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Alper Aslan

University of Erciyes, Faculty of Economics and Administrative
Sciences, Department of Economics, Kayseri, TURKEY.

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TESTING GIBRAT'S LAW: EMPIRICAL EVIDENCE FROM PANEL UNIT ROOT TESTS OF TURKISH FIRMS

Alper ASLAN

*Erciyes University, Faculty of Economics and Administrative Sciences, Department of
Economics, Kayseri, Turkey.*

Email: alperaslan@erciyes.edu.tr

Tel: + 90-352-4374901/30505; Fax: +90-352-4375239

ABSTRACT

The purpose of this paper is to use panel unit root tests to see if Gibrat's law holds in Turkey. Gibrat's Law establishes that firm growth is a random walk, it means that the probability of a given proportional change in size during a specified period is the same for all firms in a given industry. In this paper, it is examined Gibrat law in Turkey empirically by using Chen & Lu (2003) methodology and use the panel unit root method to investigate the relation between firm size and firm growth. Since it has been observed that many panel unit root tests are invalid when cross-section correlation problem and also finds that conclusion is not the same.

Keywords: Gibrat's Law, Firm Growth, MADF Test.

JEL Classification Codes: D21, L11, L20

1. INTRODUCTION

The aim of this paper is to test the Gibrat's Law (Gibrat (1931)) hypothesis for the Turkish companies by using Chen & Lu (2003) methodology and use the panel unit root method to investigate between firm size and firm growth.

Firm growth has been the focal point of many studies in the literature. The large majority of empirical studies in this field is based on testing the "Law of Proportionate Effects", also known as Gibrat's Law (Gibrat, 1931), which assumes that the size of a firm follows a random walk. Gibrat formulated the law of proportionate effect for growth rate to explain the empirically observed distribution of firms. The law of proportionate effect states that a firm's expected growth should be proportional to its current size. This implies that a firm's expected growth rate should be independent of its size. A wide and extensive empirical literature has explored this issue in different data sets with different statistical methodologies and demonstrated the validity of Gibrat's law (Simon & Bonini 1958; Masfield 1962; Hart 1962, Evans 1987a, b; Wagner 1992, Dunne & Hughes 1994; Mata, 1994; Geroski 2000; Goddard *et al.* 2002 and Oliveira & Fortunato 2003, 2006).

Simon & Bonini (1958) used 500 largest US industrial corporations from 1954-1956. Firms have been grouped into three size classes as small, medium and large and the distribution of growth rates are compared for the three groups. The results of the study have illustrated that the distributions of growth rates for the three size classes are quite equal; the regression line in the plot of approximately 45° and the plot is homoscedastic. Therefore, they concluded that Gibrat's law tends to hold.

In another study, Mansfield (1962) was based on samples of firms in three specific industries (steel, petroleum, tires) over a number of various periods. He pointed out that "*Gibrat's Law*" might be construed in different ways; the first construction is that the law holds for firms that exited the industry as well as for those that remain. The second holds that the law holds only for the firms that survive over the relevant period. The third that the law only holds for firms that are large enough to exceed the minimum efficient scale level of output. He concluded that Gibrat's law is rejected in 7 out of 10 cases; smaller firms are more likely to leave the industry.

In a similar study, Hart (1962) used four sets of data from different industries from different periods and classified firms into two groups. He used the firm's profit to measure the size of firm and then calculated the mean and variance of logarithms of growth rate. In order to illustrate whether the mean and variance of the growth rate are significantly different in each group, Hart used a statistical test and concluded that there is no significant difference between the means of growth rate in each group for all data sets at %5 level.

Despite the large amount of studies conducted on the basis of Gibrat's law in influential surveys, it has been rejected as well (Kumar 1985; Evans 1987a,b; Hall, 1987; Dunne *et al.*, 1989; Wagner 1992; Dunne & Hughes 1994; Mata, 1994; Audretsch, 1995; Hart & Oulton 1996; Harhoff, Stahl & Woywode 1998; Weiss, 1998; Audretsch *et al.*, 1999; Almus & Nerlinger, 2000; Geroski, 2000; Bechetti & Trovato, 2002; Goddard *et al.*, 2002). These surveys found that Gibrat's law fails to hold. However, in fact Gibrat's law has strong foundations in being based on empirical regularities.

To study if the growth of firms follows a random walk (Gibrat's law holds) or converges toward the mean Goddard *et al.* (2002), Del Monte and Papagni (2003), Geroski *et al.* (2003), Oliveira & Fortunato (2003), and Chen & Lu (2003) carried out the panel unit root tests. The studies differ widely in terms of both the samples used and the panel unit root tests applied. Geroski *et al.* (2003) and Del Monte & Papagni (2003) demonstrated that firm growth follow a random walk and therefore Gibrat's law holds. On the contrary, Goddard *et al.* (2002) and Oliveira & Fortunato (2003, 2006) using panel data of Japanese and Portuguese manufacturing firms are not in support of Gibrat's law. Chen & Lu (2003) have found that the law can be rejected for the former but not for the latter ones in testing Gibrat's law for the case of Taiwan.

Considering the aforementioned empirical background, this paper is designed to contribute to Gibrat literature in Turkey for the first time. It examines Gibrat law in Turkey empirically by using Chen & Lu (2003) methodology and use the panel unit root method to investigate between firm size and firm growth. Since many panel unit root tests will be invalid when cross-section dependence exists. This paper applies the Taylor & Sarno (1998) MADF test to deal with a cross-section correlation problem.

To this end, the rest of this paper is organized as follows. Section 2 introduces the panel unit root method. Section 3 is dedicated to the samples of data obtained from Turkish firms to test the Gibrat Law. In the last section, the empirical result of this study will be provided.

2. DATA DESCRIPTION

The data are derived from the annual surveys of the 500 largest firms in Turkey conducted by Istanbul Chamber of Industry (ICI). Firms with broken runs of data are excluded and the data set subject to empirical analysis involves a sample of 103 listed continuously over the period 1985-2004. There are several ways to represent firm size in the literature such as net assets, net fixed assets and number of employees. This paper uses net assets to measure firm size as well Utton (1971), Singh & Whittington (1975), Kumar (1985), Dunne & Hughes (1994) and Hart & Qulton (1996).

3. PANEL UNIT ROOT METHOD

It is known that traditional unit root tests possess low power against near unit root alternatives (Diebold & Nerlove, 1990). A popular test for verifying unit roots is the augmented Dickey-Fuller (ADF) test in which the null hypothesis is non-stationarity. However, these statistics are applied to time series data sets. The most effectual choice is therefore the application of panel unit root test. The pioneer of the panel unit root is Abuaf & Jorion (1990).

In an influential paper Abuaf & Jorion (1990) develop a multivariate unit root test based on systems estimation of autoregressive processes for a set of real exchange rate series, and use this to reject the joint null hypothesis of non-stationarity of a number of real Exchange rates. After the work of Abuaf et al. (1990), Levin & Lin (1993), and Im, Peseran & Shin (1996), O'Connell (1998), and Sarno & Taylor (1998) improved the panel unit root tests by considering cross-sectional correlation.

O'Connell (1998) was the first author to note that cross-sectional correlation in panel data will have negative effects on the Levin-Lin panel unit root test, making the test have substantial size distortion and low power. Kristian (2005) studied the performance of the Levin-Lin test under cross-sectional correlation. In his DGP (Data Generation Processes), he controlled the magnitude of the correlation, and he found results similar to the results of O'Connell (1998).

Sarno & Taylor (1998) contributed to this literature in a number of ways. *Firstly*, they provided some further evidence on panel unit root tests of this kind, by calculating the finite sample empirical distribution of a **multivariate augmented Dickey-Fuller (MADF)** statistic while allowing for higher-order serial correlation in real exchange rates and relaxing the assumption that the sums of the autoregressive coefficients are identical across the panel under the alternative hypothesis. *Secondly*, however, we point out and illustrate through Monte Carlo simulations an important potential pitfall in the interpretation of multivariate unit root tests of this kind. *Lastly*, they investigated by Monte Carlo methods the finite-sample empirical performance of

a multivariate test in which the null hypothesis is that at least one of the series in the panel is a realization of a unit root process. This null hypothesis is only violated if all of the series are in fact realizations of stationary processes.

This survey reviews panel unit root test methods. A way testing whether or not the requirements of Gibrat's law are met is to study the relationship between the logarithms of firm sizes at the beginning period and at the end of a period.

$$\Delta y_{i,t} = \sum_{j=1}^p \theta_{ij} \Delta y_{i,t-j} + p_i y_{i,t-1} + \delta_i \text{time} + \alpha_i + e_{i,t}, \quad (1)$$

Here, α_i is the intercept, time is the firm's age, $y_{i,t}$ are firm sizes (where $i=1, 2, \dots, N$), $\Delta y_{i,t} = (\ln y_{i,t} - \ln y_{i,t-1})$ and if $p_i = 0$, then Gibrat's law holds. If, $p_i < 0$, then the smaller firms will tend to grow faster. Equation 1 is the augmented Dickey-Fuller equation for individual i . All data in the past study are panel data, and in order to test Gibrat's law this study must test the unit root in the panel data.

Im, Pesaran and Shin's panel unit root test

We use panel unit root tests due to Im-Pesaran-Shin (1997) (hereafter, IPS). In this test the null hypothesis is that of a unit root. The IPS is based on averaging individual Dickey-Fuller unit root tests (t_i) according to:

Considering the model given in expression but with parameter β varying across units as given below:

$$\Delta y_{i,t} = \sigma_i + \beta_i y_{i,t-1} + \varepsilon_{i,t} \quad i=1, \dots, N \quad t=1, \dots, T \quad (2)$$

IPS propose test where $H_0 : \beta_i = 0 \quad \forall i$ and $H_1 = \exists i$ such that $\beta_i < 0$. One therefore relaxes the strong homogeneity assumption embodied in the LL tests. The simplest test proposed by IPS, the so called t-bar statistic is defined as the average of the individual Dickey-Fuller (DF) or augmented Dickey-Fuller (ADF), say τ_i statistics:

$$\bar{t} = \frac{1}{N} \sum_{i=1}^N \tau_i \quad \tau_i = \frac{\hat{\beta}_i}{\hat{\sigma}_{\hat{\beta}_i}} \quad (3)$$

Multivariate unit root tests

To estimate the above Equation 1, this study employs Zellner's seemingly unrelated estimator (SUR). The restriction in the null-hypothesis equation can be written as; $\Psi\beta - \tau = 0$. The test statistics can be written as;

$$\text{MADF} = \frac{(\tau - \Psi\hat{\beta})' \left\{ \Psi \left[Z' (\hat{\Lambda}^{-1} \otimes I_T) Z \right]^{-1} \Psi' \right\} (\tau - \Psi\hat{\beta})}{(Q - Z\hat{\beta})' (\hat{\Lambda}^{-1} \otimes I_T) (Q - Z\hat{\beta})} N(T - k - 1), \quad (4)$$

Here, $\hat{\beta}$ and $\hat{\Lambda}$ are consistent estimates of β and Λ . In fact, a consistent estimate of β as well as Λ could be obtained from OLS applied individually to each equation since, unlike the case in Abuaf & Jorion (1990), Sarno & Taylor, imposed no cross-equation restrictions. Given a non-diagonal contemporaneous residual covariance matrix, however, the SUR estimator will be a more efficient estimator of β than OLS and so the finite-sample performance of the MADF should be better using SUR rather than individual OLS estimates. In general, the Wald statistic for testing N restrictions has a limiting X^2 distribution with N degrees of freedom under the null hypothesis being tested. However, its distribution is unknown because of the theoretically infinite variance of the processes generating the real exchange rate series under the null hypothesis equation.

4. TEST RESULTS

This survey obtains a rejection result from the test in cement, plastic and pipe, textile, medicine and chemical, steel iron, automobile and other industries as shown in Table 1. Gibrat's law thus does not hold in the above seven industries, as firm size and firm growth are not independent in those seven industries. The other firms that are in food, electrical machinery, electronics and transportation cannot reject Gibrat's law and relationship between firm size and firm growth are independent.

Table 1. Test results under independent hypothesis

Industry	The number of firms	IPS statistics	Industry	The number of firms	IPS statistics
Cement	8	-2.933*	Steel Iron	8	-2.592*
Food	15	-1.760	Automobile	8	-3.291*
Plastic and Pipe	5	-3.008*	Electronics	3	-2.310
Textile1	22	-2.150 *	Transportation	9	-1.926
Electrical Machinery	6	-1.919	Other	7	-2.242*
Medicine and Chemical	8	-2.554*			
Glass Ceramics	4	-2.253			
Notes: 1. “*” implies significance at the 5% level. 2. Simulation and derivation of critical value under the Im et al. (1997) setting.					

Table 2. MADF test

Industry	The number of firms	IPS statistics	Industry	The number of firms	IPS statistics
Cement	8	150.626*	Steel Iron	8	67.568*
Food	15	123.905*	Automobile	8	62.629*
Plastic and Pipe	5	56.632*	Electronics	3	16.000
Textile1	7	57.461*	Transportation	9	98.689*
Textile2	7	72.725*	Other	7	45.520*
Textile3	8	62.623*			
Electrical Machinery	6	46.580*			
Medicine and Chemical	8	52.776*			
Glass Ceramics	4	30.867			
Notes: 1. “*” implies significance at the 5% level. 2. The critical values reported in the table are computed via stochastic simulation with 1000 replications. The simulation steps are suggested by Taylor and Sarno (1998).					

However, when this survey considers the cross-sectional correlation, Table 2 displays different results. The firms that cannot reject Gibrat’s law are those in the industries of glass ceramics and electronics. Other firms that are not in the above industries do reject Gibrat’s law. Therefore, the conclusion is different when we consider the cross-sectional correlation.

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