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Firm heterogeneity, R&D, and economic growth☆

Hyunbae Chun [a,1], Joonkyung Ha [b,*], Jung-Wook Kim [c,2]

[a] Department of Economics, Sogang University, Seoul 121-742, Republic of Korea
[b] Division of Economics, Hanyang University, Ansan 426-791, Republic of Korea
[c] Graduate School of Business, Seoul National University, Seoul 151-916, Republic of Korea

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ABSTRACT

In this paper, we establish a link between firm heterogeneity and long-run economic growth both theoretically and empirically. We show that firms' technological heterogeneity creates the diversification effect for R&D financiers, facilitating R&D investment, and thus leading to long-run economic growth. This result holds even when heterogeneity limits the possibility of a synergy effect between firms with similar technologies. In testing the model's prediction using U.S. firm-level data, we define industries with higher firm-specific or idiosyncratic stock return volatility as those exhibiting higher firm-level technological heterogeneity and find a positive link between this measure and R&D intensity. Our paper implies that an economic growth policy aimed at increasing the diversity of the corporate sector may be more effective in attracting private R&D investments than the one aimed at concentration of resources on homogeneous projects due to the foregone diversification benefit of the latter.

1. Introduction

In this paper, we attempt to establish a link between firm heterogeneity, R&D, and economic growth, both theoretically and empirically. Morck et al. (2000) report that countries with higher level of firm performance heterogeneity exhibit higher level of per capita GDP. However, the underlying reason for why firm heterogeneity and economic growth should be positively related is yet to be explained.

Existing literature on related topics focuses on the implication of diversity in products (Romer, 1990; Young, 1928) and in sectors (Acemoglu and Zilibotti, 1997) on long-run economic growth. We supplement this literature by providing a link between firm-heterogeneity and R&D financing in a simple economic model.

In our model, firm heterogeneity is viewed as diversified technologies, success of which is determined randomly. Firms with the same technology are regarded to be homogenous. Homogeneity among firms would imply that each firm's growth would exhibit higher comovement and thus, be driven more by systematic component rather than firm-specific component. In contrast, heterogeneous technologies among firms would imply that each firm's growth would be driven more by firm-specific component rather than by systematic component. We assume that the financial sector is well organized so that there is no friction in mobilizing investment funds. Households provide necessary funds for R&D activities and the R&D portfolio is constructed by a fund manager. With these assumptions, we show that the increased firm heterogeneity provides a valuable diversification opportunity for the R&D portfolio fund manager, thus increasing the overall R&D activity of the economy. This firm-level diversification effect is shown to outweigh the potential synergy effect that may come from the benefit of focusing on a small number of technologies. This has an important implication that 'focus' and 'concentration' may increase systematic risk and thus, exert a negative impact on the long-run economic growth.

We test the model's prediction using U.S. firm-level data by examining whether industries with more heterogeneous firms exhibit higher R&D intensity, which would increase the long-run industry growth. We define industries with higher firm-specific or idiosyncratic stock return volatility as those exhibiting higher firm-level technological heterogeneity. We find a positive link between this heterogeneity measure and R&D intensity. We use monthly stock returns covered in the Center for Research in Security Prices (CRSP) data from 1971 to 2006 to calculate the firm-specific heterogeneity for each firm each year and then aggregate this at the 2-digit industry-level. R&D and other variables are obtained from

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* Corresponding author. Tel.: +82 31 400 5622; fax: +82 31 436 8180.
E-mail addresses: hchun@sogang.ac.kr (H. Chun), jha@hanyang.ac.kr (J. Ha), jwkim87@snu.ac.kr (J.-W. Kim).
[1] Tel.: +82 2 705 8515; fax: +82 2 704 8599.
[2] Tel.: +82 2 880 6986; fax: +82 2 878 3154.

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Compustat for the same period. We find that industries with higher firm-specific stock return heterogeneity exhibit higher industry-level R&D intensity.

Our model's predictions are related with recent empirical and theoretical literature which examines the relationship between volatility and economic growth. Using cross-country data, Ramey and Ramey (1995) find a negative relationship between the GDP growth volatility and GDP growth. They explain that low aggregate growth volatility provides a stable environment for investment, thus prompting capital accumulation. However, an opposite relationship between volatility and growth is reported from sectoral and firm level analyses. Imbs (2007) finds that sectors with higher growth rate volatilities grow faster in his cross-country study. Chun et al. (2008) analyze U.S. firm-level data and find that industries with higher firm-specific volatilities in stock returns and sales growth grow faster. Both Imbs (2007) and Chun et al. (2008) argue that the high level of sectoral or firm-level growth volatility could be consistent with the low level of aggregate level volatility if sector-specific or firm-specific component in growth, which could be diversified, is larger than systematic component. Acemoglu and Zilibotti (1997), Koren and Tenreyro (2013), and Michelacci and Schivardi (2013) find that economies that could benefit from reduced risk through diversification would grow faster. Our paper supplements these findings by focusing on the role of firm heterogeneity in facilitating R&D funding.

Our empirical evidence obtained from firm-level analysis supplements Imbs (2007) who examines the impact of diversification on economic growth using industry-level data. Our finding is different from those studies which examine the implication of the within-firm diversification and R&D activity (Garcia-Vega, 2006; Link and Long, 1981; Peyrefitte and Brice, 2004; Tanriverdi and Lee, 2008) since our work focuses on the implication of firm heterogeneity in the industry-level R&D funding.

This paper is organized as follows; Section 2 presents the model. Section 3 shows the empirical analysis and Section 4 concludes the paper.

2. The model

The model formally shows the relationship between firm heterogeneity and R&D investment. The model follows the basic framework of Acemoglu and Zilibotti (1997), but differs in that the model does not assume any fixed cost for setting up a sector. Furthermore, the model considers the possibility of a synergy effect from concentration, and also analyzes the case where there are an integer number of firms instead of a continuum of points. The last feature enables us to analyze shocks to individual firms and provides the connection between theory and empirics. We interpret technological diversification as something happening among firms, not necessarily among sectors. We will first analyze how firm heterogeneity affects R&D activities in the macroeconomy, and then we will turn to the issue of concentration versus diversification.

The basic channel through which firm heterogeneity affects R&D is that (1) firm heterogeneity provides a richer opportunity for risk diversification, and (2) this leads to more investments in R&D through financial markets. Here, firm heterogeneity is viewed as diversified technologies: the firms with the same technology are regarded to be homogeneous. We also assume that the financial sector is well organized so that there are no frictions in mobilizing investment funds.

The model analyzes overlapping generations; individuals live two periods (young and old). The total population is constant and normalized, so that each generation has a unit mass. For simplicity, individuals born at date t are assumed to work and save in t and consume only in $t+1$.

There is an uncertainty over the state of nature in $t+1$: there are N different states with equal probability in $t+1$. We have:

$$\text{States of nature}: s \in \{1, 2, \ldots, N\} \text{ with equal probability } 1/N. \quad (1)$$

2.1. Benchmark case: no externalities of clustering

We will first analyze the benchmark case where there are no externalities driven by the synergy effect of clustering in the same technology. The expected utility function of households can be written as follows:

$$E_t U(c_{t+1}) = \sum_{s=1}^{N} \frac{1}{N} \log\left(c_{t+1}^{s}\right) \quad (2)$$

where c_{t+1}^{s} is consumption in state s at time $t+1$. Households can choose between risky asset and safe asset to maximize the expected utility. Specifically, there are two different assets that can be purchased in period t. First, one can choose the safe asset whose rate of return is r in any state for $t+1$, which means that if you invest one dollar in t, you get r dollars in $t+1$. Second, there is the risky asset or R&D fund, whose average rate of return is R, which is strictly greater than r (i.e., $R > r$).[3] The variance of R is determined by the firm sector, which will be shown later. Households make decisions on the amount of safe asset, which is B, and risky asset, which is F, given their income W in t.

In a sector, there are N firms engaged in innovative activities. Here, the number of firms, N, is the same as the number of states in $t+1$ for convenience. We assume that each firm should get financed from the R&D fund, F, to survive.

Each firm uses technology i that becomes productive only if $s = i$ in $t+1$, which means a firm's return becomes positive only if the state of nature turns out to be favorable to the firm. Therefore, we have:

$$\text{Firm's return}: \begin{cases} R, & \text{if } i = s (\text{if its bet is successful}), \\ 0, & \text{otherwise}. \end{cases} \quad (3)$$

As for the R&D fund, we assume that the fund is managed by a fund manager, who chooses the portfolio of the fund. Specifically, the fund manager chooses M different technologies that will be invested by the fund, given the amount of F. This means that only M different technologies are in operation in period $t+1$.[4] It is also assumed that the manager distributes the R&D fund F across M technologies equally. Therefore, the number of firms in each technology group i is simply N/M.

The return of the R&D fund in period $t+1$ depends on the realization of s. If $s = i$, which means that if the state of nature turns out to reward technology i, then each firm in group i generates R, so that $(N/M)R$ is the fund's return in state i. If s is not equal to i, group i's return is 0. Therefore, the expected return of the fund is:

$$E(R_F) = \sum_{s=1}^{M} \frac{1}{N} \frac{N}{M} R + 0 = R. \quad (4)$$

[3] In fact, R&D is only part of risky assets. However, the major proposition of this paper is that more heterogeneity leads to more R&D and can be rewritten as follows: higher firm heterogeneity leads to more risky investments, and more risky investments lead to more R&D. This means that the results of this paper are not affected by the fact that R&D is only part of risky investments as long as more risky investments lead to more R&D. We believe that this is warranted by reality as well as the convention of related researches such as Acemoglu (2009), Aghion and Howitt (2009), and many others where R&D cannot be undertaken without sufficient supply of funds which is subject to high risk and proper management of risks. The return of R&D is inherently uncertain and usually follows stochastic processes, so private R&D requires well developed financial markets and risky investments.

[4] This implies that firms without R&D fund do not survive, which may sound unrealistic. However, this assumption makes the model much simpler without changing the core results. In order to make the model more realistic, one could assume that no R&D firms generate lower returns than R&D firms. Our paper's main results are not affected by the new assumption.