Journal of Economic Dynamics & Control 39 (2014) 140–164

Contents lists available at ScienceDirect

Journal of Economic Dynamics & Control

journal homepage: www.elsevier.com/locate/jedc

Do firms share the same functional form of their growth rate distribution? A statistical test

José T. Lunardi [a], Salvatore Miccichè [b], Fabrizio Lillo [b,c,d], Rosario N. Mantegna [b,e,*], Mauro Gallegati [f]

[a] Departamento de Matemática e Estatística, Universidade Estadual de Ponta Grossa, Avenida General Carlos Cavalcanti, 4748, 84032-900 Ponta Grossa, PR, Brazil
[b] Dipartimento di Fisica e Chimica, Università degli Studi di Palermo, Viale delle Scienze, Ed 18, 90128 Palermo, Italy
[c] Scuola Normale Superiore di Pisa, Piazza dei Cavalieri 7, 56126 Pisa, Italy
[d] Santa Fe Institute, 1399 Hyde Park Road, Santa Fe, NM 87501, USA
[e] Center for Network Science and Department of Economics, Central European University, Nádor u. 9, 1051 Budapest, Hungary
[f] Dipartimento di Economia, Università Politecnica Delle Marche, Piazza Martelli, 8, 60121 Ancona, Italy

ARTICLE INFO

Article history:
Received 26 April 2011
Received in revised form
11 November 2013
Accepted 12 November 2013
Available online 1 December 2013

JEL classification:
C12
C15
D22

Keywords:
Growth rate distribution of individual firm
Heterogeneous firms
EDF tests

ABSTRACT

We propose a hypothesis testing procedure to investigate whether the same growth rate distribution is shared by all the firms in a balanced panel or, more generally, whether they share the same functional form for this distribution, without necessarily sharing the same parameters. We apply the test to panels of US and European Union publicly quoted manufacturing firms, both at the sectoral and at the subsectoral NAICS level. We consider the following null hypotheses about the growth rate distribution of the individual firms: (i) an unknown shape common to all firms, with all the firms sharing also the same parameters, or with the firm variance related to its firm size through a scaling relationship, and (ii) several functional shapes described by the Subbotin family of distributions. Our empirical results indicate that firms do not have a common shape of the growth rate distribution at the sectorial NAICS level, whereas firms may typically be described by the same shape of the distribution at the subsectorial level, even if the specific shape may not be the same for different subsectors.

1. Introduction

Since Gibrat (1931) proposed a stochastic model to describe the growth of a firm, an important branch of the literature has been concerned with the empirical testing of its consequences (for some recent reviews see, for example, Sutton, 1997; Santarelli et al., 2006; Coad, 2007a). Gibrat's model deals with the growth of an individual firm and it is based upon two assumptions, namely (i) the *Law of Proportionate Effect* (also known as *Gibrat's law*), stating that the proportionate growth of a firm in a given period is a random variable independent of the initial firm's size and (ii) the assumption of statistical independence of successive growths. The main features of the model are that, after a long period, the logarithmic growth rates are normally distributed and independent of the initial firm's size.

Recently, the empirical investigations on the validity of Gibrat's model or of alternative growth models are receiving an increasing and renewed interest motivated by the availability of extensive data sets containing a large number of firms

* Corresponding author at: Center for Network Science and Department of Economics, Central European University, Nador u. 9, 1051 Budapest, Hungary.
E-mail address: rn.mantegna@gmail.com (R.N. Mantegna).

0165-1889/$ - see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.jedc.2013.11.010

which could in principle allow to scrutinize alternative models with high statistical accuracy, see Stanley et al. (1996), Bottazzi et al. (2001), Bottazzi and Secchi (2003a,b), Lotti et al. (2003), Bottazzi and Secchi (2006), Bottazzi et al. (2006), Fu et al. (2006) and Riccaboni et al. (2008). However even in such data sets it is hard to empirically test the model at the level of individual firms because the available data sets typically contain a large number of firms which are sampled over a small number of time periods each. Moreover for balanced panels, the longer is the time period considered, the smaller is the number of firms in the panel.[1]

In this paper we propose a hypothesis testing procedure able to discriminate whether a given null hypothesis about the distribution of the growth rate of an individual firm is compatible with panel data characterized by a large number of firms sampled for a limited number of time records. The main motivation for the present work arises from the awareness that it is important to discriminate between the following alternative hypotheses that the non-Gaussianity of the growth rate distribution is due to (i) the intrinsic nature of the stochastic process or (ii) the heterogeneity of the firms analyzed in the panels.

The traditional approach to circumvent the difficulty of short time series has been to assume that the growth time series of each individual firm in the panel is an independent realization of the same stochastic process which governs the growth dynamics of all the firms. In other words, such an approach assumes that each firm is statistically identical to the *model firm* (MF) described by that stochastic process. Here we address as the MF hypothesis the assumption that all firms in the panel are described by the same stochastic process, which results in the same growth rate distribution, with the same parameters, for all the firms in the panel. Under this hypothesis, the statistical properties of the growth rate distribution of the model firm at a given instant of time can be inferred from the statistical properties of the set of growth rates of all firms in the panel at the same time. Moreover, if the MF stochastic process is stationary, the statistical properties of each firm and therefore of the pooled sample of all the firms is time independent. By assuming the MF hypothesis, earlier empirical investigations have in general corroborated Gibrat's model, whereas many recent studies carried over large data sets claim that it must be rejected, see Sutton (1997), Santarelli et al. (2006), and Coad (2007a). For instance, several recent works find a non-Gaussian, “tent shaped”, i.e. Laplace distributions for the aggregate of growth rates[2] (see for instance Stanley et al., 1996; Bottazzi et al., 2001; Bottazzi and Secchi, 2006; Bottazzi et al., 2006), and also evidence in some data sets for a dependence of the growth rate distributions on the firms initial size (see, for example, Stanley et al., 1996; Riccaboni et al., 2008 and references therein). These tests of Gibrat's model are implicitly based on the MF hypothesis and it is therefore important to investigate whether this hypothesis itself is supported by empirical data.

The above-mentioned shortness of the firm growth time series also makes it difficult to test the MF hypothesis directly on the time series of individual firms. In this paper we investigate the MF null hypothesis and a variant of it, denoted by MF_m, which assumes that there is a scaling relationship between the variance of the growth rate distribution of each individual firm and its average size. Finally, we also test the null hypothesis that all firms in a balanced panel share a given known *functional form* (or *shape*) for their growth rate distribution, although the parameters that characterize that distribution may be different from firm to firm. We choose five such functional forms from the Subbotin family of distributions, which have often been used in the characterization of the growth rates distribution of firms (see Subbotin, 1923; Bottazzi and Secchi, 2006 and references therein). In some data sets we consider also the testing of some shapes belonging to the Asymmetric Exponential Power (AEP) family of distributions introduced by Bottazzi and Secchi (2011).

In the hypotheses tested here it is assumed that all the idiosyncratic parameters of the growth rate distribution of an individual firm are included into the first two moments of the distribution. The main idea behind the test is that if the null hypothesis were valid, i.e., if in fact there exists a single shape that fits well the growth rate distribution of all the individual firms in the panel, then after the application of a suitable procedure removing the firm idiosyncrasies across the panel the growth rate distributions must be the same for all the individual firms. We perform several studies which indicate that the test has generally a high power to reject a false null even when the time series are short, provided that the number of firms in the panel is relatively large.

We apply our method to balanced panels of publicly quoted manufacturing firms from the European Union and United States of America. The firms are selected from Amadeus Top 250,000 and Compustat databases. Both these databases comprise only large firms. We choose to investigate balanced data because preliminary investigation we performed with unbalanced ones have put in evidence the presence of a high degree of asymmetry in the growth rate distribution. The role of entry-and-exit dynamics leads to a considerable asymmetry also in the profit rate distribution (Alfarano et al., 2012). The presence of such a pronounced asymmetry adds a further dimension in the space of the parameters and makes the approach much more complex and computationally demanding. We have therefore decided to preliminarily deal with balanced panels that are described by almost symmetric or slightly asymmetric growth rate distributions. The case of the presence of strong asymmetry is left for a future work.

In the selection of the panel data, we considered two levels according to the NAICS code. Specifically, we consider the manufacturing sector defined by the NAICS 2-digit classification code with values ranging from 31 to 33, and the three major subsectors of the manufacturing sector, characterized by a 3-digit NAICS code. Given the limitations in constructing

[1] Balanced panels contain only firms for which there are data in the whole period under study. As a consequence, firms that enter or exit the market in that period are not considered.

[2] Interestingly a recent paper (Alfarano et al., 2012) suggests that also profit rate of firms follows a Laplace distribution.