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U.S. Manufacturing: Productivity, Offshoring, and Imports

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Abstract

The impact of offshoring on average labor productivity is investigated on a panel of 17 manufacturing sectors between 1989-2006. As proxies for offshoring, we use imports and import penetration, defined as the ratio of imports to output. We disaggregate the universe of exporters into low wage countries, NAFTA and the rest of the world. Controlling for production inputs, significant increases in productivity are explained by the growth of imports weighted by import penetration. The exception are imports from NAFTA which have a negative impact on productivity.

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1 Introduction

Employment in manufacturing in 1947 was 14.3 million, peaking in 1979 at 19.4 million, and thereafter falling more or less regularly until almost completing a full cycle in 2006 at 14.2 million. The stark difference lies in the percent of total private employment these numbers represent: in 1947, 37.2 percent and in 2006, 12 percent. The decline in employment in what was arguably the most vibrant sector of the economy, providing jobs at good wages, benefits and advances in technology, was accompanied by sustained increases in productivity that significantly exceed that in the larger economy: between 1990-2007, the average annual increase in labor productivity was 2.2 percent in the non-farm business sector and 3.9 percent, 77.3% higher, in manufacturing.

Long-run increases in labor productivity can be ascribed to greater capital intensity, investment in human capital, new technology, and of more recent vintage, offshoring, defined here as substituting foreign output for domestic output at any stage of production. Short-run variations in labor productivity are usually the result of the business cycle, e.g. labor employment may fall faster or rise more slowly than output causing productivity to rise. We maintain that the offshoring of manufactures to lower wage countries initially occurred in industries where the skill and productivity requirements were low, especially in non-durables, and that the cost differential between domestic and foreign labor was substantial. What remained domestic was higher skilled, higher productivity, largely durable output, and contributed to advances in productivity. In other words, comparative advantage was at work irrespective of the employment effects. With time and technology, offshoring extended its reach into this category of output as well. The inroads of foreign competition altered and redefined comparative advantage and will continue to do so as long as technology is exportable and large cost differences persist. Table (1) reveals differences in average annual productivity in three periods between non-farm business and manufacturing, and durable and non-durable manufacturing, and their respective labor inputs as measured by hours of all persons. Productivity growth was significantly higher in durable manufactures with lower losses in employment after 1995 suggesting that durable goods embodied more sophisticated technology that enhanced productivity.

The most comprehensive survey of the literature on the relation between offshoring and productivity is Olsen (2006) (p. 3): "*Despite the attention that offshore and outsourcing currently demands in the public media, there is little empirical evidence on its economic impact. As a consequence of rising fears of job losses associated with the phenomenon, most existing research on the subject is primarily concerned with addressing related labor market issues. The impacts on productivity, however, have received little attention.*" The relationship between trade, productivity, employment and compensation in manufacturing gave rise to an extensive literature, among them Feenstra and Hanson (1999), MacDonald (1994), Egger and Egger (2006), Girma and Gorg (2004), Amato and Amato (2001), and Bloch and McDonald (2001). Of particular value is SRI International (2004) which points out that because direct measures of offshoring do not exist, two proxies may serve: (1) Imports of manufactured goods at all stages of production and distribution including retailing, and (2) Imports of intermediate inputs in manufacturing which combined

	1990-1995	1995-2000	2000-2007
Non-farm business	1.5	2.5	2.5
Hours of all persons	1.6	2.2	2.7
Manufacturing	3.4	4.6	3.7
Hours of all persons	-0.1	-0.1	-3.0
Durable	4.3	6.3	4.7
Hours of all persons	-1.1	0.8	-2.7
Non-Durable	2.0	2.6	3.7
Hours of all persons	-0.6	-1.6	-3.4

Table 1: Average annual percentage change in labor productivity and hours of all persons (source: BLS)

with input-output tables lead to estimates of the relative value of intermediate imports, pioneered by Feenstra and Hanson (1996). In this paper, since we use broad sectors of manufactured output rather than narrower industry classifications, growth in imports of manufactured goods and import penetration, defined as the fraction of imports in total output, are the proxy variables for offshoring.

We pose two questions to which answers are sought: (1) do imports and import penetration affect changes in labor productivity, (2) If so, are the effects dependent on the source of imports: low-wage countries, NAFTA (North American Free Trade Association), and rest of the world which constitutes the universe of exporters to the U.S. The paper is organized as follows: Section (2) the data underlying the empirical model, Section (3) the empirical model and the estimation results, and, finally, Section (4) the conclusion.

2 Data

Data are collected from two sources. Sector output and inputs (capital, services, materials, energy and labor hours) are derived from the Multifactor Productivity Database of the Bureau of Labor Statistics (BLS)[1]. Output is sector output or the real value of shipments from the sector including intermediate inputs purchased from domestic and foreign suppliers such as materials, energy and business services. Thus, when output is matched against labor alone, productivity can change if there is substitution of other inputs for labor. We consider 17 three-digits NAICS sectors excluding Petroleum and Coal because imports dominate output and offshoring appears irrelevant. The data on imports by sector and country are from the International Trade Administration of the U.S. Department of Commerce. Imports are aggregated into three groups: (1) *low wage* if imports originated in a country

[1] Available at `http://www.bls.gov/mfp/`.

that has a per capita GDP less than 10 percent of the U.S.[2]; (2) *NAFTA* for imports from Mexico and Canada, and (3) *Rest of the World* (ROW).

Our measure of labor productivity for industry i in year t, the log of which we denote by $lp_{i,t}$, is output per man hour. Imports are real and have been deflated by a price index of output specific to each sector. The sample period 1989-2006 is divided into three almost equal periods which capture aspects of the business cycle: 1989-1995 (recession and recovery); 1995-2001 (expansion); 2001-2006 (recession and recovery). Table (4) reveals averages for the growth rate of labor productivity (Δlp_t), growth rate of real imports disaggregated according to the classification discussed above (respectively, g_t^{LW} for imports from low-wage countries, g_t^{NAFTA} for imports from NAFTA countries, and g_t^{ROW} for the rest of the world). The measure of import penetration in year t, IMP_t, is defined as Imports/(Value Added + Imports) in year t averaged over the above macro areas. Import penetration is essentially the fraction of imports in output since, in principle, Value Added equals Real GDP, and therefore Value Added = C+I+G+(X-IM) + IM so that IMP=IM/Output. The import penetration variable is the average value disaggregated by area of origination (IMP_t^{LW}, IMP_t^{NAFTA}, and IMP_t^{ROW}).

Table (4) here

3 Model

We consider a standard specification derived from a production function. The baseline model is as follows:

$$\Delta lp_{i,t} = \alpha_i + \beta_t + X_{i,t}\gamma + \delta g_{i,t} + \epsilon_{i,t} \tag{1}$$

where $\Delta lp_{i,t}$ represents the growth rate of labor productivity in sector i in year t, $X_{i,t}$ is a vector of production inputs such as capital, materials, energy, services and labor[3] (measured in hours) all expressed in growth rates, g_t represents the growth rate of (real) imports, and α_i, β_t, γ, and δ are parameters. In the specification both industry and year effects are included to account for unobserved industry characteristics invariant over time as well as macroeconomic shocks common across sectors. The parameter of interest in this paper is δ. A positive value indicates that imports, controlling for a decline in hours worked and other inputs, increases productivity of the sector, evidence of comparative advantage. A negative sign would imply the absence of benefits from trade, evidence for comparative disadvantage. In addition to this baseline specification, we are also interested in evaluating whether the magnitude of import penetration in a certain sector intensifies or moderates the effect of imports on labor productivity. Therefore, the specification includes an interaction term between $IMP_{i,t-1}$ and $g_{i,t}$. The model is:

$$\Delta lp_{i,t} = \alpha_i + \beta_t + X_{i,t}\gamma + \delta_{IMP,g} IMP_{i,t-1} g_{i,t} + \epsilon_{i,t} \tag{2}$$

[2]We keep the classification constant over the sample period considered based on the average relative GDP per capita (obtained from the World Bank). China and India are among the biggest exporters classified in the low-wage group. A complete list of the low-wage countries is available from the authors upon request.

[3]In the empirical specification labor input is also lagged one period.

In this model it is assumed that the coefficient of import growth in Equation (1) depends on previous year's import penetration level specific to each industry, that is, $\delta_{i,t} = \delta_{IMP,g} IMP_{i,t-1}$. Hence, sectors with low import penetration will have a smaller effect (either positive or negative) on productivity compared to sectors with high levels of penetration. This allows us to test the proposition that sectors with high levels of import penetration might be more exposed to the benefit/loss derived from global competition. A related question is whether productivity is affected by the source of imports: low-wage countries, NAFTA or the rest of the world. Here, a specification is adopted in which the regressor is the growth rate of imports for each group separately:

$$\Delta lp_{i,t} = \alpha_i + \beta_t + X_{i,t}\gamma + \delta_{LW} g_t^{LW} + \delta_{NAFTA} g_t^{NAFTA} + \delta_{ROW} g_t^{ROW} + \epsilon_{i,t} \quad (3)$$

The last, and most general specification extends Equation (3) to allow the growth of imports from the three areas to exercise a differential impact based on the level of import penetration:

$$\Delta lp_{i,t} = \alpha_i + \beta_t + X_{i,t}\gamma + \delta_{IMP,LW} IMP_{i,t-1}^{LW} g_t^{LW} + \delta_{IMP,NAFTA} IMP_{i,t-1}^{NAFTA} g_t^{NAFTA} + \delta_{IMP,ROW} IMP_{i,t-1}^{ROW} g_t^{ROW} + \epsilon_{i,t} \quad (4)$$

All models are estimated by OLS and, for Equation (4), the Arellano-Bond GMM estimator is also employed. Dynamics is added to the model through a lagged value of the dependent variable. In addition, the instrumental variable estimation using lags of all independent variables permits an evaluation of the robustness of the OLS estimates. The estimation results of the models in Equation (1) to (4) are in Table (3).

Table (3) here

For Model (1), after controlling for the role of production inputs, the growth of imports has a significant positive effect on the growth of labor productivity. An increase of imports by 10 percent increases labor productivity by 1.71 percent, all else constant. The introduction of import penetration as an interaction term with import growth in Equation (2) increases the effect on productivity for industries more exposed to import penetration. The openness of an industry embodied in the ratio of imports to total domestic output results in economies of adaptation and enhanced productivity. A 10 percent increase in a sector with import penetration of 50 percent, the marginal effect on productivity is 2.23 percent compared to a sector with penetration of five percent where the marginal effect is only 0.22 percent. The increase in the goodness-of-fit statistic renders Model (2) the superior explanation.

In Model (3) imports are disaggregated into three groups of countries: low-wage countries, NAFTA, and the rest of the world. The coefficients of import growth for low-wage and NAFTA countries are not significant, while it is positive and significant for the rest of the world. The disaggregation does not provide a significantly better fit compared to Model (1). The test that the coefficients of the growth rates of imports are equal ($\delta_{LW} = \delta_{NAFTA} = \delta_{ROW}$) is not rejected at conventional significance levels. Thus far, there is no compelling evidence to indicate differences in productivity growth with respect to origin of imports. However in Model (4), we include the interaction between import penetration and import growth at the disaggregate level. Compared to other specifications, it provides the best fit, and a test of equality of the coefficients for the interaction terms ($\delta_{IMP,LW} = \delta_{IMP,NAFTA} = \delta_{IMP,ROW}$) is rejected at the five percent significance level. The coefficient estimates cast a new light on the behavior of import competition. Imports from low-wage countries have a positive and significant affect on productivity growth. This is consistent with our contention that the U.S. industry competing with low-wage countries has responded by offshoring low-productivity manufactures. The result is a passive or active concentration of output in high productivity goods. Moreover, as import penetration of goods from low-wage countries increase, productivity increases as well. Productivity benefits more from imports from high-wage non-NAFTA countries compared to low-wage countries. Competition from technologically advanced foreign goods (e.g., transportation, computer and electronics, and chemical products) spurs more efficient production and gains in domestic productivity. In a sector with 30 percent penetration of imports from ROW countries, a 10 percent increase in real imports raises U.S. labor productivity by 1.94%, keeping the production inputs and imports from other areas constant. On the other hand, NAFTA imports have a negative effect on productivity and increasingly so as import penetration increases. We interpret this result as evidence that U.S. firms under free trade may allocate high productivity segments of their business to Canada and Mexico, mostly in durable goods, to lower the cost of production. The relocation of production from the U.S. to Canada and Mexico in automobiles is documented in Klein *et al.* (2002).

Column (5) in Table (3) shows the result of estimating Model (4) using the GMM methodology of Arellano and Bond. The coefficient estimates are very similar in magnitude, affirming the overall appropriateness of the OLS estimates.

4 Conclusion

We find a significant relationship between offshoring, the substitution of foreign output for domestic output, and the growth of average labor productivity in the U.S. between 1989-2006 for 17 manufacturing sectors. The increase in offshoring is measured by the growth rate in imports and import penetration, the ratio of imports to total output. When the universe of exporters is segmented into low wage countries, NAFTA and the rest of the world, offshoring to low wage countries and the rest of the world increase domestic productivity. We attribute this result to the effect of offshoring low skill output to low wage countries especially in nondurable goods. As advanced technology spread, the mix of imports changed to include high skill output produced at lower costs of production than in the U.S. especially in durable goods. NAFTA is an exception: its negative influence on productivity we believe was induced by a relocation of U.S. production to Canada and Mexico in high productivity industries, such as automobiles.

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Sector	Period	Δlp_t	g_t^{LW}	IMP_t^{LW}	g_t^{NAFTA}	IMP_t^{NAFTA}	g_t^{ROW}	IMP_t^{ROW}
Wood products	1989-1995	0.003	0.021	0.031	0.038	0.169	0.009	0.045
	1995-2001	0.019	0.047	0.033	0.032	0.222	0.086	0.057
	2001-2006	0.034	0.119	0.048	0.004	0.219	0.101	0.091
Nonmetallic mineral products	1989-1995	0.006	0.192	0.023	0.054	0.044	0.009	0.126
	1995-2001	0.010	0.140	0.047	0.066	0.057	0.024	0.115
	2001-2006	0.020	0.076	0.078	-0.005	0.059	-0.010	0.111
Primary metals	1989-1995	0.020	0.099	0.021	0.048	0.135	0.027	0.225
	1995-2001	0.009	0.092	0.038	0.032	0.152	0.033	0.251
	2001-2006	0.048	0.130	0.071	0.047	0.171	0.022	0.259
Fabricated metal products	1989-1995	0.013	0.151	0.012	0.054	0.029	0.025	0.098
	1995-2001	0.014	0.142	0.024	0.100	0.048	0.012	0.095
	2001-2006	0.020	0.171	0.057	0.037	0.063	0.042	0.108
Machinery	1989-1995	0.019	0.281	0.009	0.080	0.045	0.038	0.286
	1995-2001	0.025	0.127	0.024	0.061	0.067	0.012	0.311
	2001-2006	0.035	0.203	0.057	0.066	0.087	0.044	0.314
Computer and Electronic products	1989-1995	0.113	0.361	0.036	0.249	0.036	0.218	0.401
	1995-2001	0.165	0.417	0.084	0.415	0.066	0.288	0.403
	2001-2006	0.073	0.322	0.188	0.187	0.090	0.128	0.367
Electrical Equipment	1989-1995	0.025	0.238	0.042	0.131	0.078	0.035	0.180
	1995-2001	0.029	0.139	0.092	0.109	0.135	0.025	0.174
	2001-2006	0.026	0.123	0.161	0.055	0.169	0.024	0.174
Motor vehicles and other transportation equipment	1989-1995	0.012	0.201	0.004	0.060	0.246	-0.016	0.334
	1995-2001	0.027	0.130	0.007	0.076	0.300	0.071	0.304
	2001-2006	0.046	0.234	0.016	0.089	0.310	0.113	0.359
Furniture	1989-1995	0.009	0.216	0.029	0.117	0.051	-0.013	0.112
	1995-2001	0.018	0.203	0.086	0.117	0.095	0.018	0.095
	2001-2006	0.039	0.169	0.214	-0.011	0.098	-0.012	0.088
Miscellanuos manufacturing	1989-1995	0.020	0.140	0.131	0.137	0.017	0.002	0.287
	1995-2001	0.032	0.088	0.199	0.095	0.025	0.044	0.259
	2001-2006	0.040	0.090	0.247	0.097	0.030	0.033	0.244
Food, beverages and tobacco products	1989-1995	0.012	0.034	0.021	0.080	0.029	0.001	0.074
	1995-2001	0.006	0.004	0.024	0.064	0.044	0.013	0.075
	2001-2006	0.019	0.107	0.029	0.074	0.061	0.075	0.095
Textile Mills	1989-1995	0.020	0.120	0.073	0.180	0.023	0.035	0.139
	1995-2001	0.030	0.082	0.118	0.136	0.059	0.001	0.138
	2001-2006	0.044	0.137	0.232	-0.007	0.073	-0.002	0.145
Apparel and leather products	1989-1995	0.026	0.163	0.270	0.185	0.024	-0.033	0.311
	1995-2001	0.045	0.074	0.409	0.187	0.075	0.013	0.242
	2001-2006	-0.012	0.093	0.555	-0.046	0.079	-0.055	0.198
Paper products	1989-1995	0.016	0.235	0.003	0.010	0.159	0.032	0.045
	1995-2001	0.017	0.135	0.009	0.000	0.171	0.007	0.055
	2001-2006	0.031	0.195	0.025	0.006	0.182	0.054	0.075
Printing and related support activities	1989-1995	-0.002	0.240	0.004	0.078	0.013	0.022	0.036
	1995-2001	0.013	0.143	0.011	0.088	0.024	-0.006	0.036
	2001-2006	0.026	0.156	0.028	0.031	0.034	-0.006	0.036
Chemical products	1989-1995	0.012	0.132	0.007	0.075	0.037	0.068	0.154
	1995-2001	0.019	0.127	0.012	0.059	0.045	0.103	0.213
	2001-2006	0.040	0.150	0.020	0.073	0.050	0.066	0.285
Plastics and rubber products	1989-1995	0.018	0.240	0.018	0.115	0.043	0.016	0.100
	1995-2001	0.029	0.109	0.033	0.101	0.066	0.026	0.090
	2001-2006	0.031	0.164	0.065	0.052	0.089	0.041	0.103

Table 2: Average growth rate of labor productivity (Δlp_t), imports (g_t^i for $i = LW$, $NAFTA$, ROW) and average value of import penetration (IMP_t^i for $i = LW$, $NAFTA$, ROW) for the subperiod indicated.

Table 3: **Regression results - Dependent variable Δlp_t**

Specification	(1)	(2)	(3)	(4)	(5)
Δlp_{t-1}					-0.052
					(0.134)
Δlk_t	0.437	0.459	0.423	0.430	0.497
	(0.002)	(0.001)	(0.003)	(0.000)	(0.000)
Δlm_t	0.272	0.258	0.269	0.256	0.259
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Δls_t	0.038	0.042	0.049	0.040	0.054
	(0.461)	(0.448)	(0.256)	(0.444)	(0.306)
Δle_t	0.067	0.072	0.060	0.074	0.061
	(0.017)	(0.013)	(0.04)	(0.014)	(0.044)
Δlh_t	-0.583	-0.584	-0.564	-0.554	-0.564
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Δlh_{t-1}	-0.174	-0.170	-0.194	-0.159	-0.181
	(0.043)	(0.034)	(0.027)	(0.034)	(0.025)
g_t	0.171				
	(0.004)				
$IMP_t * g_t$		0.447			
		(0.001)			
g_t^{LW}			0.014		
			(0.574)		
g_t^{NAFTA}			0.040		
			(0.156)		
g_t^{R0W}			0.114		
			(0.01)		
$IMP_t^{LW} * g_t^{LW}$				0.271	0.255
				(0.043)	(0.028)
$IMP_t^{NAFTA} * g_t^{NAFTA}$				-0.833	-0.771
				(0.019)	(0.019)
$IMP_t^{ROW} * g_t^{ROW}$				0.646	0.672
				(0.001)	(0.000)
R^2	0.791	0.841	0.792	0.896	
$\delta_{LW} = \delta_{NAFTA} = \delta_{ROW}$			0.187		
$\delta_{IMP,LW} = \delta_{IMP,NAFTA} = \delta_{IMP,ROW}$				0.017	0.0053

All models include industry and year effects. Models (1)-(4) are estimated by OLS while for model (5) we used the Arellano-Bond GMM methodology. Standard errors are calculated correcting for clustering at the industry level and the values reported in parethesis are the corresponding p-values. The values reported for the hypothesis of equality of the coefficients are p-values.