

R & D Expenditures and Import Competition: Recent Evidence for the U.S.

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ABSTRACT

Aims: The large and growing U.S. trade deficit since the 1980s has sparked some interests in the determination of the impact of trade (foreign imports) on research and development (R & D) expenditures response to slow down the rising U.S. imports of goods and services and reduce the trade deficit. In this paper we explore the extent to which R & D expenditures have been used by U.S. manufacturing industries as a strategic variable to recapture or gain market share from foreign companies in light of the continued increase in import competition over the 2000-2010 decade.

Study design and Methodology: Using panel dataset over the 2000-2010 period for a cross section of twenty two-digit SIC industries, we estimate the effects of import competition and some control variables (real exchange rate, real income, unit labor cost, and shipment of goods and services) on the share of R & D expenditures to net sales in low and high-tech U.S. manufacturing industries

Results and Conclusion: Our findings show that the rise in import competition continues to elicit increased R&D (process and product) expenditures response for the high-tech industries, not for the low-tech industries. A policy implication which may be drawn from the study suggests that incentives to promote and encourage domestic manufacturing industries in the form of subsidy, or tax credits to contend with import competition may only be productive for high-tech industries, not so for the low-tech.

Key words: Import competition, R & D expenditures, low- and high-tech manufacturing industries

1. INTRODUCTION

Over the last four decades, the U.S. manufacturing industries have become increasingly vulnerable to import competition, particularly in what used to be big industries such as automobiles, computers, steel, copiers, power generation equipment, and consumer electronics that had long been dominated by American firms (MacDonald, 1994). Among many observers of the eroding competitive edge of U.S. manufacturing firms, Cohen and Zysman (1987), Dertouzos et al. (1989), and MacDonald (1994) have argued that these dominant industries which had been insulated from serious domestic and international competitions became, not only top heavy with administration, but also slow to respond to changing market conditions and less responsive in terms of the advancement of manufacturing innovation.

Zietz and Fayissa (1992) have articulated that there are two strands of literature on the role of imports and their relation to foreign country R & D expenditures and trade policies. One strand of the literature treats the impact of trade (import competition) on R & D efforts as exogenously given in congruence with the premise that trade is driven by the advancement of technological progress, or the neo-factor proportions theory (Maskus, 1983; Hughes, 1986; and Hilke and Nelson, 1988). Another strand of the R

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&D and trade nexus views R & D expenditures as endogenous, i.e. as a strategic variable in competitive rivalry among companies, or countries for market share and real income growth (Farber, 1981; Connolly and Hirschey, 1984; and Zietz and Fayissa, 1992). This latter approach actually merges the trade and industrial organization literature in which R & D acts as the driving force responsible for the variations in comparative advantage and trade flows (Cheng, 1984; Caves, 1985). Except for few studies by Mansfield et al. (1979), Scherer and Huh (1992a; 1992b), Zeitz and Fayissa (1992), and MacDonald (1994), however, there still is a limited body of empirical literature which provides a systematic account of the impact of import competition on R & D expenditures.

In his recent study, Teshima (2009) finds that the reduction of tariffs on the goods produced by Mexican plants induced them to increase total R&D expenditures, suggesting that trade liberalization stimulates plants' innovative activities through increased competition. Using an instrumental variable strategy, LeLarge and Nefussi (2009) also find that firms experiencing a high competitive pressure (low-cost country) are significantly more diversified in their productions and are involved in (either) more frequent or higher reallocation of their product portfolios towards products they were not previously producing by introducing true product innovations. Their study further reveals that such firms achieve higher survival rates. Employing a new data set of Mexican manufacturers from 1998 and 2004, Iacovone et al. (2010) find that while China's emergence as a force in global trade tends to lower the rate of innovation of the typical Mexican firm, while the largest firms tend to respond by raising their rate of innovation.

Using a representative sample of Spanish manufacturing industries, the Sanatamaria et al. (2009) study results strongly support the view that non-R&D activities such as design, the use of advanced machinery and training are crucial to understanding the innovation process of any firm. The study, however, finds that the impact of these activities is especially important in low and middle level tech (LMT) industries, particularly for the achievement of product innovations. The empirical evidence also reveals the importance of external sources such as the use of consultants, the hiring of personnel, collaboration agreements and external R&D, with the greatest differences between LMT and high-technology (HT) firms being observed in process innovations.

The objective of this paper is to explore the extent to which R & D expenditures have been used by U.S. manufacturing industries as a strategic variable to recapture or gain market share from foreign companies in light of the continued increase in import competition over the 2000-2010 decade by broadly dividing U.S. manufacturing industries into low- and high-tech industries using data at the two-digit SIC level covering the years 2000-2010 to see if similar pattern of import competition persisted over the past 20 years since the Zeitz and Fayissa (1992) study.

2. PROCESS AND PRODUCT R & D EFFORT: A CONCEPTUAL FRAMEWORK

The importance of industry structure as the driving force for R & D activity in a closed economic setting has been extensively studied (Kamien and Schwartz, 1982; Dorfman, 1987). Over the past four decades, however, the globalization of business has had significant impact on the erosion of the competitive advantage of formerly insulated U.S. manufacturing industries. The steel and automobile industries are prime examples of this assertion. In spite of the reality of intense import competition that some manufacturing industries faced, there were others which were able to respond to the competitive challenge based on their ability to effectively engage in either process and/or product R & D efforts. Process R & D involves basic research which helps reduce the cost of production while product R & D involves promotional efforts which increase the demand of an industry's product.

In the absence a general empirical model which helps us to capture the impact of import of competition on R & D efforts of manufacturing industries, we adopt the Zietz and Fayissa (1992) approach by dividing the 20 two-digit manufacturing industries into low-tech and high-tech for the period of 2000-2010. In this connection, we test the hypothesis of whether or not the international market structure as well as innovation opportunities are distinctly different for the two polar cases of low-tech and high-tech industries.

For the purpose of this study, low-tech industries are separated from high-tech industries based on the observed ratio of R & D expenditures to sales revenue (*rds*). Based on *rds*, the top ten manufacturing industries are grouped as high-tech (*HT*) while the remaining ten are classified as low-tech (*LT*). Table 1 presents the ratios of R & D, imports (*ms*), and exports (*ex*) to sales (*sh*). In Table 1, we note a number of observations. First, there is a switch from a (*HT*) to a (*LT*) of Stone, Clay, and Glass Products (SIC 32) and a switch from (*LT*) to (*HT*) of Furniture and Fixtures (SIC 25) over the 2000-2010 period. This shift may have occurred due to the fact that low-cost Chinese furniture products have driven out sizable portion of U.S. furniture companies in states such as North Carolina and Alabama. To save domestic jobs and avoid extinction, furniture industries have resorted to the use of high tech production method including computer aided manufacturing (CAM), computer numerically controlled (CNC) machining, and web based marketing to contain costs (Bumgardner et al., 2004 and Schuler and Buehlmann 2003).

Key Features of High-tech and Low-tech Industries

Features	High-tech	Low-tech
Process R & D	Yes (Goto and Suzuki, 1989)	No
Product R & D	Yes (prominent role)	Yes
Standardized products	Differentiated products	Yes (apparel, lumber, tobacco, and steel)
Declining Industries	No	Yes
Lobbying Efforts	Use R & D as a defensive strategy + lobbying	Yes(Steel, Apparel)
Export/Import	Export	Import

Source: Zietz and Fayissa (1992)

Whereas the 1972-1987 data in Zietz and Fayissa (1992) clearly support the notion that most export intensive industries are also those with the highest R & D intensity, the 2000-2010 data reveal that the high-tech (*HT*) industries are also more ostensibly import intensive than otherwise. A plausible explanation of such a phenomenon is, perhaps, the intensification of outsourcing of R & D efforts overseas where cheaper human capital can cost effectively be tapped for undertaking process and product R & D and where also potential markets exist for the final products. Yet, it is difficult to discern the precise direction of causation between R & D expenditures and trade (import competition). For this reason, it is important to delineate the difference between R & D activities of low-tech and high-tech industries. We can, however, identify some differences between low-tech and high-tech industries by differentiating the features of process and product R & D.

In summary, we posit that low-tech industries are less likely to counter import competition by increasing R & D expenditures because of their low R & D opportunity and the declining status of these industries. On the other hand, high-tech industries are prone to use (both process and product) R & D expenditures as a strategic weapon to counter import competition. The oligopolistic strategic reaction of domestic high-tech industries against foreign import competition has a direct bearing on their profitability.

3. DATA AND SAMPLE

R&D expenditure is from COMPUSTAT. We collect annual R&D expenditure data for all (20 U.S. manufacturing) companies listed in Compustat for a period from 2000-2010. Then we aggregate the data based on 2-digit SIC code. We focus on industries with 2-digit SIC code from 20 to 30. 3-digit NACIS codes are converted into 2-digit SIC code based on Table 3.

Table 1: The Average Ratio of R&D to Sales, Average Ratios of Exports, and Imports to Shipment (2000-2010)

Industry	SIC	R&D	Export	Import	Labor Intensity
High-tech Industries					
Chemical and Allied Products	28	0.08827	0.31648	0.68352	0.12214
Electronic and Equipment	36	0.07233	0.35750	0.64250	0.22375
Instrument and Related Products	38	0.05847	0.12808	0.87192	0.27589
Machinery and Equipment	35	0.04413	0.38905	0.61095	0.24397
Transportation Equipment	37	0.04141	0.41006	0.58994	0.21164
Miscellaneous Manufacturing	39	0.03674	0.34639	0.65361	0.27589
Furniture and Fixtures	25	0.01319	0.22527	0.77473	0.28820
Paper and Allied Products	26	0.01310	0.46529	0.53471	0.21145
Rubber and Plastic Products	30	0.01061	0.43042	0.56958	0.23139
Fabricated Metal Products	34	0.00857	0.51894	0.48106	0.28792
Low-tech Industries					
Food Products	20	0.00690	0.53028	0.46972	0.13525
Tobacco Products	21	0.00617	0.23653	0.76347	0.08454
Primary Metal Products	33	0.00366	0.40263	0.59737	0.19634
Lumber and Wood Products	24	0.00291	0.10180	0.89820	0.26437
Stone, Clay, and Glass Products	32	0.00281	0.35037	0.64963	0.25394
Petroleum and Coal Products	29	0.00263	0.49388	0.50612	0.02635
Textile Mill Products	22	0.00261	0.54186	0.45814	0.22905
Leather and Leather Products	31	0.00163	0.31985	0.68015	0.28582
Apparel and Other Textile Products	23	0.00112	0.08644	0.91356	0.30604
Printing and Publishing	27	0.00031	0.52222	0.47778	0.32541

Table 1 summarizes sample statistics for 20 industries covered in our study. The average ratios of R&D to sales, average ratios of exports and imports to shipment for a time period from 2000 to 2010 are presented for two sub-samples, the high-tech industry and the low-tech industry, respectively. SIC is the two-digit code for Standard Industrial Classification. The “R&D” column is computed from Compustat data as company R&D expenditures times 100 divided by Sales. The “Export” and “Import” columns contains ratios of exports and imports to total industry shipments. Data for exports and imports are from US Trade Online.

Table 2 Definition and Sources of Variables

Variables	Definition	Data Sources
<i>rds</i>	R&D expenditures divided by net sales, times 100	Compustat
<i>y</i>	U.S. Real GDP (in 2005 Trillion US dollars)	The U.S. Federal Reserve
<i>ex</i>	exchange rate of IMF Special Withdraw Unit and USD	International Monetary Fund (IMF)
<i>sh</i>	Percentage change in shipments	Bureau of Economic Analysis (BEA)
<i>ms</i>	Imports divided by the term of shipments minus exports plus imports	US Trade Online
<i>ulc</i>	Unit labor cost	Bureau of Labor Statistics (BLS)

Table 2 reports the definition and sources of variables used in the study. The dependent variable *rds* is constructed as R&D expenditure divided by Sales and multiplied by 100 to maintain consistency with the definition of *rds* as in Zietz and Fayissa (1992).

Independent variables are import competition (*ms*), total domestic output (real GDP), exchange rate, changes in labor costs, and changes in total shipment. Annual imports and exports sorted based on NACIS is obtained from USA Trade Online. Imports are sorted based on 3-digit NACIS code. The data covers period from 2002-2010. The variable *ms* is established as annual imports divided by (shipment-export + import). The data is obtained from USA Trade Online (<https://www.usatradeonline.gov/>).

Imports and exports data for 2000 and 2001 are hand collected from U.S. International Trade Statistics of the U.S. Census Bureau (censtats.census.gov/naic3_6/naics3_6.shtml). We use IMF special withdraw unit as the basket of major foreign currencies. The exchange rate of SDR/USD is use in this article. The annual monthly average historical data of SDR/USD is from IMF. (<http://www.imf.org>) The missing data from 1991 to 1999 is obtained from Pacific Exchange Data Services. (<http://fx.sauder.ubc.ca/>). Real GDP is proxy for domestic output. Historical real GDP of the U.S. is obtained from the U.S. Federal Reserve. Real GDP values are expressed in 2005 US dollar. The data covers period from 1987 to 2011.

Data for historical GDP growth rates are obtained for the U.S. Federal Reserve Bank of St. Louis. (<http://research.stlouisfed.org/fred2/series/GDPC1?cid=106>). Annual change or the real GDP growth rates are computed as well. Industry level shipment data is from the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce Industry Economic Accounts (<http://www.bea.gov/industry/>). This data also contains information on industry level output and value added. The data covers the period from 1987 to 2011. Industry level annual changes in labor costs data is from the Bureau of Labor Statistics (BLS) of the U.S. Department of Labor. It is based on NACIS code system and covers a period from 1988 to 2011.

The above mentioned datasets cover various time periods. Our study focuses on a time period from 2000 to 2010.

Table 3 Converting 3-digit NACIS code to 2-digit SIC code

Industry	2-digit SIC code	3-digit NACIS code
Food Products	20	311
Tobacco Products	21	312
Textile Mill Products	22	313
Apparel and Other Textile Products	23	315
Lumber and Wood Products	24	321
Furniture and Fixtures	25	337
Paper and Allied Products	26	322
Printing and Publishing	27	323
Chemical Products	28	325
Petroleum and Coal Products	29	324
Rubber and Plastic Products	30	326
Leather and Leather Products	31	316
Stone, Clay, and Glass Products	32	327
Metal Products	33	331
Fabricated Metal Products	34	332
Machinery and Equipment	35	333

Electronic and Equipment	36	335
Transportation Equipment	37	336
Instrument and related Products	38	334
Miscellaneous Manufacturing	39	339

4. METHODOLOGY

According to Zietz and Fayissa (1992), the demand function of a domestic high-tech industry can be specified as:

$$q=q(p, z, z^*, x^*) \quad (1)$$

where q is the output, p is price, z is own product R & D, and z^* is foreign product R & D, and x^* is foreign process R & D. The expected relationship between q and its determinants can be demonstrated in terms of the partial derivatives of q with respect to its determinants: $\partial q/\partial p < 0$; $\partial q/\partial z > 0$; $\partial q/\partial z^* < 0$; and $\partial q/\partial x^* < 0$. If the above propositions are true, then it would be easy to discern that high-tech industries have the incentive to step up their R & D expenditures to counter import competition from foreign industries by investing in both product and process R & D to offer quality products at a lower price, respectively.

From the perspective of low-tech industries, the cause and response to foreign import competition may be different from that of high-tech industries. Zietz and Fayissa (1992) list a number of causes including successful export promotion by foreign competitors, reduced transportation costs, and relaxation or reductions of trade barriers as tariffs. Given the above scenario, we argue that the best strategic line of defense for the low-tech industries against import competition still remains lobbying efforts rather than investment in process or product R & D.¹ In next section, we turn to an empirical validation of the above stated hypotheses using U.S. data for the 2000-2010 period. Based on the conceptual or theoretical discussions, we can specify the determinants of R & D expenditures as:

$$rds = f(ms, ulc, sh) \quad (2)$$

where the variables are defined in Table 2, and the partial derivatives are: $\partial rds/\partial ms > 0$, $\partial rds/\partial ulc > 0$, and $\partial rds/\partial sh < 0$. Because a reverse causation may run from rds to ms , we can estimate equation 2 by the instrumental variable (IV) model to control for endogeneity and to correct parameter estimates that are biased downward. Using the real exchange rate (ex) and domestic real income as likely instruments for the imports/sales share (ms), we can re-specify equation 2 as:

$$rds = f(ex, y, ulc, sh) \quad (3)$$

where the expected signs for ex and y are the same as for (ms) in equation 2. Since we are using pooled time series and cross-sectional data, we can specify the general regression model which allows to control for the group (fixed-effect, or FE) and time (random-effect, or RE) as follow:

$$y_{it} = \beta_0 + \mu_i + \sum \beta_k x_{kit} + \varepsilon_{it} \quad i = 1, 2, \dots, N; \quad k = 1, 2, \dots, K; \quad t = 1, 2, \dots, T \quad (4)$$

where β_k are coefficients of ex , y , ulc , sh and x_k are regressors, and ε is an error term.

The coefficient $\beta_{1i} = \beta_0 + \mu_i$ is the intercept for the i th industry consisting of the average intercept over all industries. If μ_i are assumed to be fixed parameters and are the same for each industry, then the estimate of equation 4 amounts to OLS. If μ_i are assumed to be fixed, but are different among industries, then we get fixed-effects parameter estimates using the fixed-effects model. If μ_i are random, then we can use the error components model to get the random effects of the parameters. Both equations (3) and (4) are estimated in log linear form by maximum likelihood with correction for first order autocorrelation technique developed by Beach and MacKinnon (1978).

5. EMPIRICAL RESULTS

To examine the impact of import competition on R&D expenditure, we adopt the panel regression method. The dependent variable is *rds*. The independent variable of interest is import competition (*ms*). Control variables are shipment (*sh*) changes and unit labor cost (*ulc*). Exchange rate (*ex*) and real GDP (*y*) are instrumental variables for the share of imports to sales or revenue (*ms*). We will run pooled regression, fixed-effect, and random-effect panel regression as those in Zeitz and Fayissa (1992). Descriptions of data collection are given in the Appendix. We use pooled 2-digit SIC aggregate data for 20 manufacturing industries over the 2000-2010 period. Our choice of this time span is dictated by the availability of complete data and our interest in comparing the most recent response of manufacturing companies to the previous study by Zietz and Fayissa (1992).

Table 4: Panel Regression on R&D Determinants 2000-2010

	Constant	Ln y	Ln ex	Ln ulc	Ln sh	MSE & obs	R^2	F-test	H-test
All Industries									
Pooled OLS	10.77 (48.34)	-2.672 (5.29)	2.074 (4.251)	2.191*** (0.438)	0.329*** (0.109)	1.867 180	0.254		
Fixed All	-5.04 (13.33)	1.949 (1.675)	0.383 (1.184)	0.587 (0.529)	-0.541*** (0.202)	0.132 180	0.953	119.76 <0.001	
Random All	-4.72 (25.04)	1.096 (2.822)	0.040 (2.199)	0.1021 (0.558)	-0.248 (0.175)	0.881 180	0.012		14.56 0.002
High-Tech									
Pooled OLS	22.18 (36.04)	-3.118 (3.953)	2.138 (3.153)	3.174*** (0.592)	-0.045 (0.083)	0.522 90	0.2832		
Fixed Effect	18.65*** (4.45)	-2.469*** (0.508)	0.183 (0.332)	0.956*** (0.206)	0.109** (0.048)	0.382 90	0.6388	367.34 <0.001	
Random Effect	11.12 (5.96)	-1.476** (0.729)	0.477 (0.521)	0.484*** (0.258)	0.099 (0.075)	0.013 180	0.171		2.01 <0.734
Low-Tech									
Pooled OLS	1.04 (44.67)	-1.042 (5.109)	0.653 (4.125)	0.556 (0.348)	0.239** (0.109)	0.911 90	0.1178		
Fixed Effect	-25.34 (23.24)	7.736 (3.026)	0.078 (2.055)	0.903 (0.863)	-1.817*** (0.441)	0.209 90	0.8207	29.8 <0.001	
Random Effect	24.43 (47.92)	5.327 (5.373)	-0.439 (4.189)	-0.008 (0.755)	-1.112*** (0.323)	0.694 90	0.1278		7.64 <0.022

The dependent variable is *ln rds*. ***, ** are significant at 1% and 5% level respectively. Robust standard errors are in parentheses. The column "F-test" contains F-test statistics for no fixed effect. The column "H-test" contains Hausman-test statistics for no random effect.

Table 4 presents the OLS, fixed-effects, and random-effects estimates for three alternative samples: all industries (All), high-tech (HT) industries, and low-tech (LT) industries. The Hausman test of test of no difference in the parameter estimates of the fixed and random coefficients rejects the null hypothesis in favor of the fixed-effects model. Consequently, our discussion of results will be based on the fixed-effects parameter estimates for each sample (All, HT, LT).

Briefly, in the pooled OLS model which does not control for group and time-effects, the coefficient of *ulc* has the expected sign and is statistically significant (a 1 % increase in *ulc* will increase *rds* by 2.2 %). Although statistically significant, the positive coefficient of shipment (*sh*) is counter expectation, owing to the fact that the OLS estimation in the presence of possible group and time effects is not appropriate.

Over all, the fixed-effects model estimates are consistent with the theoretical expectations, except for the coefficient of real income (*y*), which is negative (i.e. a 1% increase in (*y*) will decrease R & D expenditures by approximately 2.5%) for the high-tech industries. We also find that an increase in labor intensity which is not predicated on increased productivity may increase *ulc*, pushing HT industries to step up their process and product *rds* to counter import competition (see, Table 4). The results also show that the real exchange rate did not have a statistically significant impact on *rds*. For the LT industries, the results suggest that only an increase in shipments (*sh*) will reduce R & D expenditures.

Table 5: Panel Regressions on R&D 2000-2010

	Constant	In ms	In ulc	In sh	MSE & obs	R	F-test	H-test
<u>All industries</u>								
Pooled	-16.22*** (2.309)	2.488*** (0.486)	2.774*** (0.432)	0.339*** (0.102)	1.656 180	0.334		
Fixed All	8.02** (3.433)	0.034 (0.631)	0.927** (0.472)	-0.38** (0.163)	0.133 180	0.952	105.38 <0.001	
Random All	2.804 (3.61)	0.995 (0.626)	0.636 (0.502)	-0.184 (0.159)	0.884 180	0.023		33.85 <0.01
<u>High-Tech</u>								
Pooled OLD	22.18 (36.05)	-3.118 (3.953)	2.138 (3.154)	3.174*** (0.592)	0.522 90	0.283		
Fixed Effect	-6.874*** (0.832)	2.419*** (0.222)	1.167*** (0.234)	0.208*** (0.019)	0.476 90	0.843	56.23 <0.001	
Random Effect	2.484 (1.451)	-0.353 (0.268)	-0.372 (0.242)	-0.015 (0.069)	0.015 90	0.048		37.9 <0.001
<u>Low-Tech</u>								
Pooled OLS	-6.716 (2.648)	0.431 0.476	0.797** (0.393)	0.122 (0.118)	0.917 90	0.088		
Fixed Effect	12.71 (7.23)	-0.057 (1.579)	2.075** (0.861)	-0.831** (0.348)	0.246 90	0.782	7.9 0.048	
Random Effect	4.419 (5.66)	0.356 (1.135)	1.489** (0.726)	-0.421 (0.269)	0.248 90	0.053		3.71 0.295

*The dependent variable is In *rds*. ***, ** are significant at 1% and 5% level respectively. Robust standard errors are in parentheses. The column "F-test" contains F-test statistics for no fixed effect. The column "H-test" contains Hausman-test statistics for no random effect.

Table 5 provides estimates of the coefficient the import penetration variable *ms* without controlling for the endogeneity which may arise between the real exchange rate (*ex*) and real income(*y*). All the coefficients of both the OLS and the fixed-effects models are statistically significant for the full model and the fixed-effects models, but the positive sign of the coefficient of shipment (*sh*) is unexpected. In Table 6, we ran the Instrumental Variable regression model and obtain statistically significant coefficients as well as the theoretically expected signs, after controlling for simultaneity. For the *HT* industry, an increase in import penetration does elicit increased R & D expenditures as reported in Table 6. The same cannot be

said for the low-tech (*LT*) industries, however. For the low-tech industries (*LT*), the results indicate that an increase in *ulc* has positive and statistically significant on R & D expenditures while an increase in shipment tends to decrease the size of investment in R & D expenditures.

6. ROBUSTNESS TESTS

6.1 Introducing the Instrumental variable (IV)

As discussed in section 3, *ms* could be a function of *rds*, at least for the high-tech industries. Therefore, simultaneous equation bias could exist and parameter estimates could be biased downwards (Zietz and Fayissa, 1992). To address this issue, we introduce the log function of *ms* as an instrumental variable in our analysis.

Table 6: IV Pooled Regressions on Import Penetration Ratio 2000-2010

	constant	ln <i>ms</i>	ln <i>ulc</i>	ln <i>sh</i>	MSE	AR-test	Sargan-test
All Industries	0.008 (0.053)	2.002*** (0.556)	2.438*** (0.496)	-0.278*** (0.059)	2.227	-0.49 0.688	259.9 <0.001
High-tech Industries	-0.011 (0.036)	2.526*** (0.419)	1.592*** (0.463)	-0.116* (0.060)	0.453	0.07 0.471	10.78 1
Low-tech Industries	0.083 (0.052)	0.497 (0.509)	0.822* (0.431)	-0.157*** (0.049)	1.076	-0.63 0.735	36.18 0.999

Instrumental variables are *lggdp* and *lgex*. GMM estimation procedure is utilized in the panel regression. *** and * are significant at 1% and 10% levels respectively.

Table 6 presents our estimation of equation (2) based on the instrumental variable method. It shows that the coefficient of *ln(ms)* for high-tech industries is statistically significant while that for low-tech industries is not, suggesting that import penetration ratio is positively correlated to R&D expenditure only in high-tech industries. The finding there is consistent with those in Tables 4 and 5.

6.2 The Unit Root and Co-integration Tests

Thus far our empirical results based on the panel regression framework support our theoretical prediction regarding the relation between R&D expenditure and Import pressure of high-tech industries. But a robustness issue associated with the reliability of our study is “what if the data show unit root?” If the unit root tests do not reject the null hypothesis of a unit root, then it turns out that both pooled time series and cross sectional regressions can generate reliable long-run relationship (Phillip and Moon, 1999). Suppose we have two time series, *X* and *Y*, demonstrating unit root of one. The regression results could be spurious, if two series are not co-integrated. Phillips and Moon (1999) show that there are four possible panel structures for non-stationary data: (1) no co-integrating relation, (2) heterogeneous Co-integrating vectors, (3) a homogeneous co-integrating vector, and (4) near-homogeneous relations. In all four cases, the pooled panel estimator yields consistent estimates with a normal limit distribution. This means that it doesn’t matter whether the panel data have unit roots. In any case we are estimating a meaningful regression with the usual standard errors and t-ratios.

In this section we perform additional unit root and co-integration test based on Engle and Granger (1987)’s approach. First we use Dickey-Fuller’s approach to test if time series have unit roots. Then we perform the co-integration test for series that demonstrate unit roots.

Table 7: Engle-Granger Co-integration Tests

Panel A. Dickey-Fuller unit root test

Time series	Type	Rho	Pr < Rho	Tau
rds	Zero Mean	-0.52	0.5648	-0.56
	Single Mean	-12.11	0.0811	-2.4
	Trend	-12.2	0.3044	-2.31
ln(ulc)	Zero Mean	-4.57	0.142	-1.43
	Single Mean	-0.83	0.434	-1.62
	Trend	-1.07	0.923	-0.63
ln(ms)	Zero Mean	-4.57	0.142	-1.43
	Single Mean	-10.03	0.134	-2.32
	Trend	-13.97	0.223	-2.63
ln(sh)	Zero Mean	-0.3	0.614	-0.29
	Single Mean	-1.83	0.541	-1.53
	Trend	-0.57	0.862	-0.68

Panel B. Co-integration tests (Johansen's Trace Methodology)

Pairs of time series	Eigen-value	Trace	5% critical value
rds vs.ln(ms)	0.0021	4.58	8.73

Panel A of Table 7 shows that time series of rds and ln(ms) have unit root of one. Time series of ln(ulc) and ln(sh) do not have unit roots. Therefore our main concern focuses on the long run relationship between rds and ln(ms). The co-integration test based on Johansen's trace method (Johansen, 1987) is reported in Panel B of Table 7. It shows that time series of rds and ln(ms) are co-integrated with a stable long-run relation. Therefore, our main results are robust based on our panel data unit root and co-integration tests.

6.3 Panel regressions with lag variables

To strengthen our empirical analysis, we address the time series trend issues for both dependent variable rds and the explanatory variable ln(ms) by following the traditional wisdom of introducing lag variables. In this section we introduce the lag variable of rds and the lag variable of ln(ms) in our panel regression framework to mitigate the unit root problem. We performed tests based on three alternative models, namely pooled, fixed effect, and random effect panel regressions. Results are presented in Table 8.

Table 8 Panel Regressions with Lag Variables

	Constant	lag (rds)	ln ms	lag (ln ms)	ln ulc	ln sh	F/H-test
All industries							
Pooled	-17.93*** (3.057)	0.119* (0.069)	2.552*** (0.513)	0.123 (0.095)	2.295*** (0.455)	-2.202*** (0.523)	0.343
Fixed All	8.863*** (3.361)	0.161*** (0.043)	0.158 (0.659)	-0.077 (0.299)	0.823* (0.446)	-0.407** (0.157)	21.68 <0.001
Random All	3.608	0.184***	1.027*	-0.106	0.657	-0.218	0.122 34.57

	(3.423)	(0.041)	(0.636)	(0.298)	(0.469)	(0.151)	<0.001
High-Tech							
Pooled OLD	-5.872***	0.450***	3.981***	-2.208***	1.453***	0.104**	0.796
	(1.576)	(0.069)	(0.491)	(0.508)	(0.352)	(0.055)	
Fixed Effect	3.296	0.240***	0.428***	-0.091	0.469*	-0.029	0.982
	(1.661)	(0.029)	(0.031)	(0.190)	(0.243)	(0.078)	<0.001
Random Effect	-9.423***	0.126***	3.753***	-0.938***	2.425***	0.149***	0.928
	(0.818)	(0.036)	(0.298)	(0.235)	(0.212)	(0.015)	<0.001
Low-Tech							
Pooled OLS	0.621	0.706***	-1.010	1.156*	0.282	-0.075	0.646
	(1.723)	(0.063)	(0.698)	(0.658)	(0.256)	(0.074)	
Fixed Effect	7.790	0.292***	0.254	0.416	1.871**	-0.579*	0.809
	(6.939)	(0.082)	(1.577)	(0.542)	(0.806)	(0.329)	<0.01
Random Effect	-0.139	0.365***	0.076	0.465	1.069*	-0.153	0.253
	(4.133)	(0.075)	(0.947)	(0.541)	(0.568)	(0.191)	<0.001

*The dependent variable is ln rds. ***, **, * are significant at 1%, 5%, and 10% level respectively. Robust standard errors are in parentheses. The column "F/H-test" contains F-test statistics for no fixed effect and the Hausman test for random effects.

Table 8 shows that R squares for all regressions have been improved significantly due to the incorporation of lag variable of rds, confirming that dependent variable rds has time trend and suggesting that introducing the lag variable is an effective way to address the unit root issue. Coefficients on the lag dependent variable are statistically significant, revealing a strong time series trend in rds. For all industries, consistent with previous results, the coefficient of the variable of interest ln(ms) is significant for pooled model but not for both fixed and random effect panel regression models. For high-tech industry, all coefficients on ln(ms) are significant for all three regression models. The results support our hypothesis strongly. For low-tech industry, after introducing lag variables of both rds and ln(ms), coefficients on ln(ms) remain insignificant. In summary, the panel regressions incorporating lags of both dependent variable rds and explanatory variable ln(ms) do not change our main results. Instead, it improves the validity and reliability of our empirical results.

7. CONCLUSION

The purpose to this paper is to reexamine how manufacturing industries' response to intense import competition has evolved since the Zietz and Fayissa (1992) study. Using panel data of 20 large U.S. manufacturing industries over the 2000-2010 period and the instrumental variable approach, we have demonstrated that R & D expenditures can still be used as a strategic variable against import competition, particularly for high-tech industries. In terms of public policy implication, high-tech industries may be given some sort of incentives such R & D investment tax credit to counter or slow down the flood gates of foreign imports and reduce the rapidly growing national deficit. The same cannot be concluded for the low-tech industries, however, for which the landscape of import competition has rapidly changed over the last four decades. To protect their bottom line and ensure their survival, they may have to invest in lobbying efforts to reduce, or slow down the flood gates of foreign imports as well as considering product innovations to contend with import competition.

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