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TRADE, TRADE POLICY, AND PRODUCTIVITY GROWTH IN OECD MANUFACTURING

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ABSTRACT: Trade liberalization may promote economic growth in a number of ways, including possibly by accelerating the rate of technological change It has variously been proposed that firms which face more intense import competition may be spurred to greater rates of innovation in order to remain viable, and that firms which export absorb new technologies through their contact with international markets This paper seeks to extend the literature on linkages between trade, productivity and economic growth by examining evidence on trade, trade policy and productivity growth for a sample covering thirteen OECD countries and including seventeen manufacturing sectors, using data primarily from the 1980s. Robustness of the relationships examined is explored by examining several alternate measures of total factor productivity (TFP) and labor productivity, as well as by examining alternate samples of the data

Within individual sectors, there are strong productivity convergence effects within the OECD After controlling for convergence, we find a positive association between high rates of productivity growth and low tariffs, and between high productivity growth and strong export performance We found no particular association between high productivity growth and import penetration. While some issues remain unresolved, the results are at least not inconsistent with the possibility of positive linkages between trade liberalization and accelerated productivity growth.

I. Introduction

Trade liberalization may promote economic growth in a number of ways, including possibly by accelerating the rate of technological change It has variously been proposed that firms which face more intense import competition may be spurred to greater rates of innovation in order to remain viable, and that firms which export absorb new technologies through their contact with international markets This paper seeks to extend the literature on linkages between trade, productivity and economic growth by

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II. Review of Literature

Numerous investigators have proposed that either exporting, or importing, may be a cause of greater productivity growth. It has been argued that greater import competition enhances productivity growth, by forcing less efficient firms to operate more efficiently and by rewarding more efficient domestic firms with an increase in market share. Since high tariffs and non-tariff barriers (NTBs) reduce import competition, a similar negative effect of trade barriers on productivity can be posited Increased exports might enhance productivity by exposing the exporting firm to new technological information from the customer (see Aw and Hwang (1995), for Taiwan.)

Using various econometric techniques on U S. data, Caves and Barton (1990) and MacDonald (1994) generate a positive association between import penetration and either technical efficiency or productivity growth Several investigators have found that measured productivity in developing countries increased after an episode of liberalization (Handoussa, Nishimuzu, and Page (1986) for Egypt, Tybout and Westbrook (1995) for Mexico, and Tybout, de Melo, and Corbo (1991) for Chile) Evidence

for a lagged effect of tariff cuts in stimulating productivity growth appears in work by the Economic Planning Advisory Commission of Australia (1996) Other studies have found more ambiguous results (Harrison (1994), Harrison and Revenga (1995)), and the relationship between trade and productivity growth is not yet a settled empirical question

Both theory and the available studies indicate the potential for greater import competition to lead to a short term decline in productivity, and studies testing for year to year correlations find little support for a positive relationship Studies that measure productivity as period averages or compare productivity across longer periods of time, especially across periods of notable trade liberalization, find positive correlations between trade openness and productivity This indicates that the effects of a change in the trade regime on productivity manifest themselves only gradually Therefore, investigators have applied firm-level data to examine some of the mechanisms by which higher industry efficiency may be achieved Specifically, they have tested whether increased trade competition reduces the monopolistic profits arising from market power, allows the most efficient firms to expand and exploit efficiencies of operating at a larger scale, and/or forces the less efficient to exit the industry

The exact mechanisms by which changes in import protection may affect productivity have not been firmly established with firm-level data and apparently vary greatly across countries and industries (Tybout (1992)) Given the large number of structural changes taking place in developing countries over the years for which data were collected for these studies, it is not surprising that the processes generating productivity increases proved to be complex Nevertheless, researchers have found direct links between changes in trade regime and productivity growth in developing countries when the relationship is measured over the medium term, long enough for efficiency measures to be put in place

III. Data and Methodology

We seek to investigate whether productivity growth in manufacturing is significantly related to either trade flows or trade policy These relationships are estimated after controlling for other determinants of productivity growth, such as convergence of low-productivity countries to the "state of the art," and technological effort through formal R&D Evidence is examined for a sample of thirteen OECD countries and eighteen manufacturing sectors during the period 1980-91

An important conceptual issue is the question of how one untangles the direction of causation between productivity and trade Clerides, Lach, and Tybout (1997), using firm-level data from Colombia, Mexico, and Morocco, and taking into account productivity changes before and after firms enter export markets, find that "relatively efficient firms become exporters, but .. firms' costs are not affected by previous export market participation." In the case of imports, there is a tendency for imports to increase when the national industry lags in productivity, either because foreign products then become relatively cheaper or because they embody higher quality. This tendency moves in the opposite direction from any possible positive effect that imports may have on productivity by putting pressure on less efficient firms. This makes any efficiency-enhancing effect of import competition more difficult to detect empirically.

A similar difficulty exists with estimated relationships between tariffs and productivity. One hypothesis put forward in the political economy literature is that nations tend to protect weak and declining industries (See the summary in Rodrik, 1995.) Thus high tariffs, by keeping out import competition, could reduce firms' incentive to improve productivity; or firms, having difficulty in improving productivity and finding themselves losing sales and profitability, seek to secure greater protection from import competition, or perhaps both.

The empirical work described below tests for long-run associations between trade (or trade policy) and productivity for a sample of thirteen OECD countries and eighteen manufacturing industries, spanning the universe of manufacturing A number of studies have compared OECD productivity growth for the entire economy and for aggregate manufacturing (most recently in two papers by Bernard and Jones (February 1996, December 1996)) Dollar and Wolff (1993) make some suggestive comparisons concerning trade patterns and TFP growth for Japan and the United States. Pilat (1996) analyzes productivity levels and productivity change in a manner analogous to the present study Pilat finds that a high degree of export intensity and low tariffs are associated with high and rapidly growing labor productivity, while a high degree of import penetration is associated with low labor productivity

One of the limitations of the studies discussed in the above paragraph is that they measure productivity on a value-added (or "single deflation") basis. This commonly used method counts productivity gains when output increases relative to labor and capital inputs, but ignores purchased intermediate inputs. An important advantage of the present study is that both TFP and labor productivity are measured on a quantity basis, taking into account the possibility that technological progress may operate by conserving intermediate inputs of materials, semifinished goods, and equipment This method of productivity measurement, sometimes referred to as "double deflation," requires the construction of a price index for intermediate goods in each country and industry The analysis in this chapter presents and analyzes TFP and labor productivity figures, both on a quantity basis and on a value-added basis for comparison purposes

Growth Accounting

Consider the following relationship between the value of industry output and its components;

(1) $PQ \equiv VA + P_M M$

in which PQ represents the value of output, and $P_M M$ represents the value of intermediate inputs, and VA represents value-added Further, let.

(2) $VA \equiv wL + rK$ where: wL = payments to labor, rK = payments to capital

(3) $\beta = (wL)/VA$ β = share of labor compensation in value added

(4) $\beta_L = (wL)/PQ$ β_L = share of labor compensation in output

(5) $\beta_K = (rK)/PQ$ β_K = share of capital returns in output

The various measures of productivity can be defined as a ratio of value-added (or output) to a weighted sum of the inputs used in production of value-added (or output), with the weights corresponding to the value shares of the inputs. Thus, total factor productivity on a value-added basis is defined as

(6) $$TFP_{VA} = \frac{VA}{L^{\beta}K^{(1-\beta)}}$$

while equations (7) through (9) define, respectively, total factor productivity on a quantity basis, labor productivity on a value-added basis, and labor productivity on a quantity basis:

(7) $$TFP_{Q} = \frac{Q}{L^{\beta_L}K^{\beta_K}M^{1-\beta_L-\beta_K}}$$

(8) $$LP_{VA} = VA/L$$

(9) $$LP_{Q} = Q/L$$

Several equations for total factor productivity are estimated of the form

(10) $TFPG_{t0,t1} = \alpha_0 + \alpha_1 TFP_{t0} + \alpha_2$ RESEARCH $+ \alpha_3$ TRADE or TRADE POLICY

The subscripts i,j for countries and industries apply to each variable, but are omitted for clarity of exposition. In the above equation, $TFPG_{t0,t1}$ is the annualized rate of TFP growth between an initial and terminal year, TFP_{t0} is the level of TFP in the initial year, relative to the United States, RESEARCH is a measure of research intensity, and TRADE (TRADE POLICY) is a measure of trade flows (tariffs).

(11) $LPG_{t0,t1} = \beta_0 + \beta_1 G(K/L) + \beta_2 LP_{t0} + \beta_3$ RESEARCH $+ \beta_4$ TRADE or TRADE POLICY

Analogous equations for labor productivity, of the form in equation 11, are also estimated In this equation, $LPG_{t0,t1}$ represents the annualized growth rate of labor productivity over the relevant time period, LP_{t0} is the initial level of labor productivity, measured relative to the United States; and G(K/L) is the growth rate of the capital-labor ratio. This last term is required because increases in capital per worker are important determinants of labor productivity. Since increased capital use is explicitly taken account of in measures of TFP, the corresponding variable is unneccessary in the TFP growth equation.

Industries with low initial levels of productivity compared to similar industries in other countries enjoy more opportunities for technological imitation, and thus are likely to enjoy more rapid productivity growth. Thus, the expected signs of α_1 and β_2 are negative. Since more capital per worker contributes to higher labor productivity, β_1 is expected to be positive. More intense research effort is likely to lead to greater productivity growth, so the expected signs of α_2

and β_3 are positive The expected sign of the trade or trade policy variable (α_3 or β_4) depends on the particular measure of trade or trade policy. Based on the above discussion, the expected association between export intensity and productivity growth is positive, the expected association of tariffs and productivity growth is negative, and the expected association between import penetration and productivity growth is ambiguous It should be emphasized that these expected associations do not depend on causation running from trade (or trade policy) to productivity, or from productivity to trade (or trade policy), nor does this particular test provide information on the direction of causality.

Equations (10) and (11) were estimated for each productivity measure, in each sample, using ordinary least squares (OLS), fixed country effects, and fixed industry effects. A preferred specification for each productivity measure and sample is reported based on the following testing regime. For each equation estimated, the null hypothesis of OLS was tested in turn against the alternative hypothesis of country fixed effects, and industry fixed effects, using an F-test on the fixed effects. In the event the null hypothesis was rejected against either alternative, the fixed-effects estimator is reported in the regression tables (Tables 5 through 7) If the null hypothesis of OLS cannot be rejected against either the alternative of country fixed effects or industry fixed effects, OLS is reported. In some cases, this procedure leads to two alternative specifications, one with country effects and another with industry effects. Since these specifications represent non-nested hypotheses which cannot be tested against each other directly, both are reported.

Data Sources

The data for measuring productivity growth were largely taken from the *OECD STAN Database for Industrial Analysis*. This source provided measures of output, value-added, labor

input, and annual investment. The value of materials was taken as the difference between output and value-added Measures of value-added are given both in current local currency and in constant 1985 local currency; the ratio between these two measures provided the price index for output The shares of various intermediate goods and services in M were obtained from the appropriate input-output tables in the Global Trade Analysis Project (GTAP) data base and in the OECD Input-Output data base. Country-specific prices of individual intermediate goods were obtained from a variety of sources, including the *OECD STAN Database* itself for manufactures prices, World Bank data on services prices, and United Nations *Monthly Bulletin of Statistics* prices on international markets for primary products (converted to local currency). Capital stocks for countries and industries were generated on a perpetual-inventory basis beginning in 1970. Initial values for the capital stocks and depreciation rates were calibrated based on comparable data from the *OECD International Sectoral Database*

Productivity measurements were made on data converted to 1987 constant dollars. First, annual values in local currency were converted to current dollars using product-specific cross-country price indices developed in an OECD study by Dirk Pilat (1996) Pilat calculates product-specific purchasing power parity exchange rates between OECD industries and U.S industries for 1987. The ratios of value- added at current and constant prices (mentioned above) were used to compute differences in product-specific inflation rates between the U.S. and the other countries over the 1980 to 1991 period In this way, the product-specific purchasing power parity exchange rates of 1987 could be extended to the other years covered in the study. Then, once each industry's annual data were converted to current dollars for each country, the series

were deflated from current to constant 1987 dollars by using the U.S. product-specific inflation rates

This method contrasts with our earlier treatment of the same data. (See USITC, 1997) In the earlier case, all series for a given country were converted to dollars at a single exchange rate, the purchasing-power parity exchange rate for investment from the International Comparisons Project (described in Summers and Heston (1991)).[1]

In the new approach, data by industry are converted to dollars using an industry-specific real exchange rate. This approach compensates for the phenomenon experienced by most international travelers: that even though all home currency is converted at one exchange rate, some prices in the foreign country seem unusually expensive, and some unusually cheap. The new method takes account of the differences in relative price structures across countries. If the price of a product is unusually high in one country compared to the U.S., its TFPva will be overestimated unless the measure of real value-added is deflated in a way that reflects the high relative price. For any sector that uses an unusually expensive intermediate input, TFPq will be underestimated unless the calculation of intermediate costs reflects the relatively high price of the one input. In other words, the buying sector will not be credited with enough efficiency unless the unusually high price of an input is accounted for.

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1 The PPP exchange rate for investment is the natural choice for deflating the investment time series Alternatives for the other time series include the PPP exchange rates for GDP, or for consumption. GDP includes a large share of non-tradable services (and consumption an even higher share), while investment goods (like manufactured goods in general) are largely tradable Thus, it was judged that the PPP exchange rate for investment was a better proxy for international price comparisons of manufactures than either the PPP exchange rate for GDP or that for consumption

Tables 1-3 below compare productivity growth between the current method and the comparable one-exchange-rate-per-country (naive) approach [2] In general, as Pilat notes, manufacturing prices were higher in other countries than in the U S., and thus their output and productivity levels were lower under the new TFP calculations.

The variable chosen for research intensity was the ratio of research scientists and engineers to the total number of workers The number of researchers was obtained from *OECD Basic Science and Technology Statistics*, and is available for 1981-92 An alternative variable, the ratio of R&D to sales, was also tried in the regression analysis, yielding similar results. The research variable is averaged over the sample period

Aggregate exports and imports for each country and sector were obtained from the *Statistics Canada World Trade DataBase* The export variable is expressed as the ratio of exports to output, and the import variable is expressed as the ratio of imports to apparent consumption, where apparent consumption is defined as output plus imports minus exports. Data on the average MFN tariff during the late 1980s were obtained from a CD-ROM produced by the World Trade Organization During the time period under analysis, countries made few major revisions to their MFN tariff schedules The tariff variable is measured for each industry in each country, and is aggregated from a trade-weighted tariff at the two-digit HS level, using trade weights A simple average tariff was also tried, yielding similar results.

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[2] The naive comparator in the tables is not identical to the results in USITC 1997 The 1997 results were not ideal for comparison because that approach involved first deflating to constant local currency before converting to dollars. The comparator in the tables reflects conversion of all country data into dollars at a single exchange rate followed by deflation to constant dollars Thus it isolates the effects of using a single versus product-specific exchange rates

Summary Features of Data

Each of the four measures of productivity, productivity growth is negatively correlated with the average tariff. Sectors such as food, beverages and tobacco, and textiles, apparel and leather, with particularly high average tariffs, exhibit relatively low productivity growth rates, while tariffs are lower in sectors such as electrical and non-electrical machinery which exhibit higher productivity growth In addition, high tariffs are correlated with high NTBs across sectors (Pritchett (1996); Lee and Swagel (1997)) This indicates that high productivity growth is also negatively correlated with total protection from tariffs and NTBs.

IV. Principal Results

In all estimates, the coefficient for initial 1980 productivity is strongly and significantly negative, indicating that sectors with lower productivity than their counterparts in other OECD countries do indeed enjoy faster productivity growth. (See Table 4.) For the regressions of labor productivity, the growth in capital per worker is uniformly positive and strongly significant, in accordance with economic theory The effect of sector-level research intensity, measured by research personnel as a share of workers, is uniformly positive for seven of the eight productivity measures examined, and is generally statistically significant

The results on the trade and trade policy measures are mixed. The simple negative correlation between tariffs and productivity growth is fairly robust to application of the regression framework. (See Table 5.) A total of thirteen specifications are reported for the eight productivity measures. The tariff variable is negatively correlated with productivity in twelve of these, and is statistically significant at the 10 percent level or better for eight. Three of the other five are both negatively signed and the estimated t-statistic is at least one standard deviation

away from zero, but falls short of the 10 percent level of significance For each of these three, the data do not reject an alternate specification using the same dependent variable, but with different group effects, for which the tariff variable is both negative and significant For the one specification in which the tariff variable is positively signed, its coefficient is negligibly different from zero

The share of exports in output is nearly always positively associated with productivity growth, after controlling for initial productivity, research effort and (where appropriate) growth in capital per worker. (See Table 6) This positive association is statistically significant at .10 or better in eight of the fifteen specifications reported Seven of the eight specifications which detect a significant partial correlation between productivity growth and exports utilize the country effects specification.

The share of imports in apparent consumption is uncorrelated with productivity growth after controlling for relevant determinants of productivity growth. (See Table 7.) In the fourteen specifications considered, the coefficient on imports is positive in four specifications and negative in ten, but in no case achieves significance at 10 percent or better.

We compared of the above results, using industry-specific real exchange rates, with otherwise identical regressions for which the independent variable was calculated using naive (one exchange rate per country) measures of productivity growth. Using the more accurate data is of significant use in confirming that the relationship between tariffs or export intensity, on the one hand, and productivity growth, on the other hand, is in accordance with theory Tariffs were significantly negatively correlated with productivity at the 10 percent level in only four of the thirteen comparable specifications using naive data, and never at the five percent level. Using

naive data without industry-specific real exchange rates, we obtained a perverse negative correlation between exports and productivity thirteen of fifteen times, which attained significance at the 10 percent level three times. The results on imports were similar to those reported above, usually with insignificant negative correlations We conclude that difficulties encountered by previous researchers in establishing a relationship between productivity growth and trade or trade policy has been due at least in part to difficulties with productivity measurement itself, but that these problems can be ameliorated with improved data

Concluding Observations

In summary, among manufacturing industries in the OECD, there is a positive correlation between exports and productivity growth, a negative correlation between tariffs and productivity growth, and no apparent correlation between imports and productivity growth These results are consistent with the economic considerations discussed above. However, it is premature to argue from these results that export experience directly enhances productivity in OECD manufacturing, or that protection from international competition has harmed productivity. Alternate explanations for these phenomena exist in terms of the role of productivity in determining patterns of comparative advantage, and in terms of the political economy of tariffs Further work on the simultaneity among trade flows, productivity growth, and tariff formation may yield clearer insights.

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Table 1

Growth rates of productivity, 1980-88, particular sectors
No. of countries observed in parentheses

	TFP Quantity Naive	TFP Quantity Correcte	TFP Val-adde Naive	TFP Val-adde Correcte	LP Quantity Naive	LP Quantity Correcte	LP Val-adde Naive	LP Val-added Corrected	Tariff
Autos (11)	-0.15	1.21	2.41	2.39	4.24	4.53	4.19	4.52	5.11
Chemicals (13)	3.04	1.07	6.92	3.77	5.13	2.29	7.88	4.85	4.23
Electrical machinery (13)	2.46	4 08	4.21	5.08	6.08	7.22	6.37	7.69	2.99
Food, beverages, tobacco (13)	-1.60	-2.60	1 15	-0.65	0.80	-0.79	2.46	0.84	9.53
Instruments (10)	-0.22	0.60	1.69	2.38	5.11	5.78	3.55	4.18	4.07
Iron, steel (13)	1 12	0.16	2.67	0.68	2.31	0.35	3.66	1 76	4 17
Metal products (13)	2.43	1 14	4.18	2.40	4.65	2.87	5.16	3.47	4.70
Non-electrical machinery (13)	5.11	2.23	6.85	3.25	8.10	4.48	8.00	4.57	2.65
Non-ferrous metals (13)	0.63	0.65	1.80	0.78	1 44	0.73	2.90	2.13	2.72
Non-metallic minerals (13)	1.63	1 13	3.62	2.34	3.99	2.85	4.66	3.53	6.38
Other manufacturing (11)	5.76	2.94	8.19	4.50	8.63	4.85	10.32	4.73	3.42
Petroleum refining (13)	2.52	-0.77	4.81	0.19	3.25	-1.02	8.28	3.56	1 49
Pulp, paper, printing (13)	-0.01	-0.12	1 18	-0.24	1.26	0.90	1.96	1.67	2.14
Rubber, plastic (13)	3.25	1 43	6.04	3.13	6.51	3.24	6.00	3.63	5.43
Shipbuilding (13)	2.87	6.21	5.33	6.66	4.81	6.28	5.79	7.31	1.31
Textiles, apparel (12)	1.55	0.57	3.56	1.58	4.55	2.45	4.47	2.58	13.24
Transport equipment, nec (13)	0.50	1 30	3.68	4.24	1.08	1.37	3.95	4.48	0.76
Wood, pulp, furniture (13)	1 00	0.70	3.02	1.95	2.48	1.55	3.42	2.31	3.36
Correlation with avg. tariff	-0.24	-0.39	-0.20	-0.34	-0.01	-0.14	-0.22	-0.40	

Autos excludes Denmark, Sweden
Instruments excludes Denmark, Canada, France
Other manufacturing excludes France, United Kingdom
Textiles, apparel excludes Finland

Table 2

Growth in aggregate manufacturing productivity by country, 1980-88, annualized

	TFP Quantity Naive	TFP Quantity Corrected	TFP Val-added Naive	TFP Val-added Corrected	LP Quantity Naive	LP Quantity Corrected	LP Val-added Naive	LP Val-added Corrected
Australia	0.73	-2.00	2.24	-5.04	3.79	1.99	3.43	1.65
Canada	1 35	-0.68	4.33	0.81	3.98	0.89	5.37	2.23
Denmark	1 14	-0.99	3.09	-0.18	2.61	-0.82	3.53	0.31
Finland	2.21	0.47	4.38	1 38	4.32	1.33	5.57	2.46
France	1 77	-0.51	4.22	0.34	5.06	1.27	5.75	2.10
Germany	1 94	-0.32	4.36	0.45	4.67	0.80	5.19	1.34
Italy	1.56	0.67	3.73	1.37	6.28	3.95	5.27	2.94
Japan	2.19	1.89	4.84	3.45	4.32	3.50	6.47	5.38
Netherlands	1.81	-0.59	5.15	1 48	4 42	0.01	6.25	2.05
Norway	1 41	-0.21	3.73	1 19	3.75	1 49	4.50	1.97
Sweden	1.99	0.02	4.88	1.88	4.74	1.89	5.50	2.58
United Kingdom	2.21	1.59	5.81	4.36	6.87	5.41	7.51	6.11
United States	1 14	1 14	2.68	2.65	2.85	2.85	3.78	3.78

Absolute level of aggregate manufacturing productivity by country, 1980-88 (United States in 1980 = 100)

	TFP Quantity Naive	TFP Quantity Corrected	TFP Val-added Naive	TFP Val-added Corrected	LP Quantity Naive	LP Quantity Corrected	LP Val-added Naive	LP Val-added Corrected
Australia	99 0	81.8	93.8	53.6	87.3	73.2	104.7	89.0
Canada	108.4	94.9	121.6	99.0	122.5	98.1	127.2	100.5
Denmark	93.2	81.9	81.8	82.9	67.6	63.1	74.8	70.8
Finland	103.5	99.7	94.9	87 7	101 4	98.2	101.3	95.4
France	107 1	99.6	112.9	105.3	103.5	86.4	129.6	127.9
Germany	107.5	100.9	113.2	113.7	95.5	82.9	107.6	106.3
Italy	104.9	92.3	101.8	89.4	122.7	103.5	116.0	97.9
Japan	114.3	130.1	132.4	149.3	135.0	158.0	127.5	146.1
Netherlands	101 7	98.8	101.2	98.5	113.5	96.5	122.1	112.0
Norway	96.2	97.8	79.4	82.3	99.6	106.0	84.7	84.8
Sweden	98.8	90.4	90.7	85.6	94.2	84.0	91.5	82.8
United Kingdom	95.1	92.1	82.5	68.8	93.0	74.9	93.0	72.8
United States	110.5	110.4	124.9	124.7	126.9	126.9	136.0	136.0

Table 3

Industry productivity leaders, 1988
No. of countries observed in parentheses

	TFP Quantity Naive	TFP Quantity Corrected	TFP Val-added Naive	TFP Val-added Corrected	LP Quantity Naive	LP Quantity Corrected	LP Val-added Naive	LP Val-added Corrected
Autos (11)	USA	JPN	USA	JPN	CAN	JPN	USA	JPN
Chemicals (13)	USA	USA	USA	USA	USA	USA	USA	USA
Electrical machinery (13)	CAN	JPN	CAN	JPN	ITA	JPN	CAN	JPN
Food, beverages, tobacco (13)	JPN	UK	JPN	USA	NLD	USA	USA	USA
Instruments (10)	USA	UK	USA	USA	USA	USA	USA	USA
Iron, steel (13)	JPN	JPN	JPN	JPN	JPN	JPN	JPN	JPN
Metal products (13)	ITA	JPN	USA	USA	USA	USA	USA	USA
Non-electrical machinery (13)	CAN	JPN	CAN	JPN	NOR	NOR	USA	JPN
Non-ferrous metals (13)	NLD	FIN	CAN	JPN	NLD	FIN	NLD	FIN
Non-metallic minerals (13)	CAN	NLD	CAN	FRA	CAN	FRA	CAN	FRA
Other manufacturing (11)	JPN	JPN	JPN	JPN	JPN	JPN	UK	JPN
Petroleum refining (13)	FRA	FRA	GER	GER	DNK	DNK	FRA	DNK
Pulp, paper, printing (13)	CAN	USA	CAN	USA	CAN	FIN	CAN	FIN
Rubber, plastic (13)	AUS	NLD	NLD	NLD	NLD	NLD	NLD	NLD
Shipbuilding (13)	FRA	JPN	FRA	JPN	FRA	FRA	FRA	FRA
Textiles, apparel (12)	CAN	NLD	CAN	USA	NLD	NLD	NLD	NLD
Transport equipment, nec (13)	USA	JPN	USA	USA	USA	USA	USA	USA
Wood, pulp, furniture (13)	USA	CAN	USA	CAN	CAN	CAN	USA	USA

Autos excludes Denmark, Sweden
Instruments excludes Denmark, Canada, France
Other manufacturing excludes France, United Kingdom
Textiles, apparel excluded Finland

Table 4

Consequences of data correction for significance of control variables and goodness-of-fit
(Base specifications without trade or trade policy variables)

			Growth in K/L		Initial productivity		Research		R-squared	
			Naive	Corrected	Naive	Corrected	Naive	Corrected	Naive	Corrected
Measure	Interval	Specification								
LPQ	1980-88	OLS	Positive (1%)	Positive (5%)	Negative (1%)	Negative (1%)	None	None	0.16	0.24
LPQ	1980-88	Fixed effects country	Positive (1%)	Positive (1%)	Negative (1%)	Negative (1%)	None	None	0.22	0.40
LPQ	1980-88	Fixed effects industry	Positive (1%)	None	Negative (1%)	Negative (1%)	None	Positive (5%)	0.53	0.52
LPQ	1980-91	OLS	Positive (1%)	Positive (1%)	None	Negative (1%)	None	None	0.20	0.36
LPQ	1980-91	Fixed effects country	Positive (1%)	Positive (1%)	None	Negative (1%)	Positive (10%)	None	0.28	0.43
LPQ	1980-91	Fixed effects industry	Positive (1%)	Positive (1%)	Negative (1%)	Negative (1%)	None	Positive (5%)	0.56	0.57
LPVA	1980-88	OLS	Positive (1%)	None	Negative (1%)	Negative (1%)	Positive (1%)	None	0.10	0.13
LPVA	1980-88	Fixed effects country	Positive (1%)	Positive (1%)	Negative (5%)	Negative (1%)	Positive (1%)	None	0.22	0.34
LPVA	1980-88	Fixed effects industry	Positive (1%)	None	Negative (1%)	Negative (1%)	None	Positive (1%)	0.46	0.38
LPVA	1980-91	OLS	Positive (1%)	Positive (1%)	None	Negative (1%)	Positive (5%)	Positive (10%)	0.12	0.30
LPVA	1980-91	Fixed effects country	Positive (1%)	Positive (1%)	None	Negative (1%)	Positive (1%)	None	0.21	0.38
LPVA	1980-91	Fixed effects industry	Positive (1%)	Positive (1%)	Negative (5%)	Negative (1%)	None	Positive (5%)	0.53	0.49
TFPQ	1980-88	OLS	na	na	Negative (1%)	Negative (1%)	Positive (1%)	None	0.07	0.28
TFPQ	1980-88	Fixed effects country	na	na	Negative (1%)	Negative (1%)	Positive (1%)	None	0.10	0.35
TFPQ	1980-88	Fixed effects industry	na	na	Negative (1%)	Negative (1%)	None	Positive (5%)	0.84	0.61
TFPQ	1980-91	OLS	na	na	Negative (5%)	Negative (1%)	Positive (1%)	None	0.05	0.36
TFPQ	1980-91	Fixed effects country	na	na	Negative (5%)	Negative (1%)	None	None	0.06	0.38
TFPQ	1980-91	Fixed effects industry	na	na	Negative (1%)	Negative (1%)	None	None	0.24	0.69
TFPVA	1980-88	OLS	na	na	Negative (5%)	Negative (1%)	Positive (5%)	None	0.05	0.12
TFPVA	1980-88	Fixed effects country	na	na	Negative (5%)	Negative (1%)	Positive (5%)	None	0.17	0.39
TFPVA	1980-88	Fixed effects industry	na	na	Negative (1%)	Negative (1%)	None	Positive (1%)	0.41	0.36
TFPVA	1980-91	OLS	na	na	None	Negative (1%)	None	None	0.01	0.13
TFPVA	1980-91	Fixed effects country	na	na	None	Negative (1%)	Positive (5%)	None	0.10	0.22
TFPVA	1980-91	Fixed effects industry	na	na	Negative (5%)	Negative (1%)	None	Positive (10%)	0.49	0.47

Significance levels using one-tailed test

Summary of effects of correcting for industry-specific prices

	Stronger	Weaker	(relative to expected sign)		Higher	Lower
Growth in K/L	7	5	R-squared	OLS	8	0
Initial productivity	23	1		Country effects	8	0
Research	8	16		Ind. effects	1	7

Table 5 Effects of Tariffs on OECD Manufacturing Productivity (T-statistics in parentheses)

roductivity easure	Group effects	Tariffs	Growth in capital per worker	Initial 1980 productivity	Researchers/ workers	Constant	N	Adj R^2	F-test[1]
TQ88	Ind	- 00139 (2 73)***		- 0556 (9 12)***	183 (1 95)*	0436 (3 64)***	212	590	9 73***
TQ91	Ind	- 00120 (1 88)*		- 0412 (8 39)***	077 (1 02)	0298 (2 93)***	170	643	7 92***
TVA88	Ind	- 00344 (4 53)***		- 0225 (4 24)***	385 (2 81)***	0148 (0 97)	214	360	4 87***
TVA88	Cty	-.000733 (1 11)		- 0277 (6 24)***	- 089 (0 75)	0189 (1 71)*	214	350	6.11***
TVA91	Ind	-.00195 (2 29)**		- 0150 (3 91)***	165 (1.72)*	0122 (1 04)	173	424	5 44***
LQ88	Ind	- 00135 (1 54)	0612 (1 11)	- 0449 (8 27)***	.282 (2 00)**	0249 (1 63)	214	475	6 54***
LQ88	Cty	000078 (0 10)	486 (5 45)***	- 0442 (8 28)***	- 201 (1 50)	.0074 (0 57)	214	.351	4 04***
LQ91	Ind	-.00160 (1 52)	267 (3 05)***	- 0282 (6 11)***	216 (1 84)*	0129 (0 91)	173	.519	4 25***
LQ91	Cty	- 00163 (2 26)**	587 (6 70)***	-.030 (7 06)***	- 035 (0 32)	00427 (0 40)	173	406	2.52***
LVA88	Ind	- 00147 (1 76)**	0193 (0 37)	- 0293 (5 44)***	380 (2.83)***	.0270 (1 84)*	214	.323	4 40***
LVA88	Cty	- 000603 (0 91)	341 (4 34)***	- 025 (5 45)***	- 006 (0 05)	0113 (0.99)	214	.286	4 67***
LVA91	Ind	- 00189 (2 15)**	308 (4 19)***	- 0150 (3 64)***	197 (1 99)**	0161 (1.33)	173	.442	3 18***
LVA91	Cty	- 00179 (3 06)***	487 (6.88)***	- 0138 (4 10)***	0535 (0.61)	0115 (1 32)	173	.363	2 43**

Note In this and the following two tables, test statistics identified with * are statistically significant at .10, with ** are tatistically significant at 05, and with *** are statistically significant at 01 (one-tailed test) The coefficient on imports in Tabl is interpreted using a two-tailed test In the specifications with industry fixed effects, the constant represents the intercept for t mitted industry (other manufacturing), in those with country effects, the constant represents the intercept for the omitted countr Denmark)

[1] A significant F-test implies rejection of the null hypothesis of ordinary least squares (OLS) in favor of the alternative ypothesis of fixed effects

Table 6
Effects of Exports on OECD Manufacturing Productivity

roductivity easure	Group effects	Exports/ output	Growth in capital per worker	Initial 1980 productivity	Researchers/ workers	Constant	N	Adj R^2	F-test[1]
TQ88	Ind	0141		- 0534	.236	0271	212	581	9 88***
		(1 73)*		(8 70)***	(2 49)**	(2.30)**			
TQ88	Cty	.0033		- 0448	- 114	0179	212	331	2 41***
		(3 05)***		(8 74)***	(1 09)	(1 62)			
TQ91	Ind	0023		- 0403	0981	- 0218	170	635	8 36***
		(0.34)		(8 13)***	(1.28)	(2 17)**			
TVA88	Ind	- 0117		- 0209	475	- 0147	214	296	4.26***
		(0 96)		(3.75)***	(3 33)***	(0.93)			
TVA88	Cty	0235		- 0269	- 129	0023	214	357	7 73***
		(1.89)*		(6 08)***	(1 06)	(0 19)			
TVA91	Ind	- 0051		- 0145	182	0045	173	.405	5 84***
		(0.58)		(3.74)***	(1 85)*	(0 38)			
TVA91	Cty	0289		- 0155	- 0508	- 0070	173	197	2 45***
		(2 76)***		(4 47)***	(0 53)	(0 71)			
LQ88	Ind	.00557	0282	-.0442	305	0149	214	.469	6 43***
		(0 45)	(0 56)	(8 06)***	(2 15)**	(0.95)			
LQ88	Cty	.0355	450	- 0432	- 294	0089	214	.371	4 79***
		(2 51)**	(5 10)***	(8 22)***	(2 17)**	(0.66)			
LQ91	Ind	00348	274	- 0271	239	0022	173	512	4.27***
		(0.33)	(3.10)***	(5 85)***	(2 01)**	(0 15)			
LQ91	Cty	.0413	.535	-.028	-.101	- 0258	173	.429	3 29***
		(3 42)***	(6.14)***	(6 66)***	(0 93)	(2 32)**			
LVA88	Ind	- 0015	- 0241	- 0294	.399	0201	214	.312	4 54***
		(0.13)	(0 50)	(5.40)***	(2.95)***	(1 32)			
LVA88	Cty	.0220	329	- 024	- 046	-.003	214	.293	5 43***
		(1.74)*	(4 20)***	(5.27)***	(0 38)	(0 26)			
LVA91	Ind	-.0052	.312	- 0147	.212	0088	173	426	3 51***
		(0.58)	(4 19)***	(3.50)***	(2.10)**	(0 72)			
LVA91	Cty	.0184	.464	-.0122	0494	- 0086	173	.339	2.50***
		(1.81)*	(6.33)***	(3.55)***	(0 54)	(0 91)			

[1] A significant F-test implies rejection of the null hypothesis of ordinary least squares (OLS) in favor of the alternative ypothesis of fixed effects

Table 7
Effects of Imports on OECD Manufacturing Productivity

roductivity easure	Group effects	Imports/ consumption	Growth in capital per worker	Initial 1980 productivity	Researchers/ workers	Constant	N	Adj R^2	F-test[1]
TQ88 . .	Ind	- 00578		- 0540	207	0353	212	575	9 81***
		(0 65)		(8 74)***	(2 14)**	(2 86)***			
TQ88	Cty	0120		- 0462	- 0711	0299	212	.303	1 82**
		(0 99)		(8 86)***	(0 66)	(2 64)***			
TQ91 . .	Ind	00314		- 0403	0876	0244	170	635	8 70***
		(0 44)		(8 15)***	(1 14)	(2 38)**			
TVA88 .	Ind	- 0137		- 0218	444	- 0017	214	.296	4.08***
		(1 02)		(3 90)***	(3 08)***	(0 10)			
TVA88 .	Cty	0235		- 0269	- 129	0023	214	.357	7 01***
		(1 89)		(6 08)***	(1 06)	(0 19)			
TVA91 .	Ind	- 0100	.	- 0147	172	0080	173	.409	5 94***
		(1 08)		(3 79)***	(1 75)*	(0 65)			
LQ88 . .	Ind	-.0223	0131	- 0460	259	0315	214	476	6 59***
		(1 68)	(0 27)	(8 38)***	(1 82)*	(1 89)*			
LQ88 .	Cty	- 000936	486	- 0442	- 200	0084	214	351	4 05***
		(0 60)	(5 46)	(8 27)***	(1 44)	(0 59)			
LQ91	Ind	- 00786	272	- 0277	222	0089	173	.514	4 49***
		(0 69)	(3.08)***	(5 95)***	(1 86)*	(0.60)			
LQ91	Cty	0180	569	- 0288	- 0373	- 0152	173	442	2 41**
		(1 26)	(6 34)***	(6 65)***	(0 33)	(1.25)			
LVA88 . .	Ind	- 0245	- 0321	- 0306	356	0343	214	.392	4 47***
. .		(1 95)	(0 69)	(5 65)***	(2 63)***	(2 15)**			
LVA88	Cty	- 00572	.354	-.0249	0269	0102	214	283	4 61***
		(0 42)	(4 51)***	(5 42)***	(0.22)	(0 81)			
LVA91 . .	Ind	- 0100	312	- 0149	.203	0122	173	428	3 53***
		(1 04)	(4 19)***	(3 56)***	(2 01)**	(0 96)			
LVA91 . .	Cty.	0040	484	-.0128	0899	- 0017	173	325	2 07**
.		(0 34)	(6 53)***	(3 70)***	(0 95)	(0.18)			

[1] A significant F-test implies rejection of the null hypothesis of ordinary least squares (OLS) in favor of the alternative ypothesis of fixed effects