# Modelling International Tourism Demand for the Brazilian Amazon

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**EXTENDED ABSTRACT**

The Amazon rain forest is one of the world's greatest natural wonders and holds great importance and significance for the world's environmental balance. In terms of fresh water volume, the Amazon River is by far the world's biggest, and the biodiversity in the Amazon region is one of the world's richest. The total extension of the Amazon rain forest is about 7 million square kilometres, and is distributed across nine South American countries. Around 60% of the Amazon rain forest located in the Brazilian territory, which corresponds to virtually the entire North region of the country, is called the Brazilian Amazon, and defines the so-called Legal Amazon.

The two biggest states of the Amazon region are Amazonas (the upper Amazon) and Pará (the lower Amazon), which together account for around 73% of the Brazilian Legal Amazon, and are the only states that are serviced by international airports in Brazil's North region.

Economic progress has been achieved at a cost of destroying large areas of the Amazon rain forest. In this scenario, the tourism industry would seem to have the potential to contribute to sustainable economic development in the North region of Brazil.

The primary purpose of this paper is to model and forecast sustainable international tourism demand for the Brazilian Amazon. International tourist arrivals data are analysed for Amazonas and Pará, which are also the only two states in the Brazilian Amazon for which monthly time series data over an extended period are available. The paper discusses the monthly and annual international tourist arrivals to Amazonas, Pará and the total of the two states, presents unit root tests for the monthly and annual data, estimates alternative time series models and conditional volatility models of the shocks to international tourist arrivals, and provides forecasts of monthly and annual international tourist arrivals to Amazonas, Pará and the total of the two states for 2006 and 2007.

The estimated models indicated that the persistence of shocks to international tourist arrivals was present in both the short and long run. As the second and fourth moment restrictions are satisfied for Amazonas and the total of Amazonas and Pará, the quasi maximum likelihood estimates were shown to be consistent and asymptotically normal, so that standard statistical tests were valid.

As in the case of the relatively low international tourism arrivals to the Brazilian Amazon for the 1971-2005 sample period for Amazonas and Pará, the forecasts of international tourism arrivals for 2006 and 2007 also suggested that the forecasted international tourism arrivals to the Brazilian Amazon were likely to be very small. These observations point to the need for a much wider development of the sustainable tourist industry in the Amazon rain forest region.

## 1. INTRODUCTION

The Amazon rain forest holds great importance and significance for the world's environmental balance. As an idea of its importance and monumental size, the various rivers that comprise the Amazon basin account for around 20% of the total volume of fresh water that flows into the various oceans of the world. In short, the rivers of the Amazon region form the biggest hydrographic network anywhere on the planet. Specifically, the Amazon River is by far the world's biggest river in terms of fresh water volume. In addition, the biodiversity in the Amazon region is one of the richest of the world, with a considerable amount of fauna and flora that have been sighted by very few indigenous tribes and scientists. Medical researchers have suggested that the flora in the Amazon region provide a cure in the years ahead for several diseases that afflict humanity.

The total extension of the Amazon rain forest is about 7 million square kilometers, and is distributed across nine South American countries, namely Bolivia, Brazil, Colombia, Ecuador, Guyana, French Guiana, Peru, Suriname, and Venezuela. Around 60% of the Amazon rain forest is located in the Brazilian territory, corresponding to virtually the entire North region of the country, and is called the Brazilian Amazon. The remaining 40% of the Amazon rain forest is distributed across the other eight countries that share the forest, with the largest part being in the eastern part of Peru. Large portions of the three Guineas, namely Guyana, Suriname and French Guiana, are covered by the Amazon rain forest.

The 60% of the Amazon that is located in the Brazilian territory defines the so-called Legal Amazon, and includes the states of Acre, Amazonas, Amapá, North of Mato Grosso, Pará, Rondônia, Roraima, Tocantins, and West of Maranhão. Although Maranhão is actually a state of the Brazilian Northeast region, Maranhão borders the east side of Pará state, which means that its border on the West of Maranhão is covered by the Amazon forest, and hence is a part of the Legal Amazon. The same holds for North of Mato Grosso, which is a state of the Middle-East Region that borders South of Amazonas and Pará and West of Rondonia. The two biggest states of the Amazon region are Amazonas (also referred to as the upper Amazon) and Pará (also referred to as the lower Amazon), which together account for around 73% of the Brazilian Legal Amazon.

Amazonas is the largest state of Brazil, with a total area of 1.6 million square kilometres. This state is larger than any other country of the Amazon rain forest, and virtually all of its area is occupied by rain forest or rivers. In addition to its size, Amazonas state is surrounded by land, such that access to the region is by air or along the various rives that form the Amazon River and its tributaries. Large ships have access to Amazonas from the Pará city of Belem, which is at the mouth of the Amazon River where it flows into the Atlantic Ocean.

In this scenario, the tourism industry would seem to have the potential to contribute to sustainable economic development in the North region of Brazil. Activities linked to ecotourism, for instance, would be a rational way of generating employment and income to the region without causing damage to its abundant natural resources. However, tourism, especially international tourism, is still in its infancy in the Amazon region. In this context. It is strikingly clear that tourism GDP is heavily concentrated along the Northeast coastline and in the Southeast and South regions of the country. In the North region, very few municipal districts show tourism GDP at the upper level of the distribution, with much of the states of Amazonas and Pará having very low tourism GDP. The sole exception to the low tourism DGP in the upper Amazon rain forest is the Free Zone of Manaus. In general, tourism GDP in the upper Amazon is extremely low, except in some cities and towns along the Amazon River and its various tributaries.

The primary purpose of this paper is to model and forecast sustainable international tourism demand for the Brazilian Amazon. We will analyse international tourist arrivals data for the two major states in the Amazon region, namely Amazonas and Pará, which are the only states that are serviced by international airports in Brazil's North region. As mentioned previously, these two states account for around 73% of the Brazilian Amazon, and are also the only two states in the Brazilian Amazon for which monthly time series data over an extended period are available. In terms of the extant literature, this paper may be seen as a precursor for future analyses of sustainable tourism in the Brazilian Amazon region as there would seem to be no previous research that has modelled and forecasted international tourist arrivals to the Brazilian Amazon using reliable monthly time series data.

## 2. DATA

The data set to be analysed consists of monthly time series data, as well as the annual aggregates, relating to international tourist arrivals for the two major states of the Brazilian Amazon, namely Amazonas and Pará, for the period January 1971 to December 2005. The sources of the data are the official reports of Embratur (Empresa Brasileira de Turismo – Brazilian Enterprise of Tourism), which is an official branch of the Federal Ministry of Tourism that is responsible for the compilation of tourism statistics in Brazil. According to the Embratur statistical department, the numbers of international tourist arrivals are computed from immigration cards that international tourists are required to complete and submit to the Brazilian Federal Police before entering the country. For the Brazilian Amazon, the immigration cards are tabulated from the international airports in Manaus, the capital of Amazonas, and Belém, the capital of Pará. The annual tourist arrivals series correspond to the monthly aggregates for each year. In the empirical analysis, we also consider the total number of international tourist arrivals for Amazonas and Pará for both the monthly and annual time series, which are obtained by adding the international tourist arrivals to the Amazonas and Pará states.

At the outset, it should be mentioned that there were nine missing observations for the monthly series of international tourist arrivals for the Amazonas state in 1993. According to Embratur, the missing monthly data arose from administrative problems at the International Airport of Manaus. In order to obtain a complete and homogeneous series of observations for both Amazonas and Pará, we estimated an ARMA model for the monthly data to December 1992, then forecasted all 12 months of 1993, and used the 3 months in 1993 for which there were observations to calibrate the accuracy of the forecasts. Estimation of several alternative specifications with 12 seasonal dummy variables suggested that the best fitting models were an unrestricted AR(2) model and AR(12) model with zero restrictions for lags 3-11 inclusive. The Akaike Information Criterion and Schwarz Bayesian Information Criterion slightly favoured the unrestricted AR(2) model, but the aggregated forecasts for 1993 were very similar, namely 12,551 and 12,557, respectively. As the AR(12) term was only marginally significant at the 1% level, but resulted in a loss of 10 observations, the unrestricted AR(2) model with 12 monthly seasonal dummy variables was used to forecast the monthly international tourist arrivals to the Amazonas state for the 12 months of 1993.

It is evident that there is an important seasonal component but no deterministic trend component in the monthly series of international tourist arrivals. As a result, the growth rates fluctuate around zero over time, with noticeable volatility persistence in the monthly growth rates. In addition, the monthly time series data are generally quite small numbers. For Amazonas, the monthly average of international tourist arrivals was 1,093, with a maximum of 4,109 in January 1987 and an amazing minimum of 2 in July 1991. For Pará, the situation is reasonably similar, with a monthly average of 903 international tourist arrivals. However, the Pará time series peaked in July 2005 with 4,394 international tourist arrivals, and with a minimum of an extremely low 6 in October 1988. The monthly growth rates in international tourist arrivals showed significant volatility, varying roughly between (-350%, 350%) for Amazonas, (-400%, 500%) for Pará, and (-140%, 130%) for the total of the two leading states.

On an annual basis for the period 1971-2005, the average number of international tourist arrivals to Amazonas was 13,114, while this number was lower at 10,839 for Pará. From Figure 3, it is evident that there is no tendency for the growth in the number of international tourist arrivals to increase deterministically over time as the annual growth rates have been close to zero for Amazonas, Pará and the sum of the two states since 1971. The annual growth rates in international tourist arrivals were less volatile than their monthly counterparts, and varied roughly between (-60%, 50%) for Amazonas, (-90%, 90%) for Pará, and (-50%, 50%) for the total of the two leading states.

The numbers of international tourists suggest that international tourism activity has not been encouraged in the Brazilian rain forest. The Brazilian Amazon is one of the richest geographic locations in the world for biodiversity, but the second poorest in Brazil in terms of per capita income. Thus, the development of a sustainable tourism industry should be able to preserve the rain forest and to generate substantial income for the residents of the Amazon rain forest region.

## 3. UNIT ROOT TESTS

The first step in the modelling strategy was to test the time series for the existence of one or more unit roots. A common criticism of traditional unit root tests, primarily those based on the classic methods of Dickey and Fuller (1979, 1981) and Phillips and Perron (1988), is that they suffer from low power and size distortions. However, these shortcomings have been overcome by modifications to the testing procedures, such as the methods proposed by Perron and Ng (1996), Elliott, Rothenberg and Stock (1996), and Ng and Perron (2001).

For example, Elliott, Rothenberg and Stock (1996) demonstrate that OLS de-trending is inefficient if the data present high persistence, and suggest using GLS de-trended data, which is efficient. Ng and Perron (2001) show that, in the presence of a strong negative moving average coefficient, the unit root estimate is strongly biased if the lag truncation, k, is small because the residuals of the test equation are serially correlated. In order to select the optimal value of k to account for the inverse non-linear dependence between the bias in the unit root coefficient and the selected value of k, and to avoid selecting an unnecessarily large value of k, Ng and Perron (2001) proposed a modified Akaike Information Criterion (MAIC). Thus, the modified $ADF^{GLS}$ ($MADF^{GLS}$) test uses GLS de-trended data and the MAIC in order to choose the truncation lag.

The modified Phillips-Perron test ($MPP^{GLS}$), which also uses GLS de-trended data and the MAIC to select the optimal truncation lag, is due to Phillips and Perron (1988), Perron and Ng (1996) and Ng and Perron (2001). The asymptotic critical values for both the $MADF^{GLS}$ and $MPP^{GLS}$ tests are given in Ng and Perron (2001).

The results of the unit root tests, which are obtained from the econometric software package EViews 5.0 and reported in Table 1, indicate that the logarithm of monthly international tourist arrivals for Amazonas (LAM) and the total of Amazonas and Pará (LTO) have unit roots. For Pará (LPA), however, the tests indicate a stationary time series. The annual data also indicate a stationary series for Pará. In the model with just a constant as the deterministic term, however, the null hypothesis of a unit root is rejected for Amazonas at the 5% level of significance. The aggregate of Amazonas and Pará (LTO) is still non-stationary. Unit root tests were also applied to the monthly data that were seasonally adjusted using the X11 method of the U.S. Bureau of Census, but there were no significant quantitative changes to the results.

In view of these empirical results, the first differences in the logarithms of international tourist arrivals are used in estimating the models given below. This transformation was deemed preferable as it would guarantee that all the time series are stationary and also provide the rate of growth of international tourist arrivals to Amazonas, Pará, and the aggregate of the two states.

## 4. CONDITIONAL MEAN AND CONDITIONAL VOLATILITY MODELS

The alternative time series models to be estimated for the conditional means of the monthly and annual international tourist arrivals, as well as their conditional volatilities, are discussed below. The growth rates of international tourist arrivals to Amazonas, Pará and the total of the two states show periods of high volatility followed by others of relatively low volatility. One implication of this behavior is that the assumption of homoskedastic residuals is inappropriate. In this case, in order to forecast the international tourist arrivals (or their growth rates, as appropriate), it is necessary also to forecast their conditional variances.

Time-varying conditional variances can be explained empirically through the autoregressive conditional heteroskedasticity (ARCH) model, which was proposed by Engle (1982). When the time-varying conditional variance has autoregressive and moving average components, this leads to the generalized ARCH(p,q), or GARCH(p,q), model of Bollerslev (1986). The lag structure of the appropriate GARCH model can be chosen by information criteria, such as those of Akaike and Schwarz, although it is very common to impose a GARCH(1,1) specification in advance. In the selected conditional volatility model, the residual series should follow a white noise process. Li et al. (2002) provide an extensive review of recent theoretical results for univariate and multivariate time series models with conditional volatility errors, and McAleer (2005) reviews a wide range of univariate and multivariate, conditional and stochastic, models of volatility.

Consider the stationary AR(1)-GARCH(1,1) model for international tourist arrivals (or their growth rates, as appropriate), $y_t$:

$$y_t = \phi_1 + \phi_2 y_{t-1} + \varepsilon_t, \qquad |\phi_2| < 1 \tag{1}$$

for $t = 1,...,n$, where the shocks (or movements in international tourist arrivals) are given by:

$$\varepsilon_t = \eta_t \sqrt{h_t}, \quad \eta_t \sim iid(0,1)$$
$$h_t = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1}, \tag{2}$$

and $\omega > 0, \alpha \geq 0, \beta \geq 0$ are sufficient conditions to ensure that the conditional variance $h_t > 0$. The AR(1) model in equation (1) can easily be extended to univariate or multivariate ARMA(p,q) processes (for further details, see Ling and McAleer (2003a)). In equation (2), the ARCH (or $\alpha$) effect indicates the short run persistence of shocks, while the GARCH (or $\beta$) effect indicates the contribution of shocks to long run persistence (namely, $\alpha + \beta$). The stationary AR(1)-GARCH(1,1) model can be modified to incorporate a non-stationary ARMA(p,q) conditional mean and a stationary GARCH(r,s) conditional variance, as in Ling and McAleer (2003b).

In equations (1) and (2), the parameters are typically estimated by the maximum likelihood method to obtain Quasi-Maximum Likelihood Estimators (QMLE) in the absence of normality of $\eta_t$. The QMLE is efficient only if $\eta_t$ is normal, in which case it is the MLE. When $\eta_t$ is not normal, adaptive estimation can be used to obtain efficient estimators. Ling and McAleer (2003b) investigate the properties of adaptive estimators for univariate non-stationary ARMA models with GARCH(r,s) errors.

Ling and McAleer (2003a) showed that the QMLE for GARCH(p,q) is consistent if the second moment of $\varepsilon_t$ is finite. For GARCH(p,q), Ling and Li (1997) demonstrated that the local QMLE is asymptotically normal if the fourth moment of $\varepsilon_t$ is finite, while Ling and McAleer (2003a) proved that the global QMLE is asymptotically normal if the sixth moment of $\varepsilon_t$ is finite. Using results from Ling and Li (1997) and Ling and McAleer (2002a, 2002b), the necessary and sufficient condition for the existence of the second moment of $\varepsilon_t$ for GARCH(1,1) is $\alpha + \beta < 1$ and, under normality, the necessary and sufficient condition for the existence of the fourth moment is $(\alpha + \beta)^2 + 2\alpha^2 < 1$. Extensions of several of these results for asymmetric conditional volatility models is given in McAleer et al. (2007).

## 5. ESTIMATES OF MODELS

The empirical results for the estimated models, which are obtained using the econometric software package package EViews 5.0, are reported in Table 2. For the monthly growth rate of international tourist arrivals to Amazonas, all the estimated coefficients are statistically significant at the 5% level. The AR(12) term was included in the model to capture seasonal factors. The GARCH(1,1) coefficients indicate that the persistence of shocks to Amazonas holds in both the short and long run, with the short run persistence being quite small, though statistically significant. The AR(1) coefficient of 0.41 implies that the growth rate of Amazonas is convergent. The diagnostic test, provided by a Lagrange multiplier (LM) test for ARCH disturbances, indicates that there is no need to include additional lags in the GARCH(1,1) specification. As the second and fourth moment restrictions, as given in Section 4, are satisfied for Amazonas, the QMLE are consistent and asymptotically normal, so that standard statistical inference is valid.

The estimated model for the monthly growth rate of international tourist arrivals to Pará presented some coefficients that were not statistically significant. Specifically, the constant and the GARCH(1) term were not statistically different at the 5% level. The AR(1) coefficient was negative and close to zero, indicating a convergent process. The GARCH(1,1) coefficients, however, suggest a very high persistence of shocks to Pará in the short run, with the ARCH effect being 0.99, with the long run persistence being quite small and insignificant at 0.07. The LM diagnostic test indicates that the model is well specified for the selected GARCH terms.

The estimated model for the total of international tourist arrivals to the Amazonas and Pará states shows that all the estimated coefficients, except for the constant, are statistically significant. This time series is also convergent, given the estimated AR(1) coefficient of 0.44, which is far inside the unit circle. The estimates of the GARCH(1,1) model imply that the persistence of shocks decays very slowly for the growth rate of the aggregate monthly data, with the short run persistence being small, though statistically significant. The GARCH(1,1) coefficients indicate that the persistence of shocks to Pará holds in both the short and long run, and the results for the LM test suggest that the model is well specified. As for Amazonas, there is a strong negative MA coefficient for the aggregated series. Moreover, the second and fourth moment restrictions are satisfied for the aggregates series, as for Amazonas, so the QMLE are consistent and asymptotically normal, so that standard statistical inference is valid.

For the annual data, it is interesting to note that there are no GARCH effects for any of the three time series, as the annual growth rates of international tourist arrivals show a reasonably constant variance throughout much of the sample period. The LM tests for the estimated ARMA models indicate that there is no ARCH(1) or ARCH(2) effects in the estimated residuals. Thus, the conditional variance of the residuals is constant over the period. In addition, the estimated AR(1) coefficients are inside the unit circle, implying that the annual growth rates are convergent.

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**Table 1 - Unit Root Tests**

| Variable | Monthly data | | | | Annual data | | | |
|---|---|---|---|---|---|---|---|---|
| | $MADF^{GLS}$ | $MPP^{GLS}$ | Lags | Z | $MADF^{GLS}$ | $MPP^{GLS}$ | Lags | Z |
| LAM | -2.13 | -4.16 | 11 | {1, t} | -2.33 | -11.15 | 2 | {1, t} |
| LAM | -0.79 | -0.84 | 11 | {1} | 2.11** | -8.60** | 2 | {1} |
| LPA | -3.39** | -20.11** | 13 | {1, t} | -2.93** | -10.81 | 0 | {1, t} |
| LPA | -4.73** | -1.53 | 13 | {1} | -1.94* | -6.06* | 0 | {1} |
| LTO | -1.85 | -4.08 | 16 | {1, t} | -2.35 | -9.49 | 1 | {1, t} |
| LTO | -0.25 | -0.16 | 16 | {1} | -1.50 | -4.78 | 1 | {1} |

Notes: LAM, LPA, and LTO denote the logarithm of international tourist arrivals to Amazonas, Pará and Total, respectively.
The critical values for $MADF^{GLS}$ and $MPP^{GLS}$ at the 5% significance level are –2.93 and –17.3, respectively, when Z={1,t} and –1.94 and –8.1 when Z={1}. At the 10% significance level, the critical values are –2.57 and –14.2, respectively, when Z={1,t} and –1.62 and –5.7 when Z={1}.
** and * denote the null hypothesis of a unit root is rejected at the 5% and 10% significance levels.

**Table 3 – Estimated Conditional Mean and Conditional Volatility Models**

| Variable | Monthly | | | Annual | | |
|---|---|---|---|---|---|---|
| | DLAM | DLPA | DLTO | DLAM | DLPA | DLTO |
| Constant | 0.003 (0.001) | -0.01 (–0.01) | 0.002 (0.003) | 0.01 (0.01) | 0.38 (0.06) | 0.38 (0.06) |
| AR(1) | 0.41 (0.05) | -0.16 (0.07) | 0.44 (0.06) | 0.56 (0.15) | 0.59 (0.15) | -0.70 (0.13) |
| AR(2) | --- | --- | --- | --- | --- | -0.61 (0.15) |
| AR(12) | 0.20 (0.05) | 0.12 (0.03) | 0.20 (0.04) | --- | --- | --- |
| MA(1) | -0.98 (0.02) | -0.40 (0.07) | -0.92 (0.02) | -0.96 (0.05) | -0.98 (0.04) | 0.71 (0.06) |
| MA(2) | --- | --- | --- | --- | --- | 0.96 (0.05) |
| Constant | 0.003 (0.001) | 0.08 (0.01) | 0.002 (0.001) | --- | --- | --- |
| ARCH ($\alpha$) | 0.08 (0.01) | 0.99 (0.13) | 0.03 (0.01) | --- | --- | --- |
| GARCH ($\beta$) | 0.91 (0.01) | 0.07 (0.05) | 0.95 (0.02) | --- | --- | --- |
| LM(1) | 0.20 [0.65] | 0.03 [0.86] | 0.00 [0.98] | 0.05 [0.82] | 2.41 [0.13] | 0.00 [0.98] |
| LM(2) | 0.25 [0.78] | 0.02 [0.98] | 0.30 [0.74] | 0.14 [0.87] | 1.20 [0.32] | 0.21 [0.81] |

Notes: DLAM, DLPA, and DLTO denote the log-differences, or growth rates, of international tourist arrivals to Amazonas, Pará and Total, respectively.
The numbers in parentheses are standard errors, and the numbers in brackets are p-values.
LM(1) and LM(2) are the Lagrange multiplier diagnostic tests for ARCH(1) and ARCH(2) residuals, respectively.