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A parametric decomposition of hotel-sector productivity growth

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ABSTRACT

In this paper, we decompose hotel-sector total factor productivity growth into components attributable to changes in technical efficiency, scale effect, and technical change. The hotel-sector production Frontier is approximated parametrically using a primal approach requiring no data on output and input prices while permitting the conduction of statistical tests for the various features of the hotel-sector technology. Our empirical model relies on a flexible *translog* production function which allows to distinguish between *Hicks*-neutral and factor-biased technological progress. Using this framework, we estimate hotel-sector productivity growth and its components in a sample of 25 European countries from 2008 to 2015. Based on the empirical results, a cross-country comparison is performed and the sources of hotel-sector productivity are discussed. Finally, the implications of the study for hotel operators and policy makers are presented and a set of recommendations is developed for improving hotel sector productivity growth.

1. Introduction

With the service sector being the largest contributor to GDP in Europe and the productivity gap between the service-sector and the overall economy constantly increasing in the last years (Van Der Marel et al., 2016; Van Der Marel, 2017), service productivity issues have come to the fore of public and policy discussions within EU (European Commission, 2016; World Bank, 2016). Among the various service sectors, hospitality often takes a central role in controversies over how to raise the economic benefits from this specific industry which constitutes a robust source of revenues and domestic employment for many European countries. This interest on the performance of the hospitality industry has been mainly motivated from the broadly accepted view that hotel-sector productivity rates have been relatively low compared with other sectors of the economy (Witt and Witt, 1989; Johns and Wheeler, 1991; Sigala et al., 2005), and therefore the prospects for a rapid growth there might be extremely high. Driven from this view, World Tourism Organization recently placed productivity issues in tourism at the top of the research agenda in an effort to attract attention from researchers and enhance response actions from policymakers and hotel operators.

Yet, despite the profound interest of EU and international tourism organizations in hotel productivity issues, research to date has not kept in pace with the current challenges and needs in the industry. Indeed, until now, little is known about the true levels of hotel-sector productivity growth in most European countries and even less has been documented. In addition, the driving factors behind hotel-sector productivity growth remain largely unexplored with important implications when it comes to the design and implementation of effective policies. Both an overall assessment and a cross-country comparison of hotel sector productivity are therefore required in order to gain insights about the overall and relative competitiveness of the hotel sector across European countries. Moreover, a separate assessment of the determinant factors of hotel-sector productivity is needed as a step towards initiating proper response actions from policymakers but also from hotel operators.

Previous research in the field seeks mainly to assess hotel performance using the concept of technical efficiency with the relevant literature including more than 35 studies on this topic (Pulina et al., 2010; Anderson et al., 1999; Assaf and Magnini, 2012; Barros et al., 2010; Barros, 2004, 2005; Keh et al., 2006; Chen, 2007; Hadad et al., 2012).[2] However, while technical efficiency is an important element of economic performance providing useful information about the operation management of the hotels, it should be also acknowledged that by itself is an insufficient measure of performance reflecting only specific aspects of hotels' operation (Barros, 2005). This is because technical efficiency neglects to account for innovation and output growth which undoubtedly constitute key elements of competitiveness (Coelli et al.,

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[2] See Arbelo-Perez et al. (2017) for a recent review of the literature on hotel efficiency.

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2005). On the contrary, productivity defined as the ratio of output(s) over input(s) is a multi-dimensional measure which accounts for these aspects along with that of technical efficiency (Coelli et al., 2005; Assaf and Tsionas, 2018). Because of this important characteristic, productivity is widely perceived as the most comprehensive single measure of performance across almost all industries including the hospitality industry (Coelli et al., 2005; Jones, 2007; Assaf and Tsionas, 2018) and further as one of the most reliable indicators appropriate for comparisons (Barros et al., 2011).

Recognizing this advantage, a relatively limited number of studies has emerged in the literature using the more general concept of productivity to assess hotel performance. Within a parametric framework, Brown and Dev (2000) adopted a production approach to measure hotel productivity in a sample of US individual hotels in two prominent hotel chains. Similarly, Chen and Soo (2007) used a stochastic Frontier cost function to measure and decompose parametrically hotel productivity in a sample of 47 Taiwanese hotels. Focusing on UK, Blake et al. (2006) employed a business survey data analysis to measure tourism productivity providing also measurements for hotel productivity. However, this study follows a static approach and therefore cannot account for temporal variations in productivity levels.

There is also an increasing number of studies relying on non-parametric methods to measure hotel productivity growth. Johns et al. (1997) and Neves and Lourenco (2009) used a Data Envelopment Analysis (DEA) to benchmark productivity in 15 UK and 83 hotels worldwide, respectively, while Sigala et al. (2005) used a stepwise DEA approach to measure and benchmark hotel productivity in 300 UK hotels. There are also studies relying on the Malmquist index to analyze total factor productivity (Cordero and Tzeremes, 2017a; Jorge and Suarez, 2014; Barros, 2005; Barros and Alves, 2004; Sigala et al., 2005) and labor productivity (Cordero and Tzeremes, 2017b; Hu and Cai, 2008) at the hotel level. Finally, a few recent studies employed the Luenberger productivity indicator to measure and decompose non-parametrically hotel productivity growth at the micro-level (Peypoch and Solonandrasana, 2008; Goncalves, 2013; Peypoch and Sbai, 2011; Barros et al., 2009).

Table 1 provides a summary of the most representative parametric and non-parametric studies focusing on hotel productivity. Three important observations can be drawn from the table and the review of the literature as presented earlier. First, the majority of the work in the field focuses on efficiency measures to assess hotel performance neglecting to account for broader measures producing therefore assessments which are less useful to public policy. As discussed earlier, changes in productivity are not driven solely by changes in technical efficiency but also by innovation and output growth. This, in turn, implies that the hotel-sector in a country may perform well in terms of technical efficiency but it may lag behind in terms of productivity and vice versa. From a policy perspective, this issue is crucial since much policy-making, especially in EU (for example, EU Cohesion Policy 2014–2020; Lisbon Agenda 2000), is driven by performance considerations. Similarly, several national policies and budget allocation decisions are based on performance indicators. Hence, proper benchmarking of performance using productivity rather than efficiency indexes is important for effective policy decision-making.

Second, all existing work in the field focuses exclusively at the micro level while the few studies analyzing hotel productivity at the aggregate level are country-specific. It would be quite informative though from a policy perspective to produce hotel-sector productivity estimates for a broader set of countries using the same methodology to enable direct cross-country comparisons. This could be particularly of interest to national Tourism Departments/Ministries which assess hotel-sector performance when determining the sector progress against domestic objectives and targets. Such an analysis at the international level would also allow to illuminate features which could be missed by confining the study to a single country. One obvious example is technical efficiency. By focusing on a single country, hotels are benchmarked against the best national practice but not against the best international practice. This, in turn, may provide an overestimation of the true performance of hotels in a country and mask their full productive capabilities. Finally, important lessons can be learned from comparing hotel-sector productivity growth and its components across countries. Identifying the countries that perform better but also those that perform poorly along with the reasons behind this divergence can inform and redirect national strategies and further contribute to the spread of best practices.

Third, existing work relies almost exclusively on DEA approaches to measure and decompose productivity growth while the use of SFA

Table 1
Literature survey on parametric and non-parametric studies on hotel productivity.

Study	Methodology	Sample
Cordero and Tzeremes (2017a)	DEA approach *Malmquist index*	758 Hotels in Spanish Islands
Cordero and Tzeremes (2017b)	DEA approach *Labor productivity index*	758 Hotels in Spanish Islands
Jorge and Suarez (2014)	DEA approach *Malmquist index*	303 Spanish Hotels
Goncalves (2013)	Nonparametric approach *Luenberger productivity indicator*	64 French Ski Resorts
Peypoch and Sbai (2011)	Nonparametric approach *Luenberger productivity indicator*	15 Moroccan Hotels
Barros et al. (2009)	Nonparametric approach *Luenberger productivity indicator*	15 Portuguese Hotels
Neves and Lourenco (2009)	DEA approach	83 Hotels Worldwide
Peypoch and Solonandrasana (2008)	Nonparametric approach *Luenberger productivity indicator*	10 French Hotels
Chen and Soo (2007)	SFA approach *Cost function*	47 Taiwanese Hotels
Barros (2005)	DEA approach *Malmquist index*	42 Portuguese Hotels
Sigala et al. (2005)	Stepwise DEA approach	300 UK Hotels
Barros and Alves (2004)	DEA approach *Malmquist index*	42 Portuguese Hotels
Hu and Cai (2008)	DEA approach *Labor productivity index*	242 USA Hotels
Brown and Dev (2000)	Parametric approach *Production function*	1710 US Hotels
Johns et al. (1997)	DEA approach	15 UK Hotels

approaches is quite limited. However, although DEA approaches have the advantage of not requiring any a priori assumptions about the functional form of the production technology, they cannot control for stochastic effects and measurements errors which can significantly affect technical efficiency estimates. On the other hand, SFA approaches accommodate additionally a random variable in the estimation of the production technology treating thus deviations from the Frontier as comprising both random error (white noise) and inefficiency. This enables to distinct between a random symmetrical component which accounts for measurement errors and stochastic effects and the technical inefficiency component. This specific advantage could be of a particular importance when analyzing hotel productivity, especially at the aggregate level, since stochastic fluctuations in demand and measurement errors are likely to be large and thus can significantly affect the estimates.

In this paper, we employ a parametric Stochastic Frontier Analysis (SFA) to decompose hotel-sector total factor productivity (TFP) growth into components attributable to changes in technical efficiency (movements toward or away from the Frontier), scale effect (movements along the Frontier), and technical change (shifts in the hotel-sector production Frontier). The hotel-sector production Frontier is approximated parametrically using a primal approach requiring no data on output and input prices while permitting the conduction of various statistical tests for the various features of the hotel-sector technology. Our empirical aggregate production Frontier model is based on a flexible *translog* production function which permits to distinguish between *Hicks*-neutral and factor-biased technological change and further allows for variable returns to scale and country- and time-varying output elasticities. Using this framework, we measure hotel-sector TFP growth and its components in a sample of 25 European countries from 2008 to 2015 drawn from *Eurostat*.

The remainder of this paper is organized as follows. Section 2 presents the theoretical framework for decomposing hotel-sector TFP growth within a parametric context. This is followed by the data description, the empirical model and estimation procedures. Section 4 presents and discusses the empirical results. Finally, the last section concludes the paper and discusses recommendations for hotel operators and policy makers.

2. Theoretical framework

The hotel-sector technology in a country i in period t can be represented by the following closed, nonempty, production possibilities set:

$$T(t) = \{(k, l, y): y \le f(k, l, t)\} \tag{1}$$

where $y \in \Re_+$ denotes the output of the hotel sector, $k \in \Re_+$ is capital input, $l \in \Re_+$ is labor input,[3] and $f(k, l, t)$: $\Re_+^3 \to \Re_+$, is a continuous and, strictly increasing, differentiable concave production function, representing the maximal output from capital and labor inputs given technological constraints. Using relation (1), we may define the input correspondence set as all input combinations capable of producing y, *i.e.*, $L(y) = \{(k, l): (k, l, y) \in T\}$. The input set is closed and convex satisfying strong disposability of capital and labor inputs. Since we allow for free disposability, hotel sector output might not be maximized for a given bundle of inputs given the technological constraints. Hence, the inequality sign in the production function in (1) can be restored as:

$$y = f(k, l, t)\cdot \mathrm{TE} \tag{2}$$

where *TE* is an output-oriented measure of technical efficiency defined as:

$$\mathrm{TE} = [\max_{\theta}\{\theta: \theta y = f(k, l, t)\}]^{-1} \tag{3}$$

[3] Detailed information on the choice of inputs and outputs are presented in Section 3.

The above output-oriented measure of technical efficiency ranges in the unity interval, $TE \in [0, 1]$.[4] It goes without saying that $1 - TE$ measures the inefficiency of the hotel sector. Taking logarithms in both sides of Eq. (2), and totally differentiating with respect to time, we get:

$$\dot{y} = \dot{\mathrm{TE}} + (e^k\dot{k} + e^l\dot{l}) + \mathrm{TC} \tag{4}$$

where a dot over a variable indicates its time rate of change, $TC = \partial \ln f/\partial t$ is the rate of technical change, $e^k = \partial \ln f/\partial \ln k$ and $e^l = \partial \ln f/\partial \ln l$ are the output elasticities of capital and labor input, respectively. A measure of scale elasticity can be obtained by summing up the output elasticities of the two inputs, *i.e.*, $e^k + e^l$. Relation (4) decomposes output growth into three main components, namely, the technical efficiency effect (first term), the scale effect (second term), and the technical change effect (third term).

Following Kendrick (1961), we may define the conventional *Divisia* index of TFP growth as:

$$\dot{\mathrm{TFP}} = \dot{y} - s^k\dot{k} - s^l\dot{l} \tag{5}$$

where s^k and s^l are the cost shares of capital and labor input, respectively. Following Chan and Mountain (1983) and assuming competitive input markets, output elasticities can be related to the cost shares as: $s^k = \frac{e^k}{E}$, and $s^l = \frac{e^l}{E}$ where $E = e^k + e^l$ is scale elasticity. Plugging these relations into the conventional *Divisia* index of TFP growth and using (4) results in:

$$\dot{\mathrm{TFP}} = \dot{\mathrm{TE}} + \left(\frac{E-1}{E}\right)(e^k\dot{k}_j + e^l\dot{l}) + \mathrm{TC} \tag{6}$$

which constitutes the final decomposition formula of TFP growth. The first term in (6) captures the impact of technical efficiency changes (that refers to movements toward or away from the production Frontier) on hotel-sector productivity growth. It contributes positively (negatively) to TFP growth as long as technical efficiency improves (decreases) over time and it is zero if technical efficiency remains unchanged over time. The second term measures the relative contribution of scale economies to hotel-sector TFP growth. The term is zero under constant returns to scale while it is positive (negative) under increasing (decreasing) returns to scale as long as hotel-sector inputs increase over time and *vice versa*. The last term in (6) refers to the technical change effect capturing shifts of the technological Frontier. It contributes positively (negatively) to hotel-sector TFP growth under progressive (regressive) technical change while it is zero under no technical change.

3. Data and econometric model

3.1. Data

One problem related with the measurement of hotel-sector efficiency and productivity is the proper identification of the hotel output. This is because hotel sector supplies a quite diverse range of products and services (such as accommodation, customer satisfaction, food and beverages etc.), each of which is commonly linked with a specific operation of the hotel sector. Given that most of the hotel outputs are complex to be measured and aggregated, existing studies in the field commonly focus on specific hotel operations to assess the overall hotel performance. The choice of the operation and output variable is primarily driven by the data availability and the purpose of each study (Ball et al., 1986).

As discussed in the previous section, the measurement of efficiency and productivity in our study is based on a primal production Frontier approach that requires the use of tangible variables measured in physical units. Among the various hotel operations, accommodation can be

[4] This is an output-expanding definition of technical efficiency. For the input-conserving definitions of technical efficiency, see Kumbhakar and Lovell (2000, pp. 30–42).

directly measured in physical units which enables the measurement of productivity within a production Frontier approach. Moreover, accommodation constitutes the major operation of the hotels and therefore can serve as a representative measure of the overall hotel performance. Moreover, data on accommodation services are precisely and tactically recorded and therefore are consistently available for a broad set of countries. Hence, we use in this study aggregate measures of output and inputs related with the accommodation operation of the hotels to assess the efficiency and productivity of the hotel-sector across European countries.

The data for this study were drawn from Eurostat and include aggregate information on the outputs and inputs of the hotel sector at country level.[5] Specifically, one output and two inputs were considered in our analysis. Following the relevant literature in the field (Johns et al., 1997; Barros, 2005), output was measured as the total number of nights spent by residents and non-residents at tourist accommodation establishments.[6] This specific output indicator has some favorable characteristics which make it suitable for our analysis. Specifically, changes in the output of hotel-sector as defined above might be due to changes in inputs use, changes in accommodation practices, and changes in technical efficiency. This is fully aligned with our theoretical framework. In addition, changes in output can be also driven by changes in demand. In turn, changes in demand could be attributed to changes in hotel management at the micro-level and changes in economic and other factors at the aggregate level. Such differences in demand across countries do affect the performance and thus should be reflected in our analysis. The output indicator used here allows these differences to be captured as technical inefficiencies of the hotel-sector. This is a desirable characteristic of our output indicator since differences in demand and thus in hotel-sector output levels across countries show that the hotel-sector in certain countries operate below its productive capabilities irrespective of whether this outcome is due to higher tax rates or other country specific factors.

The two inputs considered were the capital and labor input. Capital was measured as the total number of bed places available at hotels and similar accommodation,[7] while labor was measured as the total number of persons employed in accommodation services.[8] Although we are aware that additional inputs are utilized in accommodation service, our estimation results indicate that changes in labor and capital inputs explain more than 90 per cent of the variations in hotel output. Hence, the omission of those additional inputs is unlikely to affect significantly our findings.

Eurostat provides aggregate information at sectoral level about the above variables for 36 European countries (including Turkey) for the period from 2006 to 2015. Due to missing observations on key variables for specific time periods, 10 European countries and Turkey were excluded from the analysis in order to retain a balanced panel dataset. In particular, the following European countries were excluded: Iceland, Liechtenstein, Switzerland, Montenegro, FYROM, Serbia, UK, Ireland, Lithuania, and Norway. Moreover, Eurostat provides information on the labor variable for the period from 2008 to 2015. Hence, our final dataset consists of 25 European countries covering the period from 2008 to 2015.

The 25 countries in our sample were classified into four groups according to their geographical region (*i.e.*, Mediterranean, Central-Eastern, Northwestern, and Scandinavian countries)[9] since countries in the same geographical region are likely to exhibit similar accommodation characteristics in terms of seasonability and types of tourism attracted. Next, we followed Simar's (2003) approach to detect potential outliers inside the groups. This methodology uses a non-parametric DEA/FDH approach which is more robust to extreme observations and further does not envelop all data points allowing thus to accurate group together countries which exhibit similar characteristics. Using this methodology, we arrived at results confirming the initial regional grouping. Hence, this grouping which is supported by the data is also used later for comparison purposes. Table 2 presents summary statistics of the output and inputs variables for each group of countries.

3.2. Econometric model

To obtain measurements of the various components of hotel-sector TFP growth, we needed first to specify a functional form for the production function in Eq. (2). Hotel output responses to percentage changes in inputs use may vary across countries and periods of time depending critically on the level of input utilization in each country. Moreover, technological advances in hotel sectors may favor the use of specific inputs constituting thus an additional source of productivity growth. Neglecting to account for such technological characteristics when those are present can significantly bias the estimation results. To deal with such potential sources of bias, we used here the flexible transcendental logarithmic (*translog*) production function to approximate the hotel-sector production technology. This particular flexible functional form allows for variable returns to scale, input-biased technical change and country- and time-varying output elasticities permitting at the same time the conduction of statistical testing for various features of the available technology. Specifically, the following translog production Frontier model was considered:[10]

$$\ln y_{\mathrm{it}} = \beta^0 + \beta^t t + \tfrac{1}{2}\beta^t t^2 + \beta^k \ln k_{\mathrm{it}} + \beta^l \ln l_{\mathrm{it}} + \beta^{\mathrm{kt}} \ln k_{\mathrm{it}} t + \beta^{\mathrm{lt}} \ln l_{\mathrm{it}} t + \tfrac{1}{2}\left[\beta^{\mathrm{kk}} \ln^2 k_{\mathrm{it}} + \beta^{\mathrm{ll}} \ln^2 l_{\mathrm{it}} + \beta^{\mathrm{kl}} \ln k_{\mathrm{it}} \ln l_{\mathrm{it}}\right] + \nu_{\mathrm{it}} - u_{\mathrm{it}} \quad (7)$$

where $i = 1, \ldots, N$ are the countries in the sample, $t = 1, \ldots, T$ are the time periods, β's are the parameters to be estimated, ν_{it} is a symmetric and normally distributed error term, $\nu_{\mathrm{it}} \sim N(o, \sigma_v^2)$ (*i.e.*, statistical noise), representing the omitted explanatory variables, measurement errors in the dependent variable and irregular fluctuations in demand, and $u_{\mathrm{it}} \sim N(\mu, \sigma_u^2)$ is an independently and identically distributed one-sided random error term representing the shortfall from the production Frontier due to the existence of technical inefficiency. The two error terms are assumed to be independently distributed from each other.

The temporal pattern of u_{it} refers to the temporal changes in technical efficiency over time and therefore affects the first component in (6). Following Battese and Coelli (1992) specification, the temporal pattern of technical inefficiency is modeled as:

$$u_{\mathrm{it}} = \{\exp[-\eta(t - T)]\} u_i \quad (8)$$

where η captures the temporal variation of output-oriented technical efficiency. If parameter η is positive (negative), technical efficiency

[5] Data were retrieved from http://ec.europa.eu/eurostat/web/tourism/data/database.

[6] Other variables such as total revenues and beverage revenues which have been used by other studies to proxy hotel output (Hwang and Chang, 2003) are subject to criticism. This is because such variables constitute revenue measures which account for differences in output prices which in turn might reflect differences in output quality. This implies that such measures might provide an overestimation of true productivity growth if differences in the quality of capital are not considered, as well.

[7] Alternatively, the number of establishments or the number of bedrooms could have been used to proxy capital input. Given though that those variables do not control for the size of establishments, the number of bed places was preferred as a more reliable measure of capital input.

[8] The required adjustments were made in labor input to account for differences between full time and part time employees.

[9] Mediterranean countries include Croatia, Cyprus, France, Greece, Italy, Malta Slovenia, and Spain. Northwestern countries include Austria, Belgium, Germany, Luxembourg, Netherlands, and Portugal. Central-Eastern countries include Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Poland, Romania, and Slovakia. Scandinavian countries include Denmark, Finland and Sweden.

[10] The Cobb–Douglas function was statistically tested against the transcendental logarithmic functional form using the log likelihood ratio test ($\beta^{kt} = \beta^{lt} = \beta^{kk} = \beta^{ll} = \beta^{kl} = 0$). Based on the testing results (LR test statistic = 9.60), the null hypothesis was rejected at the 10% significance level. Therefore, the translog functional specification was used to approximate the production technology since it better fits the data.

Table 2
Summary statistics of the variables.

Variable	Mean	Min	Max	Std. dev.
Mediterranean countries				
No of nights spent (y)	163,602	8012	384,630	181,098
No of bed places (k)	1927	41	5247	2186
No of employees (l)	115.72	7.93	329.58	128.11
Central-Eastern countries				
No of nights spent (y)	22,789	3470	60,925	19,387
No of bed places (k)	320	36	690	245
No of employees (l)	38.49	4.71	97.18	28.68
Northwestern countries				
No of nights spent (y)	110,150	2477	344,031	120,203
No of bed places (k)	1080	67	3303	1172
No of employees (l)	115.36	1.91	452.68	168.01
Scandinavian countries				
No of nights spent (y)	32,528	19,669	49,555	15,373
No of bed places (k)	479	234	793	286
No of employees (l)	24.93	15.29	38.59	12.16
All countries				
No of nights spent (y)	89,985	1860	422,226	128,212
No of bed places (k)	1036	30	5865	1453
No of employees (l)	80.03	1.60	504.00	110.67

All variables are measures in 000's.

tends to improve (deteriorate) over time. If $\eta = 0$, output oriented technical efficiency is time-invariant. The model in (7) and (8) that corresponds to the time-varying efficiency decay model of Battese and Coelli (1992) was estimated econometrically in one stage using a maximum likelihood estimation procedure.

Our empirical model above treats differences in background characteristics across countries as technical inefficiencies. On the contrary, one could potentially control for unobserved heterogeneity arising from differences in background characteristics across countries by adopting the "true" fixed-effects SFA model developed by Greene (2005a,b). This model allows to disentangle inefficiency from unit-specific time-invariant unobserved heterogeneity across counties. However, as noted by Greene (2005b), neither of the two formulations should be considered as proper a priori but the choice should be driven by the features of the data at hand and the purpose of each study. Given that our study is further interested to develop policy recommendations, Battese and Coelli (1992) model is more preferable than that of Greene (2005a,b). This is because the heterogeneous characteristics across countries (such as differences in tax rates, seasonability, tourism types etc) that account for differences in hotel-sector output levels indicate that the hotel-sector in certain countries operate below its productive capabilities. As such, these effects should be treated as technical inefficiencies within the context of our study.

Based on the parameter estimates of the model, the various terms on the right hand-side of (6) were estimated. First, technical efficiency was estimated as:

$$\mathrm{TE}_{\mathrm{it}} = \exp(-u_{\mathrm{it}}) \tag{9}$$

where TE is a double exponential function of time referring to the technical efficiency of the hotel sector in country i at period t. The percentage changes in *TE* were next computed to obtain a measure for the first component in (6), *i.e.*, $\dot{\mathrm{TE}}$.

Next, the output elasticities of capital and labor inputs along with a measure of scale elasticity were obtained from the estimation of relation (7) as follows:

$$e_{\mathrm{it}}^{k} = \beta^{k} + \beta^{\mathrm{kt}}t + \beta^{\mathrm{kk}} \ln k_{\mathrm{it}} + \frac{1}{2}\beta^{\mathrm{kl}} \ln l_{\mathrm{it}} \tag{10}$$

$$e_{\mathrm{it}}^{l} = \beta^{l} + \beta^{\mathrm{lt}}t + \beta^{\mathrm{ll}} \ln l_{\mathrm{it}} + \frac{1}{2}\beta^{\mathrm{kl}} \ln k_{\mathrm{it}} \tag{11}$$

where e_{it}^{k} and e_{it}^{l} denote the output elasticity of capital and labor inputs, respectively. The sum of the two elasticities provide a measure for overall scale elasticity, *i.e.*, $E = e^{k} + e^{l}$. These measures combined with the observed growth in inputs use (i.e., $\dot{k}$ and $\dot{l}$) are used to measure the scale effect component in Eq. (6).

Finally, the parameter estimates of the production function are used to obtain also a measure of the primal rate of technical change (TC) as:

$$\mathrm{TC} = \beta^{t} + \beta^{\mathrm{tt}}t + \beta^{\mathrm{kt}} \ln k_{\mathrm{it}} + \beta^{\mathrm{lt}} \ln l_{\mathrm{it}} \tag{12}$$

The rate of technical change as measured by relation (12) is positive (negative) under progressive (regressive) technical change and can be decomposed into two components, *i.e.*, neutral technical change (first two terms) and factor biased technical change (last two terms). Neutral technical change refers to technological progress that leaves inputs proportion unchanged while biased technical change refers to technological progress that favors the use of specific inputs and therefore alters the proportion of inputs used.

Table 3
Parameter estimates of the translog production function.

Par.	Est.	St. error	Par.	Est.	St. error
β^{0}	0.4375	(0.2987)	β^{kt}	0.0521	(0.0329)*
β^{k}	0.8110	(0.0851)**	β^{lt}	−0.0460	(0.0268)*
β^{l}	0.2471	(0.0863)**	β^{kk}	−0.3548	(0.1728)**
β^{t}	0.0780	(0.0410)**	β^{ll}	−0.5139	(0.1532)**
β^{tt}	0.0641	(0.0703)	β^{kl}	0.9636	(0.3009**
σ_u^2	0.0952	(0.0441)**	μ	0.5120	(0.3098)*
γ	0.6711	(0.2357)**	η	0.0031	(0.0016)*
Log Pseudo-Likelihood				28.1113	

y stands for output (nights spent), k for capital input (bed places), and l for labor input (number of employees). Clustered standard errors are reported in parenthesis. ** and * indicate statistical significance at the 5 and 10 per cent level, respectively.

4. Results

The production Frontier model in (7) and (8) was econometrically estimated in one stage using a maximum likelihood (ML) estimation procedure. The ML parameter estimates along with their corresponding clustered-robust standard errors are presented in Table 3. All first-order parameters (*i.e.*, β^{k} and β^{l}) were found to be statistically significant at the 5 per cent level having the anticipated magnitude and sign while the strong majority of the remaining parameters were statistically significant at least at the 10 per cent significance level having the expected signs, as well. Concavity of the production technology with respect to capital and labor inputs is therefore satisfied at the point of approximation implying positive and diminishing marginal products. The

Table 4
Model specification statistical tests.

Hypothesis	Restriction	*LR* test-statistic	Critical value ($\alpha = 0.05$)
Constant returns to scale	$\beta^{k} + \beta^{l} = 1$ and $\beta^{kt} + \beta^{lt} = 0$	92.4	$\chi_3^2 = 7.81$
Hicks neutral technical change	$\beta^{kt} = \beta^{lt} = 0$	105.4	$\chi_2^2 = 5.99$
Zero technical change	$\beta^{t} = \beta^{tt} = \beta^{kt} = \beta^{lt} = 0$	166.7	$\chi_4^2 = 9.49$
Average production function	$\gamma = \mu = \eta = 0$	329.3	$\chi_3^2 = 7.81$
Aigner et al. (1977) SPF model	$\mu = \eta = 0$	98.3	$\chi_2^2 = 5.99$
Time-invariant TE	$\eta = 0$	79.2	$\chi_1^2 = 3.84$

SPF stands for stochastic production Frontier model, *TE* for output-oriented technical efficiency, k for capital input, and l for labor input.

Table 5
Technical efficiency and economies of scale (average values over the 2008–15 period).

Country	TE	E	Country	TE	E
Mediterranean			*Central-Eastern*		
Croatia	69.19	1.0240	Bulgaria	44.92	0.9194
Cyprus	89.14	0.8071	Czech Republic	47.08	1.0222
France	52.55	1.2291	Estonia	51.13	0.7565
Greece	59.16	1.0757	Hungary	44.14	0.9467
Italy	56.73	1.2157	Latvia	45.53	0.7214
Malta	91.41	0.7214	Poland	66.06	0.9909
Slovenia	55.77	0.8175	Romania	44.33	0.9187
Spain	70.82	1.1613	Slovakia	41.40	0.8643
Average	68.10	1.0065		48.07	0.8925
Northwestern			*Scandinavian*		
Austria	78.78	1.0479	Denmark	61.36	0.9820
Belgium	88.30	0.9634	Finland	64.80	0.9213
Germany	65.08	1.1488	Sweden	56.35	1.0466
Luxembourg	42.19	0.8293			
Netherlands	58.48	1.0872			
Portugal	69.51	0.9727			
Average	67.06	1.0082		60.84	0.9833

efficiency-related parameters presented in the lower panel of the table were also found to be statistically significant at least at the 10 per cent level, providing empirical evidence that inefficiency was present and time-variant in the hotel sectors over the period analyzed. Finally, the overall fit of the model was highly satisfactory validating thus our choice on the inputs used and the functional specification adopted.

Before measuring hotel-sector efficiency and productivity, the basic features of the hotel-sector technology were statistically tested using the generalized *LR*-test statistic. Our results are presented in Table 4. First, the assumption of constant returns to scale was statistically examined (*i.e.*, $\beta^k + \beta^l = 1$ and $\beta^{kt} + \beta^{lt} = 0$). The testing results rejected the null hypothesis suggesting variable returns to scale which in turn indicates the presence of economies or diseconomies of scale in the hotel sectors over the period analyzed. More specifically, returns to scale were found on average to be decreasing ($E = 0.9687 < 1$) for the period analyzed implying that the average operating scale of the hotel-sector in the European countries in our sample is beyond the optimal. Next, the assumptions of zero (*i.e.*, $\beta^t = \beta^{tt} = \beta^{lt} = \beta^{kt} = 0$) and *Hicks*-neutral (*i.e.*, $\beta^{kt} = \beta^{lt} = 0$) technical change were tested by imposing the corresponding parameter restrictions in (7). Our testing results rejected both hypotheses implying a progressive and factor biased technical change in the hotel sectors. Hence, our testing results suggest that progressive accommodation practices have been adopted by hotels across Europe boosting hotel-sector performance. These improved practices are factor biased favoring the use of capital input since technical change was found to be capital-intensive and labor-saving as the later is evident by the signs of the corresponding parameter estimates (β^{kt} and $\beta^{l}t$) in Table 3.

Finally, three hypotheses concerning technical efficiency were examined. First, the null hypothesis that the traditional average production function is an adequate representation of the model (*i.e.*, $\gamma = \mu = \eta = 0$) was rejected at the 5 per cent level indicating that technical efficiency is indeed present explaining output and productivity variability among hotel sectors in Europe. Second, we tested the proposed formulation against two nested alternatives. Our testing results suggested that the estimated stochastic Frontier model cannot be reduced to that of the Aigner et al. (1977) that implies $\mu = \eta = 0$. Under the specific Frontier formulation (*i.e.*, Battese and Coelli, 1992), technical efficiency is time-varying as the hypothesis that $\eta = 0$ is rejected at the 5 per cent level of significance. Hence, changes in technical efficiency are present over the period analyzed accounting for observed improvements or decelerations in productivity growth.

Technical efficiency along with scale efficiency scores were estimated for each country in the sample. The average point estimates are presented in Table 5. On average, the hotel-sector efficiency score was found to be 60.57 per cent. Mediterranean and Northwestern countries were identified to have the highest hotel-sector efficiency scores (68.10 and 67.06 per cent) followed by the Scandinavian countries (60.84 per cent). On the other hand Central-Eastern group presented the lowest hotel-sector efficiency score (48.07 per cent). These results imply that all countries carry the potential to increase quickly their performance by improving operations management and hence their efficiency. Focusing on individual countries, our results suggest that Malta, Cyprus and Spain together with Belgium and Austria are the most efficient countries in terms of accommodation service. On the other hand, Slovakia, Luxembourg, Romania, Hungary and Bulgaria present an efficiency score below 50 per cent indicating that the hotel sector in those countries does not explore the full potential of their capabilities. Improved operations management could increase net benefits without increasing operational cost.

Focusing on economies of scale, the hotel sector in Mediterranean and Northwestern countries was found to operate close to its optimal scale (*E* is close to unity). The same holds for Scandinavian countries although the hotel sector in this group of countries is characterized by slight diseconomies of scale. On the other hand, the hotel sector in Central-Eastern countries is characterized by significant diseconomies of scale indicating that decreases in inputs use would be highly beneficial in terms of productivity for those countries. Focusing on individual countries scores, our results suggest that capital investments in hotel sector along with increases in labor use would be highly productive for France, Italy, Spain, Germany and Netherlands while the opposite is true for Malta, Cyprus, Slovenia, Luxembourg, Estonia, and Latvia. All those countries were found to operate well above their

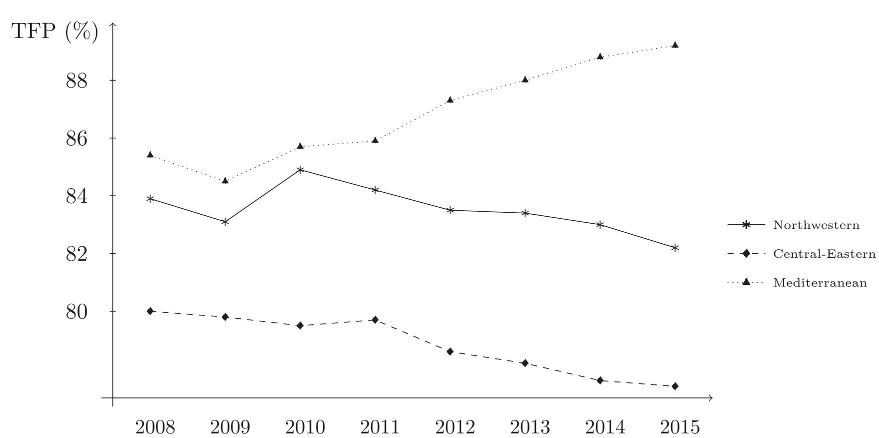

Fig. 1. Relative TFP evolution.

optimal scale. On the other hand, Croatia, Austria, Czech Republic, Poland, and Sweden were found to operate very close to their optimal scale.

Based on the parameter estimates of the *translog* production function, all components appearing in (5) along with hotel-sector TFP growth rates were estimated for every country in the sample and for each year. In order to provide a first comparison between the various counties in our sample, we first proceeded with estimating TFP as the ratio of estimated output to the weighted inputs index with estimated output elasticities serving as weights. The average TFP was next calculated for each group of countries and the group with the highest score was used as benchmark to identify the productivity performance of the remaining groups relative to the most productive one. Our results indicated that Scandinavian countries presented the highest productivity over the whole period. Hence, the group of Scandinavian countries assigned a TFP score of 100 and the relative productivity performance of the remaining groups was finally assessed.

Fig. 1 depicts the hotel sector productivity of Northwestern, Central Eastern and Mediterranean countries relative to Scandinavian countries. Our results indicate that Mediterranean countries constitute the second most productive group being approximately 11% less productive than Scandinavian countries. Northwestern countries and Central-Eastern countries follow next being 16% and 21% less productive, respectively, compared to the Scandinavian countries. Focusing on the relative evolution of hotel-sector productivity, our results provide some first evidence that Mediterranean countries tend to converge with Scandinavian countries reducing gradually the observed productivity gap. On the other hand, the decreasing trend observed for Northwestern and Central-Eastern countries indicates that hotel-sector productivity has decreased in these countries relative to Scandinavian and Mediterranean countries increasing the productivity gap between them.

To investigate whether there was enough statistical evidence to support the hypothesis of convergence between countries or groups of countries, we performed a set of $\log t$ convergence tests following Phillips and Sul (2007).[11] First, we tested the hypothesis that all countries in the sample eventually converge in terms of Hotel-Sector TFP. Our testing results rejected the null hypothesis (T-stat $= -5.1584$) failing thus to provide statistical evidence in favor of convergence. Next, we examined whether the four groups of countries converge since this possibility could not be ruled out based on the results of the first test. To do so, we repeated the test for all groups of countries rather than for all countries. Our testing results rejected again the null hypothesis implying no convergence (T-stat $= -5.3514$). Again though, the possible existence of specific convergence groups could not be ruled out based on this finding. Hence, we repeated the test for all possible pairs of groups. Our testing results indicated that Mediterranean countries converge with Scandinavian countries in terms of Hotel-Sector TFP (T-stat $= -0.1053$). However, we did not find any statistical evidence in favor of convergence in any other pair of groups (T-stat < -2.1775).

To further examine for potential productivity differences across groups of countries and across time, we also performed a set of distribution equality tests using the Epps and Singleton (1986) test.[12] First, we tested for differences in productivity distribution across time by comparing the productivity distribution of the countries in the beginning (2008) and at the end (2015) of the period under investigation. The results failed to reject the null hypothesis of equality of distributions (p-value $= 0.5439$) indicating that the distribution of hotel-sector TFP in Europe remained unchanged over this period. In turn, this implies that the productivity catch-up observed in some countries was outweighted by productivity lagging behind in other countries. Next, we repeated the test for all possible pairs of groups covering the whole period analyzed. Our results rejected the null hypothesis in all cases (p-value < 0.001) indicating significant differences across groups of countries in terms of productivity distribution.[13]

Next, we focus on the temporal variations of hotel-sector productivity and its determinants. The decomposition analysis results of hotel-sector productivity are presented in Table 6. The average annual change in hotel-sector productivity rates for all countries in the sample along with its sources is reported in the last row of the table. The estimated hotel-sector productivity is attributed to three sources: (a) changes in efficiency, (b) scale effect, and (c) technical change effect. During the 2008–2015 period, the average annual hotel-sector productivity was 0.6406 per cent. The greater share of that growth was due to improvements in accommodation practices (technical change) and a smaller share due to improvements in operations management (technical efficiency). On the other hand, the diseconomies of scale characterizing the operation of the hotel sectors in combination with the observed increases in labor and capital used decelerated significantly hotel-sector productivity rates.

Four Mediterranean countries (Croatia, Greece, Italy and Spain) along with Sweden present the highest hotel-sector productivity rates during the period analyzed with the corresponding annual average

Table 6
Decomposition of productivity growth (average values over the 2008–15 period).

Country	Changes in TE	Scale Effect	TC	TFP *Growth*
Mediterranean				
Croatia	0.1127	0.3538	0.6084	1.0748
Cyprus	0.0349	0.1858	0.5533	0.7740
France	0.1973	−0.2686	0.6262	0.5549
Greece	0.1608	0.2555	0.6065	1.0229
Italy	0.1737	0.1270	0.6209	0.9217
Malta	0.0272	−0.3401	0.5298	0.2169
Slovenia	0.1790	−0.4980	0.5558	0.2367
Spain	0.1055	0.2257	0.5874	0.9187
Average	0.1239	0.0051	0.5860	0.7151
Northwestern				
Austria	0.0728	0.0043	0.5859	0.6630
Belgium	0.0377	−0.0142	0.5907	0.6142
Germany	0.1315	0.0163	0.5704	0.7181
Luxembourg	0.2648	−0.5422	0.6204	0.3430
Netherlands	0.1644	−0.0176	0.6083	0.7551
Portugal	0.1113	−0.0311	0.5672	0.6473
Average	0.1304	−0.0974	0.5905	0.6235
Central-Eastern				
Bulgaria	0.2455	−0.1750	0.5582	0.6287
Czech Republic	0.2311	0.0337	0.5939	0.8587
Estonia	0.2057	−0.5008	0.5482	0.2531
Hungary	0.2509	−0.1713	0.5716	0.6512
Latvia	0.2413	−0.9239	0.5480	−0.1345
Poland	0.1269	−0.0079	0.5574	0.6765
Romania	0.2496	−0.0571	0.5529	0.7454
Slovakia	0.2706	−0.1665	0.5439	0.6480
Average	0.2277	−0.2461	0.5593	0.5409
Scandinavian				
Denmark	0.1496	−0.0275	0.6043	0.7263
Finland	0.1329	−0.0467	0.5904	0.6766
Sweden	0.1758	0.0366	0.6105	0.8229
Average	0.1527	−0.0125	0.6017	0.7420
All countries	0.1621	−0.1020	0.5804	0.6406

[11] The test proposed by Phillips and Sul (2007) does not require any a priori assumptions concerning trend stationarity or stochastic non-stationarity and thus is robust to the stationarity property of the series.

[12] The Epps and Singleton (1986) test has been shown to have a greater power than the Kolmogorov–Smirnov test and other distribution equality.

[13] The testing results for certain pairs of groups are suspicious given that the number of observations was quite low due to the small number of countries included in these groups which in turn decreases the power of the test.

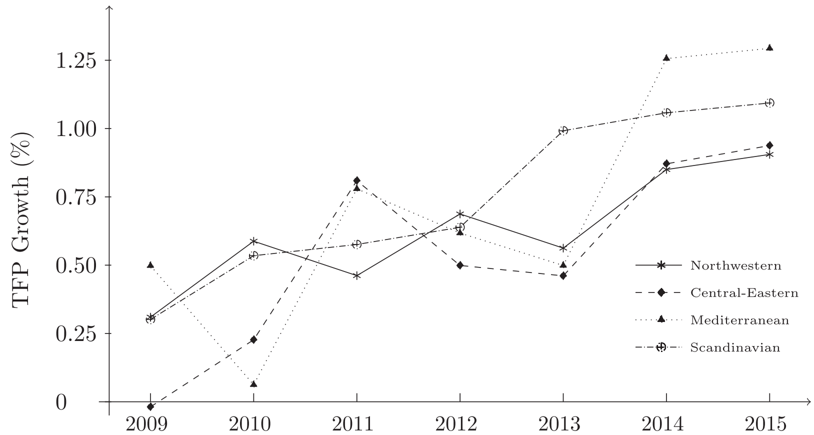

Fig. 2. TFP growth evolution.

productivity rates being 1.0748, 1.0229, 0.9217, 0.9187, and 0.8229 per cent. Those quite high gains in hotel-sector productivity rates are mainly attributable to the adoption of better accommodation practices. However, improvements in efficiency and the operation scale of the hotels in these countries were also significant determinants of productivity raising importantly hotel-sector TFP growth.

On the other hand, Malta, Slovenia, Estonia, and Latvia were found to have the less productive hotel sectors with the corresponding productivity growth rates being 0.2169, 0.2367, 0.2531, −0.1345 per cent. These low point estimates were mainly due to important diseconomies of scale which combined with the increases in capital and labor investments led to a significant productivity slowdown. This is more evident in the case of Latvia where hotel sector productivity rate turns to be negative for the period analyzed. The operation scale in those countries was already beyond the optimal and therefore the observed investments in capital and labor inputs led to lower increases in output levels causing a significant deceleration in hotel-sector productivity growth. Reductions in capital and labor use combined with improvements in operation management and practices would be very fruitful in terms of productivity for these countries.

Fig. 2 illustrates the time pattern of hotel-sector TFP growth during the period analyzed. Hotel-sector TFP growth was found to follow an increasing trend from 2008 to 2015 for all groups of countries indicating that the overall performance of the hotel sectors in Europe tends to improve over time. This is more evident after 2013 when the hotel-sector productivity growth increases constantly for all four groups. Mediterranean countries experienced productivity slowdowns in 2010, 2012 and 2013 and sharp productivity gains in the remaining period. These productivity fluctuations are also observed in Northwestern and Central-Eastern countries until 2013. On the other hand, Scandinavian countries present a more consistent performance with hotel-sector productivity growth increasing steadily for the whole period.

To gain some empirical insights about the potential effects of financial crisis on hotel-sector TFP growth, we divided our data into two financial sub-periods and next analyzed hotel productivity growth and its components separately for each sub-period. Specifically, following Cordero and Tzeremes (2017b), we distinguished two sub-periods during the crisis. The first covers the years from 2008–09 to 2009–10 which coincides with the spread of the financial crisis in Europe. The second covers the years from 2010–11 to 2014–15 which coincides with the European sovereign debt crisis period.[14] Table 7 presents information about the percentage changes in hotel-sector productivity growth and its components for each sub-period.

Our results are in line with those of previous studies indicating that the hotel sector in most European countries was able to increase its competitiveness during the financial crisis achieving the highest productivity growth rates during the sovereign debt crisis period. This result is mainly attributable to the progressive technical change observed in most countries indicating that hotels in Europe rapidly responded to the crisis by adopting better accommodation practices. Similarly, technical efficiency was found to constantly increase in all groups presenting though quite similar growth rates within the two sub-periods considered. Moreover, our results show that countries suffering most from the financial crisis (Mediterranean and Central-Eastern countries) adjusted properly the operational scale of their hotel sectors closer to their optimal level after the first sub-period which in turn enabled them to maintain their competitive position and achieve even higher productivity rates during the sub-sequent sovereign debt crisis period.

5. Conclusions and implications

In this paper, we adopted a stochastic Frontier approach to decompose hotel-sector TFP growth into three components attributable to changes in technical efficiency, scale effect, and technical change. The hotel-sector production Frontier was approximated parametrically using a primal approach requiring no data on output and input prices. The parametric nature of our study permitted the conduction of statistical tests for the various features of the hotel-sector technology which are essential for analyzing temporal variations in productivity. For the empirical approximation of the aggregate production Frontier model, we relied on a flexible *translog* production function that enables to distinguish between *Hicks*-neutral and factor-biased technological change and further allows for variable returns to scale and country- and time-varying output elasticities. Using this framework, we provided a decomposition analysis of hotel-sector productivity growth in a sample of 25 European countries from 2008 to 2015.

We found that hotel-sector productivity growth rates were indeed quite low in most European countries during the period analyzed. These low rates were partially due to relatively slow improvements in efficiency. Moreover, our results suggested that the operation scale of the hotel sector was beyond the optimal level in many European countries with the observed increases in inputs use accounting for a significant portion of the productivity slowdown. On contrary, the adoption of improved accommodation practices favored the use of capital input constituting at the same time the most important source of hotel-sector productivity growth. Nevertheless, the rate of technical change in hospitality industry is still low compared with other economic sectors. Finally, the observed differences in hotel-sector productivity growth

[14] Although the European sovereign debt crisis peaked in 2012, its effects continued after 2012 for many countries in our sample. For this reason, we included in the second sub-period the years after 2012 rather than breaking our dataset into three sub-periods.

Table 7
Percentage changes in productivity and its components during the financial crisis sub-periods.

	From 2008–09 to 2009–10				From 2010–11 to 2014–15			
	TE Ch	ScEff	TC	TFP Gr	TE Ch	ScEff	TC	TFP Gr
Mediterranean								
Mean	0.1248	−0.1078	0.2631	0.2802	0.1235	0.0503	0.7152	0.8891
Max	0.1991	1.3916	0.3668	1.7741	0.1979	1.6721	1.0083	2.4011
Min	0.0274	−1.6762	0.1406	−1.1110	0.0270	−1.9556	0.3972	−1.2739
Stdev	0.0637	0.7221	0.0743	0.6816	0.0618	0.6246	0.1887	0.6846
Northwestern								
Mean	0.1314	0.2970	0.2703	0.6987	0.1300	−0.2552	0.7186	0.5933
Max	0.2672	2.1847	0.3740	2.6919	0.2656	3.9932	0.9986	4.8869
Min	0.0380	−0.2518	0.1811	0.0683	0.0374	−3.7910	0.4338	−3.0337
Stdev	0.0762	0.7133	0.0714	0.7917	0.0735	1.2863	0.1856	1.2611
Central Eastern								
Mean	0.2294	−0.3619	0.2366	0.1041	0.2270	−0.1997	0.6883	0.7156
Max	0.2731	0.1977	0.3356	0.6943	0.2714	1.8411	0.9764	2.6446
Min	0.1277	−2.1232	0.1561	−1.7213	0.1258	−2.0991	0.4193	−1.1768
Stdev	0.0436	0.7053	0.0688	0.7196	0.0423	0.7064	0.1846	0.7077
Scandinavian								
Mean	0.1539	−0.0135	0.2776	0.4180	0.1523	−0.0121	0.7314	0.8715
Max	0.1774	0.2187	0.3509	0.7464	0.1763	0.2683	0.9892	1.4317
Min	0.1337	−0.2533	0.1999	0.2036	0.1316	−0.2666	0.4559	0.4465
Stdev	0.0195	0.1762	0.0710	0.2269	0.0182	0.1619	0.1881	0.2686
All countries								
Mean	0.1634	−0.0807	0.2581	0.3408	0.1616	−0.1105	0.7094	0.7605
Max	0.2731	2.1847	0.3740	2.6919	0.2714	3.9932	1.0083	4.8869
Min	0.0274	−2.1232	0.1406	−1.7213	0.0270	−3.7910	0.3972	−3.0337
Stdev	0.0731	0.7006	0.0710	0.7059	0.0719	0.8287	0.1850	0.8362

across countries are mainly attributable to differences in economies of scale combined with differences in practices adopted.

The findings of this study can serve as a useful guide for hotel managers, and national and EU policy makers who are looking to shape optimal operation and management strategies and develop effective policy schemes, respectively. Focusing first at the micro-level, our findings revealed significant disparities in terms of technical efficiency scores across European countries. These disparities suggest that the low efficiency scores found in certain countries are more likely to be the outcome of poor management and planning at the operational level rather than the result of a decrease in global demand for hotel occupancy. In turn, this indicates that hotels in countries such as Slovakia, Romania, Hungary and other Central-Eastern countries carry the potential to increase rapidly their competitiveness and productivity by adopting more effective operation strategies. The use of improved booking policies which would rely on computational efficient dynamic models (Badinelli, 2000) could enhance hotel yield management increasing their efficiency. The use of such models has been shown to fall within the abilities of medium size hotels. In addition, strategies aiming to handle effectively cancellations, which are known to have a great impact on hotels' output, could also increase revenues with a cost effective way. These strategies could involve the use of regular cancellation models and optimal overbooking practices which could directly increase hotels' revenues boosting their efficiency (Sierga et al, 2015; Gönsch, 2017).

Moreover, our results indicate that hotels in Scandinavian countries and in some Mediterranean countries were able to improve faster their accommodation practices than hotels in Central-Eastern countries succeeding thus higher productivity rates. This indicates that hotel managers in Central-Eastern countries can learn from these countries by adapting similar improvements and innovations which have been proven to be fruitful in terms of hotel productivity. In addition, our results suggest that hotel investors need to carefully consider the operation scale of their hotels when making their investment decisions and that these decisions are not independent of the country. International hotel chains face numerous challenges when opening a property in a foreign country. The response to those challenges and the choice of the country itself can significantly determine the new hotel's success. To this end, our findings could also help international hotel chains when considering their options in investing in foreign countries. For instance, the low efficiency scores identified in certain European countries can provide an indication that economic factors and institutions in these countries may not provide a friendly environment for operating hotel business. However, this information should not been used as a precise indicator upon which investment decisions will be based but rather as a general guide indicating the need to consider more carefully the overall environment in certain countries.

In addition, summer seasonability may have also played a role in the low efficiency scores observed in countries such as Portugal, Italy, France and other Mediterranean countries. The unequal utilization of capital input between high and low seasons in these countries suggest that hotels' capacity may remain unused for extended periods of time. In turn, this implies that hotels may experience decreased revenues during the low seasons while retaining the high fixed costs resulting thus in low efficiency levels. To deal with such decreases in efficiency due to seasonability issues, hotel managers need to offer new products directed to broader target groups including business and conference tourism and further strategies towards attracting domestic travelers which would enable them to exploit in greater extent their capital capacity during the low seasons.

At the national level, our results revealed significant differences across countries with respect to the operation scale of their hotel sector. More specifically, the scale of hotel sector in countries such as France, Italy, Spain, Germany and Netherlands was shown to be well below the optimal level implying that policies toward encouraging investments in hospitality industry would be highly beneficial for these countries. Such policies could involve the provision of direct and indirect financial incentives for business start-ups in hospitality industry including favorable loan terms, easier access to capital and tax benefits for new businesses. In addition, training seminars and other educational programs focused on hospitality services and delivered to broader audience could enable fast sectoral shifts of the labour force to the hotel sector. When combined, such policies could rapidly increase the operational scale of the hotel sector in these countries leading thus to high productivity gains.

On the contrary, countries such as Malta, Slovenia, Latvia, and Estonia were found to operate well above their optimal scale. This could be attributed to information uncertainty and information asymmetry which are known to be present within the hospitality sector and may account for market failures (Winata and Mia, 2005; Harrington, 2001; Kang et al., 2010). For these countries, policy schemes decreasing uncertainty and information asymmetries could be highly fruitful in terms of productivity. Such policies could involve measures toward enhancing corporate governance of hotels in these countries aiming to reduce information asymmetries and thus enhance decision-making and further long-run policies toward a sustainable tourism at the national level which could reduce uncertainty of future demand.

Finally, our results have also important implications at the EU level. In particular, our results suggested that hotel sector productivity growth rates are quite low within EU and therefore more attention should be drawn to strategies and policies aiming to strengthen the competitiveness of hospitality industry in Europe. Such policies could include the provision of financial support in the form of capital investments to specific member states which were found to operate below their optimal scale. In addition, EU programmes for Research and Development in tourism, which have been systematically overseen, are required as a mean to increase technological improvements in hotel sector in Europe. Such programmes should place emphasis to the development of new capital intensive practices which could directly increase hotel-sector productivity in EU. Moreover, strategies are required intended to create spillover networks in operations management between EU Members which could enable lower productive countries to catch-up the leading countries in hospitality services. Such strategies could potentially increase the efficiency of hotel sector not only in low efficient countries but in Europe as a whole. In addition, the development of multinational partners tasked with initiating the development of new products in tourism promoting the comparative advantages of European destinations could further boost hotel sector efficiency in Europe.

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