The impact of recession on airports' cost efficiency

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Thank you for your assistance.
The impact of recession on airports' cost efficiency

Augusto Voltes-Dorta a, Romano Pagliari b

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Airport cost efficiency worldwide dropped 5.85% between 2007 and 2009. This leads to a global loss of approximately USD 5.5 billion over this period. North American airports are the most severely affected by the recession. Results suggest a negative impact of outsourcing on cost flexibility. Privatization and corporatization seem to improve cost flexibility.
The impact of recession on airports’ cost efficiency

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ABSTRACT

The recent economic downturn took a severe toll on the aviation industry, leading to a significant contraction in air transport demand. In spite of that, airports’ operating costs did not mirror the declining traffic trends and continued to increase during the same period. This paper sought to estimate the impact of the recession on airports’ cost efficiency and financial performance. This is achieved by estimating the industry’s short-run cost frontier over a balanced pool database of 194 airports observed between 2007 and 2009. Results show that airports struggled to control operating costs during the recession. Efficiency losses were estimated to be in excess of USD 5.5 billion, contributing to a significant reduction in industry operating margins. Results also suggest that airports that are corporatised and have not pursued extensive out-sourcing of activities are better able to manage their costs during periods of economic recession.

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1. Introduction

The recent economic downturn has taken a significant toll on the air transport industry. As seen in Fig. 1, after a period of sustained growth between 2002 and 2007, worldwide passenger traffic stagnated in 2008 and then declined by 1.8% in 2009 (ACI, 2011). In spite of that, not all regions were equally affected, with major traffic losses in the mature markets of North America and Europe, showing a total variation of −8.3% and −4.1% in passengers, respectively, between 2007 and 2009. Other regions, such as Asia-Pacific, had the chance to grow (+6.1%), thriving on their booming domestic markets (Airbus, 2009). A similar trend can be observed for air cargo where total metric tons fell by 3.7% in 2008 and by 7.9% in 2009. In this case, all regions experienced traffic losses from the first moment, yet again, these were higher in Europe and North America (−11%) than in other regions (−2%).

As demand contracted, air carriers quickly reacted by reducing capacity and eliminating non-profitable routes in order to protect load factors and yields (ATA, 2010). From an airport perspective, this translates into reduced traffic levels, which are typically measured in terms of passengers, aircraft movements and cargo tonnage. This downward trend inevitably led to a reduction in airport revenues. ACI’s Airport Economic Survey (ACI, 2011) notes that total industry income declined by 2% between 2008 and 2009, mirroring the traffic trend, from 96 to 94.5 billion USD. Unfortunately, a similar trend is not observed on the cost side. Even under a significant reduction in traffic, industry operating costs increased by 3.6% in the same period, from 55 to 57 billion USD. This includes labor and external charges, typically considered the truly variable costs of airports (Oum et al., 2008).

Airports are particularly infrastructure-intensive, which inevitably leads to massive investments, indivisibilities and step-changes in size and capacity. The presence of these fixities, either technological or regulatory, has been traditionally linked to an inherent inability within the airport sector to be able to adjust input demands (i.e. capital, utilities, and labor) to evolving traffic levels (Graham, 2008). This assumption is supported by the evidence presented above as airports were not able to control costs in spite of the decrease in traffic. In addition to the associated reduction in operating margins, this paper hypothesizes that this behavior has also led to a general reduction in airport cost efficiency worldwide.

With this background, the objective of this paper is to estimate the impact of the recession on airports’ cost efficiency and financial performance. Results will serve to test the assumption that airports facing decreasing traffic are not flexible in costs, as empirical evidence in that regard has yet to be provided. Note that the latest downturn provides a unique background for this type of econometric research, as financial data on airports became increasingly available at a time when they were challenged to control costs. This study would be of interest for the airport industry, especially in the present context of privatization, where airport efficiency and profitability are major issues for regulators and practitioners (Sarkis and Talluri, 2004). In addition, any policy...
conclusion aimed at increasing flexibility can lead to cost savings which are crucial as airports struggle to maintain service quality through the financial crisis.

1.1. Literature review

In the last two decades there have been a growing number of empirical studies on airport efficiency and productivity. A representative sample of these contributions is shown in Table 1. During this period, the aviation industry suffered three different demand crises, all characterized by stagnation and then followed by a decrease in global passenger traffic (IATA, 2008): (i) 1991–1993, linked to the early 90’s recession, (ii) 2001–2003, linked to the 9/11 attacks, and (iii) 2008–2010, linked to the latest global crisis. Regarding this last period, there is a clear literature gap as no published study features data on airports from developed regions for the key year 2009. In spite of that, some lessons on the impact of recession on airport efficiency could still be learned from studies undertaken in earlier periods.

Out of the 49 original studies in Table 1, 39 use panel data [Panel], which is a necessary requirement for a comparative analysis of efficiency over time. Of these, 26 cover any of the relevant crisis periods in their databases [Crisis], but thereof, only three papers consider the impact of recession on airport performance [Impact].

Barros (2008c) analyzed output efficiency (OE) of 32 Argentinian airports between 2003 and 2007, a period of recession after the collapse of the banking system, leading to a 50% reduction in traffic. Results indicate that major hubs were relatively immune to the crisis while small regional airports appeared to be more vulnerable. Nevertheless, average OE grew over the period. This conclusion, however, is not easily generalizable given the country-specific airport sample. In that regard, it is preferable to have international databases, which can provide a more comprehensive approach to the subject. Pathomvisri and Haghani (2004) and Pathomsiri et al. (2005) used a worldwide database to test differences in global OE between 2000 and 2002. These studies, however, remain unpublished and no relevant conclusions on the impact of 9/11 on airport efficiency are provided. Thus, it appears the impact of demand shocks (e.g. economic recessions) on airport efficiency has not been fully covered by previous studies. This paper seeks to address this gap in the literature.

The proposed methodology is based on the econometric estimation of stochastic cost frontiers. Even though the estimation of these models requires a significant amount of financial data, which is not always easy to obtain for airports, it has the enormous advantage of easily accommodating multi-production and panel data analysis (Jara-Díaz, 2007). In addition, cost frontiers can be adapted to a short-run context, more suitable to analyze cost flexibility. Airport cost frontiers are relatively scarce in the literature, since early cost function studies did not consider inefficiencies in their sample airports. In addition, the use of very different data and methodologies provides inconsistent findings. For the long-run studies, these discrepancies are related to the extent to which airports enjoy returns to scale. Different studies have produced divergent views on the point at which returns to scale appear. These range from the constant returns in the pioneering single-output paper of Keeler (1970), using US airports; up to 1 million passengers in Doganis and Thompson (1974) using an UK sample, up to 3 million passengers in Jeong (2005), again with US airports; up to 20 million in Tolofari et al. (1990); and even beyond 120 million annual passengers in Martin and Voltes-Dorta (2011b), using a worldwide sample. This gives an indication as to how highly sensitive the estimation of a cost function is to the airport sample. Short-run cost functions are more scarce (e.g. Tolofari et al., 1990), as only Martin et al. (2011), using a sample of Spanish airports, provides individual estimates of short-run cost elasticities. Speaking strictly about stochastic frontier papers, one can highlight the long-run cost function of Martin et al. (2009) or the recent study of Barros (in press) using a small sample of African airports.

However, all of these studies are limited in the sense that they are restricted to analysis of single jurisdictions and it is difficult to apply their conclusions to the global airport industry. It is clear that, since the recession has affected many regions, the empirical study must feature a large number of airports worldwide observed before and after the onset of the global crisis. Continuing the selection started above, nine of the 26 relevant studies in Table 1 use a cross-country sample [Cross]. Among these, only six feature a large database (40 airports or more) [DB]. Adding the final restriction of a cost-efficiency [CE] approach (rather than OE	extsuperscript{2}), only two papers can be cited as suitable methodological references.

Oum et al. (2008) provided the first example of a short-run multi-output airport cost frontier estimated using Bayesian

1 Short-run models only include those costs that airports would theoretically be capable of controlling in the short-term, such as labor and utilities, as opposed to long-run models where capital costs are also considered. Cost flexibility during growth periods is commonly associated to flexible planning (modular terminals, etc.) with the objective to minimize long-run costs. On the contrary, during an economic recession, airports are stuck with existing capacity then try to minimize short-run costs. A long-run approach would be difficult to adapt to a recession context as airports delay capital investments by anticipating the contraction in demand, which introduces endogeneity in the model. Hence, a short-run approach is preferred.

2 Cost efficiency studies focus on cost minimization, while output efficiency studies focus on output maximization. Estimating cost efficiency allows for further disaggregation between the technical and allocative components of efficiency.
inference. This paper used a pool of 109 airports worldwide between 2001 and 2004, and, while it discusses the difficulties in collecting comparable financial data, it does not solve the problem of calculating airport-specific input prices (Purchasing Power Parities were used as proxy for the price of "materials").

Martin, Voltes-Dorta. (2011a) collected data on 161 airports worldwide between 1991 and 2008. The increase in observations allowed them to improve the (long-run) cost frontier estimation methodology with, for example, the specification of five outputs, the inclusion of take-off weight as an hedonic adjustment of aircraft operations (See Section 3), a new method to calculate input prices, and the joint specification of technical and allocative inefficiencies.

Taking all into consideration, we decided to adapt the method from Martin and Voltes-Dorta. (2011a) to a short-run context. A balanced pool database of 194 airports worldwide between 2007 and 2009 will be used, featuring a wide variety of airport sizes and output mixes. The present study is appended in Table 2 as described, in order to help place this contribution within the broad spectrum of airport efficiency research. The rest of this paper is organized as follows: Section 2 describes the worldwide sample and data sources and Section 3 introduces the cost frontier methodology. This is followed by Section 4 which analyzes the evolution of efficiency estimates during the sample sizes and output mixes. The present study is appended in Table 2 as described, in order to help place this contribution within the broad spectrum of airport efficiency research. The rest of this paper is organized as follows: Section 2 describes the worldwide sample and data sources and Section 3 introduces the cost frontier methodology. This is followed by Section 4 which analyzes the evolution of efficiency estimates during the sample years.
period and quantifies the impact of the recession on cost efficiency and operating margins. Finally, Section 5 summarizes the main findings.

2. Database and data Sources

The short-run cost frontier was estimated over a balanced pool database of 194 airports from all over the world, observed between 2007 and 2009; producing a grand total of 582 observations. Starting from its onset in late 2007, the sample period was chosen to cover those years were the impact on traffic of the global crisis was more severe, as the first signs of recovery were observed during the first quarter of 2010 (Eurostat, 2011). Taking into account that major traffic losses were recorded in the "mature" markets in North America and Europe, the airport sample is clearly biased to these regions. The geographical breakdown of the 194 sample airports is as follows: 72 observations from North America, 106 from Europe, and 16 from Asia-Pacific and Oceania (Appendix A).

Data collection was completed for the following variables: (i) variable costs (vc): labor (lab) and materials (mat); (ii) Outputs: Domestic-Schengen (dom) and international-transborder passengers (int), air transport movements (atm), average landed Maximum Take-off Weight (mtow), metric tons of cargo (cgo), and non-aviation revenues (rev); (iii) Fixed factors: gross floor area of the airport (gat), check-in desks (chk), and baggage claim facilities (fet), share of the dominant carrier (sdc), Hirschman–Herfindahl index of airline traffic shares (hh), share of charter traffic (scha), and non-aviation revenues (rev); (iv) Other: time (t), full-time equivalent employees (fte), share of the dominant carrier (sdc), Hirschman–Herfindahl index of airline traffic shares (hh), share of charter traffic (scha), share of low-cost traffic (slcc), and ownership form. For homogeneity purposes, all monetary variables were converted to 2009 Purchasing Power Parity (PPP) USD using OECD's exchange rates. Labor costs include all types of employee compensation, such as salaries and wages, retirement, and health benefits. Only the employees of the reporting authority, typically the airport operator, are considered. "Materials" costs include maintenance, utilities, external services and other administrative costs. Note that the share of materials will be correlated with the degree of outsourcing of each airport, thus serving as a proxy for this variable. Also note that these costs include all in-house activities, which vary widely across airports. Section 3 discusses how the calculated input prices take this heterogeneity into account.

Data was mainly extracted from annual reports published online by the respective airport authorities. In certain cases (i.e., UK, France and Turkey) comprehensive financial reports at a country level were consulted (Sharp et al., 2010; DHMI, 2010; DGAC, 2010). For the US sample, besides the annual reports, the main source is the CATS financial database published online by the Federal Aviation Administration (FAA, 2011). Additional data on costs and revenues for specific airports (e.g., Portugal, Japan, Romania, Ukraine) is available online from ICAO/ATI statistics portal (ICAO, 2011). Even though most annual reports follow the International Financial Reporting Standards (IFRS), efforts were made to improve comparability. Regarding the other variables, in most cases, airports annual reports and master plans provide enough data on traffic activity and infrastructure. Other relevant sources are ACI World Airport Traffic Reports WATR 2009–2007, ACI, 2010 and IATA Airport Capacity and Demand profiles 2003 IATA, 2003. Average landed MTOW, dominant carriers, airline concentration, and the shares of charter and low-cost flights were calculated using data on ATMs; disaggregated by either aircraft type or published operator from the Official Airline Guide iNet Schedules tool (OAG, 2011). Table 2 provides descriptive statistics for the most relevant variables in the cost frontier estimation: variable costs, outputs, and fixed factors. The scale of production ranges from 1,500 annual ATMs at Carcassonne (Southern France) in 2009, to slightly over 980,000 ATMs at Atlanta in 2007. The average sample airport serves about 168,000 annual ATMs, 9.5 million domestic and 3.9 million international passengers, and 284,000 t of cargo. Geometric means are also relevant as they provide the approximation point for the translog cost function. In total, the 194 sample airports served 2.44 billion passengers and 46.5 million tons of cargo in 2009, which represent 50% and 58% of worldwide traffic, respectively.

Table 3 provides a disaggregated look at the financial and traffic figures in order to check if the database is representative of the global trends described in Section 1. As expected, total passenger traffic at sample airports remained flat in 2008 and decreased significantly in 2009, with the percentages being very close to ACI’s worldwide estimates (in parentheses). The similarity extends to the regional estimates, where there were sharp reductions in both the North American and European
markets. The temporary deceleration and early recovery of the Asia-Pacific cluster is explained by the sample as well. A similar picture is drawn for air cargo activity, which started to decline in 2008 and then followed by further contraction in 2009. While the temporary deceleration and early recovery of the recession. This is bound to lead to increased inefficiency worldwide, the estimation of which is the objective of the next section.

### 3. Cost frontier estimation

The econometric estimation of a short-run cost frontier requires data on variable costs (VC), outputs (Y), input prices (ω) and fixed factors (K) of airports whose behavior is assumed to be cost-minimizing. The preferred functional form is the transcendental logarithmic-translog (Christensen et al., 1973), which is the most commonly used in this kind of empirical study. A second-order translog expansion of a short-run variable cost function has this general structure, where g represents statistical disturbance:

\[
\ln VC = x_0 + \sum \beta_i \ln Y_i + \sum \rho_j \ln \omega_j + \sum \sum \varphi_{ij} \ln K_m + \sum \sum \gamma_{mj} \ln \omega_m \ln \omega_j \\
+ \sum \sum \gamma_{mj} \ln K_m + \sum \sum \varphi_{ij} \ln \omega_j \ln K_m \\
+ \frac{1}{2} \left[ \sum \sum \rho_{ij} \ln Y_i \ln Y_j + \sum \sum \rho_{ij} \ln \omega_i \ln \omega_j \right] \\
+ \sum \sum \sum \rho_{ij} \ln K_m \ln K_n
\]

(1)

![Fig. 2. Total costs vs passenger and cargo traffic 2007–2009.](image-url)

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<tr>
<th>Table 3</th>
<th>Evolution of passenger traffic and operating costs at sample airports 2007–2009.</th>
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<tr>
<td></td>
<td>2007</td>
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<tr>
<td>NORTH AMERICA</td>
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<td>PAX (million)</td>
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<td>CARGO (thousand tons)</td>
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<td>COST (PPP million)</td>
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<td>LAB</td>
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<td>MAT</td>
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<td>EUROPE</td>
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<td>PAX (million)</td>
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<tr>
<td>CARGO (thousand tons)</td>
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<td>MAT</td>
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<td>CARGO (thousand tons)</td>
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In parentheses are the ACI estimates.
The translog equation is typically estimated jointly with its
cost-minimizing input shares \((s)\) by means of a Seemingly
Unrelated Equations Regression—SURE (Zellner, 1962). Input share
equations are easily obtained by differentiating and applying
Shephard’s Lemma:\(^{10}\)
\[
s_i = \frac{\partial\ln V_C}{\partial x_i} = \frac{\partial\ln V_C}{\partial x_i} + \frac{\partial\ln V_C}{\partial x_i} + \sum_j \eta_j \ln y_j + \sum_k \eta_k \ln y_k + \sum_l \eta_l \ln y_l
\]
(2)

If panel data is available, the model can be completed with the
time variable \((t)\) in order to account for technological change in
the industry (Stevenson, 1980).

A variable cost function provides insight on other technologi-
cal indicators of interest from both management and policy
perspectives. The partial derivative of logged costs with respect
to a logged output leads to the same output’s cost elasticity \((\eta)\).
The inverse of the sum of all specified outputs’ cost elasticities
leads to the airport’s degree of economies of capacity utilization
(EMU). A value of EMU > 1 indicates that the airport is operating
with excess capacity and there are opportunities for reducing
average operating costs by increasing the output. On the contrary,
a value of EMU < 1 indicates that the airport has pushed its output
level beyond maximum capacity and it is experiencing increasing
average operating costs, possibly caused as a result of the need
to employ additional resources to cope with pressures caused
by congestion. Expansion should be considered at this stage.
Finally, EMU = 1 indicates that, in theory, the airport is operating
at optimal capacity.

\[
\eta = \frac{\partial\ln y}{\partial\ln y} = \frac{1}{\sum \eta_j}
\]
(3)

Following Martin and Voltes-Dorta (2011a), the short-run cost
model features five outputs: commercial aircraft movements
(ATMs), domestic and Schengen passengers \((\text{dom})\), international/
transborder passengers \((\text{int})\), metric tons of cargo \((\text{ggo})\), and
commercial revenues \((\text{rev})\) measured in PPP USD. Furthermore,
ATMs will be hedonically adjusted using the airport’s average
landed Maximum Take-Off Weight \((\text{MTOW})\) as a quality variable.
This technique was developed in the seminal paper of Spady and
Friedlaender (1978):
\[
\ln \text{ATM}_{\text{MTOW}} = \ln \text{ATM}_i + \psi \ln (\text{MTOW}_i)
\]
(4)

This is intended to account for the significant heterogeneity in
aircraft mixes across the sample as different aircraft impose
different operating costs to the airports. The hedonic coefficient
provides an estimate of the cost elasticity of aircraft weight.
A value of \(\psi > 1\) indicates that the variable costs imposed by an
aircraft during either landing or take-off increase more than
proportionally with its MTOW.

The cost function also features two input prices: materials
\((o_m)\), and labor/personnel \((o_p)\). The price of labor is obtained by
dividing labor costs by the full-time equivalent employees \((\text{fte})\) of
the airport authority. The calculation of the price of materials is
more complex: materials costs are divided by a quantity index
based on marginal productivity ratios, calculated among a
predetermined set of inputs assumed to represent the airport’s
overall demand for utilities and maintenance (“shadow inputs”).
Marginal productivities are estimated from a ray production
frontier provided by the reference paper\(^{11}\). The “shadow”
inputs considered were check-in desks, boarding gates, and total
warehouse space. As prices are related to the observed costs, they
reflect each airport’s specific circumstances (i.e., labor policies,
scope of outsourcing, leased terminals, etc.). This reduces the
need for data homogenization and, provided there are enough
sample airports with the same internal characteristics, it allows
for fair efficiency comparisons between airports from different
regions\(^{12}\).

Regarding fixed factors, this paper follows the approach from
Martin et al. (2011) and considers total floor area of terminal
buildings \((\text{ter})\) and total runway length \((\text{run})\). The full specification
of the proposed cost system is shown in Appendix B. Note that all
explanatory variables are logged and deviated with respect to
their sample means. Additional parametric restrictions are
included in order to impose linear homogeneity in input prices.

In addition, it is likely that some, if not all, sample airports have
incurred in technical or allocative inefficiencies \((\text{AI})\) during the sample period\(^{13}\). Both impacts must be specified
separately in the model in order to avoid estimation biases
(Kumbhakar and Tsions, 2005). An additional disturbance term
should be introduced in order to account for technical ineffic-
icy, leading to a stochastic frontier specification (Aigner et al., 1977),
while the impact of AI on operating costs is formulated using
the shadow price method of Kumbhakar (1997). The resulting
specification, however, is non linear in parameters and thus too
complex to be estimated using classical techniques. In these
cases, Bayesian inference and numerical models are the preferred
alternative (Van der Brook et al., 1994). For its simplicity, the
WinBUGS software (Lunn et al., 2000) will be used in that task, as
well as the codification proposed in Griffin and Steel (2007).

This assumes that the dependent variable \(i.e.\) the logarithm of the
variable costs) is normally distributed, with the aforementioned
translog equation as the mean and \(\sigma^2\) as the white noise variance:
\[
\ln V_C = \ln (\frac{\partial\ln V_C}{\partial\ln y}) = \gamma \ln (\text{MTOW}) + \ln (\text{MTOW}) + u
\]
(5)

\(V_C\) represents actual costs, \(\bar{V}_C\) is the cost frontier \(i.e.\) minimum cost, \(\bar{V}_C\) represents the percentage increase in costs
linked to the allocative distortions \((\xi)\) and \(u\) is a positively-valued
error term measuring technical inefficiency. Once the correspond-
ing partial derivatives are taken, input share equations suffer a
similar transformation (See Appendix B).

The parameter of technical inefficiency \(u\) is allowed to vary
systematically overtime allowing firm-specific effects \(\eta\) (Cuesta,
2000). Note that a negative \(\eta\) indicates that the airport increases
efficiency over time \((T\) is the baseline year 2007). Thus, \(\eta\)
indicates the level of technical inefficiency of firm \(i\) in the time
period \(t\). The firm’s average inefficiency \(u_i\) is assumed to be
exponentially distributed\(^{14}\) with mean \(\lambda^{-1}\)
\[
V_C = \exp(\eta t) + u, \text{ where } u \sim \exp(\lambda)
\]
(6)

Prior distributions must be assigned to the parameters. The
cost frontier coefficients \((\beta)\) follow a non-informative normal
distribution with zero mean and infinite variance\(^{15}\). In the same
spirit, a gamma distribution \((0.001, 0.001)\) is assigned to the

---

\(^{12}\) German airports tend to cover a wider range of core activities in-house,
which inevitably leads to higher operating costs than similar airports in other
countries. However, since they have also higher input prices, their frontier costs
will be also higher. Thus, each airport will face a cost frontier adequate to its cost
structure.

\(^{13}\) From a cost perspective, the airport is said to be technically inefficient if,
given an output target and the actual input proportions, it fails to achieve the
minimum operating cost. Furthermore, the airport will be allocatively inefficient if
there is an alternative input combination that would reduce costs even further.

\(^{14}\) The exponential distribution was preferred because it only requires a single
coefficient to be estimated. Martin et al. (2009) estimated cost efficiencies for
Spanish airports under exponential, truncated normal and half-normal distribu-
tions finding no significant differences in the estimated efficiencies.

\(^{15}\) Normal distributions in Eq. 7 follow WinBUGS’ notation: \(N(\text{mean}, \text{inverse}-\text{variance})\).
Table 4
Short-run cost function parameter estimates.

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<thead>
<tr>
<th>Node</th>
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<td>0.070874</td>
<td>int ‘wm’</td>
<td>0.001371</td>
<td>0.000788</td>
<td>0.5 ‘dom’</td>
<td>0.009318</td>
<td>0.006642</td>
</tr>
<tr>
<td>ATMh</td>
<td>0.087782</td>
<td>0.010035</td>
<td>int ‘wp’</td>
<td>-0.001283</td>
<td>0.000893</td>
<td>0.5 ‘int’</td>
<td>0.004085</td>
<td>0.000421</td>
</tr>
<tr>
<td>dom</td>
<td>0.077115</td>
<td>0.004552</td>
<td>cg0 ‘wm’</td>
<td>-0.014463</td>
<td>0.001163</td>
<td>0.5 ‘cg0’</td>
<td>0.000434</td>
<td>0.000623</td>
</tr>
<tr>
<td>int</td>
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<td>0.002554</td>
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<td>0.005759</td>
<td>0.001323</td>
<td>0.5 ‘rev’</td>
<td>0.019821</td>
<td>0.003722</td>
</tr>
<tr>
<td>cg0</td>
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<td>0.002384</td>
<td>rev ‘wm’</td>
<td>-0.014278</td>
<td>0.002978</td>
<td>0.5 ‘ter’</td>
<td>0.052963</td>
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<tr>
<td>rev</td>
<td>0.228644</td>
<td>0.003256</td>
<td>rev ‘wp’</td>
<td>0.031942</td>
<td>0.002804</td>
<td>0.5 ‘run’</td>
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</tr>
<tr>
<td>ter</td>
<td>0.103969</td>
<td>0.008433</td>
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<td>0.072283</td>
<td>0.003415</td>
<td>ATMh ‘ter’</td>
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<td>0.016065</td>
</tr>
<tr>
<td>run</td>
<td>0.261125</td>
<td>0.013009</td>
<td>ter ‘wp’</td>
<td>-0.069291</td>
<td>0.003564</td>
<td>ATMh ‘run’</td>
<td>0.066675</td>
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</tr>
<tr>
<td>wm</td>
<td>0.582029</td>
<td>0.02093</td>
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<td>-0.054149</td>
<td>0.004796</td>
<td>t ‘run’</td>
<td>-0.074750</td>
<td>0.001314</td>
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<tr>
<td>wp</td>
<td>0.471754</td>
<td>0.02159</td>
<td>run ‘wp’</td>
<td>0.051693</td>
<td>0.004966</td>
<td>t ‘ter’</td>
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<td>0.001587</td>
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<td>ATMh ‘wm’</td>
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<td>0.003810</td>
<td>0.5 ‘wm’</td>
<td>0.064102</td>
<td>0.008333</td>
<td>ATMh ‘wm’</td>
<td>0.011722</td>
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</tr>
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<td>ATMh ‘wp’</td>
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<td>0.003818</td>
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<td>0.002526</td>
<td>psi (hedonic)</td>
<td>1.034736</td>
<td>0.069224</td>
</tr>
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<td>0.000883</td>
<td>0.5 ‘atm’</td>
<td>0.067594</td>
<td>0.009787</td>
<td>VC †</td>
<td>1.047803</td>
<td>0.039591</td>
</tr>
</tbody>
</table>

Note: ATMh: hedonically-adjusted aircraft movements; dom: domestic passengers; int: international passengers; cg0: cargo tonnage; rev: commercial revenues; ter: terminal surface; run: runway length; wm: price of materials; wp: price of labor; t: time trend. Bold indicates non-significant coefficients (5%).

White noise inverse-variance. The distributional structure of technical inefficiency, via the λ parameter, allows us to impose prior ideas about mean efficiency (r*) in the airport industry. This is set at 0.854 as indicated in Martin and Voltes-Dorta (2011a). The allocative distortion ζ is specified as a normally distributed variable with mean zero and inverse-variance 18, based on the notion that average AI is likely to be small (Kumbhakar and Tsionas, 2005) and input proportions are unlikely to deviate more than twice from the optimal ones. The prior distribution of η was also chosen to be a zero mean normal distribution representing the prior indifference, despite the circumstances, between increasing or decreasing efficiency at each airport. An inverse-variance of 10 allows for a reasonable spread. The same applies to the ψ coefficient of the hedonic ATM function that is specified as a uniform distribution U(0,2).

β ∼ N(0,0), ω ∼ N(0.01,0.001), ζ ∼ exp(−log*r*)

Since the estimation will benefit from any additional information that can be added to the system, both factor share equations (materials and labor) are included. The results of the Bayesian estimation are shown in Table 4. The R² coefficient (built in the estimation code) provides an average of 0.928, which indicates excellent goodness-of-fit of the proposed model. In addition, the standard F-test against global significance is clearly rejected. The posterior densities of the cost function coefficients are characterized by their means and standard deviations. From these values it is straightforward to show (using e.g. a t-ratio test) that the vast majority of parameters (35 out of 39) are significantly different from zero at a 5% confidence level. The first-order output variables all have the expected positive signs. Apart from that, and since it was imposed in the estimation code, linear homogeneity in variable input prices also holds in the approximation point, as proven by a built-in Wald test (Probability =0.78) on the first-order price coefficients.

The coefficients associated to the fixed factors are positive and significant, implying the existence of some degree of short-run disequilibrium. The degree of economies of capacity utilization (ECU) at the average airport is calculated as the inverse of the sum of the first-order output coefficients. This yields 2.13, showing a significant degree of excess capacity in the industry. Additional conclusions can be drawn from the squared-output interactions, which show that overall capacity is exhausted much faster by increasing ATMs than any other output16. This is seen in the case of London Heathrow, which presents diseconomies of capacity despite the recent terminal expansion (ECU =0.96). In this case, the exceptionally congested runways are offsetting any cost advantages related to the excess terminal capacity.

The posterior density of λ indicates that average technical inefficiency is 0.57 ± 0.143 for the baseline year 2007. Regarding AI, a stochastic node was built into the model (VC†) in order to measure the percentage increase in costs linked to AI. Results show that, on average, costs should be able to reduce their TE costs by almost 48% if input proportions were adequate to the observed prices. Taking into account the cost shares at the average airport (58% materials), this suggests that airports are outsourcing more than would be desirable. Nevertheless, the quality of the data does not allow for a detailed analysis of AI. Therefore, the next chapter combines both technical and allocative components in a single indicator of cost efficiency (CE) upon which the impact of the recession will be analyzed. The individual CE estimates can be obtained by multiplying each airport’s technical and allocative efficiencies (CE = TE × AE) calculated from the following expressions (Kumbhakar, 1997):

\[ VC = VC TE \times VC WM; \]
\[ VC TE = VC VC WM; \]
\[ TE = VC TE / VC WM; \]
\[ AI = VC TE × \text{AE}; \]
\[ CE = VC TE × \text{AE}; \]

4. Results and Discussion

The estimated cost frontier provides technological evidence upon which a preliminary analysis on cost flexibility can be carried out. Knowing that most sample airports operate with excess capacity (ECU > 1), therefore, costs should not increase more proportionally than traffic; the operating trends shown in Fig. 2 are clearly a symptom of decreasing cost efficiency worldwide. Even allowing for inflation and its impact over input prices, the significant increase in operating costs will hardly be explained by a falling output.

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16 Note that γ > 1, which indicates that short-run marginal ATM costs increase more than proportionally with MTOW. Nevertheless, our short-run value is lower than previous long-run estimates (Martin and Voltes-Dorta, 2011), which makes sense since ATMs are particularly capital-intensive.
As expected, the average cost efficiency of the airport sample drops approximately 6% during the recession (exactly 5.85%), from 82.8% in 2007 to 78.8% in 2008 and finally 76.9% in 2009. At first sight, it is surprising that the largest impact on airport efficiency occurred during 2008. However, it was in this year that the largest gap between traffic and operating costs was recorded. The question of whether 5.85% is a significant drop can be answered by determining its impact on global operating margins. Since ACI does not provide data on depreciation for the global industry, the airport sample will be used instead (See Table 5). The global EBIT margin\(^{17}\) in 2007 (baseline) was 29.12%. The significant increase in operating costs during 2008 was partially offset by a parallel increase in airport charges and concession fees, which had an impact on both aeronautical and commercial revenues (Airport Charges Monitor, 2008; ACI, 2009). Thus, the EBIT margin remained relatively stable at 29.13%. As expected, a slight decrease in revenues, coupled with the lack of cost control led to a significant fall in the year 2009 (22.46%). Assuming that the sharp decrease in cost efficiency during the recession can be exclusively linked to the lack of flexibility, it is possible to determine its impact on EBIT margins by just recalculating the operating costs for 2008 and 2009 under the baseline efficiency level (82.8%). The corrected margins would be approximately 21.5% and 3.25% higher than the actual ones in absolute terms (7.5% and 12.6% higher in relative terms), which gives an idea of how significant this problem is. Using a similar method, these losses can be extrapolated to the global industry, considering the baseline year 2007, and using ACI estimates (USD 55 and 57 billion in operating costs in 2008 and 2009, respectively). The calculations yield an estimated USD 5.5 billion in global losses (PPP\(^{18}\)000) in 2008 and 2009, respectively. The baseline year 2007, and using ACI estimates (USD 55 and 57 billion in operating costs in 2008 and 2009, respectively). The calculations yield an estimated USD 5.5 billion in global losses (PPP\(^{18}\)000) in 2008 and 2009, respectively.

<table>
<thead>
<tr>
<th>Country</th>
<th>2007 (PPP(^{18})000)</th>
<th>2008 (PPP(^{18})000)</th>
<th>2009 (PPP(^{18})000)</th>
<th>VAR 2007–09 (%)</th>
<th>Losses 2007–09 (PPP(^{18})000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Europe</td>
<td>0.796 0.772 0.748</td>
<td>0.772 0.748 0.728</td>
<td>0.766 0.731 0.702</td>
<td>-4.77</td>
<td>-434,716</td>
</tr>
<tr>
<td>Austria</td>
<td>0.766 0.750 0.737</td>
<td>0.772 0.748 0.723</td>
<td>0.772 0.748 0.723</td>
<td>-2.92</td>
<td>-15,000</td>
</tr>
<tr>
<td>France</td>
<td>0.772 0.731 0.723</td>
<td>0.772 0.748 0.723</td>
<td>0.772 0.748 0.723</td>
<td>-4.90</td>
<td>-21,109</td>
</tr>
<tr>
<td>Germany</td>
<td>0.813 0.795 0.780</td>
<td>0.844 0.814 0.787</td>
<td>0.844 0.814 0.787</td>
<td>-6.69</td>
<td>-25,070</td>
</tr>
<tr>
<td>Italy</td>
<td>0.844 0.814 0.787</td>
<td>0.844 0.814 0.787</td>
<td>0.844 0.814 0.787</td>
<td>-7.60</td>
<td>-9,068</td>
</tr>
<tr>
<td>Turkey</td>
<td>0.802 0.802 0.820</td>
<td>0.802 0.802 0.820</td>
<td>0.802 0.802 0.820</td>
<td>1.74</td>
<td>0</td>
</tr>
<tr>
<td>UK</td>
<td>0.834 0.780 0.748</td>
<td>0.834 0.780 0.748</td>
<td>0.834 0.780 0.748</td>
<td>-8.63</td>
<td>-271,578</td>
</tr>
<tr>
<td>TOTAL SAMPLE</td>
<td>0.828 0.788 0.769</td>
<td>0.828 0.788 0.769</td>
<td>0.828 0.788 0.769</td>
<td>5.85%</td>
<td>-1,252,743</td>
</tr>
</tbody>
</table>

As expected, the average cost efficiency of the airport sample drops approximately 6% during the recession (exactly 5.85%), from 82.8% in 2007 to 78.8% in 2008 and finally 76.9% in 2009. At first sight, it is surprising that the largest impact on airport efficiency occurred during 2008. However, it was in this year that the largest gap between traffic and operating costs was recorded. The question of whether 5.85% is a significant drop can be answered by determining its impact on global operating margins. Since ACI does not provide data on depreciation for the global industry, the airport sample will be used instead (See Table 5).

The global EBIT margin\(^{17}\) in 2007 (baseline) was 29.12%. The significant increase in operating costs during 2008 was partially offset by a parallel increase in airport charges and concession fees, which had an impact on both aeronautical and commercial revenues (Airport Charges Monitor, 2008; ACI, 2009). Thus, the EBIT margin remained relatively stable at 29.13%. As expected, a slight decrease in revenues, coupled with the lack of cost control led to a significant fall in the year 2009 (22.46%). Assuming that the sharp decrease in cost efficiency during the recession can be exclusively linked to the lack of flexibility, it is possible to determine its impact on EBIT margins by just recalculating the operating costs for 2008 and 2009 under the baseline efficiency level (82.8%). The corrected margins would be approximately 21.5% and 3.25% higher than the actual ones in absolute terms (7.5% and 12.6% higher in relative terms), which gives an idea of how significant this problem is. Using a similar method, these losses can be extrapolated to the global industry, considering the baseline year 2007, and using ACI estimates (USD 55 and 57 billion in operating costs in 2008 and 2009, respectively). The calculations yield an estimated USD 5.5 billion in global losses associated to the lack of cost control and flexible management during the recession.

Going back to the sample, for 2009 the average loss across the 194 airports is estimated at USD 1.3 billion. In spite of that, it is clear that the global impact of the recession is unevenly distributed, even within the same region. The breakdown and evolution of these cost efficiency estimates\(^{18}\) by geographical clusters is shown in Table 6. The 72 North American airports are the ones more significantly affected, dropping 6.5% in cost efficiency during the recession. US airports dropped almost 4% in 2008, clearly as a consequence of the impact of increasing fuel prices on airline activity. Taking the aggregate variable costs in

\(^{17}\) EBIT margin (Earnings Before Interest and Tax) is defined as the operating income (operating revenues minus operating costs) divided by operating revenues.

\(^{18}\) Traffic-weighted efficiency averages (related to passenger numbers) were calculated. The efficiency estimates for the individual airports can be consulted in Voltes-Dorta (2011).

As expected, the average cost efficiency of the airport sample drops approximately 6% during the recession (exactly 5.85%), from 82.8% in 2007 to 78.8% in 2008 and finally 76.9% in 2009. At first sight, it is surprising that the largest impact on airport efficiency occurred during 2008. However, it was in this year that the largest gap between traffic and operating costs was recorded. The question of whether 5.85% is a significant drop can be answered by determining its impact on global operating margins. Since ACI does not provide data on depreciation for the global industry, the airport sample will be used instead (See Table 5). The global EBIT margin\(^{17}\) in 2007 (baseline) was 29.12%. The significant increase in operating costs during 2008 was partially offset by a parallel increase in airport charges and concession fees, which had an impact on both aeronautical and commercial revenues (Airport Charges Monitor, 2008; ACI, 2009). Thus, the EBIT margin remained relatively stable at 29.13%. As expected, a slight decrease in revenues, coupled with the lack of cost control led to a significant fall in the year 2009 (22.46%). Assuming that the sharp decrease in cost efficiency during the recession can be exclusively linked to the lack of flexibility, it is possible to determine its impact on EBIT margins by just recalculating the operating costs for 2008 and 2009 under the baseline efficiency level (82.8%). The corrected margins would be approximately 21.5% and 3.25% higher than the actual ones in absolute terms (7.5% and 12.6% higher in relative terms), which gives an idea of how significant this problem is. Using a similar method, these losses can be extrapolated to the global industry, considering the baseline year 2007, and using ACI estimates (USD 55 and 57 billion in operating costs in 2008 and 2009, respectively). The calculations yield an estimated USD 5.5 billion in global losses associated to the lack of cost control and flexible management during the recession.

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suggests that what works during expansive times does not necessarily apply to recessions as well. A deeper analysis of the largest European sample airport, Frankfurt, reveals a strategy of staff reduction, combined with increased internalization and improved labor productivity in order to control operating costs (FRA, 2010). Thus, airports with a higher share of in-house activities may be more capable of implementing such policies as they have more control over their operating expenditures. The reason is that airports that outsource commit themselves to paying fixed price contracts for services to third-party suppliers that cannot be re-negotiated in the short-term if demand does not grow as planned. Furthermore, the gradual shift to public corporatization in both countries, along with Italy and Russia, is proposed as another plausible explanation for this result, especially compared to the French regional airports, which remain largely controlled by local chambers of commerce. Referring again to Fig. 2, it appears surprising that Austria outperforms Germany, which were the only ones actually successful in controlling operating costs. The likely reason is that German sample airports are, on average, larger than the Austrian and hence more cost elastic. In particular, note the relatively high cost elasticity at Frankfurt (0.86). From a technological point of view, German airports are required to cut costs much more than other smaller clusters in order to remain efficient. A similar argument can be drawn for e.g. US airports above, suggesting a negative relationship between airport size and cost flexibility. Similarly to the outsourcing example discussed above, airport size, which has been identified as a positive driver of cost efficiency by many studies (e.g. Gillen and Lall, 1997; Sarkis, 2000; Barros, 2008a; Martin et al., 2009) is likely to hamper the implementation of cost-saving programs during an economic recession due to increased organizational complexity.

The least flexible European cluster is UK. Total efficiency losses in the UK airport industry amount to USD 271 million against the pre-crisis baseline (note that the UK airport sample is comprehensive). As in the Beijing case, these losses can be mostly associated to the significant step-change in labor and material costs observed in Heathrow Airport after T5 was inaugurated in 2008, aggravated by a decrease in passenger and freight traffic during the same period. Regarding developing regions, Turkish Airlines, especially Istanbul Ataturk and Antalya, reveal themselves as a model for flexible growth in Europe, becoming one of the top-performing clusters in the sample (82%). Many of these airports’ international terminals are leased to companies that provide expertise in airport management (e.g. Frankfurt, TAV) and who have been able to capitalize on the booming leisure and low-cost markets.

5. Summary

The most recent economic downturn led to a significant contraction in the global demand for passenger travel and air cargo. In spite of that, the trend in airports’ operating costs did continue to increase, thus indicating a lack of flexibility. With this background on airports’ cost efficiency and financial performance, this is achieved by estimating the industry’s short-run cost frontier over a balanced pool database of 194 airports worldwide observed between 2007 and 2009. Taking into account that the major traffic losses were registered in the “mature” markets of Europe and North America, the airport sample is biased to these regions. However, data clearly shows that all regions have problems with cost flexibility, as operating costs grow more than proportionally than traffic in all cases. The estimated cost function parameters reveal the existence of very significant economies of capacity utilization at the average airport (ECU = 2.13). If this result is contrasted with the actual trends in costs and traffic, it is not surprising to find a global drop of 5.85% in cost efficiency for the airport sample between 2007 and 2009. Extrapolating this figure to the worldwide industry (using ACI estimates), the aggregated financial loss associated with the failure of cost control measures and flexible development programs during the recession is estimated at approximately USD 5.5 billion. Using a similar method, the impact on industry EBIT margins is also estimated between 7%–12%, in relative terms, showing that airports should indeed prepare for any contraction in demand as operating costs, for several reasons, are not quite as volatile as traffic and commercial revenues.

Efficiency results differ significantly across regions, with North American airports being the ones most severely affected by the recession. This would suggest a negative relationship between airport size and cost flexibility, which comes to no surprise given the significant step-changes in capacity experienced at large hubs. The airport’s cost structure also appears to have its influence on cost flexibility, yet in this case, the findings appear to challenge conventional views which advocate the outsourcing of airport core functions. Results suggest that reduced outsourcing may be beneficial for cost flexibility. Hence, airports with a higher share of in-house labor will be more successful at implementing cost-saving programs. The same applies to European public corporations and airports operated under long-term management leases (e.g. Turkey, Australia), as both seem to provide the right incentives to control costs and protect margins through the recession.

Acknowledgments

The authors wish to thank Zheng Lei and Rico Merkert for Cranfield University and Héctor Rodríguez-Déniz from the University of Las Palmas de Gran Canaria for their valuable comments and assistance in the early stages of this research. In addition, this work has also benefited from the suggestions of three anonymous referees.

Appendix A. Sample airports

See Table A1

Appendix B. Short-run model specification

\[
\ln V_C^0 = \ln V_C^0 + \ln V_C^A + u_v + u_t
\]

\[
\ln V_C^A = \alpha_1 + \alpha_2 atm + \alpha_3 dom + \alpha_4 int + \alpha_5 cgo + \alpha_6 rev
\]

\[
+ \beta_7 ter + \beta_8 run + \beta_9 om + \beta_{10} op + \gamma_{11} atm \ln om
\]

\[
+ \gamma_{12} atm \ln dom + \gamma_{13} dom \ln om + \gamma_{14} dom \ln op + \gamma_{15} int \ln om
\]

\[
+ \gamma_{16} int \ln om + \gamma_{17} cgo \ln dom + \gamma_{18} cgo \ln op + \gamma_{19} rev \ln om
\]

\[
+ \gamma_{20} rev \ln op + \gamma_{21} ter \ln dom + \gamma_{22} ter \ln op + \gamma_{23} run \ln om
\]

\[
+ \gamma_{24} run \ln op + \gamma_{25} v_1 \ln om + \gamma_{26} v_1 \ln op + \gamma_{27} v_1 \ln cgo
\]

\[
+ \rho_{28} 0.5 atm \ln dom + \rho_{29} 0.5 \ln int
\]

\[
+ \rho_{30} 0.5 cgo \ln dom + \rho_{31} 0.5 \ln rev + \rho_{32} 0.5 \ln ter
\]

\[
+ \rho_{33} 0.5 run + \rho_{34} 0.5 \ln atm + \rho_{35} 0.5 \ln run
\]

\[
+ \gamma_{36} run + \gamma_{37} atm \ln run + \gamma_{38} run \ln atm
\]

\[
+ \gamma_{39} run + \gamma_{40} int \ln run + \gamma_{41} int \ln atm
\]

\[
\text{atm = atm + } \psi \text{ mtow}
\]

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### Appendix A

Sample airports.

<table>
<thead>
<tr>
<th>Country</th>
<th>Airport</th>
<th>Country</th>
<th>Airport</th>
<th>Country</th>
<th>Airport</th>
<th>Country</th>
<th>Airport</th>
</tr>
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<tbody>
<tr>
<td>Canada</td>
<td>Calgary</td>
<td>US</td>
<td>Bwi</td>
<td>US</td>
<td>Louisville</td>
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<td>Pittsburgh</td>
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<td>Portland</td>
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\[
S_m = (\beta_9 + \gamma_{11} \text{ atmh} + \gamma_{13} \text{ dom} + \gamma_{15} \text{ int} + \gamma_{17} \text{ cgo} + \gamma_{19} \text{ rev} + \gamma_{21} \text{ fer} + \gamma_{23} \text{ run} + \delta_{25} \text{ wom} + \delta_{26} \text{ wop} + \delta_{28} \text{ cgp} + \Gamma) / \text{ Gd}
\]

\[
S_p = (\beta_{10} + \gamma_{11} \text{ atmh} + \gamma_{13} \text{ dom} + \gamma_{15} \text{ int} + \gamma_{17} \text{ cgo} + \gamma_{19} \text{ rev} + \gamma_{21} \text{ fer} + \gamma_{23} \text{ run} + \delta_{25} \text{ wom} + \delta_{26} \text{ wop} + \delta_{28} \text{ cgp}) / \text{ exp} \text{ p}
\]

\[
G_u = \left( \beta_9 + \gamma_{11} \text{ atmh} + \gamma_{13} \text{ dom} + \gamma_{15} \text{ int} + \gamma_{17} \text{ cgo} + \gamma_{19} \text{ rev} + \gamma_{21} \text{ fer} + \gamma_{23} \text{ run} + \delta_{25} \text{ wom} + \delta_{26} \text{ wop} + \delta_{28} \text{ cgp} \right) + \left( \beta_{10} + \gamma_{11} \text{ atmh} + \gamma_{13} \text{ dom} + \gamma_{15} \text{ int} + \gamma_{17} \text{ cgo} + \gamma_{19} \text{ rev} + \gamma_{21} \text{ fer} + \gamma_{23} \text{ run} + \delta_{25} \text{ wom} + \delta_{26} \text{ wop} + \delta_{28} \text{ cgp} \right) / \text{ exp} \text{ p}
\]

\[
\beta_9 + \beta_{10} = 1
\]

\[
\gamma_{11} + \gamma_{12} = 0; \quad \gamma_{13} + \gamma_{14} = 0; \quad \gamma_{15} + \gamma_{16} = 0; \quad \gamma_{17} + \gamma_{18} = 0; \quad \gamma_{19} + \gamma_{20} = 0
\]

\[
\gamma_{21} + \gamma_{22} = 0; \quad \gamma_{23} + \gamma_{24} = 0
\]

\[
\delta_{25} + \delta_{26} = 0; \quad \delta_{27} + \delta_{28} = 0
\]

### References


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