Patents, Innovations and Economic Growth in Japan and South Korea: Evidence from individual country and panel data

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PATENTS, INNOVATIONS AND ECONOMIC GROWTH IN JAPAN AND SOUTH KOREA: EVIDENCE FROM INDIVIDUAL COUNTRY AND PANEL DATA

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Abstract :

This paper looks at the relationship between patents and economic growth in Japan and South Korea using both individual country and panel data. For the econometric estimation, we use annual data for 1963-2005. For Japan, we find that the logarithms of real GDP and the number of patents are cointegrated. For South Korea, we do find such evidence. For Japan, we find a two-way causality between the growth of real GDP and the growth of the number of patents. For panel data, we find that the logarithms of real GDP and the number of patents are cointegrated. We find some evidence that the growth of real GDP Granger causes the growth of the number of patents. However, we do not find any evidence of reverse causality.

JEL Classification: C22, C23, O31

I. Introduction

Both Japan and South Korea achieved very high rate of growth for a sustained period during the post-second world war era. The average growth rate of real GDP for Japan during 1955-2005 was 4.52%. Table 1 shows the average growth rate of GDP of Japan by decades for 1955-2005. As it can be seen from the table, the growth rate was particularly high during the 1950s and 1960s. The average growth rate of real GDP for South Korea during 1955-2005 was 6.59%. Table 2 shows the average growth rate of GDP of South Korea by the decades for 1955-2005. The average growth rate was particularly high during the 1960s, 1970s and 1980s. Figures 1 and 2 plot the number of patents granted to Japan and South Korea in the United States for 1963-2005. It is quite clear from the figures that for the whole period, Japanese patents far exceeded South Korean patents. The yearly average for Japan was 14,465.60. For South Korea, it was 888.84. Before the mid-1980s, South Korea's patent numbers were quite low.

It is often said that inventions and innovations play a significant role in economic growth. The economic success stories of Japan and South Korea serve as examples for developing countries to emulate. The purpose of this paper is to empirically test the relationship between inventions and innovations and economic growth in these two countries. What accurately measures inventions and innovations is a matter of debate. However, most studies use patent data to measure inventions and innovations. The problem with patent data is that the process of patenting is not harmonized across countries, i.e. different countries follow different procedures to grant patents. To avoid this problem, we use data from the US Patent Office.

The rest of the paper is organized as follows. Section II discusses the objectives and data sources for this study in some details. Section III provides a brief review of the literature. In section IV, we discuss the econometric methodology and the results. Section V has some conclusions.

II. Objectives of the Study and Data Sources

The objective of this study is to empirically examine the relationship between innovations and inventions and economic growth using time-series and panel data for Japan and South Korea. In doing so, we use recent econometric techniques. A perusal of the literature suggests that such a study does not exist. The unique features of this study are as follows. First, the paper uses the recently developed Ng-Perron (see and Ng and Perron, 2001) unit root tests of time-series data. The earlier unit root tests suffer from the problem of low power. Ng-Perron tests have better power. These tests are also particularly suitable for small samples. Second, we also use panel data for these two countries. Panel data are particularly useful when the sample size for the individual countries is small. We use a number of recently developed panel unit root tests. These are Hadri (2000) test, Im, Pesaran and Shin (2003) test, and Levin, Lin and Chu (2002) test and Fisher type ADF and PP tests proposed by Maddala and Wu (1999). Third, we conduct panel cointegration tests using the methodology developed by Pedroni (1999, 2004). We also conduct Granger causality tests for panel data. There is no existing study on the relationship betweens patents and real GDP for Japan and South Korea.

We use two sources of data. The first is the International Monetary Fund (2007). We collect GDP and exchange rate data from this source. Nominal GDP in billions of national currency (yen and won) are converted into real GDP by using the GDP deflator

(2000=100). For panel data, real GDP for the two countries are converted into US dollars. The second is the US Patent Office (2007). As pointed out earlier, the system of patenting is not harmonized across countries. So, we use the number of patents granted to Japan and South Korea in the United States. US patent data have been used in some previous studies. For econometric analysis, data are for 1963-2005 for both countries. Time series data before 1963 are not available for these two countries.

III. A Brief Review of Previous Studies

There are numerous economic studies on patents. Most studies are about the United States. Here, we take a brief look at the studies which relate to Japan and South Korea. McDaniel (1998) looks at the legal features of the post-war Japanese patent system and whether and how they have influenced the pattern of diffusion in Japan. She finds that the Japanese system promotes diffusion and technical progress. The Japanese system encourages numerous filings of narrow claims. It is also characterized by pre-grant disclosure.

O'Keeffe (2005) compares the patent activities of the selected US, Japanese, Korean and EU companies in the Peoples' Republic of China (PRC). He finds that the rate of filing of patents is much higher for the Japanese, Korean and EU companies than for the US companies. While it is understandable why Japanese and Korean companies are filing many patents, the reason for the filing rate of EU companies being higher than those of US companies is not clear-cut.

Beldebros (1999) examines the characteristics and determinants of overseas R&D activities of 321 Japanese companies in the field of electronics and electrical engineering. Data from the United States shows a sharp increase in the patented innovations of these companies. This is accompanied by the increasing acquisition of the overseas affiliates by the Japanese companies. At the firm level, R&D intensity, export intensity and overseas manufacturing intensity are found to be significant determinants of overseas innovations.

We find a number of other studies regarding economics of patents in Japan and South Korea. However, these studies are even less related to our study.

IV. Econometric Methodology and Empirical Results

We take the logarithms of the variables. Thus, the first differences of the variables give us the growth rates. The logarithm of real GDP is denoted by LNGDP. Its first difference is denoted by GGDP. The logarithm of the number of patents granted is denoted by LNPAT. The first difference is denoted by GPAT. As noted earlier, we use the Ng-Perron unit root tests for individual countries. Ng-Perron tests give us four statistics. These are MZa, MZt, MSB and MPT. Even though we report MZa and MZt, the results from the other two statistics are fairly similar. The results of the Ng-Perron unit root tests for Japan and South Korea are in tables 3 and 4, respectively. The null hypothesis of unit root cannot be rejected if the test statistic is higher than the critical value. Table 3 shows that for Japan, both LNGDP and LNPAT are I(1). Table 4 shows that for Korea, LNGDP is I(1) but LNPAT is not. Johansen cointegration tests require that the variables be I(1). Thus, we can proceed with the Johansen cointegration tests only for Japan. If the variables are found to be cointegrated, the Granger causality tests can be performed on either the levels or the first differences of the variables. Although not shown here, the Johansen cointegration tests find evidence of cointegration between LNGDP and LNPAT for Japan. Thus, we can proceed with the Granger causality tests. We perform the Granger causality tests on the first differences of the variables which are denoted by

GRGDP and GPAT. These stand for the growth rates of real GDP and the number of patents, respectively. The Granger causality tests can be sensitive to lag lengths. There are a number of criteria like AIC and SBC that are available for choosing the appropriate lag lengths. In our case, these criteria never choose a lag length of more than 3. The results of the Granger causality tests between GRGDP and GPAT for lags of 1, 2 and 3 are in table 5. The null hypothesis is that there is no Granger causality. The results indicate that at the 5% level of significance, there is a two-way causality between GRGDP and GPAT for lags of both 1 and 2. For lag 3, GRGDP Granger causes GPAT at the 5% level of significance but the reverse causality does not hold. The general conclusion is that, for Japan, the growth of real GDP Granger causes the rate of growth of patents. Also, the rate of growth of patents Granger causes the rate of growth of real GDP.

Next, we form a panel using data for Japan and South Korea. We have a balanced panel with data for 1963-2005 for both countries. First, we conduct the panel unit root tests. For the panel data, the variable definitions are the same as they are for the individual country data. Thus, LNGDP and LNPAT again stand for the logarithms of real GDP and the number of patents, respectively. Similarly, GRGDP and GPAT stand for the first differences of LNGDP and LNPAT, respectively. However, as noted before, real GDP for the two countries are now expressed in US dollars.

Our first task is to conduct the panel unit root tests on the levels and the first differences of the variables. We perform 5 different tests. These are Lin, Lin and Chu (2002), Im, Pesaran and Shin (2003), Fisher-type ADF and PP (Maddala and Wu, 1999) and Hadri (200). Except for Hadri's test, the null hypothesis is that there is unit root. For Hadri's test, the null hypothesis is that there is no unit root. The results of the panel unit root tests on LNGDP, LNPAT, GRGDP and GPAT are given in tables 6, 7, 8 and 9, respectively. Results are robust in the sense that all tests give the same results. We find that at the 5% level of significance, LNGDP and LNPAT have unit roots but GRGDP and GPAT do not. In other words, LNGDP and LNPAT are I(1).

Next, we conduct panel cointegration tests for LNGDP and LNPAT. These are tests proposed by Pedroni (2004, 1999). The results of the panel cointegration tests are in table 10. The 4 statistics are panel-v, panel-rho, panel-PP and panel-ADF. Except for panel-v, all other statistics find evidence of cointegration between LNGDP and LNPAT at the 5% level of significance.

Since we find that LNGDP and LNPAT are cointegrated, we can conduct Granger causality tests on the levels or first differences of the variables. We conduct Granger causality tests on the first differences (that is, GRGDP and GPAT) of the variables. The results for lags 1, 2 and 3 are given in table 11. The results show that there is no evidence that GPAT Granger causes GRGDP. For the lag of 3, there is evidence that GRGDP Granger causes GPAT.

V. Conclusions

In this paper, we study the relationship between real GDP and patents using country data and panel data for Japan and South Korea. For policy purposes, it is important to know if there is a long run relationship between real GDP and the number of patents. Also, we examine the causality between the growth of real GDP and growth of the number of patents. For Japan, we find that the logarithms of real GDP and the number of patents have a long run relationship. We also find a two-way causality between the growth of real GDP and growth of the number of patents. For South Korea, we do not find any evidence of cointegration and causality. For panel data, we find that the logarithms of real and the number of patents are cointegrated. Panel causality tests find some evidence that the growth of real GDP Granger causes the growth of the number of patents. However, we do not find any evidence of the reverse causality.

TABLE 1. JAPAN'S REAL GDP GROWTH BY DECADES FOR 1955-2005

YEARS	GROWTH RATE
1955-1959	7.46
1960-1969	8.85
1970-1979	5.00
1980-1989	3.72
1990-1999	1.12
2000-2005	1.53
1955-2005	4.52

Source: Author's calculation from International Monetary Fund (2007)

TABLE 2. SOUTH KOREA'S REAL GDP GROWTH BY DECADES FOR 1955-2005

YEARS	GROWTH RATE
1955-1959	3.92
1960-1969	7.34
1970-1979	8.00
1980-1989	7.32
1990-1999	5.96
2000-2005	5.03
1955-2005	6.59

Source: Author's calculation from International Monetary Fund (2007)

TABLE 3. UNIT ROOT TESTS FOR JAPAN

VARIABLE	MZa	MZt
LNGDP	-1.4828 (-17.3000)	-0.6268 (-2.9100)
GRGDP	-19.9803 (-17.3000)	-3.1496 (-2.9100)
LNPAT	-1.0885 (-17.3000)	-0.4724 (-2.9100)
GPAT	-20.2992 (-17.3000)	-3.1668 (-2.9100)

Note: LNGDP and LNPAT stand for the logarithms of real GDP and the number of patents, respectively. GRGDP and GPAT are the first differences of LNGDP and LNPAT, respectively. All variables have trends. The critical values at the 5% level are in parentheses.

TABLE 4. UNIT ROOT TESTS FOR SOUTH KOREA

VARIABLE	MZa	MZt
LNGDP	-1.6043 (-17.3000)	-0.5537 (-2.9100)
GRGDP	-20.4982 (-17.3000)	-3.1984 (-2.9100)
LNPAT	-11.4461 (-17.3000)	-2.3827 (-2.9100)
GPAT	-1.3726 (-8.1000)	-0.7208 (-1.9800)

Note: LNGDP and LNPAT stand for the logarithms of real GDP and the number of patents, respectively. GRGDP and GPAT are the first differences of LNGDP and LNPAT, respectively. All variables have except GDP have trends. The critical values at the 5% level are in parentheses.

TABLE 5. GRANGER CAUSALITY TESTS BETWEEN THE GROWTH RATES OF REAL GDP AND THE NUMBER OF PATENTS FOR JAPAN

LAG	CAUSE	EFFECT	TEST STATISTIC	PROBABILITY
1	GRGDP	GPAT	7.4477	0.0096
1	GPAT	GRGDP	6.8049	0.0129
2	GRGDP	GPAT	3.6941	0.0350
2	GPAT	GRGDP	9.4042	0.0005
3	GRGDP	GPAT	3.8219	0.0190
3	GPAT	GRGDP	2.6535	0.0653

Note: GRGDP and GPAT stand for the growth rates of real GDP and the number of patents, respectively.

TABLE 6. PANEL UNIT ROOT TESTS ON LNGDP

TEST TYPE	TEST STATISTIC	PROBABILITY
LLC	-0.5715	0.2838
IPS	-0.5623	0.2870
FISHER ADF	8.5590	0.0731
FISHER PP	9.0168	0.0607
HADRI	2.7789	0.0027

Note: LNGDP stand for the logarithm of real GDP. LLC and IPS stand for Levin, Lin and Chu (2002) and Im, Pesaran and Shin (2003), respectively.

TABLE 7. PANEL UNIT ROOT TESTS ON LNPAT

TEST TYPE	TEST STATISTIC	PROBABILITY
LLC	-1.3427	0.0897
IPS	-0.6913	0.2447
FISHER ADF	-4.8996	0.2978
FISHER PP	6.6157	0.1576
HADRI	3.0891	0.0010

Note: LNPAT stands for the logarithm of the number of patents. LLC and IPS stand for Levin, Lin and Chu (2002) and Im, Pesaran and Shin (2003), respectively.

TABLE 8. PANEL UNIT ROOT TESTS ON GRGDP

TEST TYPE	TEST STATISTIC	PROBABILITY
LLC	-8.4189	0.0000
IPS	-7.9656	0.0000
FISHER ADF	-51.5003	0.0000
FISHER PP	53.9421	0.0000
HADRI	0.8238	0.2050

Note: GRGDP stands for the growth rate of real GDP. LLC and IPS stand for Levin, Lin and Chu (2002) and Im, Pesaran and Shin (2003), respectively.

TABLE 9. PANEL UNIT ROOT TESTS ON GPAT

TEST TYPE	TEST STATISTIC	PROBABILITY
LLC	-4.9934	0.0000
IPS	-4.2477	0.0000
FISHER ADF	25.6583	0.0000
FISHER PP	62.6398	0.0000
HADRI	0.5483	0.2918

Note: GPAT stands for the growth rate of the number of patents. LLC and IPS stand for Levin, Lin and Chu (2002) and Im, Pesaran and Shin (2003), respectively.

TABLE 10. PANEL COINTEGRATION TESTS BETWEEN LNGDP AND LNPAT

TEST TYPE	STATISTIC	PROBABILITY
PANEL-V	1.8209	0.0760
PANEL-RHO	-2.0826	0.0456
PANEL-PP	-2.4064	0.0221
PANEL-ADF	-2.1204	0.0421

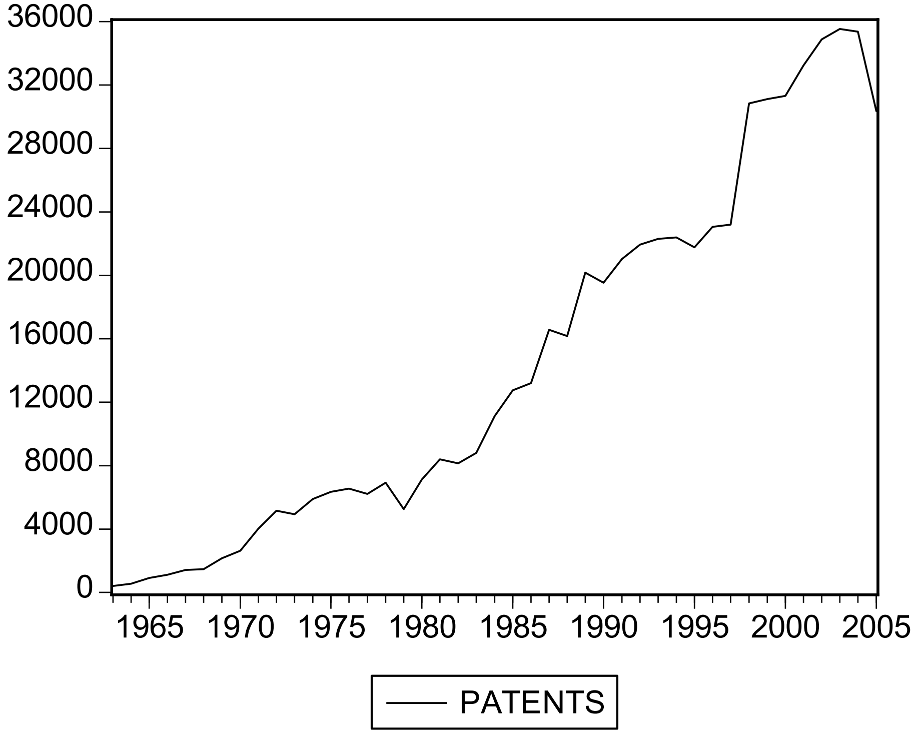
Note: LNGDP and LNPAT stand for logarithms of real GDP and the number of patents, respectively.

TABLE 11. PANEL GRANGER CAUSALITY TESTS BETWEEN THE GROWTH RATES OF REAL GDP AND THE NUMBER OF PATENTS

LAG	CAUSE	EFFECT	TEST STATISTIC	PROBABILITY
1	GRGDP	GPAT	3.5952	0.0616
1	GPAT	GRGDP	1.0628	0.3057
2	GRGDP	GPAT	4.5617	0.1350
2	GPAT	GRGDP	0.5810	0.5619
3	GRGDP	GPAT	4.8154	0.0041
3	GPAT	GRGDP	0.4242	0.7362

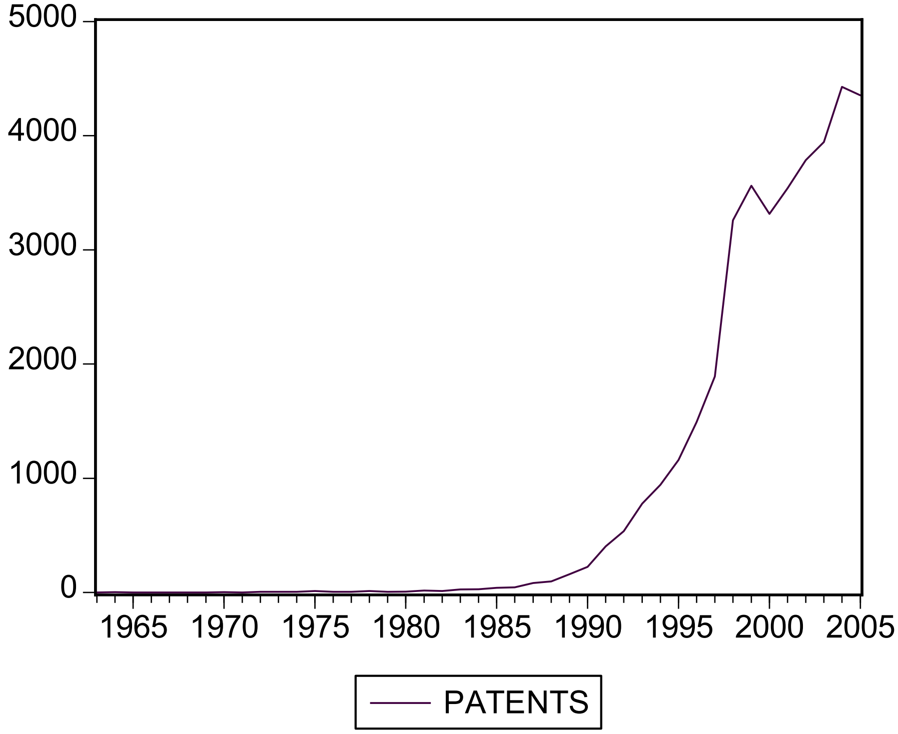
Note: GRGDP and GPAT stand for the growth rates of real GDP and the number of patents, respectively.

FIGURE 1. NUMBER OF PATENTS FOR JAPAN, 1963-2005



Source: US Patent Office (2007)

Figure 2. Number of Patents for Korea, 1963-2005



Source: US Patent Office (2007)

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