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Investment in new technology: Modelling the decision process

Gregorio Gimenez*

Department of Applied Economics, University of Zaragoza, Gran Vía, 2, 50005 Zaragoza, Spain

Abstract

This paper presents a model designed to throw light on the economic mechanisms determining the decision to acquire a new technology to replace an existing one. The investment decision is governed by a cost-benefit analysis, which is influenced by the factors analysed in the model described. These factors are the lapse of time between the acquisition of the technology currently in use and the moment at which the new technology becomes available; the useful life of the new technology; the speed of the innovation process; interest rates; the acquisition cost of the new technology; and learning costs. A static comparative analysis is performed on the basis of these factors with the aim of recommending the most appropriate instruments for technology policy measures.

Keywords: Investment in technology; Technology use; Innovation

1. Introduction

There has been a proliferation of studies treating technology as a key factor for economic growth in recent years, among which we may cite the contributions of Romer (1990), Grossman and Helpman (1991) and Aghion and Howitt (1992, 1998).

If technology plays such a significant role in growth and economic convergence between countries, it will clearly be essential to understand in detail the decision-making process behind investment in technology. This is the objective of this paper, which proposes a microeconomic model to explain the technology investment process.[1] The first part of the argument examines the factors determining the process of new technology acquisition. This requires an analysis of costs and benefits. Users will purchase a technological innovation if it generates positive net gains. The second part applies a static comparative analysis to observe how each of the factors considered affects the investment decision process. Finally, the measures that governments might take to encourage the acquisition of new technologies are considered in light of the results obtained from the study. Conclusions are presented in Section 4 of this paper.

2. Basis for the model

Technological innovations may be used either by producers, applying the technology as an intermediate input for the production of some other consumer good, or by consumers as final goods. For the purposes of this section, let us take the case of an entrepreneur using a given production factor (with an associated technology) to manufacture certain goods or services.[2] For example, we may imagine an economist using a computer program to manage his clients' investment portfolios or a reprographics business that acquires a photocopier. Embedded in these intermediate inputs is a specific technology. Let us also assume that this embedded technology is subject to a process of incremental development. These productive inputs are, then, offered for sale in the market in each period, but incorporating successive technological improvements.[3] In the examples given, this assumption translates into the appearance of new versions of

* Tel.: +34 976 762 223; fax: +34 976 761 840.
E-mail address: gregim@unizar.es.

[1] A broad review of the literature on innovation and technological change is provided in Freeman (1982) and Dosi et al. (1988). Published studies of the diffusion of new technologies among potential users include Mansfield (1968) and Mansfield et al. (1971, 1977), which focus on the diffusion of new technologies in industry, and Dosi (1991), which is more general.

[2] The results obtained from the model would be exactly the same where we take the case of a consumer of final goods obtaining a given utility from the use of the new technology.

[3] This is similar to the Schumpeterian process of creative destruction. The studies by Grossman and Helpman (1991) and Aghion and Howitt (1992, 1998) cited above are based on this concept.

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the computer program used by the economist and new, more sophisticated models of photocopier that could be acquired by the reprographics business. These improvements would raise the productivity of users of the technology. If the entrepreneur opts to purchase the program or photocopier incorporating technical improvements, business returns will rise either because it becomes possible to boost the quality of outputs or because the costs associated with the production process will fall, or for both reasons.

Let us suppose that the entrepreneur is offered a new version of the input used in the production process in each period. This version will include a series of technological improvements that would raise the profits obtained in each period. This section presents a model to explain how the producer makes the decision to acquire the new embedded technology.

In the first place, the entrepreneur starts up the business in period *0*, acquiring a technology A_0 at a cost C_0. In addition, he will have to learn to use this technology, which means incurring learning costs (time, effort and money invested) equal to Ap_0. The technology will enable the entrepreneur to obtain a profit of B_0 monetary units in each period in which it is utilised. Chart 1 provides an outline of this account.

What, then, occurs in the following period, *1*? The entrepreneur is offered the opportunity to acquire a new, more developed technology, A_1 which incorporates the technology of the preceding period. The price of this new technology is C_1. In order to adapt to the new technology, the entrepreneur will also incur learning costs of Ap_1. This innovation would make it possible to generate higher profits. To simplify, let us assume that *additional* returns equal to the initial profit (B_0) are obtained each time a new technology is acquired. Thus, profits $B_1 = 2B_0$ would be generated if the new technology A_1 was acquired. This is the same as assuming that the incremental technological improvements incorporated are of the same magnitude, which is to say the impact of each innovation is similar to the preceding one and the developments included bring the entrepreneur an identical increase in profits to that provided by the adoption of earlier technologies.

Let us assume that the entrepreneur decides *not* to adopt the new technology offered in period *1*. He will thus continue to utilise the technology pertaining to the prior period, A_0. The entrepreneur incurs no costs, because he is already familiar with the technology and knows how to use it. The profits obtained in period *1* using technology A_0 will be equal to those earned in the initial period, B_0.

What happens when we reach the second period *2*, *with technology* A_0? In this period, the technology offered, A_2, includes the technology developments A_1 and A_2. The purchase price of this technology is C_2, and the associated learning costs are $Ap = Ap_2 + Ap_1$. We may note here that these learning costs are incremental. This means that in taking up a new technology we incorporate earlier technical improvements (in this case A_1), which we must also learn to use.

Let us now suppose that a period *n* is reached with a technology adopted in previous period *m*. In *n*, the entrepreneur considers acquiring technology A_n. This would involve paying an acquisition cost of C_n and learning costs equal to $Ap = \sum_{i=m}^{n} Ap_i$. These costs reflect the need to recycle knowledge and skills since the period of the last upgrade, *m*, in order to learn how to use technological developments incorporated in each of the intervening periods. The increase in profits that would be achieved in each period with the adoption of the new technology, A_n, can be quantified as follows: $\sum_{i=m}^{n} B_i$. This includes all additional profits that would be obtained from the adoption of the new technologies incorporating all of the innovations developed since *m*, the period in which the last technology acquisition took place (Fig. 1).

Hence, if the technology offered is adopted, the net additional profit obtained in period *n* will be:

$$\sum_{i=m}^{n} B_i - C_n - \sum_{i=m}^{n} Ap_i \quad (1)$$

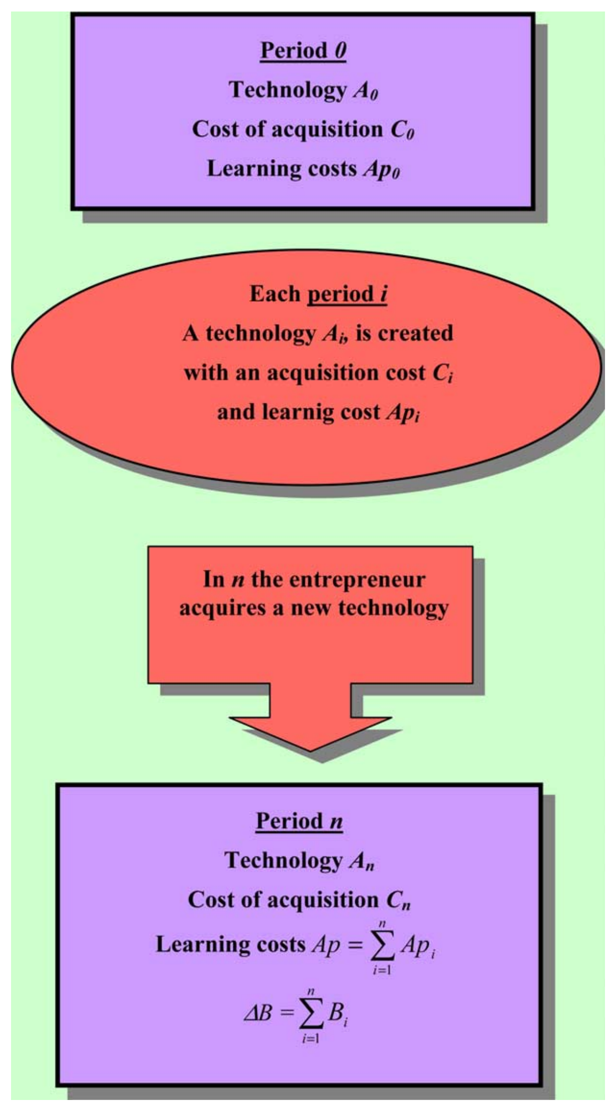

Fig. 1. Technology acquisition.