

THE INFLUENCE OF TOURIST ACTIVITIES ON AIR POLLUTION: THE CASE OF MALLORCA

Jaume Rosselló-Nadal and Óscar Sáenz-de-Miera

Universitat de les Illes Balears

Tourism brings about benefits which often enjoy high awareness from the population and government. Nevertheless, from a viewpoint of corporate management, it is important to understand tourism and its related sectors from a holistic perspective, in order to assess its net earnings, which implies the consideration of external costs as well (Dwyer and Forsyth, 1993; 1997). An important source of external costs lies in transport activities, which are crucial for the movement of passengers with holiday or leisure purposes. The increase in tourist numbers and the consequent rise of transport activities within destination countries or regions has led to an increase in the associated externalities that should be linked to the increasingly popular use of means of private transport such as hire cars (Palmer et al., 2007).

There has been wide concern, both in the literature and on the political agenda in many countries, about the external costs of road transport, and specially the emission of air pollutants which has become one of the most pressing environmental problems (Gossling et al., 2005). However, in spite of this general awareness of the need to account for the external costs of road transport, so far they have not deserved enough attention in economies where tourism plays an essential role. The failure to comprehensively account for the external costs of road transport for tourists has been mainly due to the lack of a single economic sector that can be identified with tourism.

For this reason, the purpose of the present study is to estimate models where tourism can be directly linked to levels of air pollution, especially in view of the growing proportion of overall emissions that mobile sources represent. For such purpose, the study is based on an indicator of the population stock, whose main source of seasonal variation lies in its strong tourist component, namely the Daily Indicator of Human Pressure (DIHP). This indicator was developed by Riera and Mateu (2007), in an attempt to develop a measure of the pressure from tourism in the Balearic Islands (Spain). It is a measure of the population, hence not strictly economic, that evaluates the «stock» of people that is present at any given time in the Balearic territory. This indicator considers the geography of the archipelago in order to estimate a daily measure of the population that is in the Balearic Islands, using records that are obtained from ports and airports. Thus, one can see that the high population variability throughout the year occurs in each of the islands

(Mallorca, Menorca, Ibiza and Formentera) because of the massive influx of tourists in the summer months.

The availability of daily time series data from the island of Mallorca (measured at the Bellver monitoring station), both for the population stock and for the specific pollutants considered in this study (ozone, carbon monoxide and particulate matter of 10 micrometers or less), also happens to be a crucial factor to carry out a study of this nature. On the one hand, the use of time series will be essential to capture the aforementioned seasonality on which this study focuses and it is very popular in the literature for it allows accounting for trend variables. On the other hand, daily data is one of the most common aggregation levels for studies of air pollution. This is especially relevant for the present study for it allows consideration of daily variations in the observed levels of concentration of air pollutants as well as the differences between weekends and weekdays.

Daily data are also available to include weather conditions (hours of sunshine, precipitation, relative humidity and wind speed) in the present study. These variables have stood out throughout the literature for being among the most popular predictors of the concentration levels of pollutants in the atmosphere as well as to explain the fluctuations in such levels.

Besides the availability and choice of relevant variables and their aggregation level, the estimation technique plays an important role in the study of air pollution. While regression has been a widely accepted method for this kind of studies, it is worth mentioning that during the last years there have been multiple techniques used both for explaining the levels of concentration of air pollution and for forecasting future concentration levels. When the purpose of the study is forecasting, the technique that has gained more acceptance is Artificial Neural Networks. However, it should be noted that despite their popularity, the interpretation of Neural Networks is not straightforward.

When the purpose of the study is explaining pollutant concentration levels through a set of variables, an issue to be considered when deciding the most adequate technique is the non-linear nature of the relationships between variables. For this reason, the last years have seen the popularization of non-parametric regression techniques, among which the so called Generalized Additive Models (GAM), developed by Hastie and Tibshirani (1990), have stood out.

Within the literature, there have also been works where the study of air pollution has been carried out through the use of linear regression models. While it is true that linear models are subject to the criticism that it is unlikely that the underlying chemical and physical processes are linear and additive (Thompson et al., 2001), one can argue that a first approximation of the relationship between pollutants and their determinants can be obtained by using simple regression techniques.

Thus, in order to study the influence of tourism on the concentration levels of ozone (O_3), carbon monoxide (CO) and particles of 10 micrometers or less (PM_{10}) in the island of Mallorca, the present work employs linear regression models in which the level of these pollutants are explained through the DIHP, weather related variables and day-of-the-week dummies.

According to the results and previous studies, weather variables play a crucial role in determining the concentration levels of air pollutants considered for the station of Bellver

(Mallorca). The inclusion of dummy variables for day of the week, whose purpose is to collect the different use of vehicles also proved to be very useful. It can also be seen how different levels of air pollution may be associated with the daily stock of people in the island of Mallorca, where the main source of variation of such variable is the level of tourism.

Therefore, the importance of tourism on the level of the two pollutants studied, estimated for the case of Mallorca through the daily stock of people, has shown to be a determinant which should be considered in further studies. In this sense, the difficulty of attributing externality levels of the tourism sector, given the lack of an industry as such, has been avoided by using a variable population whose main variation is attributable to tourism demand in the case of Mallorca. Thus the results of the study have allowed to place tourism as a determinant of pollution levels recorded in the last years.

Within the relevant literature no case studies that include an explicit measure of tourism were found. That's why this study has provided a first attempt, obtaining the expected positive relationship, which indicates that the increase in the population caused by tourists, leads to an increase in externalities. This is also of particular interest to the island of Mallorca, where tourism plays a crucial role.

In any case, the results presented in this work constitute a first evidence for the existence of a relationship between tourism and the concentration levels of carbon monoxide, ozone and PM₁₀. The existence of more complex structures of interaction between pollutants, or nonlinear relationships incapable of being captured with the methodology used, should not be ignored. In this context it will be necessary to continue both in the theoretical framework and in the empirical methodology to try to determine the complexity inherent to such situations.

REFERENCES

- DWYER, L., FORSYTH, P. (1993): «Assessing the Benefits and Costs of Inbound Tourism», *Annals of Tourism Research*, n° 20, pp. 751-68.
- DWYER, L., FORSYTH, P. (1997): «Measuring the benefits and yield from foreign tourism», *International Journal of Social Economics*, n° 24, pp. 223-236.
- GOSSLING, S., PEETERS, P., CERON, J., DUBOIS, G., PATTERSON, T., RICHARDSON, R. B. (2005): «The eco-efficiency of tourism», *Ecological Economics*, n° 54, pp. 417-434.
- HASTIE, T., TIBSHIRANI, R. (1990): «Generalized Additive Models», *Statistical Science*, n° 1, pp. 297-318.
- PALMER, T., RIERA, A., ROSELLO, J. (2007): «Taxing Tourism: The Case of Rental Cars in Mallorca», *Tourism Management*, n° 28, pp. 271-279.
- RIERA, A., MATEU, J. (2007): «Aproximación al volumen de turismo residencial en la Comunidad Autónoma de las Islas Baleares a partir del cómputo de la carga demográfica real», *Estudios Turísticos*, n° 174, pp. 59-71.
- THOMPSON, M. L., REYNOLDS, J., COX, L. H., GUTTORP, P., SAMPSON, P. D. (2001): «A review of statistical methods for the meteorological adjustment of tropospheric ozone», *Atmospheric Environment*, n° 35, pp. 617-630.

