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Market failure, government inefficiency, and optimal R&D policy

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HIGHLIGHTS

- The growth model can explain the coexistence of intellectual property rights and R&D subsidies.
- The mechanism that drives results is the presence of both market and government failures.
- The model can generate the observed positive correlation between the degree of patent protection and the R&D share in GDP.

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ABSTRACT

This paper presents a growth model that can explain the coexistence of intellectual property rights and R&D subsidies as a response to the presence of both market and government failures. The framework can also generate the observed positive correlation between these two policy tools.

1. Introduction

The promotion of R&D is one of the most important items in the government's policy agenda. It could not be otherwise since technological change is perceived as the main source of sustained economic growth. Two main tools of R&D policy to foster innovation are subsidies and patent protection. Both are widely used across nations, and follow clear patterns along the development process. However, standard R&D-based growth frameworks do not offer an explanation for why both tools are simultaneously used. In these models, market failures justify innovation policy, and R&D subsidies *per se* are able to achieve the first best.[1] Some of the literature on optimal intellectual property rights (IPR) suggests reasons why innovation subsidies might not be optimal, but never analyzes both tools jointly.[2] The lack of an explanation within a formal framework for the coexistence of different policy tools is an important gap in a literature that tries to shed light on the optimal design of R&D policy and its macroeconomic implications. This paper advances in that direction, and studies how this coexistence depends on financial and public sector considerations.

More specifically, we propose an R&D-based growth framework that simultaneously explains patents and government-financed R&D as a response to the existence of both market and government failures. In the model, market failures include intertemporal knowledge spillovers, diminishing returns to R&D effort, and monopoly pricing. The public sector, on the other hand, fails because the efficiency of one unit of income collected in taxes is less

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[1] Examples include the seminal contributions of Romer (1990), Grossman and Helpman (1991), and Aghion and Howitt (1992). For a review of the market failures considered in the R&D literature and policy analysis, see for example Acemoglu (2008).

[2] The study of optimal IPR goes back at least to Nordhaus (1969). More recent papers include O'Donoghue and Zweimuller (2004), Eicher and Garcia-Penalosa (2008), and Acemoglu and Akcigit (2012). Aghion and Tirole (1994) and Aghion and Howitt (1998) suggest that, in the absence of IPR, information problems might be behind the inability of R&D subsidies to achieve the first best.

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than one when invested in R&D. This can be due for example to public finance costs, bureaucracy corruption, and public sector inability to target R&D projects efficiently. The model also considers the existence of transaction costs in the private financial sector.

Under these circumstances, R&D subsidies must be paired with patent protection. This is the first-best outcome, unless one the following scenarios occurs: (i) the public sector is sufficiently inefficient, in which case subsidies are not implemented; (ii) the private financial activity incurs relatively large costs, making patent protection socially undesirable.

The model can explain the observed simultaneous increase in both government R&D spending and the strength of IPR. It occurs in our framework as the public sector becomes more efficient, because of the complementarity of private and public innovation effort. The impact on private and public R&D is, however, different depending on who becomes more efficient. While more efficient public finance increases the share of both private and public R&D in national income, a higher degree of efficiency in the financial market rises the share of private innovation effort but diminishes the public one.

2. Model

Consider a closed economy similar to the one in Romer (1990) populated by utility-maximizing infinitely-lived consumers. There are three types of activities: consumption-goods production, intermediate-goods manufacturing, and R&D investment. The second sector operates under monopolistic competition, and the other two obey perfect competition. R&D is intended to create new designs for new types of producer durables. In this economy, intellectual piracy can prevent the inventor from appropriating any benefit from his discoveries: when a new design is created, there is a probability ψ that an intermediate-goods producer acquires the perpetual patent over the design that allows monopoly pricing. The government chooses the levels of patent protection ψ and subsidies to the R&D activity.

2.1. Households

A continuum of identical consumers of size L that grows at rate n inhabit the economy.[3] Consumers are endowed with one unit of labor in each period that is supplied inelastically. Their preferences are given by the following log-utility function:

$$U = \int_t^\infty \exp\left[-\rho(j-t)\right] \ln c(j)\, dj; \tag{1}$$

where $c(j)$ is the amount of consumption per capita in period j, and ρ is the subjective discount rate.

There is a capital market that supplies consumers' saving to intermediate-goods producers that issue securities. The equilibrium interest rate r clears the market at each point in time. The representative consumer's feasibility constraint is then given by

$$\dot{a} = w + (r-n)a - c_t - \tau_h; \tag{2}$$

where w is the salary, a represents the value of the securities owned by each consumer, and $\tau_h \geq 0$ are taxes. Consumers choose the time series of consumption that maximizes (1) subject to (2). The first order condition to this problem gives the Euler equation for consumption per capita:

$$\frac{\dot{c}}{c} = r - n - \rho. \tag{3}$$

[3] When not otherwise specified, variables refer to their values at date t where decisions are made.

2.2. Final goods

A homogeneous final output Y is produced employing a variety of intermediate capital goods $x(i)$ according to

$$Y = L^{1-\alpha} \int_0^A [x(i)]^\alpha\, di, \quad 0 < \alpha < 1. \tag{4}$$

Final-goods manufacturers are price takers, and earn zero profits in equilibrium. Because intermediate goods are rented rather than sold, Eq. (4) implies that they solve the following problem:

$$\max_{\{L,x(i)\}} \left\{ L^{1-\alpha} \int_0^A [x(i)]^\alpha\, di - \omega L - \int_0^A p(i)x(i)\; di \right\}; \tag{5}$$

where $p(i)$ is the rental price of producer durable type i. For the interior solution to this problem, the first order conditions are

$$\omega = \alpha \frac{Y}{L} \tag{6}$$

$$p(i) = \alpha L^{1-\alpha} [x(i)]^{\alpha-1}, \quad i \in (0, A). \tag{7}$$

2.3. Producer durables

Firms in the intermediate sector can invest capital to buy patents on new versions of intermediate goods. The patent provides a perpetual right to practice monopoly pricing on sales of the purchased variety. Firms, however, can also obtain access to the new knowledge with probability $1-\psi$ through costless intellectual piracy. We assume that this only occurs before the patent is sold, and that when an idea is stolen from the inventor it becomes public knowledge that any firm can use. The value of ψ depends on the degree of intellectual property protection chosen by the public sector.

The manufacturing process in this activity requires investing raw capital coming from saved manufacturing output as follows: a unit of capital can be converted at no cost into one unit of any variety of intermediate goods. There is no depreciation in the model.

The problem of intermediate-goods firms that buy a patent and become monopolists is

$$\max_{x(i)} \left[p(i) - r\tau_f\right] x(i); \tag{8}$$

where $p(i)$ is given by Eq. (7), and the parameter τ_f represents a transaction cost that depends on the efficiency of financial markets. In particular, for each unit that agents want to invest, they incur a cost of $\tau_f - 1$, that is, they need to borrow $\tau_f \geq 1$ units.

The optimal solutions are standard in the literature. In particular, the price charged by the monopolist is

$$p(i) = \frac{r\tau_f}{\alpha} = p. \tag{9}$$

And the amount of profits in the symmetric equilibrium, where $x(i) = x_M$, equals:

$$\pi(i) = \left(\frac{1-\alpha}{\alpha}\right) r\, \tau_f\, x_M = \pi_M; \tag{10}$$

where from (7) and (9)

$$x_M = \left(\frac{\alpha^2}{r\tau_f}\right)^{1/(1-\alpha)} L. \tag{11}$$

Firms that obtain the new idea through piracy will also solve (8) but taking $p(i)$ as given because they operate under perfect competition. The solution is now

$$p(i) = r\tau_f. \tag{12}$$