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Partial Input-output Analysis: Potential Embodied Energy Impacts in Tourism

SXT Ariel
arielearth@gmail.com

Previous invested affiliation:
MSc. EfS Initiative, Faculty of Sciences and Technology,
University of Coimbra,Polo II,
3030-290, Portugal.

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Abstract: Energy efficiency improvements in tourism sector reduces costs of services, and under some circumstances, increases the available income spending for tourists. This contributes towards a higher demand, where additional energy consumption to accommodate the production of tourism goods and services persists. To circumvent this indirect rebound effect in the tourism trade, cleaner tourism production factors can be determined by the scale in efficient use of tourism resources. This scale can be estimated through the embodied energy intensity of tourism trade. This estimation shows the potential imbalance in energy use in a typical tourism economic performance case. The present embodiment study is expected to support future development of an energy impact assessment model. A partial input-output analysis approach is introduced in this paper, showing potential to assess the interdependencies of technological and policy changes. With restrictive economic assumptions, this proposed partial analysis highlights the theoretical foundations of this method from the perspective of input-output model traits. Illustrated with simple mathematical equations, the discussion frames a market analysis regarding the relationship between energy impacts and tourism economic performance. That is align with the current sustainable transformation in tourism markets. Results show that even in the case when tourism season is moderately low, capacity of tourism resources for production (in energy efficiency terms) is still at risk to-be managed efficiently to accommodate supply needs.

Introduction

Input-output analysis (IO analysis) has been a common impact assessment methodology used to understand the interdependencies between socio-economic impacts and energy-environment impacts. Energy input-output analysis for instance, accounts the energy flows in a service or trade economy. Since international policy changes accelerating market changes for reduction in environmental pressures, hybrid IO methods is favored by scholars and institutions as a useful tool to recognize direct, indirect, and induced impacts embodied in the consumption or production processes (Guevara and Domingos, 2017).

The unitary belief concerning policy measures such as pricing instruments (tourism tax on purchases) is exclusively useful to combat problems arising from growing energy shortages (e.g. intermittency of clean energy supply in production sector). This occurrence often overlooks the benefits of energy conservation (and energy efficiency potentials across trade flows). From the macroeconomic perspective, achieving simultaneous tourism growth and sustainable development demands a robust impact assessment methodology that will consider beyond the direct effects of energy use in the entire tourism trade flow.

Hence, underestimating the structural dependence of tourism-related production factors (e.g. labor types, energy source, seasonal tourism visits, and etc.) illustrates the importance to estimate these interactions that can have tradeoffs effects with energy performance. This linkage effects can be expressed by performance indicators such as the energy intensity or final cost of electricity attributable to tourism supply-side. The proposed IO analysis in this paper therefore contributes towards a more refine value judgements for decision makers in the planning of sustainable tourism development. In opposite to a full IO analysis, a partial assessment of identifying potential embodied energy flows within tourism economy is tabulated at a short-time frame. Thus, introducing the benefits of this technique to complement policy assessment design methodologies.

I-O Analysis Foundations

I-O table features occurring transactions in different areas (local, regional, state, or national). A primary assumption of I-O is that for every unit of output (demand), a commodity (input) transaction follows. This ratio component is expressed by the notion (a_{ij}). Intra-industry flows denoted by (z_{ii}), are arrayed in a matrix algebra framed by rows and column (Leontief, 1986:375). By adapting towards Kronenberg (2009) interpretation, a set of n linear equations that shows the composition of various sectors can be expressed as:

$$P_1 = E \cdot z_{11} + E \cdot z_{12} + \ldots + E \cdot z_{1i} + E \cdot z_{1n} + Y_1$$
$$P_2 = E \cdot z_{11} + E \cdot z_{12} + \ldots + E \cdot z_{1i} + E \cdot z_{1n} + Y_1$$
$$P_i = E \cdot z_{11} + E \cdot z_{12} + \ldots + E \cdot z_{1i} + E \cdot z_{1n} + Y_1$$
$$P_n = E \cdot z_{11} + E \cdot z_{12} + \ldots + E \cdot z_{1i} + E \cdot z_{1n} + Y_1 \quad (1)$$

whereby:

$Y_i =$ $final\ demand\ of\ sector\ i$
$Z_{in} =$ $flow\ from\ sector\ i\ to\ sector\ n$
$P_i =$ $total\ output\ of\ sector\ i\ (final\ \&\ intermediate\ demand)$
$E\ =$ $energy\ vector\ of\ each\ output$
$Z =$ $matrix\ of\ interindustry\ flows$

The I-O model adapts to quantify an infinite series of supply-side relationships in assuming constant returns to scale. Even in the case where data for computation of I-O table is limited by nature, to achieve a general equilibrium economic outcome will demand critical assumptions (or tradeoffs in varied parameters that concerns the economic infrastructure).

Table 1: I-O Table Quadrants

I Column: purchases of intermediate inputs of certain industry sector Row: sales of intermediate goods from each sector	**II** Column: commodities structure to satisfy final demand Row: distribution of commodity (e.g. exports, investments, household consumption)
III Column: payment of primary inputs (e.g. labour, capital Row: Value-added structure (e.g. intermediate imports, taxes on production, subsidies).	**IV** Primary inputs to final demand by each category

Adapted from: Figueiras (2015:30)

Table 1 shows the basic structure of I-O table subdivided into four quadrants. First quadrant concerns inter-industry transaction flows whereby homogenous sectors are allocated. The second quadrant shows the matrix of primary inputs for every productive sectors post-listing in the first quadrant. The third quadrant represent the ‘earnings’ such as household income or capital. Lastly, the fourth quadrant highlights the purchase of primary inputs by each classification group of final demand. A technical coefficient matrix is then formed to transform the transaction table into a functional I-O model. In this way, the technical coefficient matrix will highlight the amount of inputs required for every unit of output (production). For this paper, the technology is assumed to be homogenous (whereby possibilities of economies or diseconomies of scale are excluded), and there is zero elasticity of technical substitution. The matrix of technological coefficients therefore omits the consideration of imports to the domestic production (this may lead to a disproportionate equilibrium of impacts estimation when import leakages are discounted in the apportion of cost structure. E.G: energy imports or foreign attributable cost of production). When applying Cobb-Douglas (C-D) forms of production function, tourism production function in the incorporation of endogenous energy efficiency can therefore be specified as Li and Lin (2017) expression:

$$P = A \cdot K^{\alpha} L^{\beta} (\tau E)^{1-\alpha-\beta} \tag{2}$$

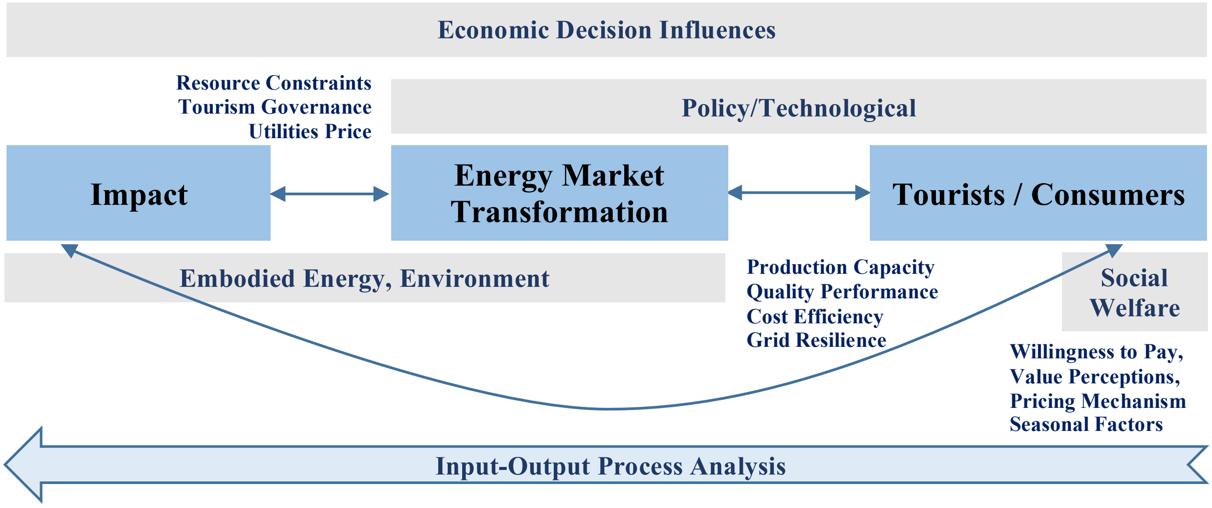
whereby:

$$\begin{aligned} \tau \quad &= energy\ efficiency \\ \alpha \quad &= capital \\ \beta \quad &= labour\ elasticity\ (cost\ of\ production) \\ 1 - \alpha - \beta &= energy\ services \end{aligned}$$

Methodology

To illustrate the interdependencies between tourism economic performance with embodied energy potentials in tourism sectors, the IO analysis employs the assumption of tourism poverty relationship. Since most of the embodiment studies in past literatures assume a competitive energy resource and consumer purchasing power parity, the case study considers only the impact of embodied energy during different seasonal visits. Seasonal visits reliance is identified to be an important determinant of a geographic energy security or energy constraints (that is influenced by policy or technological change instruments). It is clear that a poor tourism economic performance faces great exposure to risks of exogenous supply shocks. On the other hand, this assumption avoids a full evaluation of energy resilience in the tourism industry. As espoused in other works (EEA, 2017; Hu, Guevara and Domingos, 2017; Gui, and Zhang, 2017), the concept of decoupling energy-resource use can show the relationship between energy infrastructure and resource capacities (as well as production technologies factors). Inherently, this simulates a non-competitive market when the tourism economic performance is studied based on two different tourist visitation scenarios: 1) High Season and 2) Low Season. Figure 1 illustrates the inverse perspective of identifying potential embodied energy effect changes (or energy performance shocks) that exists in the energy and electric infrastructure that accommodates the tourism production and consumption trade flows.

Figure 1: IO Analysis Framework to Assess Embodied Energy Potentials in Tourism Activities



Variables and Data

In this paper, the statistical database "SIE-MAC" covering electric energy consumption attributable to tourism by Portuguese regions is used for the year 2001 and 2002. Complemented with the availability of 2001 Tourism Satellite Account for both Portuguese Island (Azores and Madeira), the pairing of tourism economic performance indicators with energy-related tourism production variables are assigned in the IO table for analysis. The inputs variables used are electric energy supply and demand capacity, as well as tourism economic performance (by visits rate and CPI index). The comprehensive energy or electric attributable to tourism is used as the main proxy for energy inputs. For a detailed data processing, Table 2 shows the statistical description of the variables.

Results and Discussion

Table 2 shows the paradoxical relationship of the roles of energy efficiency and structural change (mainly tourist consumption and production behaviours). These interdependencies stem from different definitional and 'importance' factor (that will be decided by the decision makers). Energy efficiency, for example can be expressed as the amount of energy required per unit of production output. This is expressed by the electric energy consumption attributable to tourism activities. Technically, the annual total production of electrical energy in both islands predisposes the ratio between raw energy input and useful energy resource made available. This allows a comparison to the energy intensity for tourism and non-tourism related factors of production.

Table 2: Key Variables[1] Assigned from Macroeconomic Tourism Statistics

Year	Region Island	Visits Rate[2]	Production of Electrical Energy (Mwh)	Electric Energy Consumption Attributable to Tourism Activities[3] (Mwh)	Electricity Consumption by Whole Island (Mwh)	National Average Electricity Prices Per Kwh[5]	Consumer Price Index[6]
2001	Azores	276, 178	559, 156.90	2, 929.48	485, 201.00	0.1256	3.09
	Madeira	856, 241	637, 723.00	38, 273.08	467, 920.00 (Yr 1998)[4]		4.07
2002	Azores	284, 868	600, 890.10	3, 034.98	525, 800.00	0.1262	5.41
	Madeira	852, 387	666, 382.30	39, 708.87	549, 700.00 (Yr 2000)[4]		8.75

Legend:

[1] Key variables selected for embodied energy potentials are identified at tourism-related sectors of production that is inclined to high energy consumption.

[2] Visits rate calculated by number of tourists per overnight stays.

[3] Estimate of energy consumption establishes approximation of degree of pressure exerted by tourism on the energy capacity available in the region.

[4] For Madeira Island, data was unavailable by SIE-MAC (including other period of years). Hence, we obtain the next-best information made available at other database to allow for the closest approximation of different statistics in electricity consumption at two different periods. Noting that Madeira population continue to increase with an exponential growth in electric energy production (Duić et al., 2003). Year 2001 data uptakes year 1998 data from FED (p.13), whereas for year 2002 data, we analyze year 2000 data from AREAM (p.38).

[5] Portugal annual average electricity prices for households per kwh for year 2000-2001 (Pordata, 2016).

[6] CPI: Includes restaurant and hotels facilities

If we use the standard Leontief method to calculate the embodied energy trade flows, the equation extends from the basic description where total output (P) as a function of final demand (y). The identity matrix (I) and technical coefficient matrix (A). Then, this inter-industry requirements will be denoted by Leontief's inverse feature of $(I-A)^{-1}$. By considering this fundamental IO perspective and earlier equation (2), a row vector $(\tau E)^{1-\alpha-\beta}$ of embodied energy associated with each tourism-related sector is expressed by:

$$e = (\tau E)^{1-\alpha-\beta}(I-A)^{-1}y \tag{3}$$

$$E^{nematrix} = E^{neintensity} P^{per\ unit\ of\ output\ (kwh)} \tag{4}$$

$$P^{per\ unit\ of\ output\ (kwh)} = (\Delta x_i' p_i + \Delta s) - \vartheta PE(\chi E) - 1 \tag{5}$$

whereby:

$\Delta x_i' p_{i/xE}$ = price of goods and services p_i different from energy supply p_i and $_{xE}$ is total amount of energy capacity available (kwh).

Δs = cost of energy savings for tourist operators or tourists income elasticity

$-\vartheta PE(\chi E) - 1$ = price elasticity of electricity prices that responds to energy capacity available (after energy efficiency measures)

Hence, the direct rebound effect wherein Δ (changes) of potential embodied energy in tourism trade flows is defined in simplest notion of:

$$\Delta xE = \left[1 - \frac{Actual\ Energy\ Savings}{Potential\ Energy\ Savings}\right] \cdot 100 \quad (6)$$

$$\text{Total Rebound Effect} = \left[1 - \frac{\Delta \dot{E}_{P(T)}}{\gamma \cdot a_{e_{kwh}}}\right] \cdot 100 \quad (7)$$

whereby:

$\Delta \dot{E}_{P(T)}$ =proportionate change in energy used for production P in the whole tourism (T) trade

$\gamma \cdot a_{e_{kwh}} =$ a is the share of initial energy production used in kwh in base year or annual load.

With reference to Hu, Gui and Zhang (2017) model calibration, if the row vector $e(1)$ is used to represent the direct energy impact coefficient of energy matrix, then the equation for the potential energy efficiency measures of a region to satisfy the final demand Y is $\mathrm{P = EX = E(1 - A)\ (I - A)^{-1}y}$. This equation is then transferred as P/Y= $\mathrm{E(I - A)^{-1}}$ wherein embodied energy efficiency potential E^{mbee} of each product sector is P= $\mathrm{E(I - A)^{-1}}$+ Δs^{ene}. Alternatively, this can be computed in different terms from the transfer of equation 6:

$$\mathrm{E}^{mbee} = \mathrm{E(I - A)^{-1}} + \Delta xE \quad (8)$$

When accounting changes in visits patterns (tourism season), that induces a change in final demand of tourism production and consumption patterns, a budgeted equilibrium at a fixed electricity prices and constant tourist income standpoint suggests:

$$\sum_{i=1}^{n} x_i' p_{i/xE} = y - [1 + (-PE(\chi E) - 1] + \Delta \mathrm{s}) \quad (9)$$

Technically, the annual total production of electrical energy in both islands is predisposed the ratio between raw energy input and useful energy resource made available.

This allows a comparison to the energy intensity for tourism and non-tourism related factors of production. The research explored how embodied energy changes occurs between year 2001 and 2002. The years for which with reasonable data assist in the identification of main factors that contributes for energy efficiency measures. The direct relationship between energy use (or kwh electricity attributable to tourism-related sectors) is further illustrated in Table 3.

Table 3: Summary of Output and Embodied Energy Potential Impact

Tourists Occupancy Season	Energy / Electricity Consumption Δ	Energy / Electricity Production Market Δ	Electricity Prices Δ[7]	Tourists WTP / Purchasing Power[8]	Rebound effect wherein Δ of potential embodied energy demands incorporation of energy-efficiency measures
High	Increase	Competitive with intermittency risk	Flexible	Decrease	Unlikely to occur
Low	Decrease	Flexible	Fair	Increase	Likely to occur

Legend:

[7] Electricity prices can be traded depending on contract offered by utilities for tourism operators (e.g. accommodation, services). In the case where energy management systems are implemented, cost of energy services can be more affordable for both tourism operator and less risky to be absorbed in final cost of output for tourists end-use energy consumption (mainly, embodied energy potential which can exists in the production and consumption process of tourism goods).
[8]WTP: Willingness to pay – that is affected by final cost of product and services outputs supplied by tourism operators and producers entities. Purchasing power can be affected.

The input-output model perspective applied in this study took assumptions of an independent energy sector, whereby inputs from the rest of the economy to the energy sector are disregarded by nature. Differing with full IO analysis scale, the partial assessment of this IO model inherit separate accounts wherein only electricity is treated as the primary energy transaction. The changes in energy production levels and liberalization of Portuguese electricity markets poses an interesting insight within the energy and tourism market transformation taking place during year 2000 and year 2001.

Firstly, the electricity directive 96/92/EC introduced opportunities for a competitive choice of energy suppliers (Ferreira et al., 2007). This liberalized system freed third party access in the electricity prices market regime. Following to year 2001, a protocol agreement is formed between the Portuguese and Spanish authorities. This significant development known as the Iberian pool for electricity wholesale trade commenced at year 2003, which then widened the trading options for energy market prices. Though, several political and technical operations persist with a challenging electric grid infrastructure to accommodate the feed-in of renewable energy sources that is resilient and accessible; the tourism industry continue to prosper with the inception of eco-tourism development initiative at year 2003. Thus, a ‘somewhat’ sustainable transformation among energy and tourism industry had preceded to take place before the year 2003. Robaina-Alves et al. (2016) study had shown that gross value added in tourism and internal tourism consumption continue to registered annually since year 2000, despite the stagnation of economic infrastructure and introduction of new technology change to facilitate the ‘efficient use of resources’ momentum change.

Analogously to basic IO analysis, the potential embodied energy efficiency effects among the sectors of tourism trade flow will increase and/or decrease proportionally to the total final demand and/or output of the direct and indirect energy savings and induced electricity prices.

Figure 2: Partial input-output table of embodied energy efficiency effects in tourism trade

	Tourism sectors of production	Direct embodied energy demand	Energy efficiency savings	Electricity market prices	Total output
Tourism sectors of production	$\begin{matrix} FP_{11} & \cdots & FP_{1r} \\ \vdots & \ddots & \vdots \\ FP_{r1} & \cdots & FP_{rr} \end{matrix}$	$\begin{matrix} E_{1(\tau E)^{1-\alpha-\beta}} & \cdots & E_{2(\tau E)^{1-\alpha-\beta}} \\ \vdots & \ddots & \vdots \\ E_{1(\tau E)^{1-\alpha-\beta}} & \cdots & E_{2(\tau E)^{1-\alpha-\beta}} \end{matrix}$	$\begin{matrix} S_1 \\ \vdots \\ S_r \end{matrix}$	$\begin{matrix} x'_1 p_{i/xE} \\ \vdots \\ x'_r p_{r/xE} \end{matrix}$	$\begin{matrix} P_1 \\ \vdots \\ P_r \end{matrix}$
	$\boldsymbol{FP_\theta}$	$\boldsymbol{E_{(\tau E)^{1-\alpha-\beta}}}$	$\boldsymbol{S_{ene}}$	$\boldsymbol{x'_i p_{i/xE}}$	$\boldsymbol{P}$

The evaluation of direct and indirect energy (denoted by electricity kwh consumption) demands a thorough energy analysis (including exergy assessment) of the energy conversion, extraction, and distribution in the production process of tourism value chain. The calculation of final energy cost of goods (or final income spending for the purchases of tourism goods and services) is influenced by the changes of electricity market prices.

Thus, the introduction of a technical and policy coefficient matrix during changing tourism seasons under a partial scenario assumptions during a short term projection IO analysis shows final output $\boldsymbol{P}$ as:

$$\boldsymbol{P} = \underbrace{[(\boldsymbol{x}_i'\boldsymbol{p}_{i/xE}\times\boldsymbol{V}^{occupied})}_{\substack{\text{Final goods \& services}\\ \text{purchased based on}\\ \text{tourism occupancy \& post}\\ \text{energy-efficiency regime.}}} + \underbrace{\boldsymbol{T}^{FP}\boldsymbol{P}^{FP} + \boldsymbol{S}_{ene}]}_{\substack{\text{Total factor of productions}\\ \text{classified by tourism-related}\\ \text{sectors. Total energy savings}\\ \text{obtained by each demand from}\\ \text{productive sectors to produce one}\\ \text{unit of output.}}} - \underbrace{\boldsymbol{FP}(\boldsymbol{E}_{(\tau E)^{1-\alpha-\beta}})}_{\substack{\text{Total direct embodied}\\ \text{energy flows to produce}\\ \text{one unit of output}}} + \underbrace{\boldsymbol{d}}_{\substack{\text{Demand from}\\ \text{open sector}\\ \text{(i.e. non productive}\\ \text{industry - e.g. heritage}\\ \text{assets)}}} \quad \textbf{(10)}$$

Limitations

Partial IO analysis can provide empirical policy and technical changes that endows ‘timeliness’ in market changes of an industry. The evaluation of energy efficiency savings opportunities, and identification of embodied energy flows in tourism production sectors provides some future considerations that needs to be addressed:

Issue 1: Disregard for the levels of energy use: The application of the current study does not clearly represent the primary, secondary, useful and service levels of energy use (this includes the source of electricity consumption). However, as the attributable electricity consumed is specifically recorded in the sustainable tourism micro-statistics database, the selection of the variable suits the current aim of this research (without the extrapolation of ‘feasibleness’ to apply the model for wider impact case studies).

Issue 2: Lack of energy efficiency indicators: The total energy produced in the island and total energy requirement matrices insufficiently provides a full-scale information about the phases of production where energy efficiency improvement measures can be assign. The latter means that indicators of energy efficiency (including energy savings variables) can be extended with the combination of environmental indicators (e.g. carbon footprint). That is, widely used in environmentally extended input output modelling approaches.

Issue 3: Limited detail of energy intensity sector with response to tourism demand patterns: The quality of partial IO analysis can be improved with a more precise detail representation of energy-related industries and tourism sectors of production or consumption. In this regard, the energy extension for input-output modelling calls for the additional pairing of indicators obtained from the Energy Satellite Account or separate Energy Database that is made available. PORDATA, in this case; had provided additional reference for the electricity market prices.

In spite of these limitations, the partial IO analysis remains to show potential if this method is applied with complementary assessment methods. structural decomposition analysis (for instance), helps to incites clearer answer of the remaining questions:

1. What factors influences changes in energy consumption and how does electricity prices responds to that effect?
2. How much of electricity price changes effect can be attributed to final-demand shifts (cost of production and energy services will change as well).
3. Which phase of final-demand shifts to accommodate tourism goods and services as well as when does technology changes is primarily contributing for energy efficiency measures?

Conclusion

The partial IO assessment approach offers a simple understanding and intuitive workflow of aggregating the parameters and assumptions made underlying realities of sustainable market transformation. This research uncovered some data limitations that potentially led to a counter-productive conclusion. Yet, the unconventional empirical analysis based on direct source of knowledge extracted from the meta-analysis of theoretical application in IO model as well as various 'up-to-date' sources contributed a lever in detecting systemic problems in the choice of indicators and assumptions made. To overcome the potential limits of the partial IO approach, it is important to develop more complex descriptions of the functioning of this model in two three different economic scenarios. 1. Classical economic concerns, 2. Modern economies, and 3. Evolutionary economic modelling (that is briefly exemplified in this paper). The study had shown the pressure of resource efficiency is essential for continued development in tourism socio-economic welfare development. The emergence of energy efficiency measures, and sustainable tourism initiatives (in particular), recognizes the prevailing need to assess the impacts of the policy priorities that had been planned for this aims. At the most basic level, IO analysis had successfully captured the assessment of direct, indirect, and induced impacts in varied industries with the focus of 'doing more with less' (EEA 2017).

This expression shows the relationship of maintaining socio-economic and ecological welfare that is often heavily dependent on the values and ‘endowment effect’ of a tourist and consumer in the market. Hence, to assess sustainable tourism concerns the understanding of *where* and *how* embodied energy flows in the system of production and consumption patterns. The partial IO analysis is a preliminary model that is insufficient to guarantee the reduction in environmental pressure or increase in tourism economic performance in absolute terms. However, the assessment provided a resource use for a future work to be develop concerning the area of energy or environment impact assessment. Where energy impacts and environmental pressures can be alleviated from the resource consumption patterns, this complex relationship of ‘impact decoupling’ from the tourism market behavioural trend significantly shows the deviation of economic conditions and variation in theoretical assumptions made to approximate the accurateness of a model. An integrated assessment of IO analysis in the tourism market requires a caution interpretation of information based on biophysical dimensions and wise selection of multi-scale variables that characterizes the socio-economic, energy or environment interdependencies.

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References

AREAM, Agência Regional da Energia e Ambiente da Região Autónoma da Madeira,2000. Plano de Política Energética da Região Autónoma da Madeira, [Portuguese Report, EN – *Energy Policy Plan of the Autonomous Region of Madeira],* URL https://www.aream.pt (accessed 11.08.16).

Bin Su, B.W. Ang, 2017. Multiplicative structural decomposition analysis of aggregate embodied energy and emission intensities, Energy Economics 65, 137-147, ISSN 0140-9883, https://doi.org/10.1016/j.eneco.2017.05.002.

Duić, N., Lerer, M., Carvalho, M., 2003. Increasing the supply of renewable energy sources in island energy systems. International Journal of Sustainable Energy 23, 177-186. doi:10.1080/01425910412331290760

European Environment Agency, EEA, 2017. Resource efficiency and the low-carbon economy [WWW Document], URL https://www.eea.europa.eu/soer-2015/synthesis/report/4-resourceefficiency (accessed 10. 06. 17).

FED, Forum for Energy and Development, 2000. Renewable Energy on Small Islands [Report], URL https:// www.gdrc.org/oceans/Small-Islands-II.pdf (accessed 11.08.16).

I-M.R. Figueiras Evaluation of the Economic Impact of Tourism Expenditures in Portugal, 2015:30 MSc. Tourism Economics and Regional Development, University of Algarve

Ferreira, P., Araújo, M., O'Kelly, M., 2007. An overview of the Portuguese electricity market. Energy Policy 35, 1967-1977. doi:10.1016/j.enpol.2006.06.003

Guevara, Z., Domingos, T., 2017. The multi-factor energy input–output model. Energy Economics 61, 261-269. doi:10.1016/j.eneco.2016.11.020

Kronenberg, T., 2009. Construction of Regional Input-Output Tables Using Nonsurvey Methods. International Regional Science Review 32, 40-64. doi:10.1177/0160017608322555

Leontief, W., 1986. Input output economics. Oxford Univ. Press, New York, NJ

Li, J., Lin, B., 2017. Rebound effect by incorporating endogenous energy efficiency: A comparison between heavy industry and light industry. Applied Energy 200, 347-357. doi:10.1016/j.apenergy.2017.05.087

PORDATA - Search Environment, 2016. [WWW Document]. Pordata.pt. URL: https://www.pordata.pt/en/DB/Europe/Search+Environment/Table (accessed 01. 11. 16).

Robaina-Alves, M., Moutinho, V., Costa, R., 2016. Change in energy-related CO2 (carbon dioxide) emissions in Portuguese tourism: a decomposition analysis from 2000 to 2008. Journal of Cleaner Production 111, 520-528. doi:10.1016/j.jclepro.2015.03.023

SIE-MAC, Macaronesian Statistical Information System, [database]. URL: http://www.siemac.org (accessed 12.12.16)