An Exploratory Study of the Interrelationships among Global Stock Indices

James Kelley, Ann D. Rensel, & Tenpao Lee

The advances in communication and transport technologies have lead to increasing interdependence among countries resulting in a swell of trade and investment among countries. The resulting interrelationships among the economies have encouraged economic growth and formation of trade relations among partners. However for economies to be successful, these countries now need to adopt policies to develop and sustain the relationships that are based upon the trade of goods and services. In this study, we examine the effects of these interrelationships on the U.S. economy by exploring both the impact of the world’s top economies as well as the impact of the economies of geographical neighbors on the U.S. economy as evidences by the stock indices.

**Keywords:** Trading Interrelationships, Geographical Interrelationships, GDP, Stock Index.

**INTRODUCTION**

The interrelationships that develop as a result of the linked economies are a phenomenon that has expanded in the modern business world. David Dollar, the World Bank’s Director of Policy Development has suggested that the development of these linkages can result from two dynamics, (1) advances in transport and communication technologies along with (2) the decision by large developing countries to seek and open themselves up to foreign investment (Dollar, 2008). As these two factors have evolved and expanded, the world has grown increasingly interdependent which is reflected in the swell of trade and investment among countries.
The relationships among global partners have resulted in economic growth that is more rapid than would have occurred in isolation. Formation of these economic relationships has allowed countries to share products and services that they would otherwise not have been able to produce themselves. This also has encouraged countries to specialize in producing specific goods and services and then sharing the results with their economic partners. Another major outcome of these initiatives is the rapid advancement in number and quality of the technologies and services that are shared among partners.

The impact of these interrelationships can be clearly seen in data collected from the world’s largest economies. Table 1 presents Gross Domestic Product (GDP) data from the world’s largest economies along with a measure of the integration within the global economy. The world’s largest developed countries are defined as those with the largest Gross Domestic Products (GDP) and we measure the integration as the percentage of GDP derived from merchandise and services trade.

<table>
<thead>
<tr>
<th>Country</th>
<th>GDP * (PPP in Trillions)</th>
<th>Merchandise Trade</th>
<th>Trade in Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>1</td>
<td>13.78</td>
<td>15.8</td>
</tr>
<tr>
<td>China</td>
<td>2</td>
<td>7.099</td>
<td>32.5</td>
</tr>
<tr>
<td>Japan</td>
<td>3</td>
<td>4.272</td>
<td>17.3</td>
</tr>
<tr>
<td>India</td>
<td>4</td>
<td>2.966</td>
<td>13.1</td>
</tr>
<tr>
<td>Germany</td>
<td>5</td>
<td>2.807</td>
<td>45.5</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>6</td>
<td>2.13</td>
<td>41.2</td>
</tr>
<tr>
<td>Russian Federation***</td>
<td>7</td>
<td>2.097</td>
<td>-</td>
</tr>
<tr>
<td>France</td>
<td>8</td>
<td>2.075</td>
<td>36.4</td>
</tr>
</tbody>
</table>

* Data collected from CIA Factbook collected 2007.

** Data collected from World Bank.

*** Russian Federation Integration with Global Economy data not collected in 1990.
A review of the data in Table 1 indicates that all of the countries, with the exception of the United Kingdom, have experienced an increase in the percentage of GDP derived from merchandise and service during the period from 1990 to 2005. This strongly suggests that interrelationships contribute to an important segment of overall GDP. The increasing integration among nations has foreign policy implications as well. In order for economies to succeed, countries now need to adopt policies to develop and sustain international relationships that support and stimulate the trade of goods and services within their borders as well as among their trading partners. This paper explores the impact the interrelationships among trading partners on the United States economy through an analysis of the relationships between the primary stock indexes of the United States and the stock indexes of the other largest world economies.

**Methodology**

The impact of globalization is evaluated by examining the relationships between the United States and the world’s largest economies and geographical neighbors. In this study we use a nation’s largest stock index as the indicator of the overall economic health of the country. Table 2 provides a list of countries used in this study along with the name of their stock index.

China, Japan, India, Germany, United Kingdom and France were chosen for this study because they form six out of the seven top economies in the world excluding the United States. The Russian Federation (Central Intelligence Agency, 2009) is not included because creditable stock data extending back to the year 2000 is not available. In addition, Mexico and Canada were included in this study because they are geographically linked to the United States and are part of the North American Free Trade Association (NFTA). This study will help identify which countries play a pivotal role in the overall success of the United States stock market and thus the United States economy. Once we have identified the most influential countries then we can explore the accompanying policy implications.

The dependent variable in this study is the United States economy represented as the U.S. S&P 500 stock market index, which serves as
a proxy for economic strength. The other eight countries’ stock market indexes will serve as the independent variables. Canada, Mexico, China, Japan, United Kingdom and Germany serve as the United States’ main trading partners in their respective order (Central Intelligence Agency, 2009) thus if economic distinct economic interrelationships have developed the movement in the foreign stock indexes will be directly reflected in the S&P 500 in the United States. This leads to the proposition:

*Proposition 1: The stock indexes for the main trading partner countries will have a significant and direct impact on S&P 500 index of the United States.*

Time is also an important factor in these relationships. We suggest that as time has passed technology has advanced, communications have expanded and transportation has developed leading to increased integration among countries. Formally we state:

*Proposition 2: The impact of foreign stock markets on the United States stock market has increased over time.*

On a month-to-month analysis, we examine the difference in index values for the United States and the other countries. We expect that the magnitude and direction of these changes will be directly related indicating that the economies are linked to each other:
Interrelationships among Global Stock Indices

Proposition 3: The change in index value between the primary trading partner countries stock indexes will be positively and directly related to changes in the United States S&P 500 index.

Further, the percentage change in index values will be directly related so we formally state our last hypotheses as:

Proposition 4: The percentage change in stock index value for the primary trading partner countries will be positively and directly related to the percentage change in the United States S&P 500 index.

Model Development

We use the primary stock indexes for nine countries, using the United States S&P 500 stock index as the dependent variable for each model. The data for this analysis was the Adjusted Closing Price of the index on the first open market day of each month from January 1, 2000 through November 3, 2008 was gathered from YahooFinance.com.

To determine the relationships among the stock indexes from the countries of interest, we provide the correlations in Table 3. The results indicate that the stock indexes for France, Germany, United Kingdom and Japan are strongly correlated to each other, essentially functioning as a group. This situation suggests that one country can represent this group in during the subsequent analysis. Further, this table shows that the United States S&P 500 is related to the stock indexes in China, Mexico, India and Canada. With these initial results we proceed with model development.

Our analysis procedure will involve first identifying the countries having a significant impact on the S&P 500 and then this model will be refined to remove insignificant variables. Once the most parsimonious model has been developed and the most important countries have been identified, time will be added as an interaction variable. The relationships between the monthly changes will then be entered into the analysis.

The original data containing dates (in the form MM/DD/YR) were coded into numbers in consecutive order. For example, we coded January 3, 2000 equaling ‘1’, February 1, 2000 as ‘2’ and so forth; the intermediary calculations were performed as necessary. The stock index variables were coded as indicated in Table 4.
The general form of the model are provided below:

**Model 1 (General Model)**

\[ Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_8 X_8 + \epsilon \]

**Model 2 (General Model with Time Interaction)**

\[ Y = \beta_0 + \beta_1 X_1 + \beta_1 X_1 T_1 + \beta_2 X_2 + \beta_2 X_2 T_2 + \ldots + \beta_8 X_8 + \beta_8 X_8 T_8 + \epsilon \]

The next two models are based upon the period to period change in stock index value. Model 3 is the straight change in value model while Model 4 is developed from the percentage change in stock market index.
value from time period to time period. The results will indicate how fluctuations in the global markets impact the U.S S&P 500 index values.

**Model 3 (Change in Index Values)**

\[ Y_{t+1} - Y_t = \beta_0 + \beta_1(X_{1(t+1)} - X_{1(t)}) + \beta_2(X_{2(t+1)} - X_{2(t)}) + \ldots + \beta_8(X_{8(t+1)} - X_{8(t)}) + \epsilon \]

**Model 4 (Percentage Change in Index Values)**

\[ \frac{Y_{t+1} - Y_t}{Y_t} = \beta_0 + \beta_1\left[\frac{X_{1(t+1)} - X_{1(t)}}{X_{1(t)}}\right] + \beta_2\left[\frac{X_{2(t+1)} - X_{2(t)}}{X_{2(t)}}\right] + \ldots + \beta_8\left[\frac{X_{8(t+1)} - X_{8(t)}}{X_{8(t)}}\right] + \epsilon \]

**RESULTS & ANALYSIS**

The first step in the analysis of the models involves evaluation of the entire model with all primary stock index variables included. Although the correlation results indicate that a group of these indexes are highly related, we will begin the formal analysis of the econometric models including all indexes and then refine the model as we progress.

**Results—Model 1: General Model**

The results of Model 1 indicate that the overall model is significant, exhibiting an F statistic of 242.586 (CV = 2.03, p > .05), and an adjusted \( R^2 = 0.948 \). This model also contains several significant (at a 95% confidence level) independent variables. We see that China, Mexico, Japan and Canada are significant determinants of the United State S&P 500 index. The

<table>
<thead>
<tr>
<th>( \beta )</th>
<th>CHN</th>
<th>MEX</th>
<th>FRA</th>
<th>GER</th>
<th>UK</th>
<th>IND</th>
<th>JPN</th>
<th>CAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta ) values</td>
<td>163.43</td>
<td>0.030</td>
<td>-0.008</td>
<td>0.053</td>
<td>-0.025</td>
<td>0.062</td>
<td>-0.001</td>
<td>0.012</td>
</tr>
<tr>
<td>t-ratio</td>
<td>2.10</td>
<td>3.364**</td>
<td>-3.111**</td>
<td>1.4278</td>
<td>-1.5849</td>
<td>1.5510</td>
<td>-0.1436</td>
<td>3.247**</td>
</tr>
</tbody>
</table>

**Model Results**

- F = 242.586 (critical value: 2.03)
- Adjusted \( R^2 = 0.948 \)

**TABLE 5. Model 1 Results.**

**Significant at the 95% level**
results also clearly indicate that France, Germany, United Kingdom and India do not significantly influence the U.S. S&P 500 stock index. These results are in line with what we observed earlier in the correlation table. The block of countries, France, Germany, United Kingdom and Japan were all highly correlated to each other and to the U.S. stock index. This situation is reflected in the regression results, where multi-collinearity leads to the insignificant t-ratio. Based upon the results of the regression and the correlation results, we select Japan to be included in the refined model.

The results of the refined model are presented in Table 6. In this model, we see that the stock market indexes of China, Mexico, Japan and Canada are significant, however the large variance inflation factor (VFI) indicates multi-collinearity is still exists in this model. The results are summarized in Table 7 and we observe that the multi-collinearity in the model occurs with the Mexican stock index variable and with the Canadian stock index variable. In both cases the VIF was greater than 5, which means there is more than 80% correlation among the variables. The Canadian stock index data indicated a coefficient of partial determination (CPD) of 0.492, while the Mexican stock index data exhibited a smaller CPD of 0.443. Based on the CPD result in conjunction with the VIF, we continue with the Canadian stock index in the equation and eliminate the Mexican stock index. The results of the final model are presented in Table 8.

### Table 6. Model 1—Insignificant Factors Removed.

<table>
<thead>
<tr>
<th>B₀</th>
<th>CHN</th>
<th>MEX</th>
<th>JPN</th>
<th>CAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>β values</td>
<td>213.538</td>
<td>0.048</td>
<td>-0.018</td>
<td>0.026</td>
</tr>
</tbody>
</table>

Model Results:
- F= 360.789 (CV = 2.46, p < .05)
- Adjusted R² = 0.931

** Significant at the 95% level
Interrelationships among Global Stock Indices

Table 7. Variance Inflation Factors.

<table>
<thead>
<tr>
<th></th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>China x All other variables</td>
<td>2.098</td>
</tr>
<tr>
<td>Mexico x All other variables</td>
<td>14.4647</td>
</tr>
<tr>
<td>Japan x All other variables</td>
<td>3.3409</td>
</tr>
<tr>
<td>Canada x All other variables</td>
<td>19.1745</td>
</tr>
</tbody>
</table>

Table 8. Model 1—Final Model.

<table>
<thead>
<tr>
<th></th>
<th>B₀</th>
<th>CHN</th>
<th>JPN</th>
<th>CAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>β values</td>
<td>469.06</td>
<td>0.028</td>
<td>0.042</td>
<td>0.014</td>
</tr>
<tr>
<td>t-ratio</td>
<td>3.487**</td>
<td>14.804**</td>
<td>3.157**</td>
<td></td>
</tr>
<tr>
<td>Model Results</td>
<td>F= 255.330 (CV = 2.69, p &lt; .05)</td>
<td>Adjusted $R^2 = 0.878$</td>
<td>** Significant at the 95% level</td>
<td></td>
</tr>
</tbody>
</table>

In the final model, we note the significant F-statistic and the adjusted $R^2$ is acceptable at 0.878.

Results—Model 2: Final Model with Time Included

The introduction of time into the equation yields little indication that time influences the impact of the other stock indexes on the United States S&P 500 index performance. In this model we note that the stock indexes in Japan and Canada appear to be similar to Model 1 and influence the United States S&P 500 stock index, however China has dropped out. Time exerts an influence only with the Canadian stock index, and interestingly this impact is in the negative direction. Essentially, this result seems to suggest that as time has passed, the impact of the Canadian stock index has
decreased over span of years from 2000 to 2008. The results of Model 2 are presented in Table 9.

**Model 3: Change in Stock Index Values**

In order to study the impact of fluctuations in the stock market indexes on the United States S & P 500, we next use the month-to-month changes in the foreign stock indexes as determinants of the changes in the U.S. S&P 500 index. The results of Model 3 are presented in Table 10. From these results we see that changes in the Chinese stock index values are no longer significant determinants of the changes in the United States S&P 500 index, while changes in the Japanese and Canadian markets are significant determinants. This result suggests that the changes in the stock market values of the Chinese markets do not impact in the U.S S&P 500 index.

**Table 9.** Model 2—Results Including Time.

<table>
<thead>
<tr>
<th>β values</th>
<th>B0</th>
<th>CHN</th>
<th>CHN x Time</th>
<th>JPN</th>
<th>JPN x Time</th>
<th>CAN</th>
<th>CAN x Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>217.64</td>
<td>0.004</td>
<td>0.000</td>
<td>0.0092</td>
<td>0.000</td>
<td>0.112</td>
<td>-0.0005</td>
<td></td>
</tr>
<tr>
<td>t-ratio</td>
<td>0.145</td>
<td>0.092</td>
<td>2.398**</td>
<td>1.498</td>
<td>11.541**</td>
<td>-5.709**</td>
<td></td>
</tr>
</tbody>
</table>

Model Results

F= 323.09 (CV = 2.18, p < .05)  
Adjusted R² = 0.948

**Significant at the 95% level**

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**Table 10.** Model 3—Change in Stock Index.

<table>
<thead>
<tr>
<th>β values</th>
<th>B0</th>
<th>CHN</th>
<th>CHN x Time</th>
<th>JPN</th>
<th>JPN x Time</th>
<th>CAN</th>
<th>CAN x Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>217.64</td>
<td>0.004</td>
<td>0.000</td>
<td>0.0092</td>
<td>0.000</td>
<td>0.112</td>
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<td>-5.709**</td>
<td></td>
</tr>
</tbody>
</table>

Model Results

F= 323.09 (CV = 2.18, p < .05)  
Adjusted R² = 0.948

**Significant at the 95% level**
As a further test of the model, we can see in Table 11, that the regression results using the percentage change in the stock index values are comparable to the results from the direct change in stock index value.

**Model Summary**

In summary, the results of our investigations indicate that the actual value of the United States S&P 500 is directly influenced by the stock market indexes in China, Japan and Canada. This relationship is expressed as follows:

\[
S&P500 = 469.06 + 0.028 \text{ (Chinese Index)} + 0.042 \text{ (Japanese Index)} + 0.014 \text{ (Canadian Index)}
\]

This model is significant with an \( F=255.330 \) (\( CV > 2.69, p < .05 \)), \( \text{Adj. } R^2= 0.878 \). We also found that the fluctuations in the U.S. S&P500 are directly related to changes in only the Japanese and Canadian stock markets. Changes in the Chinese market were not significantly related to the changes in the U.S. S&P 500 stock index. We express the resulting model as follows:

\[
\Delta S&P500 = -4.423 + 0.0136\Delta \text{ (Japanese Index)} + 0.0652\Delta \text{ (Canadian Index)}
\]
This model is significant with $F = 52.207$ (C.V. = 1.74, $p < 05$) and Adjusted $R^2 = 0.594$.

**Conclusion & Discussion**

The development, analysis and refinement of the regression models has yielded a significant relationship between the Chinese, Canadian and Japanese stock market indexes on the United States S&P 500 stock index. During the development of this model, we explored the impact of the eight major economies on the U.S. S&P 500 and only included 3 stock markets in our subsequent analysis because of multi-collinearity among several of the European markets. In addition, we conducted an analysis of the impact of time on the relationships and found that the Canadian stock market was significantly, but negatively related to the U.S. stock market. This was an unexpected result and the implications will be explored in further research. Overall, the model results are reasonable, China, Canada and Japan are among the top trading partners with the United States and thus we would expect significant relationship to exist among the stock market indicators. However, during the analysis we found an unexpected inverse relationship between the Mexican stock index and the U.S. S&P 500. Mexico is also considered one of America’s top trading partners and is also a member of the North American Free-Trade Agreement along with Canada, why we found the negative relationship between stock indexes is puzzling and fodder for another, more focused study of the trade relationships between the two countries. In summary we find support for proposition 1, but little support for proposition 2.

In a second set of models, we considered the relationship between the stock market index fluctuations or ‘volatility’ found among these trading partners. The model incorporating month-to-month changes and the supporting model evaluating the percentage change from month-to-month were quite similar, indicating that the results were consistent. In this model we find that the month-to-month changes in the Chinese stock market index did not significantly impact the U.S. S&P 500 index, while
changes in the Japanese and Canadian stock markets did impact the U.S. S&P 500 index. From these results we infer that actions on the Japanese and Canadian markets are closely linked to the actions of the U.S. S&P 500. In conclusion, we suggest that there are significant interrelationships between the economies of the United States, Canada, Japan and China, and that market fluctuations are reflected within the economies of the United States, Canada and Japan. These results support propositions 3 and 4, for the limited set of trading partner countries that were considered.

In general, since the United States’ stock market has a positive linear relationship with China, Canada and Japan, the United States should then take the relationships into consideration when engaging in economic foreign policy. The U.S. should adopt policies and form relationships with these countries that will provide favorable balance in trade and stimulate U.S. businesses. By doing this they will increase the value of their domestic companies which will help contribute to a healthy economy. The inter-linkages between our economy and the economies of our principle trading partners are continuing to expand. These relationships are essential to the success of the worldwide economy, thus the relationships between the partners need to be managed accordingly.

**Future Research**

Overall this study has provided some empirical support for the existence of relationships among the large economies of the world. however this study has also highlighted areas for future research. Of principle interest is discovering why the Mexican stock index indicates an inverse relationship with the United States S&P 500 when we are primary trading partners. In addition, further research investigating the inverse time relationship between the Canadian stock market index and the U.S. stock market index needs to be investigated.
REFERENCES


Durbin-Watson Critical Values <http://www.stanford.edu/~clint/bench/dw05b.htm>
