FOREIGN TECHNOLOGY, INNOVATION, AND PRODUCTIVITY EFFECTS IN MAINLAND CHINA

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ABSTRACT

This study examines the linkage between foreign technology inflows and total factor productivity at the industry level in mainland China over the period 1980 to 1995, using newly available data [2].

A simple model is estimated, in an attempt to assess the relative importance of both technology and various measures of innovative activity on productivity. The outcome suggests that both foreign direct investment and licensing have played important roles in China's growth experience and deep synergies exist between indigenous innovative efforts and inflows of foreign technology. The role of Intellectual Property Rights is discussed in light of these results, as are some related studies which evaluate these ideas in more detail.

I. MOTIVATION

China's double-digit growth over the past twenty years has aroused considerable interest in its dramatic development experience. Much of this giant's economic growth has been attributed to productivity improvements attained through structural reforms. Foreign technology has been thought to play an important, yet secondary role in these changes; however, few studies have systematically examined the results of China's technology acquisition experience.

This study focuses on the role of foreign technology licensing, foreign direct investment (FDI), and domestic innovation in creating total factor productivity (TFP) improvements in China over the period 1980 to 1995. To perform this analysis, a unique data set of technology transfer contract flows integrated with factor statistics from the Second and Third Industrial Census is used to perform an econometric analysis. This dataset is developed and described in Dougherty [2].

We only consider the industrial sector (representing about half of output), where 96% of foreign technology in the post-reform period was transferred. The unit of analysis is the Chinese Standard Industrial Code at the two-digit level, of which there are nearly forty categories. All enterprises at the township level and above have been included (before aggregation), in contrast to previous studies which only include large and medium-sized enterprises, during earlier time periods.

Several prior studies examined China's technology adoption experience using anecdotal information–most significantly Conrad [1]–but were severely limited by the lack of declassified data on technology transfers. Other studies were able to examine productivity changes using prior Census data (such as McGuckin [9] or Jefferson [7]), but they too lacked reliable data on technology. However, more recent studies by Dougherty [2], Liu and White [10], and Maskus and Dougherty [12] have taken advantage of recently forthcoming data.

Results from the latter studies suggest that the interaction of foreign technology and domestic innovative activity plays a major role in creating productivity improvements. This study will proceed along similar lines, with the aim to reveal more generally how this mechanism operates.

II. EMPIRICAL MODEL

We contend that technology flows–manifested by foreign technology licensing and foreign direct investment–play a leading role in the creation of productivity gains. Recent theoretical work on innovation has shed some new light on how these gains take place, but many open questions remain. In our empirical model, we include a selection of concepts mentioned in the literature on technological progress [4] [12] [14] [16], in an effort to try to control for some alternative explanations of productivity gains. In Dougherty [2], the measurement of these concepts is described in considerable detail. The general form of the model is as follows:

TFP rank = f(technology flows, ownership, capital intensity, innovation, assimilation efforts, human capital, starting technology level) (1)

TFP rank is defined as a ranked Total Factor Productivity estimate, with the lowest rank corresponding to the lowest TFP growth rate. Ranking is used to reduce the effect of price and factor measurement error on the results. Because TFP rank is an ordinal variable and the variables are all measured in proportional terms, the above relationship is assumed to be additive and linear, with the goal being to measure general relationships between variables, as opposed to specific functional forms.

It is useful to consider the scale of the technology flows into China. Technology transfer contracts amounted to several billion US dollars per year in the 1980s, reaching a peak of over ten billion in 1995. This represents about one-third of general high-technology imports into China by SITC code, and about one-sixth of total machinery and transport imports. Actual foreign direct investment (FDI) ranged from one-half to nearly the same size as machinery and transport imports, pouring in at the rate of under ten billion a year through 1988, and peaking at almost fifty billion in 1995. Refer to Dougherty [2] for a more complete description of the data.

III. ANALYSIS

A series of models implied by equation (1) are estimated using OLS regression techniques, applied to the industry-level dataset. In all models estimated, technology flows were found to be highly significant and to positively contribute to TFP (either independently or interactively). Some of the variables noted in equation (1) were not found to be consistently correlated with TFP change, and they have not been included here. The model which best explains industry-level productivity (with an R-squared of 0.83) is a relatively simple one, where the index of TFP growth is estimated as a function of state-owned share of production (SOEs), foreign direct investment (FDI), and the interaction between domestic R&D expenditures and foreign technology transfer contracts (R&D interaction), described in the following equation:

$$\textbf{TFP Index} = 21.9 - 20.2 * \textbf{SOEs} + 39.8 * \textbf{FDI} + 8330 * \textbf{R\&D interaction} \quad (2)$$

The effect of the R&D—foreign technology flow interaction is very strong. Thus, foreign technology transfers appear to have significantly positive impacts on productivity in sectors with domestic R&D programs. Moreover, in sectors that do not devote significant resources to R&D, foreign technology transfers do not significantly benefit productivity (this is supported by the results of the other equation estimates as well). Similarly, in sectors that do not take advantage of foreign technology, R&D does not appear to benefit productivity. This outcome suggests that deep synergies exist between innovative efforts and inflows of foreign technology.

Foreign investment is found to have a strong, but lesser effect on TFP growth, probably due to the lack of domestic ownership of the recipient firms, presumably a result of foreign firm’s protection of their Intellectual Property Rights. While IPR legal protections are still rudimentary in China, the inherent difficulty of imitation apparently makes direct acquisition of technology by domestic firms more effectual in improving TFP. However, the difficulty in funding this type of acquisition may mean that this type of strategy would encounter rapidly diminishing returns.

Ownership, the primary proxy for structural reform effects, appears to be an important explanatory variable. However, it is not as important as technology flows in terms of its statistical contribution to TFP growth (as measured by R-squared values of separate equation estimates). It merely serves a complementary role. Note that complete statistical results are available upon request.

IV. DISCUSSION

In the context of developing countries, considerable effort is required to adapt and learn from existing technologies in order to take full advantage of their embodied knowledge. This effort is probably best manifested by R&D investment. Survey evidence from Jiangsu province in the late 1980s indicates that the record of success for technology import projects has been highly uneven, and that the determining factor in project success has usually been the absorptive capacity of an enterprise [5]. These efforts can be enhanced by IPR protection for incremental innovations, such as utility patents, which further increase the incentives for firms to carry out useful adaptation.

In China, the predominance of state-owned enterprises in the import process appears to hinder productivity improvement, albeit in a paradoxical way. As illustrated in equation (2), state-owned enterprises are associated with lower productivity growth. Moreover, additional econometric evidence suggests that the use of technology developed within SOEs does not appreciably raise productivity. However, since these enterprises are the primary importers of technology, they are an important mechanism for funding its acquisition. It is possible that technology imports by SOEs and perhaps also their R&D efforts spill over into productivity gains by non-state firms in SOEs own industries. With enhanced IPR protection, the financial benefits of these import and indigenization efforts could be partly realized by the state-owned enterprise, perhaps through licensing.

From the standpoint of productivity enhancement, technology transfer through licensing is a more attractive option for technology acquisition than foreign investment, because of the higher level of disclosure involved. However, foreign providers of technology are undoubtedly hesitant to transfer their best technologies to outside firms, especially if IPR protection is inadequate. Thus a dual strategy is preferable, taking advantage of the straightforward productivity-enhancing effects of FDI and the more complex and interactive effects of technology licensing. From either perspective, a stronger IPR system increases the level and quality of technology provided through both licensing and FDI, and therefore productivity.

A remaining question is the extent to which Chinese innovation (independent of foreign technology) affects productivity, and what effect enhanced IPR protection might have on it. Defining innovation is extremely difficult in the context of a developing country. Many forms of adaptation, absorption, and even creative imitation can be legitimate manifestations of innovation.

In the evidence described above, virtually all of the measured effects of R&D on productivity could be attributed to R&D's interactive effects with foreign technology. This result is not surprising when considered in the light of a recent product innovation survey, which found that about 90% of the Chinese firms in the sample classified their innovations as unique only at the domestic or regional level—not the international level [9].

More studies of innovation are necessary but some preliminary conclusions may be drawn from the evidence provided above. While stronger IPR protection may make imitation more costly, real productivity benefits are likely to be realized through higher quality and levels of foreign technology inflows (ideally by transfer, but alternatively through direct investment). These inflows, in turn, are critical to the nourishment of domestic innovation efforts. Finding an appropriate IPRs system that can attract foreign technology and simultaneously enhance and protect domestic incremental innovation is an important challenge.

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