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# Effects of Corruption on Efficiency of the European Airports

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**Abstract:** The effect of corruption on airport productive efficiency is analyzed using an unbalanced panel data of major European airports from 2003 to 2009. We first compute the residual (or net) variable factor productivity using the multilateral index number method and then apply robust cluster random effects model in order to evaluate the importance of corruption. We find strong evidence that corruption has negative impacts on airport operating efficiency; and the effects depend on the ownership form of the airport. The results suggest that airports under mixed public-private ownership with private majority achieve lower levels of efficiency when located in more corrupt countries. They even operate less efficiently than fully and/or majority government owned airports in high corruption environment. We control for economic regulation, competition level and other airports' characteristics. Our empirical results survive several robustness checks including different control variables, three alternative corruption measures: International Country Risk Guide (ICRG) corruption index, Corruption Perception Index (CPI) and Control of Corruption Index (CCI). The empirical findings have important policy implications for management and ownership structuring of airports operating in countries that suffer from higher levels of corruption.

**Keywords:** Corruption effects, European airport operating efficiency, Residual (or net) variable factor productivity, Ownership form, Random effects model

**JEL Classification:** L93, R40, H00

**Highlights**

- We analyze the effect of corruption on operating efficiency of European airports
- Corruption has negative impact on airport operating efficiency
- Airports under mixed public-private ownership with private majority achieve lower levels of efficiency when located in more corrupt countries
- Airports under mixed public-private ownership with private majority operate less efficiently than fully and/or majority government owned airports in high corruption environment

## 1. Introduction

This paper investigates the relationship between airport efficiency and corruption in Europe. The determinants of airport efficiency have been largely analyzed in the literature. Studies found that ownership forms (Oum, Adler and Yu, 2006; Georges Assaf and Gillen, 2012; Adler and Liebert, 2014), the level of competition (Chi-Lok and Zhang, 2009; Malighetti et al. 2009), economic regulation (Georges Assaf and Gillen, 2012; Adler and Liebert, 2014) and institutional arrangements (Oum, Yan and Yu, 2008), among others, affect the performance and productivity of airports. The impacts of corruption on airport cost efficiency have received limited attention.

To our knowledge, the study by Yan and Oum (2014) appears to be the only one that investigates the effects of corruption on productivity and input allocation of airports. Using the case of major commercial US airports, their findings reveal that corruption negatively influences airport productivity: in more corrupt environments airports become less productive and tend to use more contracting-out to replace in-house labor. Nonetheless, their empirical analyses are limited to the US airports, which have limited forms of governance. US airports are owned and operated either by a branch of government (mostly municipal or metropolitan government) or through an airport or port authority set up by government. In this study, we extend the analysis of Yan and Oum (2014) to include different forms of airport management and ownership, including mixed public-private ownership with private minority, mixed public-private ownership with private majority and fully private ownership.

In recent years, the private-sector participation in airport management and/or ownership has become a worldwide trend. Starting from the seven major airports in UK including Heathrow, Gatwick and Stansted airports in 1987, many airports in Europe are fully or partially privatized and/or in the process of being privatized.[6] The main goal of airport privatization is to allow for easier access to private sector financing and investment, and to improve operating efficiency (Oum, Adler and Yu, 2006). We argue that privatized airports operating in corrupt environments may not achieve higher levels of efficiency because the incentives for managers to pursue efficiency goals are lower. Furthermore, private sector managers have more autonomy to change the allocation of inputs compared with bureaucrats, then they may focus on deriving personal benefits.

Our research is motivated by the literature on the effects of corruption on firm performance, and the empirical findings of Yan and Oum (2014)[7] and Dal Bò and Rossi (2007)[8] on the negative correlation between corrupt environments and firm productivity. Corruption, which is defined as the misuse of public resources for private gains (Svensson, 2005) is a major source of economic inefficiency, as it diverts scarce resources from their most productive use. Furthermore, corruption is found to divert firms' managerial efforts from productive activities to rent-seeking activities including political connection building (Fisman, 2001; Svensson, 2003; Clarke and Xu, 2004; Khwaja and Mian, 2005; Dal Bò and Rossi, 2007; Cai, Fang and Xu, 2011). This study attempts to contribute to both the literature on the influence of corruption on economic performance at the micro level and the literature on the efficiency of airports.

We use airports located in Europe to investigate our research question. The corruption levels of European organizations are relatively lower compared with the rest of the world; however evidence show that corruption remains a major concern in the European countries. Empirical findings of Hessami (2014)

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[6] For example, majority stakes in Copenhagen Kastrup, Vienna International, and Rome's Leonardo Da Vinci Airports have been sold to private owners.

[7] Yan and Oum (2014) argue that in corrupt environments, bureaucrats have no strong incentives to pursue mandated tasks, leading to a loss of productivity for publicly owned airports.

[8] Dal Bò and Rossi (2007) argue that corrupt countries are strongly associated with more inefficient firms (public and private) in the sense that firms employ more inputs to produce a given level of output.

suggest that corruption in the broad sense of use of government office for private benefit is an issue in OECD countries and is not limited to low-income countries. Furthermore, the OECD (2014) reports that bribes are not just a problem for developing world: bribes are being paid to officials from countries at all stages of economic development. The report also reveals that bribes are usually paid to win public contracts from western organizations and most bribe payers and takers are from wealthy countries.

The airport industry in Europe is not free from corruption scandals; for instance, the *New York Times* reported that a $183 million airport project in Spain has become a symbol of the "wasteful spending that has sunk Spain deep into the recession and the banking crisis".[9] Corruption was also exposed in the reconstruction of Terminal 2 at Germany's Frankfurt Airport in 1996.[10] More recently in 2014, bribery scandals hit the airport of Berlin Brandenburg (BER); bribes were suspected to have been paid by firms wanting to secure airport contracts.[11]

We use an unbalanced panel data set consisting of 47 major airports from 27 European countries during the 2003-2009 period to empirically investigate the impacts of corruption on operating efficiency. Our main corruption measure is the country-level International Country Risk Guide (ICRG) corruption index.[12] The residual (or net) variable factor productivity purchased from the Air Transport Research Society (ATRS) is used as measure of airport operating efficiency. We find that corruption lowers airport managerial efficiency; and the impacts depend on the airport ownership form. Our results confirm the previous findings that privately owned airports, including majority and fully private ownership, are generally more efficient than majority and/or fully government owned airports. However, privately owned airports operate less efficiently than their publicly owned counterparts in high corruption environment. We control for the form of regulation prevalent across European airports, levels of competition, airport characteristics, and potential shocks that may affect airport efficiency during the 2003-2009 period. Our empirical results withstand several robustness checks including different control variables, three alternative corruption measures: International Country Risk Guide (ICRG) corruption index, Corruption Perception Index (CPI) and Control of Corruption Index (CCI) and change in the ownership categories.

The remainder of this paper is organized as follows: Section 2 summarizes the literature on corruption and airport efficiency. Section 3 presents the methodology for computing airport efficiency and assessing the impacts of corruption on the efficiency. Data sets are described in Section 4 and Section 5 defines the variables used in the analysis. The empirical results are presented in Section 6, followed by some robustness checks in Section 7. Finally, conclusions are given in section 8.

## 2. *Literature Review*

Corruption influences economic performance at both macro and micro levels. The impacts of corruption on economic performance at the macro level are considered in Schleifer and Vishny (1993), Mauro (1995), Ades and Di Tella (1999), Wei (2000), Habib and Zurawicki (2002) and Sanyal and Samanta (2008). These studies reveal that corruption negatively affects investment and economic growth.

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[9] The management of the airport of Castellón has been questioned since the airport has not received a single scheduled flight since its inauguration in 2011. See *The New York Times* (July 19, 2012): "In Spain, a symbol of ruin at an airport to Nowhere"

[10] See *The Financial Times* (July 2, 1996): "German Airport Corruption Probe Deepens: Five Jailed and 20 Companies under Investigation" and *Reuters Business Report* (September 25, 1996): "German corruption wave prompts action", reported in Rose-Ackerman (1999).

[11] For more information, see *The Local: Germany's news in English* (May 28, 2014): "Bribery probe hits Berlin's scandal airport".

[12] Similar as in Dal Bò and Rossi (2007), we use the ICRG corruption index as our main measure of corruption. The index possesses the advantages of transitivity compared with other indices including World Bank corruption index and/or Transparency International corruption index.

With respect to the effect of corruption on firm-level performance, Murphy, Shleifer and Vishny (1991, 1993) show that corruption generates social losses because it props up inefficient firms and drives the allocation of talent, technology and capital away from the socially most productive uses. Dal Bó and Rossi (2007) investigate the role of corruption among the determinants of the efficiency of electricity distribution firms. Their theoretical model states that corruption increases the factor requirements of firms, as it diverts managerial effort away from factor coordination. They empirically find that more corruption in the country is strongly associated with more inefficient firms, and the magnitude of the effects of corruption is considerable. Fisman and Svensson (2007) empirically find that firm growth is negatively correlated to both rate of taxation and bribery. Their results reveal that corruption delays the development process to a much greater extent than taxation. Wren-Lewis (2013) confirms these findings, but argues that the participation of an independent regulatory agency reduces the correlation between corruption and efficiency.

For the aviation industry, Yan and Oum (2014) theoretically investigate the effects of local government corruption on the cost of providing public goods, and find that the impact of corruption is contingent on the governance structure and institutional arrangements of airports. Based on US commercial airports, they empirically confirm their theoretical predictions that corruption lowers airport productivity and increases the ratio of non-labor variable input to labor input of airports. The differences in the effects of corruption between airport authorities and airports managed by local government are due to the internal organization structure such as decision-making and managers' autonomy to allocate resources. As result, governance restructuring, which consists of transferring airport management from a local government to an airport authority may not necessarily lead to efficiency gains in corrupt environments.

Yan and Oum (2014) limit their analysis to the US commercial airports. The US airports are subject to specific governance structure; they are mostly owned, managed and operated by local governments either as government branches or via airport authorities. Since the first privatization of British Airports Authority in 1987, airport governance restructuring has proliferated elsewhere in the world. The goal of our paper is to extend and confirm the findings of Yan and Oum (2014) to include other forms of ownership and governance. Airports in Europe are chosen to test the impact of corruption on efficiency of fully and partially privatized airports.

Literature on airport efficiency identifies three different performance and productivity analysis methods for airports. These approaches include productivity Index Number method, Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). The multilateral index number method, the consistency of which with neoclassical theory of the firm first established by Caves, Christensen and Diewert (1982), uses total factor productivity (TFP) as measure of efficiency. TFP is defined as the ratio of output index to input index, and is easy to compute if firms use single inputs to provide single outputs. However, airports utilize multiple inputs such as labor, capital, and other resources to produce multiple services for both airlines and passengers. Similar as in Oum, Adler and Yu (2006) and Obeng, Assar and Benjamin (1992), the multilateral index number method proposed by Caves, Christensen, and Diewert (1982) can be used to aggregate inputs and outputs.[13] In the past, many studies including Hooper and Hensher (1997), Nyshadham and Rao (2000) have used TFP approach to evaluate airport performance.

Data envelopment analysis (DEA) is a non-parametric frontier method firstly proposed by Charnes, Cooper and Rhodes (1978). Based on linear programming method, DEA evaluates efficiency scores for firms (or Decision Marking Units) relative to an efficiency frontier, which is formed by enveloping the data on the frontier. While DEA assumes the continuity and convexity of the production

[13] TFP assumes that firms are under constant returns to scale and are allocatively efficient. However, TFP requires input and output prices and quantities that are not always available.

possibility set, it allows for using physical measures of capital inputs such as terminal size, number and/or length of runway as approximation of capital inputs.[14] Some applications of DEA to the aviation industry can be found in Gillen and Lall (1997), Adler and Berechman (2001), Martín-Cejas (2002), Abbott and Wu (2002), Pels, Nijkamp and Rietveld (2001, 2003) and Barros and Sampaio (2004).

Stochastic Frontier Analysis (SFA) is a parametric approach that uses regression equation to assess efficiency. Firstly developed by Aigner, Amemiya and Poirier (1976) and Meeusen and Van den Broeck (1977), SFA explains output as a function of inputs and a stochastic disturbance, which consists of two parts: a stochastic inefficiency and a traditional "noise term". For the case of estimating production (cost) function the former is always negative (positive). Similar to DEA, SFA assumes the continuity and convexity of the production possibility set. SFA further assumes a particular form of inefficiency distribution and involves a specification of frontier function, which enables it to conduct hypothesis tests and distinguish the sources of efficiency growth. Tsionas (2003), Pestana Barros (2009), Assaf (2009, 2010), Marques and Barros (2010), Brissimis, Delis and Tsionas (2010) and Suzuki et al. (2010) are among the many SFA applications. Liebert and Niemeier (2010) provide an interesting review of all three approaches. The TFP approach is chosen for the purposes of this study.

## 3. *Methodology*

To investigate the effect of corruption on airport efficiency, a two-stage procedure is used. The first stage considers the multilateral index number approach to evaluate the residual (or net) variable factor productivity (rvfp) — our measure of airport operating efficiency. The second stage specifies a regression analysis that explains airport efficiency as a linear function of corruption index and a set of business environmental factors.

### *3.1 Residual (or net) variable factor productivity (rvfp)*

The residual (or net) variable factor productivity (rvfp) computed by Air Transport Research Society (ATRS, 2011) is used as measure of airport true managerial efficiency.

To obtain the residual (or net) variable factor productivity (rvfp), we first compute the variable factor productivity (vfp) index, which is defined as the ratio of aggregate outputs to aggregate inputs. Since airports utilize multiple inputs to produce multiple outputs, we apply the multilateral index number method, devised by Caves, Christensen and Diewert (1982) to aggregate the inputs and outputs.

The number of aircraft movements (ATMs), passenger volumes and non-aeronautical revenues are considered to aggregate outputs.[15] It is noteworthy that demand for non-aeronautical services is closely related and complementary to that for aeronautical services (Oum, Adler and Yu, 2006). Moreover, the non-aeronautical revenues account for a large and increasing portion of airport revenues.[16] Thus, we need to include non-aeronautical revenues among aggregate outputs in order to circumvent serious bias in measuring airport operating efficiency.

With respect to inputs, airports utilize multiple resources including labor input, purchased goods and materials, and purchased services (outsourcing and contracting out) to produce multiple services for airlines and passengers. Labor input is defined as the full-time equivalent number of employees directly

[14] One important drawback of DEA method is the lack of transitivity

[15] Air cargo services are generally handled by airlines, third-party cargo handling companies and others, which lease space and facilities from airports. Air cargo services are not considered as a separate output in this research, as airports derive a very small percentage of their income from direct service related to air cargo

[16] On average, the non-aeronautical activities including concessions, car parking, and numerous other services account for about half of the total airport's revenue in our sample.

paid for by the airport operators. The outsourced services for goods, services, and materials purchased directly by an airport are combined with all other inputs to form a so-called “soft-cost input”. We note that our efficiency measure does not consider capital inputs. It is almost impossible to assess capital inputs and expenditures accurately on a comparable basis. Besides, capital costs are usually quasi-fixed during a long-term period while the vfp accounts for a short and/or medium term period.

The residual (or net) variable factor productivity (rvfp) is obtained by using a regression analysis, which consists of removing the effects of factors that cannot be controlled by airport managers at least in the short to medium term from the vfp index. These factors include the percentage of international passengers, cargo share, capacity constraint, average aircraft size, airport size and different macroeconomic shocks. The residual of the variable factor productivity index is deemed as more accurate for this research.

### *3.2 Econometric model*

In the econometric section, we estimate a model that explains airport efficiency, measured by the residual (or net) variable factor productivity (*rvfp*) as a linear function of a set of potential business environmental variables. These variables include the country-level corruption index of the airport (*CI*), the airport’s ownership form ($\boldsymbol{OF}$), an interaction between ownership and corruption, and a set of control variables (***X***). When the data structure is a sample of airports observed over several time periods (a panel dataset), the regression equation reads:

$$rvfp_{\ it} = \alpha + \lambda\, CI_{it} + \boldsymbol{OF}'_{it}\beta + (CI_{it} * \boldsymbol{OF}'_{it})\,\gamma + \boldsymbol{X}'_{it}\delta + \varepsilon_{it} \ (eq.1)$$

where $rvfp_{it}$ represents the residual (or net) variable factor productivity of airport $i$ at time $t$. $CI_{it}$ corresponds to the country-level corruption index (*CI*) of airport i at time t and $\boldsymbol{OF}'_{it}$ the ownership form. We include an interation between the corruption index and ownership form, $(CI_{it} * \boldsymbol{OF}'_{it})$ to capture the effects of corruption under different types of ownership. $\boldsymbol{X}'_{it}$ denotes a set of control variables that potentially affect airport efficiency in addition to corruption, including the form of economic regulation that is prevalent across Europe, the level of competition across gateways and within the catchment area, whether the airport is used as airline hub and/or international gateway, whether the airport belongs to a group from a managerial perspective, and gross domestic product (GDP) per capita. Another set of controls including indicators of institutional quality variables, a proxy of openness to trade and a measure of the importance of government in the economy are added to test the robustness of our results.[17] $\mathcal{E}_{it}$ refers to an independent and identically distributed error term over the airport $i$ and time $t$ dimensions; $\alpha$ is the regression’s intercept. The parameters $\lambda, \beta, \gamma, \delta$ represent the marginal effects of the explanatory variables.

Given the panel structure of the equation, we estimate both pooled Ordinary Least Squares (OLS) and airport/time-specific random effects (RE) models. The pooled OLS model assumes common intercepts and slopes across airports and periods, and it produces consistent estimates when the data are poolable.[18] The random effects (RE) model assumes the intercept $\alpha$ as being a random component. When appropriate, the RE estimator is usually better at capturing the individual and time heterogeneity and it can strongly improve the fit as compared to the pooled OLS model. Our econometric analysis also applies statistical tests that check the violation of fundamental hypotheses of the standard regression model

[17] These variables are largely recognized in the literature as having a strong relationship with corruption.

[18] Checking the poolability assumption requires a sample size that allows running individual time-series regressions or cross-sectional yearly regressions, see Hsiao (1986, Chapter 2). In our case, the lack of degrees of freedom prevented us to perform individual time-series regressions.

(heteroscedasticity, autocorrelation and cross-sectional dependencies), which alters inference. We apply the required corrections when needed. Other tests are also conducted to compare the competing models and select the most appropriate one from a statistical viewpoint.

### 4. *Data description*

We compile data from 47 airports located in 27 European countries during the 2003-2009 period. The airport data comes from various sources including the International Civil Aviation Organization (ICAO), Airport Council International (ACI), International Air Transport Association (IATA) and airport annual reports. Some of the data was obtained directly from the airports. Table 1 lists the airports included in the sample as well as the form of ownership that governs each airport during the 2003-2009 period.

Table 1: List of airports

| Code | Airport | Country | Time Period | Ownership |
|---|---|---|---|---|
| AMS | Amsterdam Schiphol | Netherlands | 2003-2007<br>2008-2009 | 100% government<br>Mixed public-private with government majority |
| ARN | Stockholm Arlanda | Sweden | 2003-2009 | 100% government |
| ATH | Athens | Greece | 2004-2009 | Mixed public-private with government majority |
| BCN | Barcelona El Prat | Spain | 2003-2009 | 100% government |
| BHX | Birmingham | United Kingdom | 2003-2009 | Mixed public-private with private majority |
| BRU | Brussels | Belgium | 2003-2004<br>2005-2009 | 100% government<br>Mixed public-private with private majority |
| BTS | Bratislava Milan Rastislav Stafanik | Slovakia | 2004-2009 | 100% government |
| BUD | Budapest Ferihegy | Hungary | 2008-2009 | Mixed public-private with private majority |
| CDG | Paris Charles de Gaulle | France | 2004-2005<br>2006-2009 | 100% government<br>Mixed public-private with government majority |
| CGN | Cologne/Bonn Konrad Adenauer | Germany | 2004-2009 | 100% government |
| CIA | Rome Ciampino | Italy | 2003<br>2004-2009 | 100% government<br>Mixed public-private with private majority |
| CPH | Copenhagen Kastrup | Denmark | 2003-2009 | Mixed public-private with private majority |
| DUB | Dublin | Ireland | 2003-2009 | 100% government |
| DUS | Dlughafen Dusseldorf | Germany | 2003-2009 | Mixed public-private with government majority |
| EDI | Edinburgh | United Kingdom | 2003-2009 | Fully private |
| FCO | Rome Leonardo Da Vinci/Fiumicino | Italy | 2003-2009 | Mixed public-private with private majority |
| FRA | Frankfurt Main | Germany | 2003-2009 | Mixed public-private with government majority |

| | | | | |
|---|---|---|---|---|
| GVA | Geneva Cointrin | Switzerland | 2003-2009 | 100% government |
| HAJ | Hannover-Langenhagen | Germany | 2009 | Mixed public-private with government majority |
| HAM | Hamburg | Germany | 2003-2009 | Mixed public-private with government majority |
| HEL | Helsinki Vantaa | Finland | 2003-2009 | 100% government |
| IST | Istanbul Ataturk | Turkey | 2009 | Mixed public-private with private majority |
| KEF | Keflavik | Iceland | 2007, 2009 | 100% government |
| LGW | London Gatwick | United Kingdom | 2003-2009 | Fully private |
| LHR | Heathrow | United Kingdom | 2003-2009 | Fully private |
| LIS | Lisbon Portela | Portugal | 2003-2009 | 100% government |
| LJU | Ljubljana | Slovenia | 2007-2009 | Mixed public-private with government majority |
| LTN | London Luton | United Kingdom | 2009 | Mixed public-private with private majority |
| MAD | Madrid Barajas | Spain | 2003-2009 | 100% government |
| MAN | Manchester | United Kingdom | 2003-2009 | 100% government |
| MLA | Malta | Malta | 2003-2009 | Mixed public-private with private majority |
| MUC | Munchen | Germany | 2005-2009 | 100% government |
| NAP | Naples | Italy | 2009 | Mixed public-private with private majority |
| NCE | Nice Cote d'Azur | France | 2009 | 100% government |
| ORY | Paris Orly | France | 2004-2005<br>2006-2009 | 100% government<br>Mixed public-private with government majority |
| OSL | Oslo | Norway | 2003-2009 | 100% government |
| PRG | Prague | Czech Republic | 2003-2007 | 100% government |
| RIX | Riga | Latvia | 2004-2009 | 100% government |
| SOF | Sofia | Bulgaria | 2004-2009 | 100% government |
| STN | Stansted | United Kingdom | 2003-2009 | Fully private |
| SZG | Salzburg | Austria | 2009 | 100% government |
| TLL | Tallinn | Estonia | 2003, 2006-2009 | 100% government |
| TRN | Turin | Italy | 2009 | Mixed public-private with government majority |
| TXL | Berlin Tegel | Germany | 2007-2009 | 100% government |
| VIE | Vienna | Austria | 2003-2009 | Mixed public-private with government majority |
| WAW | Warsaw Frederic Chopin | Poland | 2003-2009 | 100% government |
| ZRH | Zurich | Switzerland | 2003-2009 | Mixed public-private with government majority |

Notes: Mixed public-private ownership with private majority indicates that private companies hold more than 50% of stakes. Mixed public-private ownership with government majority indicates that government holds more than 50% of stakes. 100% government is also called public corporation.

Among the sample of 47 airports during the 2003-2009 period, 5 were fully private, 7 were owned and/or operated by mixed public-private enterprises with private majority, 9 were owned and/or operated by mixed public-private enterprises with government majority, and 21 were owned and/or operated or by 100% government (or public corporations).

Five airports including Amsterdam Schiphol (AMS), Brussels (BRU), Rome Ciampino (CIA), Paris Charles de Gaulle (CDG) and Paris Orly (ORY) have experienced ownership and management restructuring during the period of concern. These airports were traditionally fully owned, managed and operated by governments. The majority of stakes of Rome Ciampino and Brussels airports were sold to private sector interests in 2004 and 2005, respectively. The management and ownership of Paris Charles de Gaulle, Paris Orly and Amsterdam Schiphol airports were transferred to mixed private-public enterprises with government majority in 2006, 2006 and 2008, respectively.

## 5. Description of variables

### 5.1 Variables in the efficiency analysis

Details on the variables used for the efficiency analysis are summarized in Table 2. The output variables include the number of aircraft movements (ATMs), passenger volumes and non-aeronautical revenues. As for input variables, labor input, purchased goods and materials and purchased services (outsourcing and contracting out) are considered.

Table 2: Descriptive statistics of the variables used in the airport efficiency analysis

| Variable | Observation | Mean | Standard Deviation | Min | Max |
|---|---|---|---|---|---|
| Output (thousands) | 254 | 1.306 | 1.271 | 0.0539 | 5.813 |
| Number of runways | 254 | 2.25 | 0.949 | 1 | 5 |
| % Non-aeronautical revenue | 254 | 0.474 | 0.141 | 0.183 | 0.848 |
| Number of employees | 254 | 2897 | 4450.92 | 136 | 30437 |
| Variable Factor Productivity (VFP) | 254 | 1.120 | 0.419 | 0.335 | 2.472 |
| % International Passengers | 254 | 0.797 | 0.188 | 0.278 | 1 |
| Cargo share | 254 | 0.010 | 0.009 | 0.000 | 0.042 |
| Aircraft size (thousands) | 254 | 4.401 | 0.269 | 3.343 | 4.967 |
| Low Cost Carriers (thousands) | 254 | 0.319 | 0.467 | 0 | 1 |
| Terminal size (square metres) | 254 | 190620.6 | 199602.8 | 8000 | 1000000 |
| Residual variable factor productivity (rvfp) | 254 | 0.628 | 0.212 | 0.216 | 1.280 |

Source: ATRS global airport performance benchmarking reports (2003- 2009). Units of measurement are in brackets.

### 5.2 Variables in the econometric analysis

#### 5.2.1 Measures of corruption

Corruption, our main variable of interest, is defined as the misuse of public office for private gain (Svensson, 2005). We consider three indices of corruption drawn from three different sources: the corruption index computed by International Country Risk Guide (ICRG), Corruption Perception Index (CPI) provided by Transparency International and the Control of Corruption Index (CCI) delivered by the World Bank.[19] All three indices are survey-based.

The ICRG corruption index captures the likelihood and the expectations that government officials will demand special payment in the form of "bribes connected with import and export licenses, exchange controls, tax assessment, police protection, or loans". Drawn from indicators assembled by panels of international experts, it evaluates corruption mainly within the political system. ICRG corruption index allows for comparison across countries and over time, therefore it is particularly well suited to our main objective. Besides, the ICRG corruption index is widely used in the economics literature (see for example, Knack and Keefer (1995), Dal Bò and Rossi (2007)). The original index ranges between zero (highly corrupt) and six (highly clean); so a higher corruption index corresponds to a less corrupt country.

Both CPI and CCI are composite indices. While CPI looks at corruption in the public sector, CCI considers corruption in both public and private sectors. CPI corresponds to the average of ratings reported by a number of perception-based sources and business surveys[20] carried out by a variety of independent and reputable institutions. However, CCI is drawn from a large set of data sources including a diverse variety of survey institutes, think tanks, and non-governmental and international organizations. Contrary to ICRG corruption index, CCI and CPI lack "transitivity". Their country rankings can change substantially as one adds or drops one or more countries from the sample.[21] The original CPI scores countries on a scale from zero (highly corrupt) to ten (highly clean) while the original CCI scores range from -2.5 (highly clean) to 2.5 (highly corrupt).

Since it is not meaningful to compare original scores generated by each source, the corruption scores are rescaled between 0 and 10 by setting the value for the most corrupt country at 10 and the least corrupt country at 0. Table 3 compares the three alternative corruption indices in 2009.

Table 3: Corruption Indices of the sample of countries - 2009

| Country | ICRG Corruption Index | Country | CPI | Country | CCI |
|---|---|---|---|---|---|
| Finland | 0 | Denmark | 3.8 | Denmark | 0.15 |
| Denmark | 1.25 | Sweden | 3.9 | Sweden | 0.58 |
| Iceland | 1.25 | Switzerland | 4.1 | Finland | 0.58 |
| Sweden | 2.5 | Finland | 4.2 | Netherlands | 0.83 |
| Netherlands | 2.5 | Netherlands | 4.2 | Iceland | 0.97 |
| Austria | 2.5 | Iceland | 4.4 | Switzerland | 0.99 |
| Norway | 2.5 | Norway | 4.5 | Norway | 1.16 |
| Germany | 2.5 | Germany | 5.1 | Austria | 1.54 |

[19] This analysis focuses on country-level corruption. The subjective indices, which are derived from fully convincing methodology, provide satisfactory country coverage during the 2003-2009 time period. In addition, the corruption perception surveys are relatively well suited to compare countries in terms of corruption because the sources all aim at measuring the degree of corruption, using identical methodology. Mauro (1995), Svensson (2006) discussed the validity and precision of subjective corruption indices.

[20] The surveys include questions relative to the misuse of public power for private benefits such as bribery by public officials, kickbacks in public procurement, embezzlement of public funds.

[21] For more details on the methodology used by World Bank and Transparency International to compute CCI and CPI scores, readers can refer to *http://www.worldbank.org* and *http://www.transparency.org*. We note that Transparency International has improved its methodologies to compute CPI index since 2012 in order to allow for comparison over times.

| | | | | | |
|---|---|---|---|---|---|
| France | 2.5 | Ireland | 5.1 | Ireland | 1.63 |
| Belgium | 2.5 | Austria | 5.2 | Germany | 1.71 |
| Switzerland | 3.75 | United Kingdom | 5.4 | United Kingdom | 2.03 |
| United Kingdom | 5 | Belgium | 6 | Belgium | 2.24 |
| Portugal | 5 | France | 6.2 | France | 2.31 |
| Spain | 5 | Estonia | 6.5 | Portugal | 3.00 |
| Ireland | 6.25 | Slovenia | 6.5 | Slovenia | 3.01 |
| Malta | 6.25 | Spain | 7 | Spain | 3.09 |
| Estonia | 7.5 | Portugal | 7.3 | Estonia | 3.25 |
| Hungary | 7.5 | Malta | 7.9 | Latvia | 3.29 |
| Slovenia | 7.5 | Hungary | 8 | Malta | 3.29 |
| Poland | 8.75 | Poland | 8.1 | Poland | 4.26 |
| Italy | 8.75 | Latvia | 8.6 | Hungary | 4.39 |
| Slovakia | 8.75 | Slovakia | 8.6 | Slovakia | 4.58 |
| Turkey | 8.75 | Turkey | 8.7 | Turkey | 4.94 |
| Bulgaria | 10 | Italy | 8.8 | Greece | 5.01 |
| Greece | 10 | Bulgaria | 9.3 | Italy | 5.14 |
| Latvia | 10 | Greece | 9.3 | Bulgaria | 5.54 |

Notes: ICRG Corruption Index is the International Country Risk Guide's corruption indicator (average over 12 months). CPI is the Corruption Perception Index computed Transparency International and CCI compute the Control of Corruption Index by the World Bank. ICRG, CPI and CCI scores are rescaled so that each index ranges between 0 and 10, with a higher score indicating higher corruption and a lower score indicating lower corruption.

The country rankings and corruption scores are compared across the three sources. Regardless of the methodology used, Finland, Denmark, Sweden, the Netherlands and Iceland are the cleanest countries in our sample whereas Bulgaria, Greece, Italy, Turkey and Slovakia are the most corrupt countries. The country rankings in the top and bottom ranges of the scores are quite robust with respect to the methodology. By contrast, the country rankings in the middle ranges including Italy, Ireland and Poland rankings are more sensitive to the source used. Nonetheless, the three corruption indices are highly correlated with each other.[22] The correlation between CCI and CPI is the highest, indicating that both indices yield rather similar country rankings.

### *5.2.2 Ownership form*

The applied literature has established the influence of the ownership form on airports' operating efficiency. We explore this finding for European airports by including the ownership form of airport $i$ at time $t$ in the model. We observe 4 types of ownership in our sample of airports including (1) fully private ownership (2) mixed public-private ownership with private majority (above 50%) (3) mixed public-private ownership with government majority (above 50%) (4) 100% government or public corporation ownership. However, due to the limited data, we combine fully private ownership and mixed public-private ownership with private majority.[23] Thus, we categorize ownership forms according to: (1) mixed public-private ownership with private majority (including fully private) (2) mixed public-private ownership with government majority (above 50%) (3) 100% government or public corporation ownership. Ownership forms are modeled with the help of dummy variables. We denote mixed public-private ownership with

[22] The correlation coefficients between ICRG index and CPI, ICRG index and CCI and CCI and CPI are 0.8803, 0.8875, 0.9662, respectively.

[23] Seven of our sampled airports are owned and operated by mixed enterprises with private majority (50%) and five are fully privatized airports.

private majority as the reference category. We further enquire whether corruption has an effect that potentially depends on the ownership form by including interaction terms between corruption and ownership dummy variables.

#### *5.2.3 Economic regulation and competition*

Previous research has found that competition and economic regulation, individually or jointly affect airport efficiency (Chi-Lok, Yuen and Zhang, 2009; Assaf and Gillen, 2012; Malighetti et al., 2009; Adler and Liebert, 2014). Regarding economic regulation, airports in Europe are traditionally subject to rate of return or cost-based regulation. More recently there has been a trend towards implementing a form of incentive regulation — the price-cap regulation — when airports are privatized or semi-privatized (Gillen, Niemeier and Madrid, 2006). Both cost-based and price cap regulations can be set under a single or dual till regime. Following Adler and Liebert (2014), we classify the forms of airport economic regulation according to (1) no ex-ante regulation (2) single-till cost-plus regulation (3) dual-till cost-plus regulation (4) single-till price-cap regulation (5) dual-till price-cap regulation (6) charges set by airports (single and dual till).

The proxy of airport competition is defined in line with Adler and Liebert (2014). The variable is based on the number of commercial airports with at least 150 000 passengers per annum within a catchment area of 100 km around the airport. Two levels of competition are considered: strong and weak. An airport is assumed to be facing weak competition at the regional level if there is no more than one additional airport within the catchment area, and strong competition if there are at least two additional airports within the catchment area. In addition, a hub airport that serves as a regional or international gateway is classified as facing strong competition, regardless of its local catchment area. Due to the lack of information, we are not able to account for different product diversification strategies such as low cost carrier traffic. As Adler and Liebert (2014) pointed out, this measure of competition only indicates an upper level of likely competition across airports.

#### *5.2.4 Airport characteristics*

We include a set of control variables that capture the major characteristics of our sample of airports. These variables consist of the status of the airport as a hub and/or international gateway[24], whether the airport belongs to a group from a managerial perspective, and the gross domestic product (GDP) per capita. The controls are included in the model with the help of dummy variables. GDP per capita would capture time and country-specific macroeconomic factors such as productivity shocks. Details on variables used in the econometric analysis are summarized in Table 1 in the Annex.

## *6. Empirical results*

The first part consists of a discussion on airport efficiency results. In the second part, we analyze the impacts of corruption and other factors on the airport operating efficiency.

### *6.1 Estimates from the efficiency analysis*

[24] Hub airports may possess advantages in terms of efficiency because of their size and location, therefore we include a dummy variable to capture the status of the airport as an international and/or regional hub.

This study uses the residual (or net) variable factor productivity as a measure of airport operating efficiency. Efficiency scores of the sample of airports are listed in Table 4.

Table 4: Residual (or net) variable factor productivity (rvfp) efficiency scores

| Airport | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|
| AMS | 0.763 | 0.921 | 0.827 | 0.758 | 0.743 | 0.720 | 0.651 |
| ARN | 0.789 | 0.984 | 0.641 | 0.643 | 0.694 | 0.509 | 0.426 |
| ATH | - | 1.244 | 0.715 | 0.774 | 0.719 | 0.769 | 1.059 |
| BCN | 0.828 | 1.051 | 0.959 | 0.924 | 1.101 | 1.032 | 0.655 |
| BHX | 0.948 | 0.655 | 0.713 | 0.668 | 0.643 | 0.646 | 0.675 |
| BRU | 0.639 | 0.670 | 0.783 | 0.790 | 0.803 | 0.888 | 0.906 |
| BTS | - | 0.329 | 0.402 | 0.341 | 0.309 | 0.359 | 0.391 |
| BUD | - | - | - | - | - | 0.578 | 0.457 |
| CDG | - | 0.735 | 0.720 | 0.694 | 0.834 | 0.769 | 0.709 |
| CGN | - | 0.284 | 0.297 | 0.309 | 0.284 | 0.306 | 0.328 |
| CIA | 0.932 | 0.779 | 0.794 | 0.802 | 0.849 | 0.684 | 0.691 |
| CPH | 0.872 | 0.931 | 0.817 | 1.280 | 1.128 | 0.984 | 1.040 |
| DUB | 0.497 | 0.855 | 0.793 | 0.745 | 0.746 | 0.696 | 0.618 |
| DUS | 0.573 | 0.506 | 0.433 | 0.395 | 0.402 | 0.402 | 0.406 |
| EDI | 0.486 | 0.582 | 0.560 | 0.544 | 0.668 | 0.851 | 0.750 |
| FCO | 0.630 | 0.583 | 0.547 | 0.663 | 0.712 | 0.607 | 0.626 |
| FRA | 0.393 | 0.496 | 0.471 | 0.421 | 0.450 | 0.398 | 0.352 |
| GVA | 0.715 | 0.749 | 0.783 | 0.847 | 0.824 | 0.944 | 0.903 |
| HAJ | - | - | - | - | - | - | 0.727 |
| HAM | 0.350 | 0.495 | 0.496 | 0.503 | 0.474 | 0.503 | 0.508 |
| HEL | 0.520 | 0.610 | 0.600 | 0.558 | 0.494 | 0.431 | 0.391 |
| IST | - | - | - | - | - | - | 0.985 |
| KEF | - | - | - | - | 0.326 | - | 0.627 |
| LGW | 0.565 | 0.639 | 0.596 | 0.492 | 0.635 | 0.562 | 0.518 |
| LHR | 0.548 | 0.612 | 0.550 | 0.390 | 0.519 | 0.419 | 0.416 |
| LIS | 0.569 | 0.596 | 0.700 | 0.741 | 0.726 | 0.966 | 0.663 |
| LJU | - | - | - | - | 0.540 | 0.611 | 0.657 |
| LTN | - | - | - | - | - | - | 0.658 |
| MAD | 0.772 | 0.980 | 0.936 | 0.889 | 1.116 | 1.073 | 0.704 |
| MAG | | | | | 0.541 | 0.544 | 0.477 |
| MAN | 0.511 | 0.746 | 0.518 | 0.512 | 0.577 | 0.515 | 0.511 |
| MLA | 0.443 | 0.505 | 0.557 | 0.536 | 0.514 | 0.561 | 0.587 |
| MUC | - | - | 0.339 | 0.345 | 0.324 | 0.330 | 0.310 |
| NAP | - | - | - | - | - | - | 0.654 |
| NCE | - | - | - | - | - | - | 0.849 |
| ORY | - | 0.445 | 0.365 | 0.419 | 0.547 | 0.502 | 0.473 |
| OSL | 0.760 | 0.709 | 0.963 | 1.067 | 1.059 | 1.150 | 1.116 |
| PRG | 0.432 | 0.425 | 0.822 | 0.511 | 0.490 | - | - |
| RIX | - | 0.216 | 0.325 | 0.388 | 0.432 | 0.382 | 0.462 |
| SOF | - | 0.322 | 0.375 | - | - | 0.422 | 0.401 |
| STN | 0.670 | 0.747 | 0.710 | 0.587 | 0.649 | 0.642 | 0.619 |
| SZG | - | - | - | - | - | - | 0.502 |
| TLL | 0.436 | - | - | 0.477 | 0.472 | 0.475 | 0.568 |
| TRN | - | - | - | - | - | - | 0.609 |
| TXL | - | - | - | - | 0.389 | 0.329 | 0.314 |
| VIE | 0.490 | 0.503 | 0.527 | 0.537 | 0.495 | 0.536 | 0.557 |
| WAW | 0.387 | 0.487 | 0.456 | 0.454 | 0.483 | 0.422 | 0.355 |
| ZRH | 0.732 | 0.784 | 0.786 | 0.891 | 0.858 | 0.892 | 0.961 |

Notes: "-" indicates that the rvfp score of the airport for that year is not available in the dataset.

The scores vary from 0.216 (the least efficient) to 1.28 (the most efficient). The average efficiency score goes from 0.616 in 2003 to 0.613 in 2009, with around 42% of all airports categorized as relatively efficient.

Except for Brussels airport (BRU), none of the airports in the sample consistently improved their efficiency over time. Between 2003 and 2009, Brussels increased its score from 0.639 to 0.906. The private sector participation in the management and ownership of Brussels airport in 2005 may contribute to consistently maintain its improvement in terms of efficiency.

Amsterdam (AMS), Dublin (DUB), Stockholm (ARN) and Helsinki (HEL) airports enhanced their efficiencies between 2003 and 2004, but consistently exhibit an efficiency decrease between 2004 and 2009. By contrast, Paris Charles de Gaulle (CDG), Rome Fiumicino (FCO), Gatwick (LGW), Manchester (MAN), Paris Orly (ORY), Stansted (STN), Vienna (VIE) and Warsaw (WAW) airports appear to have relatively constant efficiency scores between 2003 and 2009. For some airports including Amsterdam, Paris Charles de Gaulle and Paris Orly, the minor participation of private sectors in the airport management and ownership does not necessarily lead to efficiency gains.

Copenhagen airport (CPH) is found as the most efficient airport among the sample of European airports between 2003 and 2009, with an average operating efficiency of 1.007. The top performers during the 2003-2009 period include Istanbul (IST), Oslo (OSL), Barcelona (BCN) and Madrid (MAD), with average efficiency scores of 0.985, 0975, 0.936 and 0.924, respectively. The airports of Cologne-Bonn (CGN), Munich (MUC), Berlin (TXL), Bratislava (BTS), Riga (RIX) and Sofia (SOF), by contrast, appear to be the least relatively efficient airports in the sample, with average scores less than 0.4. Cologne-Bonn suffers from excess airside capacities despite the extensive cargo operations resulting from its position as the European hub for Germanwings, FedEx Express and UPS Airlines (Adler and Liebert, 2014).

### *6.2 Econometric results*

Statistical tests show that the Random Effect (RE) model is the most appropriate, and its Pooled OLS counterpart delivers similar results without providing efficiency gains in the estimates.[25] We notice in Table 5 that the RE model explains a much higher share of the total variance of the dependent variable (*R Squared*) than the pooled OLS regression, and its *Adjusted R Squared* is much larger as well. Therefore, the RE model is superior in terms of within-sample goodness-of-fit. The Fisher tests accept the absence of time-fixed effects in both pooled OLS and RE models, indicating that no common significant shocks have affected the efficiency of European airports during the period of scrutiny.[26]

We report the estimation results from the pooled OLS model in column (2) of Table 5 and the ones from the RE model in column (3). The estimation results from the RE model are used as the basis for our analysis. Given that both models display strong heteroscedasticity and autocorrelation in the residuals, robust standard errors are stated in parenthesis.[27]

Table 5: Estimation results using pooled OLS and Random Effects (RE) models

[25] The Lagrangian Multiplier test for random effects displays a statistic of Fisher value of 161.32 and associated p-value of 0.000, indicating that Random effects model is preferred to Pooled OLS.

[26] The statistics of Fisher (and their associated p-value) for Pooled OLS and RE models are 1.58 (0.174) and 6.91(0.329), respectively indicating that we cannot reject the null hypothesis that year effects are insignificant.

[27] We employ cluster-robust standard errors as recommended by Wooldridge (2002).

| Dependent variable: residual (or net) variable factor productivity (rvfp) | Pooled OLS | Random Effects (RE) |
|---|---|---|
| Corruption Index (ICRG Index) | -0.046***<br>(0.017) | -0.041***<br>(0.018) |
| Ownership form | Base: Mixed public-private ownership with private majority | |
| Government majority (above 50%) | -0.318***<br>(0.116) | -0.332***<br>(0.098) |
| Public corporation (100% government) | -0.230**<br>(0.111) | -0.254**<br>(0.101) |
| Ownership form*Corruption Index (ICRG Index) | Base: Mixed public-private ownership with private majority * ICRG Index | |
| Government majority* ICRG Index | 0.064***<br>(0.023) | 0.048**<br>(0.019) |
| Public corporation* ICRG Index | 0.015<br>(0.018) | 0.028<br>(0.020) |
| Regulation | Base: No ex-ante regulation | |
| Cost-plus, single till | 0.188**<br>(0.080) | 0.136<br>(0.092) |
| Cost-plus, dual till | -0.093<br>(0.084) | -0.003<br>(0.079) |
| Incentive, single till | -0.040<br>(0.057) | -0.043<br>(0.060) |
| Incentive, dual till | -0.128*<br>(0.069) | -0.097<br>(0.069) |
| Charges set by airports (single & dual till) | 0.130<br>(0.080) | 0.076<br>(0.089) |
| Competition | Base: Weak competition | |
| Strong | -0.177***<br>(0.050) | -0.097<br>(0.060) |
| Status as a hub and/or international gateway | 0.082<br>(0.052) | 0.039<br>(0.060) |
| Airport group management dummy | 0.064<br>(0.054) | 0.045<br>(0.051) |
| GDP per capita | 0.002**<br>(0.001) | 0.002*<br>(0.001) |
| Intercept | 0.865***<br>(0.111) | 0.823***<br>(0.128) |
| R-Square | 0.384 | 0.820 |
| Adjusted R-Square | 0.345 | 0.772 |
| Number of observation | 254 | 254 |

Notes: "***", "**", "*" denote statistical significance at the 1%, 5%, 10% levels, respectively. Robust standard error associated to each coefficient is stated in parenthesis. We dropped "mixed public-private ownership with private majority (including fully private)" dummy, "the interaction between mixed public-private ownership with private majority and corruption index", "no ex-ante regulation dummy" and "weak competition dummy" in all regressions to avoid multicollinearity.

First, we notice that the partial effects of the main variables of interest — corruption, ownership and the interaction terms between corruption and ownership — are highly significant in the RE model and that the signs and magnitudes remain rather robust in the pooled OLS model. Given that the influence of corruption on airport operating efficiency depends on the ownership form, we ran a regression of rvfp on the corruption index, the ownership dummies and the business environmental factors without including the interaction terms in the regression. We found no significant effects of corruption on rvfp.[28] This stresses the importance of accounting for the interactions to uncover the effect of corruption on airport efficiency.

As shown in Table 5, the impact of corruption on airports' efficiency is negative, and its effect is significant at the 1% level in both RE and pooled OLS specifications. This result suggests that corruption has a negative impact on airport efficiency under mixed public-private ownership with private majority (the default ownership category). Privately owned airports located in less corrupt countries operate more efficiently than the ones situated in more corrupt countries. An increase in one point[29] in the corruption index decreases the residual (or net) variable factor productivity of 0.04 units. This negative influence of corruption on efficiency is consistent with previous literature in other sectors (see for example Dal Bò and Rossi (2007)). Indeed, corruption is found to lower productivity through a diversion of managerial efforts away from running productive activities. In a high corruption environment, airport managers would have more incentives to use bribes when they channel resources to establish lobbies and connections. Then, poor governance and culture of cronyism in highly corrupt countries spur managers of privately owned airports to focus less on airport productivity objectives, leading eventually to lower airport efficiency.

The effects of corruption on mixed public-private ownership with government majority and 100% government ownership are obtained by summing the estimated coefficient of the corruption index to the estimated coefficients' vector of the interaction terms (i.e., $\lambda + \gamma$ if we refer to *eq.1*). For each ownership category, the impact is significant if the sum is statistically different from zero. In the RE specification, mixed ownership with government majority displays a sum of 0.007, whereas fully public ownership exhibits a sum of -0.013. In both cases, the Fisher test[30] concludes that the sum is not significantly different from zero at the required cutoffs. Corruption has no effects on the efficiency of both publicly owned airports.

In a high corruption environment, privately owned airports appear to operate less efficiently than publicly owned airports. This finding lines up with the work of Yan and Oum (2014) with respect to the autonomy of airport managers in allocating inputs. Yan and Oum (2014) argue that local tax revenues can fund the operations of a government-owned airport, and that the funding source restricts the airport's flexibility to change inputs allocation.[31] By contrast, managers of privately owned airports have enough managerial autonomy to allocate inputs, so they can either pursue cost efficiency objectives or divert resources to their personal benefits. Therefore, managers of privately owned airports have more freedom to pursue personal goals via changing the allocation of inputs than those of publicly owned airports when corruption is high.

With respect to the ownership form, the estimation results reveal that privately owned airports generally provide higher efficiency scores than publicly owned airports. The effect of each ownership category is derived from the sum of the estimated coefficient of the ownership dummy and its interaction

[28] We do not report here the estimation results for the sake of parsimony.

[29] We need to be careful in the interpretation of these results. As pointed out by Mauro (1995), when using perception indexes, it is not clear if the difference between the corruption grade of one and two is the same as between 4 and 5.

[30] The Fisher statistics (and their p-values) for mixed ownership with government majority and 100% public ownership are 1.60 (0.206) and 0.58 (0.446), respectively. In both cases, the null hypothesis cannot be rejected, suggesting that the sum of the coefficients is equal to zero. Corruption has no effects on efficiency of both types of ownership.

[31] Yan and Oum (2014) state that bureaucrats treat inputs as exogenous for the US commercial airports.

with corruption index, (i.e. $\beta + \gamma$ if we refer to *eq. 1*). The sums for mixed public-private ownership with government majority and 100% government ownership are -0.284 and -0.227, respectively. The Fisher tests[32] confirm the negative and highly significant coefficients for both majority and fully public ownership. These results suggest that publicly owned airports are less efficient than privately owned airports in a highly clean environment, in line with the findings of Oum, Adler and Yu (2006) and Oum, Yan and Yu (2008). Allowing the private sectors to hold a majority stake in the airport management and ownership would improve operating efficiency in a low corruption society. As such, a change from 100% government ownership to mixed public-private ownership with private majority would lead to an efficiency gain of 0.274. [33]

The level of local and gateway competition appears to have no specific impact on airport efficiency, in line with Adler and Liebert (2014). This result may be explained by the approach used to define the level of competition. Chi-Lok and Zhang (2009) stressed that airports serve many different markets including long and short distance, transshipment, and origin-destination markets. However, we are not able to consider these different markets due to the lack of information. We thus may have ignored product diversification strategies.

The coefficients of the form of regulation dummies vary across models but are not always statistically significant. In the pooled OLS specification, airports subject to cost-plus regulation with single till appear to be more statistically efficient than unregulated airports, while the ones subject to incentive regulation with dual till seem to be statistically less efficient. The RE model delivers different estimation results — none of the dummies are statistically significant — indicating that there is no difference between regulated and unregulated airports in terms of operating efficiency. Though some studies including Assaf and Gillen (2012), Adler and Liebert (2014) have emphasized the importance of accounting for the interaction between ownership, regulation and competition to explain airport operating efficiency, our study is limited to the analysis of the effects of corruption. Thus, we may have ignored the interaction between ownership, competition and regulation.[34]

The status as hub and/or international gateway of the airport is not statistically significant in both Pooled OLS and RE models. This provides some indication that most of the hubs in our sample do not possess size and location advantages. We also find no significant impact of multi-airport management on airport efficiency, suggesting that airports included in our sample may not exploit economies of scale and learning effects when they operate with multiple units in the same region. Our findings do not support the argument by Malighetti, Martini, Paleari and Redondi (2009).

At each stage of the estimation, we include time effects in the model, but the time effects were formally rejected in all cases. We note that the residual (or net) variable factor productivity already accounts for time effects.[35] Therefore, different shocks that potentially affect airport efficiency including the 9/11 terrorist attacks or the 2008 financial crisis should be captured by the rvfp index.[36] The coefficient

[32] The Fisher statistics (and their p-values) for mixed ownership with government majority and 100% public ownership are 12.11 (0.0005) and 7.42 (0.006), respectively. These statistics confirm the rejection of the null hypothesis, indicating that the sum of the coefficients is different from zero. Both types of ownership have significant impacts on airport efficiency.

[33] The efficiency gain from privatization is obtained by using a regression of rvfp on ownership form dummies and other explanatory variables, and setting the "100% government" ownership as the reference category. Thus, the effect of a change in the ownership from 100% government to mixed public-private ownership with private majority on rvfp is explained by the estimated coefficient of the mixed ownership with private majority.

[34] This study focuses on the effects of corruption on airport operating efficiency. Competition, regulation and ownership variables are included in the model as control variables.

[35] In computing the rvfp index, we exclude factors that are beyond managerial control including year dummies.

[36] As result of the terror attacks, security requirements were legally altered in Europe, requiring substantial investments on the part of the airports. As for the financial crisis in 2008, it provoked large drops in demands.

of GDP per capita is positive and always statistically significant at the 10% level, suggesting that airports operating in more developed countries are more efficient in general.

## 7. Robustness checks

### 7.1 Using additional sets of control variables

In order to ensure the robustness of our results, we extend the controls in the $X_{it}$ matrix of our equation (*eq.1*) to add country-specific institutional quality variables. This model is dubbed *model II* in Table 6. Lambsdorff (2003) emphasizes that corruption includes many different types of behavior, and decomposing it into governance-related subcomponents can identify the channels through which it affects productivity. Mauro (1995) argues that the efficiency of institutions is relevant for any firm operating in the country of interest, since they are assessed independently of macroeconomic variables. Therefore, we include government stability, quality of bureaucracy, internal and external conflict and law and order as indicators of institutional quality variables.[37] In *model III* of Table 6, another set of controls is added to *model II*: a proxy of openness to trade (share of imports in GDP) and a measure of the importance of government in the economy (share of central government revenues in GDP). The latter regressors are largely recognized in the literature as having a strong relationship with corruption.[38] Table 6 shows the estimation results using random effects specification. Robust standard errors are in parenthesis.[39]

Table 6: Estimation results using additional control variables

| Dependent variable: residual (or net) variable factor productivity (rvfp) | model II | model III |
|---|---|---|
| Corruption Index (ICRG Index) | -0.052***<br>(0.019) | -0.053***<br>(0.020) |
| Ownership form | Base: Mixed public-private ownership with private majority | |
| Government majority (above 50%) | -0.279***<br>(0.099) | -0.291***<br>(0.097) |
| Public corporation (100% government) | -0.222**<br>(0.101) | -0.214**<br>(0.102) |
| Ownership form*Corruption Index (ICRG Index) | Base: Mixed public-private ownership with private majority * ICRG Index | |
| Government majority* ICRG Index | 0.041**<br>(0.019) | 0.046**<br>(0.019) |
| Public corporation* ICRG Index | 0.026<br>(0.018) | 0.025<br>(0.019) |
| Regulation | Base: No ex-ante regulation | |
| Cost-plus, single till | 0.099<br>(0.100) | 0.128<br>(0.101) |
| Cost-plus, dual till | -0.042<br>(0.088) | -0.030<br>(0.085) |

[37] We follow the definitions proposed by ICRG to specify the institutional quality variables. Bureaucratic quality signals the independence of administration from political pressure, the use of established mechanisms for recruiting and training, and the strength and expertise of government services. Government stability defines the government's ability to carry out its declared program(s) and its ability to stay in office. Law evaluates the strength and impartiality of the legal system while the Order scores the popular observance of the law. Ethnic tension considers the degree of tension within a country attributable to racial, nationality, or language divisions. Internal conflict evaluates political violence in the country and its actual or potential impact on governance whereas external conflict scores the risk to the incumbent government from foreign action, ranging from non-violent external pressure to violent external pressure.

[38] See for example Mauro (1995), Dal Bò and Rossi (2007)

[39] Since all models display strong heteroscedasticity and autocorrelation in the residuals, we employ cluster-robust standard errors as recommended by Wooldridge (2002).

| | | |
|---|---|---|
| Incentive, single till | -0.084<br>(0.074) | -0.048<br>(0.070) |
| Incentive, dual till | -0.135*<br>(0.076) | -0.117<br>(0.075) |
| Charges set by airports (single & dual till) | -0.024<br>(0.106) | 0.036<br>(0.094) |
| Competition | Base: Weak competition | |
| Strong | -0.150**<br>(0.074) | -0.126*<br>(0.073) |
| Status as a hub and/or international gateway | 0.091<br>(0.065) | 0.060<br>(0.064) |
| Airport group management dummy | 0.025<br>(0.062) | 0.021<br>(0.062) |
| GDP per capita | 0.002<br>(0.001) | 0.002<br>(0.001) |
| Institutional quality variables | | |
| Quality of Bureaucracy | 0.008<br>(0.009) | 0.008<br>(0.008) |
| Law and Order | 0.016<br>(0.022) | 0.013<br>(0.022) |
| Ethnic tension | -0.003<br>(0.010) | -0.005<br>(0.010) |
| Internal conflict | 0.009<br>(0.010) | 0.011<br>(0.011) |
| External conflict | 0.009<br>(0.011) | 0.012<br>(0.010) |
| Government Stability | 0.003<br>(0.005) | 0.003<br>(0.005) |
| Openness to trade | - | -0.002<br>(0.001) |
| Share of central government revenues | - | 0.005<br>(0.005) |
| Intercept | 0.699***<br>(0.225) | 0.792***<br>(0.139) |
| Number of observations | 252 | 254 |

Notes: "***", "**", "*" denote statistical significance at the 1%, 5%, 10% levels, respectively. Robust standard error associated to each coefficient is stated in parenthesis. We dropped "mixed public-private ownership with private majority (including fully private)" dummy, "the interaction between mixed public-private ownership with private majority and corruption index", "no ex-ante regulation dummy" and "weak competition dummy" in all regressions to avoid multicollinearity.

The former results remain valid whatever the control variables, and in almost all extended models, the corruption impact on airport efficiency remains negative and significant at the 1% significance level. The negative coefficients of mixed public-private ownership with government majority and 100% government ownership confirm that privately owned airports are the most efficient in the absence of corruption. The interaction term between corruption index and mixed ownership with government majority keeps its positive and significant impact at the 5% level in both extended models. However, the statistical tests indicate that the overall effects of corruption on publicly owned airports including 100% and majority government owned airports remain insignificant.

The effects of the form of regulation, competition level, hub status and airport group management dummies remain statistically insignificant. GDP per capita does not appear to have significant impacts.

When we include openness to trade and the share of government revenue to the model, the picture does not significantly change. We apply statistic tests to verify whether the overall impacts of the institutional variables, openness to trade and the share of central government revenues are significant, and the results show that these additional factors do not have significant effects.[40] To sum up, our econometric results seem very robust across models.

### *7.2 Using alternative corruption indices*

The use of alternative measures of corruption allows to check on the robustness of our results and to make sure that the latter are not driven by the use of a particular index. We then consider two other corruption measures including Corruption Perception Index (CPI) of Transparency International and Control of Corruption Index of World Bank. Both are composite indices, which have the advantages to admit the biases of specific indices to cancel each other out, thereby determining an average opinion of corruption (Méon and Weill (2010)). Using the parsimonious specification from the RE estimator, Table 7 confirms that the previous main results are robust to other measures of corruption.[41]

Table 7: Estimation results using Corruption Perception Index (CPI) of Transparency International and Control of Corruption Index (CCI) of the World Bank

| Dependent variable: residual (or net) variable factor productivity (rvfp) | Using CPI Index | Using CCI Index |
|---|---|---|
| Corruption Index | -0.044*<br>(0.024) | -0.080***<br>(0.028) |
| Ownership form | Base: Mixed public-private ownership with private majority | |
| Government majority (above 50%) | -0.495**<br>(0.235) | -0.266**<br>(0.119) |
| Public corporation (100% government) | -0.258*<br>(0.176) | -0.273***<br>(0.103) |
| Ownership form*Corruption Index | Base: Mixed public-private ownership with private majority * Corruption Index | |
| Government majority*Corruption Index | 0.072*<br>(0.039) | 0.071<br>(0.044) |
| Public corporation*Corruption Index | 0.026<br>(0.027) | 0.062*<br>(0.032) |
| Regulation | Base: No ex-ante regulation | |
| Cost-plus, single till | 0.142<br>(0.098) | 0.159<br>(0.100) |
| Cost-plus, dual till | -0.003<br>(0.096) | 0.031<br>(0.096) |
| Incentive, single till | -0.052<br>(0.094) | -0.051<br>(0.095) |

[40] We test the null hypotheses that (a) the joint effects of the institutional quality variables are null and (b) the joint effects of openness to trade and share of central government revenues are null. Chi-squared displays statistics (and its p-value) of 6.10 (0.41) and 2.37 (0.3063), respectively, suggesting that the null hypotheses cannot be rejected.
[41] The Fisher tests confirm that the coefficients of both interaction terms in each model are null, indicating that corruption has no effects on efficiency of publicly owned airports.

| | | |
|---|---|---|
| Incentive, dual till | -0.083<br>(0.098) | -0.093<br>(0.099) |
| Charges set by airports (single & dual till) | 0.051<br>(0.121) | 0.117<br>(0.124) |
| Competition | Base: Weak competition | |
| Strong | -0.088<br>(0.072) | -0.107<br>(0.072) |
| Status as a hub and/or international gateway | 0.037<br>(0.076) | 0.040<br>(0.077) |
| Airport group management dummy | 0.042<br>(0.072) | 0.053<br>(0.073) |
| GDP per capita | 0.002**<br>(0.001) | 0.003**<br>(0.001) |
| Intercept | 0.866***<br>(0.173) | 0.793***<br>(0.123) |
| Number of observations | 253 | 254 |

Notes: "***", "**", "*" denote statistical significance at the 1%, 5%, 10% levels, respectively. Robust standard error associated to each coefficient is stated in parenthesis. We dropped "mixed public-private ownership with private majority (including fully private)" dummy, "the interaction between mixed public-private ownership with private majority and corruption index", "no ex-ante regulation dummy" and "weak competition dummy" in all regressions to avoid multicollinearity.

### *7.3 Using different categories of ownership*

We want to test if our results are robust to the change in the ownership categories. For this purpose, we separate fully private ownership from mixed public-private ownership with private majority. Four types of ownership are then considered: (1) 100% government (or public corporation), (2) mixed public-private ownership with government majority (above 50%), (3) mixed public-private ownership with private majority (above 50%) and (4) fully private. The 100% government ownership is used as the reference category. The estimation results using the RE specifications are reported in Table 8, with robust standard errors in parenthesis.

Table 8: Estimation results using different ownership categories

| Dependent variable: residual (or net) variable factor productivity (rvfp) | Coefficient |
|---|---|
| Corruption Index (ICRG Index) | -0.013<br>(0.010) |
| Ownership form | Base: 100% government (public corporation) |
| Government majority | -0.075<br>(0.076) |
| Private Majority | 0.364***<br>(0.102) |
| Fully Private | 0.016<br>(0.235) |
| Ownership form*Corruption Index (ICRG Index) | Base: 100% government *ICRG Index |
| Government majority *ICRG Index | 0.020<br>(0.015) |
| Private majority* ICRG Index | -0.041**<br>(0.020) |
| Fully Private* ICRG Index | 0.007<br>(0.053) |

| Form of regulation | Base: No ex-ante regulation |
| --- | --- |
| Cost-plus, single till | 0.123<br>(0.095) |
| Cost-plus, dual till | -0.015<br>(0.080) |
| Incentive, single till | -0.032<br>(0.060) |
| Incentive, dual till | -0.112<br>(0.068) |
| Charges set by airports (single & dual till) | 0.076<br>(0.097) |
| Competition | Base: Weak Competition |
| Strong | -0.083<br>(0.063) |
| Status as a hub and/or international gateway | 0.018<br>(0.066) |
| Airport group management dummy | 0.059<br>(0.052) |
| GDP per capita | 0.002<br>(0.001) |
| Intercept | 0.592***<br>(0.095) |
| Number of observation | 254 |

Notes: "***", "**", "*" denote statistical significance at the 1%, 5%, 10% levels, respectively. Robust standard error associated to each coefficient is stated in parenthesis. We dropped "100% government (or public corporation) ownership" dummy variable, "the interaction between 100% government ownership dummy and corruption index", "no ex-ante regulation dummy" and "weak competition dummy" in all regressions to avoid multicollinearity problem.

As stated in Table 8, the coefficient of corruption index is negative but not statistically significant at the required levels, which suggests that corruption has no effects on fully government-owned airports (the reference category). This confirms our previous findings. With respect to the impact of corruption on rvfp in privately owned airports, our previous results hold only for mixed public-private ownership with private majority. The coefficients of both corruption index and interaction terms, as well as the statistic of Fisher[42] confirm the negative relationship between rvfp and corruption for this ownership category. However, we find no significant effects for the other forms of ownership including fully private ownership. This result may be explained by the limitation of data on fully private airports included in our sample.

The positive and statistically significant coefficient for mixed public-private ownership with private majority is consistent with our previous finding. Again, privatized airports exhibit higher efficiency scores than government owned airports in the absence of corruption. However, no significant difference is found between fully private, mixed public-private ownership with government majority and fully public ownership, in terms operating efficiency.

### *7.4 Treating outliers*

Given the characteristics of our dataset, we would expect important outliers for some of the countries included in the sample. To address this potential issue, we drop from the sample: (1) extreme values of

[42] The Fisher test displays a statistic of 9.37 with a p-value of 0.0022, suggesting that the overall effects of corruption on efficiency of majority private owned airports are negative and statistically significant at the 1% l level.

airport efficiency (rvfp), (2) airports that provide the largest values of rvfp, (3) airports that display the smallest values of rvfp and (4) airports that display the smallest and largest values of rvfp. Table 9 compares the estimation results according to each specification using RE model, with robust standard error in parenthesis.

Table 9: Estimation results using different set of sample

| Dependent variable: Residual (or net) variable factor productivity (rvfp) | full sample | drop the extreme values | drop the largest airports | drop the smallest airports | drop the smallest and largest airports |
|---|---|---|---|---|---|
| Corruption Index (ICRG Index) | -0.041***<br>(0.018) | -0.037**<br>(0.017) | -0.036**<br>(0.018) | -0.037**<br>(0.017) | -0.031*<br>(0.016) |
| Ownership form | Base: Mixed public-private ownership with private majority | | | | |
| Government majority (above 50%) | -0.332***<br>(0.098) | -0.312***<br>(0.094) | -0.270***<br>(0.104) | -0.299***<br>(0.099) | -0.232**<br>(0.105) |
| Public corporation (100% government) | -0.254**<br>(0.101) | -0.249**<br>(0.100) | -0.228**<br>(0.111) | -0.195**<br>(0.098) | -0.160<br>(0.114) |
| Ownership form*ICRG Index | Base: Mixed public-private ownership with private majority *ICRG Index | | | | |
| Government majority* ICRG Index | 0.048**<br>(0.019) | 0.045**<br>(0.019) | 0.043**<br>(0.019) | 0.043**<br>(0.018) | 0.037**<br>(0.018) |
| Public corporation* ICRG Index | 0.028<br>(0.020) | 0.027<br>(0.019) | 0.027<br>(0.019) | 0.022<br>(0.019) | 0.021<br>(0.018) |
| Regulation | Base: No ex-ante regulation | | | | |
| Cost-plus, single till | 0.136<br>(0.092) | 0.110<br>(0.085) | 0.008<br>(0.094) | 0.135*<br>(0.077) | 0.013<br>(0.077) |
| Cost-plus, dual till | -0.003<br>(0.079) | -0.015<br>(0.074) | -0.014<br>(0.084) | 0.028<br>(0.070) | 0.016<br>(0.078) |
| Incentive, single till | -0.043<br>(0.060) | -0.051<br>(0.059) | -0.045<br>(0.058) | -0.082<br>(0.055) | -0.083<br>(0.054) |
| Incentive, dual till | -0.097<br>(0.069) | -0.106<br>(0.068) | -0.119*<br>(0.072) | -0.093<br>(0.068) | -0.118*<br>(0.070) |
| Charges set by airports (single & dual till) | 0.076<br>(0.089) | 0.072<br>(0.086) | 0.084<br>(0.091) | 0.028<br>(0.078) | 0.024<br>(0.076) |
| Competition | Base: Weak competition | | | | |
| Strong | -0.097<br>(0.060) | -0.068<br>(0.054) | -0.045<br>(0.061) | -0.073<br>(0.058) | -0.030<br>(0.059) |
| Status as a hub and/or international gateway | 0.039<br>(0.060) | 0.028<br>(0.059) | 0.008<br>(0.064) | 0.035<br>(0.061) | -0.003<br>(0.063) |
| Airport group management dummy | 0.045<br>(0.051) | 0.046<br>(0.048) | 0.035<br>(0.049) | 0.013<br>(0.046) | -0.006<br>(0.043) |
| GDP per capita | 0.002*<br>(0.001) | 0.002<br>(0.001) | 0.001<br>(0.001) | 0.003**<br>(0.001) | 0.002<br>(0.001) |
| Intercept | 0.823***<br>(0.128) | 0.818***<br>(0.128) | 0.807***<br>(0.143) | 0.832***<br>(0.127) | 0.825***<br>(0.139) |
| Number of observations | 254 | 234 | 225 | 228 | 199 |

Notes: "***", "**", "*" denote statistical significance at the 1%, 5%, 10% levels, respectively. Robust standard error associated to each coefficient is stated in parenthesis. We dropped "mixed public-private ownership with private majority (including fully private)" dummy, "the interaction between mixed public-private ownership with private majority and corruption index", "no ex-ante regulation dummy" and "weak competition dummy" in all regressions to avoid multicollinearity.

Our results are robust to whatever the set of sample. The coefficient of corruption index remains negative and statistically significant at least at the 10% level in each specification. Corruption negatively affects efficiency of privately owned airports. Except for the last sample in which we drop the smallest and largest airports, in the absence of corruption the publicly owned airports including 100% government ownership and mixed public-private ownership with government majority appear less efficient than privately owned airports. However, the coefficients of the corruption index, the interaction terms as well as the Fisher tests confirm that in high corruption environment the mixed public-private ownership with private majority are the least efficient.

## 8. Conclusions

While a number of studies have analyzed the determinants of airport efficiency, the role of corruption has attracted limited attention. The aim of this research is to investigate the effects of corruption on operating efficiency of 47 major European airports from 2003 to 2009, using a two-stage approach. In the first stage, the multilateral index number method is applied to compute our efficiency measure, the residual (or net) variable factor productivity (rvfp) index. The same index method is used by Air Transport Research Society (ATRS, 2011) to assess and compare managerial efficiency of airports worldwide. In the second stage, the effect of corruption on the airport efficiency is assessed using robust cluster random effects model. We use the corruption index from International Country Risk Guide (ICRG) as our main measure of corruption. The estimation results are consistent across the pooled Ordinary Least Squares (OLS) and random effects (RE) models but the latter provides better fit of the data.

We find strong evidence that corruption has negative impacts on airport's operating efficiency, and the impacts depend on the airport's ownership form. Airports owned and operated by mixed public-private enterprises with private majority (including 100% private) are expected to be the most efficient in a society where corruption is low. However, they exhibit lower levels of efficiency compared with airports operated by mixed public-private enterprises with government majority and fully government owned airports in highly corrupt countries. These results reflect the differences in autonomy of airport managers when they allocate and channel resources. Accordingly, managers of privately owned airports have more freedom to allocate resources than bureaucrats. We argue that poor governance and culture of cronyism in highly corrupt countries would provide incentives for private sector managers to focus heavily on rent seeking instead of focusing on airport productivity objectives, and eventually lead to lower airport efficiency. Also, there is more room for corruption to creep in because the majority of privatized firms avoid regular audits that the government owned enterprises are usually subject to.

Our empirical findings survive several robustness checks. To deal with potential omitted variable issues, we control for the form of regulation prevalent across European airports, competition level within the catchment area and across gateways, airport characteristics, including airport status as a hub and/or international gateway, whether the airport management belongs to a group from a managerial perspective and GDP per capita. We extend the set of controls to include country-specific institutional quality indicators and variables that vary across countries and over time such as a measure of openness to trade (share of imports in GDP) and a measure of the importance of government in the economy (share of central government revenues in GDP). The main results hold despite using two additional alternative measures of corruption: Corruption Perception index (cpi) established by Transparency International and Control of Corruption index (cci) provided by the World Bank.

Findings from this paper have important policy implications for government and airport managers. Our empirical findings suggest that high corruption in the country might be a hindrance to airport efficiency. Thus, governments who want to transfer airport management and ownership to private sectors may want consider the levels of corruption in the country and allocate adequate resources to reduce corruption.

The corruption levels of European countries are relatively lower compared with many parts of the world. Nonetheless, corruption has become a major concern since the number of officials and state-owned companies from European countries involved in bribery cases and other corruption acts has been increasing. This research, which is limited to Europe, can be extended to airports in other regions including Asia, Oceania and more specifically developing countries and highly corrupted regions. Major air infrastructures in developing countries are funded by the World Bank and/or funding agencies. If corruption not only causes misuse of resources but also impacts on airport operating efficiency, the recipient countries may not be able to pay back the loans. As such, the infrastructure projects lenders may want to retain a certain percentage of their loans, and use it for the country to set up clean project bidding and tendering processes with proper checks and balances, to educate and train officials and employees, and auditing during the project implementation period as well as ex-post auditing.

Furthermore, we use a specific airport efficiency index namely the residual (net) variable factor productivity index, which accounts for the short and medium term airport operating efficiency and does not consider capital investment. Future research is advised to consider alternative measures of efficiency that include capital investment.

***Appendix***

Table 1: Descriptive statistics

| Variable | Observation | Mean | Std. Deviation | Min | Max |
|---|---|---|---|---|---|
| ICRG Corruption Index | 254 | 4.998 | 2.649 | 0 | 10 |
| Corruption Perception Index (CPI) | 253 | 5.843 | 1.671 | 3.4 | 9.7 |
| Control of Corruption Index (CCI) | 254 | 2.251 | 1.386 | 0.000 | 5.719 |
| GDP per capita (in current US Dollars) | 254 | 35 204.5 | 16 199.18 | 2 641.79 | 95 189.9 |
| Openness to trade (in %) | 254 | 43.099 | 17.175 | 23.875 | 91.575 |
| Share of central government revenues in GDP (in %) | 252 | 34.014 | 6.398 | 17.955 | 51.234 |
| Quality of Bureaucracy | 254 | 2.323 | 3.032 | 0 | 10 |
| Law and Order | 254 | 2.550 | 2.019 | 0 | 10 |
| Ethnical tension | 254 | 5.057 | 2.419 | 0 | 10 |
| Internal Conflict | 254 | 3.679 | 2.227 | 0 | 10 |
| External Conflict | 254 | 3.502 | 2.749 | 0 | 10 |
| Government Stability | 254 | 3.887 | 1.567 | 0 | 10 |
| Dummy variables | Frequency | Percent | Cumulative | Min | Max |
| Ownership form | | | | | |
| 100% government or public corporation | 126 | 49.61 | 49.61 | 0 | 1 |
| Mixed ownership with government majority (above 50%) | 56 | 22.04 | 71.65 | 0 | 1 |
| Mixed ownership with private majority (including 100% private) | 72 | 28.35 | 100 | 0 | 1 |
| Form of regulation | | | | | |
| Unregulated | 51 | 20.08 | 20.08 | 0 | 1 |
| Cost-plus, single till | 50 | 19.69 | 39.76 | 0 | 1 |
| Cost-plus, dual till | 29 | 11.42 | 51.18 | 0 | 1 |
| Incentive, single till | 55 | 21.65 | 72.83 | 0 | 1 |
| Incentive, dual till | 33 | 12.99 | 85.83 | 0 | 1 |
| Charges set by airports (single & dual till) | 21 | 8.27 | 94.09 | 0 | 1 |
| Not available | 15 | 5.91 | 100 | 0 | 1 |
| Belongs to an airport group from a management perspective | | | | | |
| Yes | 111 | 43.70 | 43.70 | 0 | 1 |
| No | 143 | 56.3 | 100 | 0 | 1 |
| Competition | | | | | |
| Strong | 164 | 64.57 | 64.57 | 0 | 1 |
| Weak | 90 | 35.43 | 100 | 0 | 1 |
| Hub Status | | | | | |
| Yes | 215 | 84.65 | 84.65 | 0 | 1 |
| No | 39 | 15.35 | 100 | 0 | 1 |

Source: ATRS annual reports (2003- 2009). International Country Risk Guide - The Political Risk Ratings (2009). Transparency International (2009). The World Bank Indicators (2009). Units of measurement are in brackets.

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