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New Economic Policies and the Diffusion of Machine Tools in Latin America

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Summary. — This paper argues that both old and new economic regimes in Latin America only partially ensured the successful diffusion of machine tools in the region. Import-substitution policies focused on suppliers, with resulting advances in domestic imitative, adaptive and innovating capabilities, but at high cost for users in expensive and technically inferior machine tools. The New Economic Model (NEM) focus on the user has provided wider availability and lower price of technologies, with resulting increases in productivity and efficiency, but domestic suppliers cannot establish themselves nor make the technologically crucial jump into the electronics era. The paper suggests an approach focusing on the joint upgrading of users and suppliers, and proposes policy initiatives aimed at addressing market failure and "systemic" issues. © 2000 Elsevier Science Ltd. All rights reserved.

Key words — Latin America, machine tools, new economic model

1. INTRODUCTION

Machine tools are at the heart of any country's technological capabilities. They embody the country's accumulation of the most advanced scientific and engineering knowledge of mechanics, nowadays increasingly used in the context of rapidly emerging findings in the field of electronics, and its capacity to develop complex mathematical models and software programs. The technological complexity of machine tools implies at the same time a deep understanding of the full range of manufacturing activities, including simple human motions and their replacement by machine functions, basic and advanced operating processes, and how to design, research and develop sophisticated products (Chudnovsky & Nagao, 1983). Technological advances in machine tools usually have the highest possible impact on the productivity of economic systems because of their potential to spread to all sectors (Rosenberg, 1982).

The adequate diffusion of machine tools, or computer-numerically-controlled (CNC) machine tools as they are known today, is therefore, a major factor in improving the productivity and reducing the costs of the activities that use them. Whether domestically manufactured or imported, successful industrializing countries have always ensured the availability of necessary machine tools. Yet, at the same time, the specificity of many production processes and the widespread externalities arising out of domestic manufacturing of machine tools calls for their local production. Therefore, society needs to maintain a balance between users that require appropriate, advanced, efficient and cheap machine tools and producers that want to create and capture arising externalities, a process that normally takes significant time and learning.

During the 1960s and 1970s several Latin American countries attempted to develop a local machine tool industry as part of their import-substitution industrialization strategy and restricted importing foreign technologies. Subsidiaries of foreign machine tool manufacturers as well as domestic producers of machine tools working under license established production facilities throughout the region. Although progress was achieved, particularly in the mechanical engineering dimension of machine tool manufacturing, producers could not keep up with the rapid advances in electronics, resulting in substandard or expensive machine tools and dissatisfied users. Following policy changes toward domestic machine tool manufacturing, much of the industry closed and, with a few exceptions, local machine tool demand is today mainly sourced from abroad.

The purpose of this paper is to examine the diffusion of machine tools in some Latin American countries and to discuss whether the

region's New Economic Model (NEM) has allowed society to benefit from improved technologies and therefore higher productivity and to reap the gains from knowledge externalities. It will proceed as follows. The next section will provide a conceptual discussion of the diffusion process. Section 3 analyzes the diffusion of machine tools during import-substitution. Section 4 examines changes in public policy relevant to the diffusion of machine tools, mainly in the areas of trade, industry, finance and technology. Section 5 analyzes machine tool diffusion since the new policies were introduced. Some policy suggestions are made in Section 6.

2. THE DIFFUSION OF NEW TECHNOLOGY

The literature on economics of innovation and technical change usually distinguishes between invention, innovation, diffusion and adoption. Invention refers to the generation of new ideas and artifacts while innovation alludes to the first commercial use or application of inventions. Diffusion, in turn, is defined as the spread of innovations, products or processes, throughout an economy while adoption concerns the incorporation of those new products and processes into individual firms (Diederen, 1993; Metcalfe, 1988; Rogers, 1995; Thirtle & Ruttan, 1987). [1] Adoption focuses, therefore, on the decisions of individual firms to incorporate technology while diffusion is an "aggregate" phenomenon centered on how innovations and new technologies are transmitted across an economy and through time.

In essence, diffusion is a process involving choices, simultaneous interactions and outcomes between suppliers and users which, in turn, are influenced by technological, economic, institutional and individual considerations (Karshenas & Stoneman, 1995; Stoneman, 1995). Despite the multiple factors at play and its apparent chaotic nature, the process would seem to have an internal logic and regularity, i.e., where there are established relationships and feedback between decisions by suppliers and users, although the extent of the impact of each decision cannot be determined *a priori* (Diederen, 1993). Indeed, while specific relationships and feed-backs are determined either by random or causal interactions, the accumulation of effects will normally result in a sigmoid or S-type diffusion curve whereby the number of firms using a technology and the intensity of its use increase over time. When causal relationships are at play, diffusion can also be seen as a learning process where developments by a supplier or the adoption by a user lead to cumulative experiences that are continuously fed back into the process for the benefit of other suppliers and users.

Stoneman and Diederen (1994) argue that for society there is a welfare optimal diffusion path, on which the rate of adoption maximizes the present value of the intertemporal stream of social costs and benefits. By the same token it can be argued that, at any moment in time, welfare optimal diffusion is achieved at the point where the marginal social benefit to be gained from the use of a technology is equal to the marginal social cost of producing that technology. Yet, welfare optimal diffusion is unattainable because technology markets cannot operate perfectly. Market failure arises for three reasons. First, due to information asymmetries and deficiencies, costless knowledge is created during diffusion. Second, particularly at the beginning of the process, both sellers and users are few and the supplying industry is concentrated, affecting the incentives to innovate and adopt new technologies. Third, a firm's adoption of a technology may result in positive or negative externalities through its impact on the adoption decision and profitability of other enterprises. Stoneman and Diederen (1994) add that diffusion goes beyond a market-mediated process and involves a number of additional issues and decisions. These include the adaptation of the new technology to individual firms' requirements and of the firms' organization to the new technology, undertaking research and development (R&D) in order to engage in adoption, the competition from related technologies and firms' capacity to learn.

While optimality is unattainable or at best can be considered as a possible benchmark, diffusion can clearly vary in intensity. At one end of the spectrum, diffusion can be characterized by a virtuous process of knowledge accumulation both in users and producers that feeds into productivity increases and cost and price reductions and then back into incremental changes in the initial innovation, further increasing productivity and reducing costs and prices. As diffusion proceeds, specific user demands become more stringent forcing producers to improve even more upon their innovations and resulting in further improve-