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The struggle to survive in the R&D sector: Implications for innovation and growth[☆]

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HIGHLIGHTS

- We model endogenous survival activity by R&D firms to prevent product obsolescence.
- We show that R&D subsidies deliver insufficient investments for *survival*.
- This may depress innovation and growth in the long run.
- This occurs when legal patent protection is too strong.

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ABSTRACT

By allowing for investment activities by research and development (R&D) firms to prevent product obsolescence, we show that if legal patent protection is too strong, a higher R&D subsidy rate delivers insufficient investments for survival in the R&D sector, depressing innovation and growth in the long run.

1. Introduction

The essential role of the entry, exit, and survival of firms has been emphasized in growth theory. In Schumpeterian growth models,[1] the economy grows through survival cycles commencing with the entry of a research and development (R&D) firm inventing a new high-quality technology and ending with the exit of the firm by destruction of its rents once a newer technology is introduced. Recent research stresses endogenous survival of firms engaging in private rent protection and examines the consequences for innovation and long-run growth (Dinopoulos and Syropoulos, 2007; Eicher and García-Peñalosa, 2008).[2] In line with these studies, this note examines the effects of R&D policies on firm survival, innovation, and growth.

The struggle to survive in the real world typically requires that firms make dynamic decisions.[3] We highlight this aspect, using a variety-based growth model with product obsolescence

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1 See Segerstrom et al. (1990), Grossman and Helpman (1991), and Aghion and Howitt (1992).

2 See Grieben and Şener (2009), Radhakrishnan (2011), and Davis and Şener (2012) for quality-ladder models based on Dinopoulos and Syropoulos's setting. See Akiyama and Furukawa (2009) and Akiyama et al. (2011) for a North–South analysis. Another related work is Thoenig and Verdier (2003), who use a quality-based model to argue that a firm can endogenously avoid obsolescence by using a defensive, more tacit-knowledge-intensive technology. More broadly, our basic framework may be related to the market quality theory of Yano (2008, 2009), in which institutions are considered endogenous.

3 This is the common view in a variety of fields including industrial organization, marketing, and technology management. See, for example, Agarwal and Gort (2002).

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(Lai, 1998). In doing so, we model R&D firms engaging in investments with the aim of increasing their probability of survival against obsolescence by means of a dynamic programming approach provided by Akiyama et al. (2011).[4] This approach results in a tractable equilibrium behavior of surviving firms, which is analogous to the equilibrium behavior in Dinopoulos and Syropoulos's (2007) quality-ladder model.

The main finding of this paper is that if R&D firms invest in their intertemporal survival, R&D subsidies may reduce innovation and long-run growth. Specifically, if patent protection is too strong,[5] a higher R&D subsidy rate delivers insufficient investments for the survival of R&D firms, depressing innovation and growth in the long run.

This contrasts with the property of the standard R&D-based growth model whereby R&D subsidies promote innovation and growth, which holds in the Dinopoulos and Syropoulos model. In addition, the policy implication of our result is new to the literature[6] in suggesting a substantial interdependence between the two R&D policy instruments of R&D subsidies and patent protection (breadth). This note extends this line of research by showing that R&D subsidies can interact with patent policy to have a negative effect on innovation and growth.

2. The model

We consider a variety expansion model of endogenous growth à la Romer (1990) and Grossman and Helpman (1991). We assume discrete time because it is useful to model endogenous survival activities of firms in a variety expansion model by means of the dynamic programming approach (Akiyama et al., 2011). There is an infinitely lived representative consumer who inelastically supplies L units of labor in each period. This consumer is endowed with the utility function $U = \sum_{t=0}^{\infty} \beta^t \ln C_t$, where $\beta \in (0, 1)$ is the time preference rate and the consumption C_t is defined as a constant elasticity of substitution (CES) function on the continuum of differentiated goods: $C_t = \left(\int_0^{N_t} x_t(j)^{(\sigma-1)/\sigma} dj \right)^{\sigma/(\sigma-1)}$, where $\sigma > 1$ is the elasticity of substitution; $x_t(j)$ is the amount of differentiated good j; and N_t is the number of goods available in period t. It is well known that the corresponding dynamic optimization problem has a solution that yields the Euler equation:

$$\frac{E_{t+1}}{E_t} = \beta(1 + r_t), \tag{1}$$

where r_t is the interest rate and $E_t = \int_0^{N_t} p_t(j)x_t(j)dj$ represents the consumer's spending in period t with the price $p_t(j)$ of good j. The static demand function for good j is given by $x_t(j) = E_t\,(p_t(j))^{-\sigma} / (P_t)^{1-\sigma}$, where P_t is the price index defined by $P_t = \left(\int_0^{N_t} p_t(j)^{1-\sigma} dj \right)^{1/(1-\sigma)}$. Assume that a unit of each good j can be manufactured from a unit of labor. If good j survives up until period t, it is manufactured by the monopolistic firm (patent holder).

To allow for a role for patent policy, we consider an upper-bound $\mu \in (1, \sigma/(\sigma-1)]$ in the markup.[7] Therefore, the equilibrium price becomes $p_t(i) = \mu w_t$, where w_t is the wage rate. As in the existing literature,[8] we interpret μ as patent breadth (i.e., a measure for the strength of patent protection). In this setting, a larger patent breadth μ means a higher markup in accordance with the seminal vision of Gilbert and Shapiro (1990) on "breadth as the ability of the patentee to raise the price." This pricing gives rise to the following demand and profit functions:

$$x_t(j) = x_t = \frac{E_t}{\mu w_t N_t} \quad \text{and} \quad \pi_t(j) = \pi_t = \left(\frac{\mu - 1}{\mu} \right) \frac{E_t}{N_t}. \tag{2}$$

2.1. R&D and survival

There are a number of perfectly competitive potential R&D firms. A potential R&D firm can innovate one new technology to produce a new intermediate good in period t by investing $1/(\kappa N_{t-1})$ units of labor in period $t-1$, where the standard assumptions regarding knowledge spillover are assumed. Here, $\kappa \in [0, \infty)$ denotes the productivity of R&D. We denote $s \in [0, 1)$ as a subsidy rate for innovation, so that the unit cost of R&D is equal to $(1-s)\,w_{t-1}/\kappa$.[9]

A firm that successfully innovates a new product, j, manufactures product j monopolistically, thereby earning a monopolistic rent in period t, π_t. This rent continues through subsequent periods. At an endogenous probability of $1 - \iota_t(j)$, where $\iota_t(j) \in [0, 1]$ stands for the probability of survival at the end of period t, we assume that an innovated good j becomes obsolete and the R&D firm innovating good j has to leave the market. This assumption is based on Lai's (1998) assumption of product obsolescence over the endogenously expanding variety of differentiated goods.[10]

We consider that the R&D firm engages in a struggle to avoid obsolescence and survive. To incorporate this, we follow Akiyama et al. (2011) by assuming that the firm can increase the probability of survival $\iota_t(j)$ by investing $z_t(j)/N_t$ units of labor in period t.[11] Specifically, $\iota_t(j) = (z_t(j))^{\alpha}$, in which $z_t(j) \in [0, 1]$ denotes the intensity of survival investment and $\alpha \in (0, 1)$ is a technological parameter.[12] An active R&D firm's value is the expectation of the net present discounted value of profits. Given that $\pi_t(j) = \pi_t$ in (2), we have $z_t(j) = z_t$ and $\iota_t(j) = \iota_t$ for all j in equilibrium. The R&D firm's behavior can be described as the following Bellman equation:

$$V_t^* = \max_{z_t \in [0,1];\ \iota_t = (z_t)^{\alpha}} \left[\pi_t - \frac{w_t z_t}{N_t} + \iota_t \frac{V_{t+1}^*}{1 + r_t} \right]. \tag{3}$$

The solution to (3) gives rise to the following policy function:

$$z_t^* = \min \left\{ \left(\frac{\alpha V_{t+1}^* / (1 + r_t)}{w_t / N_t} \right)^{1/(1-\alpha)},\ 1 \right\}.^{13} \tag{4}$$

[4] The present study differs from Akiyama et al. (2011) in two respects. First, we focus on product obsolescence in a closed economy, whereas they considered imitation of products in a North–South setting (where no product becomes obsolete). Second, we analyze the effects of R&D subsidies and patent breadth and show an interdependence between R&D policy levers.

[5] Following Li (2001) and many others, we measure the strength of patent protection by *patent breadth*.

[6] See, for example, Segerstrom (2000), Li (2001), Goh and Olivier (2002), O'Donoghue and Zweimüller (2004), Chu (2009, 2011), Chu and Furukawa (2011), Chu et al. (2012a,b), Iwaisako (2013), Iwaisako and Futagami (2013), and Yang (2013).

[7] To allow for a sufficiently large patent breadth μ, we consider that σ is sufficiently small. To verify that sufficiently large patent breadths are not empirically too restrictive, we can provide a calibration result; see Furukawa (2013, Section 4).

[8] See also Li (2001), Goh and Olivier (2002), Chu (2011), and Iwaisako and Futagami (2013) for a similar formulation in the dynamic general equilibrium model.

[9] This subsidy is financed by a lump-sum tax.

[10] Whereas his focus is on gradual obsolescence, we consider that product obsolescence is stochastic and discrete. We leave for future research the task of analyzing firm survival against gradual obsolescence.

[11] We also assume the knowledge spillover effect for the survival investment.

[12] For simplicity, we adopt the simplest function for survival probability $\iota_t(j)$, but we obtain qualitatively the same results using a more general form of the survival probability such as $\iota_t(j) = (z_t(j))^{\alpha} + \phi$ or $(\gamma\,(z_t(j))^{\alpha} + (1-\gamma)\,(\phi)^{\alpha})^{1/\alpha}$, where $\phi \in (0, 1)$ and $\gamma \in (0, 1)$ are parameters that capture market or institutional attributes for firm survival.