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Impacts of the Japanese Patent System on Productivity Growth

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IMPACTS OF THE JAPANESE PATENT SYSTEM ON PRODUCTIVITY GROWTH

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Abstract: We investigate empirically how the Japanese patent system has affected post-war growth in Japanese total factor productivity. The system has been criticized for several reasons, including that it encourages numerous filings of narrow claims that build incrementally on fundamental technologies developed by domestic and foreign inventors. Stated in different terms, the system was designed to promote technological catch-up and diffusion through incremental innovation. However, its effectiveness in achieving this purpose has not been studied systematically. We provide econometric evidence that the technology diffused through the Japanese patent system had a significant and positive impact on Japan's technical progress.

JEL Codes: F13, O31, O34

Key Words: Patents, Utility Models, Technology Diffusion

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1. Introduction

The post-war Japanese patent system (JPS) has been described as a mechanism for promoting both "diffusion and exclusion" (Ordover, 1991). To the extent that it enhances diffusion of technical knowledge through the Japanese economy and generates useful adaptive inventions, it contributes positively to productivity growth. To the degree that it safeguards exclusive use of technologies there is a tradeoff between positive growth effects from incentives for invention and negative growth effects from limited access to information. Thus, it is important to study the impacts of patenting activity on Japanese productivity growth, a task that has received little systematic attention in the empirical literature.

Existing evidence on how patent systems affect growth is largely anecdotal. Some observers point to rapid technical change and learning in key East Asian countries, such as Korea and Taiwan in the 1970s and 1980s, in the absence of strongly protective patent regimes as confirmation that weak systems that promote diffusion and imitation also spur growth. However, others note that similarly weak systems in countries such as India have not promoted similar technical adaptation. Clearly, other factors are at work and research to date has been insufficiently focused on key aspects of patent systems to detect any correlation with growth.[2]

Thus, it is fruitful to study the growth impacts of particular national regimes. Special features of the Japanese patent system have been studied qualitatively in this regard. Its design illustrates a view of patents more as a public good and less as private

[2] However, Gould and Gruben (1996) find in cross-country regressions that, other things equal, as countries strengthen their patent regimes there is a small contribution to growth in more open economies.

property (Wineberg, 1988). Ordover (1991) describes how the JPS is designed to induce innovators to disclose information sooner than does the American system through such features as first-to-file and pre-grant disclosure

In this paper we investigate econometrically how total factor productivity (TFP) growth has been affected by patent activity over the period 1960 to 1993. Our findings indicate that features of the Japanese patent system, such as narrow claim requirements and a pre-grant disclosure rule, were effective in promoting technological diffusion. In turn, this diffusion had a positive impact on technical progress. The primary channel of diffusion was through applications for utility models, which are incremental inventions of a small and applied nature that build on prior fundamental technical knowledge embodied in patent applications and that quickly are embodied in commercial uses. There was an important indirect impact of applications for invention patents through their stimulation of follow-on utility models. These results suggest strongly that the JPS encouraged diffusion in at least one way that promoted “catching-up” to advanced technologies.

The paper is organized as follows. In Section 2 we review relevant literature on growth and patents, describe important aspects of the Japanese patent system, and examine data on patenting activity in order to set context for the econometric analysis. In Section 3 we present the estimation procedure and discuss the results. The final section contains concluding remarks.

2. The Japanese Patent System and Technical Change

Technical progress, or changes in total factor productivity, is an essential element in economic growth. The classic reference is Solow (1957), in which he uses growth accounting theory to establish the link between technical progress and changes in productivity. Newer endogenous growth theory (Romer, 1993) attributes the TFP component of growth to the interaction between ideas and knowledge accumulation, which together generate increasing returns to physical and human capital.

How patents affect invention, technology use, and growth remains an area of considerable controversy. A useful recent summary of this complicated process is provided by UNCTAD (1996). Patents exist both to encourage inventive activity and to facilitate assimilation of new technologies into the broader economy. In general, there is a tradeoff between these goals and patent systems may be devised to favor one or the other, as we illustrate in this section. We describe the salient features of the JPS in the context of these conflicting objectives.

The patent system can serve as one mechanism for technology diffusion in an economy. Ordover (1991) compared the Japanese system with that of the United States and described its institutional characteristics as encouraging diffusion through narrow claims, strong licensing incentives and other salient features. In this section we discuss important aspects of the JPS in the period prior to 1993, which corresponds to the data used in our estimations.[3]

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[3] Two bilateral agreements were reached in 1994 with the United States under the Framework on Intellectual Property Rights. These agreements required fundamental changes in the Japanese patent regime (Papovich, 1997; USTR, 1997), which forces us to end our estimation period in 1993.

In Japan, the first articles of the patent law and utility model law state that their goal is to promote industrial development by encouraging the protection and exploitation of inventions and utilization of devices.[4] They do not mention inventor's rights or exclusive rights; rather, inventions are treated more as public goods in that contents of patent (and utility model) applications are made available to the public before the patent is granted. Thus, Japanese patent policy has advocated the utilization of inventions towards industrial development.

Subject Matter and Claims

All patent systems require an invention to satisfy requirements for novelty, utility, and an inventive step ("non-obviousness") in order to be patentable. The stringency of these standards sets the bar for earning exclusive rights. Patent breadth defines the extent of the claim protected and permissible activities in using the patented information. Thus, having low novelty standards and recognizing only narrow claims encourages small and incremental inventions while limiting incentives for R&D into fundamental technologies. This is especially the case if the patent laws provide liberal treatment of reverse engineering of patented products, thereby promoting imitative forms of R&D.

In this context, an important feature of the JPS was its reliance on utility models and industrial designs. The required level of inventiveness of a utility model, as well as the scope and duration of protection, has been less than those for a standard patent in Japan (Bouleware, *et al*., 1994). Further, industrial designs only needed to demonstrate novelty

[4] See Article 1, (Tokkyo Ho) Patent Law, Law No. 121, 1959, and Article 1, Utility Model Law, Law no. 123, 1959 as discussed in Foster and Ono (1966) and Yoshifuji (1991).

and not inventiveness in Japan in order to earn patent protection. This system has essentially allowed firms in Japan to receive utility model protection and design patents on technologies that were only slightly modified from the original invention.[5]

Until 1988 the Japan Patent Office (JPO) required patent applications to cover only a single invention claim.[6] Although single claims are no longer a legal requirement, Japanese patent officers and firms still seem to favor narrowly defined applications (Aoki, 1997; Kotabe, 1992; USTR, 1997). This system has generated large numbers of patent and utility model applications and limited the scope of protection for any particular patent.

The single-claim requirement has allowed firms in Japan to invent around original patent applications more easily by virtue of limiting the extent of what might be infringed by followers. In addition, this requirement has provided an incentive for "cluster filing" patent applications. This procedure involves filing a myriad of accompanying applications along with every principal application, prohibits competitors from obtaining similar patents, and forces cross-licensing (Doane, 1994). The single-claim requirement coupled

[5] The 1994 amendments to Japan's industrial property laws streamlined the utility model application process by effectively eliminating the examination, thereby ending the need for publication of the application and opposition procedures, and shortening the length of protection from 15 to six years from the application filing date (Aoki, 1997). The reduced term of protection coupled with increased registration and maintenance fees have reduced the expected value of a utility model, causing applications to decline in favor of patents.

[6] In 1987, Japan's industrial property law was amended to eliminate the "single claim requirement" on patent and utility model applications. The former law encouraged several narrow applications, often centered on one novel invention. As shown below, this revision contributed to the decline in utility model applications.

with cluster filing has enabled firms in Japan to "box in" the original inventions embodied in existing applications, effectively forcing the original applicant to cross-license its technology to those firms filing opposition claims. The latter firms were often the same firms that filed applications on technologies invented around the original claim (Ordover, 1991).

First-to-File

In granting patents, Japan followed a first-to-file rule. This rule eliminated many lawsuits regarding the identity of the original inventor and induced rapid disclosure as firms were forced to file sooner than they might otherwise elect under the alternative priority rule (Ordover, 1991). However, numerous opportunities for conflict existed under the first-to-file procedure and, as a result, firms have often resorted to licensing. In Japan firms were under pressure to file as early as possible and were free to amend the application during the first 15 months after filing,[7] heightening the possibility of similarity among patent claims and inducing firms to issue licenses to settle differences in these claims (Wineberg, 1988). In addition, if two or more applications relating to the same invention were filed on the same date, applicants were required to reach an agreement among themselves as to who would obtain the patent or else none would receive it.[8]

This aspect of Japan's patent policy illustrates how the JPS encouraged voluntary agreements and discouraged confrontation. It is claimed that the first-to-file rule has served well those Japanese firms that can patent around original inventions and have large

[7] Article 17, Japan Patent Law.
[8] Article 39, Section 2, Japan Patent Law.

patent staffs to get through the system more quickly. Accordingly, it has poorly served original inventors and small firms (Wineberg, 1988).

Pre-grant Disclosure and the Pendency Period

Patent systems require disclosure of patentable technologies through public media. The sooner is the disclosure (particularly if it occurs prior to patent grants) and the more detailed the technical specifications, the easier it becomes for rival firms to learn technologies and develop patentable improvements. Thus, liberal disclosure rules also promote technology diffusion. Moreover, narrow patent claims and rapid disclosure requirements encourage filing of large numbers of applications for slightly differentiated technologies or products, resulting in substantial cross-licensing among industry groups and rival firms, providing yet another avenue for rapid and widespread diffusion.

Pre-grant disclosure and pre-grant opposition were two important characteristics of the JPS during the relatively lengthy pendency period (Kotabe, 1992). In Japan patent applications were published 18 months after filing, well before awards were made. By laying open the application before it is granted, the JPS allowed firms to make investment decisions with less uncertainty while preventing duplication of investments in particular R&D projects. Due to these procedural differences, inventions became public knowledge sooner and were quickly diffused into the research and scientific community in Japan.

During the disclosure period in Japan, competitors were allowed to inspect and oppose the application as well as use the inventions without paying royalties until the patent was issued. The JPO permitted patent applications for improvements on inventions under review as there was no requirement for original inventorship under the first-to-file rule. Subsequently, it was during the early disclosure period that firms in Japan could extract technological knowledge from patent applications and file follow-on utility model and industrial design applications.

Under Japanese patent law, third parties could oppose a patent application during the disclosure period on the basis of novelty requirements, non-obviousness, and industrial applicability. The applicant had only a few months to provide an adequate response or the application was rejected. The pre-grant opposition procedure has been termed a "loophole" in the JPS that often was specifically directed toward foreign patents covering critical technologies.[9] These opposition proceedings could be costly for the original applicant and could lengthen the pendency period, thereby decreasing the value of patents awarded. Large Japanese firms maintained sizeable patent staffs that specialize in pre-grant oppositions and thus gained an advantage in subsequent licensing agreements (Lindgren and Yudell, 1994).

Patent Term Limits

In the period we investigate, the duration of a patent in Japan was the shorter of 15 years from the date of publication for opposition or 20 years from the filing date. Kotabe (1992) found that Japanese patent practices discriminated against foreign applicants through longer pendency periods. The average lag between the date an application was filed and a patent was issued was one to three years for a Japanese firm while it was seven to eight years for a foreign firm. Given long pendency periods and examination delays combined with the term of protection beginning with the date of filing, the average term of

[9] See U.S. Senate Subcommittee Hearing on Foreign Commerce and Tourism, June 10, 1988.

protection was relatively short under the Japanese patent system. Linking the length of the patent to the filing date effectively allowed the JPO, as well as rival firms, to dictate the length of protection through delaying the examination process.

Royalties and Licensing

Under Japanese patent law, during the early disclosure period competitors could use inventions in patent applications without paying royalties until the patent was issued. Given that rivals could file utility model applications around the original invention during this period, Japanese firms were able to earn patents on small additions to fundamental technologies.

The system could yield situations where the original inventors reaped little reward for their novel inventions. For example, a Japanese firm might slightly modify an original invention during the early disclosure period and receive a utility model or industrial design patent while paying no royalty fees to the original inventor. In addition, if a rival filed an industrial application for an invention based on a patent application that was under disclosure, the rival was later subject to lesser royalty fees if the original invention were patented (Ordover, 1991).[10] In this way, the JPS rewarded firms that reverse engineered and modified inventions while penalizing original inventors.

Testable Hypotheses

The processes just described motivate three hypotheses that we test with time-series data on growth, patents, and control variables. First, we propose that the weaker

[10] See also Curci and Takura (1995), Helfgott (1990), Kintner and Lahr (1982).

novelty and non-obviousness requirements of utility models, relative to those of patents, allowed firms to file applications for utility models based on technology learned from patent applications published prior to patent grant. That is, the JPS encouraged filing of utility models covering follow-on developments that were invented around published patent applications. We therefore have the first hypothesis, relating to incremental innovation.

Hypothesis One: The number of utility model applications may be explained by the number of previously filed patent applications. In econometric terms we expect patent applications to Granger-cause utility model applications in a positive direction.

Next we propose that Japan's pre-grant disclosure rule served as a mechanism for technology diffusion in that the laying open of patent and utility model applications enabled technology spillovers. This motivates our second hypothesis, regarding the diffusion effect of patents.

Hypothesis Two: Controlling for utility model grants and patent grants, utility model applications and patent applications Granger-cause TFP growth in a positive direction.

Finally, we propose that once protected, use of technology becomes more insulated, serving to inhibit technology diffusion. Here we are focusing on the exclusionary effect of patent grants, which would serve to diminish growth.

Hypothesis Three: Controlling for utility model and patent applications, utility model grants and patent grants Granger-cause TFP growth in a negative direction.

In investigating these hypotheses, we use measures of applications and grants, both in total and broken down between domestic and foreign petitioners. The distinction between resident and non-resident applicants is useful for assessing whether the diffusion impact applies differentially to technology developed within Japan or to technology imported from abroad.

Evidence on Patenting and Technology Use

We show trends in applications for patents and utility models in Japan in Figure 1. The data come from the Japanese Patent Office. It is clear that the number of domestic applications far exceeded the number of foreign applications, which is unusual in an international context. The percentage of domestic applications in total applications rose from around 75% to 92% over the period, reflecting a rising relative use of the JPS by domestic firms. Foreign patent applications rose sharply in the 1960s to a peak of nearly 30,000 in 1970 before leveling off at around 25,000 per year. In contrast, domestic patent applications rose continuously throughout the period, peaking at around 320,000 in 1987 before becoming steady. This reduction in the growth of patenting partially reflects the elimination of the single-claim requirement in 1987.[11] However, as noted above, there still seems to be a tradition to have fewer claims in a single patent. Thus, a single technology continues to correspond to more patents in Japan.

The number of domestic applications for utility models tripled between 1960 and 1987 before falling sharply, presumably because the elimination of the single-claim requirement in patents reduced the relative attractiveness of utility models. Foreign applications reached a high of around 2,400 in 1970 before declining to current levels

[11] It is also consistent with a general slowdown in patenting in OECD countries (Evenson, 1984).

below 1,000 per year. Domestic applications are about 98% of total applications for utility models.

Despite the high ratio of domestic-to-foreign applications for patents and utility models, Japan has been a significant net absorber of foreign technologies. As shown in Figure 2, the ratio of payments to receipts of royalties and license fees in Japan's "technology balance of payments" exceeded 4.0 in 1973. However, this ratio declined to near-balance by 1994, indicating Japan's rising relative position as a technology supplier.

3. Econometric Framework

In this section we discuss estimates of TFP growth, discuss data sources, and set out the testing procedure for our hypotheses.

Total Factor Productivity

We define growth in TFP as the annual variation in aggregate output not explained by input changes. Japanese TFP has been studied many times in the literature. For example, following the bilateral model of Jorgenson and Kuroda (1990), Nakamura (1992) identified technical change and scale effects as sources of productivity growth and found technical change to be the dominant source of Japan's TFP growth while scale effects mainly contributed to U.S. productivity growth. However, the structure of the patent system has not received attention as a determinant of such growth.

To calculate TFP, we begin with a conventional production function of the form:

$$Q_t = A_t \cdot F(L_t, K_t) \tag{1}$$

where Q is GDP, A is total factor productivity, L is a measure of labor services in natural units and K is a measure of capital services. In order for the coefficients to sum to unity and thus reflect percentage shares in GDP growth, the TFP growth model is constrained to be a standard Cobb-Douglas function. Taking logs, we then rewrite equation (1) in terms of total factor productivity:

$$\ln TFP_t = \ln Q_t - s_{Lt} \cdot \ln L_t - s_{Kt} \cdot \ln K_{t.} \quad (2)$$

where s_L and s_K are elasticities of output with respect to physical capital and labor, respectively. Under the assumptions of constant returns to scale and competitive factor markets, these elasticities equal the income shares of their respective factors.[12] The growth of TFP over the period (t-1) to (t) is then

$$\Delta \ln TFP_t = \ln TFP_t - \ln TFP_{t-1}$$

$$= (\ln Q_t - \ln Q_{t-1}) - s_{Lt}^* (\ln L_t - \ln L_{t-1}) - s_{Kt}^* (\ln K_t - \ln K_{t-1}) \quad (3)$$

where s_{Lt}^* and s_{Kt}^* are the average income shares of labor and capital for periods t and t-1.

Data on real GDP in yen terms were taken from various issues of *International Financial Statistics* of the International Monetary Fund. All price deflators come from this source as well, with the base year defined as 1990. Annual figures on total employment and wage bill were taken from various issues of *International Labor Yearbook* of the International Labor Organization.

[12] It is common in the Japanese productivity literature to assume constant returns to scale in aggregate data, while allowing for increasing returns to scale in industry data (Christensen, Cummings, and Jorgenson (1995); Nadiri and Prucha (1990)). We stay within this tradition by assuming constant returns in our aggregate growth approach.

In order to generate a physical capital stock variable we employ the perpetual inventory method. Data on aggregate real gross fixed capital formation, taken from the *International Financial Statistics*, receive declining weights (reflecting depreciation) over a span of 15 years. The depreciated investment flows are summed to compute the capital stock:

$$K_T = \sum_{t=0}^{14} (GFKF_{T-t}) \cdot (0.877)^t \quad (4)$$

Here, K_T is the capital stock in time period T in 1990 prices and GFKF is gross fixed capital formation (including public and private residential buildings, plant and equipment, and changes in stocks, expressed in 1990 prices using the wholesale price index).

Note that as the time lag approaches 14 years, the inherent contribution of that period's investment to the overall capital stock available in a given year diminishes. Thus, this is an approximation of the true capital stock. However, given the wide range of life-spans for different types of capital it is difficult to develop a completely accurate measurement. For example, although most forms of capital, such as basic manufacturing and non-manufacturing machinery and equipment, have an average life span of eight to 13 years, other types of capital, such as vehicles and dwellings, have life spans of five and 45 years, respectively (OECD, 1993). The initial year for which we found data on capital formation was 1946, so that implicitly we assume that World War II left Japan with no capital in use in 1945. With the 14-year lag required in the capital-stock computation, we begin our TFP estimation in 1960.

Figure 3 plots the resulting TFP growth estimates for 1960-1993. Total factor productivity growth was volatile during 1960s though generally positive.[13] Following the oil shock of 1973 TFP change sharply declined but the period from 1976 to 1987 displayed positive productivity change. Data for the late 1980s and thereafter attest to the beginning of the well-known productivity slowdown that many OECD countries began experiencing in that decade.

Time-Series Analysis

To test our propositions we construct Granger Causality tests with time-series data. Such tests require construction of vector autoregressive (VAR) models with stationary series. Table 1 lists acronyms for the variables we use, including applications and grants for utility models and patents, registered by domestic and foreign residents, along with TFP. The table also indicates the results of testing for the existence of unit roots. The Weighted Symmetric test and Augmented Dickey-Fuller (ADF) test did not reject the hypothesis of a unit root in most of the patent and utility model applications and grant series, nor in TFP series. However, at least one test rejected for domestic patent

[13] The sharp decline of TFP growth in 1966 is due to an evident data error in *International Financial Statistics* in reported GDP. Other sources do not report this downward shift. When we tried to correct for this problem the resulting value still generated a large outlier for productivity growth. To avoid inference errors, we incorporate a dummy variable for 1966.

grants, foreign utility model applications, and total patent grants series.[14] There was some ambiguity on the point between the two tests.

Under circumstances in which most series have a unit root but a few do not, it is standard procedure to take first differences of all series to achieve stationarity (Plosser and Schwert, 1978). Optimal lag lengths (not reported) in the unit root tests were chosen initially by the Akaike Information Criterion (AIC). Such model-selection criteria tend to favor relatively parsimonious lag specifications but a sufficient number of lags are required to eliminate autocorrelation. Thus, in choosing the order of the VARs, we used the minimum AIC-suggested lag length or longer to eliminate autocorrelation, employing standard Q-tests for white-noise residuals.

The AIC indicated two lags for domestic patent applications and four lags for domestic patent grants. However, three lags were necessary to eliminate autocorrelation in applications so we chose that lag specification. In fact, recalling that pre-grant disclosure takes place 18 months after the date of filing, in selecting the VAR specifications later we included only lags of two and three years in patent applications.[15] The appropriate specification for domestic patent grants included lags up to four years. With respect to domestic utility models we found three lags appropriate for applications and four lags for grants, respectively. Optimal lag lengths for other series were selected analogously.

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[14] The Weighted Symmetric test is recommended over the ADF test because it has (sometimes only slightly) higher power (Pantula, Gonzales-Farias, and Fuller, 1994).

[15] The results were insensitive to the inclusion of zero and one-year lags in any case.

We test for cointegration among the series in order to determine whether an error correction term must be included in the VAR estimation in order to avoid omitted variable bias. We do this using Johansen's (1988) maximum likelihood technique, incorporating lags as indicated by optimal lag lengths discussed above. Regarding the bivariate models of patent and utility model applications applicable to Hypothesis One, there was evidence of cointegration up to three lags in each case except in the relationship between foreign patent applications and domestic utility model applications. For the multivariate models applicable to Hypotheses Two and Three, cointegration existed for the three and four lag specifications, respectively.[16] Accordingly, in estimating the relevant VARs each equation incorporated an error-correction term.

Thus, the VAR equations included lags of dependent and independent variables, all in first-differenced forms, as well as the error-correction terms as regressors. Each specification was estimated both including and excluding control variables for technology creation and diffusion. In particular, we included measures of aggregate Japanese real research and development spending along with real imports of capital goods, defined as general machinery, electrical machinery, and transport equipment. The latter variable served to control for technology transfer through trade (Keller, 1995; Coe, Helpman, and Hoffmaister, 1997). Neither of these variables was significant in any specification and their inclusion did not affect the significance levels or coefficient signs of the patent variables. Accordingly, we do not report regressions with them included. Finally, a dummy variable for the year 1966 was included because of the implausible measure for GDP in that year.

[16] Results are available on request.

Empirical Results

We establish Granger-causality results to test each of the three hypotheses discussed earlier. Bivariate tests for Hypothesis One are presented in Table 2. These are joint F-tests of the significance of the error-correction term and the lagged variables in question. The column listed "Prob" indicates the significance level with which the null hypothesis of no causation may be rejected and the final column indicates the significance level for the reverse hypothesis.

The first set of results clearly demonstrates that prior domestic patent applications were Granger-causal to current domestic utility model applications, supporting Hypothesis One. The sum of the coefficients (not shown) on lagged patent applications was 0.124, which was positive and significant at the one percent level. This finding was true also for total patent applications and total utility model applications in the second set, with the coefficient sum of 0.193 being significant at the one percent level as well. Interestingly, the result did not hold for foreign patent applications, which were not causal either to foreign or domestic utility model applications. This suggests that technology diffusion through the patent system resulted more from domestic inventiveness than from imitation of foreign technologies.

These findings support the notion that, due to weak novelty requirements for utility models and pre-grant disclosure, it was common for Japanese firms to file utility model applications that were slightly altered versions of existing patent applications, perhaps modified to their own manufacturing processes. However, learning through modification of technologies in patent applications was more focused on Japanese patents than on foreign patents. Thus, diffusion in Japan, as promoted by the legal features of the patent system, flowed largely from domestic patent applications to follow-on utility model applications.

To set up the tests for Hypotheses Two and Three, we report unrestricted VAR equations in Table 3. The top panel shows the regression of TFP growth on differences in logs of lagged utility model grants and applications. In terms of individual coefficients it seems that grants had a negative impact on TFP growth while applications had a positive impact. The same pattern was true for patent grants and applications in the bottom panel.

The relevant hypotheses tests are that these coefficients are jointly zero, however, as shown in the block Granger non-causality tests in Table 4. The first panel tests the hypothesis that domestic utility applications did not cause TFP growth by setting the coefficients on applications equal to zero in the restricted model. The data rejected this null, indicating that, controlling for grants, domestic utility model applications were significantly and positively related to growth, as claimed by Hypothesis Two. The opposite causation was not supported. The second panel tests for causation running from patent applications to TFP growth. Here the rejection was weaker, coming only at the ten-percent level, but did provide further direct support for Hypothesis Two. Overall these results indicate that applications for protection raised productivity growth. Coupled with Hypothesis One these findings support the notion that patent applications directly raised growth and also that there was an important indirect impact through stimulating later utility model applications. Thus, patent applications bore information about novel inventions while follow-on utility model applications were likely to get through the JPO and into the manufacturing process more quickly.

Hypothesis Three is tested in the last two panels. Recall that this hypothesis claims that grants of protection tended to reduce growth performance through an exclusionary effect. In the third panel we find weak evidence that, controlling for utility model applications, utility model grants affected later TFP growth, with the impact being negative according to the coefficient signs in Table 3. However, the result is ambiguous in light of the opposite probability suggesting that TFP growth also Granger-caused utility grants. In the final panel we find no evidence that patent grants affected TFP growth.[17]

Overall, therefore, we find no significant exclusionary impacts of patent grants alone, and an indistinct impact from utility model grants. This may be because once a patent was granted, the grantee encountered strong licensing incentives of the JPS and chose to license the technology to rival firms. Because licensing promotes diffusion while maintaining incentives to engage in R&D, it may have been a significant channel of technology transfer among Japanese firms, thereby lessening the exclusionary effects of patent grants.

4. Concluding Remarks

This paper provides a first look at the impact of the unique characteristics of the Japanese patent system on post-war technical progress in Japan. Given certain patent procedures, such as pre-grant disclosure, single-claim requirement, first-to-file, and lengthy pendency periods, the JPS has enabled a channel of technology transfer through the application process. We find that technology diffusion through utility model applications had a positive impact on Japan's post-war productivity growth. Further,

[17] We also estimated VARs with foreign applications and grants, which had no detectable impacts on TFP

there was an important indirect impact of applications for invention patents, reflecting more fundamental industrial invention, through their stimulation of follow-on utility model applications, which were quickly diffused into commercial use. This effect seemed to be more focused on domestic patents than on foreign patents, suggesting that Japan's technical progress through the patent system was more a question of diffusing domestic inventiveness into the economy rather than imitating foreign inventions.

Overall our central observation is that features of the JPS were effective in encouraging technology diffusion and incremental innovation. This finding sheds light on the net effects of early disclosure rules. In theory, accelerated disclosure could increase aggregate innovation and raise technological progress through the channels analyzed here. However, by promoting imitative forms of R&D it also could inhibit incentives for fundamental invention and reduce long-run growth. This is particularly the case if reverse engineering is allowed, which was true in Japan during this period.

These findings are consistent with the fact that over the period concerned Japan was in a technological "catch-up" phase. Diffusion and imitation were more important than pure invention. The various features of the JPS discussed here indeed had a positive net impact on TFP growth by virtue of emphasizing incremental innovations and licensing by domestic firms.

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growth.

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References

Aoki, Reiko, 1997, Recent trends in the Japanese industrial property system, Manuscript, SUNY, Stony Brook. Prepared for the conference: Intellectual Property: Japan and the New Asia, Japan Information Access Project, Washington, D.C.

Bouleware, M., J. Pyle and F. Turner, 1994, An overview of intellectual property rights abroad, Houston Journal of International Law 16, 441-507.

Christensen, L., D. Cummings, and D. Jorgenson, 1995, Economic growth, 1947-1973: An international comparison, in: D. Jorgenson, ed., Productivity: International Comparisons of Economic Growth, Vol. 2 (MIT Press, Cambridge, MA) 203-295.

Coe, D., E. Helpman, and A. Hoffmaister, 1997, North-South R&D spillovers, Economic Journal 107, 134-149.

Curci, F. and T. Takura, 1995, Selected aspects of Japanese intellectual property law, Transnational Lawyer 8, 63-85.

Doane, M., 1994, TRIPS and international intellectual property protection in an age of advancing technology, The American University Journal of International Law and Policy 9, 465-497.

Evenson, R., 1984, International invention: Iimplications for technology market analysis, in: Z. Griliches, ed., R&D, patents, and productivity (National Bureau of Economic Research) 89-123.

Foster, R. and M. Ono, 1966, The patent and trademark laws of Japan (Asahi Press, Tokyo).

Gould, D. and W. Gruben, 1996, The role of intellectual property rights in economic growth, Journal of Development Economics 48, 323-350.

Helfgott, S., 1990, Cultural differences between the U.S. and Japanese patent systems, Journal of the Patent and Trademark Office Society 72, 231-238

International Monetary Fund, various years, International Financial Statistics Yearbook (Washington, D.C.).

International Labor Organization, various years, International Labor Yearbook (Washington, D.C.).

Japanese Patent Office, various years, Japanese Patent Office Annual Reports (Tokyo).

Johansen, Soren, 1988, Statistical analysis of cointegration vectors, Journal of Economic

Dynamics and Control 12, 231-254.

Jorgenson, D. and M. Kuroda, 1990, Productivity and international competitiveness in Japan and United States, in: C. Hulten, ed., Productivity growth in Japan and the United States (University of Chicago Press, Chicago, IL) 29-55.

Keller, W., 1995, Trade and the transmission of technology, Manuscript, University of Wisconsin at Madison.

Kintner, E. and J. Lahr, 1982, An intellectual property law primer, 2nd ed. (New York, NY).

Kotabe, M., 1992, A comparative study of U.S. and Japanese patent systems, Journal of International Business Studies 23, 147-168.

Lindgren, J. and C. Yudell, 1994, Articles protecting American intellectual property in Japan, Santa Clara Computer and High Technology Law Journal 10, 1-34.

Nadiri, M. and I. Prucha, 1990, Comparison and analysis of productivity growth and R&D investment, in: C. Hulten, ed., Productivity growth in Japan and the United States (University of Chicago Press, Chicago, IL) 109-133.

Nakamura, S., 1992, Explaining Japan and U.S. TFP difference, The Economic Studies Quarterly 43, 326-36.

OECD, 1993, Methods used by OECD countries to measure stocks of fixed capital national accounts: Sources and methods, No. 2. (Paris, France).

Ordover, J., 1991, A patent system for both diffusion and exclusion, Journal of Economic Perspectives 5, 212-229.

Pantula, S., G. Gonzales-Farias, and W. Fuller, 1994, A comparison of unit-root test criteria, Journal of Business and Economic Statistics 12, 449-459.

Papovich, J., 1997, New and unresolved U.S.-Japan intellectual property rights issues, Manuscript, Office of the U.S. Trade Representative, Washington, D.C.

Plosser, C. and G. Schwert, 1978, Money, income and sunspots: Measuring economic relationships and the effects of differencing, Journal of Monetary Economics 4, 637-660.

Romer, P., 1993, Two strategies for economic development: Using ideas and producing ideas, in: Summers, L. and S. Shah, eds., Proceedings of the World Bank annual conference on development economics (Washington, D.C.) 63-91.

Solow, R., 1957, Technical change and the aggregate production function, Review of Economics and Statistics 39, 312-320.

United Nations Conference on Trade and Development (UNCTAD), 1996, The TRIPS agreement and developing countries (United Nations, Geneva).

U.S. Senate Hearing, 1988, Committee on Commerce, Science and Transportation, Subcommittee on Foreign Commerce and Tourism, Effect of the Japanese patent system on American business, S. Hrg. 100-874, June 24, 1988.

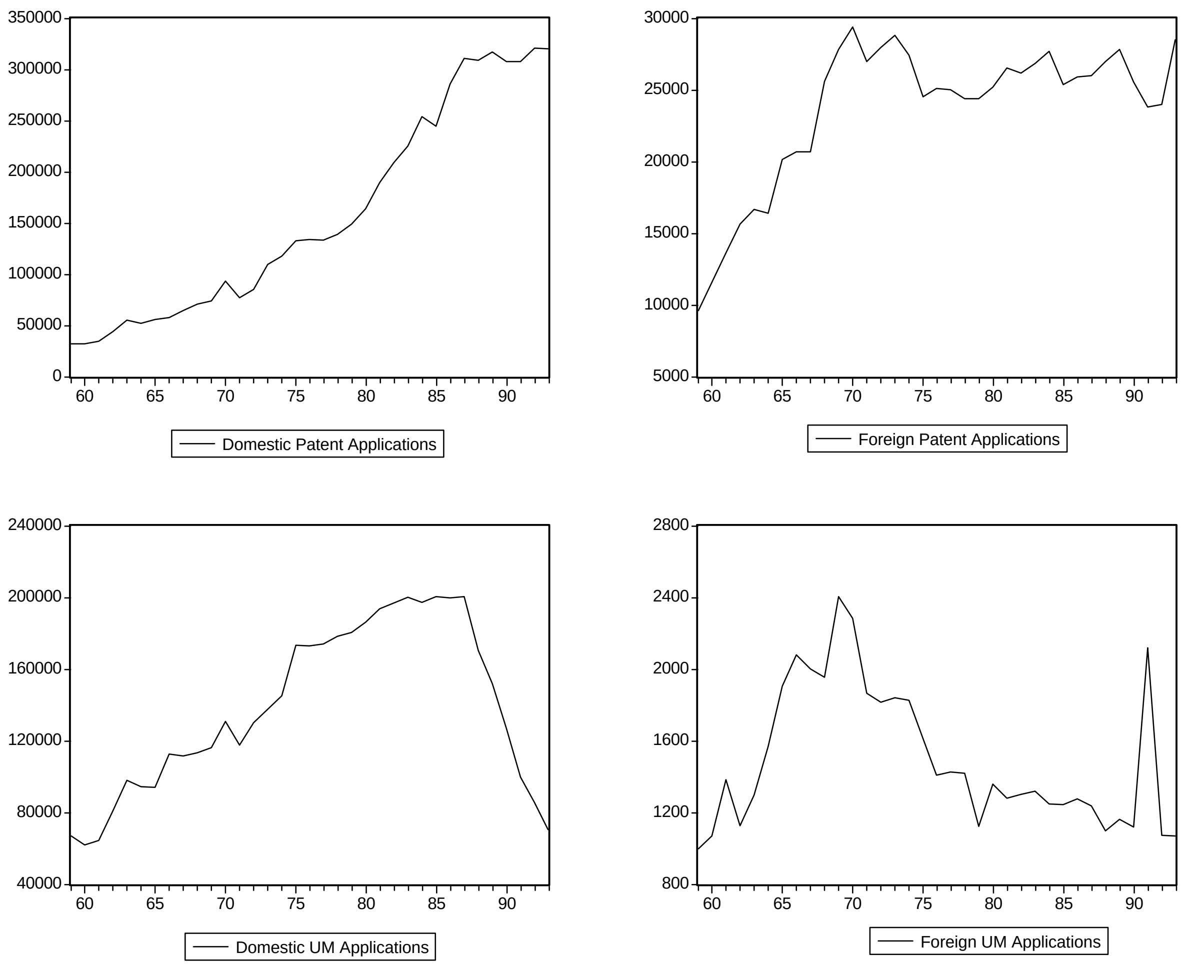
United States Trade Representative, 1997, The 1997 national trade estimates (NTE) report on foreign trade barriers, (Washington, D.C.).

Wineberg, A., 1988, The Japanese patent system: A non-tariff barrier to foreign business? Journal of World Trade Law 22, 11-22.

Yoshifuji, K., 1991. Tokkyoho Gaisestu (An Introduction to Patent Law), 9th edition, (Yuhikaku Press, Tokyo).

Figure 1

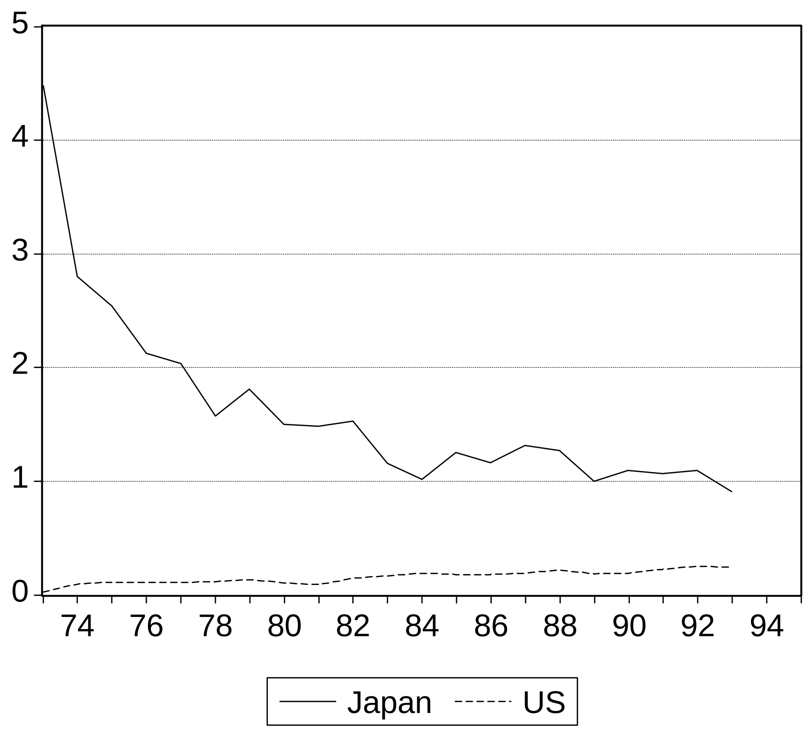
Patent and Utility Model Applications, 1960-1993



Source: Japan Patent Office

Figure 2

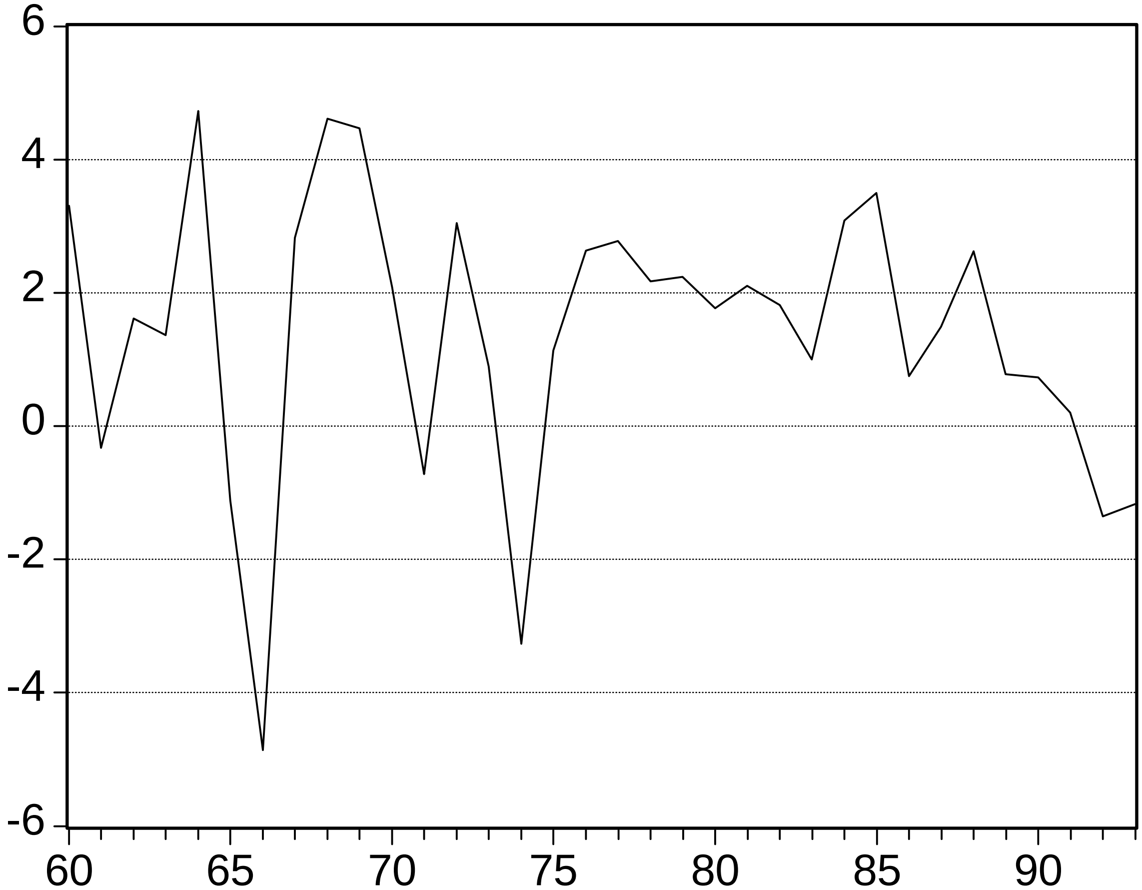
Technology Balance of Payments, Ratio of Payments to Receipts



Source: OECD, *Main Science and Technology Indicators*

Figure 3

Total Factor Productivity Growth 1960-1993



Source: Authors' calculations

Table 1: Summary of Unit Root Tests
Weighted Symmetric and Augment Dickey Fuller Test Results

Trend and Constant incorporated where appropriate

	Test Statistic		P-values	
Variable	**Wtd. Sym.**	**ADF**	**Wtd. Sym.**	**ADF**
DPA	-1.1768	-1.8132	0.9558	0.6984
DPG	-3.8207	-2.7587	0.0079	0.2125
DUA	-1.1605	1.0627	0.9578	1.0000
DUG	-1.9916	-2.7647	0.6542	0.2102
FPA	-1.0390	-2.3593	0.9703	0.4015
FPG	-1.9111	-2.3116	0.7064	0.4275
FUA	-3.0675	-3.8515	0.0706	0.0141
FUG	-1.7303	-1.6443	0.8051	0.7746
UA	-1.1492	1.0968	0.9591	1.0000
PA	-1.4662	-1.8146	0.9009	0.6977
UG	-1.9903	-2.7401	0.6551	0.2198
PG	-3.6865	-3.1800	0.0118	0.0885
APP	-1.0456	-1.8758	0.9697	0.6671
GRANT	-2.7423	-2.0241	0.1671	0.5882
TFP	-1.8172	-2.6642	0.7611	0.2512

Variable Names	
DPA	Domestic Patent Applications
DPG	Domestic Patent Grants
DUA	Domestic Utility Model Applications
DUG	Domestic Utility Model Grants
FPA	Foreign Patent Applications
FPG	Foreign Patent Grants
FUA	Foreign Utility Model Applications
FUG	Foreign Utility Model Grants
UA	Utility Model Applications
PA	Total Patent Applications
UG	Total Utility Model Grants
PG	Total Patent Grants
APP	Total Patent and Utility Model Applications
GRANT	Total Patent and Utility Model Grants

Table 2
F-Tests of Bivariate Granger Non-Causality
in the VAR

Null Hypothesis	Lags	Obs	F-stat	Prob	Prob (opp. case)
DPA does not GC DUA	2	35	14.9913	0.0000	0.1152
	3	34	8.1358	0.0005	0.2118
PA does not GC UA	2	32	14.5298	0.0001	0.1516
	3	31	6.0632	0.0032	0.3432
FPA does not GC FUA	2	35	1.9265	0.1633	0.2032
	3	34	1.9980	0.1380	0.4310
FPA does not GC DUA	2	35	0.6998	0.5046	0.5503
	3	34	0.3771	0.7702	0.4328

Table 3
VAR Estimation Results*

Unrestricted Utility Model Specification

Dependent variable: TFP growth

Independent variables	Est. Coeff.	^P-value
CONSTANT	1.7996	[.000]
EC	4.5050E-06	[.706]
TFPGR(-1)	-0.0919	[.398]
DLDUG(-4)	-2.3330	[.363]
DLDUG(-3)	-1.1408	[.760]
DLDUG(-2)	-5.4970	[.031]
DLDUG(-1)	-2.9933	[.088]
DLDUG	-5.2480	[.007]
DLDUA(-3)	8.6218	[.009]
DLDUA(-2)	4.8271	[.283]
D1	-8.6471	[.000]

Summary Statistics and Diagnostics:

Observations	30
S.E. of regression	1.5927
Adj. R-squared	0.4722
Log likelihood	-50.4483

Unrestricted Patent Model Specification

Dependent variable: TFP growth

Independent variables	Est. Coeff.	^P-value
CONSTANT	3.4084	[.016]
EC	0.0145	[.943]
TFPGR(-1)	-1.1518E-05	[.032]
DLDPG(-4)	-1.7748	[.636]
DLDPG(-3)	-3.5387	[.281]
DLDPG(-2)	-8.9070	[.032]
DLDPG(-1)	-5.6212	[.047]
DLDPG	-4.8182	[.035]
DLDPA(-3)	7.0058	[.251]
DLDPA(-2)	6.6255	[.070]
D1	-7.2548	[.001]

Summary Statistics and Diagnostics:

Observations	30
S.E. of regression	1.7677
Adj. R-squared	0.3498
Log likelihood	-52.8069

* Standard Errors are heteroskedastic-consistent.
Five-percent significance is indicated by "**" and one-percent significance is indicatedby "*".

Table 4
Joint F-Tests of Block Granger Non-Causality
in the VAR

Hypothesis Two:

Null Hypothesis: DUA ARE NOT GC TO TFP GROWTH
Utility Model Specification: Model A vs. Restricted Model A
Restriction: coefficients on DLDUA are zero
Reject Null at 5% significance level

Obs	30
F-stat	4.3183
Prob.	0.0276
Prob. (opp)	0.4483

Null Hypothesis: DPA ARE NOT GC TO TFP GROWTH
Patent Model Specification: Model A vs. Restricted Model A
Restriction: coefficients on DLDPA are zero
Reject null at 10% significance level

Obs	30
F-stat	2.7305
Prob.	0.0725
Prob. (opp)	0.8327

Hypothesis Three:

Null Hypothesis: DUG ARE NOT GC TO TFP GROWTH
Utility Model Specification: Model A vs. Restricted Model A
Restriction: coefficients on DLDUG are zero
Reject null at 10% significance level

Obs	31
F-stat	2.2826
Prob.	0.0854
Prob. (opp)	0.0564

Null Hypothesis: DPG ARE NOT GC TO TFP GROWTH
Patent Model Specification: Model A vs. Restricted Model A
Restriction: coefficients on DLDPG are zero
Do not reject null at 10% significance level

Obs	31
F-stat	1.6069
Prob.	0.1996
Prob. (opp)	0.2483