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Impact of export variety on productivity in Japan

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Abstract. This paper underlines the idea of endogenous growth theory that new or higher quality products have significant impacts on productivity and economic growth. Different with previous studies, this paper uses a quite comprehensive definition of variety, which distinguishes the country of origin of the products. With disaggregated level of export data of Japan from 1980 to 2000, the empirical results suggest that nearly half of the industries studied have positive and significant relationship between varieties and Total Factor Productivity (TFP). Most of the industries, which show the positive and significant relationship between export variety and TFP, are secondary industries. This conclusion may bring an implication for Japan to produce more differentiated products to help increase its TFP.

1. Introduction

What lies behind the economic growth of Japan - the second economy in the world - is the concern of many economists. A great number of studies have contributed to answering this question. In this article, the author would like to address one small part of the question by testing endogenous growth theory, which emphasizes the impacts of new or higher quality products on productivity and economic growth.

For the period 1980-2000, economic growth of Japan had experienced dramatical changes. In the 1980s, Japan had great economic growth as well as great diversification, leading to high productivity of the whole economy (Total Factor Productivity - TFP). From 1993, Japan's economy entered a period of economic stagnation. Product variety of Japan had also changed in a sophisticated way during this period. Since the mid-1980s, specialization and the expansion of foreign direct investment became trends in the Japan's economy, which might reduce the range of exported products. However, solid developments of Japan's economy might have the opposite effect on variety. In the stagnation period, we expect that product varieties might decrease because of the slow-down of production. Also the conclusion of many bilateral trade agreements in this period might affect Japan's trade composition as well as its varieties (Parsons, 2000 and Greaney, 1998). This paper will address an interesting question: What role did product variety play in all these ups and downs of Japanese economy?

The paper will study the impact of export variety of Japan over the period 1980-2000 on TFP of 21 main sectors of Japan's economy during this period to answer the above question.

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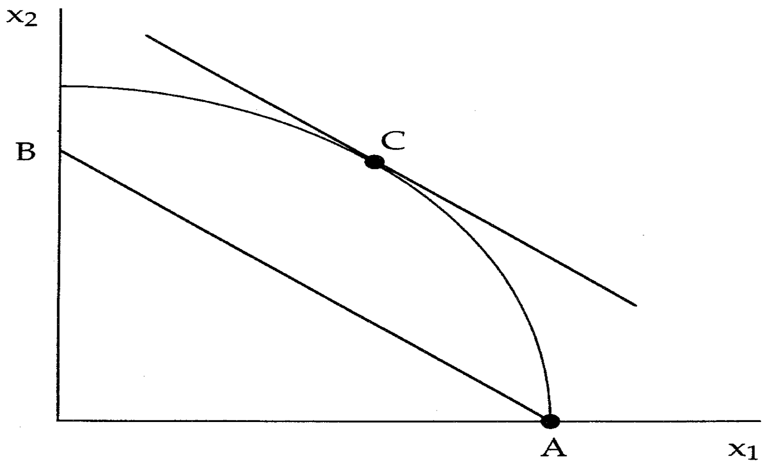
The following section will deal with literature review and methodology of the paper. The third sections then present the data, empirical specifications and result. The fourth section will come up with a conclusion.

2. Literature review and methodology

Endogenous growth models (Romer, 1990; and Grossman and Helpman, 1991) have emphasized the impacts of new or higher quality products on productivity and economic growth. The term “product variety”, therefore, has become familiar in economic growth literature.

Both variety of the inputs (input variety) and variety of the final products (output variety) have their relationship with productivity. This study limits on the relation between output variety and productivity. The following graph illustrates this relation.

The increase in output variety - holding fixed the level of inputs - can be expected to raise the value of output, i.e. raising the productivity. This is illustrated in Figure 1 by the transformation curve between the outputs x_1 and x_2.



Source: Adapted from Feenstra et al. (1999a)
Figure 1: Output Variety.

At the beginning, only production of good x_1 is feasible. In that case, the production would occur at A, and the value of production is illustrated by the budget line AB. However, if production also allows the production of good x_2, given the same level of resources, then production will move along the transformation curve to point C, with a higher budget line, representing a higher value of production. The value of production has increased while the level of inputs is fixed. This shows the increase of productivity due to new output varieties.

A number of papers have used export variety as a measurement of output variety. The idea is that the increase in export variety can increase the competitiveness of the country in the world market and thus increase productivity. Especially for secondary industries, which produce differentiated products, variety plays an important role in improving productivity.

Feenstra et al. (1999a) applied export variety indices to analyze the relationship between the changes in variety and the growth in TFP of South Korea and Taiwan in 16 sectors during 1975-1991 period. They found that export variety has a positive and significant effect on TFP of secondary industries.

The same measure of computing export variety has been used by Funke and Ruhwedel

(2005) to analyze economic growth across 14 East European transition economies. Using a panel dataset from 1993 to 2000, they conclude that export variety plays a significant role in fostering the economic growth in these countries. Similarly, Feenstra and Kee (2006) argue that the growth of export varieties benefits the aggregate productivity in exporting countries, whereas Feenstra and Kee (2007) study the effect of trade liberalization on export variety. They found that the US tariff reductions due to NAFTA had a significant effect on increasing export variety from Mexico and China to the United States.

This paper will measure export variety of Japan over the period 1980-2000 and study the relationship between export variety and productivity. This relationship is expressed by the following equation, which is adapted from Feenstra (1994), Feenstra (2003) and Nguyen Anh Thu (2009):

$$TFP = -\frac{1}{(s-1)} \Delta VARe_{t-1,t} \tag{1}$$

$\Delta VARe_{t-1,t}$ is the change in export variety of two years *t-1* and *t*. Since the elasticity of substitution $s<0$, the first part on the right hand side of the above equation $(-1/(s-1))$ will be positive. This implies that $\Delta VARe_{t-1,t}$ and TFP will have positive relationship. The increase in export variety should raise TFP and vice versa.

In order to calculate export variety indices of Japan, this paper applies the method developed by Feenstra (1994) and extended by Nguyen Anh Thu (2009) as follows:

$$\Delta VARe_{t-1,t} = \ln\left(\frac{l_{t-1}(I)}{l_t(I)}\right) = \ln\left(\frac{\sum_{i\in I_t} p_{it}x_{it} \Big/ \sum_{i\in I} p_{it}x_{it}}{\sum_{i\in I_{t-1}} p_{it-1}x_{it-1} \Big/ \sum_{i\in I} p_{it-1}x_{it-1}}\right) \tag{2}$$

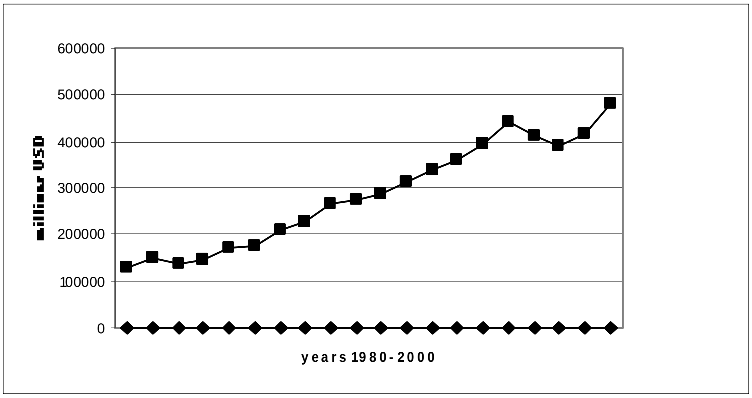
where x_{it}, x_{it-1} are the export of good i in period *t* and *t-1*, respectively; p_{it} and p_{it-1} are the export prices of good i in two periods. I_t, I_{t-1} are the sets of export available in period *t* and *t-1*. The set of export products is changing over time, but there are some products available in both periods $I = I_t \cap I_{t-1}$.

3. Data

The period between 1980 and 2000 witnessed dramatic changes in the export performance of Japan. In the 1980s, Japanese economy had solid growth whereas it experienced long term stagnation during the 1990s.

Figure 2 presents export values of Japan from 1980 to 2000. In 1980s, export values steadily increased. In the early 1990s, despite stagnation, Japan's export volume still increased. However, there was some slowdown in exports in the late 1990s.

In this paper, a good is defined as a four or five digit SITC-2 category, and a variety is the export of a particular good from a particular country (Arminton, 1969). This definition is different with that in previous studies of variety, which defined a variety as the export of a particular goods from all countries, regardless the country of origin. Using this definition of variety and a simple count-based method, we see the changes of export varieties of 21 sectors and total export varieties between 1980 and 2000, illustrated in table 1. Despite the growth of total export volume, export variety by the simple count-based method decreased quite sharply, from 58403 varieties in 1980 to 43552 varieties in 2000, meaning a decrease of nearly 30%.



Source: UNComtrade database.

Figure 2: Japan's export value (1980-2000).

Table 1: Simple count-based variety in Japan's exports (1980-2000)

	Industry	1980	2000
1	Agriculture	756	689
2	Food and kindred products	958	923
3	Textile mill products	5915	3846
4	Apparel	2642	1839
5	Lumber and wood	606	338
6	Furniture and fixture	589	433
7	Paper and allied	1309	992
8	Printing, publishing and allied	876	662
9	Chemicals	7807	6424
10	Petroleum and coal products	427	272
11	Leather	179	105
12	Stone, clay, glass	1648	1284
13	Primary metal	4091	2861
14	Fabricated metal	4950	3419
15	Machinery, non-elect	9436	7844
16	Electrical machinery	5279	3818
17	Motor vehicles	478	353
18	Transportation equipment and ordnance	447	372
19	Precision instruments	4480	3074
20	Rubber and misc. plastics	1531	1374
21	Misc. manufacturing	3999	2630
	Total	**58403**	**43552**

Source: UNComtrade database, compiled by author.

In the simple count-based method, export variety shows a decrease over the 21 years. However, it only provides us with a rough estimate of the changes in variety. We have to measure more accurate export variety indices as described in previous section and see how export variety changes. To compare the changes of export variety between the two years *t* and *t-1* ($\Delta VA\mathrm{Re}_{t-1,t}$), equation (2) will be used, then the result will be multiplied by 100 to have the rate in percent terms. Appendix 1 shows the changes in export varieties for 21 sectors of Japan from 1980-2000.

In order to smooth the variety indices, a 3-year moving average is calculated ($MA\Delta VA\mathrm{Re}_{it} = 1/3(\Delta VA\mathrm{Re}_{it-2} + \Delta VA\mathrm{Re}_{it-1} + \Delta VA\mathrm{Re}_{it})$. 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.

Beside export variety, TFP is affected by R&D as well. More specifically, technology progress and R&D activities in one industry help to expand variety of that industry, leading to the increase of the competitiveness, which in turn increases productivity of the industry. R&D data is taken from the ESRI-HISTAT-JIP project launched by Economic and Social Research Institute (ESRI) and the statistics of the Ministry of Internal Affairs and Communications of Japan(1). R&D index for each industry is calculated as the expenditure on R&D over output of that industry. R&D might have the lagged effects on TFP because research and development may take some time to become realized in production. Therefore, R&D indices are adjusted for a 3-year moving average, similar to that done for export variety.

The data on TFP for Japan are from the ICPA project launched by RIETI (Research Institute of Economy, Trade and Industry)(2). This project provides us with TFP for 33 sectors, 21 of which are analyzed in this paper (I exclude services and some other industries such as mining, construction). This project is based on the EU KLEMS framework, i.e., industry level data on capital (K), labor (L), energy (E), material (M), service (S) as well as gross output to produce the TFP values.

TFP is measured as a Divisia index, i.e. the rate of growth of output minus a weighted average of the growth of inputs. Appendix 2 shows the growth (in percent) of TFP for 21 industries of Japan for 21 years, from 1980 to 2000.

4. Empirical specification and results

The relation between export variety and TFP will be estimated by the following equation:

$$TFP_{it} = a_i + b_i STAGDUMMY + g_i MAVAR\mathrm{e}_{it} + +m_i STAG \times MAVAR\mathrm{e}_{it} + h_i MAR\&D_{it} + e_{it} \qquad (3)$$

where a_i is a constant term for each industry *i*, b_i is a dummy variable capturing the impact of stagnation in Japan starting from 1993, g_i is the estimated relation between the change in export variety and the growth in TFP in one industry. m_i is the effect of the interaction between stagnation and variety on TFP, whereas h_i is the estimated effect of R&D expenditure on TFP. Variety and R&D indices are adjusted for the moving average of three years as explained in previous section.

The results of the regressions are reported in table 2. The values in bold are the coefficients that are positive and significant at a 10% level. There are nine such industries. Among them, six industries, including furniture and fixture, leather, fabricated metal, non-electrical machinery, electrical machinery and rubber and miscellaneous plastics, are secondary industries. All of these six industries produce highly differentiated products. For industries like furniture and fixture, leather, electrical machinery

(1) Websites: http://www.esri.go.jp/index-e.html, http://www.stat.go.jp/english/index.htm

(2) Website: http://www.rieti.go.jp/en/database/d03.html

and rubber and miscellaneous products, producing new products to respond to the ever increasing demand of consumers is the crucial task. Industries like fabricated metal, non-electrical machinery also require the supply of a new range of products to other manufactured industries. New products and therefore new variety plays an important role in these industries. Productivity has to be improved to produce more variety and vice-versa; variety will increase when productivity grows. This is the basis of endogenous growth theory: the expansion of export variety plays an important role in productivity growth. Table 2 also shows that Japanese major exports, such as fabricated metal, non-electrical machinery and electrical machinery, are well explained by endogenous growth theory.

Table 2: Coefficients of (moving average) export varieties (1980-2000)

	Industry	**MAVARe**	**t-statistics**	**R^2**
1	Agriculture	-0.09	-0.41	0.15
2	Food and kindred products	0.56	0.80	0.12
3	Textile mill products	**3.49**	**3.74**	0.26
4	Apparel	-2.07	-1.11	0.17
5	Lumber and wood	**1.49**	**2.52**	0.44
6	Furniture and fixture	**2.95**	**1.68**	0.36
7	Paper and allied	0.66	0.63	0.20
8	Printing, publishing and allied	0.83	1.43	0.44
9	Chemicals	0.24	0.40	0.43
10	Petroleum and coal products	**1.24**	**3.09**	0.55
11	Leather	**0.57**	**2.27**	0.38
12	Stone, clay, glass	1.29	1.32	0.26
13	Primary metal	-1.66	-0.47	0.12
14	Fabricated metal	**1.57**	**1.78**	0.31
15	Machinery, non-elect	**3.68**	**1.69**	0.27
16	Electrical machinery	**4.60**	**2.27**	0.41
17	Motor vehicles	-0.70	-0.38	0.04
18	Transportation equipment and ordnance	-0.44	-0.73	0.08
19	Precision instruments	0.10	0.13	0.08
20	Rubber and misc. plastics	**3.80**	**2.50**	0.50
21	Misc. manufacturing	0.46	0.27	0.29

Note: The values in bold are the coefficients that are significant at a 10% level

Table 3: Coefficients of STAGDUMMY and STAG*MAVARe in export variety regressions

	Industry	STAGDUMMY	(t-statistics)	STAG*MAVARe	(t-statistics)	R^2
1	Agriculture	0.87	0.26	0.78	1.42	0.15
2	Food and kindred products	0.22	0.18	-0.54	-0.18	0.12
3	Textile mill products	-0.84	-0.42	-1.79	-0.48	0.26
4	Apparel	-1.22	-0.55	1.77	0.50	0.17
5	Lumber and wood	3.17	1.19	-0.15	-0.11	0.44
6	Furniture and fixture	-0.74	-0.92	-2.88	-1.18	0.36
7	Paper and allied	0.70	0.49	-0.67	-0.30	0.20

8	Printing, publishing and allied	-0.88	-0.61	1.10	1.41	0.44
9	Chemicals	0.55	0.30	1.31	1.04	0.43
10	Petroleum and coal products	**-6.12**	**-2.44**	-0.61	-1.06	0.55
11	Leather	**2.78**	**1.86**	0.49	0.24	0.38
12	Stone, clay, glass	0.82	0.76	1.09	0.69	0.26
13	Primary metal	0.42	0.27	2.42	0.62	0.12
14	Fabricated metal	-1.57	-1.27	-0.39	-0.22	0.31
15	Machinery, non-elect	0.92	0.41	0.51	0.19	0.27
16	Electrical machinery	1.68	1.12	-1.87	-0.69	0.41
17	Motor vehicles	0.41	0.25	3.42	0.56	0.04
18	Transportation equipment and ordnance	-1.56	-0.63	0.82	0.86	0.08
19	Precision instruments	1.90	1.18	1.62	1.27	0.08
20	Rubber and misc. plastics	0.04	0.02	-2.43	-1.56	0.50
21	Misc. manufacturing	2.69	0.96	1.94	0.82	0.29

Note: The values in bold are the coefficients that are significant at a 10% level.

Table 3 shows the coefficients of STAGDUMMY and STAG*MAVARe variables. Only petroleum and coal products has a negative and significant coefficient of STAGDUMMY. Generally, the results of these regressions show no evidence of the relation between stagnation and TFP.

Table 4: Coefficients of MAR&D in export variety regressions

	Industry	MAR&D	t-statistics	R^2
1	Agriculture	-61.24	-0.62	0.15
2	Food and kindred products	1.67	0.64	0.12
3	Textile mill products	**5.45**	**1.77**	0.26
4	Apparel	1.59	0.47	0.17
5	Lumber and wood	8.06	0.57	0.44
6	Furniture and fixture	**-0.97**	**-1.82**	0.36
7	Paper and allied	-4.60	-0.65	0.20
8	Printing, publishing and allied	-1.45	-0.35	0.44
9	Chemicals	-0.87	-1.33	0.43
10	Petroleum and coal products	-2.12	-0.65	0.55
11	Leather	-2.82	-1.40	0.38
12	Stone, clay, glass	-0.12	-0.07	0.26
13	Primary metal	4.74	0.84	0.12
14	Fabricated metal	5.68	1.04	0.31
15	Machinery, non-elect	-0.92	-1.29	0.27
16	Electrical machinery	0.19	1.01	0.41
17	Motor vehicles	-0.08	-0.15	0.04
18	Transportation equipment and ordnance	0.09	0.09	0.08

19	Precision instruments	-0.10	-1.23	0.08
20	Rubber and misc. plastics	5.36	0.82	0.50
21	Misc. manufacturing	-1.77	-1.61	0.29

Note: The values in bold are the coefficients that are significant at a 10% level.

Table 4 shows no evidence of a positive relation between R&D and TFP. Only one industry (textile mill products) has a positive and significant coefficient of MAR&D. Similar to the import variety regressions, separate regressions for each industry might not capture the long term effect of R&D on TFP.

Next, we look at the result of fixed effect panel regressions. Table 5 shows that both MAVARe and MAR&D have positive and significant coefficients. The result strongly confirms the endogenous growth model: export variety has positive and highly significant effect on TFP. R&D index in the fixed effects panel regressions has a coefficient of 0.05, which is significant at a 5% level. This result confirms our expectation that the increase in R&D expenditure contributes to the improvement of productivity. One problem is that there might be a correlation between R&D and export variety. If we spend more on R&D, we might increase the export variety of the industry. However, R&D might also lead to specialization and thus reduce export variety. In this case, the regressions result might overstate or understates the effects of export variety since we set export variety and R&D as two separate variables.

Table 5: Fixed effects pooled least squares regression for 21 industries (export)(3)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	**0.28**	0.15	**1.82**	0.07
MAVARe	**0.38**	0.09	**4.25**	0.00
STAG*MAVARe	0.20	0.17	1.17	0.24
MAR&D	**0.04**	0.02	**1.76**	0.08

Total observations: 420
R-squared: 0.08

5. Conclusion

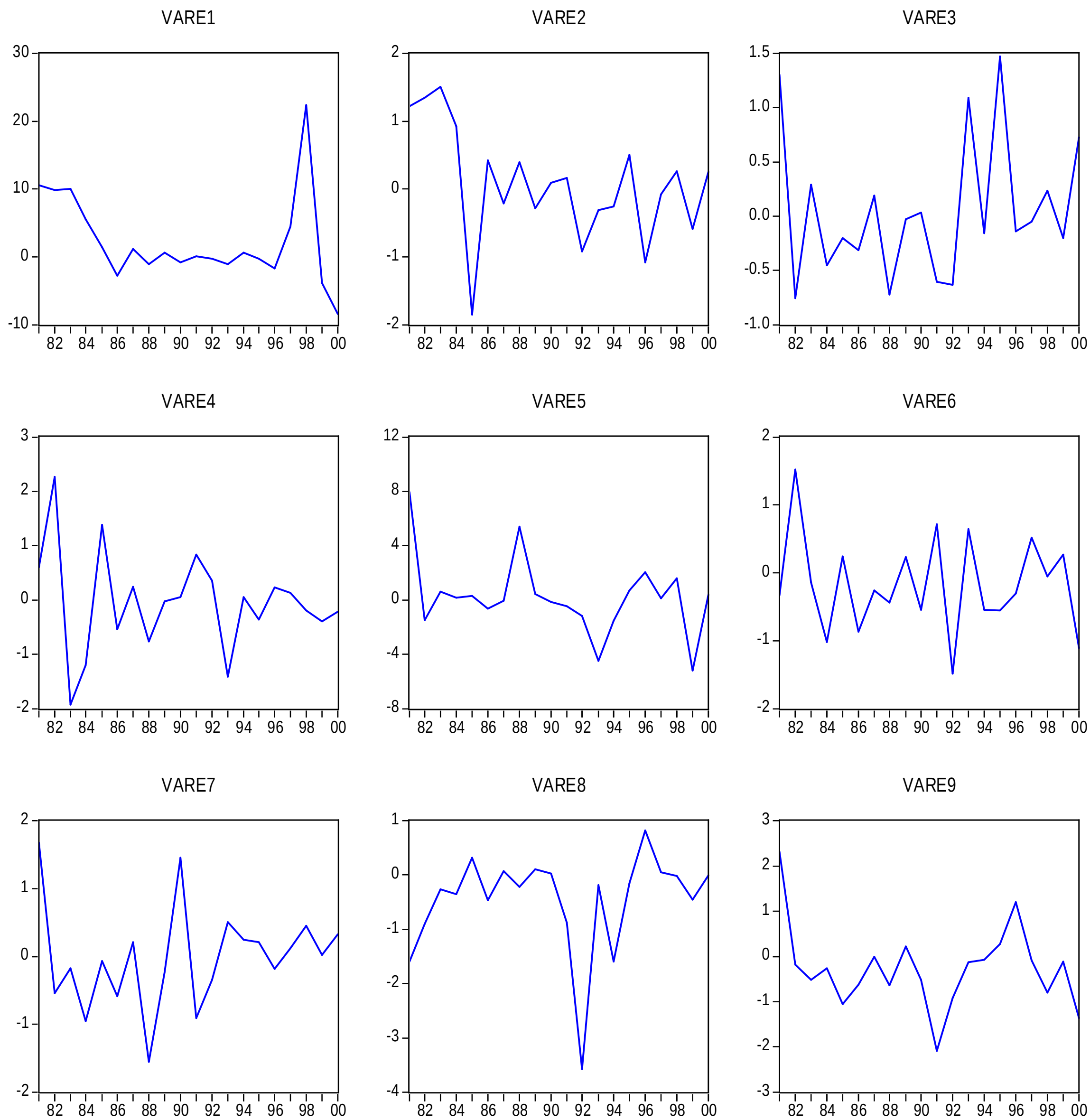
OLS regressions for each industry as well as fixed effect PLS regressions for all 21 industries on export variety of Japan during period 1980-2000 has contributed to evidence supporting endogenous growth theory. Specifically, nine out of 21 industries studied show the positive and significant relation between export variety and TFP. This result fit well with the idea that the increase in export variety can increase the competitiveness of the country in the world markets and thus increase productivity. Especially for secondary industries, which produce differentiated products, variety plays an important role in improving productivity. This theory has also been applied to Japan: six out of nine industries with positive and significant coefficients of variety, are secondary industries. However, this paper has found no relation between stagnation and TFP in Japan during 1980-2000 period. The reason might be the relatively small size of the data -20 years of annual data for each industry. In the future, the extension of the data is necessary and helpful.

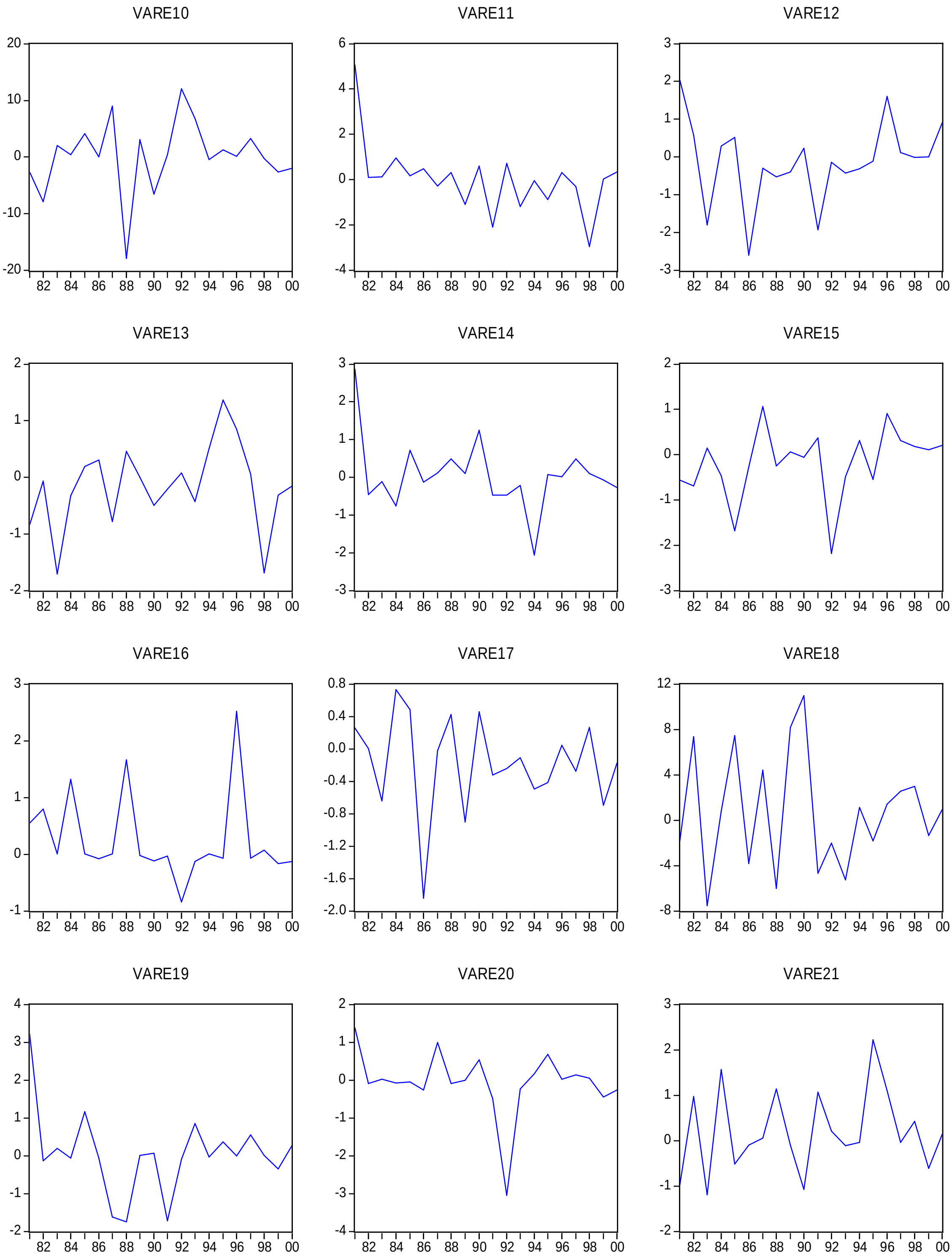
The role of variety is widely illustrated in many studies for many countries (Broda and Weinstein, 2006; Jorgenson et al., 1987; Kocherlakota and Yi, 1997). This paper presents further evidence of Japan’s gain from trade through variety. By trading more varieties

(3) Fixed effects were found to be significant but not reported here.

of products, Japan's TFP increases. With all the ups and downs of Japan's economy, export varieties and TFP of many industries have moved in one direction. The story is quite the same with import varieties of Japan during 1980-2000 (see Parsons and Anh Thu Nguyen, 2009). This conclusion may bring an implication: Japan should produce more differentiated products to help increase its productivity. More investment on R&D and access to new foreign markets might be the best way to this target.

Appendix 1
Changes of Japan's export varieties for 21 industries
(1980-2000)

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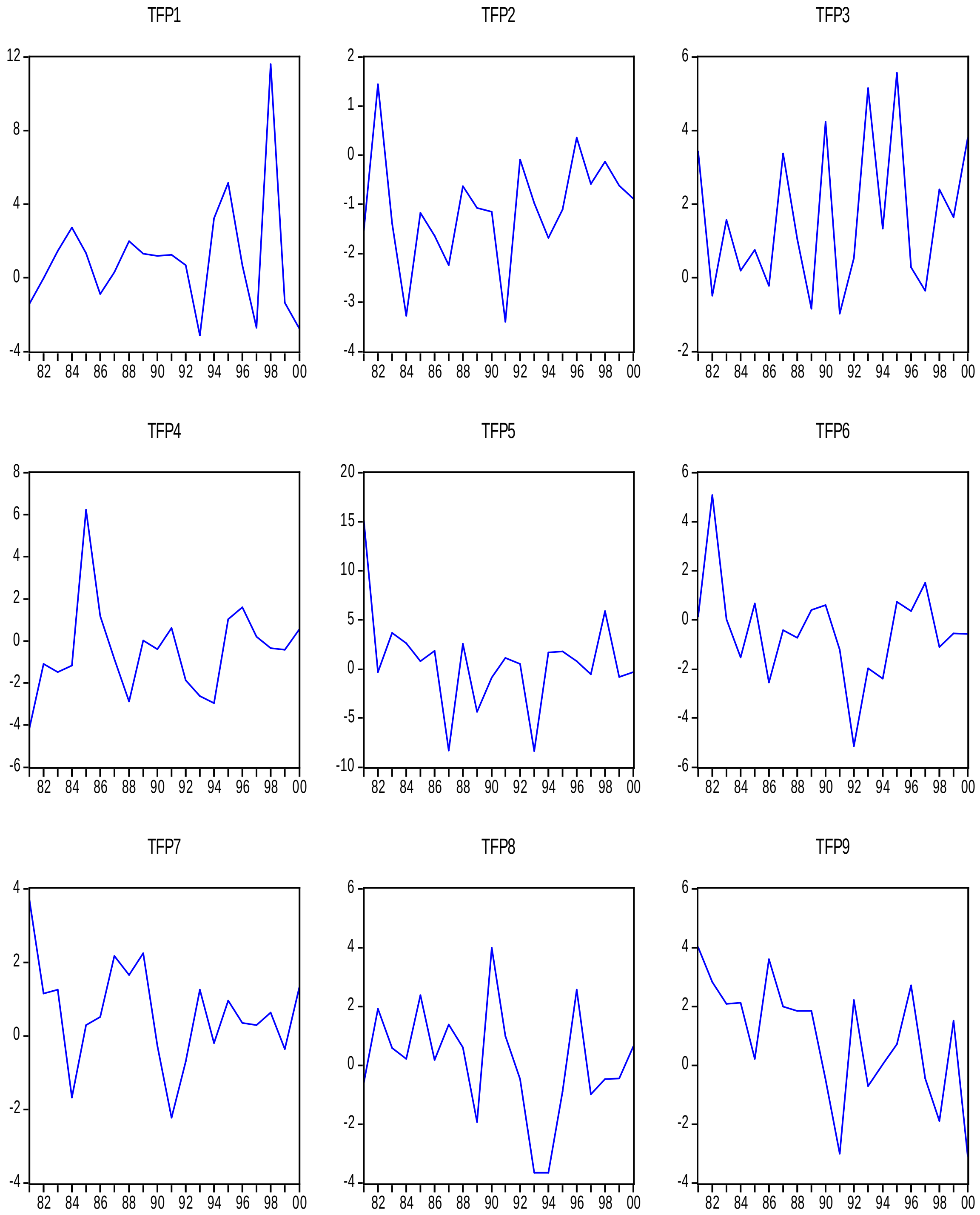
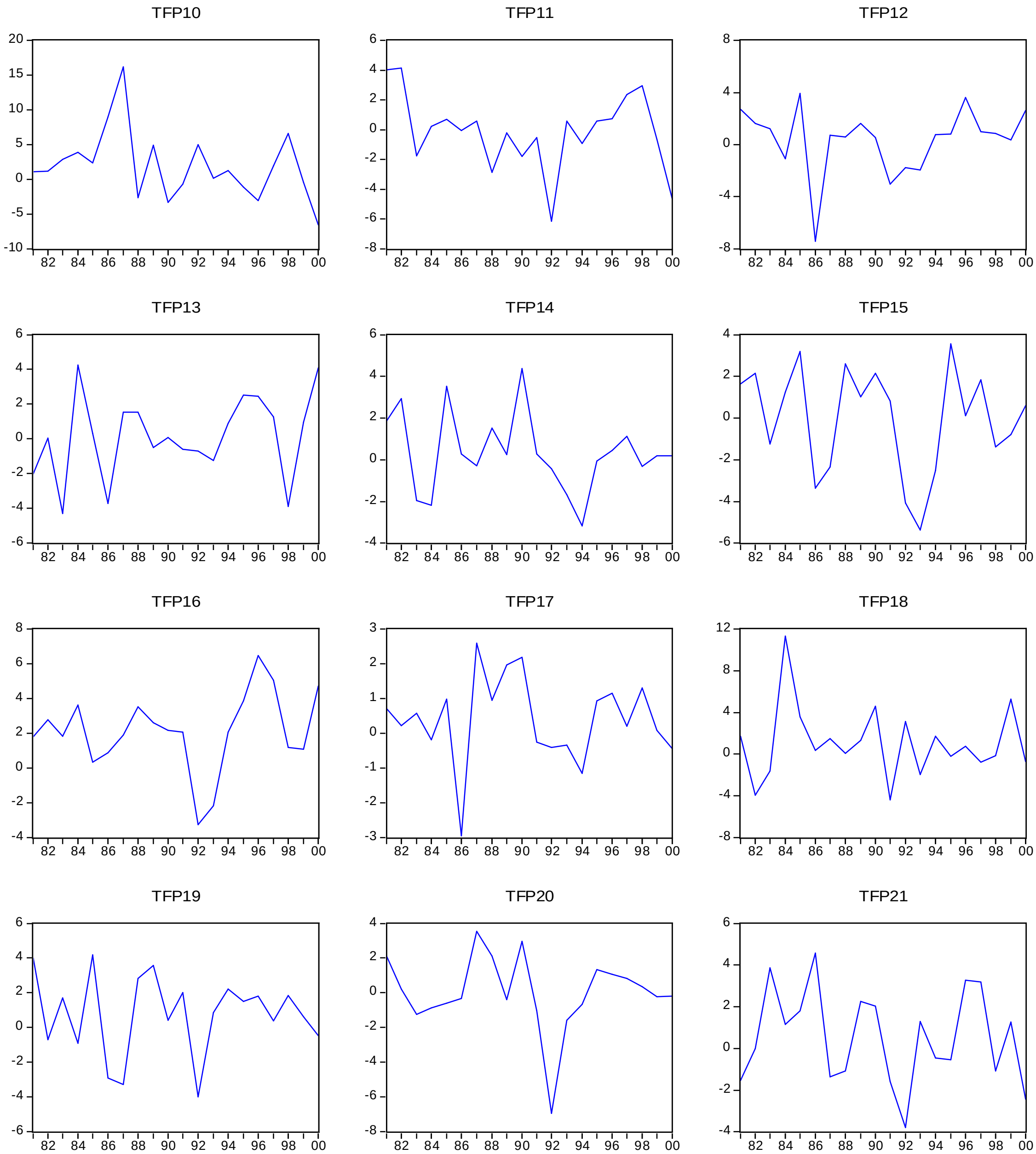
Appendix 2
Growth of Japan's TFP for 21 industries (1980-2000)





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Tác động của đa dạng xuất khẩu đối với vấn đề năng suất ở Nhật Bản

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Tóm tắt: Bài viết nhấn mạnh quan điểm về lý thuyết tăng trưởng nội sinh cho rằng sản phẩm mới hoặc có chất lượng cao ảnh hưởng đến vấn đề năng suất và tăng trưởng kinh tế. Khác với những nghiên cứu trước đây, bài viết vận dụng khái niệm tương đối toàn diện về tính đa dạng để phân biệt nước xuất sứ của sản phẩm. Với các dữ liệu tới mức độ chi tiết trong lĩnh vực xuất khẩu của Nhật Bản trong giai đoạn từ 1980-2000, kết quả cho thấy trong gần một nửa các ngành công nghiệp mà chúng tôi nghiên cứu có tồn tại mối quan hệ tích cực và thiết yếu giữa sự tính đa dạng và Năng suất các yếu tố tổng hợp (Total Factor Productivity - TFP). Hầu hết các ngành công nghiệp thể hiện mối quan hệ tích cực và thiết yếu giữa sự đa dạng của hoạt động xuất khẩu và Năng suất các yếu tố tổng hợp đều là các ngành công nghiệp thứ cấp. Kết luận này có thể bao hàm một gợi ý cho Nhật Bản trong việc tăng cường sản xuất thêm nhiều sản phẩm đa dạng hơn nữa để nâng cao TFP của mình.