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Competing engines of growth: Innovation and standardization ☆

Daron Acemoglu [a,*], Gino Gancia [b], Fabrizio Zilibotti [c]

[a] *MIT, United States*
[b] *CREI, Spain*
[c] *University of Zurich, Switzerland*

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Abstract

We study a dynamic general equilibrium model where innovation takes the form of the introduction of new goods whose production requires skilled workers. Innovation is followed by a costly process of standardization, whereby these new goods are adapted to be produced using unskilled labor. Our framework highlights a number of novel results. First, standardization is both an engine of growth and a potential barrier to it. As a result, growth is an inverse U-shaped function of the standardization rate (and of competition). Second, we characterize the growth and welfare maximizing speed of standardization. We show how optimal protection of intellectual property rights affecting the cost of standardization vary with the skill-endowment, the elasticity of substitution between goods and other parameters. Third, we show that, depending on how competition between innovating and standardizing firms is modelled and on parameter values, a new type of multiplicity of equilibria may arise. Finally, we study the implications of our model for the skill premium and we illustrate novel reasons for linking North–South trade to intellectual property rights protection.

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* Corresponding author at: MIT, Economics Department, 50 Memorial Drive, Cambridge, MA, United States.
E-mail addresses: daron@mit.edu (D. Acemoglu), ggancia@crei.cat (G. Gancia), zilibott@iew.uzh.ch (F. Zilibotti).

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1. Introduction

The diffusion of new technologies is often coupled with *standardization* of product and process innovations. New technologies, when first conceived and implemented, are often complex and require skilled personnel to operate. At this stage, their use in the economy is limited both by the patents of the innovator and the skills that these technologies require. Their widespread adoption and use necessitates the tasks involved in these new technologies to become more routine and standardized, ultimately enabling their cheaper production using lower-cost unskilled labor. However, such standardization not only expands output but also implies that the rents accruing to innovators will come to an end. Therefore, the process of standardization is both an engine of economic growth and a potential discouragement to innovation. In this paper, we study this interplay between innovation and standardization.

The history of computing illustrates the salient patterns of this interplay. The use of silicon chips combined with binary operations were the big breakthroughs, starting the information and communication technology (ICT) revolution. During the first 30 years of their existence, computers could only be used and produced by highly skilled workers. Only a lengthy process of standardization made computers and silicon chips more widely available and more systematically integrated into the production processes, to such a degree that today computers and computer-assisted technologies are used at every stage of production with workers of very different skill levels. At the same time that the simplification of manufacturing processes allowed mass production of electronic devices and low prices, competition among ICT firms intensified enormously, first among few industry leaders and then more broadly at a global scale.

More generally, the business literature has documented a common pattern in the life-cycle of industries. New industries are often highly concentrated due to the complexity of their products. Over time, both entry and process innovation intensify until the introduction, often by newcomers, of a “dominant standard” facilitates more standardized, large-scale production and erodes the monopoly advantage of incumbent firms. For instance, in the early 1960s the American calculator industry consisted of five major companies producing complex and expensive electronic machines with more than 2300 parts. These companies lost most of their market share after the introduction, in 1971, of the calculator on a chip, which made the assembly of units extremely simple—merely piecing together the chip, display device and keyboard [55]. Similarly, although the production of transistors was initiated in 1947 by Bell Laboratories, the first industry standard, the planar transistor, was introduced in 1959 by the newly founded company Fairchild Semiconductor. The great advantage of this design was its flat surface, on which electrical connections could be achieved by depositing an evaporated metal film; previously this process required skilled manual work on the irregular surface of the mesa transistor [55]. Another example is provided by the introduction of the Banbury Mixer in the tire industry, which eliminated the slow and hazardous process of mixing rubber with other compounds, paving the way for mass production and forcing many incumbent firms to exit [40].