The dynamic effects of general purpose technologies on Schumpeterian growth*

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Abstract. General purpose technologies (GPTs) are drastic innovations characterized by pervasiveness in use and innovational complementarities. The dynamic effects of a GPT are analyzed within a quality-ladders model of scale-invariant Schumpeterian growth. The diffusion path of a GPT across a continuum of industries is governed by S-curve dynamics. The model generates a unique, saddle-path long-run equilibrium. Along the transition path, the measure of industries that adopt the new GPT increases, consumption per capita falls, and the interest rate rises. The growth rate of the stock market depends negatively on the rate of GPT diffusion and the magnitude of the GPT-ridden R&D productivity gains; and positively on the rate of population growth. It also follows a U-shaped path during the diffusion process of the new GPT. Finally, the model generates transitional growth cycles of per capita GNP.

Keywords: General purpose technologies – Schumpeterian growth – Scale effects – R&D races

JEL Classification: E3, O3, O4

1 Introduction

In any given economic "era" there are major technological innovations, such as electricity, the transistor, and the Internet, that have far-reaching and prolonged impact. These drastic innovations induce a series of secondary, incremental innovations. The introduction of the transistor, for example, triggered a sequence of

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secondary innovations, such as the development of the integrated circuit and the microprocessor, which are themselves considered drastic innovations. These main technological innovations are used in a wide range of different sectors, inducing further innovations. For example, microprocessors are now used in many everyday products such as telephones, cars, personal computers, and so forth.

In general, drastic innovations have three key characteristics. The first feature refers to the generality of purpose, i.e., drastic innovations affect a wide range of industries and activities within industries. Consequently, Bresnahan and Trajtenberg (1995) christened these types of drastic innovations "General Purpose Technologies" (GPTs henceforth). Several empirical studies have documented the cross-industry pattern of diffusion for a number of GPTs.[1] In addition, a strand of empirical literature has established that the cross-industry diffusion pattern of GPTs is similar to the diffusion process of product-specific innovations and that it is governed by standard S-curve dynamics.[2] In other words, the internal-influence epidemic model can provide an empirically-relevant framework within which to analyze the dynamic effects of a GPT. During this diffusion process, these drastic innovations could generate growth fluctuations and even business cycles.

Second, the dynamic effects of these GPTs take a long period of time to materialize. For instance, David (1990) argues that it may take several decades before major technological innovations can have a significant impact on macroeconomic activity. Third, these GPTs act as "engines of growth". As a better GPT becomes available, it gets adopted by an increasing number of user industries and fosters complementary advances that raise the industry's productivity growth. As the use of a GPT spreads throughout the economy, its effects become significant at the aggregate level, thus affecting overall productivity growth. In his presidential address to the American Economic Association, Jorgenson (2001) documents the role of information technology in the resurgence of U.S. growth in the late 1990s.[3] There is plenty of evidence that the rise in structural productivity growth in the late 1990s can be traced to the introduction of personal computers and the acceleration in the

[1] For example, Helpman and Trajtenberg (1998b) provided evidence for the diffusion of the transistor. They state that transistors were first adopted by the hearing aids industry. Later, transistors were used in radios, followed by their adoption by the computer industry. These three industries are known as early adapters. The fourth sector to adopt the transistor was the automobile industry, followed by the telecommunications sector.

[2] Griliches (1957), for example, studied the diffusion of hybrid seed corn in 31 states and 132 crop-reporting areas among farmers. His empirical model generates an S-curve diffusion path. Andersen (1999) confirmed the S-shaped growth path for the diffusion of entrepreneurial activity, using corporate and individual patents granted in the U.S. between 1890 and 1990. Jovanovic and Rousseau (2001) provided more evidence for an S-shaped curve diffusion process by matching the spread of electricity with that of personal computer use by consumers.

[3] At the aggregate level, information technology is identified with the output of computers, communications equipment, and software. These products appear in the GDP as investments by businesses, households, and governments along with net exports to the rest of the world.