Economics Bulletin

Volume 29, Issue 3

Import variety and productivity in Japan

Craig R. Parsons
Yokohama National University

Anh Thu Nguyen
Yokohama National University

Abstract

This paper constructs import variety indices, as developed by Feenstra (1994), for 21 industries over a twenty year period for Japan. Next, both single-equation and panel regressions of productivity (TFP) on import variety and R&D are conducted. Results find that increased import variety, both own-variety and upstream inputs, positively affect productivity.

This is an extension of the doctoral dissertation of Anh Thu Nguyen. We are very grateful for comments made by Eiichi Tomiura, Kiyotaka Sato, Tsunao Okumura and Masahito Kobayashi in the early stages. Valuable research assistance was also provided by Mr. Xuan Bac Nguyen. Any remaining errors are by the authors alone.

Citation: Craig R. Parsons and Anh Thu Nguyen, (2009) "Import variety and productivity in Japan", *Economics Bulletin*, Vol. 29 no.3 pp. 1947-1959.

Submitted: Apr 28 2009. **Published:** August 17, 2009.

1. Introduction

Many observers of the Japanese economy feel its import behavior had undergone a fundamental shift during the 1980s.[1] The reasons behind this apparent change have been much debated. A more important question may be: what was the *effect* of this apparent change in import behavior on the Japanese economy? The gains from (more) trade manifest themselves in a number of ways: gains from exchange, gains from specialization, increased competition, and gains from variety. It is this last channel in which we are interested. That is, what was the effect on increased variety of imports on the productivity of various sectors in Japan? In this paper, we apply Feenstra's measure of variety to determine which sectors, if any, benefited from the change in import behavior that occurred over the 1980-2000 period.

This paper looks at the impact on the increased availability in the variety of imported intermediate goods on the productivity of these industries. Moreover, we assess whether this effect, if any, changed in the 1990s during the stagnant years. These questions are explored with a newly constructed variety data set applied to TFP data for 21 industries over 21 years. The findings vary across industries, but the overall message is clear. Many Japan industries had significant gains in productivity which can be attributed to increased access to a larger variety of imported goods.

There are four major contributions of this paper. First, a careful documentation of the change in import variety by constructing the Feenstra variety index for the 1980-2000 period for 21 industries in Japan. Second, the relationship between *import* variety and productivity for Japan has been econometrically tested. While in some ways this is similar to Feenstra, Madani, Yang and Liang (1999), who examined Korea and Taiwan, export data was used in that study.[2] A handful of empirical studies (see footnote 2) on product variety have been carried out for the OECD, East European countries and some Asian countries, but none have studied the effects of increased *import* variety. Third, input-output (I-O) tables are used to give a weighted average of the changes in variety of the inputs used by each of the 21 industries. This has also not been done elsewhere. Fourth, this study complements the relative few extant papers which examine the link between variety and productivity for Japan, the second largest economy in the world, and a country which saw both great changes in import demand and great stagnation over the 20 year period. Thus, the case of Japan may yield new insights.[3]

The remainder of the paper is as follows. Section 2 will explain the theoretical underpinnings and describe the methodological approach of this paper. In section 3, we will describe how we assembled the data and constructed the new variety indices, and the source of the TFP data for the 21 industries. Section 4 presents the econometric specification and discusses the empirical results of the estimation. Section 5 summarizes the results and concludes.

---

[1] See Ceglowski (1996) who asserts this most strongly. Krugman (1991) and Hamori and Matsubayashi (2001) also imply this to some extent.

[2] Funke and Ruhwedel (2001a, 2001b, 2005) also use Feenstra's measure of export variety to examine its effect on economic growth and/or exports, but this is done at a national level across many OECD, East Asian and East European countries, respectively.

[3] Moreover, in the 1980s, Japanese firms were still experiencing large increases in productivity in the manufacturing sector (Marston, 1987) in contrast to the US, a mature economy, which was the subject of Broda and Weinstein's (2006) study.

2. Methodology

The variety index created by Feenstra (1994) can be used to measure the impact of new inputs (or outputs) on economic growth or productivity. In short, the wider availability of inputs in the Constant Elasticity of Substitution (CES) production function results in a lower isocost curve. This implies lower unit costs. This results in, almost by definition, an increase in productivity. This is apparent when looking at the dual of the production function, the CES unit-cost function (simplifying equation 10.42 in Feenstra, 2004 a bit).

$$c = \left[\sum_i b_i p_i^{1-\sigma} \right]^{1/(1-\sigma)}$$

Here, c is the unit cost, b_i a constant parameter greater than 0, p_i is the price of the input, $\sigma > 1$, and the subscript i refers to the input(s). As one increases the number of inputs from one input (i=1) to two inputs (i=2), and then to three inputs (i=3) and so on, unit costs will fall. Graphically, this will push the isoquant lower, i.e. toward the origin, as shown in Feenstra and Kee (2007).

This idea fits well with the theory that if one firm or economy can have access to a greater variety of inputs, it can produce more efficiently. We also expect that industries which purchase large amounts of inputs from upstream industries will be affected more by the variety of those upstream industries than by variety in their own industry. In order to capture these effects, we will calculate a weighted-average of the variety of the upstream industries for each of the 21 industries.

As mentioned above, import variety has not been studied broadly in empirical papers. Among the few papers dealing with import variety, Broda and Weinstein (2006) study how the import of new varieties contributed to national welfare gains in the United States. They show that over the last three decades (1972-2001), the number of imported product varieties of the U.S. increased by a factor of three and estimate that welfare gains for the U.S. consumers from cumulative variety growth in imports were 2.6 per cent of GDP in 2001.

In this paper, we also study import variety of Japan during the period 1980-2000, but instead of estimating consumer welfare gains from variety, we estimate the impact of import variety on Japan's TFP. As mentioned above, Feenstra, Madani, Yang and Liang (1999) studied the relationship between variety and TFP but they used export data and only for South Korea and Taiwan. Feenstra, Yang and Hamilton (1999) studied the relationship between product variety and business groups in Korea, Taiwan and Japan. Elsewhere, Feenstra and Kee (2007) use export variety as a proxy for total variety of inputs in the economy. Our interpretation here is somewhat different, and in a sense, more straightforward. By using imports instead, the majority of which are intermediate goods and therefore imported inputs, we hope to better capture the increase in inputs available to Japanese industry over this time.[4] In particular, we hope to get a better

[4] Roughly speaking, intermediate goods were about two-thirds of all Japanese non-energy imports according to Ceglowski, 1996 (table 2). This fell over the period of this study. However, our import data *does* include oil and other energy, most certainly intermediate goods which should, in theory, benefit from a greater variety of inputs. Thus, we conclude that the majority of Japanese imports over this time were intermediate goods. There would be, of course, large consumer gains as well from increased variety, though here we are focusing on the production function interpretation of the Feenstra index.

understanding of how Japan's changing import structure in the late 1980s affected productivity in Japan.

Feenstra's (1994) variety index is briefly explained below. There are two periods *t* and *t-1*. The set of inputs changes over time, but there are some inputs available in both periods $I = I_{t-1} \cap I_t$. The change in variety between two periods is measured by:

$$\Delta VAR_{t-1,t} = \ln\left(\frac{\lambda_{t-1}(I)}{\lambda_t(I)}\right) = \ln\left(\frac{\sum_{i\in I_t} p_{it}x_{it} \Big/ \sum_{i\in I} p_{it}x_{it}}{\sum_{i\in I_{t-1}} p_{it-1}x_{it-1} \Big/ \sum_{i\in I} p_{it-1}x_{it-1}}\right) \qquad (1)$$

where x_{it} is the input of good *i* in period *t*, I_t is the set of input available in period *t* at price p_{it} and similar for period *t-1*. As Feenstra (2004, p. 365) shows, with a CES production function, TFP is a function of the change in input variety and the elasticity of substitution, σ

$$TFP = \frac{1}{(\sigma-1)}\Delta VAR_{t-1,t} \qquad (2)$$

Given σ >1, it is apparent that the increase in variety, reflected as the increase in $\Delta VAR_{t-1,t}$, will lead to an increase in TFP. As such, equation (2) provides us with a direct way to test the endogenous model with expanding variety.

However, as mentioned above, inputs for one industry include not only inputs from its own industry but also inputs from other industries as intermediates. Therefore, it is not enough to include only variety indices for each industry (called "VAR" in this paper) in our estimation equation. As such, we have calculated another I-O-weighted variety index ("VARS") for each of the 21 industries. As an oversimplified example, suppose for example, "motor vehicles", one of the 21 industries, was comprised of 50% "fabricated metal", 30% "electrical machinery" and 20% "rubber". Then, the VARS variety index applicable to the motor vehicle industry would be a weighted average of the three separately constructed Feenstra import variety indices for metal, electrical machinery and rubber. We feel this more accurately captures the multiple channels in which an increase in a variety of inputs can result in higher productivity.[5]

3. Data

We use disaggregated imports of Japan for the period 1980-2000 to construct the product variety indices. In reality, the input variety includes not only imports but also the domestically-produced inputs in the country. Unfortunately, domestic industrial data for Japan, the US, and elsewhere is very aggregate, the equivalent of say, the two or three digit level in trade data, at best. This typically gives less than one hundred "goods" (industries), thereby aggregating and masking a wide range of subcategories. However, imports account for a significant portion of total inputs in a heavily trade dependent Japan. Thus, the increase in import variety should also, at least partially, explains changes in productivity.

[5] It is also possible that the variable VAR, has a more direct competitive effect on TFP. That is, as an increase in the import variety of goods likely implies more direct competition with the Japanese made good, possible reducing market power and increasing efficiency in that way.

To maintain consistency in the classification of goods, we use disaggregated UN COMTRADE trade data at the five-digit level (SITC revision 2) for Japan from 1980-2000. The classification distinguishes 1,473 commodities according to the Standard International Trade Classification. We define a *good* to be a four or five digit SITC-2 category, and a *variety* as the import of a particular good from a particular country as in Armington (1969) and Broda and Weinstein (2006). 21 variety indices were constructed from the UN trade data in a concordance with the already defined 21 sectors for the TFP data constructed by the Japanese RIETI (Research Institute of Economy, Trade and Industry) project. This, of course, was no light task, but for the most part trade data for the major manufacturing sectors examined here usually fell neatly into one category or another, and few arbitrary decisions were needed. For more details see Nguyen (2009). These 21 sectors are further delineated in this paper as either primary or secondary industries. (See table I for a list. Primary industries are in italics.) Secondary industries are defined, as in Feenstra, Madani, Yang and Liang (1999) as those industries which require more inputs from upstream industries than from themselves.

Before discussion of the more sophisticated variety indices, a simple "count-measure" of the increase in variety of goods imported to Japan over time may be useful. Presented in detail in Anh Thu Nguyen (2009) and Nguyen and Parsons (2009), we find that by a simple count measure, import variety has increased in all 21 industries. Interestingly, this is not the case for exports. Again, by the simple count measure, variety in all of the 21 industries actually declined over time. Using the Feenstra variety index, however, export variety is shown in the various industries to have sometimes increased and sometimes decreased over this period. Thus, in order to understand whether there is a link between increased import (and input) variety and productivity, a more precise measure of variety is needed. Here is where the Feenstra "exact" index is far superior. By generating an expenditure-share, weighted average which incorporates prices as well as new goods into the optimization problem of the firm, we obtain a far better relative weighting of the increase in inputs (or imports) than a simple count (sum) of import varieties could provide.

To compare the changes of variety between two years *t* and *t-1*, we calculate $\Delta VAR_{t-1,t}$ by using equation (1) and multiplying it by 100. In order to smooth the variety indices we calculate a 3-year moving average. Another reason for calculating the moving average is that TFP in one year can be affected by the variety of the previous years. The increase (or decrease) in import variety in one year, meaning the changes in intermediates input, may take some time to influence TFP.

The data on TFP for Japan are taken from the ICPA project launched by RIETI. This project provides us with TFP for 33 sectors, 21 of which are analyzed in this paper (services and some other industries such as mining and construction are excluded). TFP is measured as a Divisia index, i.e. the rate of growth of output minus a weighted average of the growth of inputs.

The increase in variety means the appearance of new products or, in this case, at least new sources/countries of products. While more, and perhaps better, inputs for Japanese firms may increase productivity (TFP) there are likely many other reasons why TFP may rise over time. R&D activity in the industry is clearly one likely source of TFP growth. As such, it is also included as an additional right-hand side variable.[6] R&D data is taken from the ESRI-HISTAT-

[6] There is also the possibility that while R&D may increase TFP in an industry, it may also cause increased specialization (i.e. less variety) in that industry. In this case, an increase in R&D may decrease variety in that industry, thus econometric estimation may overstate any positive relationship between variety and TFP. R&D, of

JIP project launched by Economic and Social Research Institute (ESRI) and the statistics of the Ministry of Internal Affairs and Communications of Japan.[7] An R&D variable for each industry is calculated as the expenditure on R&D over output of that industry. R&D may have lagged effects on TFP because research and development may take some time to become realized in production, so we used 3-year moving averages of R&D, similar to that done for import variety.[8]

4. Empirical specification and results

Based on equation (2), we estimate the relationship between TFP and import variety as follows:

$$TFP_{jt} = \alpha_j + \beta_j STAGDUMMY + \gamma_j VAR_{jt} + \mu_j STAG \times VAR_{jt} + \lambda_j VARS_{jt} + \eta_j R\&D_{jt} + \varepsilon_{jt} \qquad (3)$$

where α_j is a constant term for each industry *j*, β_j is the estimated impact of the slowdown in Japan during its "lost decade" (STAGDUMMY takes a value of 1 starting from 1993). γ_j reflects the estimated relation between the change in own import variety (VAR) and the growth in TFP in one industry, and λ_j is the estimated effects of the changes in other upstream industries' varieties (VARS) on industry *j*'s TFP. μ_j is an interaction term for variety and the stagnation on TFP, and η_j is the coefficient for the R&D variable. Variety and R&D are both 3-year moving averages as explained above.

TFP_{jt} is the dependent variable, and is calculated as the growth of TFP between two years *t-1* and *t*. VAR_{jt} is the import variety index, calculated as described in the previous section and presents the change in variety between two years *t-1* and *t*. The above equation is consistent with equation (2), where γ_j equals $1/(\sigma_j - 1)$, where σ_j is the elasticity of substitution between differentiated products in industry *j*.

Individual industry regressions for each of the 21 industries were done by simple OLS, with standard errors corrected for heteroskedasticity. Results are presented in tables I through III. A panel SUR of all 21 industries was also estimated (see table IV). The data are time-series, which means they have potential non-stationarity issues. However, with only 21 years of data of annual data, any unit root test, let alone cointegration test, would be unreliable (see Toda, 1994 *inter alia*). Panel unit root tests were conducted, however, for all four variables (TFP, VAR, VARS, R&D), and the null of a unit root was strongly rejected in a battery of panel unit root tests. (Results available upon request.) Thus, we feel satisfied with this relatively straightforward approach (i.e. 21 separate industry OLS regressions and a single SUR for the panel.)

Table I presents the parameter estimates on 21 separate industry regressions for the own-industry variety variable, VAR and VARS. For VAR, most of the industries have positive

---

course, could also increase variety, by generating new goods. As we do not have a strong *a priori* here, and it would certainly differ across industries, we do not explore this any further here.

[7] The TFP data can be found at www.rieti.go.jp/en/database/d03.html while the R&D data was taken from two Japanese government sources found at www.esri.go.jp/index-e.html and www.stat.go.jp/english/index.htm.

[8] We are grateful to Eiichi Tomiura for suggesting both inclusion of the R&D variable and the use of moving-averages.

coefficients on import variety. However, only six (6) of the coefficients (in bold) are positive and significant at a 5% (or even 10%) level.

Table I. Coefficients for own industry's variety (moving average of "VAR" and "VARS")

	Industry	VAR	VARS	R^2
1	*Agriculture*	0.73 (0.18)	-0.08 (-0.02)	0.04
2	Food and kindred products	2.51 (1.00)	0.20 (0.51)	0.36
3	*Textile mill products*	2.60 (1.11)	-2.56 (-1.11)	0.31
4	Apparel	**4.89**(1.97)**	2.09 (0.99)	0.34
5	*Lumber and wood*	1.27 (0.91)	**3.00**(1.97)**	0.32
6	Furniture and fixture	1.49 (1.09)	**4.43** (3.58)**	0.63
7	Paper and allied	**4.31**(4.41)**	-1.17 (-1.49)	0.64
8	Printing, publishing and allied	2.67 (0.90)	**2.77* (1.76)**	0.34
9	Chemicals	-1.30 (-0.91)	**1.63*(1.85)**	0.36
10	*Petroleum and coal products*	0.89 (0.59)	-1.02 (-0.19)	0.17
11	Leather	**4.12**(2.45)**	-0.26 (-0.10)	0.50
12	*Stone, clay, glass*	**2.49**(2.52)**	2.34 (1.51)	0.45
13	*Primary metal*	1.74 (1.27)	-0.25 (-0.31)	0.38
14	Fabricated metal	1.23 (0.56)	1.35 (1.17)	0.38
15	Machinery, non-elect	0.32 (0.19)	**4.66**(1.94)**	0.41
16	Electrical machinery	-2.80 (-1.44)	**6.93**(3.71)**	0.63
17	Motor vehicles	**2.56**(2.27)**	-0.06 (-0.05)	0.44
18	Transportation equipment and ordnance	0.08 (0.08)	0.73 (0.29)	0.17
19	Precision instruments	-0.98 (-0.79)	2.34 (1.23)	0.18
20	*Rubber and misc. plastics*	**3.22**(1.93)**	-0.53 (-0.25)	0.51
21	Misc. manufacturing	0.02 (0.03)	2.49 (1.48)	0.48

n=18 for each of the 21 regressions. T-stats are in parentheses. * and ** denote significance at 10% and 5% levels of significance, respectively.

Of the six industries that have positive and significant effects between variety and TFP, four are secondary industries. This is in line with the results in Feenstra *et al.* (1999) who argue that the expansion of input variety plays a more important role in increasing TFP in secondary industries.

The separate industry estimates of coefficients for upstream variety indices, VARS, are also presented in table I. Six coefficients are positive and significantly different from zero at a 10% level or more. Five of these six industries are secondary industries. Most of these industries purchase large amounts of inputs from upstream industries rather than from themselves. The positive and significant coefficients of VARS of these industries again supports the idea that secondary industries' TFP benefit more from the variety of upstream industries. Looking across variables, we found no evidence of a relationship between TFP and variety in either VAR or VARS in nine (9) industries.

Table II presents the results for the "lost decade" dummies. We see that two of the coefficients of STAGDUMMY and two of the STAG*VAR coefficients are significant. Economic intuition might suggest the stagnant years would have caused TFP to fall, *ceteris paribus*. Empirical analysis seems to back this up, at least at the aggregate level. Kuroda et al. (2007) found aggregated TFP growth rate for Japan in the 1980's to be 2.57%, while in the 1990's it was 0.77%. Furthermore, there certainly seems to be a significant change in TFP at the sectoral level over the two periods as seen in figures 1 and 2. In many of the industries, TFP growth rate turns negative in the post-bubble period. However, both the direct and interaction dummies show virtually no effect in the regression results of this paper.

This inability to derive any explanatory power for TFP in the pre- and post- bubble years is, of course, somewhat disappointing. But at a more detailed sectoral level, what happened to individual industries (and firms) during the "lost decade" is full of puzzles and paradoxes. Nishimura, Nakajima and Kiyota (2005), for example, find that in a detailed firm level study of entry, exit, and TFP for Japanese firms in the 1990s, more often *efficient* firms (as measured by TFP) went out of business and inefficient ones survived. This, coupled with the effect (often lagged) of increased import variety on TFP makes the task of unbundling these effects a difficult one and one unfortunately not captured here with the simple year-dummies on industry-level regressions.

Table II. Coefficients of STAGDUMMY, STAG*VAR

	Industry	STAGDUMMY	t-stat	STAG*VAR	t-stat	R^2
1	*Agriculture*	0.25	0.07	0.43	0.10	0.04
2	Food and kindred products	-0.66	-0.84	-1.51	-0.47	0.36
3	*Textile mill products*	0.57	0.23	1.45	0.36	0.31
4	Apparel	-0.10	-0.03	-2.50	-0.57	0.34
5	*Lumber and wood*	-1.96	-0.73	0.36	0.13	0.32
6	Furniture and fixture	**3.18****	**3.23**	-1.73	-1.19	0.63
7	Paper and allied	-0.62	-0.76	**-4.42****	**-2.53**	0.64
8	Printing, publishing and allied	-2.42	-1.51	-1.68	-0.50	0.34
9	Chemicals	1.29	0.72	2.59	1.23	0.36
10	*Petroleum and coal products*	-3.27	-1.07	-0.97	-0.43	0.17
11	Leather	0.10	0.07	-3.18	-1.69	0.50
12	*Stone, clay, glass*	0.06	0.04	-0.27	-0.14	0.45
13	*Primary metal*	1.21	0.76	1.23	0.62	0.38
14	Fabricated metal	-1.32	-0.66	0.79	0.27	0.38
15	Machinery, non-elect	-1.17	-0.45	-0.56	-0.20	0.41
16	Electrical machinery	1.90	0.94	**3.96****	**2.19**	0.63
17	Motor vehicles	-0.41	-0.39	-0.79	-0.39	0.44
18	Trans. equipment and ordnance	-0.66	-0.36	-2.05	-0.65	0.17
19	Precision instruments	3.32	0.79	1.98	0.51	0.18
20	*Rubber and misc. plastics*	0.35	0.16	-1.84	-1.27	0.51
21	Misc. manufacturing	**6.27****	**2.76**	2.02	1.47	0.48

n=18 for each of the 21 regressions. ** denotes significance at a 5% level.

Figure 1. Average TFP growth (1980-1992)

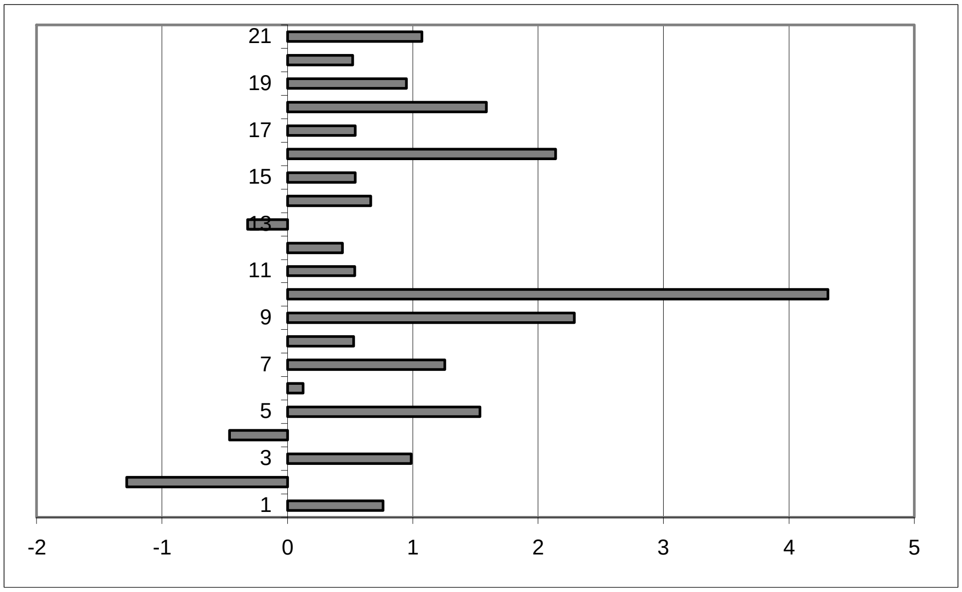
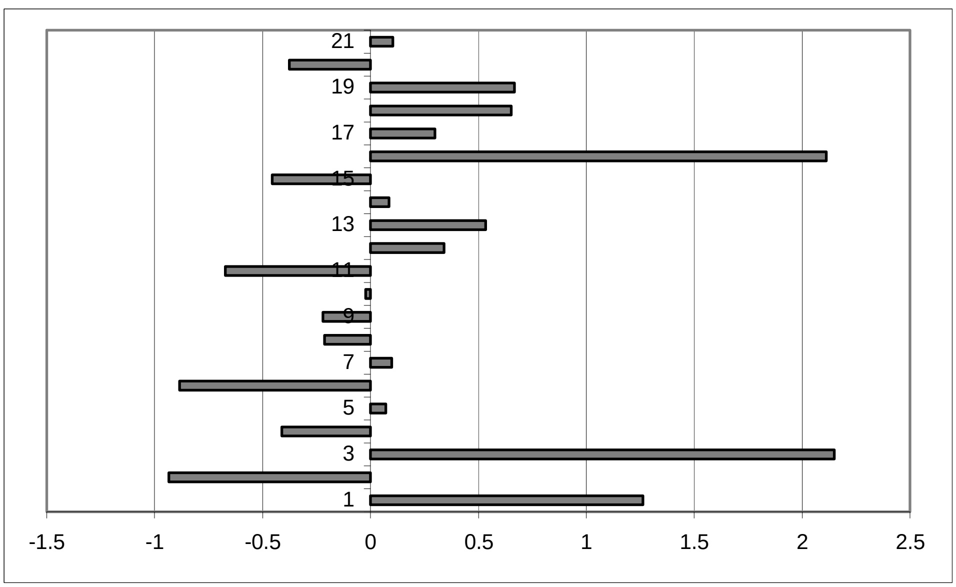


Figure 2. Average TFP growth (1993-2000)



Figures 1 and 2 source: ICPA project conducted by RIETI (2007),
http://www.rieti.go.jp/en/database/d03.html
Note: rates are percentages.

Table III presents the estimates of the R&D coefficients for each of the 21 industry regressions. While the *a priori* is a positive coefficient, most of the coefficients are not significant. Only two coefficients (in bold) are significant, but one of them has a negative sign. This result may arise from the possibility that our separate regressions for each industry might not cover the long term effect of R&D on TFP. This issue is further exacerbated by the short time series for each of the industry-level regressions.

Table III. Coefficients of R&D in import variety regressions

	Industry	R&D	t-stat	R^2
1	*Agriculture*	-32.20	-0.28	0.04
2	Food and kindred products	3.22	1.66	0.36
3	*Textile mill products*	0.49	0.10	0.31
4	Apparel	0.15	0.03	0.34
5	*Lumber and wood*	-0.89	-0.08	0.32
6	Furniture and fixture	**5.10****	**3.09**	0.63
7	Paper and allied	6.26	1.52	0.64
8	Printing, publishing and allied	14.79	1.44	0.34
9	Chemicals	-1.53	-1.45	0.36
10	*Petroleum and coal products*	-2.23	-0.29	0.17
11	Leather	-0.71	-0.34	0.50
12	*Stone, clay, glass*	1.66	0.83	0.45
13	*Primary metal*	-0.62	-0.11	0.38
14	Fabricated metal	5.26	0.70	0.38
15	Machinery, non-elect	0.15	0.16	0.41
16	Electrical machinery	-0.48	-0.84	0.63
17	Motor vehicles	-0.73	-0.61	0.44
18	Transportation equipment and ordnance	-0.97	-0.36	0.17
19	Precision instruments	-0.21	-0.76	0.18
20	*Rubber and misc. plastics*	2.82	0.32	0.51
21	Misc. manufacturing	**-3.26****	**-2.41**	0.48

n=18 for each of the 21 regressions. ** denotes significance at a 5% level of significance.

As mentioned above, to address the weakness of the short time-series, as well as the paucity of explanatory variables in the basic regression, a panel SUR regression was conducted. As innovation in manufacturing may very well occur in many sectors at the same time, particularly with sectors buying inputs from each other, the case for allowing errors to be correlated across industries seems strong *a priori*. If this assumption is true, the SUR is far more powerful. The results are presented in table IV. [9] The results are more compelling than the individual industry regressions, though the stagnation dummies are still not significant.[10] Table IV shows that VAR, VARS and R&D all have positive and significant coefficients. The result more forcefully demonstrates the effect of import variety on productivity, as also illustrated in the separate regressions, at least for many secondary industries. Differing with the separate regressions' results, the R&D variable in the fixed effects panel regressions is now positive and significant. This result may have benefitted from the larger pooled sample as well as the SUR procedure, capturing cross-

[9] Fixed effects regressions were also done, as well as a pooled OLS. The results are very similar to those found in the SUR, with the exception that the R&D variable was not significant in the fixed effect mode, while it was in the pooled OLS.
[10] Both stagnation dummies were also included, but both were insignificant, jointly and separately, and are not reported here.

industry innovation spillovers. This result confirms our *a priori* that increases in R&D expenditure contribute to the improvement of productivity. [11]

Table IV. Results from Panel SUR regression (across 21 industries)

Variable	Coefficient	Std. Error	t-Statistic	P-value
C	-0.010	0.15	-0.06	0.95
VAR	**1.12**	0.16	**7.04**	0.000
VARS	**0.90**	0.29	**3.16**	0.001
R&D	**0.04**	0.02	**1.79**	0.074

Total panel (balanced) observations: 378

R-squared: 0.15. Boldface indicates significance at a 10% level or more.

5. Conclusion

This paper has demonstrated the importance that increases in import variety can play in productivity increases. The regression results are based on Japanese TFP data for more than 20 years matched with a newly constructed data set measuring the variety of imports over the same period. The regression results, both individually and in the panel regression, generally confirm the prediction of endogenous growth theory; that is, an increase in a variety of inputs increased productivity. However, in this paper we focused on import variety, which suggests that not only domestic variety (the kind envisioned in most growth models) but imported variety can also be a source of productivity gains. However, the channels by which this occurs, in reality, are less clear. In some industries the own industry variety effect was stronger, in others, variety upstream had a positive effect. Here, the novel use of the input-output tables to calculate the weighted-varieties of other industries helped distinguish between these two channels.

As to which channel is more important, one could argue they are about equal. In the panel, both estimated coefficients are nearly one. (Though the own-industry variable coefficient was slightly higher in our preferred SUR, this result was sometimes reversed in different specifications.) There is also some support, in the single equation estimations, that these effects were more prevalent in secondary industries than in primary ones. While Japan is already a very open country, any further liberalization (to be interpreted very broadly as reductions in NTBs, increased arms-length imports rather than intra-firm, increased flexibility in general) may see larger benefits in secondary industries.

References

Armington, P. (1969) "A Theory of demand for products distinguished by place of production" International Monetary Fund Staff Papers **16**, 159-178.

Bresnahan, T. F. and Gordon, R. J., Eds. (1997) *The Economics of new goods*, NBER Studies in

[11] Kwon (2004) also finds a positive relation between R&D and TFP for Japan during the period 1970-1998.

Income and Wealth Volume 54, University of Chicago Press: Chicago.

Broda, C. and Weinstein, D.E. (2006) “Globalization and the gains from variety” *Quarterly Journal of Economics* **121**, 541-585.

Ceglowski, J. (1996) “The recent behavior of Japanese imports: A disaggregated analysis” *Japan and the World Economy* **8**, 443-457.

Feenstra, R.C. (1994) “New product varieties and the measurement of international prices” *American Economic Review* **84**, 157-175.

Feenstra, R.C. (2004) *Advanced International Trade*, Princeton University Press: Princeton.

Feenstra, R.C., and Kee, H.L. (2007) “Trade liberalization and export variety: A comparison of Mexico and China” *The World Economy* **30**, 5-21.

Feenstra, R.C., Madani, D., Yang, T-H. and Liang, C. (1999) “Testing endogenous growth in South Korea and Taiwan” *Journal of Development Economics* **60**, 317-341.

Feenstra, R.C., Yang, T-H. and Hamilton, G.G. (1999) “Business groups and product variety in trade: evidence from South Korea, Taiwan and Japan” *Journal of International Economics* **48**, 71-100.

Funke, M. and Ruhwedel, R. (2001a) “Export variety and export performance: Evidence from East Asia” *Journal of Asian Economics* **12**, 493-505.

Funke, M. and Ruhwedel, R. (2001b) “Product variety and economic growth: Empirical evidence from the OECD countries” *IMF Staff Papers* **48**, 225-42.

Funke, M. and Ruhwedel, R. (2005) “Export variety and economic growth in East European transition economies” *Economics of Transition* **13**, 25-50.

Grossman, G.M. and Helpman, E. (1991) *Innovation and growth in the global economy*. Cambridge, MIT Press: Cambridge, MA.

Hamori, S. and Matsubayashi, Y. (2001) “An empirical analysis on the stability of Japan’s aggregate import demand function” *Japan and the World Economy* **13**, 135-44.

Krugman, P. (1991) “Has the adjustment process worked?” in *International adjustment and financing: The lessons of 1985-1991* by C. F. Bergsten, Ed., Institute for International Economics: Washington, D.C.

Kuroda, M., Motohashi, K. and Shimpo, K. (2007) “Investigating productivity slowdown in the 1990’s by using KLEM database in Japan” in *Productivity in Asia: economic growth and competitiveness* by D. W. Jorgenson, M. Kuroda, and K. Motohashi, Eds., Edward Elgar Publishing: Cheltenham, U.K.

Kwon, H.U. (2004) “Productivity Growth and R&D Spillovers in Japanese Manufacturing Industry” Hitotsubashi University Research Unit for Statistical Analysis in Social Sciences, A 21st-Century COE Program, Discussion Paper Series no. 16.

Lincoln. E. J. (2001) *Arthritic Japan – The Slow Pace of Economic Reform*, Brookings Institution Press: Washington, D.C.

Marston, R.C. (1987) “Real exchange rates and productivity growth in the United States and Japan” in *Real-financial linkages among open economies* by S.W. Arndt and J.D. Richardson, Eds., MIT Press: Cambridge, MA.

Nishimura, K. G., Nakajima, T. and Kiyota, K. (2005) “Does the natural selection mechanism still work in severe recessions? Examination of the Japanese economy in the 1990s” *Journal of Economic Behavior and Organization* **58**, 53-78.

Nguyen, A.T. (2009) *Variety and productivity in Japan*, unpublished PhD dissertation, Yokohama National University, Japan.

Nguyen, A.T. and Parsons, C. R. (2009) Import Variety and Productivity in Japan, Yokohama National University CITS Working Paper #2009-1.

Romer, P.M. (1990) “Endogenous technological change” *Journal of Political Economy* **98**, S71 S102.

Toda, H. Y. (1994) “Finite sample properties of likelihood ratio tests for cointegrating ranks when linear trends are present” *Review of Economics and Statistics* **76**, 66-79.