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Total Factor Productivity and the R & D Expenditures

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ABSTRACT

The total factor productivity (TFP) growth comes from improvements in the quality of labor and capital and from other sources of technological change, many of them in the form of externalities, spillovers, representing contributions of science and innovations in other enterprises, industries and countries. Economies of scale and scope, as well as improving x-efficiency, are among the other potential sources of total factor productivity growth. The goal of this paper is to advance the debate on the contribution of R & D to productivity. We used the method of constructing a proxy variable for inter-industry technology spillovers and test its statistical association with the TFP growth.
Keywords: total factor productivity, R & D, proxy variable, the Cobb-Douglas type.

1. INTRODUCTION

The recent revival of interest in the growth theory focused attention on the potential contribution of investment in human capital, R & D and the accompanying externalities. However, the empirical evidence remains scattered and often inconclusive.

Investment in R & D comes closest to a proxy variable for economic resources allocated by a firm, industry or nation to adoption, adaptation and creation of new technology. R & D spending by private firms and its support by various levels of government reflects the belief that new technology is contributing significantly to economic growth and competitiveness of domestic industries.

In the next section, we will focus on the theoretical model of the relationship between R & D and productivity and the stock of productive knowledge, including spillovers.

2. THE MODEL

Supposing a production function of the Cobb-Douglas type, the output *Q* of an industry in period *t* is a combination of two separable functions, the technological progress function A_t and a conventional inputs function F_t.

$$Q_t = A_t F_t \tag{1}$$

The technological progress is a function of the productive knowledge specified as follows:

$$A_t = \phi K_t^{\gamma}.e^{\lambda t} \tag{2}$$

where *K* is the stock of productive knowledge, ϕ is a constant, λ is the trend of technological change and γ the output elasticity of the knowledge capital.

The function of *m* inputs X_m (capital, labor and intermediate inputs) is written as:

$$F_t = \Pi X_{mt}^{\alpha m} \tag{3}$$

where α_m are elasticities of output with respect to input *m*. Unless stated otherwise, the returns to scale are assumed constant, $\sum \alpha_m = 1$. Substituting (2) and (3) into (1) determines the output

$$Q_t = \phi K_t^{\gamma} . e^{\lambda t} \Pi X_{mt}^{\alpha m} \quad (4)$$

The stock of productive knowledge is $K_t = \Delta K_t + (1-\delta) K_{t-1}$, where ΔK_t is the investment in productive knowledge in period *t*, and δ is the depreciation rate (obsolence) of technical knowledge. Defining an index of total factor productivity $TFP_t = \frac{Q_t}{F_t}$ we can write:

$$\ln TFP_t = \ln \phi + \gamma \ln K_t + \lambda t \quad (5)$$

Expressed in terms of annual growth rates:

$$\frac{\Delta TFP}{TFP} = \lambda + \gamma \frac{\Delta K}{K} \quad (6)$$

Since the assumption of a common elasticity of output with respect to productive knowledge (i.e. R&D) across industries with significant differences in R&D intensity is unrealistic, it can be specified alternatively in terms of a common rate of return (marginal product) of R&D across industries. The output elasticity of R&D capital γ, being replaced by its marginal product $\rho = \frac{\partial Q}{\partial K}$, common across industries: $\gamma \frac{\Delta K}{K} = \frac{\partial Q}{\partial K} . \frac{K}{Q} . \frac{\Delta K}{K} = \rho \frac{\Delta K}{Q}$ and the *TFP* growth becomes function of R&D intensity.

$$\frac{\Delta TFP}{TFP} = \lambda + \rho \frac{\Delta K}{Q} \quad (7)$$

A significant portion of the new knowledge cannot be perfectly appropriated by those who created it. The stock of productive knowledge is therefore the result of the past R&D activity of the firm (industry) and of its capacity to benefit from technological externalities-spillovers-created in other firms, both domestic and foreign.

Imperfect appropriation of the results of R&D shifts the productivity effects to new technology from firms that create and manufacture innovations to those using it. Assuming that these technology shifts can be aggregated to industry level, it is possible to identify industries that are sources of technology and those using technology developed by their suppliers. The stock of productive knowledge is a function of the industry's own R&D, and spillovers from other domestic industries, S, and from industries abroad, *F*:

$$K_{tj} = R_{tj} + s_{tj} \sum_i S_{tij} + f_{tj} \sum_i F_{tij} \quad (8)$$

where *j* is the industry using spillovers, *i* industry generating them, s_{tj} and f_{tj} are empirically determined parameters identifying respectively the effective contribution of inter-industry and international spillovers.

3. CONCLUSION

The theoretical model assumes implicitly that productivity has been growing over time and its increase is mainly a function of advancing productive knowledge. Fluctuations and the short-term evolution of conventionally measured total factor productivity may have little to do with innovation shifting the production possibility frontier assumed in the model.

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