

## **Do Forest Fires Deter Tourists? A Dynamic Demand Model for Greek Tourism, 1980–2024**

*By Gregory T. Papanikos\**

*This paper estimates the determinants of international tourist arrivals to Greece over the period 1980–2024, with particular focus on the effect of forest fires. A log-log model identifies four determinants: per capita income of origin countries (elasticity  $\approx 3.4$ , confirming Greek tourism as a luxury good), number of forest fires (elasticity  $\approx -0.23$ ), COVID-19 (implying a 57% reduction in arrivals during 2020–2021), and euro adoption (associated with an 18% reduction). A complementary dynamic levels model provides evidence of a nonlinear fire effect, with the deterrent impact strongest at moderate fire frequencies and diminishing beyond a turning point of approximately 1,854 fires per year. Area burned is not statistically significant, suggesting that fire frequency — and its associated media coverage — rather than fire severity drives visitor deterrence. The findings carry direct implications for environmental, competitiveness and crisis management policy in tourism-dependent economies.*

**Keywords:** *forest fires; international tourism demand; Greece; income elasticity; nonlinear effects; dynamic model; time-series analysis*

### **Introduction**

International tourism is a major income-generating sector of the Greek economy. In 2024, tourism receipts reached a record €21.6 billion, and arrivals totaled 40.7 million, accounting for 8.4% of GDP (Bank of Greece). While previous studies have highlighted the roles of income, relative prices, exchange rates, and exceptional events such as geopolitical crises and pandemics in shaping tourism flows (Lim 1997, Crouch 1994), one potentially important determinant has been largely overlooked in quantitative demand analyses: the occurrence of forest fires.

This omission is notable for two reasons. First, in southern Europe, the peak tourist season coincides with the period of highest fire risk, and Greece has experienced some of the most destructive wildfires on record, including the 2007 Peloponnese fires (225,734 hectares), the 2021 Evia fire (108,418 hectares), and the 2023 Evros fire (136,499 hectares), the largest single fire event in EU history (European Commission, 2025). Second, international media coverage of fires is extensive, and there is strong reason to expect that such coverage influences destination image and booking decisions. To date, however, no study has directly estimated the effect of forest fire frequency on international tourist arrivals to Greece or, to the author's knowledge, any country using a national time-series framework.

The closest antecedent is Otrachshenko and Nunes (2022), who use panel data for 278 Portuguese municipalities over 2000–2016 and find that a 1% increase in burned area reduces inbound arrivals by 1.12%. Their study focuses on area burned

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at the sub-national level; the present paper differs in three important respects. First, it models fire frequency (number of fires) rather than — or alongside — area burned, and finds that frequency is the empirically relevant variable while area burned is not statistically significant, a distinction with direct policy implications. Second, it employs a national aggregate time-series approach over a 45-year horizon, capturing long-run structural forces alongside short-run dynamics. Third, it tests explicitly for nonlinearity in the fire effect, allowing the marginal deterrent impact to vary with the level of fire activity.

This paper makes three specific contributions. First, it provides the first estimates of the elasticity of international tourist arrivals with respect to forest fire frequency, using annual data for Greece from 1980 to 2024. Second, it incorporates this variable within a comprehensive demand model that simultaneously accounts for foreign income, relative prices, euro adoption, and the COVID-19 shock, employing HAC-robust standard errors to address residual autocorrelation. Third, it uses a dynamic levels specification with quadratic fire terms to test whether the deterrent effect of fires is constant — as assumed by a log-log model — or diminishes at high fire frequencies, finding suggestive evidence of the latter, with an empirically meaningful turning point of approximately 1,854 fires per year.

The remainder of the paper is structured as follows. The next section analyses the time series of forest fires and burned area in Greece over the sample period. The third section presents the empirical specifications and discusses the role of each variable. The fourth section reports the estimation results, comparing the log-log and dynamic levels models. The fifth section discusses policy implications, and the sixth section concludes.

### **Forest Fires and burned area in Greece, 1980–2024**

This section provides a descriptive synopsis of the two-fire series used in the empirical analysis — the annual number of forest fires and the total area burned (hectares) — drawing on data from the European Commission's annual reports on forest fires in Europe (European Commission, 2025). Figures 1 and 2 display the full time series from 1980 to 2024, and Table 1 presents summary statistics.<sup>1</sup>

#### *Visual Inspection*

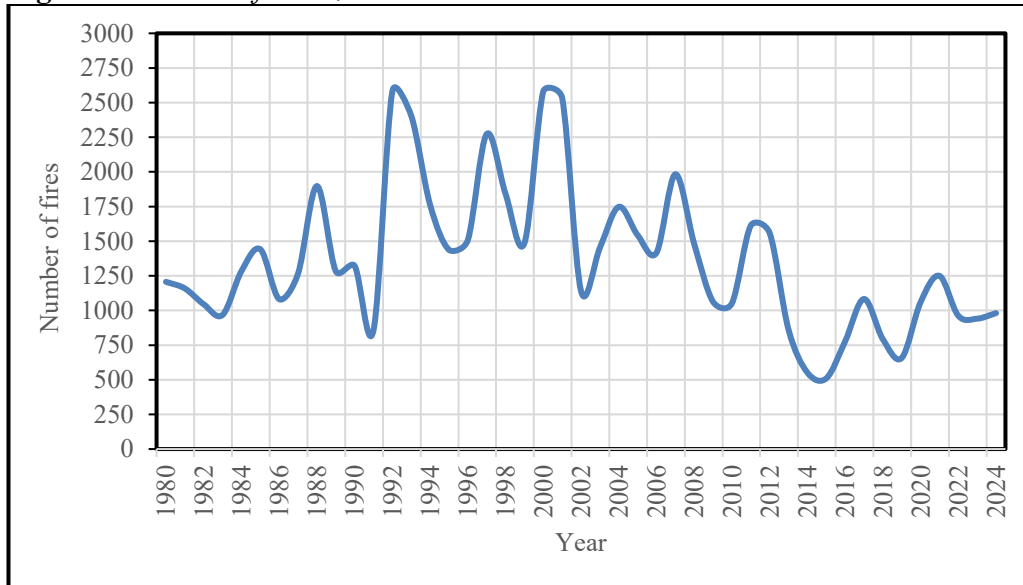
Figure 1 shows that fire frequency in Greece is highly volatile, with no simple linear trend over the 45-year period. Two distinct peaks are visible: 1992–1993 and 2000–2001, both exceeding 2,500 fires per year. The 2010s saw a pronounced and sustained decline, with the series reaching its sample minimum of 510 fires in 2014,

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<sup>1</sup>The literature on forest fires extensively addresses aspects such as prevention, management, evacuation, and restoration. While some studies discuss the impacts of fires on tourism, they do not quantify these effects as this study does (e.g., Boustras and Boukas, 2013; Diaz, 2012; Fernandes et al., 2025; Molina-Terrén et al., 2019; Neger et al., 2024; Ritchie, 2004). Several of the issues highlighted in these studies are revisited in the policy section of this paper.

before a partial rebound in the 2020s driven by prolonged heatwaves and drought conditions associated with climate change.

**Figure 1.** *Number of Fires, 1980-2024*



Source: <https://forest-fire.emergency.copernicus.eu/reports-and-publications/annual-fire-reports>

Figure 2 reveals a weaker relationship between fire count and burned area than might be expected. The 1990s, despite recording the highest fire frequencies, produced moderate burned areas, while 2007 stands alone as a catastrophic outlier at 225,734 hectares — the result of the devastating Peloponnese fires. The 2020s have introduced a new pattern of mega-fires: the 2021 Evia fire (108,418 ha) and the 2023 Evros fire (136,499 ha, the largest single fire event in EU recorded history) suggest that Greece is entering an era of fewer but vastly larger events, driven by extreme heat and drought rather than high ignition frequency.

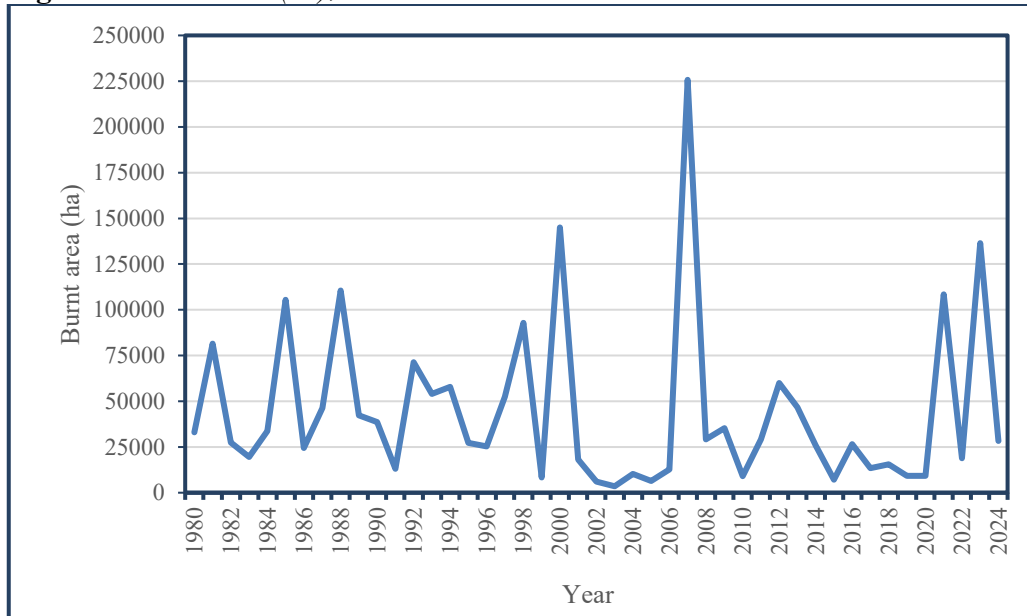
### *Summary Statistics*

As shown in Table 1, the number of fires averages 1,371 per year with a standard deviation of 524, and the distribution is only mildly right-skewed (skewness = 0.78, kurtosis = 3.11). The Jarque-Bera test does not reject normality ( $p = 0.10$ ), confirming that fire frequency fluctuates around a roughly stable mean — a prerequisite for treating the variable as stationary in the empirical model.

The burned area series has markedly different distributional characteristics. The mean of 44,470 ha is far above the median of 28,288 ha, reflecting the influence of a small number of extreme years. The standard deviation (45,163 ha) actually exceeds the mean, implying a coefficient of variation above unity — an extraordinary level of dispersion. Skewness of 2.00 and kurtosis of 7.45 confirm a heavily right-tailed distribution, and the Jarque-Bera statistic of 67.38 ( $p < 0.001$ ) overwhelmingly rejects normality. This distributional difference between the two series is relevant to the regression results: fire frequency, which is approximately normally distributed and

stationary, proves to be a more reliable predictor of tourism arrivals than burned area, which is dominated by a handful of outlier observations.

**Figure 2.** *Burnt Area (ha), 1980-2024*



Source: <https://forest-fire.emergency.copernicus.eu/reports-and-publications/annual-fire-reports>

**Table 1.** *Summary Statistics of Total Number of Fires and Area Burned, 1980–2024*

Statistic	Number of Forest Fires	Area Burned (ha)
Mean	1,371	44,470
Median	1,284	28,288
Maximum	2,582	225,734
Minimum	510	3,517
Std. Dev.	524	45,163
Skewness	0.78	2.00
Kurtosis	3.11	7.45
Jarque-Bera	4.61	67.38
(Probability)	(0.1)	(0.00)
Observations	45	45

**Notes:** Number of fires refers to the total annual count of forest fires incidents recorded in Greece (European Commission, 2025). Area burned is measured in hectares. The Jarque-Bera statistic tests the null hypothesis of normality; it is rejected at the 5% level for number of fires ( $p = 0.01$ ) and at the 1% level for area burned ( $p < 0.01$ ), the latter reflecting strong positive skewness (2.00) and substantial excess kurtosis (7.45) driven by catastrophic fire years such as 2007.

### Stationarity

Unit root tests confirm that both series are stationary. For the number of fires, the Augmented Dickey-Fuller (ADF) test rejects the null hypothesis of a unit root when an intercept is included ( $t = -3.56$ ), indicating stationarity around a constant mean — consistent with the absence of a visible deterministic trend in Figure 1. Similar results are obtained for burned area. Both series can therefore be used directly in the regression without differencing, and the inclusion of lagged dependent variables in the dynamic specification is justified on economic rather than statistical grounds.

### The Empirical Specification

In this section, we present the empirical specifications and discuss the effects of the explanatory variables. The parameter estimates are presented in the next section.

#### The Two Specifications

In this paper we use two specifications: a log-log specification and a dynamic nonlinear specification. To estimate their effect on international arrivals to Greece, we employ the following empirically motivated and parsimonious models.

$$\log(\text{ITA}_t) = \alpha + \beta_1 \log(F_t) + \beta_2 \log(Y^w)_t + \beta_3 \log(P^w/P^g)_t + \beta_4 \mathbf{D}_t + \varepsilon_t \quad (1)$$

$$\text{ITA}_t = \alpha + \beta_1 \text{ITA}_{t-1} + \beta_2 \text{ITA}_{t-2} + \beta_3 T_1 + \beta_4 T_2 + \beta_5 F_t + \beta_6 (F_t)^2 + \beta_7 \Delta(Y^w)_t + \beta_8 (P^w/P^g)_t + \beta_9 \mathbf{D}_t + \varepsilon_t \quad (2)$$

where:

$\text{ITA}_t$  = Total foreign tourist arrivals to Greece in year (t)

$F_t$  = The number of forest fires in year (t)

$(Y^w)_t$  = Average per capita GDP of USA, UK, Germany and France in period (t)

$(P^w/P^g)_t$  = The ratio of the average price level of the four countries relative to Greek price level in period (t)

$T_1, T_2$  = Time trend variables

$\mathbf{D}_t$  = A vector of dummies to be discussed in the next section

$\varepsilon_t$  = Disturbance term

$\alpha$  = Constant term

$\beta_1, \dots, \beta_9$  = Estimated coefficients

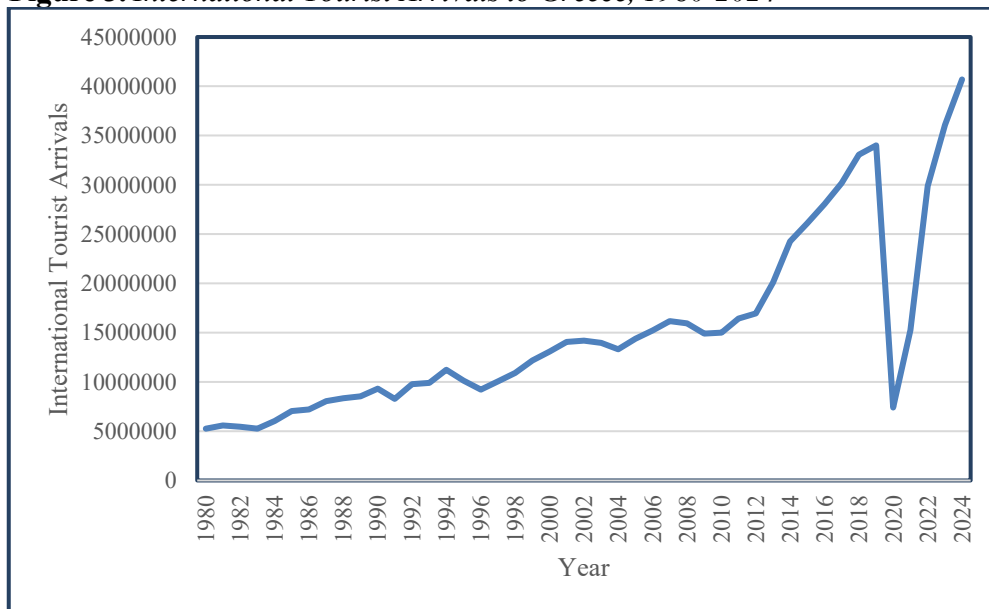
Specification (1) is considered the standard model for the reasons explained in the next section. The two specifications are estimated using Greek data from 1980 to 2024, and the results are reported in the following section. The remainder of this section examines the role of the variables in the two empirical specifications.

*The Dependent Variable: International Tourism Arrivals to Greece*

The dependent variable is the number of international tourists arriving in Greece (ITA). Figure 3 shows ITA from 1980 to 2024. Arrivals increased gradually from 5.3 million to about 14.2 million, roughly doubling over two decades, with only minor dips (notably in 1991, likely tied to the dampening effect of the Gulf War on travel). The post-9/11 environment, the 2004 Athens Olympics (Papanikos 1999), and the onset of the Greek economic crisis kept arrivals in the 13–17 million range for almost a decade. Overall, growth was relatively flat.

The period 2013–2019 represents the most striking phase. Arrivals nearly doubled, rising from 20 million to 34 million in just six years. The economic crisis ironically contributed by lowering the cost of visiting Greece, while the country simultaneously invested in tourism promotion. As a result, Greece emerged as one of Europe's top destinations.

**Figure 3.** *International Tourist Arrivals to Greece, 1980–2024*



Source: National Statistics of Greece and Bank of Greece

The year 2020 was catastrophic — arrivals fell to just 7.4 million, a drop of approximately 78%, marking the lowest level since the mid-1980s (Papanikos 2020, 2022b). The recovery was swift: by 2022, Greece had nearly returned to pre-pandemic levels, and by 2023–2024, it surpassed all previous records, reaching 40.7 million in 2024.

In conclusion, Greece's tourism has been a remarkable growth story, particularly in the last decade. The 2024 figure of roughly 40.7 million represents an almost 20% increase over the pre-pandemic peak of 2019, indicating that the sector has fully recovered and entered a new phase of expansion. Going forward, the key challenge will be managing the pressures of overtourism, especially in popular destinations such as Santorini, Mykonos, and Athens.

ITA is trend-stationary. Unit root tests indicate that the series becomes stationary only when both a constant and a deterministic trend are included, with a t-statistic of  $-4.32$ , significant at conventional levels. This confirms that  $ITA_t$  exhibits a systematic upward movement over time, reflecting the long-term growth of Greece's tourism sector. Consequently, including lagged values of the series in regression models is justified, and inference based on these regressions is valid, as the residuals do not display unit root behavior. The results also suggest that shocks to international tourist arrivals have only temporary effects relative to the deterministic trend.

### *Trends*

To account for structural changes over the sample period (1980–2024), specification (2) includes two separate time trends:

1. **T<sub>1</sub> (1980–2010)**: captures the historical growth trend in tourism prior to the economic crises of the 2010s.
2. **T<sub>2</sub> (2011–2024)**: captures the more recent trend, including recovery and expansion following the crisis.

Including these trends in the dynamic model ensures that the deterministic growth pattern in tourist arrivals is properly modeled, preventing spurious regression results. The two trend periods (T<sub>1</sub> and T<sub>2</sub>) allow us to assess whether the long-term growth rate of tourist arrivals differs between the historical (1980–2010) and post-crisis (2011–2024) periods.

### *The Effect of Forest Fires on Tourism*

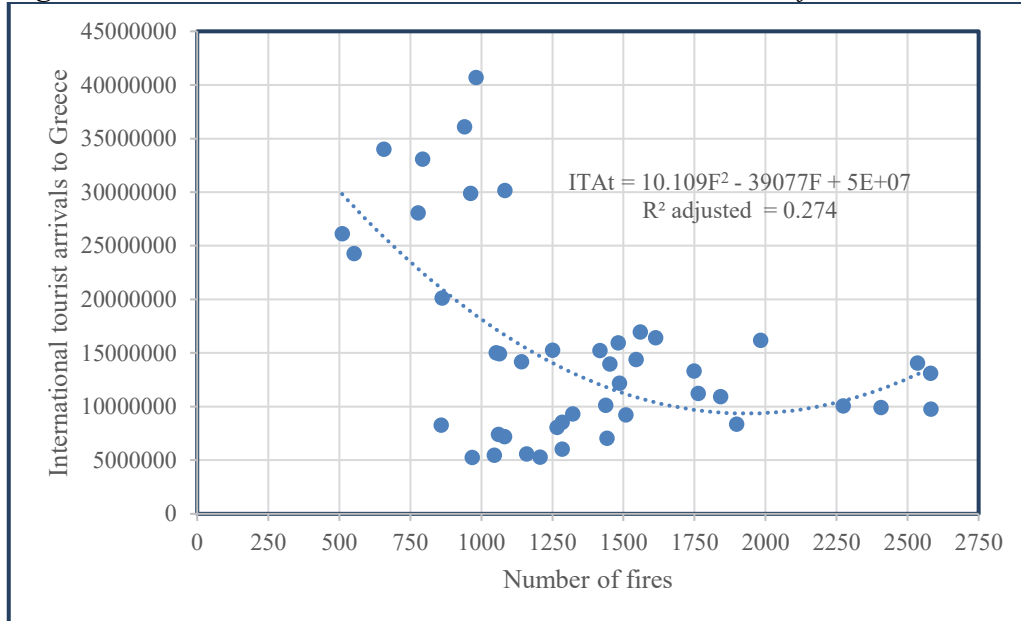
In specification (1), forest fire elasticity is assumed constant. In the dynamic specification, forest fires (F) are modeled nonlinearly, using both a linear term ( $\beta_5 F_t$ ) and a quadratic term ( $\beta_6 (F_t)^2$ ), allowing the impact on total tourist arrivals (ITA) to vary with fire severity. In the short run, more fires reduce arrivals, with larger effects as fire frequency increases, reflecting heightened safety concerns and reduced destination attractiveness. In the long run, this negative impact is amplified by the persistence of arrivals captured by lagged dependent variables, indicating that severe fires can depress tourism over multiple years. Figure 4 shows a scatter plot of international arrivals and fires, which visually supports a nonlinear relationship, justifying the quadratic specification in (2).

Foreign real per capita GDP in source countries is a key determinant of Greek international tourism arrivals, as it reflects the purchasing power of potential tourists and their ability to afford international travel. Higher real income increases the affordability of trips, generally leading to more arrivals, while lower income is associated with reduced travel demand.

The ratio of the foreign CPI to Greek CPI, conditional on real per capita GDP, primarily captures relative price changes between Greece and the source countries. A higher ratio can make Greece relatively cheaper in nominal terms, enhancing its

price competitiveness and potentially increasing tourism arrivals. Conversely, if Greek prices rise proportionally, the effect may be negligible.

**Figure 4.** *International Tourist Arrivals to Greece and Number of Fires, 1980-2024*



*Per Capita Foreign Income and relative Consumer Price Indices (CPI)*

Overall, the net impact of these macroeconomic variables reflects two distinct channels: the positive income effect captured by real GDP per capita and the price competitiveness effect captured by foreign inflation. While the effect of foreign income is expected to be positive, the effect of foreign inflation is theoretically ambiguous and depends on the relative evolution of prices between Greece and the tourists' home countries.

### Empirical Results

This section presents the estimation results of Equations (1) and (2). First, we discuss the sources and limitations of data followed by the parameter estimates of the model.

#### *Sources and Limitations of Data*

Data on international tourist arrivals to Greece are obtained from two national sources: the National Statistics Office of Greece (ESYE) for the period 1980–2005 and the Bank of Greece for 2006–2024. These data include only overnight visitors and are available from 1995 onward. The series has been revised multiple times, and several breaks are present due to changes in methodology. To assess whether these limitations affect the empirical findings, we test the time series separately for

the periods before and after 1995 and apply tests for structural breaks in specific years. No evidence of such breaks was found.

Data on the number of fires and the forest area burned, measured in hectares, are reported in a publication by the European Commission (2025) and are available from 1980 onward.

Data on GDP per capita, along with exchange rates and consumer prices, are obtained from the World Development Indicators of the World Bank. Ideally, we would use a weighted average of GDP per capita and inflation across all countries, weighted by their share of international arrivals to Greece. However, such data are unavailable. Instead, we use data from four main source countries—the United States, the United Kingdom, Germany, and France—and compute a simple average. We apply the same procedure to the Consumer Price Index (CPI), averaging the CPI of these four source countries. We consider these variables to be good proxies for per capita GDP and CPI relevant to Greek tourism.

### *Summary Statistics*

Table 2 presents summary statistics of the continuous variables used in the estimation. The summary statistics reveal substantial variation across the four variables, reflecting differing distributional characteristics and degrees of volatility. International tourist arrivals (ITA) exhibit a relatively high mean of approximately 15.3 million and a median of 13.3 million, indicating that the distribution is influenced by higher values in later years. This is supported by the positive skewness (1.19), suggesting a right-tailed distribution in which periods of exceptionally high tourism inflows pull the mean above the median. The relatively large standard deviation (9.15 million) confirms significant variability over the sample period, likely reflecting structural changes in tourism demand and external shocks. The Jarque–Bera statistic is statistically significant ( $p = 0.004$ ), indicating deviation from normality.

The number of fires (F) has a mean of 1,371 and a median of 1,284, with moderate dispersion (standard deviation  $\approx 523$ ). The positive skewness (0.78) indicates that years with unusually high fire incidence occur, but they are not extreme. The Jarque–Bera probability ( $p \approx 0.10$ ) suggests that normality cannot be rejected at conventional significance levels, implying a relatively symmetric distribution compared with the other variables.

The analysis of average per capita GDP ( $Y^w$ ) for the United States, United Kingdom, Germany, and France from 1980 to 2024 indicates a relatively stable and moderately dispersed growth pattern. Over the 45-year period, the mean GDP per capita is approximately 38,189 USD, slightly below the median of 39,639 USD, reflecting a small negative skew in the distribution. The standard deviation of 7,509 USD and a range spanning from 25,338 USD to 49,507 USD suggest moderate variability across the years, while the kurtosis of 1.80 indicates a slightly flatter-than-normal distribution. The Jarque-Bera test fails to reject the null hypothesis of normality ( $p = 0.20$ ), confirming that the GDP per capita data are approximately normally distributed with only minor deviations due to occasional lower GDP values.

**Table 2.** Summary Statistics of the Continuous Variables Used in the Regression, 1980–2024

	ITA	F	Y <sup>w</sup>	P <sup>w</sup> /P <sup>g</sup>
Mean	15,255,926	1,371	38,189	1.46
Median	13,313,000	1,284	39,639	1.13
Maximum	40,693,879	2,582	49,507	3.15
Minimum	5,258,372	510	25,338	0.99
Std. Dev.	9,147,606	523	7,509	0.65
Skewness	1.19	0.78	−0.26	1.57
Kurtosis	3.48	3.11	1.8	4.06
Jarque-Bera	11.06	4.61	3.21	20.46
Probability	0.004	0.1	0.2	0.0000
Observations	45	45	45	45

**Notes:** ITA = international tourist arrivals to Greece; F = number of forest fires in Greece; Y<sup>w</sup> = average per capita GDP of the United States, United Kingdom, Germany and France (constant 2015 USD); P<sup>w</sup>/P<sup>g</sup> = ratio of the average CPI of origin countries to the Greek CPI. The Jarque-Bera statistic tests the null hypothesis of normality; rejection at conventional significance levels is indicated for ITA ( $p = 0.004$ ) and P<sup>w</sup>/P<sup>g</sup> ( $p < 0.001$ ).

The ratio of the average consumer price index of the four main origin countries to the Greek CPI (P<sup>w</sup>/P<sup>g</sup>) serves as a measure of the relative price competitiveness of Greece as a tourist destination. A value greater than unity indicates that prices in the origin countries are, on average, higher than in Greece, implying a cost advantage for Greek tourism. The descriptive statistics reveal that the variable has a mean of 1.46 and a median of 1.12 over the sample period 1980–2024, confirming that Greece has generally been a relatively affordable destination for visitors from the United States, the United Kingdom, Germany and France. The range is, however, considerable: the series reaches a maximum of 3.15 and a minimum of 0.99. The standard deviation of 0.65 reflects substantial variation over time, driven largely by the inflationary episodes of the 1980s, the post-2010 internal devaluation period in Greece, and the sharp divergence in inflation rates between Greece and its origin markets during the energy crisis of 2021–2023. The distribution is positively skewed (skewness = 1.57) with excess kurtosis (4.05), and the Jarque-Bera statistic of 20.46 ( $p < 0.001$ ) formally rejects the null hypothesis of normality, indicating that the series is characterized by occasional large upward spikes rather than symmetric fluctuations around its mean. This asymmetry is consistent with the view that episodes of strong Greek price competitiveness — most notably during the post-2010 fiscal adjustment — were exceptional rather than typical features of the sample.

### *The Log-log Specification*

The estimation results of the log-log specification are presented in Table 3. The model explains approximately 94.4 per cent of the variation in international tourist

arrivals to Greece over the period 1980–2024 ( $R^2 = 0.944$ ), with an adjusted  $R^2$  of 0.937, indicating a very good overall fit. Given evidence of residual autocorrelation — the Durbin-Watson statistic of 1.379 falls below the conventional threshold — all inference is based on heteroskedasticity- and autocorrelation-consistent (HAC) standard errors following the Newey-West procedure with a fixed bandwidth of four lags. Column (2) of Table 1 reports conventional OLS t-statistics as a robustness check; since the two columns yield qualitatively identical conclusions for all variables except  $\log(P^w/P^g)$  and EURO, the discussion below focuses on the preferred HAC specification.

#### Income of Origin Countries

The income variable, measured as the average per capita GDP of the four principal origin markets (United States, United Kingdom, Germany and France), enters with a coefficient of 3.4 and is highly significant under both specifications ( $t = 6.314$  under HAC;  $t = 12.310$  under OLS). The estimated income elasticity of demand for Greek tourism thus exceeds unity by a substantial margin, confirming that international travel to Greece behaves as a luxury good. This finding is consistent with the broader tourism demand literature, where income elasticities above two are commonly reported for Mediterranean destinations (e.g. Lim 1997, Crouch 1994). The magnitude of the estimate implies that a sustained one per cent increase in real incomes in the origin countries is associated, on average, with a 3.4 per cent increase in arrivals to Greece, underscoring the high sensitivity of Greek tourism revenues to business cycle conditions abroad.

#### Environmental Quality: Forest Fires

The number of forest fires in Greece, used as a proxy for environmental degradation and negative destination publicity, carries a coefficient of  $-0.228$  and is statistically significant at the one per cent level under both specifications ( $t = -2.622$  under HAC;  $t = -3.337$  under OLS). The negative elasticity implies that a ten per cent increase in the number of fires reduces tourist arrivals by approximately 2.3 per cent. Based on 2024 arrivals of 40.69 million, this elasticity corresponds to a reduction of nearly one million tourists. Assuming an average expenditure of €500 per tourist, this decline would result in a revenue loss of approximately €500 million.

The finding aligns with the destination image literature, which documents that natural disasters and environmental incidents generate persistent negative media coverage that deters prospective visitors (Ritchie, 2004; Papatheodorou et al., 2010).

#### The COVID-19 Effect

The COVID-19 dummy variable, which takes the value of one for the years 2020 and 2021, produces the largest estimated effect in the model.<sup>2</sup> The coefficient of  $-0.849$  is highly significant under both specifications ( $t = -6.934$  under HAC;  $t = -8.018$  under OLS) and implies a reduction in tourist arrivals of approximately 57 per cent during the pandemic years relative to the counterfactual [ $e^{-0.849} - 1 \approx -0.572$ ]. This estimate is consistent with official data showing that international

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<sup>2</sup>The impact of COVID-19 has been examined by Boutsioli et al. (2022a, 2022b), Jones (2022), Jones and Comfort (2020), and Papanikos (2020, 2022b).

arrivals to Greece collapsed from approximately 31 million in 2019 to fewer than 8 million in 2020, before partially recovering in 2021. The inclusion of the COVID dummy also serves to isolate the structural break introduced by the pandemic, thereby protecting the estimates of the other coefficients from contamination by this exceptional event.

#### Relative Price Competitiveness

The relative price variable, defined as the ratio of the average consumer price index of the four origin countries to the Greek CPI, carries a positive coefficient of 0.332, consistent with the expected sign: when prices abroad rise relative to Greece, the destination becomes relatively cheaper and more attractive to foreign visitors. Under the preferred HAC specification, the coefficient is not statistically significant at conventional levels ( $t = 1.516$ ,  $p = 0.138$ ); however, it becomes significant at the one per cent level under conventional OLS standard errors ( $t = 2.780$ ,  $p = 0.008$ ).

The discrepancy between the two columns for this variable is attributable to the presence of autocorrelation in the residuals, which inflates OLS precision. The HAC result is therefore the more reliable basis for inference. The absence of robust price significance may reflect the well-documented difficulty of measuring tourism price competitiveness with aggregate CPIs, which capture a broader consumption basket than the goods and services typically consumed by tourists. Alternatively, it may indicate that demand for Greek tourism is driven primarily by income and destination image rather than relative price levels, a pattern also noted by Dritsakis (2004) for the Greek case.

#### Euro Adoption

The euro dummy variable, which takes the value of one from 2002 onwards, carries a negative coefficient of  $-0.203$ . Under the HAC specification the variable is marginally significant at the ten per cent level ( $t = -1.939$ ,  $p = 0.060$ ), while under OLS it is significant at the five per cent level ( $t = -2.277$ ,  $p = 0.028$ ). The negative sign suggests that euro adoption was associated with a reduction in tourist arrivals of approximately 18 per cent [ $e^{-0.203} - 1 \approx -0.184$ ], after controlling for income, prices and other factors.

This result is likely driven by the real appreciation of the Greek economy following monetary union (Papanikos 2015, 2022a). With the exchange rate no longer adjustable, rising costs of living could not be offset by currency depreciation, reducing price competitiveness relative to non-eurozone destinations. This aligns with evidence from other eurozone studies, which indicate that adopting the common currency had an ambiguous effect on inbound tourism in peripheral member states (Santana-Gallego et al. 2010).

#### Robustness

To assess the stability of the baseline results, the model was also estimated excluding the relative price variable  $\log(P^w/P^g)$  (not reported in the table). The restricted specification yields an adjusted  $R^2$  of 0.926, compared with 0.937 in the full model, and a higher Akaike Information Criterion ( $-0.834$  versus  $-0.971$ ), indicating a worse fit. Moreover, the coefficient on EURO loses significance ( $p =$

0.103), consistent with the conceptual overlap between the price ratio and euro adoption as measures of cost competitiveness. The core results — the income elasticity, the fires coefficient and the COVID effect — are qualitatively unaffected by the exclusion, confirming the robustness of the main findings. On balance, the evidence favors retaining the full specification.

**Table 3.** *Determinants of International Tourism Arrivals to Greece, 1980–2024*  
Dependent variable:  $LOG(ITA)$ . Observations: 45

Variable	Coefficient	(1) HAC	(2) OLS
		t-statistic	t-statistic
Constant	-17.994	-3.013***	-5.982***
LOG(F)	-0.228	-2.622**	-3.337***
LOG(Y <sup>w</sup> )	3.424	6.314***	12.310***
COVID	-0.849	-6.934***	-8.018***
LOG(P <sup>w</sup> /P <sup>g</sup> )	0.332	1.516	2.780***
EURO	-0.203	-1.939*	-2.277**
R-squared		0.944	0.944
Adjusted R-squared		0.937	0.937
S.E. of regression		0.140	0.140
Akaike info criterion		-0.971	-0.971
Durbin-Watson stat		1.379	1.379

**Notes:** All continuous variables are in natural logarithms. ITA = tourist arrivals; F = forest fires; Y<sup>w</sup> = average per capita GDP of US, UK, Germany and France; COVID = dummy for 2020–2021; P<sup>w</sup>/P<sup>g</sup> = ratio of average CPI of origin countries to Greek CPI; EURO = dummy for euro adoption years. Column (1) reports t-statistics based on HAC standard errors (Bartlett kernel, Newey-West fixed bandwidth = 4), which are robust to heteroskedasticity and autocorrelation and constitute the preferred specification given evidence of residual autocorrelation (Durbin-Watson = 1.379). Column (2) reports conventional OLS t-statistics and is included as a robustness check; coefficients are identical across both columns. Significance levels: \*\*\* p < 0.01, \*\* p < 0.05, \* p < 0.10.

### *Modeling Nonlinearity in the Fire Effect: A Dynamic Levels Approach*

As a complement to the log-log specification, Table 4 presents an alternative model estimated in levels with a dynamic autoregressive structure and quadratic fire terms as has been discussed in the previous section.

The model includes two lags of the dependent variable, ITA(-1) and ITA(-2), a piecewise linear time trend to capture structural breaks in the long-run growth path of arrivals, the number of fires and its square, per capita income of the origin countries, and the relative price ratio. The specification is estimated with HAC

standard errors over 43 observations after lag adjustments, and ITA has been confirmed to be stationary in levels through unit root testing, validating the use of OLS in this framework.

#### Dynamic Adjustment and Trend

The two lagged dependent variables are both highly significant ( $t = 6.101$  and  $t = -6.142$  respectively, both  $p < 0.001$ ), confirming the presence of substantial persistence in tourist arrivals. The positive coefficient on  $ITA(-1)$  and negative coefficient on  $ITA(-2)$  together imply a second-order autoregressive process in which arrivals adjust gradually toward their equilibrium level, reflecting the well-documented inertia in tourism demand driven by repeat visitation, established travel patterns, and the slow adjustment of tour operator capacity and airline routes. The two piecewise time trend components are also highly significant ( $p < 0.001$ ), indicating that the underlying trend growth rate of arrivals shifted over the sample period — a finding consistent with the structural acceleration of Greek tourism observed from the mid-1990s onwards and the subsequent disruptions of the post-2010 fiscal crisis and the COVID-19 pandemic.

#### Nonlinear Effect of Forest Fires

The central contribution of the level's specification is the identification of a nonlinear relationship between fire frequency and tourist arrivals. Both  $F$  (coefficient =  $-9,089$ ,  $t = -1.739$ ,  $p = 0.091$ ) and  $F^2$  (coefficient =  $2.451$ ,  $t = 1.720$ ,  $p = 0.095$ ) are marginally significant at the ten per cent level. The negative sign on the linear term and positive sign on the quadratic term imply that the deterrent effect of fires on tourism is strongest at moderate fire frequencies and diminishes at higher levels of fire activity, suggesting a degree of tourist desensitization once fires become sufficiently frequent.

The implied turning point, calculated as  $-(-9,089) / (2 \times 2.451) \approx 1,854$  fires, lies above the sample mean of 1,371 but within the observed range of the data, confirming that the nonlinearity is empirically relevant rather than an extrapolation beyond the sample. These results suggest that the marginal reputational damage inflicted on Greek tourism by an additional fire event is greater when fire activity is below approximately 1,854 incidents per year, and diminishes thereafter — a finding with direct implications for the threshold at which fire prevention investment yields the highest tourism protection returns.

#### Income and relative Prices

Per capita income of the origin countries ( $Y^w$ ) is positive and statistically significant at the five per cent level ( $t = 2.367$ ,  $p = 0.024$ ), consistent with the log-log finding that Greek tourism is strongly income-driven. The relative price ratio ( $P^w/P^g$ ) is also significant at the five per cent level ( $t = 2.038$ ,  $p = 0.049$ ), with a positive coefficient indicating that when prices in origin countries rise relative to Greece, arrivals increase — the expected competitiveness effect. Notably, while the price variable was not robustly significant in the preferred log-log specification under HAC standard errors, it achieves significance in the levels model, which may reflect the fact that the dynamic structure — by controlling for persistence through

the lagged dependent variables — reduces residual autocorrelation and improves the precision of the price coefficient estimate.

**Table 4.** *Dynamic Model of International Tourism Arrivals to Greece in Levels, 1980–2024*

Dependent variable: ITA. Method: OLS with HAC standard errors (Bartlett kernel, Newey-West fixed bandwidth = 4). Observations: 43 after adjustments.

Variable	Coefficient	t-Statistic
Constant	481,367	0.074
ITA(-1)	0.961	6.101***
ITA(-2)	-0.496	-6.142***
T1	444,579	4.243***
T2	405,258	6.121***
F	-9,089	-1.739*
F <sup>2</sup>	2.451	1.720*
Y <sup>w</sup>	4,449	2.367**
P <sup>w</sup> /P <sup>g</sup>	2,016,087	2.038**
<hr/>		
R-squared	0.927	
Adjusted R-squared	0.910	
S.E. of regression	2,726,673	
Akaike info crit.	32.657	
Durbin-Watson stat	1.953	
Wald F-statistic	164.517 [0.000]	

**Notes:** ITA = international tourist arrivals to Greece; F = number of forest fires; F<sup>2</sup> = squared number of forest fires; Y<sup>w</sup> = average per capita GDP of the United States, United Kingdom, Germany and France (constant 2015 USD); P<sup>w</sup>/P<sup>g</sup> = ratio of average CPI of origin countries to Greek CPI; T1 and T2 are piecewise linear time trends. ITA is stationary in levels as confirmed by unit root testing. The turning point implied by the quadratic fire terms is approximately 1,854 fires [= 9,089 / (2 × 2.451)], above the sample mean of 1,371 but within the observed range. Significance levels: \*\*\* p < 0.01, \*\* p < 0.05, \* p < 0.10.

#### Comparison with the log-log specification

The levels and log-log specifications yield broadly consistent conclusions regarding the direction and significance of the main determinants of Greek tourism demand, but they differ in important respects that make them complementary rather than competing models. The log-log model achieves a higher adjusted R<sup>2</sup> (0.937 versus 0.910) with a more parsimonious specification — six parameters versus nine — and produces coefficient estimates that are directly interpretable as elasticities, facilitating comparison with the existing tourism demand literature. The constant income elasticity of 3.4 and fire elasticity of -0.228 are clean, theoretically

grounded estimates that characterize the average proportional sensitivity of arrivals to each determinant over the full sample period.

The levels model, by contrast, sacrifices parsimony and direct comparability in exchange for two additional insights. First, the inclusion of lagged dependent variables explicitly models the dynamic adjustment process in tourism demand, capturing the persistence and habit formation that the static log-log specification abstracts from. Second, and most importantly for the contribution of this paper, the quadratic fire terms in the levels model allow the elasticity of arrivals with respect to fire frequency to vary with the level of fire activity — precisely the restriction that the log-log model imposes and cannot test internally. The marginal significance of  $F^2$  in the levels model provides suggestive evidence that this restriction may be binding at high fire frequencies, while the failure of the analogous test in log space — where  $[\text{LOG}(F)]^2$  was not significant — indicates that the nonlinearity, if present, operates through the level rather than the proportional scale of fire activity.

On balance, the log-log specification is retained as the primary model for the reasons of parsimony, fit, and interpretability outlined above. The levels model is presented as a complementary specification that corroborates the core findings and additionally provides evidence of a nonlinear fire effect with an empirically meaningful turning point. Together, the two specifications paint a consistent and mutually reinforcing picture of the determinants of international tourism demand in Greece, with fire frequency emerging as a statistically and economically significant deterrent whose marginal impact on arrivals is greatest when fire activity is moderate and diminishes — though does not disappear — at the extreme fire counts observed in catastrophic years such as 2007.

#### *Additional Variables and Specifications*

Although the number of forest fires has a statistically significant negative effect on tourist arrivals, the total area burned does not appear to influence demand. This apparent paradox can be explained by differences between perceived and actual risk. Tourist decisions are typically made in advance and are strongly shaped by media coverage and destination image.

Each fire event generates separate news exposure and social media attention, regardless of its eventual size, making fire frequency a more accurate proxy for reputational damage than hectares burned.

In addition, the largest fires in Greece have historically occurred in mainland regions such as the Peloponnese and Evia, while major tourist destinations—Crete, the Aegean islands and the Ionian islands—have been less affected. This geographic mismatch weakens the link between burned area and aggregate arrivals. Statistically, the burned-area variable is highly skewed due to rare catastrophic seasons (e.g. 2007), inflating standard errors and reducing precision.

Additional dummy variables (recession years, election years, the 2004 Olympics, and the pre-euro exchange rate) were tested but proved insignificant. Their effects were either captured more accurately by continuous variables (income and relative prices) or offset by countervailing forces, and their inclusion did not alter the main results.

## Policy Implications and Recommendations

The empirical findings carry several implications for tourism and environmental policy in Greece and, more broadly, for tourism-dependent Mediterranean economies.

### *The Income Effect*

The income elasticity of approximately 3.4 is the single most policy-relevant finding. Its magnitude indicates that Greek tourism revenues are highly sensitive to business cycle fluctuations in the main origin markets: a one per cent decline in foreign per capita income due to a recession reduces arrivals by more than three per cent. This structural vulnerability calls for two complementary strategies.

First, market diversification toward high-income emerging markets—China, the Gulf states, and India—whose growth cycles are less correlated with the European business cycle. Second, a deliberate shift toward the premium segment of the international tourism market.

These policies are currently being implemented by Greek tourism authorities, including the introduction of new direct flights to China and India, a revised visa approach with Türkiye, and strengthened geopolitical collaboration with Israel, all of which have increased tourism flows from these markets.

### *Environmental Protection as Tourism Infrastructure*

The statistically significant fire elasticity of  $-0.228$  establishes a direct quantitative link between environmental degradation and tourism revenue loss. Fire prevention expenditure — on early detection systems, firebreaks and land-use management in tourism-intensive areas — should therefore be budgeted and evaluated as tourism infrastructure rather than purely as ecological expenditure.

The finding that fire frequency, rather than area burned, drives visitor deterrence implies that the prevention of ignitions yields a higher tourism protection return than investment in large-fire suppression alone. Proactive destination image communication following fire events can further mitigate the reputational damage that the results suggest persists beyond the immediate incident.

### *Crisis Preparedness*

The COVID-19 coefficient — implying a 57% reduction in arrivals — underscores the vulnerability of tourism-dependent economies to large-scale external shocks. A robust crisis management framework should include pre-negotiated liquidity support for tourism enterprises, flexible short-time work schemes calibrated to the seasonal labor structure, and contingency plans for rapid route reactivation when demand recovers. Longer-term economic diversification would reduce the macroeconomic cost of future shocks. The EU recovery plan was an effective instrument for mitigating the impact of COVID-19, as discussed by Papanikos (2021).

*Price Competitiveness within the Eurozone*

The negative euro dummy coefficient reflects the loss of exchange rate flexibility following monetary union. Since internal devaluation is the only available competitiveness mechanism within the eurozone, policy should focus on containing costs in the tourism supply chain — labor, energy, port fees and VAT on accommodation and food services — relative to non-eurozone competitors such as Turkey, Egypt and Morocco. Structural reforms that improve supply chain efficiency and reduce bureaucratic costs for tourism investment can partially substitute for the exchange rate adjustment that euro membership forecloses.

*Integrated Tourism Governance*

The determinants identified in this study — foreign income, environmental quality, currency regime and crisis management — span the responsibilities of multiple ministries and public bodies. Effective tourism policy therefore requires cross-ministerial coordination mechanisms and the regular production of updated demand elasticity estimates to inform promotional and investment decisions.

**Conclusions**

This paper has estimated the determinants of international tourist arrivals to Greece over 1980–2024, embedding the novel variable of forest fire frequency within a comprehensive demand framework. Two complementary specifications — a parsimonious log-log model and a dynamic levels model with quadratic fire terms — yield a consistent picture of the forces shaping Greek tourism demand over four and a half decades.

*Principal Findings*

The log-log model (adjusted  $R^2 = 0.937$ ) identifies four robust determinants. Foreign per capita income dominates, with an elasticity of approximately 3.4, confirming Greek tourism as a luxury good. Forest fires exert a significant deterrent effect (elasticity  $\approx -0.23$ ), with fire frequency — rather than area burned — the empirically relevant variable, consistent with the view that media coverage of fire events, rather than ecological damage per se, drives booking decisions.

The COVID-19 pandemic caused a 57% reduction in arrivals during 2020–2021, the largest single shock in the sample. Euro adoption is associated with an 18% reduction in arrivals, reflecting the erosion of price competitiveness following monetary union.

The dynamic levels model corroborates these findings and additionally identifies a nonlinear fire effect: the deterrent impact is strongest at moderate fire frequencies and diminishes beyond a turning point of approximately 1,854 fires per year — above the sample mean but within the observed range.

### *Limitations and Future Research*

Several avenues for future research arise from the limitations of the present study. First, the use of a simple average of four origin-country income and price variables is a pragmatic approximation; a weighted demand model disaggregated by country of origin could reveal heterogeneity in income elasticities and fire sensitivity across markets. This approach would also allow testing for variation in income elasticities by country of origin.

Second, the annual frequency of the data prevents precise identification of the lag between fire events, media coverage, and booking decisions; a monthly or quarterly analysis, if data were available, would provide a clearer dynamic picture.

Third, the nonlinearity finding is based on marginally significant coefficients and should therefore be treated as suggestive; a cross-country panel of Mediterranean destinations could offer a more robust test.

Fourth, regional disaggregation within Greece could show whether the islands—which account for the majority of arrivals—respond differently to fire events than mainland destinations. These opportunities have been limited by data availability; however, the Bank of Greece has recently begun reporting regional data. Given that fires inherently affect specific regions, such data could enable more precise modeling of local impacts.

### *Concluding Remarks*

To the author's knowledge, this is the first study to include forest fire frequency as a determinant in a national tourism demand model, and the first to test explicitly for nonlinearity in that relationship. As climate change increases the frequency and severity of wildfire events across the Mediterranean, the economic cost to tourism-dependent economies is likely to grow. Quantifying this cost is a necessary first step toward designing the policy responses — in fire prevention, destination marketing and crisis management — that will be required to protect the sector in the decades ahead.

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