Cold Fusion—Hot Metal: An Analysis of the Metals Futures Market Reactions to the Cold Fusion Announcement

Stephen R. Hill
Norman H. Moore
Stephen W. Pruitt

INTRODUCTION

On March 23, 1989, Stanley Pons and Martin Fleischmann rocked the world. At a hastily arranged news conference originating from the University of Utah, Pons and Fleischmann announced that they had successfully achieved a sustainable, energy producing fusion reaction at room temperature. The materials employed in their experiments were staggeringly simple—indeed, little more than a beaker of heavy water, some storage batteries, and a few palladium and platinum rods were used to achieve what hundreds of scientists and billions of dollars had previously failed to accomplish. Across the world, scores of scientific and engineering experiments were hurriedly launched in a race to become the first to confirm the startling results. The news media, whipped to a frenzy by a story unlike any since the advent of the nuclear age, clamored for more and more information about the discovery, its implications, and its unassuming folk-hero inventors. Overnight, Pons and Fleischmann, known hitherto only to a select portion of the scientific community, were proclaimed "new Einsteins" whose genius would usher in an era of unsurpassed technological innovation and a limitless source of clean and inexpensive energy for all mankind. Nirvana, it seemed, had finally arrived.

Of course, fact is seldom as pleasing as fiction, and Pons and Fleischmann's visions of a better world were eventually shattered by the reality of universal condemnation. Long before a special governmental blue-ribbon task force released its final

The authors are grateful to Mark J. Powers and an anonymous referee for numerous helpful comments.

Stephen R. Hill, O.D. is the President of Hill Commodities Research in Indianapolis.

Norman H. Moore is an Assistant Professor of Finance at Indiana University.

Stephen W. Pruitt is an Assistant Professor of Finance at Indiana University.

The Journal of Futures Markets, Vol. 11, No. 3, 385–397 (1991)
 CCC 0270-7314/91/030385-13$04.00

report on the cold fusion process on November 3, 1989, Pons and Fleischmann's technological Eden had been transformed into a modern-day Paradise Lost.

RESEARCH OBJECTIVES

In an age where even minor changes in supply or demand can profoundly affect metals prices, it should come as no surprise that financial press reports following Pons and Fleischmann's March 23 announcement suggested frenzied activity in the futures markets for palladium.[1] Accordingly, this study attempts to scientifically document the reactions of the palladium market around the time of the announcement to determine whether the increases in palladium prices, volatility, and contract trading volume noted by the financial press were, in fact, statistically and economically significant. Since the purpose of this study is to examine the efficiency of the futures markets for metals in response to the cold fusion announcement, and since Pons and Fleischmann's discovery was eventually discredited, market efficiency dictates that the price of palladium, regardless of the extent of its post-announcement increases, return to levels similar to those experienced prior to March 23.

While questions concerning the reactions of palladium futures to the cold fusion announcement are interesting, far more important, from a market efficiency standpoint, are the reactions elicited by participants in the futures markets for other metals such as copper or gold and, particularly, platinum. As will be discussed later, the platinum rods employed in Pons and Fleischmann's experiments were utilized solely as a matter of convenience and served only to complete a hydrolytic circuit. All of the "cold fusion effect" was supposedly isolated in the atomic lattice of the palladium rods. Given the dipolar function of the two metals in Pons and Fleischmann's work, the precepts of market efficiency dictate vastly different price, volatility, and contract trading volume effects in the futures market for palladium *vís a vís* those of platinum. Indeed, documentation of abnormal platinum price and/or volatility effects in response to the cold fusion announcement would provide strong evidence of inefficiency in the futures market for platinum. Similarly, since gold, silver, aluminum, or copper were in no way involved in Pons and Fleischmann's work, evidence of abnormal cross-market price behavior in the futures markets for these metals around the time of the March 23 announcement would also suggest key efficiency failures in the markets for these important metals.

Although the present study seeks to examine the efficiency of the futures markets for metals in response to a single evolving event, the implications of the research are broader than this single-event emphasis might initially suggest. Indeed, for the futures markets of any commodity grouping to prove generally price efficient with respect to *all* information, they must also prove efficient with respect to *any* given information set. Thus, documentation of efficiency failures in response to the cold fusion announcement would suggest that the market may be likely also to misprice other information unrelated to the specific event examined. However, to the extent that the market proves itself able to properly interpret the infor-

[1]The impact of the cold fusion announcement was not lost by the financial press. Numerous stories in both *The New York Times* and *The Wall Street Journal* reported that trading activity in the palladium market had pushed prices for the metal to the highest levels since early 1980, when "...rampant inflation, international political tension, and an abortive attempt by the Hunt brothers of Texas to corner the silver market drove precious metals to dizzying peaks." (*NYT*, 4/14/89).

mation presented by complex, evolving phenomena such as the cold fusion announcement and subsequent developments, market participants and governmental authorities alike may take considerable comfort in the knowledge that the prices of important commodities such as metals are likely to be very efficient indeed. At a time when increasing numbers of influential politicians and certain elements of the federal bureaucracy are suggesting a need for enhanced governmental regulation of the futures markets, such knowledge is very relevant.

A BRIEF CHRONOLOGY OF THE COLD FUSION FUROR

Prior to Pons and Fleischmann's press conference, the prospect of achieving a controlled fusion reaction at anything close to room temperatures seemed highly remote. As early as 1979, Dr. Steven Jones of Brigham Young University had received financial support from the Department of Energy to develop a process known as piezoelectric fusion. In Jones' research, the electron in deuterium atoms (the hydrogen isotope employed in the creation of "heavy" water) was replaced by a much heavier particle known as a muon. Although Jones' process did appear to produce isolated fusion reactions, the extremely short life of the created muons (two-millionths of a second) suggested that his discovery would never amount to anything more than a scientific curiosity.

Pons and Fleischmann's cold fusion procedures differed from those employed earlier by Jones in several respects. First, Pons and Fleischmann claimed to have achieved a *sustainable* fusion reaction, something Jones' research had indicated was all but impossible. Second, the research announced on March 23, did not require the extremely costly mass production of muons. Third, Pons and Fleischmann's experiments reportedly produced far more energy than they consumed. Jones' work never suggested a finding of such significance. The final and most important difference between the two procedures is, of course, the fact that Jones' experiments appeared to produce fusion reactions at room temperatures—Pons and Fleischmann's almost certainly did not.

Media coverage of the cold fusion announcement was immediate and thorough. Following the March 23, 1989 press conference, scores of newspapers throughout the United States and abroad carried lengthy articles describing the few details known at the time and the potential implications of the discovery. Despite the quantity of coverage, however, most of the stories published in the major media retained a rather skeptical tone with news of the potential advance counterbalanced by interviews with doubting nuclear physicists. After all, reasoned most of the scientific community, the new procedure had yet to be confirmed by independent researchers. In fact, Pons and Fleischmann's original paper had yet to be formally published in the scientific press.

Following the initial media uproar, coverage of the cold fusion discovery ceased to be deemed "newsworthy" until April 9, 1989, when a team of 10 scientists at Texas A&M University announced that they had replicated several of Pons and Fleischmann's more important results, particularly with regard to the quantity of energy produced by the reaction. The following day, April 10, 1990, researchers at Georgia Tech University announced that they had detected the release of neutrons in similar experiments.

The first solid evidence that experimental flaws resulted in the Pons and Fleischmann's results was reported on April 13, 1990. At that time, the Georgia

Tech team announced that its neutron detector was highly temperature sensitive (a previously unknown phenomenon). Almost overnight, the most significant independent empirical verification of the Pons and Fleischmann results vanished.

All was not lost, however. In a scientific furor unmatched since the "discovery" of polywater[2] in 1962, hundreds of experiments were launched in an effort to either confirm or refute Pons and Fleischmann's startling findings. Not surprisingly, news reports of the results of these experiments flowed in rapidly over the next several weeks. Some of these experiments supported Pons and Fleischmann. Others refuted all or part of their claims. By the middle of May 1989, however, it was becoming increasingly apparent that the original cold fusion announcement was merely the result of considerable (con)fusion on the part of Pons and Fleischmann.

The final blow came on November 3, 1989, when a panel of experts convened by the federal government stated that there remained no convincing evidence that low-temperature nuclear fusion would ever lead to useful sources of energy. In its final report, the 22-member scientific committee strongly opposed additional governmental funding for cold fusion research.

The Appendix presents a daily synopsis of the major news releases related to the cold fusion furor as reported in *The New York Times* from the date of its first announcement on March 23, 1989 to November 3, 1989, the date of release of the government's final negative report.[3]

A DESCRIPTION OF THE DATA AND EMPIRICAL METHODOLOGY

Data

In an effort to assess the informational content of the cold fusion announcement and subsequent developments, intermediate-term (contracts for August, September, and October 1989 delivery) closing futures prices of six metals are obtained through the Dow Jones Information Retrival Service. (The actual contracts included in the analysis and the exchange are listed in Table I.) Daily returns for each of the six metals are calculated from the raw price data as follows:

$$R_{i,t} = (P_{i,t} - P_{i,t-1})/P_{i,t-1}, \tag{1}$$

where $R_{i,t}$ is the daily holding period return on the ith metal, and $P_{i,t}$ and $P_{i,t-1}$ are the futures prices of the ith metal on event days t and $t - 1$, respectively.

[2]In 1962, Nikolai Fedyakin, a researcher from an obscure Soviet laboratory, reported that when water vapor condenses as liquid in very fine glass tubes, it forms a viscous fluid heavier than ordinary water and with some very peculiar properties. This new "water" was dubbed polywater, and its discovery galvanized the world press, because it implied that if polywater should get out of control, the world's water might be converted to jelly with all life extinguished. Famed British crystallographer J. D. Bernal called the discovery of polywater "...the most important physical-chemical discovery of the century." The bubble burst in the early 1970s, when researchers at Bell Laboratories and the Los Alamos National Laboratory proved, by very careful analysis, that there was actually no water in polywater at all—it consisted solely of a mixture of impurities, including sodium, chlorine, potassium, and other elements.

[3]All date lines have been adjusted to reflect information available for trading in the palladium futures market. Thus, for example, a story reported in the *New York Times* on March 24, 1989 stating that "...at a press conference yesterday morning," would be shown in the Appendix as having occurred on March 23. Not reported in the Appendix are summarizing articles which dealt with the implications of cold fusion and articles concerning Pons and Fleischmann as personalities.

Table I
METALS AND FUTURES CONTRACT MATURITIES INCLUDED IN THE ANALYSIS

Metal	Expiration Date	Exchange
Gold	8/89	CBT
Silver	8/89	CBT
Copper	9/89	CMX
Aluminum	9/89	CMX
Platinum	10/89	NCE
Palladium	9/89	NYM

The return data for four of the metals (gold, silver, aluminum, and copper) are then combined into an equally weighted index which serves as a "market" proxy for changes in the general level of commodities prices independent of that induced by the cold fusion announcement. These metals are included in the index since, *a priori,* there would appear to be no reason for the cold fusion announcement to lead to changes in their prices other than via trivial substitution effects.[4] Since both palladium and platinum were employed in the fusion experiments of Pons and Fleischmann, these metals are, of course, treated separately in the analysis which follows.

Empirical Methodology

To gauge the impact of any event on metals futures prices, a model of normal return behavior must be developed. Although a variety of approaches are employed in previous tests of futures market pricing rationality, market-adjusted technologies (that is, techniques which explicitly adjust for changes in the overall level of *all* futures prices due to factors such as inflation or other market-wide influences) are particularly well-suited for tests in which the event(s) under study occur at identical moments in calendar time.[5] In an earlier *JFM* study, Pruitt, Tawarangkoon, and Wei (1987) employ the market-adjusted returns technique to analyze the effects of the Chernobyl nuclear accident on the commodity futures prices of grain products reportedly produced in quantity in the region of the reactor. Although the market-adjusted returns technique does effectively adjust for changes in the overall level of futures prices due to market-wide influences such as inflation, it neglects the possibility that the prices of differing commodity items might respond with differing sensitivities to identical changes in the underlying economic fundamentals. By contrast, the market-model methodology outlined explicitly corrects for such problems.[6]

[4]In addition to the created metal index, the CRB commodity index was also employed as a market proxy to assess the robustness of the study. No substantive differences were observed between the two sets of results.

[5]Brown and Warner (1985) present compelling evidence for the use of market-adjusting abnormal return methodologies for studies of events occurring in close temporal proximity.

[6]Despite the justification of the theoretically preferable market-model methodology employed in the present study, it should be noted that the results remain virtually identical regardless which of the two return-generating models is actually employed in the analysis.

Mathematically, abnormal returns for event day t for either the platinum or palladium futures returns series are calculated as follows:

$$AR_{i,t} = R_{i,t} - (\alpha_i + \beta_i R_{m,t}) \qquad t = -15\ldots100, \tag{2}$$

where α_i and β_i are ordinary least squares regression coefficients calculated separately for each metal over the interval from event days -90 to -16, relative to the cold fusion announcement date of $t = 0$.

Cumulative abnormal changes in palladium and platinum returns from event day T_1 to T_2 are defined as:

$$CAR_i = \sum_{t=T_1}^{T_2} AR_{i,t}. \tag{3}$$

Test statistics for the daily abnormal returns for each metal for each event day t, and the cumulative abnormal returns over event intervals from T_1 to T_2, are calculated via procedures identical to those employed previously by Pruitt, Tawarangkoon, and Wei (1987) and are not reproduced here. In all cases, the test statistics are assumed distributed asymptotically unit normal (t).

EMPIRICAL RESULTS

Price Effects

Table II presents a summary of the actual daily returns, daily abnormal returns, daily abnormal return test statistics (t), and cumulative abnormal returns for palladium futures prices around the time of the cold fusion announcement. As might be expected, there is no evidence of information leakage in the pre-event interval from event days -15 to -1. The less than 2% cumulative abnormal return registered over this interval ($t = 0.29, P > 0.10$) does not differ from what would be expected simply by random chance.

Although the cold fusion discovery was announced on March 23, the first statistically significant increase in palladium futures prices did not occur until March 27 (event day +1). This slight delay in market response is interesting in view of Pons and Fleischmann's press conference statement that "...the discovery will be relatively easy to make into a usable technology," but is almost certainly due to an inherently skeptical attitude on the part of futures markets traders concerning the actual merits of the discovery. What is clear, however, is the fact that the almost 15% excess return over the first five trading days following the announcement (event days +1 to +5) was not due to random chance. The test statistic (t) for this cumulative abnormal return increase is 4.17 ($P < 0.01$).

As the results presented in Table II indicate, the maximum price level reached in the palladium futures market occurs on event day +14, when the cumulative abnormal return reached 24.69%. From this point, the general trend is clearly, if inconsistently, downward, finally reaching a level of 4.25% by event day +100. Thus, while the price increases registered in the palladium futures market in response to the cold fusion announcement are very sharp and rapid, they are temporary. This result is precisely what is expected given the initial furor and eventual outcome of the cold fusion technology and, as such, the results are supportive of rational pricing in the context of the palladium futures market.

While it is clear from the previous discussion that the cold fusion announcement led to economically and statistically significant price increases (and, subsequently,

Table II
DAILY RETURNS, DAILY ABNORMAL RETURNS, DAILY STANDARDIZED ABNORMAL RETURNS, AND CUMULATIVE ABNORMAL RETURNS FOR INTERMEDIATE MATURITY PALLADIUM FUTURES CONTRACTS AROUND THE TIME OF THE COLD FUSION ANNOUNCEMENT

Event Day	Calendar Date	RET(J)	AR(J)	STDAR(J)	CAR
−15	3/2	−.00106	−.00124	−.08332	−.00124
−5	3/16	.00248	.00335	.22573	.00677
−4	3/17	.00637	.00599	.40309	.01276
−3	3/20	.00738	.00890	.59927	.02167
−2	3/21	.00000	.00025	.01672	.02191
−1	3/22	−.00558	−.00520	−.35008	.01671
0	3/23	.00983	.01048	.70500	.02719
1	3/27	.04171	.04207	2.83106*	.06926
2	3/28	−.00801	−.00723	−.48666	.06202
3	3/29	.04036	.04085	2.74885*	.10287
4	3/30	.03136	.03220	2.16691*	.13507
5	3/31	.03072	.03077	2.07063*	.16584
6	4/3	−.02281	−.02135	−1.43682	.14449
7	4/4	.00031	.00026	.01760	.14475
8	4/5	.03205	.03230	2.17357*	.17705
9	4/6	.01417	.01464	.98506	.19168
10	4/7	−.03567	−.03581	−2.40985*	.15587
11	4/10	.00247	.00184	.12370	.15771
12	4/11	.02245	.02296	1.54492	.18067
13	4/12	.03098	.03091	2.08030*	.21158
14	4/13	.03501	.03528	2.37425*	.24686
15	4/14	−.00282	−.00238	−.16023	.24448
20	4/21	−.01857	−.01843	−1.24035	.20554
30	5/5	.01540	.01636	1.10097	.12552
40	5/19	−.00390	−.00305	−.20550	.12224
50	6/5	.00224	.00366	.24642	.15400
60	6/19	.00742	.00745	.50114	.15621
70	7/3	.00159	.00232	.15603	.17135
80	7/18	.00166	.00120	.08045	.13084
90	8/1	−.02721	−.02688	−1.80904	.05885
100	8/15	.00663	.00664	.44671	.04251

*Significant at the 5% level (two-tailed test).

decreases) in the palladium futures market, a far more interesting question, from the standpoint of market efficiency at least, concerns the impact of the announcement on platinum futures—the other metal employed in Pons and Fleischmann's experiments. As illustrated by the information presented in Table III, and similar to the case of palladium futures prices, there is no evidence of abnormal platinum futures price activity in the pre-event interval from event days −15 to −1. Although the cumulative abnormal return for day −1 exceeds 3.7%, the test statistic for this increase does not approach statistical significance ($t = 0.59$, $P < 0.10$). Further, while the level of the cum lative abnormal return fluctuates considerably in the 15-day period following the cold fusion announcement, these price level changes are not statistically significant when measured over 10-day intervals. Finally, casual inspection of the cumulative abnormal return totals for platinum futures prices at each of the 10-day intervals from event days +20 to +100 indicates that the cold fusion announcement did not affect platinum prices to any significant degree.

The observed differential performance between palladium and platinum is indicative of a highly informationally efficient futures market due to the crucial (insignificant) role played by palladium (platinum) in Pons and Fleischmann's cold fusion experiments. Whereas both palladium and platinum rods were employed in their test cells, the palladium rods, due to their well-known hydrogen absorption characteristics, served as the site for the "cold fusion effect" supposedly observed by the experimenters.[7] The platinum rods served merely to complete the circuit and were employed as a conductor only because of the high concentration of ionizing acid in the test cells.

Volatility and Volume Effects

In an effort to further explore the impact of the cold fusion announcement and subsequent furor on the futures markets for metals, additional tests involving price volatility and contract trading volume are performed. Tables IV and V summarize the results of these empirical tests. Futures contracts of all maturities are included in these tests.

Table IV presents an analysis of the impact of the cold fusion announcement on the daily standard deviation of returns of the six studied metals over the 50-day pre-announcement (event days −50 to −1) and post-announcement (event days +1 to +50) intervals.[8] Whereas both silver and platinum (with increases of 17.5% and 14.0%, respectively) register relative increases in return variability around the time of the cold fusion announcement, these changes are very small when compared with the 117% increase in palladium variability experienced over the identical period of calendar time. Further, as reported in Table IV, only that volatility increase registered in the palladium futures market is statistically significant at the 5%

[7]Palladium has long been useful as a catalyst in certain chemical reactions involving oxygen and hydrogen. Indeed, under suitable conditions, palladium absorbs more than 900 times its own volume of hydrogen.

[8]Although virtually identical results are achieved when the pre- and post-event windows are expanded to the 90-day limit of the intermediate-maturity futures contracts, virtually all of the dramatic price activity of the palladium market was confined to the first 50 days following the cold fusion announcement. Since our goal was to determine whether the unusual pricing dynamics in the palladium market were transferred to the other studied metals, it was felt that limiting our analysis to a comparison of event days −50 to −1 with event days +1 to +50 provides the strictest possible test of market efficiency.

Table III

DAILY RETURNS, DAILY ABNORMAL RETURNS, DAILY STANDARDIZED ABNORMAI RETURNS, AND CUMULATIVE ABNORMAL RETURNS FOR INTERMEDIATE MATURITY PLATINUM FUTURES CONTRACTS AROUND THE TIME OF THE COLD FUSION ANNOUNCEMENT

Event Day	Calendar Date	RET(J)	AR(J)	STDAR(J)	CAR
−15	3/2	.00624	.00504	.30823	.00504
−5	3/16	.01432	.01542	.94370	.03449
−4	3/17	.00843	.00678	.41500	.04127
−3	3/20	−.00436	−.00182	−.11158	.03945
−2	3/21	.00091	.00065	.03964	.04010
−1	3/22	−.00292	−.00289	−.17667	.03721
0	3/23	−.01683	−.01622	−.99214	.02099
1	3/27	.00112	.00109	.06676	.02208
2	3/28	−.02639	−.02549	−1.55981	−.00341
3	3/29	−.00115	−.00089	−.05474	−.00431
4	3/30	−.00076	.00027	.01642	−.00404
5	3/31	.01588	.01517	.92792	.01113
6	4/3	.00113	.00354	.21631	.01466
7	4/4	−.00884	−.00976	−.59723	.00490
8	4/5	−.00019	−.00045	−.02757	.00445
9	4/6	−.00228	−.00206	−.12597	.00239
10	4/7	.00190	.00079	.04824	.00318
11	4/10	−.00019	−.00239	−.14601	.00079
12	4/11	.00936	.00961	.58815	.01041
13	4/12	.00755	.00619	.37883	.01660
14	4/13	.04483	.04463	2.73025*	.06123
15	4/14	.01591	.01606	.98286	.07729
20	4/21	−.00812	−.00863	−.52787	.04673
30	5/5	−.00818	−.00689	−.42151	.02186
40	5/19	−.00339	−.00233	−.14234	−.03454
50	6/5	−.01194	−.00963	−.58890	−.01917
60	6/19	.01319	.01244	.76111	−.02870
70	7/3	.01357	.01436	.87843	−.00295
80	7/18	−.00839	−.01024	−.62621	−.00239
90	8/1	.00398	.00388	.23756	−.00947
100	8/15	.02155	.02076	1.26992	−.02403

*Significant at the 5% level (two-tailed test).

Table IV
PRE-EVENT (EVENT DAYS −50 TO −1) AND POST-EVENT (EVENT DAYS +1 TO +50) STANDARD DEVIATIONS OF DAILY RETURNS AND F-STATISTIC TESTS OF VARIANCE EQUALITY OF AGGREGATED (ALL MATURITIES) FUTURES CONTRACTS FOR SIX METALS AROUND THE COLD FUSION ANNOUNCEMENT

Metal	Pre-Event Standard Deviation	Post-Event Standard Deviation	F-Test of Variance Equality
Gold	0.0071	0.0061	0.7488
Silver	0.0114	0.0134	1.3821
Copper	0.0206	0.0200	0.9411
Aluminum	0.0163	0.0151	0.8550
Platinum	0.0407	0.0464	1.3047
Palladium	0.0131	0.0285	4.7659

Note: F-Statistic values (5% level): 1.60 and 0.63.

Table V
MEAN PRE-EVENT (EVENT DAYS −50 TO −1) AND POST-EVENT (EVENT DAYS +1 TO +50) FUTURES CONTRACT DAILY TRADING VOLUMES AND TEST STATISTICS OF AGGREGATED FUTURES CONTRACTS (ALL MATURITIES) FOR METALS AROUND THE COLD FUSION ANNOUNCEMENT

Metal	Mean Daily Pre-Event Contract Volume	Mean Daily Post-Event Contract Volume	t-Test of Change in Mean
Gold	824.7	184.0	−3.61
Silver	962.3	903.7	−0.34
Copper	10694.0	9128.0	−2.27
Aluminum	4.8	3.1	−1.06
Platinum	5464.5	5581.3	0.19
Palladium	729.7	1678.0	5.45

level.[9] The fact that the large volatility increases registered in the palladium market did not lead to undesirable volatility perturbations in the prices of other metals (particularly platinum) suggests strong pricing rationality in the context of the studied metals markets.

The results of the mean daily contract trading volume tests summarized in Table V mirror the volatility responses discussed previously. Again, the fact that the very large increases in relative trading volume observed in the palladium futures market in response to the cold fusion announcement did not lead to increases in trading volume of the remaining five metals (again, particularly that of platinum) suggests strong support for the efficiency of the futures market for metals. Whether the decreases in trading volume observed in the gold, silver, copper, and aluminum markets following the announcement were due to arbitrage shifts from these metals

[9]The F tests of variance equality are conducted as follows:

$$F_{(50,50)} = \mathrm{VAR}_{(+1,+50)}/\mathrm{VAR}_{(-50,-1)}.$$

into palladium is, at this point, strictly a matter conjecture. However, in each case, the mean level of daily total contract open interest for these metals registers statistically significant declines in the post-event interval, relative to the levels experienced over event days −50 to −1.[10]

CONCLUSIONS

Stanley Pons' and Martin Fleischmann's March 23, 1989 announcement of their ability to create sustained, energy-producing fusion reactions at room temperature resulted in a scientific frenzy perhaps unique in this century. This study attempts to quantitatively analyze the impact of this complex, evolving event on the futures markets for metals.

As would be expected given the obvious potential increase in demand from the cold fusion "breakthrough," palladium prices initially soared in the weeks following the announcement. Further, palladium prices returned to their pre-announcement levels once it was determined that the cold fusion technology, if it existed at all, would likely never result in the production of useful quantities of energy. Both of these results are fully consistent with the notion of an informationally efficient futures market for palladium. The fact that prices of platinum, the "other" metal employed in Pons and Fleischmann's experiments, did not respond to the announcement, is similarly consistent within the context of an efficient futures market. This is true since platinum's role is that of an electrical conductor in the experiments, and not as the site of the apparently observed fusion reactions.

Tests of changes in daily price volatility and daily contract trading volume clearly suggest that the cold fusion furor resulted in large changes in the characteristics of the palladium futures market. Indeed, both the daily standard deviation of price returns and mean daily contract trading volume more than doubled in the post-announcement period when compared with pre-announcement levels. The fact that the futures markets for gold, silver, aluminum, copper, and, particularly, platinum remained fully isolated from the changes observed in the palladium market are completely consistent with the implications of informationally efficient futures markets for metals since, *a priori,* there would appear to be no rational reason to expect unusual perturbations in the markets for these metals other than through trivial substitution effects.

In summary, while this study is quite clearly focused upon an analysis of a single economic event, the results achieved would appear to provide no basis for the con-

[10]Tests for changes in mean daily contract open interest levels comparing event days −50 to −1 with +1 to +50 yielded the following results:

Metal	Pre-Event Mean Daily Open Interest	Post-Event Mean Daily Open Interest	*T*-Statistic
Gold	2344.1	1684.6	−4.35
Silver	10008.2	9195.9	−8.82
Copper	34420.6	32678.0	−3.53
Aluminum	166.2	143.8	−9.19
Platinum	19219.2	19788.4	2.33
Palladium	6624.9	8924.4	15.85

As should be evident from inspection of the figures presented above, with the exception of palladium, the large *t*-statistics for the changes in open interest levels for most of the metals are due to extremely small relative variances rather than large shifts in the means.

cerns expressed by many observers that enhanced federal regulation of the commodity futures markets is necessary. Rather, the results of this study are fully consistent with the view that the futures markets for metals are both rational and efficient.

Bibliography

Brown, S., and Warner, J. (1985): "Using Daily Stock Returns: The Case of Event Studies," *Journal of Financial Economics,* 11:3–31.

Pruitt, S., Tawarangkoon, W., and Wei, J. (1987): "Chernobyl, Commodities, and Chaos: An Examination of the Reaction of Commodity Futures Prices to Evolving Information," *Journal of Futures Markets,* 7:555–569.

Appendix

DAILY SUMMARY OF DEVELOPMENTS OF THE COLD FUSION PROCESS AS REPORTED IN THE PAGES OF THE EASTERN EDITION OF *THE NEW YORK TIMES*

Calendar Date	Development Summary
3/23/89	Pons and Fleischmann announce cold fusion discovery. Many experts express grave doubts.
3/28/89	First detailed descriptions of the cold fusion procedure presented.
4/1/89	Cold fusion experiments by Dr. Steven Jones at Brigham Young University are reported. Jones emphasizes the lack of energy produced in his experiments.
	Hungarian scientific team announces success in cold fusion efforts.
4/9/89	Texas A&M researchers announce partial success in replication efforts. Cite excess heat production from test cell.
4/10/89	Georgia Tech researchers announce the discovery of excess neutrons from cold fusion tests.
4/12/89	Pons discusses details of experiment at National Meeting of American Chemical Society.
4/13/89	Georgia Tech team announces flaw in their replication of cold fusion experiment. Neutron finding cast in serious doubt.
	Graduate students at the University of Washington report tritium release in cold fusion test cell.
4/18/89	Pons claims that 60 scientists have informed him of successes in replication efforts.
	Italian team reports achieving cold fusion via new technique involving temperature and pressure changes.
	Stanford University researchers report excess heat from cold fusion test cell.
4/19/89	Indian team reports replication success.

4/25/89	Utah researchers report cold fusion processes may keep continents in motion.
	University of Utah seeks $25 million from US to continue cold fusion experiments.
4/26/89	US House panel hears debate on cold fusion.
4/27/89	Large numbers of US companies reported joining cold fusion race.
4/28/89	Brookhaven and Yale scientists report key failures in cold fusion replication efforts.
5/1/89	National meeting of American Physical Society pans cold fusion efforts. Teams at Cal Tech, MIT, Berkeley, Oak Ridge, and Rochester report failures to replicate cold fusion tests.
5/2/89	"Devastating" blows to cold fusion dealt by annual meeting of nuclear physicists.
5/8/89	British cold fusion effort fails.
5/9/89	Pons and Fleischmann defend fusion experiment before Annual Meeting of Electrochemical Society.
5/23/89	Scientists at first federal conference on cold fusion told of failure to find key byproducts. Pons and Fleischmann fail to attend conference.
5/24/89	Federal conference continues—reports of successes by some labs are immediately challenged by others.
5/30/89	Headline: "At conference on cold fusion, the verdict is negative." Procedure, if it exists at all, likely to be nothing more than curiosity, scientists claim.
6/6/89	Federal team visits Utah lab, but divides on claims.
6/14/89	Efforts by the Los Alamos National Laboratory and Utah researchers to confirm cold fusion results collapses.
6/20/89	British government abandons cold fusion quest.
6/26/89	Team at Los Alamos reports new evidence in support of cold fusion claims.
6/29/89	G.E. and University of Utah join in cold fusion experimentation.
7/13/89	Preliminary report from federal panel appointed to investigate cold fusion claims recommends no new research funding.
8/7/89	State of Utah votes $4.5 million for further cold fusion research.
10/19/89	Scientists at National Science Foundation and Electric Power Research Institute report recent test results justify further cold fusion research.
11/3/89	Final report of team of experts convened by US government concerning cold fusion is released. Panel recommends no large scale funding of work, citing no evidence process will ever produce usable energy.