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How Do Gold Markets Interact? Evidence from Australia, Switzerland and the U.S.

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This paper examines the international transmission mechanism of gold market movements by using the daily spot-contract data from Australia, Switzerland, and the U.S. over the period 1997-2004. With the intraday return as the variable in regression models, we find that the Australian market positively affects the Swiss market, that the Swiss market positively affects the U.S. market, and that the U.S. market positively affects the Australian market. When using the variable of the intraday return volatility in further analysis, the above three lead-lag relationships become much stronger. These results have important implications for investment strategies, portfolio management, option markets, and policy making. Overall, the new evidence contributes to the existing literature in financial market integration by suggesting that three gold markets are interrelated in terms of intraday returns and that there are high degrees of return volatility linkages among the Australian, Swiss, and U.S. gold markets.

JEL Codes: F36, G14 and G15

1. Introduction

How national financial markets are interrelated has long interested and, sometimes, concerned academics, practitioners, regulators, policy makers, and even the general public. One simple reason is that when two national financial markets are highly correlated, the financial trouble in one country can easily spill over to another country. Most prior papers on this topic use national equity markets to test various theories and/or hypotheses. Although earlier research finds low or insignificant interactions among national stock markets, almost all later papers conclude that major national stock markets are interrelated to varying degrees.

Based upon theoretical foundations and empirical findings of prior research on international market linkages, this paper extends the existing literature by studying the interactions of national gold markets. Specifically, we investigate how the gold prices in different time zones (Australia, Switzerland, and the U.S.) affect one another. With so many forms, gold trading ranges from the spot contract to the abstractions of futures contracts and to the solid tangibility of bracelets and rings. Since gold is traded around the clock and in many countries, gold has become one of the most invested commodities. Therefore, it is appropriate to use gold to investigate price transmission around the world. Some interesting questions arise. First, do the gold prices in the three major markets behave similarly in return and return volatility? Second, what are the causality relationships in the gold prices between these three markets?

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This paper differs from most of previous studies in three important aspects. First, while most previous papers research the topic using national equity markets, we focus on the linkages between national gold markets. Second, unlike many previous studies that use close-to-close return data (i.e., 2 days' closing prices are used), we use open-to-close return data (i.e., same-day opening and closing prices are used) in three major gold markets (Australia, Switzerland, and the U.S.). Close-to-close returns tend to contain noises over a 24-hour period that may distort the true performance of a financial market in a trading day. In contrast, open-to-close returns make direct tests of market efficiency easier. Finally, we study how a change in return volatility in one gold market affects the change in return volatility in another gold market. Prior research normally examines how a change in the index return in one stock market affects the change in the index return in another stock market. The focus on return volatility is interesting and important because return volatility is one key variable determining the price of an option contract.

We find evidence that three gold markets are significantly interdependent, in terms of the intraday return. This suggests that a profitable trading strategy, assuming no transaction cost, may be developed to take advantage of inefficiencies between two markets. When using the variable of the intraday return volatility in regression analysis, we find that the Australian market affects the Swiss market positively and strongly, that the Swiss market affects the U.S. market positively and strongly, and that the U.S. market affects the Australian market positively and strongly. This new evidence contributes to the existing literature by suggesting that there are high degrees of return volatility linkages among the Australian, Swiss, and U.S. gold markets. It implies that gold option markets, if existing, should also be significantly interrelated.

The remainder of this paper is organized as follows. Section 2 briefly discusses related literature. In Section 3, we describe the data and methodology. Section 4 presents and discusses empirical results. We summarize and conclude in Section 5.

2. Literature Review

In the literature of financial market integration, studies typically focus on investigating the merits of portfolio diversification, co-movements of equity prices, or lead-lag relationships among national stock market indexes. Earlier research on stock market interactions across different countries (e.g., Grubel 1968, Levy and Sarnat 1970, Agmon 1972, Ripley 1973, and Hilliard 1979) looks into the benefits of international diversification in reducing portfolio risk. With weekly or monthly return data, most of these studies conclude that return correlations across countries are low or statistically insignificant. This result may not be surprising because a month or even a week is long enough to obscure the effect of an event that may last for a day or two.

Research in the 1980s on market interdependence uses higher-frequency data. Jaffe and Westerfield (1985), using daily closing prices for five countries, find that return correlations between the U.S. and four other national markets are generally positive and significant for each day of the week. Schollhammer and Sand (1985) study the co-movements of stock market indices of major European countries and the U.S. Contrary to the findings of previous research, a significant degree of interdependence is found

between the stock prices of Germany, the UK, the Netherlands, and Switzerland. In addition, a change in the US stock price index normally leads to a same-direction change of all the European markets except Italy. Employing the vector autoregression (VAR) methodology to examine cross-country price transmissions of nine national stock markets, Eun and Shim (1989) find high degrees of linkage among these national stock markets. Consistent with Schollhammer and Sand (1985), they also discover that the U.S. market often has significant impacts on other national stock markets unilaterally because it is the most important information producer.

More recently, Becker, Finnerty, and Gupta (1990) use the opening price to the closing price returns of the Japanese and U.S. stock markets and find that the U.S. market Granger-causes the Japanese market, while the Japanese market has only a small impact on the U.S. market. Campbell and Hamao (1992) find evidence of common movements in expected excess stock returns between the Japanese and U.S. financial markets, suggesting a high degree of integration between the long-term capital markets of these two countries. Also, Drakos and Kutan (2005) suggest that there is a significant transmission of financial shocks between Turkish and Greek market. In addition, Chiou (2011) finds strong evidence that Tokyo, London and New York stock markets are significantly interdependent in terms of equity return volatility.

Overall, previous research on the interactions and integration of financial markets shows that the degree of interdependence among national stock markets increases over time. This result is confirmed by Koch and Koch (1991) who examine the relationships between daily closing index prices of eight national stock markets for the years 1972, 1980, and 1987. The increased degree of market interdependence seems consistent with the increased trade and capital flows across country borders in the past 50 years.

3. Data and Methodology

To examine the return and volatility transmissions of gold prices across Asia, Europe, and North America, we selected Australia, Switzerland, and the U.S. as the representative markets for each of three continents. Because these three markets are in different time zones, they can be used for studying international linkages of financial markets. Also, we chose these three markets because they are consistently among the most active in the world in terms of market size, breadth, depth, liquidity, and foreign participation. Following previous papers in the market-integration literature, the main hypothesis of this study is that major gold markets are interdependent.

To conduct empirical analysis, we obtained the daily opening and closing prices of spot gold contracts for the Australian, Swiss, and U.S. markets from a Wall Street firm over the period 1997-2004 (96 months). All of these prices are expressed in local currency units.

Because holidays and non-trading days in Australia, Switzerland, and the U.S. differ, we first aligned the opening and closing prices by the calendar date for these three markets. We then deleted the dates in which at least one market did not trade. To examine the

pricing transmission of the spot gold contract, we then calculated the intraday return (= (close - open)/open) for each day and for each of the three markets.

Table 1 shows the summary statistics of intraday (open-to-close) returns over the 96-month period for each of three markets. During the sample period, the Australian market has the highest average return (0.0427%) while the Swiss market has the lowest average return (-0.0069%). Interestingly, the Australian market also has the highest standard deviation (0.8767%), followed by Switzerland and the U.S. When comparing the return distributions, we find that while the return distribution of the Australian market is more right-skewed (the largest positive skewness), the Swiss market is more peaked (the largest kurtosis) than those of Australia and the U.S.

Since we are interested in how the gold price transmits continually from one gold market to another, the simple regression model, as used in Becker, Finnerty, and Gupta (1990) which study equity market integration, is appropriate for capturing the pricing transmission. Specifically, we use simple regression models to examine the causal relationships between Australia and Switzerland, Switzerland and the U.S., and the U.S. and Australia, using the daily open-to-close intraday returns and return volatility.

4. Empirical Findings and Interpretations

On a typical business day, the chronological trading sequence is as follows: (1) Australia opens; (2) Australia closes; (3) Switzerland opens; (4) the U.S. opens (a few hours before Switzerland's close); (5) Switzerland closes; and (6) the U.S. closes. There is a trading-hour overlap between Switzerland and the U.S. To investigate the causal relationship between different pairs of gold markets, all regression models in this paper are in the sequence of Australia, Switzerland, and the U.S.

Table 2 presents the regression results using intraday returns in regression models. Panel A shows that although only 6.2% of the variability of the Swiss intraday return can be explained by the variability of the Australian intraday return, the coefficient of the independent variable is significant at the 1% level. Panel B shows that about 84.6% of the variability of the U.S. intraday return can be explained by the variability of the Swiss intraday return, with the slope coefficient significant at the 1% level. Surprisingly, Panel C shows that although the slope coefficient is significant at the 5% level, only 0.29% of the variability of the Australian intraday return can be explained by the variability of the U.S. intraday return. Given three significant slope coefficients, the above three results indicate that when the intraday return of one market is positive (negative), the intraday return of the next market is likely to be positive (negative), too. That is, there are significant interactions between major gold markets in terms of the intraday return.

Because volatility is an important element in option pricing, we are also interested in how return volatility transmits from one market to another market. Table 3 exhibits the regression results, using the volatility of intraday returns for both the dependent and independent variables. Panel A shows that 51.52% of the variability of the Swiss intraday return volatility can be explained by the variability of the Australian intraday return volatility, with the slope coefficient significant at the 1% level. Panel B shows that

about 87.65% of the variability of the U.S. intraday return volatility can be explained by the variability of the Swiss intraday return volatility, with the slope coefficient significant at the 1% level. Similarly, Panel C shows that 53.92% of the variability of the Australian intraday return volatility can be explained by the variability of the U.S. intraday return volatility, with the slope coefficient significant at the 1% level. These results are interesting in that in terms of the intraday return volatility, the Australian market affects the Swiss market positively and significantly, the Swiss market affects the U.S. market positively and significantly, and the U.S. market affects the Australian market positively and significantly.

The findings of this paper have at least four important implications. First, when the intraday return of one gold market can predict the intraday return of another gold market that trades next, it implies that a profitable trading strategy can be adopted to take advantage of the inefficiencies between two gold markets if transactions costs are not considered. Second, portfolio theory suggests that when the correlation between two assets is lower, all else being equal, the portfolio risk decreases. If national gold markets are highly correlated (in terms of intraday returns), then international diversification of gold investments cannot help too much in reducing the portfolio risk of global gold investments. Third, because one key variable in regressions is return volatility, which is one major determinant in option pricing, the strong interactions of gold markets may indicate the integration of gold option markets if such markets exist. Finally, the strong volatility linkages between financial markets should concern national regulators and policy makers. They need to have a good understanding of world financial markets, watch these markets closely, communicate frequently with their counterparties in other countries, and be prepared to handle adverse situations such as financial crises.

5. Summary and Conclusions

This paper studies the lead-lag relationships between three major gold markets over the period 1997-2004, using the intraday-return and return-volatility variables, which are different from prior papers. In terms of the intraday return variable, we discover that three markets are significantly interdependent. When using the variable of the intraday return volatility, we find evidence that the Australian market affects the Swiss market positively and strongly, that the Swiss market affects the U.S. market positively and strongly, and that the U.S. market affects the Australian market positively and strongly.

The findings of this paper have important implications for trading strategies, portfolio management, option markets, and policy making. First, because the intraday return of one gold market can predict the intraday return of another gold market that trades subsequently, exploring the inefficiencies between two gold markets to make a profit may be feasible. Second, when national gold markets are strongly correlated (in terms of intraday returns), international diversification of gold investments can hardly reduce the portfolio risk. Third, the strong interactions of gold markets, in terms of return volatility which is a key element in option pricing, may imply the integration of gold option markets if these option markets exist. Finally, national regulators and policy makers should be concerned about the return volatility linkages between financial markets. In addition to having a good understanding of how world financial markets function and interact, they

need to watch these markets closely and be prepared to handle adverse situations such as financial crises.

Overall, this paper extends the existing literature in market integration by using gold prices to test how one gold market affects another gold market. Our new evidence suggests that, in terms of intraday returns and return volatility, there are high degrees of linkage among the Australian, Swiss, and U.S. gold markets.

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Table 1 Summary statistics of the intraday returns of spot gold contracts in Australia, Switzerland, and the U.S. over the period 1997-2004 (96 months)

Spot contracts (in local currency units)

	Australia	Switzerland	the U.S.
Sample size	2014	2014	2014
Mean (%)	0.0427	-0.0069	0.0090
Standard Dev (%)	0.8767	0.8641	0.8640
Max (%)	8.3170	7.8767	7.8699
Min (%)	-2.9357	-6.0156	-5.3006
Skewness	1.0217	0.3332	0.4213
Kurtosis	8.0228	9.3243	7.2864

Table 2 The results of causality tests using the intraday return in egression models

Regression variable = intraday return of spot gold prices = (close- open)/open
Time period = 1997-2004 (96 months)
* Significant at the 5% level
** Significant at the 1% level
AU = Australia
SW = Switzerland
US = the U.S.

Panel A: # of observations = 2014

SW = -0.0036 + 0.2469(AU)

R^2 = 6.27%

t-value of the X variable coefficient = 11.61**

Panel B: # of observations = 2014

US = 0.0026 + 0.9195(SW)

R^2 = 84.6%

t-value of the X variable coefficient = 105.13**

Panel C: # of observations = 2013

AU = 0.0426 + 0.0543(US)

R^2 = 0.29%
t-value of the X variable coefficient = 2.4034*

Table 3 The results of causality tests using the volatility of intraday returns in regression models

Regression variable = volatility of intraday returns
Time period = 1997-2004 (96 months)
* Significant at the 5% level
** Significant at the 1% level
AU = Australia
SW = Switzerland
US = the U.S.

Panel A: # of observations = 2014

SW = 1.624 + 0.843(AU)

R^2 = 51.52%

t-value of the X variable coefficient = 46.24**

Panel B: # of observations = 2014

US = 0.874 + 0.930(SW)

R^2 = 87.65%

t-value of the X variable coefficient = 119.48**

Panel C: # of observations = 2013

AU = 5.146 + 0.628(US)

R^2 = 53.92%

t-value of the X variable coefficient = 48.51**