The Schumpeterian Growth Paradigm

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Abstract

In this review, we argue that the Schumpeterian growth paradigm, which models growth as resulting from innovations involving creative destruction, sheds light on several aspects of the growth process that cannot be properly addressed by alternative theories. We focus on three important aspects for which Schumpeterian growth theory delivers predictions that distinguish it from other growth models, namely, (*a*) the role of competition and market structure, (*b*) firm dynamics, and (*c*) the relationship between growth and development.

1. INTRODUCTION

Formal models allow us to make verbal notions operational and confront them with data. Schumpeterian growth theory has operationalized Schumpeter's notion of creative destruction—the process by which new innovations replace older technologies—in two ways.[1] First, it has led to models based on creative destruction that shed new light on several microeconomic aspects of the growth process: in particular, the role of competition, firm dynamics, and cross-firm and cross-sector reallocation. Second, it makes use of rich micro data, in particular on entry, exit, and firm size distribution, to confront predictions, which distinguishes it from other growth theories. In both respects, Schumpeterian growth theory has helped bridge the gap between micro- and macroeconomics.

In this article, we consider three aspects on which Schumpeterian growth theory delivers distinctive predictions. First, the Schumpeterian paradigm allows us to analyze the relationship between growth and industrial organization (IO). Faster innovation-led growth is generally associated with higher turnover rates (i.e., higher rates of creation and destruction and of firms and jobs). Moreover, competition appears to be positively correlated with growth, and competition policy tends to complement patent policy. Second, the paradigm sheds light on the relationship between growth and firm dynamics. Small firms exit more frequently than large firms. Conditional on survival, small firms grow faster, and there is a very strong correlation between firm size and age. Additionally, the firm size distribution is highly skewed. Third, we argue that Schumpeterian growth theory helps us reconcile growth with development: first, by looking at how growth is related to the size distribution of firms, which itself depends on local institutional constraints and, second, by bringing out the notion of appropriate growth institutions and policies, that is, the idea that what drives growth in a sector (or country) far below the world technology frontier is not necessarily what drives growth in a sector or country at the technological frontier, at which creative destruction plays a more important role. In particular, we point to democracy being more growth enhancing in more frontier economies.

The article is organized as follows. Section 2 lays out the basic Schumpeterian model. Section 3 introduces competition and IO into the framework. Section 4 analyzes firm dynamics. Section 5 investigates the relationship between growth and development. Section 6 concludes.

We provide a word of caution before proceeding: This article focuses on the Schumpeterian growth paradigm and some of its applications. It is not a survey of the existing (endogenous) growth literature. For more information on that literature, we refer the reader to growth textbooks (e.g., Aghion & Howitt 1998, 2009; Barro & Sala-i-Martin 2003; Acemoglu 2009; Galor 2011; Weil 2012; Jones & Vollrath 2013).

2. SCHUMPETERIAN GROWTH: BASIC MODEL

The Schumpeterian growth model is based on three main ideas: (*a*) Long-run growth results from innovations; (*b*) innovations result from entrepreneurial investments that are themselves motivated by the prospects of monopoly rents; and (*c*) new innovations replace old technologies. In other words, growth involves creative destruction.

[1]The theory was initiated in the fall of 1987 at the Massachusetts Institute of Technology. During that year, Aghion and Howitt wrote their model of growth through creative destruction (see Section 2), which was published in 1992 (Aghion & Howitt 1992). Parallel attempts at developing Schumpeterian growth models include Segerstrom et al. (1990) and Corriveau (1991).

More formally, in the basic Aghion-Howitt model (see Aghion & Howitt 1992), time is continuous, and the economy is populated by a continuum of mass L of individuals. Individuals are risk neutral, and each individual is endowed with one unit flow of labor per unit of time, which he or she can devote either to manufacturing or to research and development (R&D).

A final output is produced at any time using an intermediate input, according to

$$Y = Ay^{\alpha},$$

where A denotes the current quality of the input, which is multiplied by a factor $\gamma > 1$ each time a new innovation occurs. Innovations arrive at Poisson rate λz, where z is the amount of labor devoted to R&D. The intermediate is itself using labor one for one; thus, y also denotes the amount of labor working in manufacturing the intermediate input.

The model revolves around two basic equations. The first is a labor market clearing equation:

$$y + z = L, \tag{1}$$

where L denotes the total labor supply. The second is a research arbitrage equation that states that in equilibrium, an individual is indifferent between working in R&D and working in manufacturing, namely,

$$w_k = \lambda V_{k+1}, \tag{2}$$

where w_k is the wage rate paid by the intermediate input sector after the k-th innovation, and V_{k+1} is the value of the next [i.e., the $(k+1)$-th] innovation.[2]

These two equations allow us to determine the equilibrium R&D using Equations 1 and 2. The resulting equilibrium aggregate R&D, z, depends on the parameters of the economy. In particular, higher productivity of the R&D technology as measured by λ, a larger size of innovations γ, or a larger size of the population L has a positive effect on aggregate R&D. Conversely, a higher α (which corresponds to the intermediate producer facing a more elastic inverse demand curve and therefore getting lower monopoly rents) or a higher discount rate ρ tends to discourage R&D.

Finally, the expected growth rate,

$$\mathbb{E}(g_t) = \lambda z \ln \gamma,$$

inherits the comparative static properties of z with respect to the parameters λ, γ, α, ρ, and L.

A distinct prediction of the model is the following.

Prediction 1: The turnover rate λz is positively correlated with the growth rate g.

Another distinctive implication of the model is that innovation-led growth may be excessive under laissez-faire. Growth is excessive (insufficient) under laissez-faire when the business-stealing effect associated with creative destruction dominates (is dominated by) the intertemporal knowledge spillovers from current to future innovators.[3]

[2]If innovating gave the innovator access to a permanent profit flow π_{k+1}, then the value of the corresponding perpetuity would be π_{k+1}/r. However, there is creative destruction at the aggregate rate λz. As a result, we have $V_{k+1} = \pi_{k+1}/(\rho + \lambda z)$. That is, the value of innovation is equal to the profit flow divided by the risk-adjusted interest rate $\rho + \lambda z$, where the risk is that of being displaced by a new innovator.

[3]Which of these effects dominates will depend, in particular, on the size of innovations. Assessing the relative importance of these two effects in practice requires estimating the structural parameters of the growth model using micro data (see footnote 6).

3. GROWTH MEETS INDUSTRIAL ORGANIZATION

Both empirical studies (e.g., see Blundell et al. 1995, 1999; Nickell 1996) and casual evidence point to a positive correlation between growth and product market competition. However, this is at odds with the predictions of non-Schumpeterian growth models. AK models assume perfect competition and therefore do not address the relationship between competition and growth. Additionally, in Romer's product variety model, higher competition amounts to a higher degree of substitutability between the horizontally differentiated inputs, which in turn implies lower rents for innovators and therefore lower R&D incentives and thus lower growth.

In contrast, the Schumpeterian growth paradigm can account for the positive correlation between competition and growth found in linear regressions. In addition, it accounts for several interesting facts about competition and growth that no other growth theory can explain. [Aghion & Griffith (2006) provide a first attempt at synthesizing the theoretical and empirical debates on competition and growth.] Our focus is on the following three findings. First, innovation and productivity growth by incumbent firms appear to be stimulated by competition and entry, particularly in firms near the technology frontier or in firms that compete neck and neck with their rivals, less so in firms below the frontier. Second, competition and productivity growth display an inverted-U relationship. Starting from an initially low level of competition, higher competition stimulates innovation and growth; starting from a high initial level of competition, higher competition has a less positive or even a negative effect on innovation and productivity growth. Third, patent protection complements product market competition in encouraging R&D investments and innovation.

Understanding the relationship between competition and growth also helps improve our understanding of the relationship between trade and growth. Indeed, there are several dimensions to that relationship. To begin, there is the scale effect, in which liberalizing trade increases the market for successful innovations and therefore the incentives to innovate. This is naturally captured by any innovation-based model of growth, including the Schumpeterian growth model. But there is also a competition effect of trade openness, which only the Schumpeterian model can capture. This latter effect appears to have been at work in emerging countries that implemented trade liberalization reforms (e.g., India in the early 1990s), and it also explains why trade restrictions are more detrimental to growth in more frontier countries (see Section 5).

3.1. From Leapfrogging to Step-by-Step Innovation[4]

In this section, we uncover the main counteracting effects of competition on innovation and analyze conditions under which each effect dominates.

3.1.1. The argument. Let us replace the leapfrogging assumption of the model in Section 2 (in which incumbents are systematically overtaken by outside researchers) with a less radical step-by-step assumption: Namely, a firm that is currently m steps behind the technological leader in the same sector or industry must catch up with the leader before becoming a leader itself. The underlying idea is that an innovator acquires tacit knowledge that cannot be duplicated by a rival without engaging in its own R&D to catch up. This step-by-step assumption implies that firms in some sectors will be neck and neck. Now in such sectors, by making life more difficult for neck-and-neck firms, increased product market competition will encourage these firms to innovate in

[4]The following model and analysis are based on Aghion et al. (1997, 2001, 2005) and Acemoglu & Akcigit (2012) (see also Peretto 1998 for related work).

order to acquire a lead over their rival in the sector. We refer to this as the escape-competition effect. Conversely, in sectors that are not neck and neck, increased product market competition will have a more ambiguous effect on innovation. In particular, it will discourage innovation by laggard firms when these firms do not put much weight on the (more remote) prospect of becoming a leader and instead mainly look at the short-run extra profit from catching up with the leader. We call this the Schumpeterian effect. Finally, the steady-state fraction of neck-and-neck sectors will itself depend on the innovation intensities in neck-and-neck versus unleveled sectors. We refer to this as the composition effect.

Thus, the effect of competition on innovation depends on the technological state of the sector. In unleveled sectors, the Schumpeterian effect is at work even if it does not always dominate. But in leveled (neck-and-neck) sectors, the escape-competition effect is the only effect at work. That is, more competition induces neck-and-neck firms to innovate in order to escape from a situation in which competition constrains profits.

On average, an increase in product market competition will have an ambiguous effect on growth. It induces faster productivity growth in currently neck-and-neck sectors and slower growth in currently unleveled sectors. The overall effect on growth will thus depend on the (steady-state) fraction of leveled versus unleveled sectors. But this steady-state fraction is itself endogenous, as it depends on equilibrium R&D intensities in both types of sectors. One can show that the overall effect is an inverted U, and at the same time, this model generates additional predictions for further empirical testing.

3.1.2. Composition effect and the inverted U.

The inverted-U shape results from the composition effect in which an increase in competition changes the steady-state fraction of sectors that are in the leveled state, in which the escape-competition effect dominates, versus the unleveled state, in which the Schumpeterian effect dominates. At one extreme, when there is not much product market competition, there is not much incentive for neck-and-neck firms to innovate, and therefore, the overall innovation rate will be highest when the sector is unleveled. Thus, the industry will be quick to leave the unleveled state (which it does as soon as the laggard innovates) and slow to leave the leveled state (which will not happen until one of the neck-and-neck firms innovates). As a result, the industry will spend most of the time in the leveled state, in which the escape-competition effect dominates. In other words, if the degree of competition is very low to begin with, an increase in competition should result in a faster average innovation rate. At the other extreme, when competition is initially very high, there is little incentive for the laggard to innovate in an unleveled state. Thus, the industry will be slow to leave the unleveled state. Meanwhile, the large incremental profit from innovation gives firms in the leveled state a relatively large incentive to innovate, so that the industry will be relatively quick to leave the leveled state. As a result, the industry will spend most of the time in the unleveled state in which the Schumpeterian effect is the dominant effect. In other words, if the degree of competition is very high to begin with, an increase in competition should result in a slower average innovation rate.

3.2. Predictions

The main testable predictions from the above discussion are listed below.

> **Prediction 2:** The relationship between competition and innovation follows an inverted-U pattern, and the average technological gap within a sector increases with competition.

This prediction is analyzed by Aghion et al. (2005) using panel data on UK firms spanning 17 two-digit Standard Industrial Classification (SIC) industries between 1973 and 1994. The chosen measure of product market competition is equal to 1 minus the Lerner index. The Lerner index, or price-cost margin, is itself defined by operating profits net of depreciation, provisions, and financial cost of capital, divided by sales, averaged across firms within an industry-year. **Figure 1** shows the inverted-U pattern, and it also demonstrates that if we restrict attention to industries above the median degree of neck-and-neckness, the upward-sloping part of the inverted U is steeper than if we consider the whole sample of industries. Aghion et al. also show that the average technological gap across firms within an industry increases with the degree of competition to which the industry is subject.

The following prediction characterizes the sectors where the escape-competition effect dominates the Schumpeterian effect.

> **Prediction 3:** More intense competition enhances innovation in frontier firms but may discourage it in nonfrontier firms.

Intuitively, a frontier firm can escape competition by innovating, unlike a nonfrontier firm, which can only catch up with the leader in its sector. This prediction is tested by Aghion et al. (2009a), who use a panel of more than 5,000 incumbent lines of businesses in UK firms in 180 four-digit SIC industries over the time period 1987–1993.

With the measure of technologically advanced entry of new foreign firms that Aghion et al. (2009a) construct from administrative plant-level data as the proxy of competition, **Figure 2** illustrates the following two results. First, the upper line, which depicts how productivity growth responds to entry in incumbents that are more-than-median close to the frontier, is upward sloping. This reflects the escape-competition effect at work in neck-and-neck sectors. Second, the lower line, which depicts how productivity growth responds to entry in incumbents that are less-than-median close to the frontier, is downward sloping. This reflects the Schumpeterian effect of competition on innovation in laggards. In the main empirical analysis, Aghion et al. also control for the influence of trade- and average profitability-related competition measures and address the issue that entry, as well as the other explanatory variables, can be endogenous to incumbent productivity growth, as well as incumbent innovation. To tackle entry endogeneity, in particular, instruments are derived from a broad set of UK- and European Union–level policy reforms.

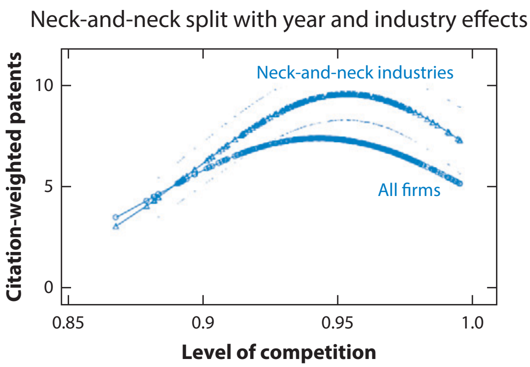

Figure 1

Competition and innovation. Figure taken from Aghion et al. (2005).

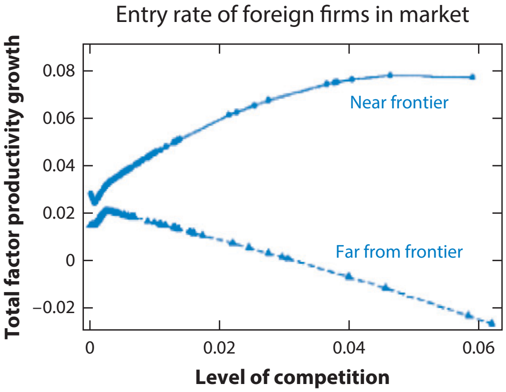

Figure 2

Entry and growth. Figure taken from Aghion et al. (2009a).

The following prediction ties the product market competition to patent policy.

> **Prediction 4:** There is complementarity between patent protection and product market competition in fostering innovation.

Intuitively, competition reduces the profit flow of noninnovating neck-and-neck firms, whereas patent protection is likely to enhance the profit flow of innovating neck-and-neck firms. Both contribute to raising the net profit gain of innovating neck-and-neck firms; in other words, both types of policies tend to enhance the escape-competition effect.[5] This prediction is confirmed by Aghion et al. (2013) using Organization for Economic Co-operation and Development (OECD) country-industry panel data for many industries in OECD countries since the 1980s. Aghion et al. find that the implementation of a competition-increasing product market reform, the large-scale European Single Market Programme, has increased innovation in industries of countries with strong intellectual property rights (IPRs) since the presample period, but not so in those with weaker IPRs. Moreover, the positive response of innovation to the product market reform in strong IPR countries is more pronounced among firms in industries that rely more on patenting than in other industries. Overall, these empirical results are consistent with a complementarity between IPRs and competition.

4. SCHUMPETERIAN GROWTH AND FIRM DYNAMICS

The empirical literature has documented various stylized facts on firm size distribution and firm dynamics using micro firm-level data. In particular, (*a*) the firm size distribution is highly skewed; (*b*) firm size and firm age are highly correlated; (*c*) small firms exit more frequently, but the ones that survive tend to grow faster than the average growth rate; (*d*) a large fraction of R&D in the

[5]That competition and patent protection should be complementary in enhancing growth rather than mutually exclusive is at odds with Romer's (1990) product variety model, in which competition is always detrimental to innovation and growth (as discussed above) for exactly the same reason that IPRs in the form of patent protection are good for innovation: Namely, competition reduces postinnovation rents, whereas patent protection increases these rents. Acemoglu & Akcigit (2012) provide a general analysis of optimal patent protection in Schumpeterian models with step-by-step innovation.

United States is done by incumbents; and (*e*) the reallocation of inputs between entrants and incumbents is an important source of productivity growth.

These are all facts that non-Schumpeterian growth models cannot account for. In particular, the first four facts listed require a new firm to enter, expand, then shrink over time, and eventually be replaced by new entrants. These and the last fact on the importance of reallocation are all embodied in the Schumpeterian idea of creative destruction.

Instead, the Schumpeterian model by Klette & Kortum (2004) can account for these facts. This model adds two elements to the baseline model. First, innovations come from both entrants and incumbents; second, firms are defined as a collection of production units in which successful innovations by incumbents will allow them to expand in product space (see **Figure 3**).[6] Creative destruction is the central force that drives innovation, invariant firm size distribution, and aggregate productivity growth on a balanced growth path.

This model delivers a number of interesting predictions that are matched by the empirical evidence. The first prediction concerns the size distribution of firms.

Prediction 5: The size distribution of firms is highly skewed.

This prediction, which is illustrated in **Figure 4**, is linked to a vast empirical literature (Simon & Bonini 1958, Ijiri & Simon 1977, Schmalensee 1989, Stanley et al. 1995, Axtell 2001, Rossi-Hansberg & Wright 2007). Recall that in this model, firm size is summarized by the number of product lines of a firm. Hence, a firm needs to have succeeded many attempts to innovate in new lines, and at the same time survived many attempts by potential entrants and other incumbents at taking over its existing lines, in order to become a large firm. This in turn explains why there are so few very large firms in steady-state equilibrium (i.e., why the firm size distribution is highly skewed, as shown in a vast empirical literature).

The next prediction links the firm size and firm age.

Prediction 6: Firm size and firm age are positively correlated.

In the model, firms are born with a size of 1. Subsequent successes are required for firms to grow in size, which naturally produces a positive correlation between size and age. This regularity has been documented extensively in the literature (for recent discussions, see Akcigit & Kerr 2010 and Haltiwanger et al. 2013).

The following prediction links the exit rate to the size of the firm.

Prediction 7: Small firms exit more frequently. The ones that survive tend to grow faster than average.

In the above model, it takes only one successful entry to make a one-product firm exit, whereas it takes two successful innovations by potential entrants to make a two-product firm exit. That small firms exit more frequently and grow faster conditional on survival has been widely documented in the literature (see Akcigit & Kerr 2010 for references).[7]

The next prediction underlines the role of incumbents in aggregate R&D spending.

Prediction 8: A large fraction of R&D is done by incumbents.

[6]Various versions of this framework have been estimated using microlevel data by Lentz & Mortensen (2008), Acemoglu et al. (2013), Akcigit & Kerr (2010), and Garcia-Macia et al. (2014).

[7]In recent work, Acemoglu et al. (2013) analyze the effects of various industrial policies on equilibrium productivity growth, including entry subsidies and incumbent R&D subsidies, in an enriched version of the above framework.

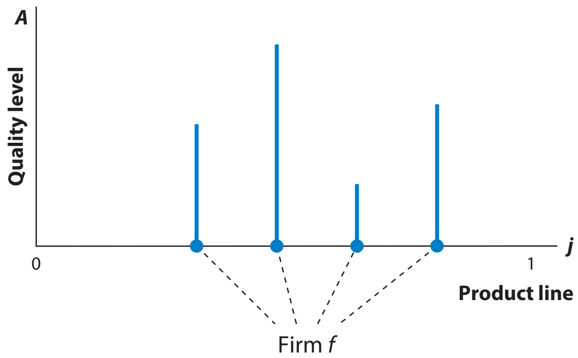

Figure 3

Example of a firm.

There is an extensive literature studying R&D investment and the patenting behavior of existing firms in the United States (see, e.g., Acs & Audretsch 1988, 1991; Griliches 1990; Cohen 1995; Cohen & Klepper 1996; Hall et al. 2001). In particular, Freeman (1982), Pennings & Buitendam (1987), Tushman & Anderson (1986), Scherer (1984), and Akcigit & Kerr (2010) show that large incumbents focus on improving existing technologies, whereas small new entrants focus on innovating with radical new products or technologies. Similarly, Akcigit et al. (2012) provide empirical evidence on French firms showing that large incumbents with a broad technological spectrum account for most of private basic research investment. On the theory side, Akcigit & Kerr (2010), Acemoglu & Cao (2011), and Acemoglu et al. (2015) also provide alternative Schumpeterian models that capture this fact.

The following prediction links growth to factor reallocation between entrants and incumbents.

> **Prediction 9:** Both entrants and incumbents innovate. Moreover, the reallocation of resources among incumbents, as well as from incumbents to new entrants, is the major source of productivity growth.

A central feature of this model is that both incumbents and entrants innovate and contribute to productivity growth. Bartelsman & Doms (2000) and Foster et al. (2001) show that 25% of productivity growth in the United States is accounted for by new entry, with the remaining 75% accounted for by continuing plants. Moreover, Foster et al. (2001, 2006) demonstrate that the reallocation of resources through entry and exit accounts for approximately 50% of manufacturing and 90% of US retail productivity growth. In the recently growing cross-country literature, Hsieh & Klenow (2009, 2014), Bartelsman et al. (2013), and Syverson (2011) describe how variations in reallocation across countries explain differences in productivity levels. Lentz & Mortensen (2008), Akcigit & Kerr (2010), and Acemoglu et al. (2013) estimate variants of the baseline model in Klette & Kortum (2004) to quantify the importance of reallocation and study the impacts of industrial policy on reallocation and productivity growth.

5. GROWTH MEETS DEVELOPMENT

In this section, we argue that Schumpeterian growth theory helps bridge the gap between growth and development economics, first, by analyzing how institutional development (or the lack of it) affects the firm size distribution and firm dynamics and, second, by offering a simple framework

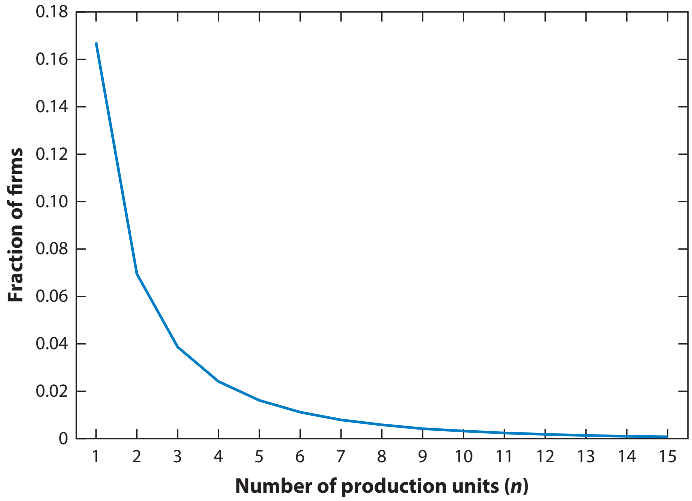

Figure 4

Firm size distribution.

to capture the idea that growth-enhancing policies or institutions may vary with a country's level of technological development.

5.1. Innovation, Institutions, and Firm Dynamics in Developing Countries

Firm dynamics show massive differences across countries. In recent work, Hsieh & Klenow (2014) show that although establishments grow four times relative to their entry size by the age of 30, Indian counterparts barely show any growth (**Figure 5**). Clearly, not all firms are the same. For instance, Hurst & Pugsley (2011) demonstrate that 75% of the small businesses in the United States express no interest in growing and report that these businesses intentionally choose to remain small mainly because of nonpecuniary reasons. However, many of these small firms are being pushed out by other firms that are growing very rapidly. According to Hurst & Pugsley, among young firms (0–10 years old), the fraction of firms with less than 20 employees is 86% in terms of count and 35% in terms of overall employment. These numbers go down to 72% and 16%, respectively, by the time these firms become medium aged (10–25 years old). This is a result of the massive reallocation and turnover that takes place among firms in the US economy. Foster et al. (2001, 2006) report that the reallocation among firms is responsible for 50–75% of the productivity growth in the US economy. However, such reallocation is absent in India. Akcigit et al. (2014) show that the fraction of Indian establishments with at most two workers remains around 80% throughout the life cycle of a cohort (**Figure 6**).

Why do establishments not grow in India? Bloom et al. (2013) empirically demonstrate that a lack of trust and a weak rule of law are major obstacles to firm growth. In their empirical study, they show that the managerial span of control is a binding constraint among Indian textile firms. Family members do not trust nonfamily members for managerial tasks: If the owners of the firm find that a manager is stealing, it is very hard to prosecute him or her owing to the inefficiency of the Indian courts. Because of the lack of delegation to nonfamily members, firms are not able to expand beyond a certain size. Hence, one of the best predictors of firm size in India is the size of the family, specifically the number of male members of the family. Akcigit et al. (2014) show that the

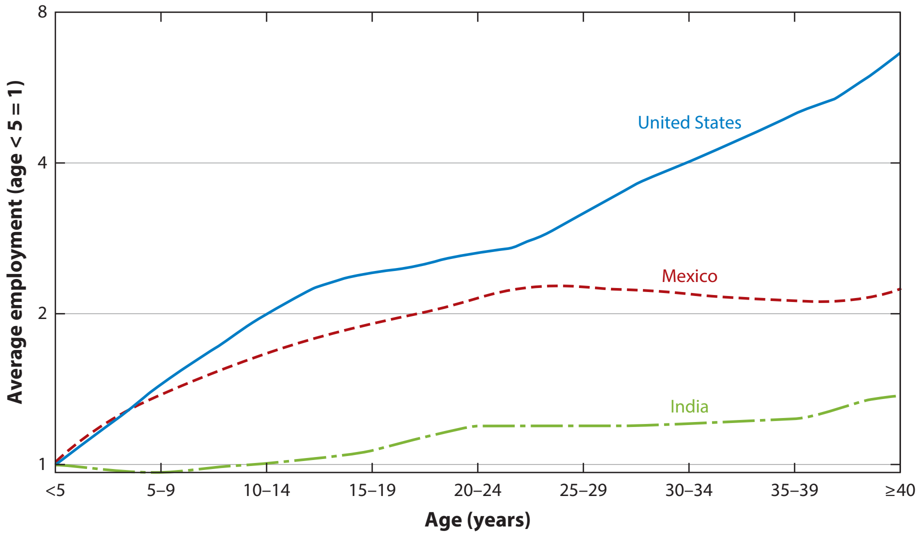

Figure 5

Life cycle of plants. Figure taken from Hsieh & Klenow (2014).

correlation between firm size and family size becomes weaker in Indian regions in which the level of trust is higher. In an economy in which the legal institutions are strong, such interactions should not have any significance. Therefore, both at the country and regional levels, it is no surprise that the strength of the rule of law or the level of trust is very significantly and positively correlated with the average firm size and also with the fraction of the workforce that works as managers (e.g., La Porta et al. 1997, Kumar et al. 1999, Laeven & Woodruff 2007, Bloom et al. 2012, Akcigit et al. 2014). Bloom et al. (2013) also show that because good firms do not expand, reallocation from bad to good firms does not take place, and badly managed firms are able to survive for very long times.

What are the aggregate implications of the lack of delegation and weakness of the rule of law on productivity and firm dynamics? To answer this question, Akcigit et al. (2014) build a Schumpeterian model that substantially extends the firm dynamics model introduced in Section 4. There are two major ingredients of their analysis. First, production requires managers and firm owners to have limited managerial time. In this model, unless firm owners delegate some tasks, firms run into the span of control problem (similar to Lucas 1978). Second, firm owners can be of two types: high or low. High-type firms are more creative and have the potential of expanding much faster than low-type firms. Whether this fast expansion materializes depends on the return to expansion, which itself depends on the possibility of delegation. The predictions of the model, both on the delegation margin and on the firm dynamics, can be summarized as follows.

> **Prediction 10:** Everything else equal, the probability of hiring an outside manager and, conditional on hiring, the number of outside managers are (*a*) increasing in firm size, (*b*) decreasing in the owner's time, and (*c*) increasing in the rule of law.

The intuition for this prediction is as follows. Larger firms operate with more product lines, and hence they have less time from the owner directly. Hence, the marginal contribution of an outside manager is much higher in larger firms. The second part relates the family size to delegation. If the owner has more time (e.g., owing to larger family size), then the owner already has more time to

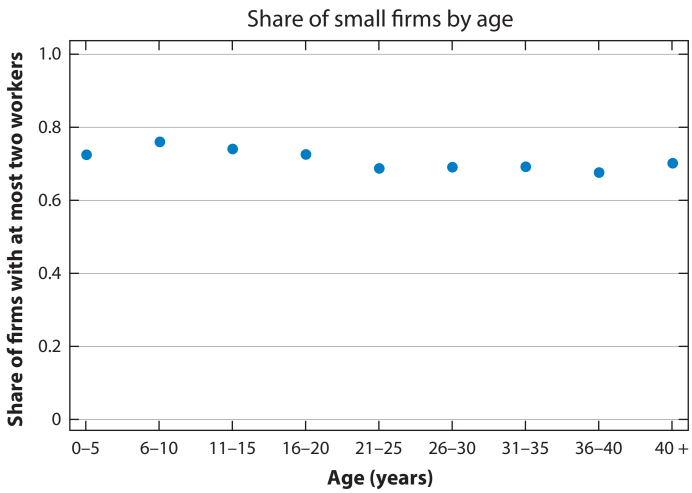

Figure 6

Small plants in India. Figure taken from Akcigit et al. (2014).

invest in the business, and this lowers the demand for outside managers. Finally, a stronger rule of law implies a higher net return to delegation. Akcigit et al. (2014) provide empirical support for these predictions using Indian manufacturing establishments.

Bloom et al. (2013) provide empirical support that firm value is increasing in owner time, and therefore, firms are willing to innovate and expand more when the firm value is higher. The positive link between firm size and the rule of law has been extensively documented in the literature (see, e.g., Bloom et al. 2012 for a detailed discussion). Finally, Akcigit et al. (2014) show that the link between firm size and family size is weaker in high-trust regions in India.

The following prediction links the rule of law to the relationship between firm growth and firm size.

> **Prediction 11:** Firm growth decreases in firm size, more so when the rule of law is weaker.

This prediction follows from the fact that in larger firms, the owner has less time to allocate to each product line, and hence the frictions to delegation become much more important for large firms. Thus, when the rule of law is weak, larger firms have less incentive to grow, which means that the difference in growth incentives between large and small firms will be much more pronounced in regions and countries with a weak rule of law. Akcigit et al. (2014) show that growth decreases faster with firm size in low-trust regions in India.

The next prediction links the rule of law to the amount of creative destruction and reallocation in the economy.

> **Prediction 12:** Everything else equal, creative destruction and reallocation among firms will be much higher in economies in which the rule of law is stronger, thanks to the delegation possibilities.

Clearly this prediction is in line with the main findings of Hsieh & Klenow demonstrating the missing growth and reallocation in developing countries. Understanding the reasons behind the lack of reallocation and creative destruction is essential to designing the right development policies.

The Schumpeterian growth framework provides a useful framework to conduct counterfactual policy exercises that can shed light on this important debate.

5.2. Innovation Versus Imitation and the Notion of Appropriate Institutions

Policies and institutions that are appropriate for countries close to the global technology frontier are often different from those that are appropriate for nonfrontier countries. This is because those policies and institutions that help a country copy, adapt, and implement leading-edge technologies are not necessarily the same as those that help it make leading-edge innovations. Acemoglu et al. (2006) develop the idea of appropriate institutions more systematically, and it underlies more recent work, in particular, Acemoglu & Robinson's (2012) best-selling book, *Why Nations Fail*, in which the authors rely on a rich set of country studies to argue that sustained growth requires creative destruction and therefore is not sustainable in countries with "extractive institutions."

A particularly direct and simpler way to formalize the idea of appropriate growth policy is to move for a moment from continuous to discrete time. Following Acemoglu et al. (2006) and more remotely Nelson & Phelps (1966), let A_t denote the current average productivity in the domestic country and $\overline{A}_t$ denote the current (world) frontier productivity. Then, think of innovation as multiplying productivity by factor γ and of imitation as catching up with the frontier technology.

Then, if the fraction μ_n of sectors innovates and the fraction μ_m imitates, we have

$$A_{t+1} - A_t = \mu_n(\gamma - 1)A_t + \mu_m\left(\overline{A}_t - A_t\right).$$

This in turn implies that productivity growth hinges upon the country's degree of frontierness, that is, its proximity $a_t = A_t/\overline{A}_t$ to the world frontier, namely,

$$g_t = \frac{A_{t+1} - A_t}{A_t} = \mu_n(\gamma - 1) + \mu_m\left(a_t^{-1} - 1\right).$$

In particular, we have the following prediction.

> **Prediction 13:** The closer to the frontier an economy is (i.e., the closer to 1 the proximity variable a_t is), the more growth is driven by innovation-enhancing rather than imitation-enhancing policies or institutions.

Section 3 discusses some recent evidence for the prediction that competition and free entry should be more growth enhancing. Using a cross-country panel of more than 100 countries over the 1960–2000 period, Acemoglu et al. (2006) regress the average growth rate on a country's distance to the US frontier (measured by the ratio of GDP per capita in that country to GDP per capita in the United States) at the beginning of the period. Then, they split the sample of countries into two groups: countries that are more open than the median and countries that are less open than the median. The prediction is as follows.

> **Prediction 14:** Average growth should decrease more rapidly as a country approaches the world frontier when openness is low.

To measure openness, one can use imports plus exports divided by aggregate GDP. But this measure suffers from obvious endogeneity problems; in particular, exports and imports are likely to be influenced by domestic growth. To deal with the endogeneity problem, Frankel & Romer (1999) construct a more exogenous measure of openness that relies on exogenous characteristics

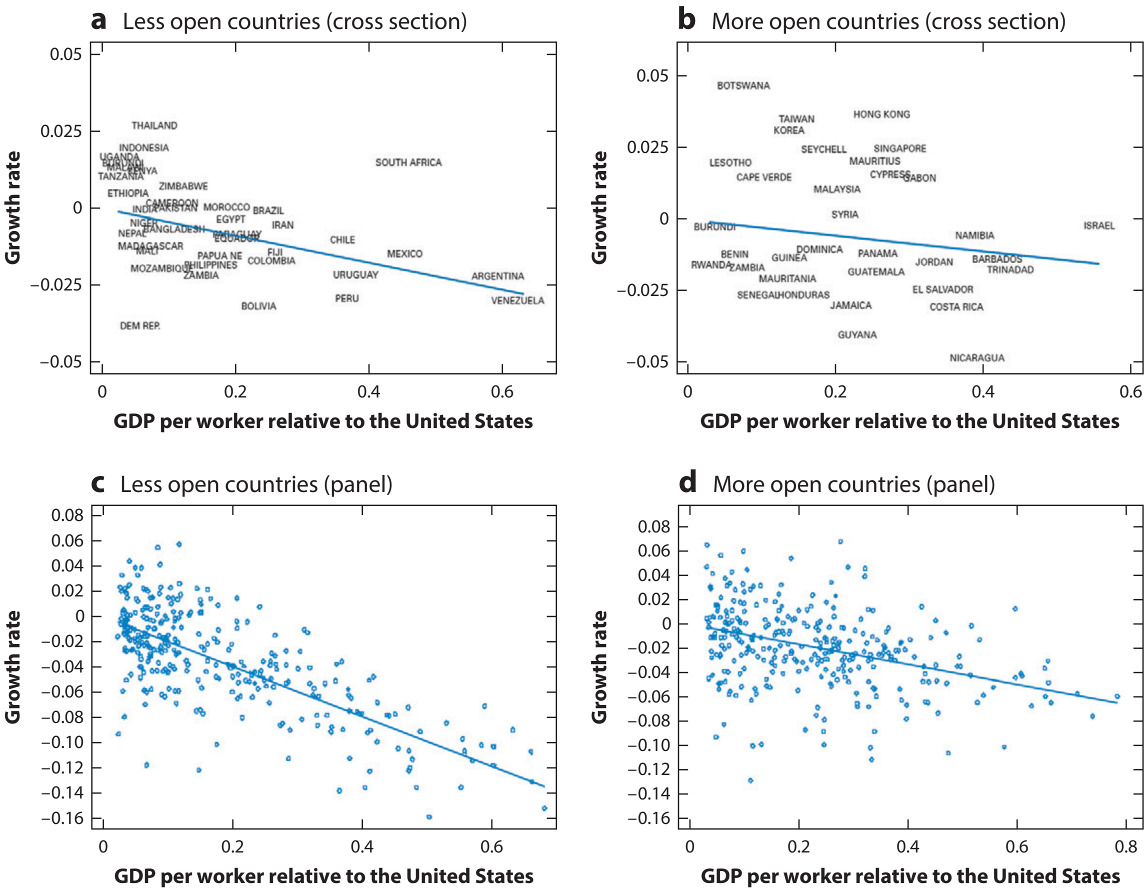

Figure 7

Growth, openness, and distance to the frontier. Figure taken from Acemoglu et al. (2006).

such as land area, common borders, geographical distance, and population, and it is this indicator that Acemoglu et al. (2006) use to measure openness in **Figure 7**.

Figure 7*a*,*b* shows the cross-sectional regressions. Here, average growth over the whole 1960–2000 period is regressed over the country's distance to the world technology frontier in 1965 for less open and more open countries, respectively. A country's distance to the frontier is measured by the ratio between the log of this country's level of per capita GDP and the maximum of the logs of per capita GDP across all countries (which corresponds to the log of per capita GDP in the United States).[8]

Figure 7*c*,*d* shows the results of panel regressions in which Acemoglu et al. (2006) decompose the period 1960–2000 into five-year subperiods and regress average growth over the subperiod on the distance to the frontier at the beginning of the subperiod for less open and more open countries,

[8]That all the regression lines should be downward sloping reflects that countries farther below the world technology frontier achieve bigger technological leaps whenever they successfully catch up with the frontier (this is the advantage of backwardness mentioned above). More formally, for a given μ_n and μ_m, $g_t = \mu_n(\gamma - 1) + \mu_m(a_t^{-1} - 1)$ is decreasing in a_t.

respectively. These latter regressions control for country fixed effects. In both cross-sectional and panel regressions, we see that, although a low degree of openness does not appear to be detrimental to growth in countries far below the world frontier, it becomes increasingly detrimental to growth as countries approach the frontier.

Acemoglu et al. (2006) repeat the same exercise using entry costs faced by new firms instead of openness. The prediction is the following.

> **Prediction 15:** High entry barriers become increasingly detrimental to growth as a country approaches the frontier.

Entry costs in turn are measured by the number of days to create a new firm in the various countries (see Djankov et al. 2002). Here, the country sample is split between countries with high barriers relative to the median and countries with low barriers relative to the median. **Figure 8*a,b*** shows the cross-sectional regressions for high- and low-barrier countries, respectively, and **Figure 8*c,d*** shows the panel regressions for the same two subgroups of countries. Both types of regressions demonstrate that, although high entry barriers do not appear to be detrimental to

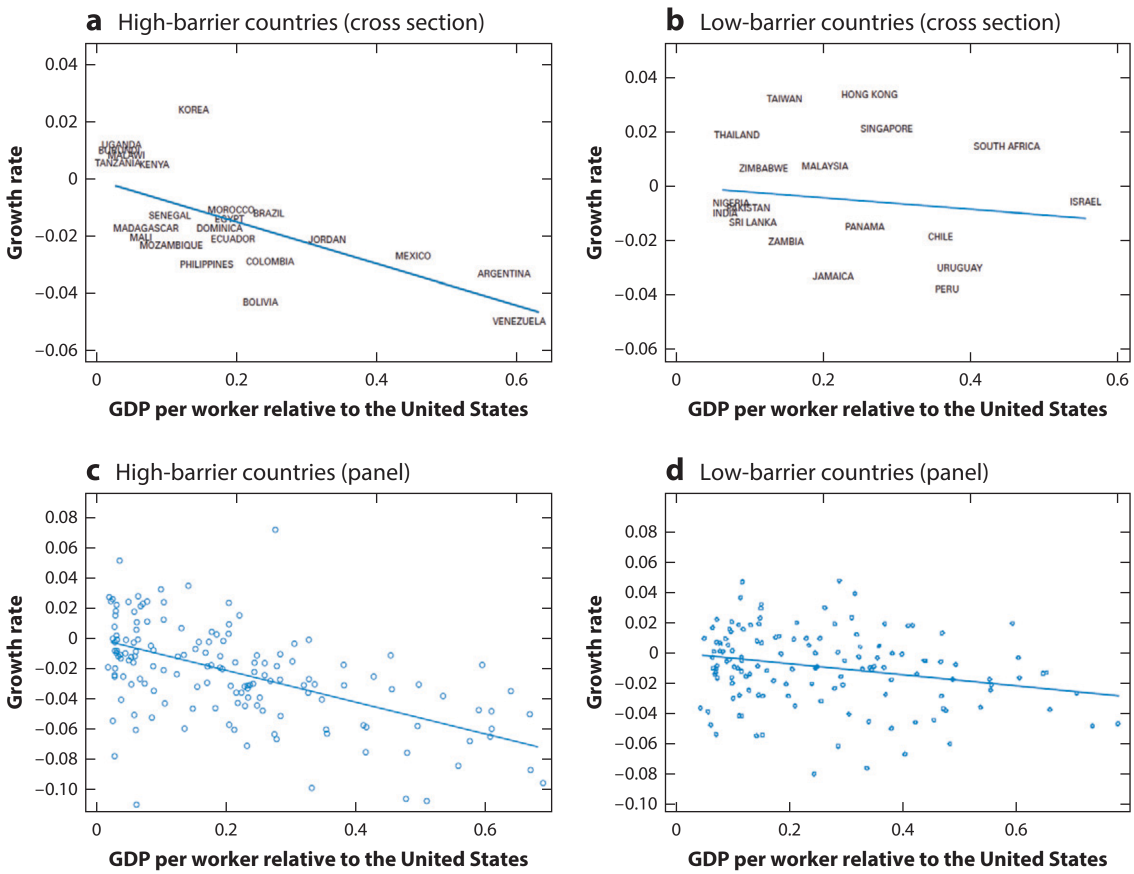

Figure 8

Growth, entry, and distance to the frontier. Figure taken from Acemoglu et al. (2006).

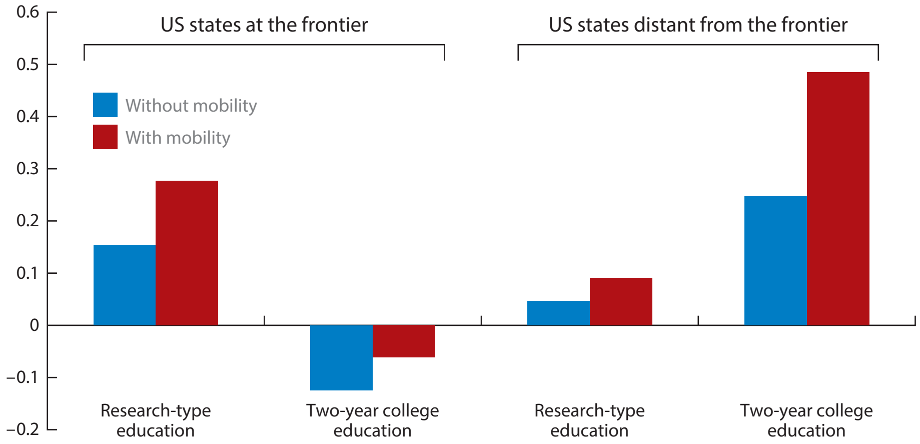

Figure 9

Growth, education, and distance to the frontier. Data taken from Aghion et al. (2009b).

growth in countries far below the world frontier, they indeed become increasingly detrimental to growth as countries approach the frontier.

These two empirical exercises point to the importance of interacting institutions or policies with technological variables in growth regressions: Openness is particularly growth enhancing in countries closer to the technological frontier, and entry is more growth enhancing in countries or sectors closer to the technological frontier. Below we see that higher (in particular, graduate) education tends to be more growth enhancing in countries or in US states that are closer to the technological frontier, whereas primary-secondary (possibly undergraduate) education tends to be more growth enhancing in countries or in US states that are farther below the frontier.

Another piece of evidence is provided by Aghion et al. (2009b), who use cross-US-states panel data to look at how spending on various levels of education matters differently for growth across US states with different levels of frontierness as measured by their average productivity compared to frontier-state (Californian) productivity (**Figure 9**). The more frontier a country or region is, the more its growth relies on frontier innovation; therefore, we have the following prediction.

> **Prediction 16:** The more frontier an economy is, the more growth in this economy relies on research education.

As shown in **Figure 9**, research-type education is always more growth enhancing in states that are more frontier, whereas a bigger emphasis on two-year colleges is more growth enhancing in US states that are farther below the productivity frontier. This is not surprising: Vandenbussche et al. (2006) obtain similar conclusions using cross-country panel data, namely, that tertiary education is more positively correlated with productivity growth in countries closer to the world technology frontier.

6. CONCLUSION

Above we demonstrate how Schumpeterian growth theory generates predictions that make use of the fact that innovations involve creative destruction (i.e., with current innovators driving out previous technologies). Thus, Schumpeterian growth theory manages to put IO into growth, allowing us to discuss the relationship between growth and product market competition. The framework can be used to link growth with firm dynamics, thereby generating predictions on the dynamic patterns of markets and firms (e.g., entry, exit, reallocation) and on the ways in which these patterns shape the overall growth process. We argue that Schumpeterian growth theory helps us reconcile growth with development. First, it helps us look at how institutional development shapes the relationship among firm size distribution, reallocation, and growth. Second, it brings out the notion of appropriate growth institutions and policies, that is, the idea that what drives growth in a sector (or country) far below the world technology frontier is not necessarily what drives growth in a sector or country at the technological frontier, at which creative destruction plays a more important role.

The Schumpeterian growth framework can be further developed in several interesting directions. We are currently exploring three new avenues. One is the relationship among innovation-led growth, top income shares, and social mobility. The Schumpeterian paradigm predicts that more innovation should increase both top income shares (these include the rewards to successful innovators) and social mobility (by virtue of creative destruction, which implies that new innovators should continuously challenge the vested interests of previous innovators). A second avenue is the analysis of the relationship between innovation-led growth and well-being. On the one hand, more creative destruction implies more job destruction, which should reduce the well-being of currently employed workers. On the other hand, more creative destruction implies more new job creation and a higher growth rate, both of which should be welfare enhancing. A third avenue is to analyze how firm size relates to the type of innovation the firm pursues. In particular, are more radical innovations pursued by smaller or by larger firms, and is the answer to this question the same in developed and less developed countries? These and many other potential applications of the Schumpeterian paradigm are left for future research.

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LITERATURE CITED

Acemoglu D. 2009. *Introduction to Modern Economic Growth*. Princeton, NJ: Princeton Univ. Press

Acemoglu D, Aghion P, Zilibotti F. 2006. Distance to frontier, selection, and economic growth. *J. Eur. Econ. Assoc.* 4:37–74

Acemoglu D, Akcigit U. 2012. Intellectual property rights policy, competition and innovation. *J. Eur. Econ. Assoc.* 10:1–42

Acemoglu D, Akcigit U, Bloom N, Kerr W. 2013. *Innovation, reallocation and growth*. NBER Work. Pap. 18993

Acemoglu D, Akcigit U, Hanley D, Kerr W. 2015. Transition to clean technology. *J. Polit. Econ.* In press

Acemoglu D, Cao D. 2011. *Innovation by entrants and incumbents*. Unpublished manuscript, Mass. Inst. Technol., Cambridge, MA

Acemoglu D, Robinson J. 2012. *Why Nations Fail*. New York: Crown Bus.

Acs Z, Audretsch D. 1988. Innovation in large and small firms: an empirical analysis. *Am. Econ. Rev.* 78:678–90

Acs Z, Audretsch D. 1991. Innovation and size at the firm level. *South. Econ. J.* 57:739–44

Aghion P, Bloom N, Blundell R, Griffith R, Howitt P. 2005. Competition and innovation: an inverted-U relationship. *Q. J. Econ.* 120:701–28

Aghion P, Blundell R, Griffith R, Howitt P, Prantl S. 2009a. The effects of entry on incumbent innovation and productivity. *Rev. Econ. Stat.* 91:20–32

Aghion P, Boustan L, Hoxby C, Vandenbussche J. 2009b. *Exploiting states' mistakes to identify the causal effects of higher education on growth*. Unpublished manuscript, Harvard Univ., Cambridge, MA

Aghion P, Griffith R. 2006. *Competition and Growth: Reconciling Theory and Evidence*. Cambridge, MA: MIT Press

Aghion P, Harris C, Howitt P, Vickers J. 2001. Competition, imitation and growth with step-by-step innovation. *Rev. Econ. Stud.* 68:467–92

Aghion P, Harris C, Vickers J. 1997. Competition and growth with step-by-step innovation: an example. *Eur Econ. Rev.* 41:771–82

Aghion P, Howitt P. 1992. A model of growth through creative destruction. *Econometrica* 60:323–51

Aghion P, Howitt P. 1998. *Endogenous Growth Theory*. Cambridge, MA: MIT Press

Aghion P, Howitt P. 2009. *The Economics of Growth*. Cambridge, MA: MIT Press

Aghion P, Howitt P, Prantl S. 2013. *Patent rights, product market reforms and innovation*. NBER Work. Pap. 18854

Akcigit U, Alp H, Peters M. 2014. *Lack of selection and limits to delegation: firm dynamics in developing countries*. Work. Pap., Univ. Pa., Philadelphia

Akcigit U, Hanley D, Serrano-Velarde N. 2012. *Back to basics: basic research spillovers, innovation policy and growth*. Unpublished manuscript, Univ. Pa., Philadelphia

Akcigit U, Kerr W. 2010. *Growth through heterogeneous innovations*. NBER Work. Pap. 16443

Axtell R. 2001. Zipf distribution of US firm sizes. *Science* 293:1818–20

Barro RJ, Sala-i-Martin X. 2003. *Economic Growth*. New York: McGraw-Hill

Bartelsman E, Doms M. 2000. Understanding productivity: lessons from longitudinal microdata. *J. Econ. Lit.* 38:569–94

Bartelsman E, Haltiwanger J, Scarpetta S. 2013. Cross-country differences in productivity: the role of allocation and selection. *Am. Econ. Rev.* 103:305–34

Bloom N, Eifert B, McKenzie D, Mahajan A, Roberts J. 2013. Does management matter? Evidence from India. *Q. J. Econ.* 128:1–51

Bloom N, Sadun R, Van Reenen J. 2012. The organization of firms across countries. *Q. J. Econ.* 127:1663–705

Blundell R, Griffith R, Van Reenen J. 1995. Dynamic count data models of technological innovation. *Econ. J.* 105:333–44

Blundell R, Griffith R, Van Reenen J. 1999. Market share, market value and innovation in a panel of British manufacturing firms. *Rev. Econ. Stud.* 66:529–54

Cohen W. 1995. Empirical studies of innovative activity. In *Handbook of the Economics of Innovations and Technological Change*, ed. P Stoneman, pp. 182–264. Oxford, UK: Blackwell

Cohen W, Klepper S. 1996. Firm size and the nature of innovation within industries: the case of process and product R&D. *Rev. Econ. Stat.* 78:232–43

Corriveau L. 1991. *Entrepreneurs, growth, and cycles*. PhD Diss., Univ. West. Ontario

Djankov S, La Porta R, Lopez-de-Silanes F, Shleifer A. 2002. The regulation of entry. *Q. J. Econ.* 117:1–37

Foster L, Haltiwanger J, Krizan C. 2001. Aggregate productivity growth: lessons from microeconomic evidence. In *New Directions in Productivity Analysis*, ed. E Dean, M Harper, C Hulten, pp. 303–72. Chicago: Univ. Chicago Press

Foster L, Haltiwanger J, Krizan C. 2006. Market selection, reallocation, and restructuring in the U.S. retail trade sector in the 1990s. *Rev. Econ. Stat.* 88:748–58

Frankel J, Romer D. 1999. Does trade cause growth? *Am. Econ. Rev.* 89:379–99

Freeman C. 1982. *The Economics of Industrial Innovation*. Cambridge, MA: MIT Press

Galor O. 2011. *Unified Growth Theory*. Princeton, NJ: Princeton Univ. Press

Garcia-Macia, D, Hsieh C, Klenow P. 2014. *How destructive is innovation?* Unpublished manuscript, Stanford Univ., Stanford, CA

Griliches Z. 1990. Patent statistics as economic indicators: a survey. *J. Econ. Lit.* 28:1661–707

Hall B, Jaffe A, Trajtenberg M. 2001. *The NBER patent citation data file: lessons, insights and methodological tools*. NBER Work. Pap. 8498
Haltiwanger J, Jarmin R, Miranda J. 2013. Who creates jobs? Small versus large versus young. *Rev. Econ. Stat.* 95:347–61
Hsieh C, Klenow P. 2009. Misallocation and manufacturing TFP in China and India. *Q. J. Econ.* 124:1403–48
Hsieh C, Klenow P. 2014. The life cycle of plants in India and Mexico. *Q. J. Econ.* 129:1035–84
Hurst E, Pugsley B. 2011. What do small businesses do? *Brookings Pap. Econ. Act.* 43(2):73–142
Ijiri Y, Simon H. 1977. *Skew Distributions and the Sizes of Business Firms*. Amsterdam: North-Holland
Jones C, Vollrath D. 2013. *Introduction to Economic Growth*. New York: Norton
Klette T, Kortum S. 2004. Innovating firms and aggregate innovation. *J. Polit. Econ.* 112:986–1018
Kumar KB, Rajan RG, Zingales L. 1999. *What determines firm size?* NBER Work. Pap. 7208
La Porta R, Lopez-de-Silanes F, Shleifer A, Vishny RW. 1997. Trust in large organizations. *Am. Econ. Rev.* 87:333–38
Laeven L, Woodruff C. 2007. The quality of the legal system, firm ownership, and firm size. *Rev. Econ. Stat.* 89:601–14
Lentz R, Mortensen D. 2008. An empirical model of growth through product innovation. *Econometrica* 76:1317–73
Lucas RE. 1978. On the size distribution of business firms. *Bell J. Econ.* 9:508–23
Nelson R, Phelps E. 1966. Investment in humans, technological diffusion, and economic growth. *Am. Econ. Rev.* 61:69–75
Nickell S. 1996. Competition and corporate performance. *J. Polit. Econ.* 104:724–46
Pennings JM, Buitendam A. 1987. *New Technology as Organizational Innovation: The Development and Diffusion of Microelectronics*. Cambridge, MA: Ballinger
Peretto P. 1998. Technological change, market rivalry, and the evolution of the capitalist engine of growth. *J. Econ. Growth* 3:53–80
Romer P. 1990. Endogenous technical change. *J. Polit. Econ.* 98:71–102
Rossi-Hansberg E, Wright M. 2007. Establishment size dynamics in the aggregate economy. *Am. Econ. Rev.* 97:1639–66
Scherer FM. 1984. *Innovation and Growth: Schumpeterian Perspectives*. Cambridge, MA: MIT Press
Schmalensee R. 1989. Inter-industry studies of structure and performance. In *Handbook of Industrial Organization*, Vol. 2, ed. R Schmalensee, RD Willig, pp. 951–1009. Amsterdam: North-Holland
Segerstrom P, Anant T, Dinopoulos E. 1990. A Schumpeterian model of the product cycle. *Am. Econ. Rev.* 88:1077–92
Simon H, Bonini C. 1958. The size distribution of business firms. *Am. Econ. Rev.* 48:607–17
Stanley M, Buldyrev S, Havlin S, Mantegna R, Salinger M, Stanley E. 1995. Zipf plots and the size distribution of firms. *Econ. Lett.* 49:453–57
Syverson C. 2011. What determines productivity? *J. Econ. Lit.* 49:326–65
Tushman ML, Anderson P. 1986. Technological discontinuities and organizational environments. *Adm. Sci. Q.* 31:439–65
Vandenbussche J, Aghion P, Meghir C. 2006. Growth, distance to frontier, and composition of human capital. *J. Econ. Growth* 11:97–127
Weil D. 2012. *Economic Growth*. Englewood Cliffs, NJ: Prentice Hall

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