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The effects of the market structure on the adoption of evolving technologies

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ABSTRACT

We study the speed at which technologies are adopted depending on how the market power is shared between the firms that sell technologies and the firms that buy them. Our results suggest that, because of a double marginalization problem, adoption is fastest when either sellers or buyers hold all the market power. Thus, competition between sides of the market may delay the adoption of technologies.

1. Introduction

The adoption of new technologies is regarded as one of the main contributors to economic growth (see, for instance, Lucas, 1993; Barro and Sala-i-Martin, 1995). The time at which a new technology is adopted has a significant impact on the growth rate of a country or a firm. Adopting new technologies too quickly may be disadvantageous given the sunk cost the establishment of a new technology carries. On the other hand, delaying the adoption of a new technology can lead to high opportunity costs or to a disadvantageous position with respect to competitors. This trade-off has been widely studied in the literature.

Most of the literature so far has focused on the pace of adoption of new technologies from the perspective of a firm which by adopting a new technology incurs in a fixed cost that is compensated over time by the increase in productivity. In this respect, the problem of adopting new technologies was reduced to two basic settings: an optimal stopping problem (Farzin et al., 1998; Jovanovic and Nyarko, 1996) and a competition game between firms buying technologies (Götz, 1999; Chamley and Gale, 1994).

Two articles, Stoneman and Ireland (1983) and Ireland and Stoneman (1986), modify this approach and take into account the interaction between firms adopting new technologies, buyers, and the firms that sell these technologies, sellers. Stoneman and Ireland (1983) try to replicate the fact that the penetration of a new technology usually follows a sigmoid (S-shaped) path. On the other hand, Ireland and Stoneman (1986) focus on the role of expectations (rational and bounded rational) in the adoption of new technologies. We follow Stoneman and Ireland (1983) and Ireland and Stoneman (1986) in that we consider the interaction between sellers and buyers but focus instead on how the different market structures, i.e. how the market power is shared between supply and demand, affect the timing of the adoption of new technologies.

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In the model we present sellers have a trade-off between price and time: setting up a higher price means that the income from selling the technology is higher. However, it also means that buyers wait more before adopting a new technology as technologies are more expensive. On the other hand, buyers have a trade-off between early adoption, which implies an earlier increase in productivity, and late adoption, which implies a greater (but later) increase in productivity since a newer technology is adopted. We explain how these trade-offs are solved when we consider three different market structures that are distinct in how the market power is shared among the buyers and the sellers.

In the first market structure we consider there is only one firm selling technologies and many firms willing to buy technologies. Hence, in this setting, the supply side holds all the market power and buyers act as price takers. In the second market setting considered in this paper, there are many firms supplying technologies and only one firm interested in buying. In this setting the demand side holds all the market power and, therefore, sellers compete in prices and make profits equal to their outside option of not participating in the market. In the last market setting we consider there is one firm on each side of the market. In this last setting sellers and buyers compete for the surplus in the economy.[1]

We find that if there is competition between sellers and buyers then, because of a double marginalization problem, the adoption of new technologies occurs at a slower pace than when either sellers or buyers hold all the market power. This suggests that competition between both sides of the market, instead of competition within each side, can delay the adoption of new technologies. We round off our results by introducing some comparative statics.

The present paper tries to shed light on the speed of adoption of new technologies with respect to different market structures. Rather than focusing on the nature of the technology itself or other factors, we choose to study how market power can explain the differences in speed of adoption. We do not claim market power is the only reason why we might observe different behaviors. However, as we shall show, it is a factor that can explain these differences by itself.

From the theoretical point of view, many models study the optimal timing of technology adoption. Jovanovic and Nyarko (1996) present a model where the decision maker increases productivity by either learning by doing or by switching to a better technology. Karp and Lee (2001) extend this model by introducing discount factors. Farzin et al. (1998) introduce a setting where the increase in productivity caused by the adoption of the newest technology is known only in expected terms. Adopting a new technology has a sunk cost that is independent of the productivity level of the new technology. In an article by Doraszelski (2004) a distinction between technological breakthroughs and engineering refinements is introduced. Other papers that consider the adoption of new technologies from the point of view of the agents adopting the technologies (buyers) are Chamley and Gale (1994) and Götz (1999).

From the empirical perspective, there is no doubt that the timing of technology adoption has been a concern. Hoppe (2002) presents a literature review on this topic. To cite some, Karshenas and Stoneman (1993) present a study on the diffusion of CNC (computer numerically controlled machine tools) in the UK engineering industry. Factors determining the delaying in the adoption of the new technology were found to be, among others, the learning effects and the cost of the new technology. Weiss (1994) studied the adoption of a new process technology called the surface-mount technology by printed circuit board manufacturers.

The rest of the paper is organized as follows. In Section 2 we introduce the model. Section 3 presents our findings for the three different market structures considered. In Section 4 we present a comparative statics analysis. Finally, Section 5 concludes.

2. The model

Consider a continuous time model where the two sides of the market, supply and demand, play a repeated game. On the supply side of the market there are $n_s \geq 1$ sellers (firms that sell technologies). On the other hand, the demand side of the market has $n_d \geq 1$ buyers (firms that buy technologies). An exogenous process determines the appearance of new technologies that are sold by sellers to buyers. Sellers have to decide a price for these technologies. On the contrary, buyers produce output given an initial level of technology and decide when to buy a new technology. All firms are assumed to be risk neutral and have common knowledge.

As an illustrative example, consider the case of micro-processors for computers. Intel™, represented in the model by the exogenous process creating new technologies, develops new microprocessors. These microprocessors are sold by computer manufactures, sellers, to consumers, buyers. Consumers deriving utility from buying computers with microprocessors are represented in the model by buyers producing output given a level of technology.

Technologies are denoted by $\theta \in \mathbb{R}$ where higher θ means that the technology is more efficient. Buyers are all endowed with the same initial level of technology, $\theta_0 > 0$. As a simplification, we assume that only two different technologies coexists in the economy at any given point in time t. These are the initial level of technology, θ_0, and the newest technology, θ_t. Sellers have no control over the release of new technologies. They own the newest technology and their role is to price it. If a seller sells a given technology θ, then it has to pay a fix cost $C > 0$ for the transaction to take place. In our example above, C can be regarded as the price computer manufacturers pay to Intel™ for a microprocessor.

[1] The many sellers to many buyers case is redundant as we discuss in Section 3.4.