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Is there Convergence and Causality between the Drivers of Energy-Related Carbon Dioxide Emissions among the Portuguese Tourism Industry?

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ABSTRACT

The various subsectors related to tourism have different impacts on the level of emissions but also different factors that contribute to these emissions. The purpose of this paper is to study: (i) Whether the various subsectors of tourism in Portugal behaved similarly in the period 1996-2009 in relation to the intensity of carbon dioxide (CO_2) emissions and for their determinant ratios. This question is studied through the convergence analysis, dividing tourism subsectors between their direct or indirect impact on tourism industry, and (ii) the prediction of the interaction between the intensity of emissions and its determinant ratios in the future. The lower divergences in tourism activities would facilitate the implementation of measures on how to mitigate CO_2 emissions at tourism industry and as a result, commit to Kyoto protocol.

Keywords: Carbon Dioxide Emissions Intensity, Convergence, Decomposition, Generalized Variance Decomposition, Impulse Response Functions, Tourism, Portugal
JEL Classifications: Q49, Q53, Q58

1. INTRODUCTION

In Portugal, as in many other countries, tourism plays a major economic role. In recent years it has had important (positive and negative) impacts socially, environmentally and economically, despite the major revenues and employment it provides. As such, one of the challenges we face is to assess the trends and changes of those impacts from a sustainable perspective. There are clear interdependencies between tourism and the environment as tourism activities depend on a natural or man-made environment and on the consumption of natural resources. On the other hand, tourism activities have environmental impacts associated with both the consumption of natural resources and the pollution caused.

The reduction of carbon dioxide (CO_2) emissions and other atmospheric pollutants constitutes a foremost objective at a global scale. The tourism industry, linked with several sectors like trade, transport, accommodation, dining and attractions, contributes to climate change namely by producing greenhouse gases (GHG) emissions. The rapid growth of tourism activities has caused a rise in tourism-related emissions, posing a great challenge to this industry (Scott et al., 2013).

Several studies suggest that it is possible to make significant reductions in pollution provoked by these sectors. Specifically for the travel industry, the inter-governmental panel on climate change estimates that about 15-20% of emissions can be reduced cost-effectively by 2020 and an additional 10% emissions reduction (around 6 $MtCO_2$) would require around $430 million investment (at an average abatement cost of $75/ton of CO_2). For the accommodation sector, Chiesa and Gautam (2009) say that it's possible to reduce carbon emissions specially by using existing mature technologies in lighting, heating and cooling that significantly improve hotel energy efficiency.

Portugal has been recently investing on its tourism industry potential: In 2011, 10.5% of its total capital investment was on tourism. According to the WTTC (2011), Portugal has been performing well above average in the world rankings in what pertains to tourism contribution to gross domestic product (GDP) or employability. However, Portugal's real growth future expectations are below the world average, which is a clear indication either of an efficacy or a strategy problem. As tourism plays such an important role in the Portuguese economy, it is important to identify and manage economic, environmental and social development activities in order not to be held back. Portugal is a country with a high potential for tourism, rich in landscapes, culture and history, with very favourable natural and climatic conditions. The Portuguese strategic plan for tourism for 2007-2015 has proposed to increase the tourism contribution to the Portuguese economy. One of the challenges is the reduction of the tourism energy consumption and CO_2 emissions. On the other hand, Portugal has integrated European Union (EU) directives and decisions related to mitigation (2008/101/EC and 406/2009/EC) into national law. Furthermore, there is national financial support and incentive systems for investments in energy efficiency and renewable energies, and more sustainable tourism practices are expected, to face the emerging tourist demand (Organisation for Economic Co-operation and Development [OECD], 2011).

Different tourism-related subsectors not only impact differently on the level of emissions but also contribute differently to these carbon emissions. Tourism contributes around 5% to global CO_2 emissions on a worldwide perspective. Whereas accommodation and other tourism activities are responsible for, respectively, 21% and 4%, transportation is responsible for 75% of the sector's emissions (air transport accounting for 50%). Although tourism is not considered a very polluting activity, tourism growth projections need to change rapidly, since tourism emissions are expected to duplicate up to 2035 (Gössling, 2013; UNWTO, UNEP, WMO,2008). As such, it is important to know what the main pollution drivers in the tourism sector are. Some of the possible factors are the following ones: The increase of energy consumption, the increase of the proportion of fossil fuels used when compared to renewable sources, the increase of tourism consumption *viz.,* total added value supplied and a greater weight of tourism activities in the economy. Other tourism-related subsectors, such as trade, telecommunications and recreational services have a strong impact on emissions.

This study has two main objectives. The first is to analyse whether the various subsectors of tourism behaved similarly in the period 1996-2009 in relation to the intensity of CO_2 emissions and for their determinant ratios, such as the carbon intensity, the share of fossil fuels on the total energy consumption, energy intensity and the importance of the sector in the economy in terms of GDP. This question is studied through the convergence analysis, for all effects decomposed dividing tourism subsectors on tourism industry. If the sectors or groups of sectors behave differently in view of these ratios they should be subject to different energy or environmental policies, or at least these differences should be taken into consideration when formulating those policies.

The convergence analysis show stochastic long-term differences among important sectors for tourism industry, which means that accumulated short-term random differences may explain if the shocks on those series persist over time. This is also of interest to energy policy makers as a random shock can reverse the direction wanted to those environmental and economic variables, namely those that increase efficiency in sectors with new cleaner technologies. Economic sectors tend to have similar behaviour in what concerns to sigma convergence, CO_2 emissions and energy intensity. Moreover, these similarities are tighter for a group of three sectors, namely Group B (accommodation and food services, transports and wholesale and retail trade), which is the most polluting tourism industry group. One can also find convergence in the economic structure for the aggregated group of six sectors (namely Group A). Therefore, there is a trend towards harmonization of sectors for the whole period, for the intensity of emissions and for energy intensity, which is evident in Group B, one of the most polluting manufacturing sectors. There is more harmonization in Group A for emissions by fossil fuel.

It is important for the Portuguese tourism industry to understand that the progressive increase of regulatory incentives may contribute to the growth of economic added value of the tourism industry, particularly in terms of incentives and public policies in order to promote investment among sectoral operators of the tourism industry. On the other hand, if there is evidence of deterministic long-term differences, it means that the deterministic random components of the series, over time, are diluted. In such situation, policy makers need not intervene, since the same series follows the desired path.

The second objective has to do with the prediction of the interaction between the intensity of emissions and its determinant ratios in the future. Their relationships and mutual influences must be included and considered in environmental and energy policies and strategies to be implemented in the tourism sector. This prediction is useful, given the lack of data on the second phase of the Kyoto protocol and on the post Kyoto period. This question is studied through a forecast error variance decomposition and impulse response function (IRF) among the variation of CO_2 emissions intensity, and their drivers or effects.

The article is designed as follows: The introductory Section 1 describes the research context, objectives and study motivation. In Section 2, we researched important literature that examines the energy-related CO_2 emissions, in the tourism industry. Section 3 introduces the investigation methodology. The results about convergence and forecast causality from 1996 to 2009 are presented in Section 4. Finally, Section 5 presents the conclusions drawn from the research findings.

2. LITERATURE REVIEW

The existence of studies in the revised literature applied to the tourism industry is scarce and it is important to identify factors that influence global changes in CO_2 emissions intensity.

Only a few studies have been published showing the relationship between tourism and economic growth, either be it bidirectional[1]

1 This means that tourism causes economic growth and economic growth causes tourism activity.

or unidirectional causality. For example, bidirectional causality is found in Europe, while in America, Latin America and Caribbean and the rest of the World is found only from GDP to tourism, according to Caglayan et al. (2012); whereas the inverse was found from tourism revenue to GDP in East Asia, South Asia and Oceania, while Asia, Middle East and North Africa, Central Asia and Sub Saharan Africa do not present any existence of causal relationship between tourism and economic growth. Moreover, unidirectional causality relationship from tourism development to economic growth was found in OECD countries by Lee and Chang (2008), while non-OECD countries presented bidirectional relationships. Cortês Jimênez (2010) focused his studies on the influence of tourism in the economic growth of Spanish and Italian regions, and demonstrated that both international and domestic tourism plays a significant and positive role in regional economic growth, even though presenting a different pattern of these effects depending on the regions. However, Chang et al. (2012) pointed out that tourism growth does not always lead to substantial economic growth.

In the tourism literature reviewed, there are some studies about energy consumption in tourism activities and its implications on CO_2 emissions and global warming, for instance, Bode et al. (2003); Ceron and Dubois (2003; 2007); Stern (2006); Scott et al. (2013); Scott (2011); Weaver (2011); Gössling et al. (2011), among others. In specific sectors associated to tourism industry, there are studies with significant policy contribution and practice changes in air travel and transport emissions reductions, and about sustainability of tourism in what concerns climate change, for example, Hoyer (2000); Becken et al. (2001); Gössling (2002); Black (2004); Lee et al. (2009); Bows et al. (2009); Martin-Cejas and Sanchez (2010); Liu et al. (2011); Wang et al. (2011); Pu and Peihua (2011); Lee and Brahmasrene (2013); Tiwari et al. (2013); Dwyer et al. (2010); Andreoni and Galmarini (2012); O'Mahony et al. (2012) among others. Other studies focus on accommodation and food services, with respect to the sources of energy used as well as the amount of energy consumed in those sectors, such as Deng and Burnett (2000; 2002); Bohdanowicz (2005); Bohdanowicz et al. (2011); Kasim (2007; 2009); Mihalič et al. (2012); Gössling et al. (2011); Kasim and Ismail (2012).

Some recent literature reports that tourism makes a significant contribution to environmental degradation with negative social and cultural impacts and habitat fragmentation, for example: Tovar and Lockwood (2008); Peeters and Dubois (2009); Dolnicar (2006); Dolnicar and Leisch (2008); Dolnicar et al. (2009); Bramwell (2011); Bramwell and Lane (2011); while other link of literature explain that climate change and environmental perceptions are likely to alter destination choice and influence tourism demand, for instance, Becken and Hay (2007); Gössling et al. (2008; 2011) Gössling (2009; 2010).

From our knowledge there are no studies for energy related CO_2 emissions in tourism industry, which use the converge analysis or decomposition variance and generalized impulse response techniques to examine this environmental problem.

In this context, it is important to mention some recent studies, which applied the convergence analysis. Liddle (2009) analysed the aggregated and sectoral convergence in the electricity intensity and energy intensity in International Energy Agency/OECD countries, Camarero et al. (2013) studied the convergence of CO_2 emissions intensity and their determinants among OECD countries over the period 1960-2008. More recently, Robaina-Alves and Moutinho (2013) joined the decomposition analysis and innovative accounting approach (IAA), that is, variance decomposition and impulse function response, to examine CO_2 emissions intensity and its effects for 36 economic sectors.

3. DATA AND METHODOLOGY

3.1. Data

All data was collected from INE (National Accounts). The most important economic activities for the tourism industry were considered, identified into six categories: Wholesale and retail trade, repair of motor vehicles and motorcycles (Category G), transportation and storage (Category H), accommodation and food service activities (Category I), telecommunications (Category JB), arts, entertainment and recreation (Category R) and others services (Categories S + T), over 1996-2009 period. This was the most recent period for which we had common data for all variables considered in this study.

These activities were chosen because statistics of Portugal in National Accounts classifies them as tourism characteristic industries. Furthermore, studies that focus on tourism activities such as Liu et al. (2011); Scott et al. (2013) regard these sectors as comprising directly or indirectly to tourism. Sectors which include hotels, restaurants and transports, or trade in general, affect the tourism activity whereas activities that provide goods and services to tourism enterprises such as telecommunications, arts, entertainment, handicraft, certain local and domestic activities, affect tourism indirectly. Therefore, apart from the inclusion of these sectors, we also opted to apply the methodology used by dividing the subsectors of tourism in two Groups (B and C), one considering the highest influence (G, H and I) and another considering the activities with a lowest influence on tourism (R, JB, S + T).

Considered groups	Code A 38 classification by statistics Portugal	Description
Group A		
Group B	G	Wholesale and retail trade, repair of motor vehicles and motorcycles
	H	Transportation and storage
	I	Accommodation and food service activities
Group C	JB	Telecommunications
	R	Arts, entertainment and recreation
	S+T	Other services activities+Activities of households as employers of domestic personnel and undifferentiated goods and services production of households for own use

We considered the driving forces (effects) resulting from the decomposition analysis developed by Robaina-Alves and

Moutinho (2013). The authors decomposed the variation of CO_2 emissions intensity in the following effects: (i) The changes in the CO_2 emissions compared to the fossil fuels consumption (denoted by CI effect), (ii) the changes in the fossil fuels consumption compared to total energy consumption (denoted by CE effect), (iii) the change in energy intensity effect (denoted by EI effect), and (iv) changes in the economic structure effect (denoted by ES effect).

These effects can be used to evaluate various points related to energy consumption and the impact of tourism sectors on the environment, through the level of CO_2 emissions. For example, we can evaluate the quality of fossil fuels and the replacement that can be done between them (through the effect CI), the ability to adopt abatement technologies and replace fossil fuels with renewable energy (through the effect CE), the energy intensity (through the effect EI) and the relative position of each tourism subsector in the overall economic activity (ES effect).

3.2. Convergence Analysis

This empirical strategy on this section follows in particular the work by Strazicich and List (2003) and the work by Romero-Ávila (2008). The novely of this study, we employed the case of convergence in CO_2 emissions intensity at tourism industry sectoral level. For that purpose, we compute the logarithm of the CO_2 emissions intensity levels for the sample of six sectors in Portugal, most important associated at tourism industry. The normalisation of sectoral-specific emissions against average emissions, allows us to distinguish sectoral-specific movements from common trends in emissions caused by global shocks, such as the dependence of the group of three most polluting sectors (concerning emissions intensity), composed mainly by tourism intensity activities.

The convergence analysis aims to see if there are stochastic differences in the long-term between driving forces related to CO_2 emissions intensity in tourism industry (six subsectors). The convergence was calculated for the variation of the emissions intensity and for the four effects referred above.

As in Boyle and McCarthy (1997) we calculated two measures of convergence: Sigma convergence and gamma convergence. Sigma convergence tracks the inter-temporal change. For each variable X it is calculated as:

$$\sigma = \left(\frac{\text{var}\,(X_{\text{ti}}) / \text{mean}\,(X_{\text{ti}})}{\text{var}\,(X_{\text{t0}}) / \text{mean}\,(X_{\text{t0}})} \right)$$

Where, *ti* is the current year and *t*0 is the 1st year (1996). If we observe a fall in this measure it means that there is sigma convergence, that is, the dispersion was reduced.

Gamma convergence has to do with the rank of the effect. For each variable X it is calculated as:

$$\gamma = \left(\frac{\text{var}\,(RX_{\text{ti}} + RX_{\text{t0}})}{\text{var}\,(RX_{\text{t0}} * 2)} \right)$$

If the value is equal to one it means that the variance is the same. If the value is far from 1, there is evidence of sector mobility and reduced dispersion for the analysed effect. In this case, the importance of the emissions intensity drivers is not the same throughout the studied period. RX is the rank of the sector in the current year *ti* or in the 1st year *t*0, for the variable X.

3.3. IAA for Granger Causality

We employ the IAA to investigate the dynamic causality relationship among the variation of CO_2 emissions intensity, and their drivers or effects. This approach includes a forecast error variance decomposition and IRF[2].

The forecast error variance decomposition explains the proportion of movements in the data series due to its own shocks as well as to shocks stemming in other variables in the study and uses a vector autoregressive regression (VAR) system to test the strength of causal relationships between the variables.

For instance, if CI effect explains more of the forecast error variance of CO_2 emissions intensity variation, then we deduce that there is unidirectional causality from CI effect to emissions intensity variation. The bidirectional causality exists if shocks in CO_2 emissions intensity variation also affect CI effect in a significant way. If shocks occurring in both series do not have any impact on the changes in CO_2 emissions intensity variation and in CI effect then there is no causality between the variables.

IRFs helps us to trace the time path of shock impacts on variables in the VAR. One can determine how much the CI, CE, EI and ES effects vary due to its shocks or to a shock in CO_2 emissions intensity variation. For example we support the hypothesis that CI effect causes CO_2 emissions intensity variation if the IRF indicates a significant response of CO_2 emissions intensity variation to shocks in CI effect.

4. RESULTS

4.1. Convergence Analysis

For variation of the intensity of CO_2 emissions, there is general sigma convergence. However, there is a period of divergence between 2003 and 2006 when sectors of Group B clearly contributed, while Group C sectors continued their process of convergence during this period. The gamma convergence analysis for the variation of intensity of emissions shows that for Group A and Group C there is some mobility of sectors, over the ranking they had at the beginning of the period. For Group B there is instability in the path of convergence, and this indicator has a value very close to 1 in 2009, which means that these sectors continue to have the same relative importance in the intensity of emissions.

For all subsectors of tourism (Group A) there is some sigma convergence between the conditioning effects of the intensity of emissions, although the path of convergence has a lot of

2 Robaina-Alves and Moutinho (2013) to a similar methodology applied to Portuguese industrial sectors, using the CO_2 emissions intensity and its determinant ratios.

instability. The effect in which there is the greatest convergence in the total period is the CI effect, although this presents a period of divergence between 1998 and 2002, thereafter it converged significantly. This group of industries has some homogeneity in the behaviour of the effects in this period as a whole (with some periods of divergence), particularly in the replacement of fossil fuels with each other, which changes the ratio of emissions from consumption of fossil fuels.

But if we analyse the sigma convergence for the other two groups, the evolution of this indicator is different. For Group B the trajectory of convergence of the effects is much more stable, being rare the years in which the variables diverge. The exception to this is the CI effect, which has large periods of divergence, although in the total period it converges. For this group, CE effect presents a very significant degree of convergence, as this value in 2009 is close to zero (0.152), which means that these sectors have had a similar behaviour in respect to the weight of fossil fuels in the total energy used.

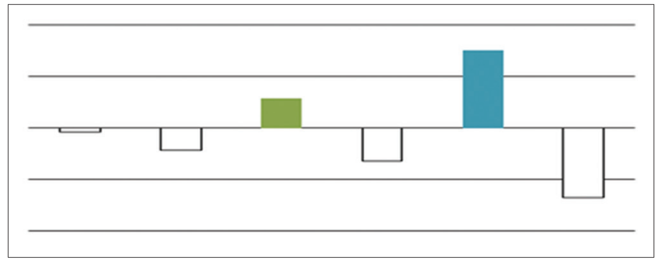
For Group C there is some convergence between effects, but EI and CI are those with greater convergence, despite having a period of divergence in 2003-2007 and 1996-1998 respectively.

Regarding gamma convergence, we can see that in Group A all ratios have a tendency to converge in the period as a whole. However, in certain periods divergence occurs, particularly for CI in 1997-1998, for EI in 2004-2006 and for CE in 2004-2008. The convergence is quite pronounced for ES and CI, the value being very close to zero in 2009. This means that for this group there was mobility and reduction of dispersion for these effects.

In Group B there is a big divergence in the CI effect with a peak in 2003 with a value of 15.25. The CE effect also diverges in the period as a whole and in 2009 the value is of 2.78. ES and EI effects follow a marked pattern of convergence in this period.

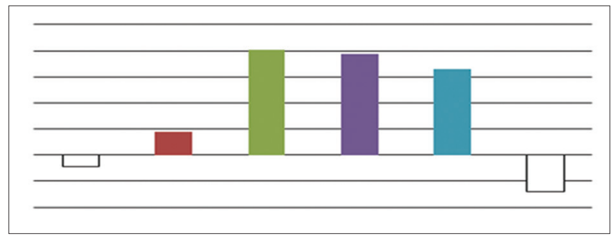
For Group C, the convergence is relevant for all effects, and only CI effect diverged significantly between 1996 and 1998, thereafter converging sharply (Figures 1-4).

Figure 1: Variation (%) of emissions intensity in tourism



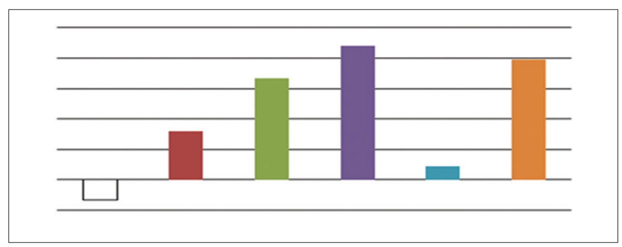
Source: Own elabration based on data from INE (National accounts)

Figure 2: Variation (%) of fossil fuels consumption by total energy consumption in tourism



Source: Own elabration based on data from INE (National accounts)

Figure 3: Variation (%) of economic structure (sector gross domestic product (GDP)/total GDP) in tourism



Source: Own elabration based on data from INE (National accounts)

4.1.1. Stochastic convergence

Univariate KPSS test results are displayed in Panel A of Table 1. Column 1 focuses on the specification with time trends, which corresponds to the notion of stochastic convergence. Among the six Portuguese tourism sectors, two sector's null of stationarity was rejected at the 5% level - wholesale and retail trade, — at the 10% level we are able to reject the null for three sectors — accommodation and food services activities, arts, entertainment and recreation and others services activities, in sum, the univariate KPSS tests point to divergence in relative CO_2 emissions intensity in all sectors associated at tourism industry.

Table 1: Stochastic and deterministic convergence

Panel A: KPSS stationarity test		
Panel A: Sectoral-specific tests	**Stochastic convergence trend**	**Deterministic convergence no trend**
Wholesale and retail trade	0.194**	0.425*
Transportation and storage	0.212*	0.392*
Accommodation and food services activities	0.186**	0.328
Telecommunications	0.212**	0.348*
Arts, entertainment and recreation	0.208**	0.391*
Other services activities	0.215**	0.377*

The 1%, 5% and 10% finite-sample critical values for the KPSS test for the specification are compared with the values computed for each time-series, which result of max lags (2) are chosen by Schwert criterion

4.1.2. Deterministic convergence

Having established the existence of stochastic convergence in CO_2 emissions intensity for Portuguese sectors aggregated for tourism industry, we shift the focus to investigate deterministic convergence in CO_2 emissions intensity. This notion of convergence allows emissions in one specific sector to move in parallel over the long run relative to average emissions intensity. As with the stochastic convergence analysis, Panel A of Table 1 shows that univariate KPSS tests we fail to reject the stationarity null at 5% significance levels for the specification without trends for three specific sectors: Transportation and storage, arts, entertainment and recreation other services activities, according the Table 1 second column. Panel B of Table 2 reports the results from the panel stationarity

Figure 4: Sigma and gamma of CO_2 emissions intensity for Groups A, B and C

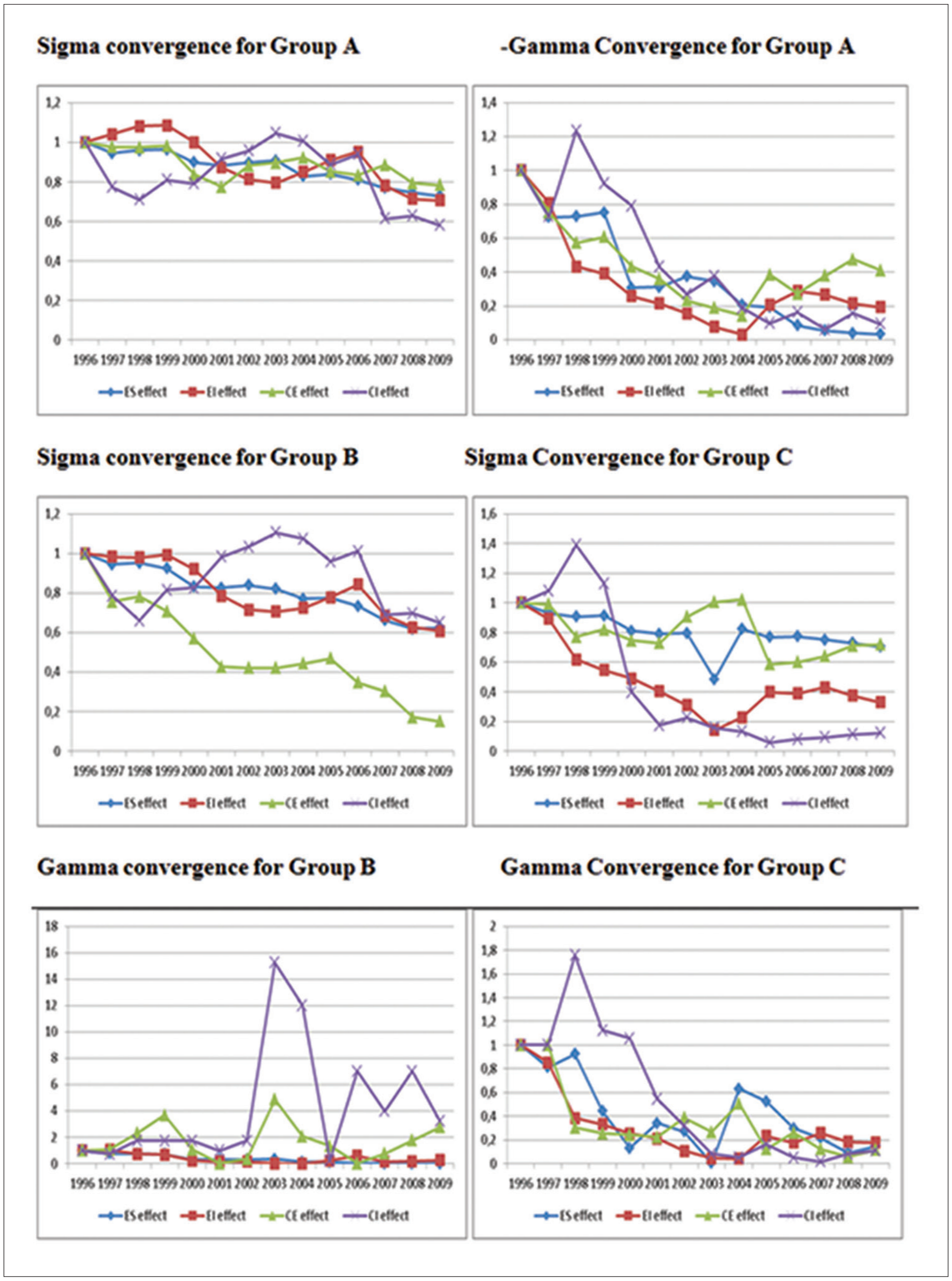


Table 2: Stochastic and deterministic convergence

Panel KPSS test	Tests	*P*-value
Panel B: Panel KPSS test:		
Specification with trends		
LM homogeneous (Group B)	3.9265***	0.000
LM heterogeneous (Group C)	4.5996***	0.000
Panel B: Panel KPSS test:		
Specification without trends		
LM homogeneous (Group B)	1.6800**	0.0465
LM heterogeneous (Group C)	2.5404**	0.0055

LM_homogeneous and LM_heterogeneous denote the panel KPSS test of Hadri (2000) for the case of homogeneity and heterogeneity in the estimation of the long-run variance, respectively. ***,** and *Imply rejection of the null hypothesis at 1%, 5% and 10%, respectively

test of Hadri (2000) for the case of cross-sectional independence, for the case of homogeneity and heterogeneity in the estimation of the long-run variance. Remarkably, we are able to reject the null of joint stationarity at the 1% significance level for the case of cross-independence.

Divergence in CO_2 emissions intensity for all six sectors associated in tourism industry was supported after strongly rejecting the null of regime-wise trend stationarity in relative CO_2 emissions intensity at the 1% level, as it can be seen in the panel KPSS test that assumed cross-independence. This is likely to be a result of the higher statistical power of the panel statistic through exploiting the cross-sectional variation of the data. This results explain that sectors associated at tourism industry with structural differences will tend to grow toward their own pollution level, while convergence becomes conditional upon country characteristics. In this case, a set of exogenous explanatory factors (in our case, the drivers of energy-related CO_2 emissions) is added in order to naturally investigate the conditional b-convergence.

Our results can be compared indirectly with other studies, like the work carried out by Miketa and Mulder (2005) that made a convergence analysis of energy productivity across 56 countries in 10 manufacturing sectors considering a period before 1995. A convergence between countries was detected, particularly for less energy intensive industries, which may be due to the differences between countries in terms of productivity in energy sector, not just by the catch-up mechanism, but also by other exogenous and country-specific factors. By studying the decomposition to understand the effects that influence the amount of energy in sectors in the various countries, Mulder and De Groot (2012) analysed only the convergence of several individual sectors in a cross country analysis for the variable energy intensity. Compared to studies carried out by Miketa and Mulder (2005); Mulder and De Groot (2012), our study was able to analyse not only the convergence in energy intensity, but also all the other ratios that explain the intensity of CO_2 emissions. Our approach is different, since the authors referred to disaggregate sectors, but consider the aggregated panel of countries, whereas we aggregate sectors in a panel and applied to a particular country. Nevertheless we made the distinction in a group where there were the most polluting sectors. Both works show the existence of specific factors to each country, which can influence the intensity of convergence. In this sense it is important to make the study of convergence to a particular country as is the case in our study.

To sum it up, given the studies that evaluated the emissions at the sectoral level, our results are accurate to the level of disaggregated information supporting the hypothesis that, in terms of emissions intensity, its main drivers are connected to different sectoral energy productivity levels. Thus, the breakdown for the subgroup of five industrial sectors tend to show the general trend of intensity rates of CO_2 emissions to the overall level of economic activity in Portugal, where convergence tends to be conditioned to specific characteristics of each sector rather unconditional or absolute convergence.

Moreover, in the near future, given the international environmental commitments, our results help to implicitly identify the underlying effects contributing to the growth of emissions intensity, in particular for Group B. We assume that in this group could be sectors that individually tend to show faster growth on average than group as a whole.

It seems also reasonable to assume that our results further support the hypothesis that industry and energy sectors with higher emission intensity may suffer from diminishing returns in energy intensities. The sectors with lower emission intensity can benefit from knowledge transfer and technology transfer, whereby the production processes can converge because of increased competition, international exposure and environmental commitments.

Table 3 presents the results for the generalized variance decomposition over a 10 years period for Group B and Group C. The empirical evidence indicates that 71.87% and 48.61% of CO_2 emissions intensity are due to their own innovative shocks respectively for Groups B and C. The standard deviation shock in EI and CI are the two effects that better explain CO_2 emissions intensity in Group B, with a percentage of 15.58 and 7.2 respectively. For Group C the most important effects are ES (21.06%) and CI (14.33%).

In Group B, a 38.2% of CI is explained by its own innovative shocks and 55.4% is explained by one standard deviation shock in emissions intensity, while in Group C, the most important influences on CI come from their own variations (56.12%), from the variations in ES (20.46%) and variations in CE (12.33%).

Variations of CE in Group B are mainly justified by changes in the variable itself (32.4%), by variations in ES (26.3%), in CI (19.3%) and in EI (16.4%). In Group C, CE changes are mainly explained by variations in ES (29.7%), in emissions intensity (24.3%), in CE (23.6%), and in EI (12.3%).

Changes in EI are strongly determined by variations in the intensity of emissions (73.2%) and in EI (14.1%) in Group B. In Group C the influence on EI is distributed primarily by CE (31.3%), by the intensity of emissions (24.3%) and by CI (24.3%).

Finally ES is influenced primarily by its own variations in Group B (87.9%) and in Group C (35.5%). In the latter, variations in emissions intensity (28.6%) and in EI (19.1%) are shown to be significant.

From this analysis we can identify some patterns of causality between variables. These patterns appear to be different for the two groups. For example in Group B we found bidirectional causality between the intensity of emissions and EI and between the intensity of emissions and CI. In Group C the bidirectional causality exists between the intensity of emissions and ES and between EI and CE.

Regarding unidirectional causality, it exists in Group B from ES, CI and EI to EC. In Group C we found stronger relationships of causality between variables, namely from CI to the emissions intensity, from ES and CE to CI, from ES and emissions intensity to CE, from emissions intensity to EI and from EI to ES.

4.2. IRF

For Group B we have the IRFs presented in Figure 11. We can see that emissions intensity reacts positively to shocks in CI and CE, and negatively to shocks in EI. The response to a shock in CE increases until the third time horizon, then becoming linear and decreasing. The reaction to ES is linear and constant.

CI effect reacts positively to shocks in emissions intensity (A) and negatively to shocks in EI. Concerning shocks in ES, the short run reaction is negative but after the second period it dissipates until the seventh time horizon becoming constant and approximately zero.

The reaction of CE to a shock in emissions intensity is negative and turns positive after the sixth period. When a shock in CI occurs, CE has a slightly negative reaction in the short run, turning

Table 3: Variance decomposition of group B and group C of Tourism activities

Period	CO_2 emissions intensity		CI		CE		EI		ES	
	Group B	Group C	Group B	Group C	Group B	Group C	Group B	Group C	Group B	Group C
Variance decomposition of CO_2 emissions intensity										
1	100.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	88.33	92.92	0.11	0.00	2.03	0.33	9.52	5.69	0.00	1.05
3	78.64	75.29	1.83	10.47	5.29	1.09	14.24	4.20	0.00	8.95
4	75.82	65.15	2.83	16.70	6.98	0.96	14.33	5.17	0.00	12.02
5	74.94	50.92	3.41	19.34	7.24	1.07	14.37	5.39	0.04	14.27
10	71.87	48.61	7.20	14.33	5.14	3.86	15.58	12.14	0.21	21.06
Variance decomposition of CI										
1	29.75	9.49	70.25	90.51	0.00	0.00	0.00	0.00	0.00	0.00
2	36.33	5.62	57.93	89.57	0.029	0.00	0.01	2.57	5.69	2.23
3	39.17	6.67	54.62	80.35	0.18	0.06	0.51	2.51	5.51	10.40
4	42.54	8.67	51.52	72.79	0.20	0.31	0.83	2.44	4.92	15.80
5	45.90	9.12	48.31	67.97	0.17	2.68	1.33	2.33	4.28	17.89
10	55.35	7.73	38.19	56.12	0.31	12.33	3.63	3.36	2.52	20.46
Variance decomposition of CE										
1	1.01	16.44	53.73	20.47	45.26	63.07	0.00	0.00	0.00	0.00
2	1.53	14.34	35.47	21.64	47.48	58.93	0.18	0.97	15.53	4.38
3	1.78	15.63	29.78	17.84	45.18	50.25	1.87	1.78	21.38	14.30
4	2.43	15.86	24.89	16.82	42.15	42.29	7.32	3.54	23.19	21.48
5	2.87	16.59	22.36	16.32	39.39	36.88	11.94	4.70	23.43	25.52
10	5.54	24.34	19.29	9.85	32.43	23.61	16.44	12.55	26.29	29.65
Variance decomposition of EI										
1	98.76	40.16	0.00	5.14	0.19	41.52	1.05	13.18	0.00	0.00
2	91.10	34.10	0.00	6.21	1.40	47.55	7.42	11.18	0.06	0.95
3	81.35	25.68	1.56	15.60	4.73	42.49	12.23	15.19	0.13	1.04
4	78.09	23.05	2.53	20.30	6.76	40.49	12.31	15.22	0.31	0.94
5	77.08	22.01	3.03	22.91	7.22	38.36	12.28	15.80	0.38	0.92
10	73.20	24.93	6.75	24.93	5.14	31.27	14.06	13.55	0.85	4.17
Variance decomposition of ES										
1	7.57	6.06	1.24	27.99	3.24	0.97	20.37	1.83	67.59	63.16
2	5.12	15.26	1.98	22.64	1.87	0.59	12.83	7.15	78.19	54.35
3	3.63	20.11	1.71	17.97	1.29	3.63	10.18	8.89	83.18	49.40
4	2.85	23.19	1.79	13.89	1.01	6.54	9.34	11.27	85.00	45.11
5	2.50	25.35	2.02	11.17	0.93	8.28	8.56	13.05	85.99	42.14
10	2.35	28.59	2.75	638	1.08	10.47	5.96	19.05	87.86	35.50

into positive in the fifth period. CE reacts negatively to EI and positively to ES.

EI reacts positively to shocks in the intensity of emissions, in EI and in CE, but in the latter case the reaction dissipates in the long run. EI has a negative but very soft reaction to shocks in ES.

ES reacts very discreetly to shocks in the other variables. Its reaction is negative with respect to EI and to intensity of emissions, and positive with CI and CE.

The results in Figure 12 show the reactions of the considered variables for the Group B tourism activities.

We confirm a positive response of emissions intensity due to one standard deviation shock in CI. The response to CE, changes from increase to decrease after the second time horizon, and maintains its level in the long run. The reaction to shocks in EI and ES is negative.

CI reacts negatively to shocks in the intensity of emissions in the short term. In the second period it becomes positive, and then negative in seventh period. CI almost does not react in the short-term to variations in CE, but after the third period the effect is negative. The reaction of CI to shocks in EI and in ES is positive.

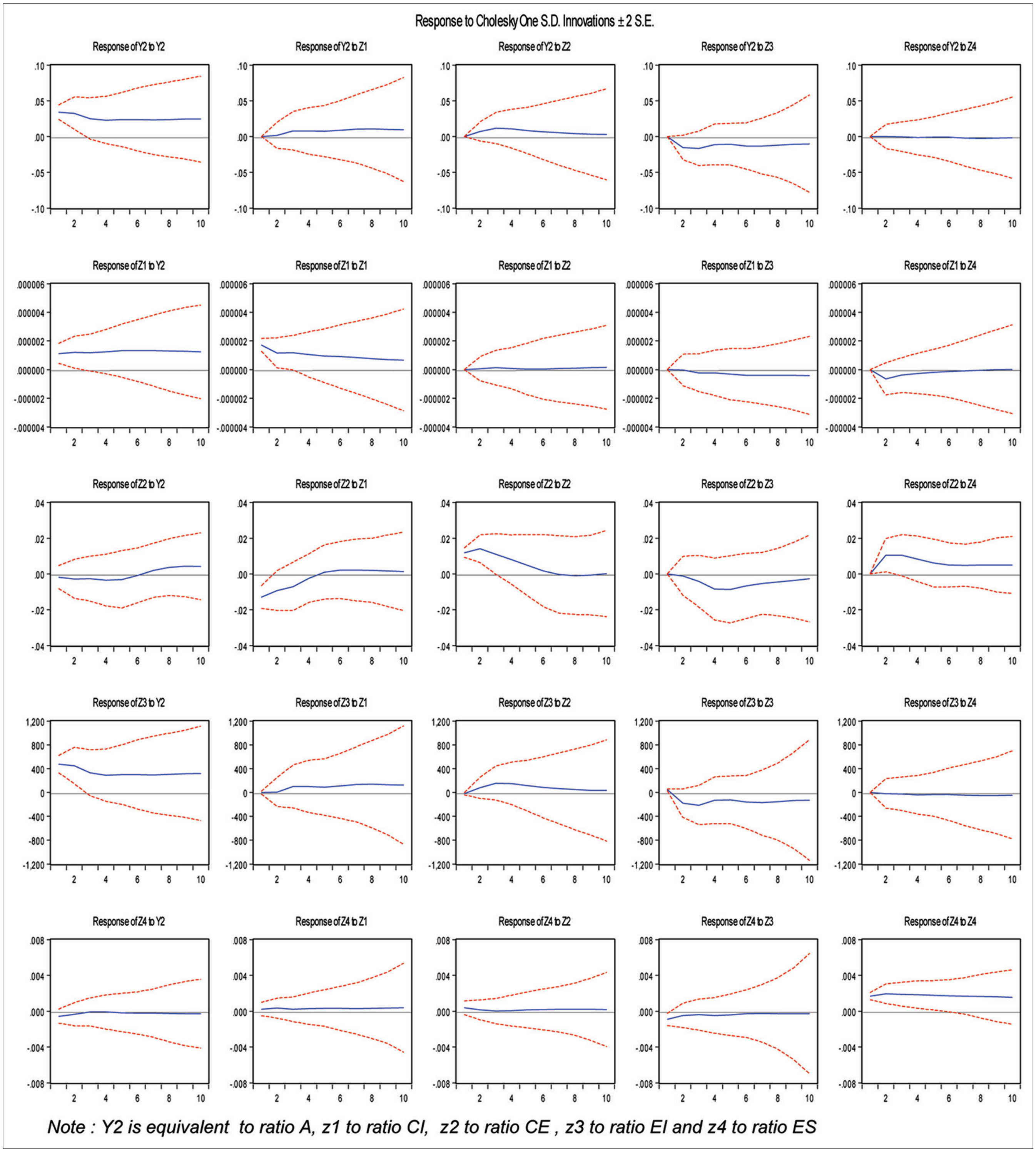
The response of CE to shocks in emissions intensity is positive and to shocks in EI and ES is negative. CE reacts negatively to shocks in CI but the effect becomes positive in the second period.

The reaction of EI to a shock in CE is negative but becomes positive at the seventh time horizon. For a shock in CI, in emissions intensity and in ES, the reaction is positive, but for the latter the effect becomes negative after the third period. ES reacts negatively to all other variables except to EI.

5. CONCLUSIONS AND POLICY RECOMMENDATIONS

The purpose of this paper is to study: (i) Whether the various sectors aggregated at tourism industry in Portugal behaved similarly in the period 1996-2009 in relation to the intensity of CO_2 emissions and to their determinant ratios. This question is studied through the convergence analysis, dividing tourism subsectors between their direct and indirect impact on tourism industry,

Figure 5: IRFs functions of Group B in Tourism Industry

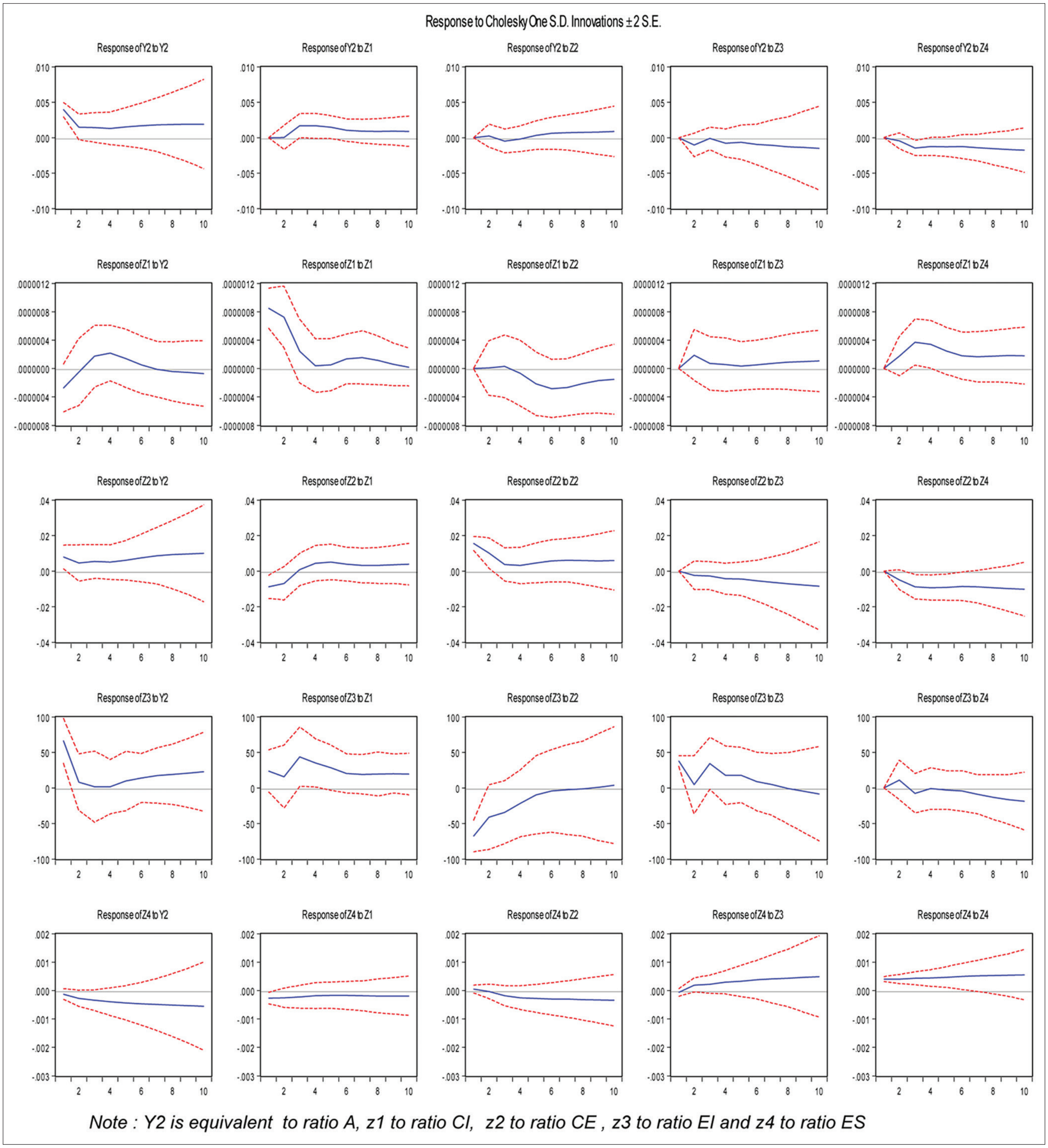


and (ii) the prediction of the interaction between the intensity of emissions and its determinant ratios in the future. This question is studied through a forecast error variance decomposition and IRF among the variation of CO_2 emissions intensity, and their drivers or effects.

Therefore, two sets of conclusions can be drawn: (i) On the convergence sigma and gamma, (ii) on the generalized variance decomposition and the IRFs.

In general it can be said that there was convergence between the sectors regarding the emission intensity. This reflects a slowdown or reduction in the most polluting sectors and an increase in the less polluting ones. However, for Group B (sectors with more direct influence on tourism) there was some divergence between 2003 and 2006. We also saw that in Groups A and C there was mobility between sectors, that is, the most polluting sectors decreased their rank on the intensity of emissions, and less polluting sectors rose in rank. In Group B we didn't find this mobility, or rather, sectors

Figure 6: IRFs functions of Group C in Tourism Industry



occupy substantially the same relative importance they had in the beginning of the period.

Concerning the effects of the determinants of emissions intensity in Group A, although there appears to be a general convergence of all effects, the carbon intensity (emissions/consumption of fossil fuels) is the effect that converges more. This means that sectors became more similar in terms of the mix of fossil fuels used. In Group B the convergence effect is even more stable, which means that in these sectors that directly affect tourism, the evolution of the determinants of emissions are very similar across sectors. This may require more specific and targeted policies for these subsectors included in Group B (trade, transportation, accommodation and food service activities). The exception is on carbon intensity, which contrary to what happened in the Group A, Group B presents periods of great divergence (despite checking the global convergence in the period). This means that the sectors in this group have a different behaviour in relation to the mix of fossil fuels used, which is related to the most appropriate fuel type in the different economic activities.

In Group C (activities affecting tourism in a more indirect way) there is convergence in general for all the effects, but most clearly in energy intensity and carbon intensity.

Regarding the rank of sectors on the effects of emissions, there is convergence in Group A, that is, there was mobility between sectors. The convergence is quite pronounced for economic structure and carbon intensity. This means that for this group there was reduction of mobility and dispersion for these effects. In Group B there is a great divergence in the carbon intensity effect and in the effect of fossil fuels by energy consumed. This means that differences between sectors persist in relation to the fossil fuels used and to the percentage of fossil fuels and renewable energy used. For Group C, the convergence is relevant for all effects, and only CI effect diverged significantly between 1996 and 1998, thereafter converging sharply.

To summarize, sectors tend to have similar behaviour, even these similarities are greater for Tourism Industry in trade, transportation, accommodation and food services activities. The lower divergences in tourism activities would facilitate the implementation of measures on how to mitigate CO_2 emissions at tourism industry and as a result commit to Kyoto protocol targets in the first phase.

When linking the conclusions about the generalized variance decomposition and the IRFs, one can notice for the Group, B that there is bidirectional causality between the intensity of emissions and energy intensity. The effect of intensity of emissions is positive on energy intensity, and the effect of energy intensity on emissions intensity is negative. This may show that the sectors are using more energy per unit of output, but are replacing fossil fuels by renewable energy.

In Group C energy intensity causes a negative effect on the percentage of fossil fuels in total energy consumption, which reflects that sectors that consume more energy became aware of change to renewable energy in the future. The percentage of fossil fuels in total energy consumption also has a negative effect on energy intensity, that is, sectors in where the percentage of fossil fuels increase, try to reduce the consumption of energy by unit produced. But in the long run this effect becomes positive with a negligible value. Intensity of emissions and economic structure have a negative relation of causality. This means that the most polluting sectors tend to reduce its economic importance and that sectors that improve their economic importance can reduce their intensity of emissions.

It was also found that in the Group B sectors, the percentage of fossil fuels used, reacts positively to the economic structure and to carbon intensity, in other words, when a sector gains economic importance, it tends to use more fossil fuels, and when it raises its carbon intensity, in the future the use of fossil fuels may rise. On the other hand, a positive shock on energy intensity tends to reduce the percentage of fossil fuels used.

In Group C, if carbon intensity raises it leads to an increment of emissions intensity. In addition, carbon intensity rises when sectors improve their economic importance. In these sectors, a positive shock in economic structure diminishes the use of fossil fuels, but the increase of emissions intensity leads to an increase in the use of fossil fuels. Emissions intensity causes a positive effect on energy intensity, and this effect in turn causes a reduction on the economic structure.

The similarity of behaviour between tourism subsectors towards emissions intensity and their determinant effects (particularly between sectors including hotels, restaurants and transports, or trade in general, that affect the tourism activity directly), could imply equal treatment, although specific to each activity, in relation to energy and environmental policies. Recapitulating Section 3.1.1, although in trade and transportation sectors emissions intensity has decreased, in accommodation and food services this variable increased in the studied period.

Of all the tourism activities, only recently was the aviation sector included in the EU Emissions Trade System (EU ETS). All other activities were excluded from this market. The aviation sector was brought into the EU ETS on January 1, 2012 through directive 2008/101/EC. For 2012 the cap on aviation allowances was set at a level equivalent to 97% of aviation emissions in the 2004-2006 reference period and 85% of allowances were given to aircraft operators for free.

The European Commission is taking the first steps to reduce the GHG emissions from the maritime transport industry. The proposed legislation (only for 2018) will oblige owners of large ships using EU ports to monitor and report the ships' annual CO_2 emissions, as well as to provide information about the ships' energy efficiency.

An agreement between the European Parliament, Council and European Commission on a further reduction in CO_2 emissions from cars is expected to reduce average CO_2 emissions from new cars to 95 g/km from 2020 (European Commission, 2012). This represents a 40% reduction from the mandatory 2015 target of 130 g/km. The target is an average for each manufacturer's new car fleet; some models will emit less than the average and some will emit more.

As already mentioned, in accommodation and food services CO_2 emissions intensity rose between 1996 and 2009. Since 2009-2010, implemented measures have been adopted under the Ecodesign and Energy Labelling Directives on energy related products. These measures reduce the energy demand of industrial and household products, and have been adopted for a number of electronic appliances, including domestic dishwashers, refrigerators, washing machines, televisions and well as tyres and industrial products such as motors, fans and pumps. The estimated impact of the adopted ecodesign and labelling measures are energy savings in the range of 90 Mtoe in 2020 (European Commission, 2013).

On the other hand, dealing with the energy consumed in the building field, in particular for heating and cooling purposes, the EU adopted a revised Energy Performance of Buildings Directive in 2010. The member states have to apply minimum energy performance requirements for new and existing buildings, and to ensure that by 2021 all new buildings are "nearly zero-energy buildings." (European Commission, 2013).

At the national level, green taxation has shown as an important instrument in the Portuguese tax system. The government implemented in 2010 a set of green tax measures, including the strengthening of environmental aspects in automobile tax, a tax on energy efficient light bulbs, and tax deductions for the use of renewable instruments. The Stability and Growth Programme foresees strengthening environmentally related fiscal measures from 2010 onwards. Proposed measures include tax rebates for electric vehicles and higher energy taxes (European Union, 2012). All these instruments affect tourism activities directly and can be justified by the causal relations and future predictions pointed above, particularly for transport and accommodation activities.

Some limitations can be drawn: First, the timeframe used in this study can be considered short, even though other studies were conducted during similar periods of time (Mulder and De Groot, 2012); secondly, the data available regarding the consumption of renewable energy per industry was found to be scarce. The added value given by the inclusion of the ratio (fossil fuel/total energy) is also very useful, although in an implicit way: It provides useful information concerning the use of renewable energy (if one sector decreases this ratio it means more renewable energy is being used). More detailed and up to date information will be useful in a near future in order to make estimates with sufficient disaggregation, using concrete values for renewable energy.

Future research could be to apply the study of Robaina-Alves and Moutinho (2013) to the tourism sector in Portugal and/or in other countries. The objective would be to complement and confront the results of the present study with another methodology, which identifies the effects in which the intensity of CO_2 emissions in tourism can be broken down and analysed, as well as their evolution and which of them has more importance in determining the intensity of emissions. This future study, through the calculation of these effects over time, could also allow us to evaluate aspects such as the substitution between fossil fuels, the substitution of fossil fuels for renewable energy sources, the energy efficiency of tourism activities as well as technology choices, investments for energy saving, and also give us signals about the diversification of tourist products among the various subsectors analysed and the preferences of the consumer.

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