Economics Bulletin

Volume 37, Issue 2

Japan's Lost Decade: Did Decline in Innovation Lead to Loss of Competitiveness in Japanese Industries?

Masami Imai
Wesleyan University

Jonah Wolfson
Wesleyan University

Binghui Zheng
Wesleyan University

Abstract

It is widely recognized that technological progress in the Japanese economy slowed down during the so-called "Lost Decade" of the 1990s. We attempt to shine additional light on the economic implications of this general slowdown in technological progress by examining the effect of changes in innovativeness over time on the international competitiveness of Japanese industries. Our econometric analysis deploys industry-level panel data on patenting activity and Japanese exports to the United States. We find that the loss of competitiveness in Japan's exporting industries in the 1990s is closely related to eroding growth in the innovativeness of these industries.

Citation: Masami Imai and Jonah Wolfson and Binghui Zheng, (2017) "Japan's Lost Decade: Did Decline in Innovation Lead to Loss of Competitiveness in Japanese Industries?", *Economics Bulletin*, Volume 37, Issue 2, pages 1318-1326
Contact: Masami Imai - mimai@wesleyan.edu, Jonah Wolfson - jwolfson@wesleyan.edu, Binghui Zheng - bzheng@wesleyan.edu.
Submitted: April 30, 2017. **Published:** June 11, 2017.

1. Introduction

For the Japanese economy, the 1990s is known as the "Lost Decade." During these years the Japanese economy suffered through a bout of dramatic stagnation. The rate of Japanese per-capita GDP growth was only 0.5% during the period from 1991-2000, compared to 2.6% in the United States.[1] Although insufficient aggregate demand is considered to have played an important role in the sluggish growth of the Japanese economy (e.g., Bernanke, 2000 and Kuttner and Posen, 2001), some observers emphasize the role of sluggish technological progress as the main contributing factor. Most notably, Hayashi and Prescott (2002) use a growth-accounting framework to attribute the slowing of Japan's economic growth to a concurrent slowdown in TFP growth throughout the decade. Specifically, annual TFP growth fell from 2.4% in the 1983-1991 period to 0.2% in the period from 1991-2000.

Moreover, following Hayashi and Prescott (2002), some papers use disaggregated firm-level data to show that the observed decline in TFP was caused in part by resource misallocation as inefficient firms failed to exit markets in Japan during the period in question.[2] In the innovation-intensive IT industry, Arora et al. (2013) find that through the 1990s and early 2000s, the U.S. IT industry benefitted disproportionately from technological innovation due to its greater ability to capitalize on the increasingly software-intensive nature of innovation in that sector. They also find that the Japanese IT industry lagged significantly in this area.

This paper seeks to document how Japan's innovativeness evolved during this critical time period using data on patents granted in the United States Patent Office from 1972-1999, and examine the statistical link between patenting activity and Japanese exports to the U.S. using industry-level panel data. While it is widely regarded that innovation can increase international competitiveness, we examine whether the notion of the technology-competitiveness nexus applies to Japanese exporting industries in particular, and shed light on the nature of the Japanese slump of the 1990s.

We focus our analysis on Japanese exports to the United States in particular. In so doing, we aim to illuminate the particular historical dynamics examined in Arora et al. (2013) – namely, shifts in relative technological progress in the countries' respective high-tech sectors. Furthermore, the United States comprises a significant portion of the Japanese export market during the time period we examine, having received on average 30.1% of Japan's total yearly exports in the 1977-1999 period, and more than any other country.[3] Thus, competition with the U.S. is perhaps one of the most critical determinants of Japan's success on the international market, at least during the time period we examine. This approach also allows us to examine the innovation-competitiveness relationship specifically through the lens of *relative* innovation; i.e., did the observed decline in Japan's innovation relative to that of the U.S. have a negative effect on the ability of Japanese exporting industry to compete in U.S. markets? We also focus our analysis to the industry-level, including an industry designation designed to proxy the "IT" industry in particular, following Arora et al.'s (2013) study. In so doing, we aim to include industries of various presumed technology-intensities in order to bolster and nuance the evidence for the relationship we describe.

---

[1] Hayashi and Prescott (2002), 206.

[2] See, for example, Fukao and Kwon (2006) and Caballero, Hoshi, and Kashyap (2008).

[3] See: Statistics Bureau of Japan, "Value of Japan Exports by Principal Country (Area) of Destination (1962–2004)"; http://www.stat.go.jp/english/data/chouki/18.htm

Our paper is closely related to two strands of literature: one concerning the relationship between technological innovation and trade competitiveness and the other concerning the determinants of productivity growth in Japan. Soete (1987) finds a strong correlation between technological innovation and export shares among OECD countries. Similarly, Amable and Verspagen (1995) use export data for five industrialized countries (Germany, Italy, the UK, Japan and the U.S.) and 18 industries to find that the effect of innovation is most likely to be significant in the "science-based sectors" such as chemicals, computers and electrical machinery.[4] Ito and Lechevalier (2009, 2010) use firm-level data to show that both innovation (measured in terms of R&D) and exports have positive effects on productivity growth. In particular, Ito and Lechevalier (2010) show that the interaction of innovation to exports is important (i.e., innovation-intensive firms benefit more from exports) and that such interaction effects might make productivity differences across firms persistent over time.

To summarize our main findings, we observe that, on aggregate, Japanese technological innovation did slow down relative to U.S. innovation in the late 1980s and 1990s. The regression analysis with industry-level panel data shows that Japan's exports to the U.S. are closely related to patenting activity in the broader 1972-1999 period, suggesting that decreasing innovative activity of Japanese industries, relative to that of the U.S., had a negative effect on international competitiveness in technology-intensive sectors during the Lost Decade. These results are consistent with the general finding of the aforementioned papers that innovation and industries' ability to compete in global markets is tightly linked. To the extent that the interaction of innovation to export is critical for productivity growth for Japanese firms (Ito and Lechevalier, 2010), the decline in innovativeness might have caused persistent slowdown in productivity growth during the 1990s through its negative effects on export.

2. Data and Methodology

The key independent variable of interest is the difference between the number of Japanese and U.S. patents granted in natural logs – that is, ln(number of Japanese patents granted)–ln(number of U.S. patents granted). This variable captures the evolution of relative innovativeness over time. We follow Soete (1987), and Amable and Verspagen (1995) in deploying patents granted in the U.S. Patent Office as a proxy for innovativeness. Using foreign patents filed in the U.S. helps control for differences in national patent regimes, while the prominence of the U.S. as a major international technology market is usually taken to indicate that patents filed in its office do not unfairly favor U.S. inventions, even when measuring absolute number of patents filed. We are further reassured by Arora et al.'s (2013) note that "Japanese firms have historically been among the most enthusiastic foreign users of the U.S. patent system."[5,6] While we deployed a similar measure using the relative number of citations received by patents from each respective country in some specifications, we find that this measure closely follows patents granted, and yields very similar econometric results. Thus, we

---

[4] See also Fagerberg (1988), Fagerberg (1996), Gustavsson, Hansson and Lundberg (1999).

[5] Arora et al. (2013), 759.

[6] R&D spending has frequently been invoked in the literature as a competing proxy for technology innovation (Soete, 1987; Carlin et al., 2001; Madsen et al., 2008). However, we follow Soete's (1987) method and focus our analysis on patent data alone, as he shows that patents and R&D spending are highly collinear.

select patents granted as our proxy for technological innovation.

The source of our patent data is the NBER U.S. Patent Citations Dataset, which has detailed information on almost 3 million U.S. patents granted between January 1963 and December 1999. The main data file we use is "PAT63_99," which contains the variables *patent* (Patent Number), *gyear* (Grant Year), *country* (Country of First Inventor), and *nclass* (Main Patent Class, or USPCS code).[7] We extract those patents that are granted to Japanese and U.S. inventors and count the total number of patents by country, year, and USPCS industry code.

Our dependent variable is the log customs value of imports from Japan into the U.S., ln(custom), which is drawn from the United States Import and Export Database. The main data files we use are "SIC 87-level U.S. import and export data," which contain SIC (Standard Industrial Classification) codes for identifying industry-disaggregated imports. The variables we use are *year*, *wbcode* (World Bank Country Code), *SIC* (Standard Industrial Classification), and customs value of imports (in millions of USD) for each year. This data file starts from the year 1972 and ends in the year 2005.[8]

We use Schettino's (2009) concordance table to match the industry classifications used by the U.S. patent office (USPCS) to the standard SIC industry delimiters found in the customs data for 11 SIC industrial categories as follows: textiles and apparel; primary metals; electrical equipment; fabricated metal products; food, kindred and tobacco products; machinery; chemicals and allied products; transportation equipment; petroleum manufacturing and extraction; rubber products; stone, clay and glass products.

For controlling variables, we include the logs of Japanese GDP and U.S. GDP, which capture the economic conditions prevailing in each country, the log difference between Japanese and U.S. annual labor compensation per employee as a measure for relative labor cost, the log difference between Japanese and U.S. labor productivity measured as GDP per worker-hour, and exchange rate, measured in terms of yen per U.S. dollar.[9] We control for industry-fixed effects in panel regressions in order to control for time-invariant industry-specific factors. We also estimate random effects models, but the results turn out to be nearly identical to fixed effects model and thus are not reported to conserve space.

3. Results

Table 1 shows summary statistics. Figure 1 shows trends in the difference in patenting activity between Japanese industries and their U.S. counterparts (in logs). Japan has been steadily receiving a greater number of patents compared to the U.S. over the course of the time period examined. However, we observe a flattening of relative gains in Japanese patenting staring in the late 1980s and continuing through the 1990s to the end of our sample. This trend indicates that there is indeed a measurable slump in 1990s Japanese innovation performance in our sample industries, consistent with the "Lost Decade" analysis. We even observe a slight downturn in relative Japanese patenting beginning in the late 1980s or early 1990s in several industries (e.g.,

---

[7]See: National Bureau of Economic Research, "The NBER U.S. Patent Citations Data File".

[8] See: Schott, Peter K. "Schott's International Economics Resource Page".

[9] GDP data is provided by the World Bank, with GDP measured at market prices (current U.S. Dollars). See: worldbank.org, "World Bank Open Data". Other control variable indicators are sourced from the OECD database. Labor compensation is measured in PPP-adjusted USD, and GDP per worked hour is measured in constant 2010 USD.

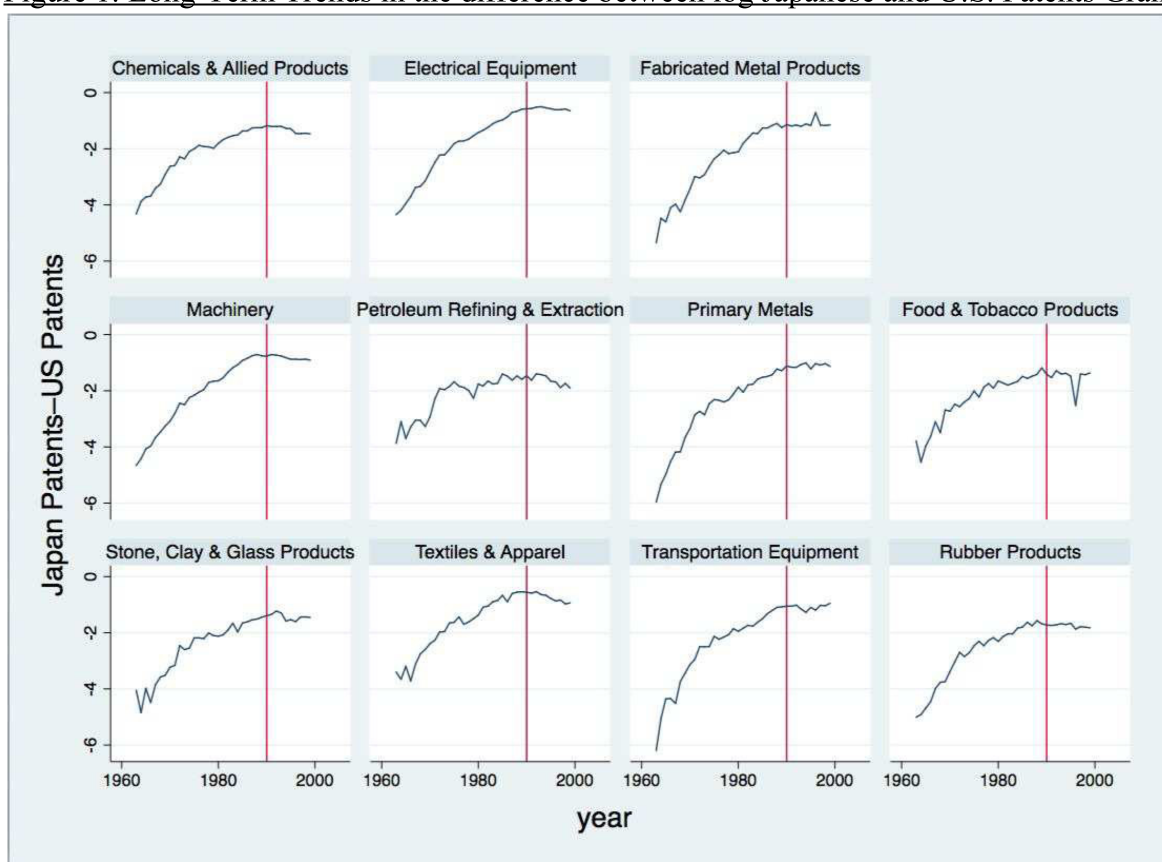
chemical and machinery).

Table 1: Descriptive Statistics

VARIABLES	Obs.	Mean	SD	Min	Max
Patents Granted	302	-1.482	0.497	-2.71	-0.504
Imports	302	-1.482	0.497	-2.71	-0.504
Japan GDP	302	7.258	1.814	3.091	10.66
US GDP	302	10.25	0.205	9.898	10.51
Labor Compensation per employee	302	10.16	0.153	9.894	10.43
GDP per worker-hour	302	-0.424	0.0504	-0.533	-0.339
Exchange Rate	302	-0.536	0.151	-0.79	-0.351

Imports, Japan GDP, U.S. GDP and Exchange Rate are taken as natural logs. Patents Granted, Labor Compensation per employee and GDP per worker-hour are measured as the difference between log Japanese and U.S. values for each respective measure.

Figure 1: Long-Term Trends in the difference between log Japanese and U.S. Patents Granted



"Japanese Patents – U.S. Patents" is measured as the natural log of each respective count. The vertical line represent 1990.

Table 2 shows our results from panel regressions. The coefficient on relative patents granted is consistently positive across all specifications. That is as Japan produces more patents compared to its U.S. competitor, it also exports more goods to the U.S., *ceteris paribus*. This is consistent with the hypothesis that innovative performance is associated with competitiveness in international trade. In the models containing control variables, the coefficient varies only slightly (from 0.725-0.782), and is statistically different from zero at the 5% level in model 2, and at the 10% level in models 3-5. We interpret the coefficient on "patents granted" as the percent increase in the value of U.S. imports of Japanese goods (aggregated across our sample industries) for a 1% increase in the ratio of patents granted. For example, Model 5 indicates that a 1% increase in the relative amount of Japanese patenting is associated, *ceteris paribus*, with a 0.725% increase in U.S. imports of Japanese goods. The coefficient on U.S. GDP is also positive and statistically significant to the 5% level in all specifications in which it is included, as we expect. Its positive coefficient suggests that the U.S. tends to import more goods (including Japanese goods) as its GDP grows.

We turn now to an industry-disaggregated analysis. We run OLS regressions over the 11 industries and across the five specifications detailed above to explore whether there is meaningful heterogeneity across industries in the strength of the innovation-competitiveness relationship. Table 3 presents our results of specification 5 which includes all of the controls provided for in our model. The coefficient on the difference between number of Japanese and number of U.S. patents granted is significantly different from zero at the 1% level in the electrical equipment, machinery, rubber products, and textiles and apparel industry categories. It is statistically different from zero at the 5% level for transportation equipment. In particular, we find positive and statistically significant coefficients across our specifications for the "electrical equipment" industry. This indicates that the innovation-competitiveness model holds for the IT industry, corroborating Arora et al.'s (2013) conclusion that IT industry performance (as proxied by ability to export) is indeed a product of changes in innovative activity.[10]

[10] We do, however, caution that the "Electrical Equipment" delimiter is not a perfect proxy for the IT industry, due to the somewhat rough concordance between SIC and USPCS categorizations.

Table 2: Industry-Aggregated OLS Regression Results (11 industries from 1972-1999)

	(1)	(2)	(3)	(4)	(5)
VARIABLES	ln(Imports)	ln(Imports)	ln(Imports)	ln(Imports)	ln(Imports)
Patents Granted	1.270***	0.782**	0.777*	0.733*	0.725*
	(0.257)	(0.289)	(0.355)	(0.366)	(0.374)
Japan GDP		-0.683		-2.772	-2.375
		(1.126)		(1.783)	(1.635)
US GDP		2.662**		2.711***	2.802***
		(1.032)		(0.693)	(0.733)
Labor Compensation per employee			-1.274	-0.064	0.032
			(1.280)	(1.368)	(1.438)
GDP per worker-hour			2.138**	2.847	2.501
			(0.778)	(1.846)	(1.748)
Exchange Rate					0.127
					(0.126)
Constant	9.137***	-11.616*	9.005***	10.728	4.927
	(0.398)	(6.112)	(0.404)	(13.881)	(12.566)
Observations	308	308	308	308	308
R-squared	0.606	0.660	0.652	0.662	0.662

Standard errors (clustered by industries) in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Imports, Japan GDP, U.S. GDP and Exchange Rate are taken as natural logs. Patents Granted, Labor Compensation per employee and GDP per worker-hour are measured as the difference between log Japanese and U.S. values for each respective measure.

4. Concluding Remarks

We put together industry-level panel data on exports from Japan to the U.S. and on patenting activity for 11 industries from 1972-1999 to investigate the statistical link between technological innovation and trade competitiveness of Japanese industry. The patent data show that while the level of Japan's innovation was approaching that of the U.S. since the mid 1970s, there was a significant slowdown in technological progress in some industries in the late 1980s and 1990s. We also find a strong link between patenting activity and exports to the U.S., suggesting that Japan's trade competitiveness in U.S. markets might have been stronger during "the Lost Decade" if it were not for the slowdown in innovative activity in Japanese industries.

Table 3: Industry-Disaggregated OLS Regression Coefficient on difference between number of Japanese and U.S. Patents Granted (1972-1999)

	Model 1	Model 2	Model 3	Model 4	Model 5
	Patent Coeff.	Patent Coeff.	Patent Coeff.	Patent Coeff.	Patent Coeff.
Chemicals and Allied Products	2.393***	0.315	0.164	0.141	0.162
Electrical Equipment	1.710***	1.214***	1.596***	1.513***	1.524***
Fabricated Metal Products	0.898***	0.388***	0.167	0.123	0.117
Food, Kindred and Tobacco Products	0.609***	0.209*	0.262*	0.183*	0.170*
Machinery	2.099***	1.155***	1.224***	1.125***	1.153***
Petroleum Manufacturing and Extraction	0.198	0.876*	0.350	0.693	0.683
Primary Metals	0.156	1.165***	0.747**	0.394	0.198
Rubber Products	2.363***	0.772***	0.928***	0.898***	0.894***
Stone, Clay and Glass Products	1.169***	0.501**	0.274	0.243	0.185
Textiles and Apparels	0.426***	0.850***	1.033***	1.085***	1.075***
Transportation Equipment	1.761***	1.591***	1.330***	1.082***	1.062**

*** p<0.01, ** p<0.05, *p<0.1

The "Patent" variable once again represents the difference of the log values of number of Japanese and number of U.S. patents granted.

References

Amable, B. and B. Verspagen (1995). "The role of technology in market shares dynamics." *Applied Economics* 27(2): 197-204.

Arora, A., L.G. Branstetter and M. Drev (2013). "Going Soft: How the Rise of Software-Based Innovation Led to the Decline of Japan's IT Industry and the Resurgence of Silicon Valley." *The Review of Economics and Statistics* 95(3): 757-775.

Bernanke, B. (2000). "Japanese Monetary Policy: A Case of Self-Induced Paralysis?" in R. Mikitani and A. Posen (eds.), *Japan's Financial Crisis and its Parallels to U.S. Experience*. Washington, DC: Institute for International Economics.

Caballero, R.J., T. Hoshi and A.K. Kashyap (2008). "Zombie Lending and Depressed Restructuring in Japan." *American Economic Review* 98(5): 1943-1977.

Carlin, W., A. Glyn and J.V. Reenen (2001). "Export Market Performance of OECD Countries: An Empirical Examination of the Role of Cost Competitiveness." *The Economic Journal* 111(468): 128-162.

Fagerberg, J. (1996). "Technology and competitiveness." *Oxford Review of Economic Policy* 12(3): 39-51.

Fagerberg, J. (1988). "International Competitiveness." *The Economic Journal*, 98(391): 355–374.

Fukao, K. and H.U. Kwon (2006). "Why Did Japan's TFP Growth Slow Down in the Lost Decade? An Empirical Analysis Based on Firm-Level Data of Manufacturing Firms." *Japanese Economic Review* 57(2): 195-228.

Gustavsson, P., P. Hansson and L. Lundberg (1999). "Technology, resource endowments and international competitiveness." *European Economic Review* 43(8): 1501-1530.

Hayashi, F. and E.C. Prescott (2002). "The 1990s in Japan: A Lost Decade." *Review of Economic Dynamics* 5: 206-235.

Ito, K., and S. Lechevalier (2010). "Why some firms persistently out-perform others: investigating the interactions between innovation and exporting strategies." *Industrial and Corporate Change* 19(6) : 1997-2039.

Ito, K., and S. Lechevalier (2009). "The evolution of the productivity dispersion of firms: a reevaluation of its determinants in the case of Japan." *Review of World Economics* 145(3): 405-429

Kuttner, K.N. and A.S. Posen (2001). "The Great Recession: Lessons for Macroeconomic Policy from Japan." *Brookings Papers on Economic Activity* 2001(2): 93-160

Madsen, J.B. (2008). "Innovations and manufacturing export performance in the OECD countries." *Oxford Economic Papers* 60(1): 143-167.

S., Francesco (2009) "Scale effect on endogenous growth: an evaluation." *Economics Bulletin* 29(1): 205-213.

Soete, L. (1987). "The impact of technological innovation on international trade patterns: The evidence reconsidered." *Research Policy* 16(2): 101-130.