Panel unit root tests of firm size and its growth

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This paper investigates Gibrat’s law by using a panel unit root test, as a panel unit root can increase power in contrast to a conventional individual ADF test. At first this paper uses the panel unit root test to testify Gibrat’s law under independent and identical distribution, with the test results rejecting the null hypothesis of Gibrat’s law. Independent and identical distributions are not reasonable in a real situation. Any firm in a given industry may have some correlation with other firms. Moreover, the limiting distribution of Im, Pesaran, and Shin (IPS) statistic is invalid and will produce a large distortion. This paper applies the Taylor and Sarno (1998) MADF test to deal with a cross-sectional correlation problem and study the issue. This paper finds that the conclusion is not the same.

I. INTRODUCTION

According to Gibrat’s law, a firm grows proportionally at a certain time and the growth of a firm is independent to its size. Gibrat focuses on the random growth process. The market structure this paper observes at any given time is the conclusion of historical evolution. However, under Gibrat’s assumption, although the starting condition is the same, the market structure will concentrate due to luck. If some firms have good luck, then they may have great growth continuously and the other firms cannot keep up with those firms, while the growth of a firm at time $t-1$ does not affect the growth of a firm at time $t$ under Gibrat’s assumption.

There is much econometric evidence on this topic after Gibrat’s literature, as shown by Jovanovic (1982) arguing that the growth of a firm does not follow proportional law from the view of learning by doing and its production efficiency. A firm will judge from its previous experience whether it enters the market, and once it enters the market, it will absorb new experiences and learn from its production experience. Baumol (1962) argues that the size of a firm can be interpreted from the optimal behaviour of a firm. Similarly, the growth rate of a firm is determined by the optimal behaviour of a firm. Optimal growth rate is also settled on its marginal cost and marginal revenue.

Most relative research papers find that Gibrat’s Law does not hold. Hall (1987) and Evans (1987) investigate the relation between a firm’s growth rate and its size. They find that small firms grow faster than big firms. There is also much in the literature on plant level concerning the plant growth issue. Howenstine and Zeile (1994) and Dom and Jensen (1998) show a significant difference between foreign-owned (Japanese) and domestic-owned (US) manufacturing plants. In particular, foreign-owned plants in the US tend to be larger, more capital-intensive, more productive, and pay higher wages than domestic-owned ones. Their estimates strongly reject Gibrat’s law for these plants and suggest smaller plants grow faster.

This paper uses the panel unit root method to investigate the relationship between firm size and firm growth. This is a new approach to check Gibrat’s law and to avoid the problem of low power. Many panel unit root tests will be invalid when cross-section dependence exists. This study tries to consider the cross-section dependence by using an MADF test. When this study executed the MADF test, this paper divides textile and electronics industry into 3 and 2 parts to obtain more detailed conclusion. The next section introduces the panel unit root method. Section III uses the

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samples of Taiwan’s public-listed firms data to test the relation between firm growth and firm scale. In the last section this provides the empirical results.

II. DATA DESCRIPTION

The data are derived from the Taiwan Economic Journal (TEJ) database from 1988 to 1999, containing 48 seasons of data of publicly-traded companies, including 258 firms in the sample. Thus, the study is really about the relationship between growth and size across firms that have already reached a certain minimum size, large enough to require outside capitalization. There are several ways to represent firm size in the literature such as number of employees, net assets, net fixed assets, and so on. This paper uses fixed assets to measure firm size.

III. PANEL UNIT ROOT METHOD

The pioneer of the panel unit root is Abuaf and Jorion (1990). After the work of Abuaf et al. (1990), Levin and Lin (1992), Levin and Lin (1993) and Im et al. (1997), O’Connell (1998), and Sarno and Taylor (1998) updated the panel unit root tests by considering cross-sectional correlation. This paper deals with the nonstationary time series in the economics field through their efforts. The panel unit root test has been applied widely in many economic fields, because of the problem of low power, as mentioned in the previous section. To test the Purchasing Power Parity (PPP) hypothesis (which is a well-known topic) one can use the panel unit root test, like MacDonald (1996) and Papell (1997) did in applying their unit root test in a PPP hypothesis test. Lee and Wu (2001) investigate the mean reversion of inflation rates of about thirteen OECD countries by the panel unit root test, while McCoskey and Selden (1998) use the panel unit root test to study health care expenditures and GDP.

This study now reviews those panel unit root test methods and this model in the rest of this section. A way of 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.

\[
\Delta y_{i,t} = \sum_{j=1}^{p} \theta_{ij} \Delta y_{i,t-j} + \rho_{i} y_{i,t-1} + \delta_{i} t + \alpha_{i} + e_{i,t},
\]

where \(\alpha_{i}\) is the intercept, time is the firm’s age, \(y_{i,t}\) are firm sizes (where \(t = 1, 2, \ldots, N\)), \(\Delta y_{i,t} = \ln y_{i,t} - \ln y_{i,t-1}\), and \(\rho_{i}\) is determined by \(T^{1/3}\). If \(\rho_{i} = 0\), then Gibrat’s law holds. If \(\rho_{i} < 0\), 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 to test Gibrat’s law this study must test the unit root in the panel data. The test statistic is not a standard \(t\) distribution and this study cannot apply a \(t\) distribution table to check its critical value.

**Im, Pesaran, and Shin’s panel unit root test**

Im et al.’s panel unit root test (IPS) is the extension of the individual ADF test. Like the Levin and Lin test (LL), the IPS test also needs an independent assumption. The null hypothesis is \(\rho_{i} = 0, \forall i = 1, \ldots, N\). Under the independent assumption, the IPS test statistic is derived from running an individual ADF regression. The IPS test statistic is

\[
\Gamma_{i} = \frac{\sqrt{N}(\bar{t}_{i} - \bar{E}(t_{T} | \rho_{i} = 0))}{\sqrt{\text{Var}(t_{T} | \rho_{i} = 0)}},
\]

where \(\bar{t} = 1/N \sum_{i=1}^{N} t_{i}\), \(\bar{E}(t_{T} | \rho_{i} = 0)\) and \(\text{Var}(t_{T} | \rho_{i} = 0)\) is the expectation and variance by Monte Carlo simulation. In general, \(\Gamma_{i}\) is a standard normal distribution while \(N\) and \(T\) tend to be infinity. The IPS test is more powerful than the LL test, because of \(\rho_{i} \neq \rho\) and simple calculation.

**Multivariate unit root tests**

To estimate the above Equation 1, this study employs Zellner’s seemingly unrelated estimator (SUR). The restrictions in the null-hypothesis equation may be written as: \(\psi \beta - \tau = 0\). The test statistics can be shown as:

\[
\text{MADF} = \frac{(\tau - \psi \hat{\beta})'(\psi [Z(\hat{\Lambda}^{-1} \otimes I_{T})Z]' \psi')(\tau - \psi \hat{\beta})N(T - K - 1)}{(Q - Z \hat{\beta})'(\hat{\Lambda}^{-1} \otimes I_{T})(Q - Z \hat{\beta})}
\]

Here, \(\hat{\beta}\) and \(\hat{\Lambda}\) are consistent estimates of \(\beta\) and its variance. In general, the Wald statistic for testing \(N\) restrictions has a limiting chi-square distribution with \(N\) degrees of freedom when the null hypothesis is being tested. However, in the present case its distribution is unknown, because of the theoretically infinite variance of the processes generating the real exchange rate series under the null hypothesis equation.

IV. TEST RESULTS

Under iid assumption, this study obtains a rejection result from the test in the food, textile, electronics, and other industries as shown in Table 1. Gibrat’s law thus does not hold in the above four industries, as firm size and firm growth are not independent in those four industries. The other firms that are not in those four industries cannot reject Gibrat’s law and the relationship between firm size and firm growth are independent under the iid assumption. However, when this paper 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, paper pulp, automobile, tourism, and department stores. Moreover, 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.

REFERENCES

