Modern Economy, 2023, 14, 41-49
https://www.scirp.org/journal/me
ISSN Online: 2152-7261
ISSN Print: 2152-7245

Demographic Structure and Productivity Catch-Up: Theory and Evidence

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How to cite this paper: Li, Y., & Lo, C.-P. (2023). Demographic Structure and Productivity Catch-Up: Theory and Evidence. *Modern Economy, 14,* 41-49.
https://doi.org/10.4236/me.2023.142004

Received: January 6, 2023
Accepted: February 3, 2023
Published: February 6, 2023

Abstract

A simple model is presented to show that productivity growth falls with firm age in a country with well-developed financial market (e.g., the U.S.), but increases with firm age in a country with poor financial development (e.g., India). However, although being poor in formal financial development, China's prosperous folk financing helps small young firms break through the limitation of credit constraint, achieving higher productivity growth than the old ones. This paper suggests that governments should support start-ups through financial development, a complement rather than a complete replacement of folk financing, to encourage the creation of more productive new companies.

Keywords

China, India, Folk Financing, Misallocation, Credit Constraint

1. Introduction

Hsieh & Klenow (2009) document that misallocation reduces aggregate productivity in a country. Compared to old firms, young firms might achieve higher productivity growth on average due to less adjustment costs.[1] By plotting the log of average total factor productivity by the percentile of firm age, they show that the productivity growth of the U.S. does steadily fall with firm age. Conversely, productivity growth in India steadily increases with firm age. Nevertheless, productivity growth in China, similar to the U.S., decreases with firm age. Only for a

[1]The literature presents that, when exploring some new business or changing the level of production, firms will undertake substantial adjustment costs, consisting of hiring and layoff costs, overtime costs, inventory costs, and machine set-up costs (Holt et al., 1960; Peck, 1974; Ito, Bresnahan & Greenstein, 1999; Hamermesh & Pfann, 1996). Installing new equipment or structures not only generates disruption costs during installation, but also often involves delivery lags and time to install the new investment (Cooper & Haltiwanger, 2006).

small portion of firms in the youngest decile does productivity growth in China (like in India) rise with firm age (**Figure 1**).

It is not the scope of Hsieh & Klenow (2009)'s research to examine the asymmetric impact of misallocation between young and old firms. To fill this gap in the literature and to address this issue, we employ Acemoglu, Aghion, & Zilibotti (2006)'s framework, where financial development is crucial to innovation (Aghion, Howitt, & Mayer-Foulkes, 2005). Generally, old firms suffer greater adjustment costs when engaging in new business than do young firms, but credit markets exhibit a higher threshold against the latter. We argue that productivity growth falls with firm age in a country like the U.S. that has good financial development, but increases with firm age in a country like India with poor financial development.[2]

Although China's formal financial development is also poor,[3] its folk financing is rather large and prosperous and in fact provides at least 30% of the total amount of financing, especially to mostly small private firms in China (Gao, 2006).[4]

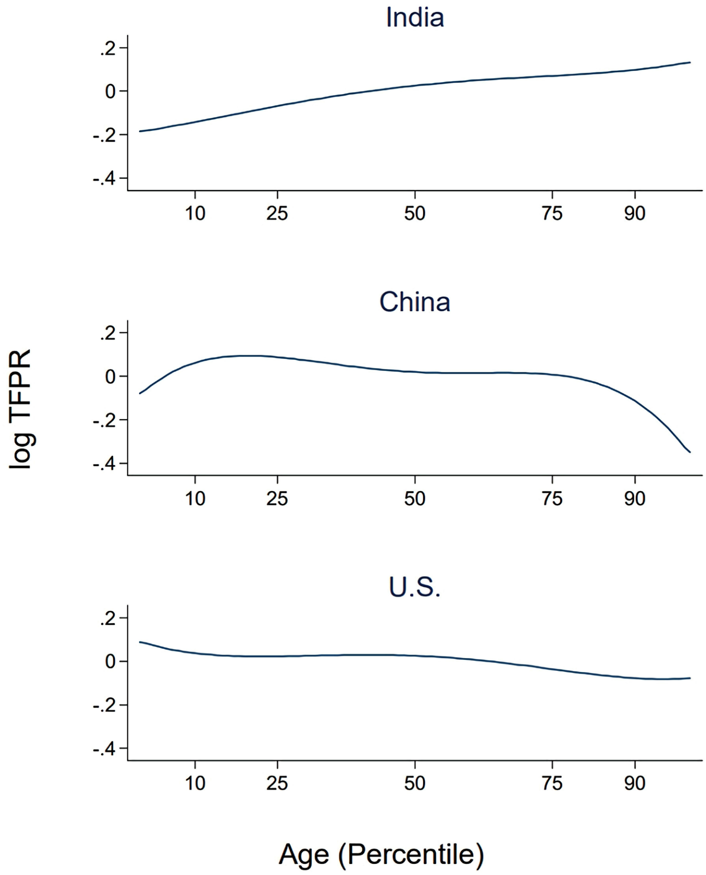

Figure 1. Log of productivity growth against firm age. Source: Hsieh & Klenow (2009: Figure 7).

[2]The banking sector in India has remained heavily regulated for a long time (Pal, 2014).

[3]Previously, all banks in China were state-owned and made more than 85% of their loans to state-owned enterprises (SOE).

[4]Folk financing, which is mostly borrowing among families, relatives, and friends, is extremely active in China, due to the "high threshold" of the SOE bank credit limitation against small private firms.

Folk financing helps small, private Chinese firms break through the limitation of credit constraint, such that firm productivity growth in China, similar to the U.S., falls with firm age.

Why productivity growth might fall with firm age in a country with well-developed financial market (e.g., the U.S.), but increase with firm age in a country with poor financial development (e.g., India)? In order to investigate this issue, we present a simple model to argue that folk financing could be one of the reasons behind the scene. We argue that, although being poor in formal financial development, China's prosperous folk financing helps small young firms break through the limitation of credit constraint, achieving higher productivity growth than the old ones.

The paper proceeds as follows. Section 2 sets up our benchmark model. Theoretical predictions are discussed in section 3. Section 4 concludes the paper.

2. The Model

Following Acemoglu, Aghion, & Zilibotti (2006), this study sets up one representative closed economy with a fixed labor supply L in each of two discrete periods. Each individual lives for two periods and is endowed with two units of labor services in each period. One unit of labor service is engaged in final-good production, while the remaining one is devoted to innovation. Everyone shares the same utility function linear in consumption: $U = c_1 + \beta c_2$, $1 > \beta > 0$.

2.1. The Final-Good Sector

The country produces one final-good in each period, which is manufactured by labor and a continuum of specialized intermediate goods as

$$Z_t = L^{1-\alpha} \int_0^1 A_t(i)^{1-\alpha} x_i(i)^{\alpha} \, \mathrm{d}i, \quad 0 < \alpha < 1, \tag{1}$$

where $x_i(i)$ is the input of the latest version of intermediate good *i*, and $A_t(i)$ is the productivity parameter associated with it. The final good is not only for consumption, but also serves as capital input to both intermediate-good production and innovation.

For convenience we presume a continuum of individuals in this country by normalizing L to unity. Thus, aggregate and per-capita quantities are identical. The production function in (1) can be rewritten as:

$$Z_t = \int_0^1 A_t(i)^{1-\alpha} x_i(i)^{\alpha} \, \mathrm{d}i .$$

The general final-good is produced under perfect competition, and so the price of each intermediate good equals its marginal product as below:

$$p_t(i) = \alpha \left(\frac{x_i(i)}{A_t(i)} \right)^{\alpha-1} . \tag{2}$$

2.2. The Intermediate-Good Sector

Each individual is capable of being an innovator to create a specific technology to produce the firm-specific intermediate-good, say *i*. We presume similarity for simplicity, such as $A_{t-1}(i) = A_{t-1}, \forall i$, to remove the subscript *i* hereafter. In this model, a portion of intermediate-good producers are old firms, denoted by an exogenous parameter λ_t, while the remaining $1-\lambda_t$ portion denotes young firms. In period one, old firms are generally endowed with better technology than young firms due to such advantages as first mover or larger economies of scale, implying $A_{t-1}^o \geq A_{t-1}^y$.

Let μ_f be the probability that a firm succeeds in innovation for every intermediate-good, where $f \in (y, o)$, *o* denotes old, and *y* denotes young:

$$A_t^f = \begin{cases} \kappa \bar{A}_t & \text{with proability } \mu_f \\ \kappa \bar{A}_{t-1} & \text{with probability } 1-\mu_f \end{cases}, \tag{3}$$

where $\bar{A}_t$ is the global technology frontier that grows at a constant rate *g*, such that $\bar{A}_t = (1+g)\bar{A}_{t-1}$. Here, we assign a constant parameter κ to represent the limitation of technology diffusion across borders, whereby $1 \geq \kappa > 0$.

As for a country, where a firm is able to make profits by producing any amount of the intermediate good at a unit cost of χ if the individual innovator succeeds in innovation; otherwise, the firm makes zero profit since it could only employ the outdated technology as production takes place under perfect competition. Employing (2), the quantity demanded of the intermediate-good is:

$$x_t^f = \kappa (\alpha/\chi)^{\frac{1}{1-\alpha}} A_t^f .$$

The profit of a firm with successful innovation is $\pi_t^f = \pi \bar{A}_t$, where $\pi = \kappa(\chi - 1)\varsigma$ and $\varsigma = (\alpha/\chi)^{1/(1-\alpha)}$.

2.3. Young and Old Firms

We define the country's "average productivity" as $A_t = \int_0^1 A_t(i)\,\mathrm{d}i$. The innovations are distributed randomly across sectors, such that

$$A_t = \lambda_t A_t^o + (1-\lambda_t) A_t^y , \tag{4}$$

where $A_t^o \equiv \mu_o \kappa \bar{A}_t + (1-\mu_o)\kappa \bar{A}_{t-1}$ and $A_t^y \equiv \mu_y \kappa \bar{A}_t + (1-\mu_y)\kappa \bar{A}_{t-1}$ denote the expected productivity of one representative young firm and old firm, respectively.

Substituting (4) into (1), the gross output of the general good is:

$$Z_t = \varsigma A_t .$$

Define the country's technology gap as it relates to its technology frontier as

$$a_t = A_t / \bar{A}_t .$$

Define the country's productivity gap of the young firms related to old firms as

$$G_t = A_t^y / A_t^o .$$

Through (4), the productivity gap evolves according to:

$$G_t = \frac{1+g\mu_y}{1+g\mu_o} . \tag{5}$$

Since final-good sector is perfectly competitive, wage rate w_t is the marginal product of labor in producing the final good:

$$w_t = (1-\alpha) Z_t = (1-\alpha)\varsigma A_t . \tag{6}$$

2.4. Innovation Sector

Acemoglu, Aghion, & Zilibotti (2006) set up the cost function of innovation as:

$$N_t = \tilde{n}(\mu_f)\kappa \bar{A}_t ,$$

where N_t is the quantity of the general final-good that must be invested in innovation, $\kappa \bar{A}_t$ is the achieved technology stock after successful innovation, and the term $\tilde{n}(\mu_f)$ denotes a positive relation between the above two terms. Considering that there exist the "fishing-out" effect in innovations, we suggest $\tilde{n}(\mu_f) = (\eta\mu_f + \delta_f \mu_f^2/2)$ to capture this effect that further ahead the frontier moves, the more difficult it is to innovate. Compared to young firms, when engaging in new production, an old firm not only incurs more disruption costs, but also encounters longer delivery lags and time to adjust (Cooper & Haltiwanger, 2006). We thus argue that old firms incur a larger fishing-out effect than young firms, which is seen as $\delta_o > \delta_y$.

Free entry by innovators makes the expected net payoff from the innovation equal the cost of innovation investment:

$$\beta\mu_f \pi(\kappa \bar{A}_t) - N_t = 0 , \tag{7}$$

which gives an equilibrium probability of successful innovation $\mu_f^* = (\beta\pi - \eta)/\delta_f$.

The equilibrium expenditure in innovation is thus:

$$N_t^{f*} = \frac{1}{2\delta_f}\left((\beta\pi)^2 - \eta^2\right)\bar{A}_t ,$$

where we presume $\eta < \beta\pi$ to ensure positive investment. With $\delta_o > \delta_y$, it is interesting to obtain $N_t^{y*} > N_t^{o*}$ and $\mu_y^* > \mu_o^*$, that is, due to less fishing-out effects, young firms are more likely to invest on innovation and hence become more creative than old firms.

2.5. Equilibrium Innovation under Perfect Credit Markets

Suppose that only old firms can borrow unlimited quantities, and a longer credit record is one of the reasons behind that. In (7), an old firm's equilibrium expenditure on innovation is $N_t^{o*} = n_o^* \kappa \bar{A}_t$. With (6), we obtain $n_o^* = (1-\alpha)\varsigma\kappa a_t$. Put the above together, the optimal probability of innovation for old firms becomes:

$$\begin{aligned} \mu_o^* &= \frac{1}{\delta_o}\left(\sqrt{2\delta_o n_o^* + \eta^2} - \eta\right) \\ &= \frac{1}{\delta_o}\left(\sqrt{2\varsigma\kappa a_t (1-\alpha)\delta_o + \eta^2} - \eta\right), \end{aligned} \tag{8}$$

which decreases with the fishing-out effect.

2.6. Credit Constraints

We now suppose that credit markets are imperfect, especially to young firms, such that the young firms cannot sufficiently access the credit market as the old firms. With the wage income w_t, a firm thus investing N_t in an innovation project has to borrow:

$$l_t = N_t^f - w_t .$$

Following Aghion, Banerjee, & Piketty (1999), suppose at a cost cN_t^f that an innovator can default even after achieving a successful innovation, where $1 > c_f > 0$. It should be a costly option for old/large firms to conduct fraud than for young/small firms, since the former usually have more collateral security and a better credit record as $c_o > c_y$. Therefore, by being better protected, creditors are more likely to make loans to old/large entrepreneurs.

Aghion, Banerjee and Piketty refer to this cost as an indicator of the degree of creditor protection. An innovator chooses whether to default, conditioned on the following incentive-compatibility constraint:

$$c_f N_t^f \geq \mu_f R\left(N_t^f - w_t\right), \tag{9}$$

where R is the interest factor on the loan. An arbitrage condition is satisfied as

$$\mu_f^*\left(n_f^*\right) R = 1/\beta .$$

The incentive-compatibility condition in (9) and the above condition boils down to an upper limit on a young firm's investment:

$$N_t^f \leq \frac{1}{1-\beta c_f} w_t .$$

This limit will be binding if the innovation investment reaches its optimal level.

The equilibrium expenditure on innovation for young firms is $N_t^{f*} = n_f^* \kappa \bar{A}_t$. With (6), we get $n_f^* = \varsigma(1-\alpha)\left(1-\beta c_f\right)^{-1} \kappa a_t$, where $n_f^* = \tilde{n}\left(\mu_f^*\right) = \left(\eta\mu_f^* + \delta_f \mu_f^{*2}/2\right)$. Similarly, the optimal probability of innovation for firms becomes:

$$\mu_f^* = \frac{1}{\delta_f}\left(\sqrt{\frac{2\varsigma\kappa a_t (1-\alpha)\delta_f}{1-\beta c_f} + \eta^2} - \eta\right), \tag{10}$$

which increases with an improvement on financial development (larger *c*) and decreases with the fishing-out effect (larger δ). A country's productivity gap of young firms relative to old firms in (5) becomes:

$$G_t^* = \frac{1+g\mu_y^*}{1+g\mu_o^*}, \tag{11}$$

which is solely determined by their relative rate of innovation.

3. Discussion

In the following, we highlight three cases of financial development to discuss the productivity growth of old firms versus young firms.

Case 1: A country with good financial development (i.e., $c_o = c_y \to 1$).

If the credit market limitation to young firms is sufficiently small, such as young firms are almost easily access to the final markets as the old firms as $c_o = c_y \to 1$, then with (10), we get the optimal probability of innovation for old and young firms as $\mu_o^* = \frac{1}{\delta_o}\left(\sqrt{\frac{2\varsigma\kappa a_t(1-\alpha)\delta_o}{1-\beta}+\eta^2}-\eta\right)$ and $\mu_y^* = \frac{1}{\delta_y}\left(\sqrt{\frac{2\varsigma\kappa a_t(1-\alpha)\delta_y}{1-\beta}+\eta^2}-\eta\right)$, respectively. While we allow the "fishing-out" effect in innovation to increase with the age of firms as $\delta_o > \delta_y$, it is easy to observe that firm productivity decreases with the age of firms as $\mu_o^* < \mu_y^*$. Thus, in (11) we obtain $G_t^* > 1$ in a country with a strongly developed financial market, as is just illustrated in **Figure 1** (e.g., the U.S.).

Case 2: A country with poor financial development (i.e., $c_o \to 1; c_y \to 0$).

If the credit market limitation to young firms is substantially large while, instead, is favorable to old firms. For expedient, let's take an extreme case as $c_o \to 1; c_y \to 0$, then with (9), we get the optimal probability of innovation for old and young firms as $\mu_o^* = \frac{1}{\delta_o}\left(\sqrt{\frac{2\varsigma\kappa a_t(1-\alpha)\delta_o}{1-\beta}+\eta^2}-\eta\right)$ and $\mu_y^* = \frac{1}{\delta_y}\left(\sqrt{2\varsigma\kappa a_t(1-\alpha)\delta_y+\eta^2}-\eta\right)$, respectively. While the discount factor β is usually vary large as it comes close to one, we can argue that in those cases as $c_o \gg c_y$ the financial market distortion dominates the fishing-out effect such that $\mu_o^* > \mu_y^*$. In (11), we obtain $G_t^* < 1$ in a country with a poorly developed financial market, where young firms are generally less productive than old firms (e.g., India in **Figure 1**).

Case 3: A country with poor financial development, but prosperous folk financing (i.e., $c_y \to c_o$).

Even when formal financing is poor, a prosperous informal (folk) financing channel might make young firms indirectly access to financial market, such as c_y is considerably getting close to c_o as $c_y \le c_o$. As a result, with (10) again, we get the optimal probability of innovation for old and young firms as

$$\mu_o^* = \frac{1}{\delta_o}\left(\sqrt{\frac{2\varsigma\kappa a_t(1-\alpha)\delta_o}{1-\beta c_o}+\eta^2}-\eta\right) \text{ and } \mu_y^* = \frac{1}{\delta_y}\left(\sqrt{\frac{2\varsigma\kappa a_t(1-\alpha)\delta_y}{1-\beta c_y}+\eta^2}-\eta\right),$$

respectively. With $\delta_o > \delta_y$, it is easy to observe $\mu_o^* < \mu_y^*$ if the difference between c_y and c_o is sufficiently small. It turns out that $G_t^* > 1$ in a country where folk financing is a good supplement to formal financing (e.g., China). As illustrated in **Figure 1**, young firms are more likely to be productive than old firms. Only the youngest decile firms might be too small to have access to even folk financing, such that their productivity growth rises with firm age.

4. Concluding Remarks

It has been well documented that young firms, especially technology-oriented business start-ups, play a significant role in innovation and in high-technology employment, accounting for a disproportionately large share of aggregate job creation (Haltiwanger, Jarmin, & Miranda, 2013; Malfense Fierro, 2015) and playing a vital role in pioneering and developing new markets through productivity-enhancing creative destruction (Foster, Haltiwanger, & Krizan, 2006). However, mostly due to credit limitation in financing, young firms tend to have a lower probability of survival than incumbent larger enterprises. A policy implication of this paper suggests that governments should support start-ups through a number of mechanisms, which functions as a complement rather than a complete replacement of the folk financing, in order to ensure their survival and encourage the creation of more productive new companies.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Acemoglu, D., Aghion, P., & Zilibotti, F. (2006). Distance to Frontier, Selection, and Economic Growth. *Journal of the European Economic Association, 4,* 37-74. https://doi.org/10.1162/jeea.2006.4.1.37

Aghion, P., Banerjee, A., & Piketty, T. (1999). Dualism and Macroeconomic Volatility. *The Quarterly Journal of Economics, 114,* 1359-1397. https://doi.org/10.1162/003355399556296

Aghion, P., Howitt, P., & Mayer-Foulkes, D. (2005). The Effect of Financial Development on Convergence: Theory and Evidence. *Quarterly Journal of Economics, 120,* 173-222.

Cooper, R. W., & Haltiwanger, J. C. (2006). On the Nature of Capital Adjustment Costs. *Review of Economic Studies, 73,* 611-633. https://doi.org/10.1111/j.1467-937X.2006.00389.x

Dwesar, R., & Kesharwani, A. (2019). Examining Intra-Industry Trade between India & China: Is India on the Right Track? *Theoretical Economics Letters, 9,* 1834-1851. https://doi.org/10.4236/tel.2019.96117

Foster, L., Haltiwanger, J., & Krizan, C. J. (2006). Market Selection, Reallocation, and Restructuring in the US Retail Trade Sector in the 1990's. *Review of Economics and Statistics, 88,* 748-758. https://doi.org/10.1162/rest.88.4.748

Gao, F. (2006). The Development of China's Non-Governmental Finance. *Commercial Research,* 60-64.

Haltiwanger, J., Jarmin, R., & Miranda, J. (2013). Who Creates Jobs? Small versus Large versus Young. *Review of Economics and Statistics, 95,* 347-361. https://doi.org/10.1162/REST_a_00288

Hamermesh, D. S., & Pfann, G. (1996). Adjustment Costs in Factor Demand. *Journal of Economic Literature, 34,* 1264-1292.

Holt, C., Modigliani, F., Muth, J., & Simon, H. (1960). *Planning Production, Inventories, and Work Force.* Prentice-Hall.

Hsieh, C.-T., & Klenow, P. J. (2009) Misallocation and Manufacturing TFP in China and India. *Quarterly Journal of Economics, 124,* 1403-1448. https://doi.org/10.1162/qjec.2009.124.4.1403

Ito, H., Bresnahan, T., & Greenstein, S. (1999). *The Sources and Effects of Investment Irreversibility: Large Scale Computing.* Mimeo.

Malfense Fierro, A. (2015). How should governments support small firms? *World Economic Forum*. https://www.weforum.org/agenda/2015/12/how-should-governments-support-small-firms/

Pal, M. (2014). Financial Development in India: An Empirical Test of the Mckinnon—Shaw Model. In: A. Ghosh, & A. Karmakar (eds.), *Analytical Issues in Trade, Development and Finance*, Springer. https://doi.org/10.1007/978-81-322-1650-6_24

Peck, S. (1974). Alternative Investment Models for Firms in the Electric Utilities Industry. *Bell Journal of Economics and Management Science, 5,* 420-458. https://doi.org/10.2307/3003117