SUSTAINING COMPETITIVENESS IN A GLOBAL ECONOMY: INSIGHTS OFFERED BY TOTAL FACTOR PRODUCTIVITY INDICATORS FOR THE U.S.

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ABSTRACT

Determination and implementation of effective policies that enhance and sustain U.S. competitiveness internationally requires a clear understanding of the concept of competitiveness as it relates to a nation. This paper addresses the ambiguity that surrounds the notion of nations competing, and presents a Total Factor Productivity (TFP) based model that more adequately measures the state of U.S. ability to compete in the international marketplace. TFP growth and total output are estimated using data from key sectors of the U.S. economy during 1986-1997. Results indicate that the U.S. remained competitive over this period, even though other popularly used indicators discussed in the paper appeared to suggest otherwise. The paper discusses appropriate policy measures and potential for future research in light of the findings.

JEL: D2; F1; M2; O4

KEYWORDS: Productivity growth, competitiveness, efficiency

INTRODUCTION

The concept of international competitiveness is hardly new. Rather, a dynamic phenomenon that has evolved with time. Traditionally, a nation's international competitiveness has been implied by international trade theories that have originated since the works of Adam Smith. In the context of globalization, however, today's global economy has become more complicated. Therefore, earlier attempts to explain competitiveness, no longer offer adequate explanations on how nations compete today. For example, critics of international trade theories argue that nations do not compete in a similar manner as firms do. Especially, international trade theory implies that nations are only winners and cannot be losers in international trade; otherwise they would not engage in trade (Lachmann, 2001). In today's competitive world, however, the reality is that some nations succeed and others fail in international competition.

The concept of competitiveness has gained importance in recent decades from perspectives of growth and development, and has become one of the central preoccupations of government and industry in every nation (Porter, 1990). It is a particularly fundamental subject for the United States considering its leadership role in the global economy. Given that the ability to compete in the international market is increasingly becoming an indicator of economic health, ultimately, living standards in the U.S. will be impacted by the competitiveness of its firms in the international market.

This study, among other things, seeks to explain how nations compete, and to offer more adequate criteria of measuring the ability of U.S. firms to compete in the international market. Primary findings indicate that using trade performance indicators alone to measure the ability to compete internationally, may in fact be a misconception; the U.S. sustained its productivity increases amidst a period of growing trade deficits. This paper proceeds with a brief literature review, followed by an explanation of methodology used, the empirical analysis, results of the analysis, policy analysis and conclusions.

LITERATURE REVIEW

The Meaning of International Competitiveness

Some theories that exemplify earlier attempts at explaining international competitiveness include David Ricardo's factor productivity theory, Eli Heckscher and Bertil Ohlin's factor abundance theory, Joseph Schumpeter's dynamic change and theory of economic development, and Robert Solow's technological progress model. Ezeala-Harrison (1998) offers a contemporary definition of international competitiveness as the relative ability of a country's firms to produce and market products of standard or superior quality at lower prices relative to rivals in the international market. This ability determines the country's relative performance in international trade. That is, where international trade may be an "engine" that drives economic growth of nations, international competitiveness represents the "fuel" that empowers that engine (Ezeala-Harrison, 1999).

The notion of a competitive nation is not as clear as that of a competitive firm. Ultimately, competitiveness is determined at the industry level. Most research in international competitiveness examines firms and industries to determine what gives some countries advantages in certain industries. Thus, Porter's (1990) contributions prove to be crucial in that he suggests an approach that focuses on resources and their productivity, both of which are firm level parameters of competitiveness. The definition that relates competitiveness to productivity necessarily measures the efficiency of the production process in terms of output obtained for units of input used. The challenge with this approach is that of obtaining productivity measures without leaving out the contributions of any inputs used in the production process.

It would be misleading to attribute changes in productivity to changes in the use of a single factor of production because factors are used in combination with other factors in the production process. While any list of measurements of productivity can cover a substantial number of factors, no list can be exhaustive. In this study, a framework that uses total factor productivity (TFP) measurements as indicators of international competitiveness is presented. TFP measures the relationship between output and its total factor inputs. It is a residual measure of changes in total output not accounted for by total factor input changes, after the output of the weighted sum of all inputs has been determined. This approach is suited to overcome the problem of attributing changes in productivity to changes in the use of a single factor of production. Also, TFP measurement is not subject to diminishing returns, unlike increments of capital and labor (assuming a combination with a fixed factor). These qualities enhance TFP's suitability as a tool for analyzing international competitiveness.

Given the definition of competitiveness offered in this study, a country's state of competitiveness is shown to be a dynamic phenomenon due to changes in either or both micro and macro level packages of parameters. Sustainability of competitiveness will endure if the sources of a firm's cost advantage are difficult for competitors to replicate or imitate. Therefore, TFP can be thought of as the level of technological advancement.

TFP is calculated as a Solow residual from real income after accounting for the contribution of various factor inputs of production. It is well established that most of the difference in income between countries is attributed to TFP (Porter, 1990; Ezeala-Harrison, 1995; Krugman, 1996; Klenow and Rodriguez-Clare, 1997; Hall and Jones, 1999; Aiyar and Feyrer, 2000). To this end, a methodology to calculate Solow residuals values for the U.S. economy is formulated.

METHODOLOGY

Following Ezeala-Harrison (1995, 1996, and 1999) in the study of Canada's international competitiveness, a TFP analysis derived from the application of a Solow residual approach to be applied to the U.S. case is presented. It is assumed that the aggregate production function is of an implicit form:

$$Y_i = Y_i (L_i, K_i, R_i) \tag{1}$$

where: Y = quantity of output (GDP),
L = labor input,
K = capital input,
R = amount of natural resources,
and subscript i denotes the i^{th} sector.

The growth rate of output in each sector of the economy is made up of the sum of the products of each input's marginal productivity and the rate of expansion the input. This can be shown from differentiating equation (1) with respect to time, t, as follows:

$$dY_i/dt = (\partial Y_i/\partial L_i \,.\, dL_i/dt) + (\partial Y_i/\partial K_i \,.\, dK_i/dt) + (\partial Y_i/\partial R_i \,.\, dR_i/dt) \tag{2}$$

Assume that each sector is characterized by a Cobb-Douglass production function of the type:

$$Y = \lambda L^{\alpha} K^{\beta} R^{\gamma}$$

where λ = TFP index
α = factor share of labor
β = factor share of capital
γ = factor share of material resources

Therefore, the growth rate of output can be shown as:

$$dY/dt = (\partial Y/\partial \lambda \,.\, d\lambda/dt) + (\partial Y/\partial L \,.\, dL/dt) + (\partial Y/\partial K \,.\, dK/dt) + (\partial Y/\partial R \,.\, dR/dt)$$

That is,

$$dY/dt = d\lambda/dt + \alpha \,.\, dL_i/dt + \beta \,.dK/dt + \gamma \,.\, dR/dt \tag{3}$$

Changes in λ (TFP growth) over time for the i^{th} sector of the economy are given as:

$$d\lambda_i/dt = dY_i/dt - (\alpha_i\, dL_i/dt + \beta_i dK_i/dt + \gamma_i dR_i/dt) \tag{4}$$

Substituting (3) into (4) we obtain:

$$d\lambda_i/dt = (\partial Y_i/\partial L_i . dL_i/dt) + (\partial Y_i/\partial K_i . dK_i/dt) + (\partial Y_i/\partial R_i . dR_i/dt) - (\alpha_i dL_i/dt + \beta_i dK_i/dt + \gamma_i dR_i/dt)$$

That is,

$$d\lambda_i/dt = dL_i/dt\, (\partial Y_i/\partial L_i - \alpha_i) + dK_i/dt\, (\partial Y_i/\partial K_i - \beta_i) + dR_i/dt\, (\partial Y_i/\partial R_i - \gamma_i)$$

Since α_i, β_i, and γ_i are factor shares, then:

$$\alpha_i = \frac{(\partial Y_i/\partial L_i)}{(Y_i/L_i)}, \qquad \beta i = \frac{(\partial Y_i/\partial K_i)}{(Y_i/K_i)}, \qquad \gamma_i = \frac{(\partial Y_i/\partial R_i)}{(Y_i/R_i)}$$

Therefore:

$$d\lambda_i/dt = dL_i/dt\ (\alpha_i Y_i/L_i - \alpha_i) + dK_i/dt\ (\beta_i Y_i/K_i - \beta_i) + dR_i/dt\ (\gamma_i Y_i/R_i - \gamma_i)$$

alternatively:

$$d\lambda_i/dt = \alpha_i\,.\ dL_i/dt(Y_i/L_i\,-1) + \beta_i\,.\ dK_i/dt(Y_i/K_i\,-1) + \gamma_i\,.\ dR_i/dt(Y_i/R_i\,-1_i) \qquad (5)$$

This gives the measure of TFP growth for any given sector of the economy. Therefore, the aggregate TFP change for the n sectors of the economy, where i = 1,2,3,….n is given as:

$$\lambda^* = d\lambda_i/dt = \Sigma_1^n\ \{\alpha_i\,.\ dL_i/dt(Y_i/L_i\,-1) + \beta_i\,.\ dK_i/dt\ (Y_i/K_i\,-1) + \gamma_i\,.\ dR_i/dt\ (Y_i/R_i\,-1_i)\} \qquad (6)$$

This obtains the national measure of TFP growth, posited as a more appropriate index for measuring competitiveness. Competitiveness is thus presumed to be the relative effective utilization of resources (the components of the production function) in the most efficient manner. Equation (5) can be used to show that the growth in any particular factor's productivity depends on the growth in the TFP. For example, for labor productivity:

$$dL_i/dt\ (Y_i/L_i - \alpha) = d\lambda_i/dt - \{\beta_i\,.\ dK_i/dt(Y_i/K_i\,-1) + \gamma_i\,.\ dR_i/dt(Y_i/R_i\,-1)\}$$

Capital productivity:

$$dK_i/dt(Y_i/K_i - \beta) = d\lambda_i/dt - \{\alpha_i\,.\ dL_i/dt(Y_i/L_i\,-1) + \gamma_i\,.\ dR_i/dt(Y_i/R_i\,-1)\}$$

Resource productivity:

$$dR_i/dt(Y_i/R_i - \gamma) = d\lambda_i/dt - \{\beta_i\,.\ dK_i/dt(Y_i/K_i\,-1) + \alpha_i\,.\ dL_i/dt(Y_i/R_i\,-1)\}$$

Appropriate data for the U.S. is employed to compute the trend values of:

(i) sectoral TFPs (λ_i) using equation (5). This way, comparisons can be obtained for intersectoral TFP performance, thereby obtaining a picture of relative competitiveness of the various sectors of the economy.

(ii) aggregate TFP growth over time, $\lambda^{*,}$ using equation (6). Besides indicating whether, and at what particular points in time the economy might (or might not) be losing the ability to sustain its relative competitiveness, this operation also gives an indication of the potential competitiveness profile of the U.S.

The Empirical Analysis and Data

The empirical analysis of this study provides insights and possible conclusions about the state of U.S. competitiveness. Further, when compared to U.S. trade performance in recent decades, the analysis allows us to ascertain the extent to which the growing trade deficits experienced by the U.S. economy during the 1980s and 1990s are (are not) a sign of a loss of its competitiveness, given what constitutes competitiveness, as presented here. Conclusions that emerge from the empirical analysis enable us to offer policy recommendations and propositions for future research.

The data employed in the analysis covers the years 1986-1997, and is adapted to the U.S. standard industrial code (SIC) format. Where variables in the model are not directly measurable, proxies are employed to make estimates. For each sector, the factor share inputs (α,β,γ) are proxied by the size of the respective input expenditures of each of these factors for the given sector in proportion to total input expenditures for that particular factor across all sectors. The relevant data is readily obtained from the U.S. Bureau of Economic Analysis (BEA). While data on all input variables is complete and readily available for the particular period specified, the level of accuracy in the tertiary (service-related) sector estimations cannot be verified with reasonable confidence. This is because, admittedly, output measurement for the service sector proves to be challenging, and there is little consensus on how it can be done.

In equation (7), factor shares of inputs (α,β,γ), are proxied by the size of expenditures on each of these factors. For example, labor share of the total input is proxied by worker compensation costs-output ratios. The relevant data are available with the U.S. Bureau of Labor Statistics (BLS). Capital share of total input is proxied by capital expenditure for structures and equipment-output ratios. The relevant data are available with the U.S. Bureau of Economic Analysis (BEA). While data for capital and labor inputs is mostly available, or otherwise relatively easy to proxy, the service sector presents a challenge. This is simply because different firms in the service sector produce services that differ.

Therefore, what constitutes raw material for each firm is likely to be unique across the industry. In the analysis, the raw material component is estimated be the remaining portion of the cost of production after subtracting costs incurred by labor, and investment in capital equipment. This idea is based on the assumed production function for the economy as expressed in equation (1). While it is possible to identify actual costs that account for the proxies selected to represent raw material costs for the service producing sectors, the process is hampered by unavailability of detailed production costs data necessary for such an approach. Also, compared to the proposed procedure, this (item proxy) approach does not guarantee the level of data uniformity that is necessary for reliable analysis. Output (Y) data is proxied by real GDP values, and is readily available from the BEA.

The dependent varibale, international competitiveness, is proxied by TFP index obtained from the U.S. Bureau of Labor Statistics (BLS). Other sources found useful for the data collection include the U.S. Bureau of Census and the National Bureau of Economic Research (NBER). The data used in the analysis is a combination of time series range of the years 1986-1987, and cross-section across a sample of 12 major industries that represent the three broad sectors of the U.S. economy namely: primary, secondary and tertiary, for a combined set of 120 panel observations.

The regression analysis is conducted as follows: the dependent variable is the index for international competitiveness, and is proxied by the BLS TFP index for the U.S. The independent variables are: the product of rate of human resource development and productivity of labor; the product of rate of investment growth and productivity of capital; and the product of rate of raw materials discovery and productivity of raw materials. The regression is run using equation (6), the linear form of which is written as:

$$IC = \omega_0 + \omega_1 L^* + \omega_2 K^* + \omega_3 R^* + e_i \quad (7)$$

Where,

ωs = parameter estimates
L^* = product of labor input share growth rate and its average productivity
K^* = product of capital input share growth rate and its average productivity
R^* = product of raw material factor input share growth rate and its average productivity, and e_i = error term

The data was screened using standard econometric screening procedures to ensure that it met the necessary requirements before conclusions can be drawn. The model was tested for violations of multiple regression assumptions. Following successful data screening and violation tests, we ran regressions on equation (7) for each of the sectors previously described. Table 1 shows the results obtained.

Results of the Analysis

The results for the primary sector show that all variables are statistically significant at 95% confidence level, except for R*. The F-statistic seems to indicate that the overall fit of the model is significant. The R^2 value is also significantly high for the primary sector. The relationship between the independent variables and the dependent is positive as is expected. The coefficient for L* seems to indicate that competitiveness for the U.S primary sector is largely driven by labor productivity and expansion rate.
The secondary sector results returned a significantly high R^2 value. Similar to the primary sector, all variables are statistically significant at 95% confidence level, except R*. All explanatory variables show a positive relationship with the dependent variable as is expected. K* had the highest co-efficient in the secondary sector, which seems to indicate that competitiveness in the secondary sector is largely influenced by K*. This result supports the idea that innovation is crucial to sustaining competitiveness (productivity increases) for the secondary sector. The F-statistics seem to indicate that the overall fit for the model is significant at 95% confidence level.

Generally, the tertiary sector results show a departure between theory and practice. Also, the results obtained from the tertiary sector seem to offer little insights than anticipated. It was expected that an analysis of the tertiary sector, which is dominated by service industries, would offer meaningful insights into the state of U.S. competitiveness, given that more than 70% of the U.S. output is accounted for by the service-oriented sector. A positive relationship is observed between international competitiveness and the explanatory variables except for R*. Suspicion is that this unexpected result may be explained by either one of two factors: inadequacy in data and measurement procedures for the tertiary sector as previously mentioned, or a possible misspecification of the model.

According to the results in Table 1, the F value for the tertiary sector was relatively low, even though the F-tests indicate an overall model fit at 95% level of confidence. The results seem to show a relatively strong influence of L* on competitiveness as indicated by the coefficient values. However, the results for the tertiary sector analysis must be taken with caution for the reasons explained. It is also important to note that the dependent variable, which is proxied by the U.S. TFP index obtained from the BLS, does not factor the contributions of most of the tertiary sector industries. This may help in explaining the diluted nature of results obtained for the tertiary sector.

Table 1: Regression Results of Equation (7) with TFP Index as the Dependent Variable

Variable	**Coeff.**		**Std. Error**	**t-Statistic**	**P-value**
(constant)	-0.00165		0.0010	-2.6660	0.0370
Primary L*	0.10200		0.0200	5.1350	0.0020
Primary K*	0.04665		0.0120	4.0180	0.0070
Primary R*	0.00729		0.0110	0.6460	**0.542
R-squared	0.89300	Mean dep. var.	0.00026		
Adj. R-square	0.84000	S.D. dep. Var.	0.00250		
S.E. of regression	0.00100	F-Statistic	16.77100		
Sum of squared resid.	0.00000	P-value	0.00300		
Durbin-Watson Stat.	1.94300				

Variable	**Coeff.**		**Std. Error**	**t-Statistic**	**P-value**
(constant)	0.00253		0.00100	3.55000	0.01200
Secondary L*	0.04128		0.02400	1.72000	0.05400
Secondary K*	0.06106		0.02200	2.75600	0.03300
Secondary R*	0.23500		0.13000	1.81100	**0.120
R-squared	0.742000	Mean dep. var.	0.002456		
Adj. R-square	0.614000	S.D. dep. Var.	0.001255		
S.E. of regression	0.000780	F-Statistic	5.764000		
Sum of squared resid.	0.000000	P-value	0.034000		
Durbin-Watson Stat.	1.937000				

Variable	**Coeff.**		**Std. Error**	**t-Statistic**	**P-value**
(constant)	0.007721		3.707000	0.008000	
Tertiary L*	0.049080		0.043000	1.139000	0.029000
Tertiary K*	0.001030		0.015000	0.089000	0.053000
Tertiary R*	-0.094800		0.044000	-2.150000	**0.069
R-squared	0.6030	Mean dep. var.	0.000701		
Adj. R-square	0.4330	S.D. dep. Var.	0.002078		
S.E. of regression	0.0016	F-Statistic	3.544000		
Sum of squared resid.	9971381	P-value	0.056000		
Durbin-Watson stat.	2.0230				

The Dependent variable was TFP Index; the Method was Least Squares. Sample (adjusted was 1988-1997. It Included 10 observations, the number of cross sections was 12 and total panel observations (balanced) was 120.
*** The P-value results for all sectors, which seem to indicate insignificance of the R* variable, may be explained by the fact that the TFP index value computed for the U.S. by the Bureau of Labor Statistics does not take into consideration the contributions of material inputs. It focuses mainly on labor and capital contributions.*

Table 2: Summary Statistics of Total Factor Productivity Variables

	L*	K*	R*
Primary Sector:			
Mean	0.0229989	-0.01128255	0.0150486
Median	0.0186567	-0.0177065	0.0058909
Max.	0.0563268	0.041018	0.1000291
Min.	-0.0000992	-0.044203	0.0005964
Std. dev.	0.01169804	0.0295994	3.0231334
Skewness	0.671452599	0.7854754	1.0207845
Kurtosis	0.291417687	-0.63300589	3.332028
Secondary Sector:			
Mean	0.00864428	0.03201947	-0.0039472
Median	0.00806235	0.02835395	-0.0043145
Max.	0.0143637	0.0578634	0.002095
Min.	0.0014219	-0.00814	-0.00814
Std. dev.	0.003863999	0.01482376	0.002596
Skewness	-0.1931027	0.6420197	1.119162
Kurtosis	0.0555255	-0.426825	3.526985
Tertiary Sector:			
Mean	0.03250662	0.0436615	0.0282925
Median	0.03234775	0.0459909	0.02818615
Max.	0.0434275	0.0786566	0.0448499
Min.	0.0218121 `	0.0032025	0.0061315
Std. dev.	0.007141686	0.0283643	0.00981
Skewness	-0.02672639	0.181576	-0.905601
Kurtosis	-0.07838493	-1.3711346	3.183503
Observations	10	10	10
Cross sections	12	12	12

This table is a summary statistics of variables used in the model presented. In general, the kurtosis and skewness values for our variables are not significantly far from zero, indicating that the data set was obtained from a fairly normally distributed population. However, we observe slight variations for R kurtosis values. This may be an indication that the data sets for R* are not relatively normally distributed. This may be explained by variations in the type of data collected by the BLS for materials input. Some data sets are inclusive of energy inputs while some exclusively consist of material inputs. The highest mean values obtained were those for K* and L* variables in the secondary and tertiary sectors. Generally, the secondary and tertiary sectors are most active in the U.S. economy, and it is therefore expected that these sectors would show a relatively strong productivity performance.*

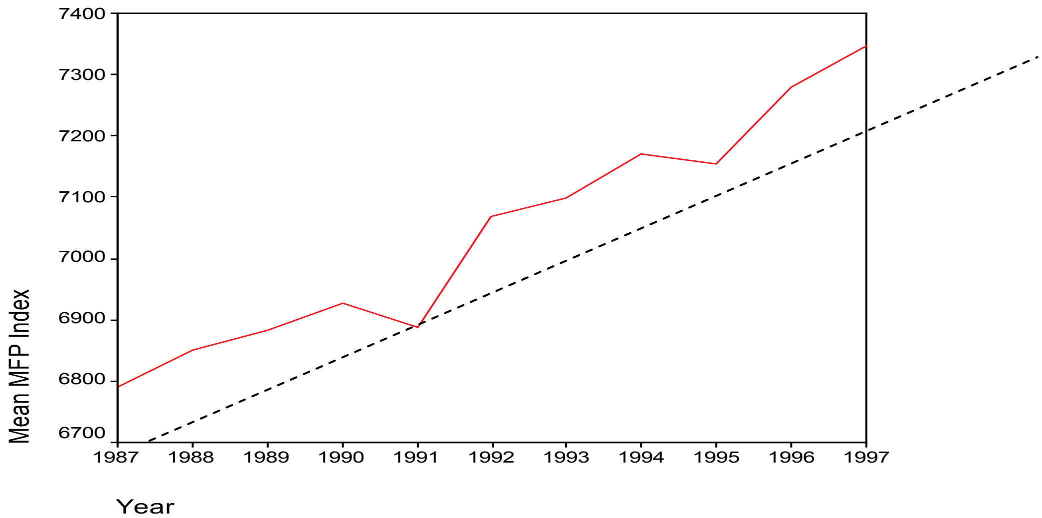
Graphical Analysis

Figure 1 depicts the aggregate TFP growth trends for the U.S. over the years 1987-1997. The figure indicates an upward trend in economy wide TFP. During this period, the U.S. continued to experience large trade deficits, which were widely interpreted as a symptom of loss of competitiveness. The trends seem to support the study's argument that trade performance alone must not be taken as an indicator of competitiveness.

POLICY ANALYSIS AND CONCLUSIONS

The results obtained show that in general, productivity increases in each of the sectors analyzed is directly related to competitiveness of the U.S. The secondary sector, which is dominated by manufacturing industries, was found to be the dominant when it comes to impacting competitiveness, as indicated by its relatively high mean value for the competitiveness index.

Figure 1: U.S. National Aggregate TFP Trends



The implication is that improvements in TFP growth for the secondary sector are likely to improve the U.S. competitive position abroad relatively more than improvements in the other sectors. In particular, manufacturing is an integral part of the U.S. and global economy. It is has proven to be a part of the network of inter-industry relations that create a stronger economy and the conditions for growth. According to the U.S. Bureau of Economic Analysis (BEA) and Bureau of Labor Statistics (BLS), the sector currently accounts for about 14% of the GDP and employs some 14 million workers. An International Monetary Fund report (IMF) ranks U.S. manufacturing sector as the world's largest. In fact, according to the IMF, the U.S. manufacturing alone would be the world's 7th largest economy, nearly equal to China's economy. In international trade, manufactures account for about 60% of all U.S. exports in goods and services. Therefore, appropriate policies must be aimed at productivity increases in the secondary sector, particularly manufacturing. More specific, TFP growth, which is driven by innovation technologies and technology-based entrepreneurship, should top the agenda of policies aimed at building and sustaining U.S. international competitiveness.

Limitations and Future Research

Previously failed policies such as trade protectionism should be avoided. Useful frameworks such as those used by this study to understand the dynamics of competitiveness, obtain that it makes sense to talk about competitiveness at the industry level, and points us to micro-level parameters as a point of focus in improving the competitive position of the U.S. A TFP criterion seems to be a better indicator of the U.S. firms' ability to compete internationally. Focusing on international trade performance alone as the sole indicator of the ability to compete internationally presents problems that render it a misconception.

The study was limited in the analysis of the tertiary sector, which is increasingly dominant in the changing structure of the U.S. economy. There does not seem to be a consensus as to how exactly productivity in services can be measured, without which it is difficult to determine competitiveness from the perspective of TFP. There is a need to determine a solid framework of measuring productivity in the service industry. In addition, the exclusion of material inputs in computation in TFP index for the U.S. limited the ability to fully analyze TFP measurements of international competitiveness. A comprehensive TFP index that incorporates materials inputs would help strengthen future studies on competitiveness.

Given the controversy around recent trends in the outsourcing of operations by U.S. firms, a study to ascertain the exact impact of outsourcing on U.S. competitiveness would help address these controversies. It is also not clear if a country has any choice of selecting industry(ies) to be globally competitive in a world that is increasingly moving towards free market policies. Further research on this aspect may shed light on the degree of "market freedom" allowable before countries can shape their industries for competitiveness. While the study is telling on the state of U.S. international competitiveness, it neither predicts it nor ranks it globally. Research that would allow for a reasonable prediction of future state of competitiveness, and rank the present state internationally would be gainful.

APPENDIX

Appendix A: Causality between Trade Performance and Competitiveness

To further investigate the idea that international competitiveness is the "fuel" that drives the "engine" of trade performance, a supplementary analysis was conducted to examine the precedence relationship between international competitiveness as measured by total factor productivity, and trade performance as measured by the trade performance index. A detailed explanation of methodology and data employed for the trade performance indicators (TPI) may be found in (Mutsune, 2008). Ezeala-Harrison (1999) seems to suggest that changes in TFP precede changes in trade performance. Berhanu and Kibre (2002), Driffield and Taylor (2001), and Salvatore (2001) seem to suggest that changes in certain aspects of trade performance preceded changes in TFP. The Granger causality test was used to analyze for the precedence relationship implied in this paper. The procedure involves estimating equations (1A) and (2A) as shown below:

$$TP_t = \Sigma^n{}_{i=1}\, ə_i TFP_{t-i} + \Sigma^n{}_{j=1}\, Ώ_j TP_{t-j} + u_{1t}, \qquad (1A)$$

$$TFP_t = \Sigma^n{}_{i=1}\, \lambda_i TFP_{t-i} + \Sigma^n{}_{j=1}\, \delta_j TP_{t-j} + u_{2t} \qquad (2A)$$

Where, ə, Ώ, λ and δ are constants, and t = time, u = disturbance term, n = sectors represented

The data used in the causality analysis covers the period 1980-2004 for both TPI, and TFP. The analysis is conducted in two formats: the first uses changes in TFP index versus changes in TPI, and the second uses changes in TFP raw values versus changes in TPI. In both cases, the analysis includes one, two, and three period lags and a 95% confidence interval. E-views was the software of choice for the analysis. The results are shown in Table 1A:

Table 1A: Granger-Precedence Analysis Results

Test: Pairwise Granger Precedence Test			
Sample (balanced): 1980-2004			
Null Hypothesis:	Obs.	F-Stat.	P-value
Lags: 1			
TFP index does not Granger-precede precede TPI change	23	6.86626	0.01639
TFP value does not Granger-precede TPI change	23	6.83722	0.01659
*Decision: We reject both the null hypotheses at 95% confidence level			
Lags: 2			
TFP index does not granger-precede TPI change	22	5.98839	0.01075
TFP value does not Granger-precede TPI change	22	6.02152	0.01054
*Decision: We reject both the null hypotheses at 95% confidence level			
Lags: 3			
TFP index does not Granger-precede TPI change	21	3.74612	0.03637
TFP value does not Granger-precede TPI change	21	3.79801	0.03494
*Decision: We reject both the null hypotheses at 95% confidence level			

This table provides a summary of the results in the analysis of causation between trade performance and competitiveness. Tests beyond 3 period lags were not found to be statistically significant.

The results obtained indicate that in fact changes in TFP may precede changes in TPI. These results seem to support Ezeala-Harrison's (1999) argument that, international competitiveness (TFP) is the 'fuel that runs' the trade performance 'engine' and therefore its applicability for the U.S. economy. This finding is important for practical purpose in policy decisions.

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