The competitive environment hypothesis revisited: Nonlinearity, nonstationarity and profit persistence*

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Abstract

Much empirical literature dealing with the competitive environment hypothesis tends to find nonstationary behaviour and very high persistence in time series of company profits. We model profit time series using a simple time series model that allows for nonstationary behavior over subsamples, but overall mean reversion. Using a new dataset consisting of profits for more than 150 US companies over a time period of 50 years, we present statistical evidence that the high persistence observed in profits when using linear autoregressive models is often due to the misspecification of the data generating process.

Keywords: Profit Persistence; Competition; Unit roots; TAR models.

JEL classification: L00, C22.

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1 Introduction

The competitive environment hypothesis is one of the basic ideas in mainstream economic theory. It states that the competitive process eliminates all economic profits and losses in the long run and the intuition behind it is straight forward: if a firm has excess profits, competitors enter the market and offer similar products at lower prices, reducing the profit margin of the incumbent. This continues until profitability in that market equals the competitive rate. If firms have profits below average, investors move to markets with higher profits and therefore, unless corrective measures are introduced, restoring at least normal profits, firms with lower than average profitability are eliminated.

Because of the basic importance of this idea as a building block of economic theory, much research has been undertaken in order to shed light on the empirical relevance of the competitive environment hypothesis. Starting with the seminal contributions by Mueller (1977, 1986), some examples of this branch of research are given by Geroski and Jacquemin (1988), Mueller (1990), Kambahampati (1995), Goddard and Wilson (1999), McGahan and Porter (1999), Cable *et al.* (2001) and Glen *et al.* (2001), to mention just a few. The main conclusion of this literature is that deviations of profit rates from the norm are very persistent. One of the most recent contributions by Maruyama and Odagiri (2002) follows 376 Japanese firms which were previously analyzed for the period 1964-82 and finds that by adding 15 more years of data the conclusion stays the same: profits persist. Gschwandtner (2003) looking at 187 surviving US firms from 1950-1999 finds that competitive forces were even not able to erode profits for time period of 50 years. Cable and Jackson (2003) using structural time series analysis point out the importance of cycles in profits, but still find "around 60 % of the companies exhibiting non-eroding long run persistence".

Evidence of nonstationary (unit root) behaviour in company profits is often reported in the empirical literature dealing with the competitive environment hypothesis. Kambhampati (1995), using the Dickey-Fuller (DF) test, could reject non-stationarity of profits in only 13 out of 42 cases for Indian industry-level data. Goddard and Wilson (1999) employing data for 335 U.K firms over the period 1972-91 likewise report non-stationarity in 76-81 % of firms in the sample. Gschwandtner (2003) fails to reject the unit root hypothesis in 69 out of 187 cases (36,9%) for US companies. Univariate methods for testing for unit roots are well known to have low power, especially for relatively small sample sizes such as those used in most of the empirical literature on profit persistence. Several different tests have been recently proposed in order to improve the power of unit root testing by exploiting the cross-section dimension in datasets with a panel structure.[1] Ioannidis *et al.* (2003) apply a panel unit root test recently proposed by Chang (2002) to the same data set used by Goddard and Wilson (1999) and strongly reject the hypothesis of a joint unit root. They interpret the results as suggesting that profit rates are mean reverting and that a nonlinear framework of analysis provides a different perspective on previous empirical results. It should be noticed however that in many cases the alternative hypothesis of DF-type panel unit root tests allows for nonstationary behaviour in some cross-sections. While the null hypothesis in the test by Chang (2002) is that the autoregressive parameter equals one for all cross sectional units (firms), the alternative hypothesis is that the profit rates of some companies have an autoregressive parameter whose absolute value is smaller than one. It is thus unjustified to conclude that individual profit rates are stationary after rejection of a common unit root when testing in panels. The alternative hypothesis in the panel unit root test by Im *et al.* (1995),[2] for instance, states that a fixed, strictly positive proportion of the cross-sections is stationary. The relative size of the stationary units with respect to the cross-section dimension of the panel plays no direct role in the testing procedure, and could actually be minimal.

In this paper we propose an alternative nonlinear modelling strategy for company profits that allows for a "band of inactivity" in which profits may present nonstationary behaviour, but where the global behaviour of the variable is mean reverting. The model takes the form of a simple TAR (threshold autoregression) and can be reconciled with theoretical explanations based on the

[1] See for example Chang (2002), Levin *et al.* (2002) and Im *et al.* (2003).

[2] This test has been used in the framework of persistence of profits analysis by, for example, Glen et al (2001).

existence of fixed costs in models of entry-exit decision à la Dixit (1989). With fixed costs, only if the profit exceeds a specific level is it attractive enough for competitors to enter the market, and only if profits fall below a certain level, firms are forced to exit the market. The idea that firms might not react to shocks until their effects have accumulated beyond a certain threshold is mentioned also in Geroski (1998). This can generate regions of inactivity and thresholds in the adjustment process of profits of the type that are modelled using a TAR. The simple specification of the model allows for testing against pure unit root processes using the methodology developed by Caner and Hansen (2001).

Using a newly developed dataset comprising 50 years of profit data for more than 150 US companies, we find statistical evidence that the persistence of profits is overestimated if the existence of such nonlinearities is not taken into account. Furthermore, when tested against the TAR model, the null of a unit root process can be rejected for a high proportion of the series that appeared nonstationary according to the DF test.

The structure of the paper is as follows. Section two presents the nonlinear specification proposed, its characteristics and differences with the linear alternative. Section three introduces the data and the empirical results, and section four concludes.

2 Assessing persistence of profits: Methodological underpinnings

Since the seminal contribution of Mueller (1986), the autoregressive process of first order (AR(1)) has been the most widely used representation of the dynamics of profits. Let $\pi_{i,t}$ be the profit rate of firm i in period t, eventually normalized by taking the difference to the sample average profit rate in period t. The dynamic behaviour of $\pi_{i,t}$ is assumed to be given by

$$\pi_{i,t} = \alpha_i + \lambda_i \pi_{i,t-1} + \varepsilon_{i,t}, \tag{1}$$

where $\lambda_i \in (-1, 1)$ and $\varepsilon_{i,t}$ is white noise with constant variance σ_i^2. Notice that the specification given by (1) can be justified theoretically (see Geroski, 1990, for example) as a reduced form of a two-equation system where profits are assumed to depend on the threat of entry in the market, and the threat is itself assumed to depend on the profits observed in the last period.

The unconditional expectation of $\pi_{i,t}$ in (1) is given by $\alpha_i/(1-\lambda_i)$. The empirical literature on profit persistence usually compares the estimates of the unconditional expectations from (1) (or alternative AR(p) generalizations) and tests the equality of unconditional expectations – long run projections of the series – across companies. However, this procedure is appropriate only for stationary AR processes, as $\alpha_i/(1-\lambda_i)$ is not defined for unit root processes, where $\lambda_i = 1$. Furthermore, the specification given by (1) cannot replicate nonlinear adjustments and bands of inaction such as the ones implied by fixed costs for entry to and exit from the market.[3] .

We propose an alternative specification that explicitly models the existence of such an inaction band for profit rates in the interval $[\bar{\pi}_1, \bar{\pi}_2]$ and mean reversion outside the bands. Inside the inaction bands the profit rate behaves like a random walk (eventually, with drift), while the overall behaviour of the series is mean reverting to the interval $[\bar{\pi}_1, \bar{\pi}_2]$. A possible parametrization is given by

$$\pi_{i,t} = \alpha_i + \begin{cases} \lambda_i(\pi_{i,t-1} - \bar{\pi}_2) + \bar{\pi}_2 + \varepsilon_{i,t} & \text{if } \pi_{i,t-1} > \bar{\pi}_2, \\ \pi_{i,t-1} + \varepsilon_{i,t} & \text{if } \bar{\pi}_1 < \pi_{i,t-1} \leq \bar{\pi}_2, \\ \lambda_i(\pi_{i,t-1} - \bar{\pi}_1) + \bar{\pi}_1 + \varepsilon_{i,t} & \text{if } \pi_{i,t-1} \leq \bar{\pi}_1, \end{cases} \tag{2}$$

where $\lambda_i \in (-1, 1)$ and $\varepsilon_{i,t}$ is an i.i.d. disturbance with constant variance σ_i^2. For simplicity, the speed of adjustment outside the inaction band has been set

[3] The empirical literature on profit persistence uses two different but interrelated definitions of persistence of profits. The persistence measure related to long-run deviations from normal profits is given by the unconditional expectation of the AR(1) process, as defined above. Short run persistence (which corresponds to the context in which "persistence" is usually used in time-series analysis), on the other hand, is given by the size of the parameter λ_i. We will refer to persistence in the latter sense. We will concentrate on the cases where $\lambda_i = 1$ cannot be rejected, implying perfect persistence in the short run and the impossibility of using the unconditional expectation as a measure of long-run persistence.

equal in the upper and lower regime. This feature allows direct comparison with the persistence estimates of simple AR(1) models. Notice as well that the whole interval $[\bar{\pi}_1, \bar{\pi}_2]$ acts as an attractor of $\pi_{i,t}$ in a similar fashion as the unconditional expectation of $\pi_{i,t}$ in model (1), which is interpreted as the long run projected profit rate, does. A similar model to (2) is recommended by Taylor (2001) to approach the study of purchasing power parity. Taylor (2001) shows that if the underlying data generating process contains bands of inaction such as in (2) and the linear model given by (1) is applied, the estimates of λ_i will be biased towards one, and the severity of the bias depends on the number of observations inside the band of inaction. Simulations in Taylor (2001) show that the size of this bias can be rather large and that the power of the Dickey-Fuller test is significantly reduced if nonlinearities of the type given in (2) are present but the linear autoregressive model is used.

Estimation and testing in models such as (2) can be carried out following the methodology developed in Caner and Hansen (2001). For each firm, given $\bar{\pi}_1$ and $\bar{\pi}_2$, estimates of α_i and λ_i can be easily found just by dividing the sample into observations corresponding to the upper, medium and lower regime and running individual regressions for each subsample. In order to find estimates of $\bar{\pi}_1$ and $\bar{\pi}_2$ for company i, a grid search is done across all (pairs of) realized profit rates, and the estimates are given by

$$(\hat{\bar{\pi}}_1, \hat{\bar{\pi}}_2) = \text{argmin}_{(\bar{\pi}_1, \bar{\pi}_2)} \sum_t [\hat{\pi}_{i,t}(\bar{\pi}_1, \bar{\pi}_2) - \pi_{i,t}]^2.$$

That is, the estimate is given by the pair of profit rates that minimizes the sum of squared residuals when used as threshold values in (2). Given the discussion above, we are interested in testing model (2) against a pure unit root model. Caner and Hansen (2001) develop an asymptotic theory for inference in TAR models allowing for the existence of an autoregressive unit root in the data generating process, and the results in this contribution will be used as a basis for the methodology applied to the profit rates of US companies. The testing procedure is explained in the following section.

3 Nonlinearity and unit roots in profit rates: Empirical analysis

This section presents the empirical results concerning the evidence of nonlinear behaviour of the type given by (2) in US company profits. The methodological framework will be applied to a newly compiled database (Gschwandtner, 2003) containing profit data on 156 US companies.

3.1 Data description

The database was compiled using Compustat, Global Vantage and Moody's Industrial Manual as sources, and it contains yearly data on profits for 156 surviving companies for the period 1950-1999. The sample corresponds to those firms among the largest 500 US manufacturing companies (in terms of sales) as of 1950 for which a complete time series on profits spanning the period 1950-1999 existed. Profit (returns on assets) is defined as income over total assets, and throughout the study the profit rate of company i at time t ($\pi_{i,t}$) is defined as the relative deviation from the sample mean profit at time t.

The Compustat variable name corresponding to the proxy for income is "Income before extraordinary items" and it represents the income of a company after all expenses, including special items, income taxes and minority interests, but before provisions for common and/or preferred dividends. Total assets includes current assets plus net property, plant and equipment plus other noncurrent assets. For more information on the construction on the database, see Gschwandtner (2003). Figure 1 shows the smoothed distribution of profit rates for the whole sample using an Epanechnikov kernel function. The distribution of profit rates for the companies considered in the period 1950-1999 is extremely asymmetric and leptokurtic, with skewness and kurtosis values of -2.6 and 47.8, respectively. The low skewness value is caused by the clustering of observations in the low end of the distribution of profit rates, and is not representative of the shape of the central part of the distribution. The skewness of the distribution if profit rates below -0.5 are trimmed increases to -0.13 (see Figure 1). This implies that, although for the pooled dataset of profit rates most of the observations gather around the normal profit rate, with a big mass of observations close to the mean for the right tail, the distribution has a heavier weight on the left tail. Notice that the normal profit rate was computed as the sample average profit for each year. This implies that the profit performance of some firms could be underestimated due to the fact that the average is computed using exclusively data belonging to surviving firms.

– Insert Figure 1 around here –

3.2 Nonstationarity and nonlinearity in profit rates

Table 1 shows the distribution of the estimates of λ from (1). There is a single estimate with a value higher than one and in 55 (more than 35%) of the cases the null of a unit root cannot be rejected at a 5% significance level using individual Dickey Fuller tests. The number of series that cannot reject the null of unit root nonstationarity increases to 75 (approximately 48% of the cases) if the significance level is set to be 1%.

– Insert Table 1 around here –

The nonlinear model given by (2) is estimated for those companies that present evidence of nonstationarity with the method presented in the previous section. Following Caner and Hansen (2001), a test for nonlinearity of the type given by (2) against unit root nonstationarity is performed for those profit series where the null of a unit root cannot be rejected. The standard Wald test statistic for this purpose is given by

$$W = T\left(\frac{\hat{\sigma}^2_{UR} - \hat{\sigma}^2_{NL}}{\hat{\sigma}^2_{NL}}\right), \tag{3}$$

where T is the number of observations, $\hat{\sigma}^2_{UR}$ is the residual variance of the unit root model, given by (1) with the restriction $\lambda_i = 1$, and $\hat{\sigma}^2_{NL}$ is the residual variance corresponding to the nonlinear model given by (2). The asymptotic distribution of (3) under the null of a unit root is nonstandard, and will be obtained by means of bootstrapping, as proposed by Caner and Hansen (2001). The procedure is carried out as follows: Given a profit series $\{\pi_{i,t}\}_{t=1}^T$ and the corresponding test statistic W, a sample $\{\tilde{\pi}_{i,1}, \ldots, \tilde{\pi}_{i,T}\}$ is drawn from a unit root process such as (1) with $\lambda_i = 1$ and with the innovations being random draws from the empirical distribution of the residuals corresponding to fitting the unit root process to the actual sample. For these simulated data, both a unit root and a nonlinear model are fitted, and the corresponding Wald test statistic, $\tilde{W}$ is computed. This procedure is repeated N times and the bootstrap p-value is estimated by the proportion of simulated $\tilde{W}$s exceeding W. Table 2 shows some descriptive statistics of the results for the profit rate series for which the Dickey Fuller test gave evidence of nonstationarity, including the distribution of threshold estimates. The p-values were calculated using 1000 replications of the procedure described above.

– Insert Table 2 around here –

Out of the 55 series that could not reject the null of a unit root, 21 (38%) present evidence of nonlinear behaviour when testing linearity at the 5% significance level. The number of series rejecting unit root linearity against the nonlinear model is 33 (60%) if the significance level is set to 10%. The search for estimates of the threshold values $\bar{\pi}_1$ and $\bar{\pi}_2$ was done after trimming the extreme 10% of the distribution of the profit series being studied. The estimates suggest an average band with a lower bound roughly corresponding to the 30% quantile of the distribution of profits in the period considered and an upper bound around the 80% quantile.

For the series where the null of a unit root cannot be rejected, Figure 2 presents the distribution of estimates of λ (smoothed using an Epanechnikov kernel function) from the nonlinear estimation compared to those resulting from estimating a simple AR(1) model such as (1). The grey and black solid lines present the distribution of point estimates of λ for the nonlinear models in series where the null of a unit root is rejected against the TAR model with a p value smaller than 0.05 and 0.1, respectively. The dotted line presents the estimates corresponding to the estimates from (1) for those series that cannot reject the null of the DF test.

– Insert Figure 2 around here –

Figure 2 exemplifies the differences in interpretation of the evidence on profit persistence that can arise if nonlinear dynamics are not considered in the modelling strategy. Estimating (1) for this subsample one would conclude that there is extremely high persistence in profits, and considering the results of the DF test, perfect persistence of shocks to profits would not be rejected for any firm in this subsample. The picture appearing from the estimation of the nonlinear model differs strongly from perfect persistence of profits outside the estimated bands.

Figure 3 presents the distribution of estimates of λ for the whole sample using AR(1) specifications (dotted line) and the distribution of $\hat{\lambda}$ for the whole sample substituting the estimates of the linear model by those implied by (2) for those series where the DF test cannot reject stationarity at 1% significance level and the p-value of the linearity test is smaller than 0.1 (solid line). The profit persistence estimates corresponding to the augmented class of models is considerably different from those emerging from ignoring the potential presence of nonlinear adjustment and inaction bands. The estimates including band adjustment, when there is statistical evidence for it, have a lower average and median value (0.511 and 0.498 versus 0.565 and 0.573, respectively) and the distribution of estimates based exclusively on the linear AR(1) model is significantly more asymmetric and platykurtic than the one including inaction bands (the skewness and kurtosis values for the estimates including bands are -0.162 and 2,798 respectively, against -0.344 and 2.289 for the AR(1) estimates).[4] The mode of the distribution of $\hat{\lambda}$ is around 0.77 for the AR(1) estimates and 0.47 for the model with inaction bands. The mode of the distribution of linear estimates is clearly influenced by the inclusion of series where there is evidence of perfect profit persistence, but tends to exhibit higher persistence levels also if those series are excluded (notice that the distribution is quasi-bimodal, with a large concentration of estimates around 0.6).

Both Figure 2 and Figure 3 indicate that the choice of the model specification can affect the results concerning the degree of profit persistence strongly. If an inaction band is included for those series where there is statistical evidence of nonlinear profit adjustment, the distribution of autoregressive parameters

[4]A simple Jarque-Bera test gives evidence against Gaussianity in the distribution of $\hat{\lambda}$ for the linear estimates, while the null of normal distribution cannot be rejected at any sensible significance level for the estimates including bands of inaction.

indicates an overall lower degree of profit persistence, and the individual persistence parameters appear more concentrated around the mean value than if linear models are used.

4 Conclusions and paths of further research

The empirical literature on profit persistence tends to report evidence of unit root nonstationarity for many time series of company profit rates. This piece of research proposes a simple alternative modelling strategy for profit rate series which present unit root behaviour. We propose to use a threshold autoregression with a central inaction band where the profit rate is allowed to behave in a nonstationary fashion. The data generating process has upper and lower reflecting boundaries that provide overall mean reverting properties to the model. This particular model allows testing against pure unit root processes using the methodology developed in Caner and Hansen (2001).

Using a new dataset comprising profit rate data for 156 US companies in the period 1950-1999, we show that there is statistical evidence of this type of nonlinear adjustment for a high proportion of those firms where the null of a unit root cannot be rejected using the DF test. The overall evidence on the level of persistence of profits in US companies changes significantly if inaction bands are taken into account. The distribution of estimates implies lower levels of profit persistence if the model with inaction bands is implemented for those series with evidence of nonlinear adjustment. The shape of the distribution of persistence estimates is also significantly affected by the use of the nonlinear model.

Throughout our study we kept the nonlinear model as simple as possible in order to allow comparisons with the estimates based on the AR(1) process. Generalizations of the model with inaction bands, allowing for different autoregressive parameters in the mean reverting regimes, could shed more light on the properties of the adjustment process to normal profits. In order to make use of the longest time series available, the empirical analysis was restricted to surviving firms in the period 1950-1999. Applying nonlinear models of the type put forward in this piece of research to firms exiting the market (provided that the samples are long enough for inference to be reliable) would also be an interesting avenue for future research. For non-survivors, it would be of relevance to assess whether the profit-attracting regime is significantly above or below the normal profit rate.

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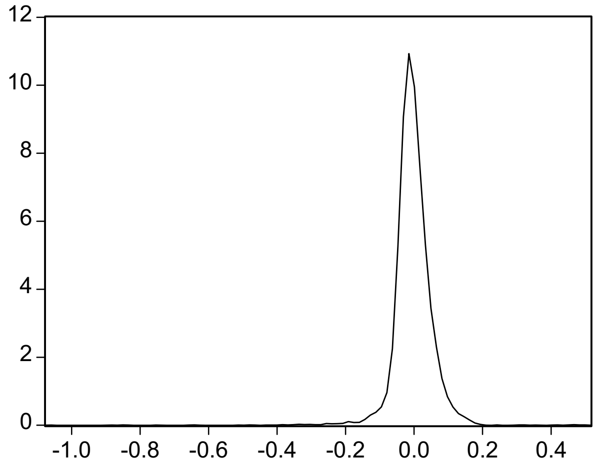
$\hat{\lambda}$	Count	Percentage	$\lambda = 1$ at 5% sig.lev.
[-0.2, 0)	1	0.64%	0
[0, 0.2)	11	7.05%	0
[0.2, 0.4)	25	16.03%	0
[0.4, 0.6)	46	29.49%	0
[0.6, 0.8)	42	26.92%	24
[0.8, 1)	30	19.23%	30
[1, 1.2)	1	0.64%	1
Total	156	100%	55

Table 1: Distribution of $\hat{\lambda}$, AR(1) process



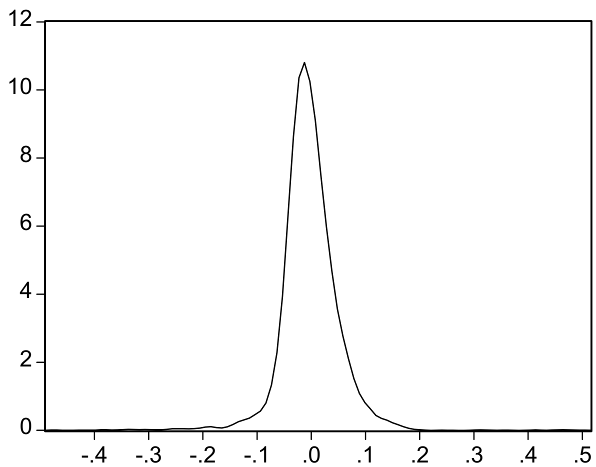


Figure 1: Distribution of profit rates (156 US companies, 1950-1999). Top: Complete distribution. Bottom: Trimmed distribution, for $\pi_{i,t} > -0.5$

# p-value ≤ 0.05					# p-value ≤ 0.10				
Number of firms: 21 (38.2%)					Number of firms: 33 (60%)				
	$\hat{\hat{\pi}}_1$		$\hat{\hat{\pi}}_2$			$\hat{\hat{\pi}}_1$		$\hat{\hat{\pi}}_2$	
	Count	Percentage	Count	Percentage		Count	Percentage	Count	Percentage
[-0.25, -0.2)	1	4.76%	0	0%	[-0.25, -0.2)	1	3.03%	0	0%
[-0.2, -0.05)	2	9.52%	0	0%	[-0.2, -0.05)	3	9.09%	0	0%
[-0.05, 0)	13	61.9%	3	14.29%	[-0.05, 0)	21	63.64%	5	15.15%
[0, 0.05)	4	19.05%	13	61.9%	[0, 0.05)	7	21.21%	19	57.58%
[0.05, 0.15)	1	4.76%	5	23.8%	[0.05, 0.15)	1	3.03%	9	27.27%
	Average $\hat{\hat{\pi}}_1$=-0.029		Average $\hat{\hat{\pi}}_2$=0.034			Average $\hat{\hat{\pi}}_1$=-0.024		Average $\hat{\hat{\pi}}_2$=0.034	

Table 2: Nonlinearity versus unit root: Results

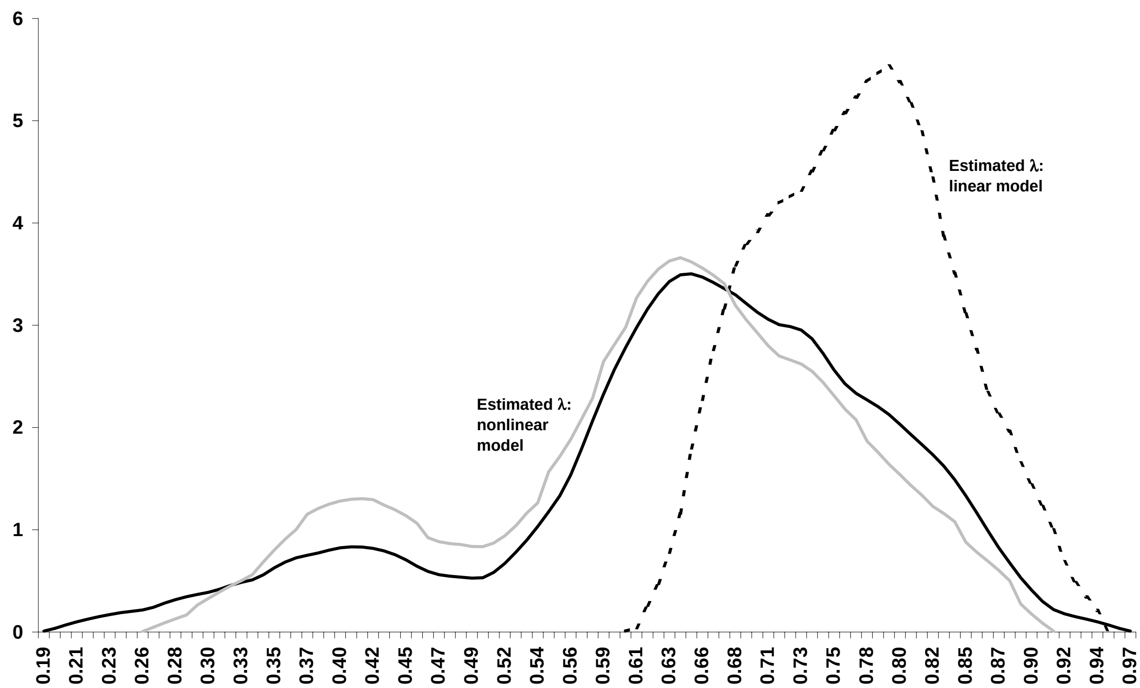


Figure 2: Distribution of λ estimates (series with unit root evidence): Nonlinear model for series with a p-value ≤ 0.05 (solid, grey line), with a p-value ≤ 0.1 (solid, black line) and linear AR(1) model (dotted line)

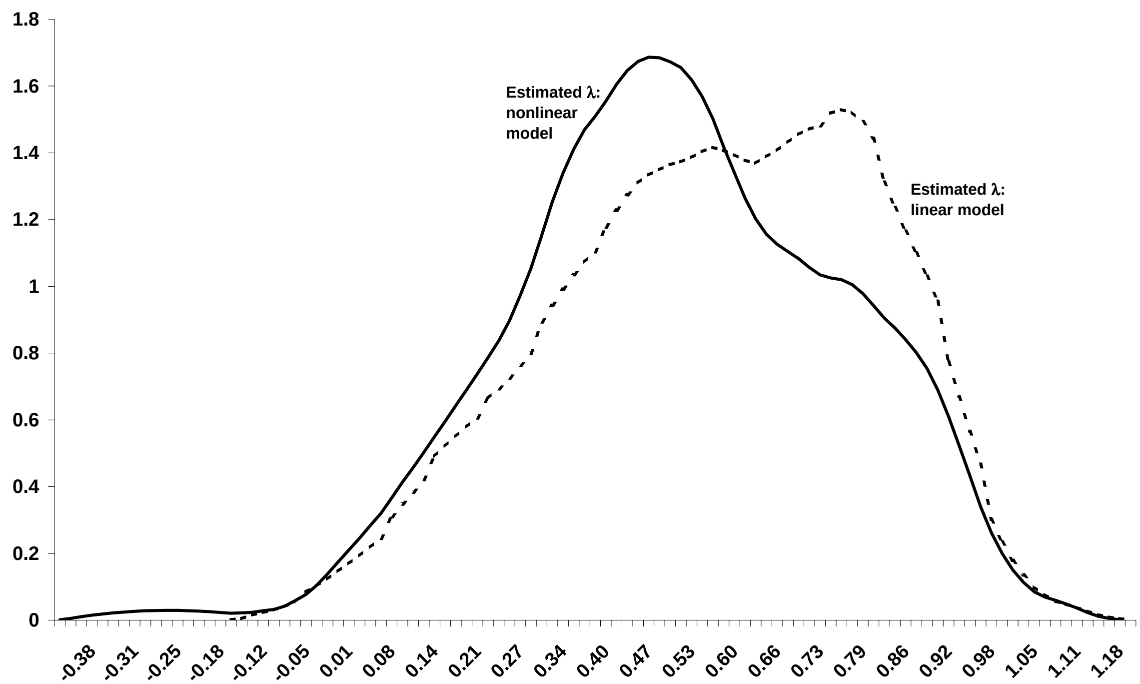


Figure 3: Distribution of λ estimates (full sample): Linear model and nonlinear model for series that cannot reject the DF test at 1% significance level and with a p-value ≤ 0.1 (solid, black line) and linear AR(1) model (dotted line)