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The Effects of International Diversification on Portfolio Risk

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Research Honors 2007
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Abstract: With the growing global economy, understanding international stock market correlations has become a vital instrument for investors wishing to diversify their portfolios on a global basis. For investors to have effective international portfolio diversification it is important to determine the countries whose stock prices move together, those whose stock prices move in opposite directions and those whose stock prices are unrelated all together. In order to analyze the impact of stock market correlations, this paper will focus on stock market indices in the U.S., Shanghai and the European Union. According to theory, maintaining portfolios primarily in highly positively correlated markets allows for unnecessary portfolio risk due to the presence of diversifiable risk in the portfolio. Through linear regression, results have shown that markets for the most part move together, especially in times of high volatility. However, diversification of international stock indices can reduce risk.

I. Introduction

With the ever growing global economy, understanding international stock market correlations has become a vital instrument for investors wishing to diversify their portfolios on a global basis. Therefore, for investors to have effective international portfolio diversification, it is important to determine the countries whose stock prices move together, those whose stock prices move in opposite directions and those whose stock prices are unrelated all together. Countries whose stock prices move in the same direction (comovements) are considered positively correlated while countries whose stocks move in opposite directions are negatively correlated. According to the principle of diversification, a portfolio containing mainly positively correlated assets holds the portfolio at a higher risk than a portfolio with stock prices that are negatively correlated. In addition, investors wishing to diversify a risky investment, such as stocks in an emerging market, through international diversification, would have more success in countries found to be negatively correlated as well. The lack of accurate determination of stock market price movements holds any portfolio at a higher risk level than necessary due to the presence of the diversifiable risk.

In order to analyze the impact of stock market correlations, this paper will focus on stock market indices in the U.S., the European Union, and Shanghai. The stock markets within the European Union, on initial analysis, would appear to be the most highly correlated due to the unique presence of the Economic and Monetary Union (EMU). This union, among 11 European Union countries, was formed on January 1, 1999. It essentially created a fixed exchange rate, a common monetary policy, and introduced a single currency to be used among these countries, the Euro. Furthermore,

during the first years of its implementation, there was a convergence of inflation rates, an increase in fiscal policy coordination, and a synchronization of legal and regulatory organizations. Money and bond market integration also immediately followed the formation of the union (Harhouvelis, Malliaropulos and Priestley, 2001).

The simplification of regulatory and monetary policy across borders creates a strong argument for market integration within the E.U. The definition of foreign market integration is the level of free flowing information and capital across international borders (Karolyi & Stulz, 1996). The creation of the EMU eliminated the intra-European portfolio allocation barriers. It reduced transaction costs, standardized pricing of financial assets, and enhanced transparency of financial markets (Harhouvelis, Malliaropulos and Priestley, 2001). Because of the integration of markets across Europe, one would expect individual European stock market indices to have strong positive correlations with one another.

Thus maintaining a portfolio in mainly European stocks leaves the presence of diversifiable risk for investors. As stated earlier, in order to effectively diversify a portfolio internationally, an investor would *not* want to concentrate their investments in positively correlated markets. The theory of diversification is to reduce risk within a portfolio by combining a variety of investments which are *unlikely* to move in the same direction during a business cycle, and therefore are negatively correlated. This allows for more consistent performance under changing economic conditions. Therefore for an investor to reduce risk by international diversification, it is better to complement a portfolio containing mainly European stocks (which are believed to be highly integrated)

with stocks from other regions that are not believed to be a highly integrated, such as the U.S. or Shanghai.

This paper analyzes correlations among stock market indices of several markets. It is hypothesized that the stock market indices of the two European markets (the DAX and the CAC) will have strong positive correlations due to the integration of the European economies. In addition, markets outside of the EU are hypothesized to be less positively correlated. The non-European indexes examined in the study include the S&P 500 (United States) and the SSEC (Shanghai, China).

These two additional markets outside of the EU were selected to reflect two different diversification decisions. The stock market in the U.S. is characterized as a developed market with low volatility. On the other side of the spectrum is the Shanghai market. It is an emerging market with high volatility, and has recently been characterized with extraordinary returns (a “bubble” market) and risks. These two different markets will be used to describe the degree of riskiness an investor will have to decide between: a secure investment with moderate expected return or a more risky investment with the chance higher return.

The structure of this paper is organized as follows. Section II presents the literature background of the paper. The theoretical framework is developed in Section III. Section IV describes my empirical model and variables. Lastly, Section V and VI present my results and conclusions.

II. Literature Review

This paper will be an extension of recent research that has focused on the increasing level of correlations among stock markets by also incorporating the effects of various shocks to an economy that drive a stock market in one direction or another. As hypothesized earlier in this paper, Syllignakis (2006) found that stock market correlations have increased in the EU throughout the years after the establishment of the EMU. Of the stock markets in that study, correlations between France and Germany were found to be the highest. Boucrelle et. al (1996) also found a slight increase in individual market correlations with the U.S. market over the past 37 years, however this did not hold true for the past 10 years. They concluded that benefits of international diversification from a risk standpoint are being reduced because of the increasing correlations among markets within the European Union. International diversification is most valuable during times of negative shocks, however their study showed that during these times of high volatility that markets tend to be the most highly correlated.

Accurately determining market correlations is imperative for reducing risk. Combining two perfectly negatively correlated stocks, in theory, is the only way to completely eliminate risk in a portfolio. However, Chan, Karceski, and Lakonishok (1999) found that on average markets tend to be positively correlated. They estimated that two randomly selected stocks tend to have an average correlation coefficient of 0.3. Thus, adding additional stocks to any portfolio can further reduce risk, but only to a certain level. The risk that remains that cannot be diversified away is considered the market risk (Brigham and Houston, 2007).

In addition to analyzing portfolio risk, this study will further develop the theoretical framework of Karolyi and Stulz (1996). Their study focused on the movements of the Japanese and U.S. stock markets with respect to multiple types of shocks to the economy that would move stock market indices in differing directions. The first type of shock studied by Karolyi and Stulz (1996) are the global shocks. These shocks are defined as those that affect “the value of all firms in the same direction,” such as an increase in world oil prices. Theory suggests that a global shock would cause the integrated markets to move together (comovements) in addition to increasing the volatility of the markets. Boucrelle et al. (1996) confirmed this theory, finding that during these times of high volatility, markets showed high correlation. During these times of strong negative global shocks is precisely when international portfolio diversification is needed the most, however with highly correlated markets the benefits are negligible.

The second type of shock is the competitive shock. These types of shocks are defined as those that “increase the market value of a firm relative to the value of another firm.” They analyze large changes in exchange rates in their study. Theory suggests that competitive shocks will cause integrated markets to move together as well, but in opposite directions, negative correlation, thus achieving the benefit of international diversification. Karolyi and Stulz (1996) also found that global shocks led to higher correlations in stock markets than competitive shocks, primarily because global shocks propagate more than competitive shocks. However competitive shocks were still significant.

In addition, Karolyi and Stulz (1996) also discussed the spill over effects of large global shocks. Large overnight return shocks led to a higher covariance measure the next day in another market. They found these spillover effects to be significant and have a positive effect on returns. Boucrelle et. al (1996) also had a similar finding, showing that markets tended to be highly positively correlated during times of high market volatility.

Another spillover effect that may take place is contagion. Furstenberg (1989) discusses the effects of contagion on stock market movements further in his study. Contagion is characterized as enthusiasm for stocks in one market that leads to enthusiasm for stocks in another market. Similar to a global shock, contagion causes the stock market movements to be in the same direction. Fustenberg (1989) found that these artificial market trends may account for some unexpected returns, however they only play a minimal role in price determination.

This study will also develop a third type of shock, the local shock. This type of shock is defined as a shock that would directly affect only one country, such as unemployment. Theory suggests that an increase in unemployment would directly affect stock performance in one country. However, if markets are integrated, there should be movement of capital from one market to the next with the change in stock market performance and therefore comovements should be observed. Boyd, Hu, and Jagannathan (2005) studied the effects of changing unemployment rates on the stock market. They found that an increase in unemployment rates during recessions hurt stock market prices, driving the numbers down. However, during times of economic expansion, rising unemployment actually helped the markets, driving numbers up. This

type of movement maps out a Kuznets “inverted U” curve, when plotting the hypothetical relationship between stock prices and the unemployment rate.

III. Theory

To develop the first part of the theoretical framework, we will first consider an investor with no knowledge of market trends. The investor is assumed to have no knowledge of rates of return in any one market and therefore assumes all rates of return are equal. This assumption will be relaxed later in the paper. Under the assumption of equal rates of return across markets, the investor will base allocation decisions on risk only. Using only historical data of market indices, the investor must determine how to allocate his money between international markets to receive the lowest risk for the given period of time. Monthly rates of return will be used to determine the standard deviations of multiple allocation possibilities in order to assess the estimated level of risk, assuming the future is expected to be like the past. Funds will be divided equally among markets considered in each possible portfolio. For this exercise, transaction costs and other allocation barriers are assumed to be zero.

In order to analyze the use of diversification, we will explore a few hypothetical situations: two perfectly positively correlated markets, two perfectly negatively correlated markets, and two partially correlated markets. First, Figure 1 shows two positively correlated stocks, thus their returns move up and down together. They both maintain an average rate of return of 15 percent and a standard deviation of 22.6 percent. The standard deviation is used to assess the level of risk for stocks and portfolios. When Stock W and Stock N are combined into a portfolio, the average annual rates of return

and standard deviation remain exactly the same. Thus holding a portfolio with two perfectly positively correlated stocks does nothing to reduce risk. (Brigham and Houston, 2007, p. 259)

Next, Figure 2 demonstrates the effects of combining two perfectly negatively correlated stocks in a portfolio. When Stock W is decreasing, Stock M is increasing at the same rate. Thus, when combined into a portfolio, their movements offset one another, creating a constant average annual rate of return of 15 percent with no deviation from that rate. Therefore Portfolio MW is considered a riskless portfolio.

However, perfectly negatively and positively correlated stocks do not occur in real life. Typically, as discussed earlier, stocks tend to be moderately positively correlated, thus bringing us to the next hypothetical portfolio. In Figure 3 there are two partially correlated stocks. Stocks W and V again both have an average rate of return of 15 percent and standard deviation of 22.6 percent. Since they do not move in perfect unison, they are able to offset each other slightly, therefore when they are combined in the portfolio, the standard deviation, 18.6 percent, is reduced. The risk of the portfolio is less than the individual stocks, thus demonstrating the effects of diversification.

But since a typical investor does care about market trends and trying to predict the future of market movements, the assumption of equal rates of return across markets is now relaxed, therefore allowing investors to use economic variables to predict differences in rates of return between markets. To set up the second part of my theoretical framework, a simple supply and demand function will be used to determine the effects of the global, local, and competitive shocks, as discussed in section II. The supply and demand model for the global and competitive shocks consists of two stock markets in

Fig. 1: Rate of Return Distribution for Perfectly Positively Correlated Stocks

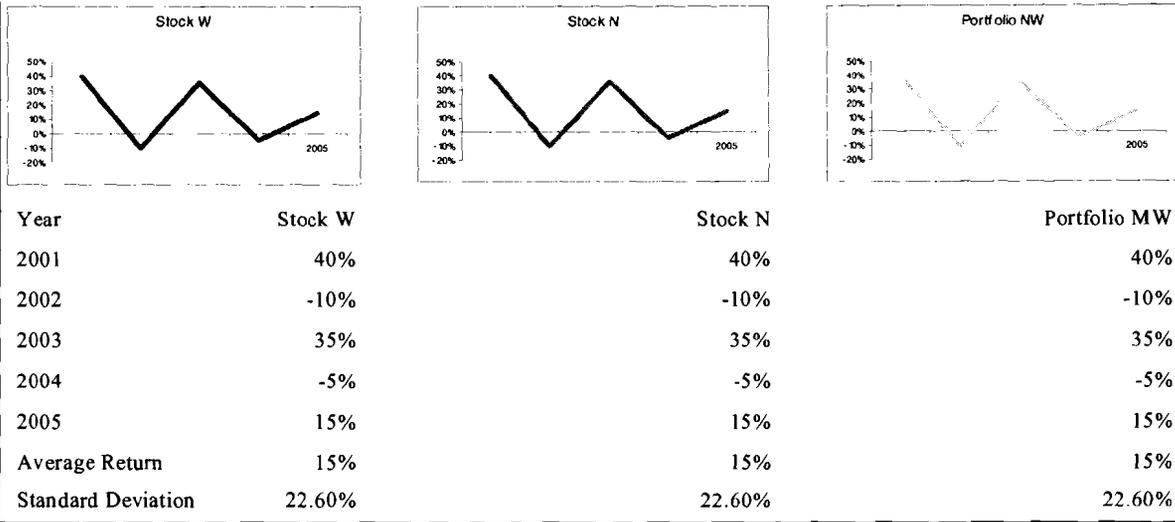


Fig. 2: Rate of Return Distribution for Perfectly Negatively Correlated Stocks

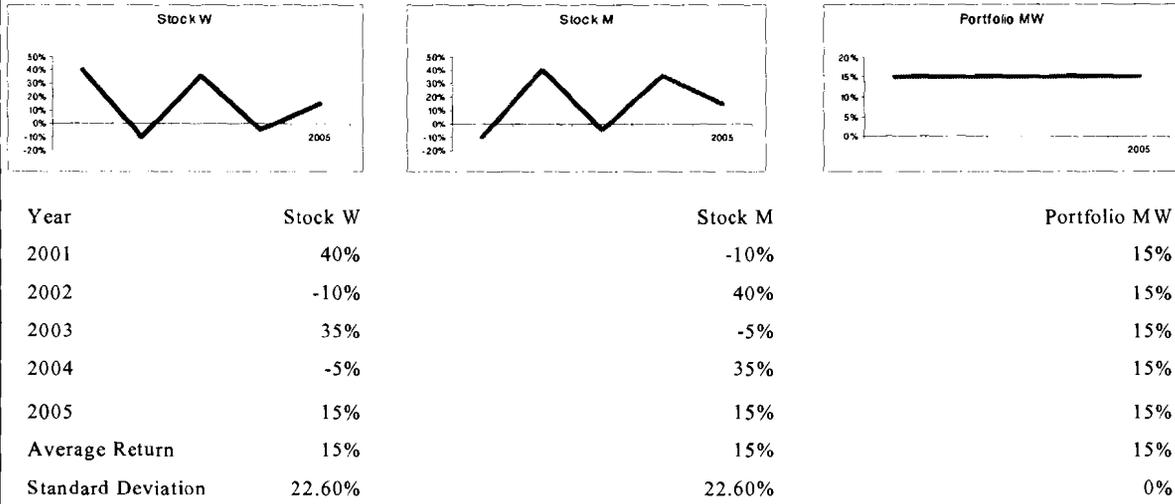
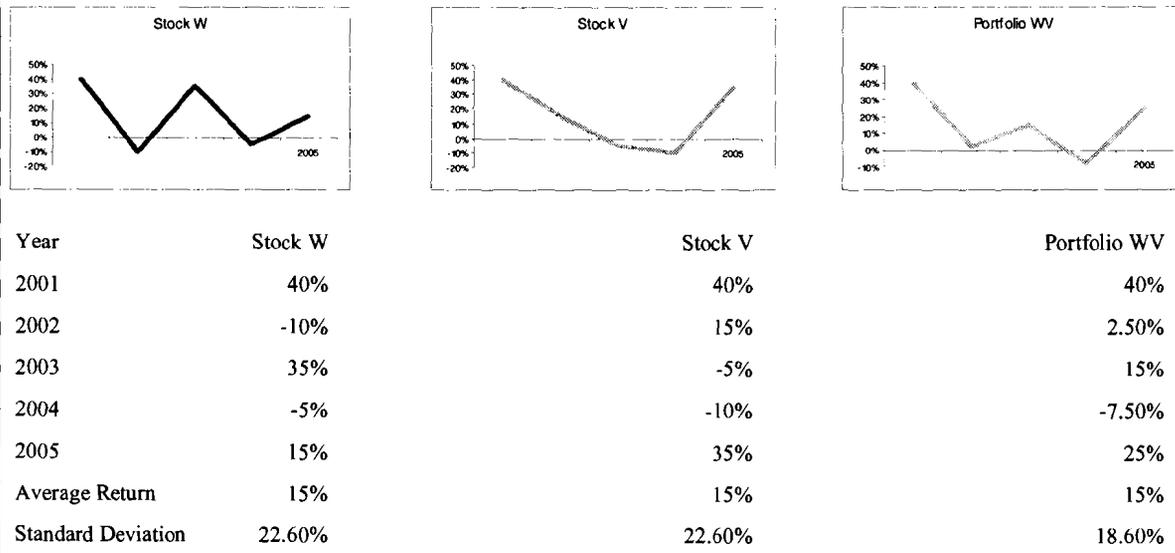


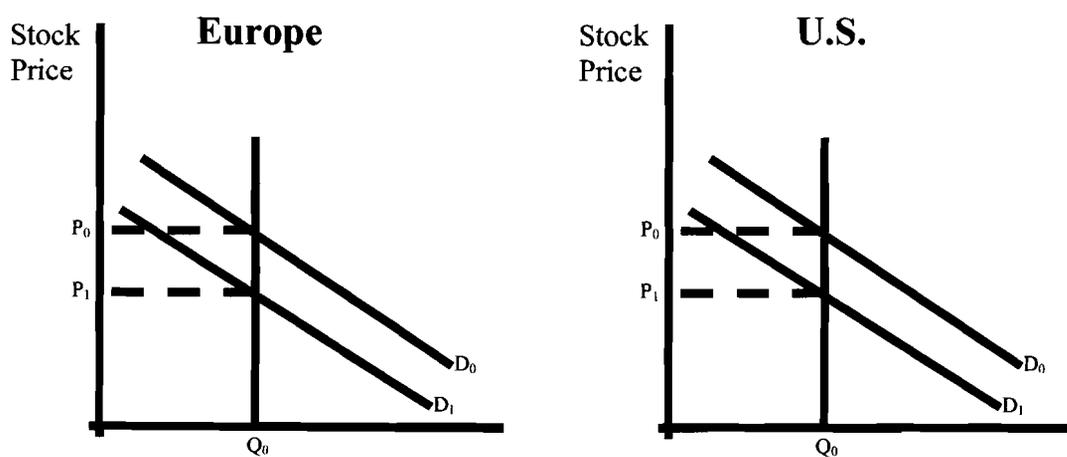
Fig. 3: Rate of Return Distribution for Partially Correlated Stocks



different countries that trade only one stock respectively. The price of a share of a stock depends on the discounted expected profits of a company divided by the number of shares. For analysis purposes, a vertical supply curve is used indicating that the total number of shares outstanding is fixed, as seen in Fig. 4. In addition, since we will be discussing the effects of macro shocks to an economy to measure the discounted expected profits, this analysis will focus on the demand side of the model. Using this framework we can start to understand how global, competitive and local shocks will affect expected profits.

First, we assess the effects of global shocks, shocks that affect “the value of all firms in the same direction.” For this study, world oil prices are used to examine this effect (Fig. 4). Note that the stock markets in this example are assumed to be oil consuming rather than oil producing, therefore an oil price shock would cause an increase in operational costs in all industries. The increase in costs causes a decrease in expected profits. Investor reactions to the shock cause the demand to shift from D_0 to D_1 , therefore

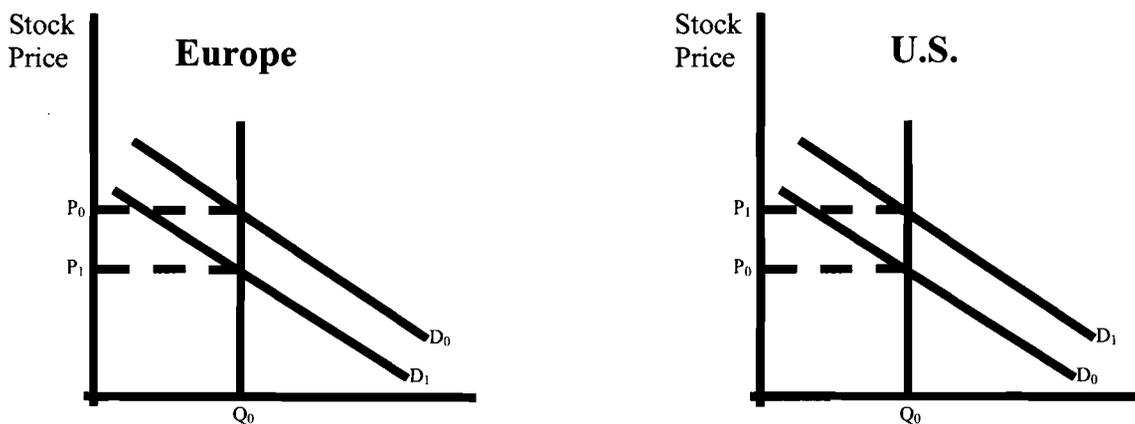
Fig. 4: Global Shock: Increase in World Oil Price



driving the stock price down. Since a world oil price increase is a global shock, this reaction would be seen in both stock markets, the U.S. and Europe. Thus, global shocks cause positive correlations of stock markets.

Next, the effects of competitive shocks on stock market prices of our two countries are analyzed using exchange rates as the shock. As a reminder, competitive shocks are those that increase the market value of a firm relative to the value of another firm. Exchange rates are used because as the currency price of one country increases relative to the other, one country becomes more expensive relative to the other. Therefore the “expensive” currency can buy more in the other country for less. This effect can be seen in Fig. 5 with the increase in the value of the Euro relative to the U.S. dollar. This means that U.S. goods will be cheaper for Europeans to purchase. The demand for the U.S. stocks (a.k.a. the “cheaper” country) will increase, shifting demand from D_0 to D_1 . Meanwhile, as Europeans shift their investments from the E.U. market to the U.S market, the demand for the European stocks drop to D_1 . Stock prices in the U.S. market increase while the stock prices in the E.U. market decrease. Thus, competitive

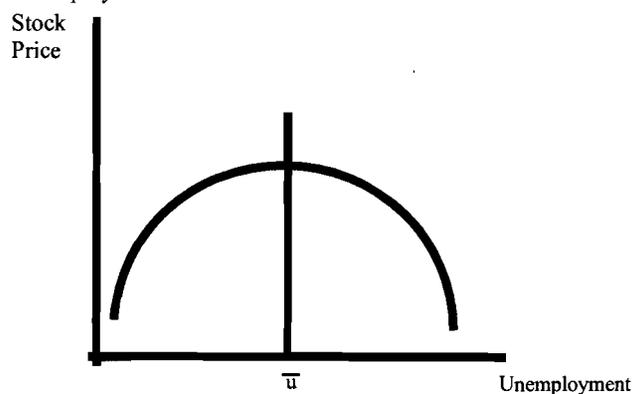
Fig. 5: Competitive Shock: Increase in Exchange Rate



shocks cause negative correlations in stock markets.

Lastly, unemployment rates are used to analyze the effects of local shocks on the markets. The unemployment rate should only affect the market in one country. Therefore, only one market is depicted in Figure 6. As discussed earlier, Boyd, Hu, and Jagannathan (2005) showed that an increase in the unemployment rate will take the shape of a Kuznets inverted U curve. During booms, unemployment is below the natural rate

Fig. 6: Effect of Unemployment on Stock Price



of unemployment, \bar{u} . As unemployment falls below the natural rate, bottlenecks and inflationary pressures will cause stock prices to fall. However, during recessions, when unemployment is above the natural rate, an increase in unemployment decreases investor outlooks, therefore decreasing prices. Thus, a purely local shock, like unemployment, will produce movements in one market without directly affecting the other.

IV. Empirical Model

For my analysis, monthly index prices for the DAX (German index), the CAC (French index), the S&P500 (U.S. index) and the SSE (Chinese index) were extracted from Yahoo Finance for the years 2000 through 2006 (Yahoo! Finance, 2007).

Additionally, monthly unemployment and exchange rates were taken from the European Central Bank (2007) and monthly world oil prices were taken from the Energy Information Administration (2007) for the same time period. The data were used to determine an index's risk, portfolio risk and to run an OLS regression to test the following two hypotheses:

1. Because adding additional stocks to a portfolio can reduce risk based on the principle of diversification, an international portfolio of stock indices will be less risky than an individual index.
2. In addition, global, competitive and local shocks to the economy can be used to predict an index's prices movements relative to other indices.

The equations used for my regressions are as follows:

$$\ln DAX = \beta_1 + \beta_2 \ln CAC + \beta_3 OIL + \beta_4 UNEMPG + \beta_5 UNEMPG2 + \mu_1 \quad (1)$$

$$\ln DAX = \alpha_1 + \alpha_2 \ln SP + \alpha_3 OIL + \alpha_4 EXCHUS + \alpha_5 UNEMPG + \alpha_6 UNEMPG2 + \varepsilon_1 \quad (2)$$

$$\ln DAX = \alpha_1 + \alpha_2 \ln SSEC + \alpha_3 OIL + \alpha_4 EXCHCN + \alpha_5 UNEMPG + \alpha_6 UNEMPG2 + \varepsilon_1 \quad (3)$$

In each equation, the German index (DAX) is the dependent variable. Also, each equation includes a global shock (world oil prices) and a local shock (unemployment rate). Equations 2 and 3 control for competitive shocks (exchange rates). Because of the single common currency under the EMU, the exchange rate within the EU is fixed and not needed in equation 1. Each of the equations includes a control for another market index to determine the degree of correlation after controlling for the macro shocks. All four indices have been logged, therefore giving elasticities in the results.

Table 1 contains the list of definitions for the dependent and independent variables with the predicted signs. The three indices are predicted to be positive due to contagion of markets and high positive correlations during times of high volatility. Also past studies that have shown that markets tend to be positively correlated, with an average correlation coefficient of .3 (Chan, Karceski, and Lakonishok, 1999). The degree to which the French, U.S., and Chinese markets are correlated with the German market is what is under speculation. The predicted signs for the exchange rates are negative due to the nature of the competitive shocks causing negative correlations between markets. The local shock, unemployment, is predicted to take an inverted U curve. Therefore, the predicted sign on the unemployment variable is positive while the unemployment squared variable would be negative. Lastly, world oil prices are predicted to be negative because the global shock was theorized to cause negative correlations between markets.

Table 1: Variables and Predicted Signs

Variable	Description	Predicted Sign
Dependent Variable:		
lnDAX	German stock market index	
Independent Variables:		
lnCAC	Log of French stock market index	+
lnSP	Log of S&P 500, U.S. stock market index	+
lnSSEC	Log of the Chinese stock market	+
EXCHUS	Exchange rates for the Euro in US dollar prices	-
EXHCN	Exchange rates for the Euro in Chinese Yuan prices	-
UNEMPG	German unemployment rates	+
UNEMPG ²	German unemployment rate squared	-
OIL	World oil prices	-

V. Results

To examine the results for the analysis of portfolio risk, we must return to the first investor discussed in section II. This investor has no prior knowledge of market trends and, using only historical data of market indices, he must determine which investment options would give him the highest rate of return with the lowest risk for the given period of time. In Table 2, monthly data are used to compute the average annual rates of return and the standard deviations for each of the four indices, German, French, U.S., and Chinese. The S&P500 has the lowest standard deviation out of all four indices.

Table 2: Yearly Averages of Index's Volatility (Averaged from monthly percent changes)

Year	DAX		CAC		S&P500		SSEC	
	Expected Return	Standard Deviation						
2000	4.42	3.67	2.83	3.14	3.76	3.08	3.87	3.27
2001	6.79	4.44	5.70	3.65	4.63	3.25	4.47	3.67
2002	8.58	7.33	7.05	5.17	5.11	3.37	6.88	4.27
2003	6.95	5.62	4.84	3.09	2.96	2.39	3.48	3.11
2004	2.86	1.01	1.71	0.69	1.86	1.09	4.77	2.68
2005	3.29	2.26	3.24	1.39	1.85	1.20	4.76	3.58
2006	2.62	1.92	2.39	1.79	1.60	1.09	8.09	7.66
Ave	5.07	3.75	3.96	2.71	3.11	2.21	5.19	4.03

Therefore, during this time period, an investment in the U.S. market is the lowest risk.

However, the S&P500 also yields the lowest average rate of return. The SSEC yields the highest average rate of return, but it also has the highest standard deviation, therefore it is the riskiest investment.

However, based on the theory of diversification, by combining these indices into portfolios and through proper market selection, risk can be reduced. Table 3 shows the average rates of return and standard deviations for four possible portfolio combinations. For the first portfolio, the Euro Portfolio, funds would be equally divided between the

German and French indices. The Euro/US Portfolio equally divides funds three ways among the two European countries and the U.S. The Euro/Chinese also divides the funds

Table 3: Yearly Averages of Portfolio's Volatility (Averaged from monthly percent changes)

Year	<u>European Portfolio</u>		<u>Euro/US Portfolio</u>		<u>Euro/Chinese Portfolio</u>		<u>All</u>	
	Expected Return	Standard Deviation	Expected Return	Standard Deviation	Expected Return	Standard Deviation	Expected Return	Standard Deviation
2000	3.62	3.32	3.67	2.54	3.71	3.20	3.72	2.60
2001	6.23	3.78	5.69	3.42	5.64	2.63	5.39	2.56
2002	7.82	6.18	6.92	5.17	7.50	4.07	6.91	3.80
2003	5.89	4.27	4.91	3.41	5.09	2.64	4.56	2.42
2004	2.28	0.66	2.14	0.70	3.11	0.98	2.80	0.78
2005	3.26	1.76	2.79	1.36	3.76	1.18	3.28	1.01
2006	2.50	1.78	2.20	1.45	1.60	3.13	3.67	2.47
Ave	4.51	3.12	4.05	2.58	4.74	2.55	4.33	2.23

three ways among the two European countries and the Chinese index. The last portfolio divides the funds equally among all four countries.

When the portfolios are created, the idea of diversification is clearly demonstrated. The Euro Portfolio has a standard deviation lower than the DAX alone. Yet it is still higher than the CAC. This can be explained by the hypothesis that the European countries tend to be highly positively correlated due to the EMU. When the U.S. index is added to the Euro Portfolio the standard deviation decreases dramatically and even more so when the Chinese index is added. The lowest standard deviation is from the portfolio with all four indices. When comparing the portfolio with all four indices to the individual indices, the risk level is similar to the lowest risk index, the S&P500. However, the rate of return on the portfolio is significantly higher than the S&P500 because the portfolio is reflective of the higher rates from the other indices.

The above analysis indicates that an investor can reduce risk by diversifying across market indices. Because historical data are used, this exercise demonstrates what

has happened in the past in the markets. However, most investors are looking towards the future, trying to predict indices' movements in order to more effectively allocate resources. Therefore, for the second part of the empirical analysis, we explore whether international investors could use the global, competitive and local shocks discussed in the theory section, in order to anticipate differences in the rates of return. Regression analysis is used to predict the German index using the macro proxies for the global, competitive and local shocks to an economy while controlling for one of the indices. An important question for investors is whether these shocks could be used to predict the DAX.

On the initial run of my regressions, all variables were significant and the correlation coefficients were very high. However, the Durbin-Watson statistic ranged from .16 to .97. The first differences of each variable were taken to correct for the autocorrelation.

The regression results are presented in Table 4 through 6. The German index (DAX) is the dependent variable in each regression. In each table, Model 1 shows the simple correlation between the two indices. In Model 2 and 3 the macro variables are added. Model 2 uses the hypothesized empirical model with all variables. The unemployment squared is taken out of the third model because the predicted signs were incorrect in the U.S. and Chinese regression.

In Table 4, the regressions predicting the German index as a function of the French index (CAC) and the macro variables are presented. The R squared for Model 1, showing the simple correlation between the French and German Indices was very high.

Table 4: Regression of French index, Dependent Variable: lnDax (German Index)

Variables	Model 1	Model 2	Model 3
lnCAC	1.258 (27.273)***	1.262 (26.073)***	1.256 (25.814)***
EXCH	-	-	-
UNEMPG	-	0.0318 (1.562)	0.007 (0.562)
UNEMPG ²	-	-0.017 (-1.562)	-
OIL	-	-0.001 (-0.907)	-0.001 (-0.910)
R Squared	0.901	0.901	0.900
n	83	83	83
Durbin Watson	1.713	1.870	1.780

Note: Values in parenthesis are t-statistics

* significance at the .1 level

** significance at the .05 level

*** significance at the .01 level

Table 5: Regression of U.S. index, Dependent Variable: lnDax (German Index)

Variables	Model 1	Model 2	Model 3
lnSP	1.405 (12.731)***	1.381 (12.078)***	1.381 (12.155)
EXCH	-	-0.333 (-1.894)*	-0.337 (-1.951)*
UNEMPG	-	-0.069 (-0.184)	-0.024 (-1.105)
UNEMPG ²	-	.003 (0.121)	-
OIL	-	-0.001 (-0.551)	-0.001 (-0.555)
R Squared	0.663	0.668	0.672
n	83	83	83
Durbin Watson	2.435	2.411	2.409

Note: Values in parenthesis are t-statistics

* significance at the .1 level

** significance at the .05 level

*** significance at the .01 level

Table 6: Regression of Chinese index, Dependent Variable: lnDax (German Index)

Variables	Model 1	Model 2	Model 3
lnSSEC	0.128 (1.086)	0.113 (0.920)	0.101 (0.849)
EXCH	-	-0.031 (-0.851)	-0.028 (-0.789)
UNEMPG	-	0.205 (0.312)	-0.064 (-1.772)*
UNEMPG ²	-	-0.015 (-0.409)	-
OIL	-	-0.005 (-2.289)**	-0.005 (-2.287)**
R Squared	0.002	0.052	0.062
n	83	82	82
Durbin Watson	1.964	1.908	1.922

Note: Values in parenthesis are t-statistics

* significance at the .1 level

** significance at the .05 level

*** significance at the .01 level

The French index could explain 90.1 percent of the variation in the German index. Also, the coefficient on the lnCAC variable is an elasticity, showing that a one percent change in the French index is associated with a 1.258 percent change in the German index.

However, the relationship for each index with one another is a simple correlation without implying any causation. The coefficient on the French index being greater than one is expected, due to the low volatility of the French index (in reference to the standard deviation found in Table 2) compared to the German index. Models 2 and 3 in Table 4 added the macro proxies for the global, competitive and local shocks. Unfortunately, none of the macro variables were significant and therefore did not predict the movements in the German index.

The regression predicting the German index as a function of the U.S. index (SP) and the macro variables is presented in Table 5. Model 1 also shows a high R squared. The U.S. market was able to explain 66.3 percent of the variation of the German market. To some extent, this is not a complete surprise, because of the positively correlated nature

of markets. Because the indices are elasticities, the coefficient on the U.S. index shows a one percent change is associated with a 1.405 increase in the German index. Since the volatility (in reference to the standard deviation found in Table 2) of the U.S. market is the lowest of the other three markets, the coefficient on the U.S. index (SP) is the largest of the three regressions. In Models 2 and 3 the macro variables are added. Most of these variables are also found to be insignificant, except for exchange rates. The coefficient for exchange rates shows that for every increase in the exchange rate of Euros in U.S. dollars by one dollar will cause the German index to decrease by .33 percent. This finding supports the competitive shock theory by showing a negative relationship of the exchange rate.

Table 6 presents the regression predicting the German index as a function of the Chinese index (SSEC) and the macro variables. In Model 1 of this regression, there was almost no correlation found between the two indices. In fact, the Chinese index was not significant in any of the three models. The only variables that were significant were world oil prices in Models 2 and 3 and unemployment in Model 2. The relationship of the world oil prices with the stock prices is consistent with the hypothesized global shocks, showing a negative relationship. Also, the unemployment variable was negative and significant only in Model 3. The hypothesized Kuznets inverted U curve did not hold because both unemployment and unemployment squared were not significant in Model 2. However, the R squared for each model (Table 6) is so low that the variables did not explain very much of the variation in the German index.

V. Conclusion

With an increasing global economy, understanding international stock market movements in order to diversify a portfolio is very important for effective allocation of investment funds. In the first exercise in this study, we showed that a portfolio containing the two European (DAX and CAC) indices had the highest risk of all portfolios. As hypothesized, the German and French markets were found to be highly correlated from the regression. Combining these two indices into a portfolio did little to reduce risk as confirmed by the theory that perfectly positively correlated indices would not reduce risk. Since these markets were not perfectly positively correlated, the risk level on the portfolio was less than the German index alone, however it was still higher than the French.

As seen in this study and other past studies, a strong interconnectivity is being formed among stock markets. The U.S. market was found to have a strong positive correlation with the German index. However, since the correlation was still significantly less than the correlation of the French market, when the U.S. index is added to the European portfolio, the risk level is decrease dramatically. This shows that diversification of less correlated indices will allow further risk reduction as theory had predicted.

Lastly, risk was further reduced when a market found to have no correlation to the German index was added to the portfolio. Even with the extraordinarily high standard deviation of the Chinese index alone, when added to a portfolio that contains uncorrelated markets, risk can significantly be reduced. What does remain from the Chinese index, however is part of its high rate of return.

Since the risk level of the U.S. index and the portfolio with all four indices are similar, any risk-averse investor would be indifferent to either option. Because of the other higher rates of return that are combined into the portfolio, the U.S. index would appear to be a less attractive investment. Thus, a rational investor would chose to diversify across all four markets.

Unfortunately, the macro variables selected did not predict well. Market movements must be, to some extent, independent of these macro shocks to the economy. This suggests that predicting movements in these global, competitive and local shocks may not be good guides for allocation purposes. Future research can look for better ways to predict these movements, probably using different variables than those selected here.

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