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The determinants of growth in the U.S. information and communication technology (ICT) industry: A firm-level analysis

Giorgio Canarella, Stephen M. Miller *

Department of Economics, Lee Business School, University of Nevada, Las Vegas, Las Vegas, NV, USA

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ABSTRACT

Using a mildly unbalanced panel data set of 85 U.S. information and communication technology (ICT) firms that survived for 24 years from 1990 to 2013, we examine the effect of firm size, agency costs, R&D investments, capital structure, profitability, and the Great Recession of 2007–2009 on firm growth. We overcome several econometric issues such as the problems of unobserved heterogeneity, persistence, and endogeneity by adopting the system GMM estimator for linear dynamic panel models. We document that firm-specific characteristics drive growth in the ICT industry, contrary to the well-known Gibrat's law. In particular, we find compelling evidence that in the U.S. ICT industry, firm growth depends on firm size. Differing from most findings in the literature, however, small firms in the ICT industry do not grow faster than large firms. We find a non-linear and concave-in-size relationship between growth and size. We also find that: a) firm growth exhibits positive persistence; b) agency costs and financial leverage impede firm growth; and c) R&D investment and financial performance facilitate growth. As expected, the Great Recession (2007–2009) curbed firm growth in the ICT industry.

1. Introduction

What determines firm growth? Does size have an impact on growth? Do small firms growth faster than large firms? These questions, which highlight the controversial nature of the dynamics of firm growth, have spawned an extensive theoretical and empirical literature. Understanding how firms grow after they enter the market is an important issue, because, as Geroski (1995) famously states, "entry is easy, but survival is not." Knowledge of the determinants of firm growth is also important because it can provide insights into the underpinning of corporate strategic behavior, the dynamics of the competitive process, the evolution of market structure, and ultimately, the development of the aggregate economy (Coad, 2009).

The early contributions of Gibrat (1931) and Penrose (1959) still dominate the field.[1] The Penrose (1959) resource-based theory of growth, which underlies a great deal of the strategic management and entrepreneurship literature, implies that growth depends primarily on idiosyncratic configurations of internal resources. Internal resources and capabilities determine strategic choices and become, in the resource-based view of strategic management and entrepreneurship, firm-specific, not capable of easy imitation or replication by rivals (Barney, 1991). In contrast, in the industrial economics literature, Gibrat's law, originally formulated in *Les Inégalités économiques* (Gibrat, 1931), provides the benchmark of an extensive literature on firm growth and remains one of the most conflicting and relentlessly explored issues in the industrial economics literature. According to Gibrat's law, firm growth does not depend on firm size and/or firm history. Firms within an industry draw growth rates from an identical distribution for all firms regardless of their current size and/or previous growth history. Firms possess an initial endowment of resources that determine firm capabilities, technology, and social and financial capital. Over time, this endowment accumulates or depletes by a series of independent random draws from a Gaussian distribution that generate a composite measure of firm size and/or firm growth (Coad, 2009). Put differently, Gibrat's law states that small firms grow at the same rate as large firms.

Gibrat (1931) promulgated a large literature that extended the basic model of firm growth to a multivariate framework. Mounting empirical evidence shows that firm growth depends on firm size and/or firm history. Empirical research, using firm-level data, identifies a large amount of heterogeneity within industries as well as between firms within

* Corresponding author.
E-mail addresses: giorgio.canarella@unlv.edu (G. Canarella), stephen.miller@unlv.edu (S.M. Miller).

[1] In *Principles of Economics*, Marshall discusses the entry of firms, their growth, and, finally, their decline and exit using the famous analogy of "trees in the forest." Firms, like trees in the forest, "struggle upwards through the benumbing shade of their older rivals. Many succumb on the way, and a few only survive … One tree will last longer in full vigor and attain a greater size than another; but sooner or later age tells on them all" (Marshall, 1925, 316).

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industries. This heterogeneity in firm growth appears in size, profitability, R&D intensity, capital structure, and other firm characteristics, and proves inconsistent with the proposition that growth follows a random and erratic process, as argued by Gibrat's law.[2]

The empirical literature on firm growth mainly focuses on the manufacturing sector (Hymer and Pashigian, 1962; Hall, 1987; Wilson and Morris, 2000; Coad, 2009; Oliveira and Fortunato, 2006; Fotopoulos and Giotopoulos, 2010), whereas a limited number of studies consider the service sector (Audretsch et al., 2004; Fotopoulos and Louri, 2004; Oliveira and Fortunato, 2008; Giotopoulos and Fotopoulos, 2010), the financial sector (Tschoegl, 1983; Vander Vennet, 2001; Wilson and Williams, 2000; Hardwick and Adams, 2002; Goddard et al., 2004), and the real estate sector (An et al., 2011).

Despite the vast literature on firm growth and Gibrat's law, however, work that examines within a rigorous empirical framework the determinants of firm growth in the ICT industry in the United States is practically nonexistent.[3] This is rather surprising, given that many ICT firms have experienced spectacular growth and, more specifically, given the crucial role of the ICT sector in the aggregate growth of the United States and world economies (Kraemer and Dedrick, 2001).[4]

The ICT industry is the largest, most dynamic, most ubiquitous (Andersen and Coffey, 2011), fast-paced, innovative, and productive of all U.S. industries (Mendelson and Pillai, 1998, 1999), and its effects run well beyond the boundaries of the industry itself, if such boundaries even exist (Mendelson and Whang, 2000).[5] The ICT industry experienced unprecedented progress over the last several decades, expanding from plain old telephone service (POTS) to advanced fiber optics, cable, and wireless technologies. Yet, the ICT industry is still not fully grown, still retaining significant opportunities for innovation and growth (Andersen and Coffey, 2011). The ongoing development of 5G wireless technologies represents a unique opportunity to radically expand the capacity and flexibility of wireless networks, which will profoundly influence broadband competition and productivity growth.

In 2009, the ICT industry contributed $1 trillion to U.S. GDP, or 7.1 percent of GDP, including $600 billion from the sector itself and $400 billion in benefits to other sectors that rely on ICT (Shapiro and Mathur, 2011). The ICT sector's direct contributions to GDP have increased 25 percent since the 1990's, growing from 3.4 percent in 1991–1993 to 4.2 percent in 2005–2009, the highest gains of any industry sector (Shapiro and Mathur, 2011). Over the last two decades, the development and use of IT has accounted for as high as 60 percent of annual U.S. labor productivity gains, and estimates imply that a 1-percent increase in broadband deployment can create as many as 300,000 new jobs. The National Research Council reports that the ICT industry accounted for 25 percent of U.S. economic growth from 1995 to 2007, measured as real change in GDP (President's Council of Advisors on Science and Technology (PCAST), 2007).

The ICT sector is one of the most R&D-intensive sectors whose growth significantly depends upon technological innovations. ICT firms operate in an increasingly "knowledge-based" economy, and the survival of ICT firms depends, more than any other firms, on their capacity to innovate. Innovation, in particular, "radical innovation" (Leifer et al., 2000), proves critical to the growth of ICT firms, since it enables them to remain competitive in an ever-changing landscape of products and services. "Radical innovation", as opposed to "incremental innovation", is an important and enduring characteristic of the ICT industry (Leifer et al., 2000). In the literature of innovation management, radical innovations transform market structures and reinvent industries, moving them towards a new competitive landscape through a Schumpeterian process of creative destruction. R&D investment is one of the main factors that affects the rate of, and capacity for, innovation. ICT firms operate in an uncertain environment, which mirrors, in varying degrees, the inherent uncertainty of their R&D activity. ICT firms make large, risky investments in inventive activity, where outcomes are unpredictable, idiosyncratic, and long-term in nature (Anderson et al., 2000). Moral hazard problems, in particular, can amplify because of the inherent uncertainty of the R&D investment (Coad and Rao, 2008).

The ICT sector accounts for a large share of R&D expenditures in the United States. The Business R&D and Innovation Survey (BRDIS) reports $323 billion of R&D performed in 2013, where the ICT sector accounted for 41 percent ($133 billion). In the United States, the ICT manufacturing and the ICT services sectors recorded approximately the same amount of R&D spending, accounting for 20.8 and 20.5 percent, respectively, of total R&D spending in 2013. The R&D activity in the ICT industry in the United States is highly labor-intensive, as reflected in labor costs, which accounted for 76 and 67 percent of R&D expenditures paid for by ICT services and ICT manufacturing industries, respectively, in 2013. Computer system design and related services (NAICS 5415) prove the most labor-intensive in R&D spending, with labor costs accounting for 83 percent of R&D expenditures. In comparison, the aerospace industry and the pharmaceutical and medical industries spend less than 40 percent of their R&D expenditures on labor costs.

This paper contributes to the firm growth literature in three ways. First, to the best of our knowledge, this is the first study of ICT firm growth in a dynamic framework, which fills the gap in the Gibrat's law literature by examining the size-growth relationship in the ICT industry in the United States. Of all the studies examining Gibrat's law in the United States, none provides a firm-level analysis specific to the ICT industry. Second, this paper complements the existing literature by broadening the latitude of the analysis on firm growth. Specifically, we bring together, within the context of Gibrat's law, two different perspectives on firm growth. On the one hand, we rely on the industrial organization literature (Comanor, 1965; Mansfield, 1968; Hall, 1987; Amirkhalkhali and Mukhopadhyay, 1993; and Klette and Griliches, 2000) and, in particular, the newly developed microeconomics of R&D-based endogenous firm growth (Thompson, 2001), which emphasizes the importance of R&D as a mechanism of firm growth. On the other hand, we rely on the corporate finance literature (Jensen and Meckling, 1976; Myers, 1977; Myers and Majluf, 1984; Stein, 2003), which suggests that capital structure, corporate debt, and agency costs caused by conflicts of interest and informational asymmetries between corporate

[2] For recent surveys on empirical studies of firm growth, see Santarelli et al. (2006), and Coad and Hölzl (2012).

[3] Yang and Huang (2005) and Liu et al. (1999) document the relationship between R&D, firm size and growth rates for the electronics industry in Taiwan. Liu et al. (1999), using the OLS and fixed-effects models, provide evidence of an inverse relationship between firm growth and size. Yang and Huang (2005), using GMM models, find that an increase in R&D expenditure induces higher growth. Furthermore, they show that, contrary to Gibrat's law, smaller firms growth faster than larger firms, while size does not depend on firm growth in large firms, in support of Gibrat's law. Das (1995) examines the relationship between firm growth and size for the computer hardware sector in India. Using both fixed-effect and random-effect models, Das (1995) finds that both current size and lagged size negatively affect growth. Using difference GMM and system GMM models, Corsino and Gabriele (2011) document that firm growth in the global integrated circuits sector negatively relates to size. Using a strategy approach, Bothner (2005) documents the size-growth link in the global computer industry. De and Dutta (2007) detail the role of organizational capital in the IT software industry in India using system GMM.

[4] Studies in the 1980s found no connection between IT investment and productivity in the U.S. economy, a situation referred to as the "productivity paradox"(Dedrick et al., 2003). Since then, a decade of studies at the firm and country level consistently show that the effect of IT investment on labor productivity and economic growth is significant and positive. Jorgenson (2003) shows that the growth of IT investment jumped to double-digit levels after 1995 in all G7 economies – Canada, France, Germany, Italy, Japan, the United Kingdom, as well as the United States. These economies account for nearly half of world output and a much larger share of world IT investment. The surge of IT investment after 1995 resulted from a sharp acceleration in the rate of decline of prices of IT equipment and software. Jorgenson (2001) traces this outcome to a drastic shortening of the product cycle for semiconductors from three years to two years, beginning in 1995. For a survey of these studies, see Dedrick et al. (2003).

[5] Using the North American Industrial Classification System (NAICS), the ICT industry is defined as the sum of ICT manufacturing (NAICS 334: Computers and Electronic Products, including Computer and Peripheral Equipment, Communication Equipment and Semiconductors), and ICT services (NAICS 5112: Software Publishers; NAICS 517: Telecommunications, including Wired and Wireless Telecommunications; NAICS 518: Data Processing, Hosting, and Related services; NAICS 5415: Computer Systems Designs and Related Services; and NAICS 51: Information), excluding traditional paper publishing.