

**International Trade and California Employment:
Some Statistical Tests**

Professor Dwight M. Jaffee

Fisher Center for Real Estate and Urban Economics
Haas School of Business
University of California
Berkeley CA 94720-1900

Tel: 510-643-6105

Email: jaffee@haas.berkeley.edu

(Second in a series of working papers on the general topics of *Foreign Trade and California's Growth*, by Dwight M. Jaffee, Cynthia A. Kroll, Ashok Deo Bardhan, Josh Kirschenbaum, and David Howe)

Working Paper: 98-259

February 1998

Acknowledgement

I want to express thanks to my colleagues on this project, Cynthia A. Kroll, Ashok Deo Bardhan, Josh Kirschenbaum, and David Howe, as well as David Lyons and other participants at the Public Policy Institute of California, for their comments on an earlier draft of this paper.

International Trade and California Employment: Some Statistical Tests

Abstract

This paper presents preliminary statistical tests of the effects of rising international trade on California employment. We found a strong positive relationship between exports and manufacturing employment and a weak, but *positive*, effect of imports on manufacturing employment. Since higher imports are normally expected to reduce domestic production, the latter result suggests that there exists an additional link between imports and domestic demand.

A particular mechanism for this additional link is that low-cost imports of a good, based on foreign production, may lead to an expansion in domestic demand for the good. Although manufacturing employment in that industry will probably still fall as a result of the low-cost imports, employment in the associated service sector for that industry is likely to rise. Indeed, the increase in service sector employment may dominate, leading to an overall increase in the industry's employment. The paper uses California's computer industry to illustrate and quantify this mechanism.

1 Introduction

International trade for the United States has been expanding rapidly in recent years, and it seems likely that it will continue growing rapidly for the foreseeable future. Based on the available evidence, California's international trade is expanding at an even faster pace. In this paper, we present preliminary statistical tests of the effects of rising international trade on California employment. A primary innovation is that we look at the effect of international trade on both manufacturing and service sector employment.

In the traditional analysis of the manufacturing sector, imports and exports, the two components of international trade, are presumed to have opposite effects on a region's employment. Everything else the same, rising exports are expected to raise domestic employment. This occurs because, if domestic demand is fixed at a moment in time, then rising export demand creates rising domestic production and employment.¹ Comparably, everything else the same, rising imports are expected to decrease domestic employment. This occurs because, if domestic demand is fixed at a moment in time, then rising imports substitute for domestic production, which creates falling domestic employment.

In reality, the connections between international trade and domestic employment are much more complex. Compared with the simple description, everything else is *unlikely* to be the same. At a fundamental level, international trade may not have any long-run effect on the employment level, if wages, prices, and exchange rates are always adjusting to maintain full employment. Of course, there may still be a short-run impact of trade on employment because the economy's equilibrium adjustment takes time. In the context of this study, there

¹ This assumes the economy is not operating at full capacity or full employment.

are three further reasons why international trade may influence employment even if total US employment is fixed:

- 1) International trade may influence the distribution of employment among the states.
- 2) International trade may influence the level of employment across sectors and industries.
- 3) International trade may influence the employment share of production and non-production workers.

As an example of this third effect, international trade may switch the proportions of total employment between the manufacturing and service sectors of an economy. Specifically, in this paper, we consider the possibility that rising international trade creates *rising service sector* employment, even as it creates *falling manufacturing sector* employment. In fact, we find in the computer industry that international trade may actually be the source of *rising total* employment, even though it creates falling manufacturing sector employment!

As another example, international trade may alter the proportions of domestic employment between low skill and high skill jobs. Specifically, Bardhan and Howe (1998b) study the extent to which imports tend to reduce low skill jobs, while exports tend to expand high skill jobs. This, of course, is related to the switch between service sector and manufacturing sector employment created by international trade.

The organization of this paper is as follows:

In Section 2, we present regression tests of the basic relationship between international trade and California's *manufacturing* employment. These tests rely only on US international trade data, since California import data do not yet exist, as described in detail in Jaffee (1998). The results confirm a strong relationship between international trade and manufacturing sector employment, especially that rising exports are associated with rising employment.

In Section 3, we expand the analysis to include the effect of international trade on *service sector* employment. Since the international trade data for service industries is extremely limited, (recall the discussion in Jaffee (1998)), we cannot carry out a detailed statistical analysis that would be comparable to the analysis in Section 2 for the manufacturing sector. Instead, we focus on one important industry, the computer industry, to illustrate how international trade interacts with both manufacturing and service sector employment. We find that the impact of international trade on computer industry *service* employment is decidedly positive, so much so that the impact of international trade on total employment in the computer industry is likely to be positive, even if the effect of trade on manufacturing employment in the computer industry is negative. These results are reconfirmed by our detailed interview study of the computer industry, described in Bardhan and Howe (1998a).

Section 4 provides a summary of the paper's conclusions.

2 Estimates of Trade Effects on California's Manufacturing Employment

In this section, we develop and test a simple model of the relationship between international trade and manufacturing employment in California. We evaluate the effects of international trade at three different levels:

1. The influence of international trade on US production for each industry.
2. The influence of international trade on California production for each industry.
3. The influence of international trade on California employment for each industry.

We begin with the influence of international trade on US production.

A Model of The Influence of International Trade on Production

At the US level, for each SIC code i and at each time t , a basic identity links domestic demand D_i with domestic production P_i , exports X_i , and imports M_i :

$$(1) \quad D_i(t) = P_i(t) + M_i(t) - X_i(t)$$

This states that US domestic demand for a good is satisfied by US production, plus imports, minus exports.² It is more useful to solve the equation for production:

$$(2) \quad P_i(t) = D_i(t) + X_i(t) - M_i(t)$$

The relationship can be transformed into annual percent changes (where \bar{Y} indicates the percentage change operator on any variable Y):

$$(3) \quad \bar{P}_i(t) = d_i(t)\bar{D}_i(t) + x_i(t)\bar{X}_i(t) - m_i(t)\bar{M}_i(t)$$

where

$$d_i(t) = \frac{D_i(t-1)}{P_i(t-1)}, \quad x_i(t) = \frac{X_i(t-1)}{P_i(t-1)}, \quad m_i(t) = \frac{M_i(t-1)}{P_i(t-1)}.$$

Equation (3) indicates that the growth rate of production is determined by the weighted growth rates of domestic demand, exports, and imports, where each weight represents the lagged share of that variable relative to production. In particular, for a given value of demand growth \bar{D}_i , changes in the weighted growth rates of exports and imports create comparable changes in production growth (positive for rising exports and negative for rising imports).

Rising exports or imports, of course, may also create changes in domestic demand, in which case the total effect of export and import growth on production growth may vary from that

² A similar relationship was used in Jaffee (1998), equation (3).

shown in equation (3). The magnitude of these total trade effects can be evaluated by eliminating the identity by removing the industry demand variable from equation (3).

Specifically, we replace industry demand variable \bar{D}_i with an aggregate measure (over all SIC codes) \bar{D} . For each industry i , all of the effects of international trade will then be attributed to the export and import variables. The estimated equation is thus :

$$(4) \quad \bar{P}_i(t) = \mathbf{a}_0 + \mathbf{a}_1[x_i(t)\bar{X}_i(t)] + \mathbf{a}_2[m_i(t)\bar{M}_i(t)] + \mathbf{a}_3\bar{D}(t).$$

The null hypothesis is that the correlation of both export and import growth with demand growth for industry i is zero. In this case, the expected coefficient estimates for equation (4) are $\mathbf{a}_0 = 0$, $\mathbf{a}_1 = 1$, $\mathbf{a}_2 = -1$, $\mathbf{a}_3 > 0$. On the other hand, for example, if export growth were positively correlated with demand growth for industry i , then we would expect $\alpha_1 > 1$, and if import growth were positively correlated with demand growth for industry i , then we would expect $\alpha_2 > -1$.

Estimates of The Influence of International Trade on Production

Pooled time-series, cross-section, estimates based on equation (4) are shown in Table 1. All variables are measured as annual percent changes, consistent with equation (4). The data cover the years 1989 to 1995, so the estimation period is 1990 to 1995 annually taking into account the lagged values of the variables. The equations are estimated with ordinary least squares. The “a” equations in the upper half of the table are based on the cross-section of 2-digit SIC codes and the “b” equations in the lower half of the table are based on the cross-

section of 3-digit SIC codes. We begin by looking at the results based on the 2-digit SIC code cross-section.

Results Based on the 2-Digit SIC Code Cross-section

Equation (1a) in Table 1 provides estimates of the total effects of exports and imports on US production growth across 2-digit SIC codes. Export growth is the most significant factor, with a coefficient close to 1.0, which is consistent with the null hypothesis that export growth and domestic demand growth are uncorrelated. Import growth, in turn, actually receives a positive, although small and insignificant, coefficient, quite different from the expected coefficient of -1.0 under the null hypothesis. This results suggests that imports tend to have a positive correlation with the growth of demand across goods. This could arise, for example, if the market demand for goods rises in response to the expansion of low-cost imports. We will discuss this mechanism in more detail in the following section. Finally, the control variable for aggregate demand has a significant and positive coefficient as expected. The R^2 is 0.40, which is respectable for a percentage change specification estimated using pooled data. Overall, the equation indicates a significant and positive net effect of international trade on US production growth.

Equation (2a) in Table 1 provides comparable estimates of the trade determinants of California's production growth across 2-digit SIC codes. The export and import variables use the same US data as in equation (1a), due to the lack of a full set of California trade data. The aggregate production growth variable is the total for California's 2-digit industries. The estimated coefficients indicate that exports are a significant determinant of California's production growth, and that imports have a positive effect that is actually larger and more significant than for the US. This could reflect the importance of high technology products for

the California economy, based on a mechanism described in the next section. The R^2 of equation (2a) is 0.27, a value lower than for equation (1), but still respectable. Overall, the equation indicates a significant net positive effect of international trade on production growth at the California level.

Equation (3a) in Table 1 provides comparable estimates of the trade determinants of California employment growth across 2-digit SIC codes. The right-hand-side variables are exactly the same as in equation (2a). The trade effects on California's employment growth and its production growth should be similar, since production is the primary determinant of employment. The estimates bear this out. In fact, exports are an even more significant determinant of employment growth, while imports remain a significantly positive factor. The R^2 is 0.21, slightly lower than the value for California's production growth. Overall, the equation indicates a significant net positive effect of international trade on employment growth at the California level.

Results Based on the 3-Digit SIC Code Cross-section

Estimates of the effects of international trade based on 3-digit SIC code data are presented in the "b" equations in the bottom half of Table 1. In each equation, we find very low R^2 values, even just 0.04 for the California employment equation. This implies, not surprisingly, that factors other than international trade and aggregate demand are the most important determinants of the growth of employment in each specific industry in California. Nevertheless, the coefficients for international trade and aggregate demand for the 3-digit SIC code data are statistically significant, even more so than for the estimates from the 2-digit SIC code data. Furthermore, the coefficient values for the 3-digit regression coefficients are similar

to those estimated from the 2-digit data. Thus, these equations confirms that there is a significant net positive effect of international trade on production growth at both the US and California levels, and on employment growth at the California level.

Some Qualifications

There are 3 important qualifications to these results:

1. Imports and exports are based only on US data, because a full set of California international trade data are not currently available.
2. The growth in aggregate production is the only control variable used in evaluating the effects of international trade across industries. Control variables for the “idiosyncratic” aspects of specific industries would also be useful, but data for appropriate variables, such as world-wide sales, are not available.
3. The regression estimates are based on data that are disaggregated only to the 3-digit SIC code level.

Unfortunately, it is beyond the scope of the present study to resolve these issues. We know of no particular bias, however, that these issues create in our estimated equations.

Conclusions for the Regression Analysis

The regression estimates of the response of California’s manufacturing employment growth to export growth are 0.78 for the 3-digit SIC code data and 0.82 for the 2-digit data. These estimates are close to the value of 1.0 that would be expected were export growth and US demand growth uncorrelated across SIC codes. This is reasonable, since we would expect *foreign* demand to be the primary determinant of US exports.

The regression estimates of the response of California’s manufacturing employment growth to import growth are 0.07 for the 3-digit SIC code data and 0.44 for the 2-digit data. These estimates are much greater than the value of -1.0 that would be expected were export growth and US demand growth uncorrelated across SIC codes. This suggests that there is a positive

correlation between import growth and US demand growth. In the next section, we look at a mechanism that could create such a correlation.

3 International Trade and California's Service Sector

In this section, we extend the results of the previous section to include employment in the service sector of the economy. We cannot, however, carry out a statistical analysis across all service industries, comparable to our analysis of the manufacturing sector, because the international trade data for service industries is extremely limited even at the US level. Instead, we focus on one important industry, the computer industry

Service Employment in the Computer Industry

Data for the computer sector are tabulated both as a manufacturing industry (mainly SIC code 357) and as a service industry (SIC code 737, "computer programming, data processing, and other computer related services). A comparison of the computer manufacturing and computer service industries in terms of employment, sales, and international trade is provided in Table 2.

In terms of employment, the computer service industry is more than 4 times the size of the manufacturing industry at the US level and is almost 3 times the size of the manufacturing industry at the California level. In terms of sales, the computer service industry is about 1.6 times the size of the manufacturing industry at the US level (comparable data are not available for sales of the California computer services industry). These data thus indicate the importance, indeed the greater importance, of the computer service industry.

In terms of international trade, the reported 1995 numbers for the computer services industry indicate net exports (i.e a trade *surplus*) of over \$3 billion in 1995, while the

manufacturing industry had a trade deficit of over \$17 billion. The \$3 billion of net exports for computer services is the sum of the categories for “computer and data processing services” and “data base and other information services”.

The computer industry, moreover, is the source of two other sets of international transactions. First, the computer industry earns substantial income on its foreign direct investments. Table 2 shows that in 1995 the US received foreign direct investment income of over \$3 billion from computer manufacturing and over \$1 billion from computer services. Second, the computer industry is the source of large amounts of net royalties and license fees, although specific quantitative estimates are not available.

The Direct Effects of Trade on Service Employment in the Computer Industry

International trade is likely to have a strong positive effect on employment in the computer service industry, since the US is a net exporter of computer services. However, the net exports of computer services were only 2.2% of the total sales of the US computer service industry in 1995. We can apply this percentage to California’s computer service industry employment, to obtain an estimate of the amount of California employment in that industry that can be attributed to international trade. The result indicates an increase of less than 4,000 jobs. Although alternative estimation methods might give different results, the relatively small amount of international trade in computer services makes it unlikely that trade can be a direct and significant source of employment in the California computer service industry.

Computer Industry Employment and Low Cost Foreign Production

We now consider an alternative, indirect, mechanism through which international trade may be the source of substantial numbers of new jobs in California's computer service industry. This mechanism is based on 3 relationships:

1. Low cost foreign production is a key source of the falling cost of computers.
2. The falling cost of computers is a key basis for the industry's rapid growth.
3. The computer industry's rapid growth has created large amounts of service employment for computer research and design and for software creation.

It is useful to provide a quantitative benchmark for the amount of employment in California's computer service industry that could be attributed to international trade through the above mechanism. Two key parameter estimates are required to calibrate the size of this trade effect: (1) the degree to which foreign production has reduced computer costs and (2) the growth in computer sales that can be attributed to the reduced computer costs. Since detailed data are not available to calibrate these parameters, the estimates are necessarily "back of the envelope" in nature. Nevertheless, the exercise is instructive.

Table 3 shows 3 sets of estimates for the employment impact of low-cost, foreign, production in the computer service industry. Column [1] shows the cost (i.e. price) reduction that is assumed to be created by low-cost foreign production; the estimates range from a 25% to a 75% reduction in costs. Column [2] shows the alternative assumptions for the price elasticity of demand for computers. the elasticities range from -0.75 to -1.25 .³ The percentage change in computer industry sales that can be attributed to these factors is given by:

³ These are actually very low estimates. Estimates from 2.9 to 7.2 are given in Joanna Stavins (1997).

$$(5) \quad \frac{\Delta S}{S} = \left[\frac{\Delta C}{C} \right] \left[\frac{\Delta Q/Q}{\Delta P/P} \right], \quad \text{where}$$

$\Delta C/C$ = percentage change in costs (column 1 in Table 3)

$[\Delta Q/Q][\Delta P/P]$ = price elasticity of demand (column 2 in Table 3)

$\Delta S/S$ = percentage change in sales attributed to low-cost, foreign, production.

Column [3] in Table 3 shows the share of total industry sales that can be attributed to the foreign production factor, FS, which is computed as:

$$(6) \quad FS = \frac{\Delta S/S}{1 + \Delta S/S}$$

Column [4] in Table 3 shows the estimated number of jobs in the computer service industry that can be attributed to low-cost, foreign production, derived by multiplying FS in column (3) by total California employment in the computer service industry in 1994 (see Table 2).⁴ The estimated number of jobs gained in California range from 26,000 to 79,000. In contrast, the total decline in computer *manufacturing* employment in California between 1987 and 1995 was 28,000. Thus, even if a large part of this loss of manufacturing jobs is attributed to the expansion of low-cost, foreign, computer manufacturing, the loss is strongly dominated by the gain in jobs in the computer service industry that can be attributed to foreign computer production.

4 Conclusions

⁴ The assumption here is that low-cost foreign computer production has increased jobs across the entire spectrum of the computer service industry. Arguably, certain computer sectors, such as data processing could be excluded. This change would not have an important effect on our conclusions.

This paper has provided empirical evidence concerning the impact of international trade on California employment. We presented results for all 2-digit and 3-digit manufacturing SIC codes and for the computer service industry (SIC code 737).

With regard to manufacturing employment, in Section 2 we tested the extent to which US exports and imports influence the growth in US production, California production, and California employment. We found a strong effect of exports on all three of these variables. This is consistent with the hypothesis that production (and employment) growth basically depends on the sum of export and domestic demand growth. We found a weak, but positive effect of imports on all three of the variables. Since the direct effect of higher imports should be lower domestic production, this suggests that imports tend to have an additional, indirect, effect that raises domestic demand.

In Section 3, a particular mechanism for this indirect effect, involving service sector employment, was developed. The key point is that low-cost imports of a good, based on foreign production, will lead to an expansion in the total domestic demand for the good. Although manufacturing employment in that industry will probably fall as a result of the low-cost imports, employment in the associated service sector for that industry is likely to rise significantly. Indeed, it is quite possible that the increase in service sector employment may dominate the decline in manufacturing employment, leading to an overall increase in the industry's employment.

The computer industry (SIC code 357) was used in Section 3 as a prime example to carry out "back of the envelope" estimates of the possible size of this effect. Since employment in the computer services industry is from 3 to 4 times as large as employment in the computer manufacturing industry, this is likely to provide a favorable case to illustrate the

mechanism. The results reported in Table 3 showed that low-cost foreign production created from 16% to 48% of the employment, which is to say 26,000 to 79,000 jobs, in California's computer service sector (SIC code 737). In contrast, employment in California's computer *manufacturing* sector declined by about 28,000 jobs between 1987 and 1995. The computer industry thus provides a clear example in which low-cost, foreign, production of a good can lead to a net gain in the industry's employment, because the gain in service sector employment significantly exceeds the loss in manufacturing sector employment. This relationship is discussed further in Kroll and Kirschenbaum (1998), which reports the results of interview studies of the computer industry.

Table 1: Regression Estimates of the Effects of International Trade

Absolute value of t statistics in parentheses below coefficients

Pooled cross-section (SIC codes), time series (1990-1995), estimation with ordinary least squares

Equation #	Dependent Variable	R ²	a ₀	Weighted Export Growth: a ₁ [x _i (t)X̄ _i (t)]	Weighted Import Growth: a ₂ [m _i (t)M̄ _i (t)]	Aggregate Production Growth*: a ₃ D̄(t)
<u>Cross-Section based on 2-Digit SIC Codes</u>						
1a	$\overline{P}_i^{US}(t)$ Growth US Production	.40	-.02 (2.0)	.97 (6.9)	.11 (0.6)	1.09 (3.0)
2a	$\overline{P}_i^{CA}(t)$ Growth CA Production	.27	-.02 (2.0)	.65 (3.0)	.56 (2.1)	1.76 (3.1)
3a	$E_i^{CA}(t)$ Growth CA Employment	.21	-.05 (5.3)	.82 (4.3)	.44 (1.9)	.22 (0.4)
<u>Cross-Section based on 3-Digit SIC Codes</u>						
1b	$\overline{P}_i^{US}(t)$ Growth US Production	.18	-.01 (1.5)	.87 (10.5)	.03 (0.6)	.53 (6.2)
2b	$\overline{P}_i^{CA}(t)$ Growth CA Production	.08	-.01 (1.6)	.95 (5.9)	.22 (2.8)	.62 (3.8)
3b	$E_i^{CA}(t)$ Growth CA Employment	.04	-.04 (5.0)	.78 (4.9)	.07 (0.9)	.42 (2.5)

* Aggregate production growth is the sum total over all SIC codes and refers to US production growth in equations (1a and 1b) and California production growth in all other equations.

Data sources: Exports and imports are from International Trade Administration data, see Jaffee (1998), Tables 8A to 9B. California employment is from Annual Survey of Manufacturers data, see Jaffee (1998), Tables 1A and 1B. California production is from Annual Survey of Manufacturers sales data, see Jaffee (1998), Tables 6A and 6B. US production growth is measured by sales from the same source.

Table 2: Computer Industry, Manufacturing and Services										
357 = Computer manufacturing; 737 = Computer services										
Employment	Source	Y1987	Y1988	Y1989	Y1990	Y1991	Y1992	Y1993	Y1994	Y1995
US 357	ASM	328	330	305	288	265	251	243	237	250
US 737	CES	629	673	736	772	797	836	893	959	1090
CA 357	ASM	93	93	90	84	73	78	69	61	65
CA 737	CBP	101	110	115	123	126	130	156	164	
Sales, \$ Million										
US 357	ASM	60627	67644	65426	64073	58755	66747	69249	78230	90249
US 737	ASS	56004	68305	78653	88299	94363	104651	116834	133143	152213
CA 357	ASM	16293	18958	18924	20309	18529	23271	23444	28516	30817
CA 737	Not Avail.									
Net Exports, \$Million										
US 357	ITA			2178	3031	1343	-2895	-8928	-13243	-17205
US 737	SCB	683	1248	1106	1216	2013	2330	2588	3452	3484
Net Income, Direct Investment, \$ Million										
US 357	SCB					3406	1562	2271	1855	3233
US 737	SCB					194	259	394	341	1175
Sources:										
ASM = Annual Survey of Manufacturers										
ASS = Annual Survey of Services										
SCB = Survey of Current Business, issues of September and November 1996										
ITA = International Trade Administration, Bureau of the Census										
CBP = County Business Patterns										

Table 3: Employment Effects of Low-Cost, Foreign, Computer Production				
	Cost Change Due to Low-Cost Foreign Production [1]	Price Elasticity of Computer Industry Demand [2]	Share of Industry Sales Due to Foreign Production [3]=[1][2]/(1+[1][2])	Computer Service Employment Due to Foreign Production [4]
Case 1	-0.25	-0.75	0.16	25895
Case 2	-0.50	-1.00	0.33	54667
Case 3	-0.75	-1.25	0.48	79355

References

Bardhan, Ashok Deo and David K. Howe (1998a), "Globalization and Labor: The Effect of Imported Inputs on Blue Collar Workers," Working Paper 98-261, Fisher Center for Real Estate and Urban Economics, University of California, Berkeley, 1998.

Bardhan, Ashok Deo and David K. Howe (1998b) "Transnational Social Networks, Transportation Costs and the Geographic Distribution of California's Exports," Working Paper 98-262, Fisher Center for Real Estate and Urban Economics, University of California, Berkeley, 1998.

Jaffee, Dwight M. (1998), "International Trade and California's Economy: Summary of the Data," Working Paper 98-259, Fisher Center for Real Estate and Urban Economics, University of California, Berkeley, 1998.

Kroll, Cynthia A. and Josh Kirschenbaum (1998), "The Integration of Trade into California Industry: Case Studies of the Computer Cluster and the Food Processing Industry," Working Paper 98-260, Fisher Center for Real Estate and Urban Economics, University of California, Berkeley, 1998.

Stavins, Joanna (1997), "Estimating Demand Elasticities in a Differentiated Product Industry: The Personal Computer Market," Journal of Economics and Business 1997:347-367.