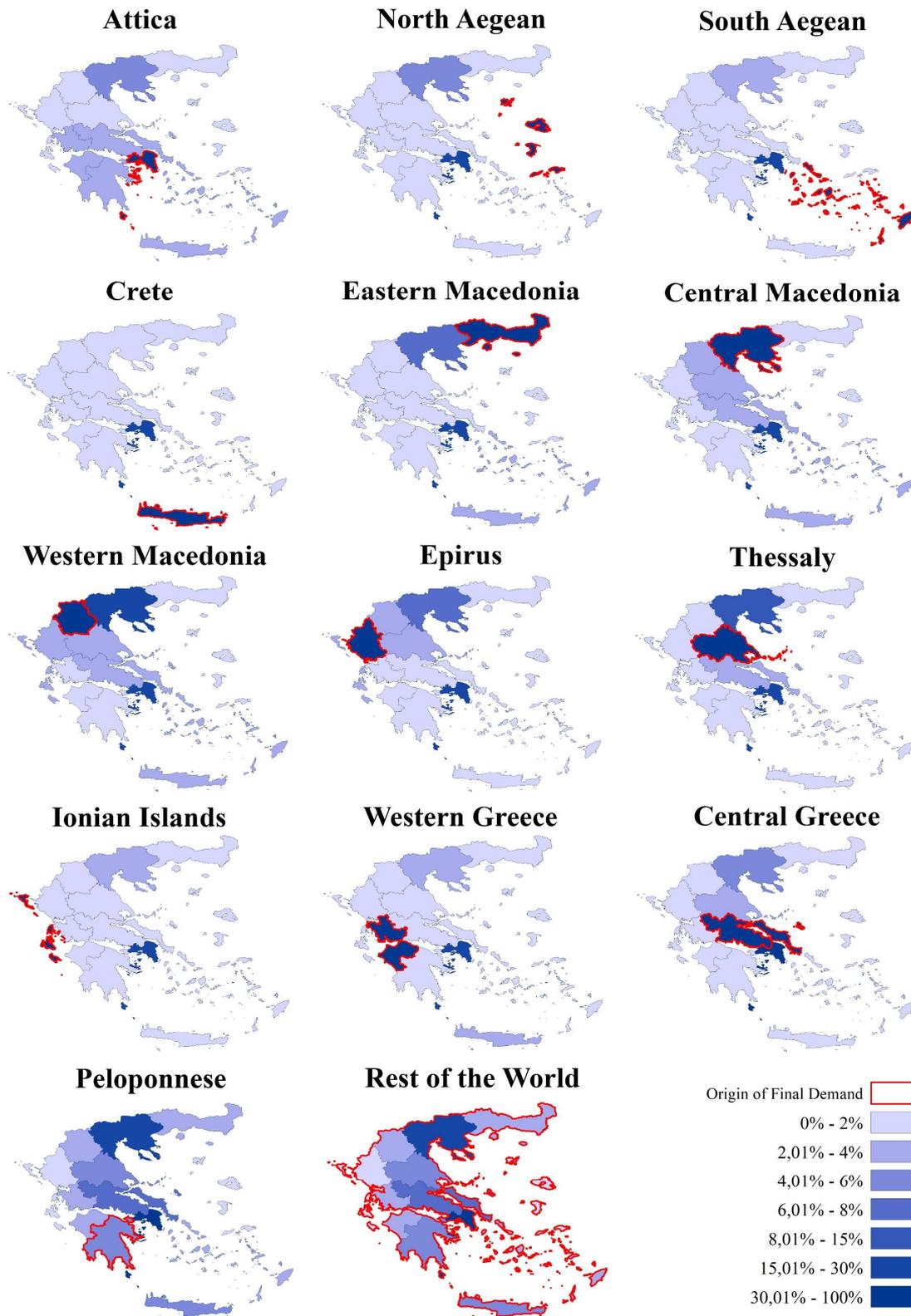
**Table 2. Components of Decomposition of Regional Output Based on the Sources of Final Demand: Greece, 2013 (in %)**

		ORIGIN OF FINAL DEMAND													
		R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	ROW
REGIONAL OUTPUT	R1	54.20	0.63	0.32	0.77	2.06	6.55	1.40	1.31	3.09	0.29	2.62	2.58	2.96	22.08
	R2	10.78	64.83	0.20	0.35	1.76	5.38	1.01	0.68	1.46	0.14	1.01	0.96	0.87	12.45
	R3	30.79	0.84	28.15	0.88	2.87	10.46	2.15	1.31	2.79	0.16	2.33	1.82	2.03	10.72
	R4	23.61	0.60	0.33	40.12	3.30	6.07	1.19	1.03	2.15	0.19	1.98	1.55	1.81	15.82
	R5	9.81	0.62	0.29	0.40	61.48	5.95	1.08	0.75	1.55	0.20	0.92	0.98	0.82	17.09
	R6	13.03	0.65	0.27	0.44	2.35	50.77	2.67	1.40	3.62	0.30	1.23	1.66	1.04	21.72
	R7	20.51	0.78	0.29	0.69	3.04	13.85	30.08	2.49	4.30	0.55	2.53	2.30	2.01	18.52
	R8	17.25	0.50	0.20	0.51	1.71	8.68	3.08	47.98	2.63	0.46	1.98	1.86	1.52	15.53
	R9	16.02	0.47	0.21	0.43	1.56	9.70	1.96	1.14	48.14	0.25	1.22	2.55	1.14	17.06
	R10	25.93	0.51	0.12	0.36	2.14	11.88	3.24	3.30	3.52	30.92	2.79	2.10	1.88	12.06
	R11	19.22	0.38	0.19	0.45	1.11	3.99	1.03	0.99	1.46	0.22	53.35	1.30	1.74	16.15
	R12	23.83	0.51	0.30	0.71	1.65	7.32	1.38	1.12	3.84	0.29	1.74	31.96	1.62	26.58
	R13	22.67	0.50	0.27	0.70	1.42	4.27	0.92	0.97	1.77	0.25	2.00	1.41	32.44	31.18
GREECE		35.09	1.46	1.10	2.55	4.16	12.99	2.34	2.40	5.17	0.78	4.36	3.64	4.05	20.97

Source: Calculations by the authors

A more systematic approach to visualize the influence of final demand from different regions is to map the column original estimates that generated Table 2. The results, illustrated in Figure 1, provide an attempt to reveal the spatial patterns of income dependence upon specific sources of final demand. The 13 regions are grouped in seven different categories in each map, so that darker colors represent higher values.

**Figure 1. Identification of Regions Relatively More Affected by a Specific Regional Demand, by Origin of Final Demand**



Source: Calculations by the authors.

#### 4. Final Remarks

The main aim of this paper was to describe the process of estimation of two interregional input-output systems for Greece, for the years 2010 and 2013. Further understanding of the changing structure of the Greek regional economies during the crisis, within an integrated system, is one of the main goals of a broader project underway at the University of São Paulo Regional and Urban Economics Lab (NEREUS). With this paper, we make available not only the details of the methodological procedures adopted to generate the interregional systems, but also the database itself to be used by other researchers and practitioners.

The database generated in this project can be downloaded at:

Interregional Input-Output Tables for Greece, 2010 and 2013 (DOI: 10.13140/RG.2.2.25151.41124)

[https://www.researchgate.net/publication/325049146\\_Interregional\\_Input-Output\\_Tables\\_for\\_Greece\\_2010\\_and\\_2013](https://www.researchgate.net/publication/325049146_Interregional_Input-Output_Tables_for_Greece_2010_and_2013)

**Acknowledgements.** Eduardo A. Haddad acknowledges financial support from CNPq and Fapesp. This work was partially supported by the Brazilian Research Network on Global Climate Change FINEP/Rede CLIMA [grant 01.13.0353-00] and the INCT for Climate Change II (INCT-MC) [grant 2014/50848-9]. Vinicius A. Vale acknowledges financial support from Fipe.

#### References

- Chenery, H. B. (1956). Interregional and International Input-Output Analysis. In: T. Barna (Ed.), *The Structure Interdependence of the Economy*, New York: Wiley, p. 341-356.
- Dixon, P. B. and Rimmer, M. T. (2004). *Disaggregation of Results from a Detailed General Equilibrium Model of the US to the State Level*. General Working Paper No. 145, Centre of Policy Studies, April.
- Flegg, A.T., Mastonardi, L.J. and Romero, C.A. Evaluating the FLQ and AFLQ formulae for estimating regional input coefficients: empirical evidence for the province of Córdoba, Argentina. *Economic Systems Research*, v. 18, n. 1, 21-37, 2016.

- Guilhoto, J.J.M. and Sesso Filho, U.A. (2010). Estimação da Matriz Insumo-Produto Utilizando Dados Preliminares das Contas Nacionais: Aplicação e Análise de Indicadores Econômicos para o Brasil em 2005, *Economia & Tecnologia*, ano 6, v. 23.
- Guilhoto, J.J.M. and Sesso Filho, U.A. (2005). Estimação da Matriz Insumo-Produto a Partir de Dados Preliminares das Contas Nacionais. *Economia Aplicada*, v. 9. n. 2. p. 277-299.
- Haddad, E.A. (2014). Trade and Interdependence in Lebanon: An Interregional Input-Output Perspective, *Journal of Development and Economic Policies*, v. 16, n. 1, p. 5–45.
- Haddad, E.A., Ait-Ali, A. and El-Hattab, F. (2017a). *A Practitioner's Guide for Building the Interregional Input-Output System for Morocco, 2013*, OCP Policy Center Research Paper.
- Haddad, E.A., Faria, W.R., Galvis-Aponte, L.A. and Hahn-De-Castro, L.W. (2016a). Interregional Input-Output Matrix for Colombia, 2012, *Borradores de Economia*, n. 923, Banco de La Republica, Bogotá.
- Haddad, E.A., Gonçalves Junior, C.A., Nascimento, T. O. (2017b). Matriz Interestadual De Insumo-Produto Para o Brasil: Uma Aplicação do Método IIOAS. *Revista Brasileira de Estudos Regionais e Urbanos*, v. 11, n. 4, p. 424-446.
- Haddad, E.A., Lahr, M., Elshahawany, D., Vassallo, M. (2016b). Regional Analysis of Domestic Integration in Egypt: An Interregional CGE Approach, *Journal of Economic Structures*, v. 5, n. 1, p. 1–33.
- Haddad, E.A., Silva, V., Porsse, A.A. and Dentinho, T.P. (2015). Multipliers in an Island Economy: The Case of the Azores. In: Batabyal, A.A. and Nijkamp, P. (Org.). *The Region and Trade: New Analytical Directions*. Singapore: World Scientific, p. 205–226.
- Hewings, G.J.D. and Hulu, E. (1993). The Development and Use of Interregional Input-Output Models for Indonesia Under Conditions of Limited Information. *Urban & Regional Development Studies*. v. 5, n. 2, p. 135-153.
- Isard, W. (1951). Inter-regional and regional input-output analysis: a model of a space economy. *The Review of Economics and Statistics*, Cambridge, v. 33, n. 4, p. 319-328.
- Leontief, W., Hollis, B., Chenery, P., Clark, P., Duesenberry, J., Ferguson, A., Grosse, R., Hlzman, M., Isard, W. and Kistin, H. (1953). *Studies in the Structure of the American Economy*. White Plains, NY: International Arts and Science Press.
- Miller, R.E. and Blair, P.D. (2009). *Input-Output Analysis: Foundations and Extensions*. Cambridge University Press, Cambridge, Second Edition.
- Moses, L.N. (1955). The Stability of Interregional Trading Patterns and Input-Output Analysis, *American Economic Review*, v. XLV, n. 5, p. 803-832.

- Riddington, G., Gibson, H. and Anderson, J. (2006). Comparison of Gravity Model, Survey and Location Quotient-based Local Area Tables and Multipliers. *Regional Studies*, v. 40.9, p. 1069-1081.
- Round, J.I. (1983). Nonsurvey Techniques: A Critical Review of the Theory and the Evidence. *International Regional Science Review*. v. 8, 3 p. 189-212.
- Tobben, J. and kronenberg, T. (2015). Construction of Multi-Regional Input-Output Tables Using the CHARM Method. *Economic Systems Research*. v. 27, n. 4, p. 487-507.
- Zhang, Z., Shi, M. and Zhao, Z. (2015). The Compilation of China's Interregional Input-Output Model 2002. *Economic Systems Research*. v. 27; n. 2, p. 238-256.

## Annex 1. List of Regions

---

1	R1	Attica	Attiki
2	R2	North Aegean	Voreio Aigaio
3	R3	South Aegean	Notio Aigaio
4	R4	Crete	Kriti
5	R5	Eastern Macedonia and Thrace	Anatoliki Makedonia, Thraki
6	R6	Central Macedonia	Kentriki Makedonia
7	R7	Western Macedonia	Dytiki Makedonia
8	R8	Epirus	Ipeiros
9	R9	Thessaly	Thessalia
10	R10	Ionian Islands	Ionia Nisia
11	R11	Western Greece	Dytiki Ellada
12	R12	Central Greece	Stereia Ellada
13	R13	Peloponnese	Peloponnisos

---

## Annex 2. List of Sectors

---

1	A	Agriculture, forestry and fishing
2	B	Mining and quarrying
3	C10-C12	Manufacture of food products, beverages and tobacco products
4	C13-C15	Manufacture of textiles, wearing apparel and leather products
5	C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
6	C17	Manufacture of paper and paper products
7	C18	Printing and reproduction of recorded media
8	C19	Manufacture of coke and refined petroleum products
9	C20	Manufacture of chemicals and chemical products
10	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
11	C22	Manufacture of rubber and plastic products
12	C23	Manufacture of other non-metallic mineral products
13	C24	Manufacture of basic metals
14	C25	Manufacture of fabricated metal products, except machinery and equipment
15	C26	Manufacture of computer, electronic and optical products
16	C27	Manufacture of electrical equipment
17	C28	Manufacture of machinery and equipment n.e.c.
18	C29	Manufacture of motor vehicles, trailers and semi-trailers
19	C30	Manufacture of other transport equipment
20	C31_C32	Manufacture of furniture; other manufacturing
21	C33	Repair and installation of machinery and equipment
22	D35	Electricity, gas, steam and air conditioning supply
23	E36	Water collection, treatment and supply
24	E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services
25	F	Construction
26	G_H	Wholesale and retail trade, transportation and storage
27	I	Accommodation and food service activities
28	J58	Publishing activities
29	J59_J60	Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities
30	J61	Telecommunications
31	J62_J63	Computer programming, consultancy and related activities; information service activities
32	K	Financial and insurance activities
33	L	Real estate activities
34	M69_M70	Legal and accounting activities; activities of head offices; management consultancy activities
35	M71	Architectural and engineering activities; technical testing and analysis
36	M72	Scientific research and development
37	M73	Advertising and market research
38	M74_M75	Other professional, scientific and technical activities; veterinary activities
39	N77	Rental and leasing activities
40	N78	Employment activities
41	N79	Travel agency, tour operator reservation service and related activities
42	N80-N82	Security and investigation activities; services to buildings and landscape activities; office administrative, office support and other business support activities
43	O_Q	Public administration, defence, education, human health and social work activities
44	R_U	Other services

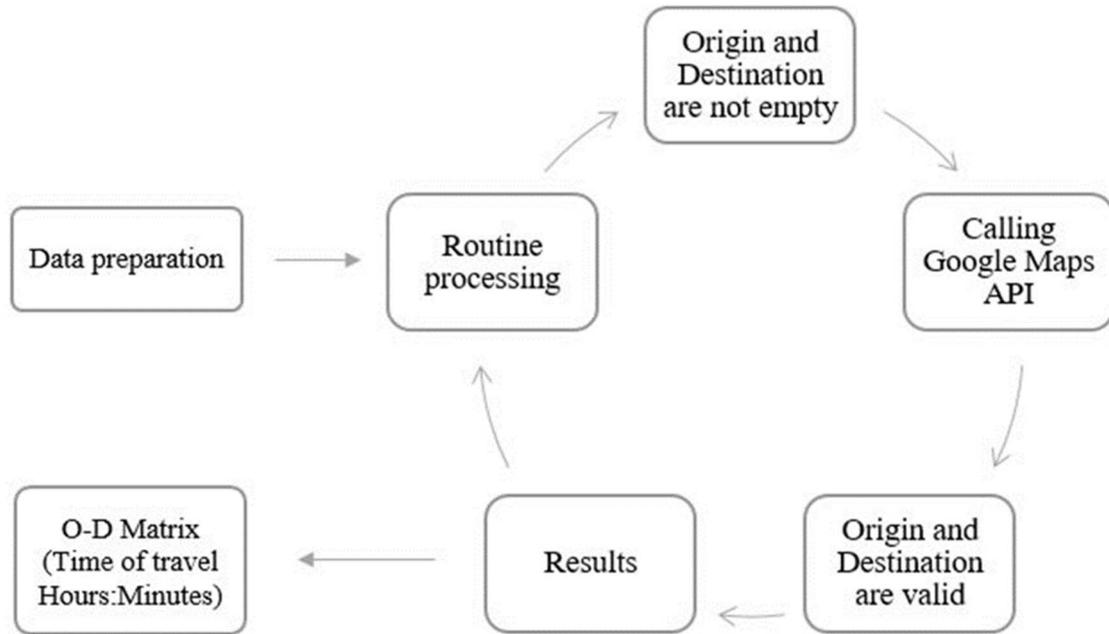
### **Annex 3. Greece GIS Data**

The estimation of travel time between set of origins and set of destinations (O-D travel time matrix) through a transportation network is necessary for interregional trade calculations in Equation (21) .

Actually, we are able to tap into the dynamically updated transportation network data and the routing rules maintained by Google and obtain a reliable estimate of O-D travel time matrix developing a custom routine by Application Programming Interface (API) of Google Maps. Among the advantages compared to other traditional methods for distance estimation, such as Euclidean distance, stands out the consideration of numerous routes and multimodal transport network based on broad real-time traffic data in the determination of the optimal route (in the case of the present work, the route that minimizes the transport time).

The Google Maps API is a development interface for applications based on Google Maps that has as one of the attributes to allow the estimation of distance and time of several routes between two regions, without the need to update the user interface via internet browser, helping large-scale estimates. The following figure shows in a simplified way how this structure was used to generate the O-D travel time matrix.

**Figure A.1. Travel Time Estimation Process**



The preparation of data consists basically in the conversion of the identification of regions to recognizable input data, usually coordinates. The constructed routine uses the combinations of these coordinates to perform the requests for Google Maps and progressively build the O-D Time Travel Matrix.<sup>4</sup>

<sup>4</sup> For more detail, see Google API (2017). Web Services, Distance Matrix API: <https://developers.google.com/maps/documentation/distance-matrix/intro?hl=en-us> Accessed September 20, 2017