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Analysis of Linkage Dynamics between Commodity and Stock Markets in India using entropy theory

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The temporal relationship between the commodities market and the stock market has a lot of implications for not only the participants of the markets but also for the policy makers and the producers of the commodities and, in the case of developing nations, for the economy as a whole. This relationship may be studied using various methods and by identifying lead – lag relationship between the values of representative indices of the markets. In this paper, the dynamics of such information transfer among the commodities spot, the commodities derivatives, the stock and the stock derivatives markets in India are studied using the information theoretic concept of entropy, which captures non-linear dynamic relationship also.

Keywords : *causal relationship, non-linear characteristics, transfer entropy, mutual information,time delay*

Introduction

The listing of various commodities and commodity indices on commodity exchanges and the listing of ETFs (Exchange Traded Funds) which track commodities and commodity indices on stock exchanges, offer new instruments for investment and hedging purposes, improve the function of price formation and facilitate arbitrage trading between the commodity and the stock exchanges. This will benefit not only the market participants of both the exchanges but also the industry and the financial community as a whole. Kuchiki (1990) has found that the commodities pricing mechanism has basically changed since the 1970's and that the main characteristics of the changes are as follows.

- The cyclical periods of commodity prices have become shorter and the amplitudes of the cycles have intensified.
- A linkage of primary commodity markets with the financial markets (stocks, bonds and currencies) has been formed, though the relationships have time differentials (leads or lags).
- The prices of crude oil, gold, T-bills and stocks provide the same periods of cycles.

According to Legomsky (2008), the postulation that stock market returns and commodity prices may be linked rests on two key assumptions – (a) the explosive growth in emerging market countries is a major driver of commodity prices (b) commodity prices are major determinants of emerging market economic growth and therefore, of equity returns. In spite of the intuitive appeal, the relationship between commodities and stock markets may be less straightforward than is generally assumed.

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Giamouridis and Tamvakis (2001) have observed that the relationship between return and volatility in the commodity markets is the inverse of that observed in the stock markets. The inverse relationship may exist under specific circumstances. For instance, geopolitical concerns would pull the stock market down, but prove positive for energy and metals because of the potential for supply disruption. Further, changes in commodity prices do impact the share prices of companies, whether they are commodity producers or consumers. For instance, a rise in steel prices would be positive for producers but not for consumers.

Vanguard Investment Counseling and Research (2008) has studied the correlation between the performance of the Goldman Sachs Commodity **Index** (GSCI) and the **Morgan Stanley** Capital International (MSCI) Emerging Markets Index from 1988 through 2006 and found that while there have been periods of similar performance, generalizing the relationship between commodity prices and stock market performance in emerging countries is difficult. According to the study, the strong relationship from 1994 through 1999 may have been more coincidental than causal and there are many other forces that impact a particular market in any given period.

Murphy (1991) has reported that during June 1988 - June 1989, the statistical correlation between bond futures prices and futures prices of the New York Stock Exchange Composite Index was + 94% and bond prices showed - 91% correlation to commodities and + 94% correlation to stocks, which demonstrate the fulcrum effect of the bond market. Thus the commodity markets become indirectly linked to stocks through their influence on the bond market.

In this article, the dynamics of such linkage, if any, between commodity and stock markets in India are studied using the information theoretic concept of entropy. One version of entropy viz. transfer entropy which is used in this article captures not only the dynamic aspects but also the non-linear characteristics of such relationship. In order to appreciate the evolution of the organized commodity derivatives market in India, a brief history of the same is given in Annexure I.

A Comparison of Commodity Derivatives and Stock Markets in India

The most important policy goal in commodity derivatives trading is safeguarding of the interests of producers (particularly farmers), consumers as well as manufacturers and other functionaries in the supply-chain. Unlike the securities market where the impact of the price volatility is on the willing participants in the market, the impact of sharp rise or fall in price of commodities is borne by the entire economy. If commodity derivatives markets function well, then some of the core policy goals of addressing volatility of agricultural prices may be addressed in a market-oriented fashion.

There is close resemblance between commodity derivatives and securities derivatives in so far as trade practices and mechanism are concerned. A commodity futures contract is tradable and fungible. Most of the commodity futures contracts are squared off and do not result in delivery. In this case, the users of commodity futures markets are using the contracts for purely financial purposes. Thus, almost all commodity futures contracts are akin to securities.

Though derivatives in commodities resemble securities and financial futures and provide many of the same economic functions, there are some major differences.

- There are actively traded spot markets for financial instruments and prices are generally not discovered in the futures market. Further, futures contracts are often settled from spot prices or spot price indices.
- The spot market of securities is highly organized and effectively regulated by even agencies other than SEBI like the Department of Company Affairs whereas the spot market for agricultural commodities is not so organized, though there are many laws to curb free markets in the agricultural sector.
- The settlement and delivery process in the two markets is different. While financial futures are fully cash settled in India, commodity futures are settled either in cash or physical form. The moot point about cash settlement is that of well-respected and trusted settlement prices. If there is an underlying with a highly fractured spot market, where good data are not available, then it is difficult to construct a well-respected settlement price. In this case, a cash settled contract will not be trusted and a physically settled contract will be preferred.
- The costs involved in dealing with physical goods (or warehouse receipts) are always higher than the costs of moving money. Further, the scale and mode of depositing / warehousing are structurally different.
- There are other supplementary legislations such as the Depository Act which make the functioning of stock markets smooth. In case of commodity futures markets such supplemental institutions (like dematerialized warehouse receipts) do not exist which makes the delivery mechanism complex.
- Agricultural commodities have different shelf life, demand-supply factors, and price determination. Precious metals also have different market conditions.
- Unlike the stock market, the factors affecting commodity prices are more complex and commodity-specific.
- Indirect taxation cascades in commodities and income tax treatment also is different. Loss due to speculation is not adjusted in corporate taxation in case of commodity futures but is only carried forward.
- The investor base and the number of registered brokers in the stock market are much larger when compared to the commodity derivatives market in India.
- Financial institutions are not permitted to deal in commodity derivatives though they can invest in a restricted way in the stock market in India. Banks and financial institutions are considered as stable institutions to provide market-making services, all over the world.
- Both commodity and financial derivatives are traded in the same exchanges world over whereas in India, only financial derivatives are traded in stock exchanges and there are separate commodity derivatives exchanges.

- The regulator of commodity exchanges does not have jurisdiction over spot markets even in non-agricultural commodities, like bullion and other metals. Both the spot and the derivatives segments of stock exchanges are regulated by SEBI.

It is apprehended that the possibilities of interactions are limited in so far as commodity futures trading requires highly specialized knowledge which is different from that required for securities trading. It is also stated that the firms that engage in commodity futures trading differ from the firms that engage in securities trading.

Implications of Interactions

The identification and quantification of causal relationships between the stock and the commodity derivatives markets, by analyzing the values over time of a nation's stock market index, stock derivatives prices, commodity spot price index and the commodity derivatives index, furthers the understanding of the markets' internal dynamics. The inter-linkage of the two markets has a potential for providing growth impetus to commodity derivatives and opening new avenues of business opportunities to the securities market participants thereby deepening and broadening the market.

If the causal relationship from a market to the other is not detected, then informational efficiency exists in the second market. If causality is not found in both the directions, then the two markets are independent of each other. Presence or absence of causal relationship has a lot of implications including the following, for all the participants of the markets.

- At present, the government engages in many policy measures which interact with agricultural spot markets. These policies are unaffected by the question regarding the integration of commodity futures and stock markets. Whether the two markets are closely integrated or not has no impact upon the conduct of policies such as public procurement, support prices, etc. To the extent that interactions between commodity derivatives and stock markets helps strengthen price discovery on the commodity derivatives markets, this will facilitate the design of public policy. If shortages or gluts are expected to take place on a future date, this will be revealed in the futures price well ahead of time. This information will help the policy-makers to respond pro-actively, if desired.
- If there is feedback in both the directions, then investors may predict the behaviour of one market using information on the other market. Since an impulse in a market is reflected quickly in the other market, policy intervention becomes more effective in the desired direction within a reasonable time horizon.
- If the markets are not related, investors may reduce risk exposure by diversifying their portfolios across the markets.

Methods to Study the Interaction

The interaction between the two markets is studied using a set of simultaneously recorded variables – value of the stock index, the commodity derivatives index and derivatives contracts on those indices - over a period of time. The information generation in the markets and the rate

of information exchange among these markets are measured using the time series corresponding to such variables. Various methods like cross-correlation and cross-spectrum are used for the analysis of linear relationships between such time series and the introduction of time delay between the corresponding observations pertaining to the markets facilitates identifying the direction of information flow. The error correction model introduced by Granger (1988) is an econometric inferential technique which studies causal relationship between co-integrated variables by the estimation of simultaneous linear equations in a pair of variables with time lags.

Praveen and Sudhakar (2006) using Granger causality test on the Indian stock and commodity markets, draw a comparison for price discovery between the grown stock market and the growing commodity market. Shanmugam and Prasad (2007) have analyzed 2 years data of crude oil prices in the Multi-Commodity Exchange of India (MCX) and the 30 stock index Sensex of BSE, India using regression analysis and found that an increase in crude oil price has led to a fall in the Sensex. It has also been reported that the equity prices of a few base metal companies and the associated metal futures prices in MCX are correlated.

Using the information theoretic concept of entropy, tools have been provided for the detection of non-linear dynamic relationships between time series. For example, relative entropy based measures have been proposed by Joe (1989) and a transformed metric entropy measure by Granger et al (2004). Mutual information which measures the deviation from independence of two variables, has been proposed by Vastano and Swinney (1988), with the introduction of time delay in one of the variables, to define velocity of information transport in spatio-temporal systems. Another measure called transfer entropy has been introduced by Schreiber (2000) to study the relationship between dynamic systems. An improved estimator called effective transfer entropy has been used by Marschinski and Kantz (2002) to study the impact of the US stock index Dow Jones on the German stock index DAX. Back et al (2005) have applied transfer entropy on the daily closing prices of 135 stocks in the New York Stock Exchange for studying information flow among groups of companies and discriminated the market-leading companies from the market-sensitive ones. A short note on transfer entropy is given in Annexure II.

Presentation of Data

National Stock Exchange of India (NSEIL) being the leading stock exchange of India, the 50 stock index of the Exchange viz. Nifty is taken as the representative of the stock market and the price of the near month futures contract on the Nifty is taken as the representative of the stock derivatives market. National Commodity & Derivatives Exchange Ltd., the leading commodity derivatives exchange of India has launched two indices – NCDEXAGRI and FUTEXAGRI. NCDEXAGRI is an equally weighted, composite index of spot prices of important agricultural commodities in every sub-sector and is updated three times a day with price data received from various mandis and spot markets. FUTEXAGRI is constructed on the basis of online prices of the nearest month expiry futures contracts traded in NCDEX, for the same basket of commodities in NCDEXAGRI. It is proposed to compute the transfer entropy among Nifty, Nifty futures contract, NCDEXAGRI and FUTEXAGRI so that informational transfer

may be analyzed between any two of the commodities spot, the commodities derivatives, the stock and the stock derivatives markets. Due to the high liquidity in these markets and the fast information transport, enabled by digital communication network, among these markets which have a large number of closely connected participants, there is a need to look at daily data. The use of lower frequency data such as weekly or monthly observations may not be adequate to capture the dynamics of the fast-moving stock prices, stock derivatives prices and commodity derivatives prices.

Data on the stock index Nifty and Nifty futures contract are available on the web-site of NSEIL from end 1995 and daily values of NCDEXAGRI and FUTEXAGRI are available on the web-site of NCDEX from June 2005. Hence the data for the period from June 2005 to September 2007 has been considered for the study. Thus four time series, each with 575 data points were obtained for the variables viz. the stock derivatives price – near month Nifty futures contract (W), the stock index - Nifty (X), the commodities spot index - NCDEXAGRI (Y) and the commodities derivatives index – FUTEXAGRI (Z). These price series were transformed to log returns series since such transformation satisfies the additive property of the returns and makes the results invariant in spite of arbitrary scaling of the price data. Further, such transformation improves the stationary character of the time series so that meaningful analysis may be made**.**

Empirical Results

The computation of transfer entropy using symbolic encoding method partitions the range of the data set into disjoint bins and assigns a symbol to each bin, with marginal equal probability for every symbol. The transfer entropy value depends on the number of bins (S) into which the data set is partitioned and also on the block length k chosen for the transferee variable and the block length l for the transferor variable (however, l is chosen to be 1 generally). Hence transfer entropy $T_{Z \to Y}$ from commodity derivatives (Z) to commodity spot (Y) is computed for the number of bins S ranging from 2 to 8, the block length k of Y ranging from 1 to 10 and the block length l of Z equal to 1. Further, transfer entropy $T_{Y \to Z}$ from commodity spot (Y) to commodity derivatives (Z) is computed for the number of bins ranging from 2 to 8, the block length for Z ranging from 1 to 10 and the block length for Y equal to 1. Similarly, transfer entropy between any two markets is computed in both the directions. Such transfer entropy values for the period from June 2005 to September 2007 between commodity spot and commodity derivatives markets are presented in Table 1, between commodity spot and stock markets are given in Table 2, between commodity derivatives and stock markets are given in Table 3, between commodity spot and stock derivatives markets are given in Table 4 and between commodity derivatives and stock derivatives markets are given in Table 5.

The transfer entropy in all the cases behaves reasonably for partitions S = 4, 5, 6, 7, 8 of the data analyzed and for block length of the transferee series $k \geq 3$. Further, in order to consider appropriate values of k, the mutual information of the time series containing the values of near month Nifty futures contract (W), Nifty (X), NCDEXAGRI (Y) and FUTEXAGRI (Z), for delays

ranging from a day to 20 days are computed and given in Table 6. It may be observed that the first minimum has occurred for k = 2, 3 and 4 respectively. Hence, meaningful results may be obtained from transfer entropy values computed for partitions S = 4, 5, 6, 7, 8 and block length of the transferee series k 4. For interpreting the transfer entropy values, the measures - Net information flow, Normalized directionality index and Relative explanation added - have been computed and given in the respective tables. These measures have been defined in Annexure III.

From the transfer entropy values, a flow of information from day t of one market to day t+1 of the other markets is observed, which suggests interactions among the markets at a time scale of a day or less. The information flows between any two markets in both the directions are more or less at the same level, when up to 6 past values of the transferee series are considered and hence in such cases the NIF values are not significant. Also, the REA in such cases either increases or remains at high levels thereby implying that whatever information flown from one market towards the prediction of the next price in the other market cannot be compensated by the inclusion of more number of past values realized by the transferee market, up to 6 days. Further, the absolute value of NDI has been generally less than 0.33 except in a few cases, indicating that the feedbacks in both the directions between any two markets do not vary much.

If the time series are partitioned into 4 or more bins and when 7 or more past values of the transferee market are considered (i.e. $k \geq 7$), even the entropy rates (given lagged values of the same market only) and the conditional entropy rates (given lagged values of both the same and the transferor markets) approach or become zero in respect of all the markets and hence the transfer entropy between any two markets approaches or becomes zero. Hence, price data beyond 6 days in any market do not have significant informational value in the same market or in any other market.

Thus the results obtained across the markets are more or less consistent and reiterate that

- There exist interactions between any two markets, with up to 6 days old price information and the feedback between any two markets is almost at the same level in both the directions
- Information generation in the markets tend to zero if 7 or more past values are considered.

Conclusion

Entropic analysis is a novel area in the Indian financial market and there is a lot of scope for the application of entropic analysis in the Indian markets. In this paper entropic analysis has been used to study interaction between commodities and stock markets and transfer entropy values among commodities spot, commodities derivatives, stock and stock derivatives markets in India for the period June 2005 – September 2007 have been computed and it is found that interactions existed between any two markets, thus reiterating the observations made in earlier studies using other methods**.** More importantly, transfer entropy has enabled quantification of the information transmission and identification of the direction of flow. Also, with the help of three interpretive measures, the meaning of the absolute value of transfer

entropy has been made explicit. Above all, as mentioned already, the formula for computation of transfer entropy recognizes non-linear and dynamic relationships between the markets. Also, transfer entropy is found to be useful in determining the memory level of the market, in terms of the number of past price data taking part in information generation at any point of time. It may further be noted that, in the computation of transfer entropy, determination of the appropriate partition of the data series and the block length of the transferee time series, has to be done with utmost care.

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Table 1: Commodity Derivatives and Spot Markets

Bins	Block	FUTEXAGRI(Z) to NCDEXAGRI(Y)					NCDEXAGRI(Y) to FUTEXAGRI(Z)				
		h(Y,Z)	h(Y)	T(Z->Y)	REA(Z->Y)	h(Z,Y)	h(Z)	T(Y->Z)	REA(Y->Z)	NIF(Z->Y)	NDI(Y,Z)
2	1	0.964796	0.991233	0.026437	0.0266708	0.995021	0.996298	0.001276	0.0012807	0.025161	0.907913254
2	2	0.957691	0.988932	0.031241	0.0315906	0.993717	0.996026	0.00231	0.0023192	0.028931	0.862299186
2	3	0.953114	0.986098	0.032984	0.033449	0.986257	0.995399	0.009141	0.0091833	0.023843	0.566005935
2	4	0.93705	0.979216	0.042166	0.043061	0.976222	0.989756	0.013534	0.0136741	0.028632	0.514039497
2	5	0.896833	0.955616	0.058784	0.0615142	0.948712	0.986449	0.037737	0.0382554	0.021047	0.218056174
2	6	0.807908	0.911569	0.103662	0.1137182	0.856285	0.955284	0.098999	0.1036331	0.004663	0.023008867
2	7	0.617054	0.803198	0.186143	0.2317523	0.687603	0.869514	0.181911	0.20921	0.004232	0.011498313
2	8	0.394818	0.581538	0.18672	0.3210796	0.43709	0.644433	0.207343	0.3217449	-0.020623	-0.05233427
2	9	0.238947	0.398074	0.159127	0.3997423	0.228355	0.361839	0.133484	0.3689044	0.025643	0.08763512
2	10	0.148312	0.270216	0.121904	0.4511354	0.117491	0.179582	0.062091	0.3457529	0.059813	0.325079486
3	1	1.507158	1.552344	0.045185	0.0291076	1.568974	1.581231	0.012256	0.0077509	0.032929	0.573266482
3	2	1.457165	1.523794	0.066629	0.0437257	1.527417	1.571639	0.044222	0.0281375	0.022407	0.202136201
3	3	1.279649	1.457905	0.178256	0.1222686	1.369934	1.511138	0.141205	0.0934428	0.037051	0.115979728
3	4	0.874069	1.272292	0.398222	0.3129958	0.960127	1.360366	0.400239	0.2942142	-0.002017	-0.00252611
3	5	0.466171	0.929889	0.463718	0.498681	0.500091	0.866797	0.366707	0.4230598	0.097011	0.116820905
3	6	0.162721	0.47675	0.31403	0.658689	0.218588	0.424867	0.206279	0.4855143	0.107751	0.207090402
3	7	0.043891	0.221264	0.177373	0.8016352	0.077144	0.148067	0.070924	0.4789994	0.106449	0.428716416
3	8	0.014185	0.08999	0.075805	0.8423714	0.03546	0.056738	0.021277	0.3750044	0.054528	0.561669516

Table 1: Commodity Derivatives and Spot Markets

Bins	Block	FUTEXAGRI(Z) to NCDEXAGRI(Y)					NCDEXAGRI(Y) to FUTEXAGRI(Z)				
		h(Y,Z)	h(Y)	T(Z->Y)	REA(Z->Y)	h(Z,Y)	h(Z)	T(Y->Z)	REA(Y->Z)	NIF(Z->Y)	NDI(Y,Z)
3	9	0.003546	0.028368	0.024822	0.875	0.014185	0.021276	0.007092	0.3333333	0.01773	0.5555555563
3	10	0	0.014185	0.014185	1	0.003546	0.003546	0	0	0.014185	1
4	1	1.892944	1.96928	0.076336	0.0387634	1.943596	1.988591	0.044995	0.0226266	0.031341	0.258309913
4	2	1.675602	1.918674	0.243072	0.1266875	1.759322	1.947945	0.188623	0.0968318	0.054449	0.126128401
4	3	1.018655	1.685279	0.666625	0.3955576	1.103738	1.723981	0.620244	0.3597743	0.046381	0.036041742
4	4	0.420382	1.010551	0.590169	0.5840071	0.387306	0.998184	0.610878	0.6119894	-0.020709	-0.01724246
4	5	0.126791	0.398413	0.271622	0.6817599	0.10685	0.383113	0.276263	0.7211006	-0.004641	-0.00847076
4	6	0.042555	0.114815	0.07226	0.6293603	0.024823	0.086445	0.061622	0.7128463	0.010638	0.07945803
4	7	0.010638	0.024822	0.014184	0.5714286	0	0.017731	0.017731	1	-0.003547	-0.11113896
4	8	0.003547	0.007092	0.003546	0.5	0	0	0	NA	0.003546	1
4	9	0.003547	0.007092	0.003546	0.5	0	0	0	NA	0.003546	1
4	10	0	0	0	NA	0	0	0	NA	0	NA
5	1	2.142648	2.28875	0.146102	0.0638348	2.19407	2.300939	0.106869	0.0464458	0.039233	0.155088923
5	2	1.543819	2.149866	0.606047	0.2818999	1.622654	2.185847	0.563193	0.2576544	0.042854	0.036651158
5	3	0.661267	1.555506	0.894238	0.5748856	0.691087	1.603141	0.912054	0.5689169	-0.017816	-0.0098633
5	4	0.140974	0.658754	0.51778	0.785999	0.146727	0.546949	0.400223	0.7317373	0.117557	0.128057316
5	5	0.028369	0.139636	0.111267	0.7968361	0.024822	0.156496	0.131674	0.8413889	-0.020407	-0.08399982
5	6	0	0.024822	0.024822	1	0	0.024823	0.024823	1	-0.000001	-0.00000001

Table 1: Commodity Derivatives and Spot Markets

Bins	Block	FUTEXAGRI(Z) to NCDEXAGRI(Y)					NCDEXAGRI(Y) to FUTEXAGRI(Z)				
		h(Y,Z)	h(Y)	T(Z->Y)	REA(Z->Y)	h(Z,Y)	h(Z)	T(Y->Z)	REA(Y->Z)	NIF(Z->Y)	NDI(Y,Z)
5	7	0	0.003547	0.003547	1	0	0.007092	0.007092	1	-0.003545	-0.33320801
5	8	0	0	0	NA	0	0	0	NA	0	NA
5	9	0	0	0	NA	0	0	0	NA	0	NA
5	10	0	0	0	NA	0	0	0	NA	0	NA
6	1	2.257476	2.526744	0.269269	0.1065676	2.334964	2.551707	0.216743	0.0849404	0.052526	0.108075521
6	2	1.365308	2.270288	0.904981	0.3986195	1.419446	2.37573	0.956285	0.4025226	-0.051304	-0.02756403
6	3	0.401962	1.346492	0.94453	0.7014746	0.407536	1.280855	0.873319	0.681825	0.071211	0.039173221
6	4	0.089991	0.33474	0.244749	0.7311615	0.073599	0.284623	0.211024	0.7414158	0.033725	0.073995169
6	5	0.017731	0.070922	0.053191	0.749993	0.014184	0.053191	0.039007	0.7333383	0.014184	0.153842817
6	6	0.003547	0.007092	0.003546	0.5	0.003547	0.010638	0.007092	0.6666667	-0.003546	-0.33333333
6	7	0	0	0	NA	0	0.003547	0.003547	1	-0.003547	-1
6	8	0	0	0	NA	0	0	0	NA	0	NA
6	9	0	0	0	NA	0	0	0	NA	0	NA
6	10	0	0	0	NA	0	0	0	NA	0	NA
7	1	2.356776	2.741844	0.385068	0.1404413	2.363341	2.767436	0.404095	0.1460178	-0.019027	-0.02411035
7	2	1.116447	2.351417	1.234969	0.525202	1.14999	2.318683	1.168694	0.5040335	0.066275	0.027572501
7	3	0.239395	0.998057	0.758662	0.7601389	0.279518	1.009968	0.73045	0.7232407	0.028212	0.018945519
7	4	0.039007	0.208819	0.169812	0.8132019	0.03546	0.193296	0.157836	0.8165508	0.011976	0.036551421

Table 1: Commodity Derivatives and Spot Markets

Bins	Block	FUTEXAGRI(Z) to NCDEXAGRI(Y)					NCDEXAGRI(Y) to FUTEXAGRI(Z)				
		h(Y,Z)	h(Y)	T(Z->Y)	REA(Z->Y)	h(Z,Y)	h(Z)	T(Y->Z)	REA(Y->Z)	NIF(Z->Y)	NDI(Y,Z)
7	5	0.010639	0.031915	0.021276	0.6666458	0.007092	0.042554	0.035461	0.8333177	-0.014185	-0.25001322
7	6	0	0.003547	0.003547	1	0	0	0	NA	0.003547	1
7	7	0	0	0	NA	0	0	0	NA	0	NA
7	8	0	0	0	NA	0	0	0	NA	0	NA
7	9	0	0	0	NA	0	0	0	NA	0	NA
7	10	0	0	0	NA	0	0	0	NA	0	NA
8	1	2.327146	2.940391	0.613245	0.208559	2.334021	2.930249	0.596229	0.2034738	0.017016	0.014068926
8	2	0.890742	2.328055	1.437313	0.6173879	0.898853	2.324353	1.4255	0.6132889	0.011813	0.004126361
8	3	0.14539	0.739737	0.594347	0.8034572	0.16272	0.743926	0.581206	0.7812686	0.013141	0.011178569
8	4	0.024822	0.104175	0.079352	0.7617183	0.031915	0.116153	0.084238	0.7252331	-0.004886	-0.02986735
8	5	0.003547	0.024823	0.021276	0.8571083	0.007092	0.01773	0.010637	0.5999436	0.010639	0.333375114
8	6	0	0	0	NA	0	0.003547	0.003547	1	-0.003547	-1
8	7	0	0	0	NA	0	0	0	NA	0	NA
8	8	0	0	0	NA	0	0	0	NA	0	NA
8	9	0	0	0	NA	0	0	0	NA	0	NA
8	10	0	0	0	NA	0	0	0	NA	0	NA

Table 2: Commodity Spot and Stock Markets

Bins	Block	NCDEXAGRI (Y) to NIFTY(X)					NIFTY(X) to NCDEXAGRI(Y)				
		h(X,Y)	h(X)	T(Y->X)	REA(Y->X)	h(Y,X)	h(Y)	T(X->Y)	REA(X->Y)	NIF(Y->X)	NDI(X,Y)
2	1	0.999585	0.999846	0.000261	0.000261	0.986564	0.991233	0.004669	0.00471	-0.00441	-0.89412
2	2	0.998124	0.999359	0.001235	0.001236	0.983084	0.988932	0.005848	0.005913	-0.00461	-0.65128
2	3	0.990292	0.998531	0.008238	0.00825	0.977217	0.986098	0.008881	0.009006	-0.00064	-0.03756
2	4	0.966664	0.989682	0.023018	0.023258	0.956574	0.979216	0.022641	0.023122	0.000377	0.008257
2	5	0.923974	0.970726	0.046753	0.048163	0.915256	0.955616	0.040361	0.042236	0.006392	0.073375
2	6	0.830558	0.938004	0.107447	0.114549	0.813894	0.911569	0.097675	0.10715	0.009772	0.04764
2	7	0.640989	0.832155	0.191166	0.229724	0.597772	0.803198	0.205426	0.25576	-0.01426	-0.03596
2	8	0.354747	0.61525	0.260503	0.42341	0.368768	0.581538	0.21277	0.365875	0.047733	0.100857
2	9	0.178712	0.377139	0.198427	0.526138	0.247894	0.398074	0.15018	0.377267	0.048247	0.138399
2	10	0.094875	0.192894	0.098019	0.50815	0.154757	0.270216	0.115458	0.42728	-0.01744	-0.08169
3	1	1.563854	1.579512	0.015658	0.009913	1.53408	1.552344	0.018263	0.011765	-0.00261	-0.0768
3	2	1.500995	1.547676	0.046682	0.030163	1.473953	1.523794	0.049841	0.032708	-0.00316	-0.03273
3	3	1.323054	1.493361	0.170306	0.114042	1.293003	1.457905	0.164902	0.113109	0.005404	0.016121
3	4	0.899231	1.318121	0.41889	0.317793	0.882579	1.272292	0.389713	0.306308	0.029177	0.036083
3	5	0.447949	0.887578	0.439629	0.495313	0.43568	0.929889	0.494209	0.531471	-0.05458	-0.05845
3	6	0.175567	0.444979	0.269412	0.605449	0.143649	0.47675	0.333101	0.698691	-0.06369	-0.10571
3	7	0.070921	0.181789	0.110868	0.609872	0.052321	0.221264	0.168942	0.763531	-0.05807	-0.20755
3	8	0.021276	0.070922	0.049645	0.699994	0.014185	0.08999	0.075805	0.842371	-0.02616	-0.20853

Table 2: Commodity Spot and Stock Markets

Bins	Block	NCDEXAGRI (Y) to NIFTY(X)					NIFTY(X) to NCDEXAGRI(Y)				
		h(X,Y)	h(X)	T(Y->X)	REA(Y->X)	h(Y,X)	h(Y)	T(X->Y)	REA(X->Y)	NIF(Y->X)	NDI(X,Y)
3	9	0.007092	0.021277	0.014185	0.666682	0.003546	0.028368	0.024822	0.875	-0.01064	-0.27269
3	10	0.003547	0.007092	0.003546	0.5	0	0.014185	0.014185	1	-0.01064	-0.60002
4	1	1.926498	1.977431	0.050932	0.025757	1.915572	1.96928	0.053708	0.027273	-0.00278	-0.02653
4	2	1.662118	1.912159	0.250041	0.130764	1.682228	1.918674	0.236445	0.123234	0.013596	0.027947
4	3	0.988593	1.636838	0.648245	0.396035	1.026938	1.685279	0.658341	0.390642	-0.0101	-0.00773
4	4	0.370916	1.014262	0.643346	0.6343	0.406598	1.010551	0.603953	0.597647	0.039393	0.031583
4	5	0.106853	0.434276	0.327423	0.753951	0.112605	0.398413	0.285808	0.717366	0.041615	0.067862
4	6	0.028369	0.140974	0.112605	0.798764	0.046101	0.114815	0.068714	0.598476	0.043891	0.242065
4	7	0.010638	0.024822	0.014184	0.571429	0.007092	0.024822	0.01773	0.714286	-0.00355	-0.11111
4	8	0.003547	0.010639	0.007092	0.666604	0	0.007092	0.007092	1	0	0
4	9	0	0	0	NA	0	0.007092	0.007092	1	-0.00709	-1
4	10	0	0	0	NA	0	0	0	NA	0	NA
5	1	2.192635	2.272418	0.079784	0.03511	2.175169	2.28875	0.11358	0.049625	-0.0338	-0.17478
5	2	1.580817	2.16092	0.580103	0.268452	1.521086	2.149866	0.62878	0.292474	-0.04868	-0.04027
5	3	0.608234	1.569467	0.961232	0.612458	0.591488	1.555506	0.964018	0.619746	-0.00279	-0.00145
5	4	0.156965	0.608822	0.451857	0.742182	0.157367	0.658754	0.501388	0.761116	-0.04953	-0.05196
5	5	0.024822	0.147842	0.12302	0.832105	0.031915	0.139636	0.107721	0.771441	0.015299	0.066304

Table 2: Commodity Spot and Stock Markets

Bins	Block	NCDEXAGRI (Y) to NIFTY(X)					NIFTY(X) to NCDEXAGRI(Y)				
		h(X,Y)	h(X)	T(Y->X)	REA(Y->X)	h(Y,X)	h(Y)	T(X->Y)	REA(X->Y)	NIF(Y->X)	NDI(X,Y)
5	6	0.003546	0.052322	0.048777	0.932246	0.003546	0.024822	0.021276	0.857143	0.027501	0.392574
5	7	0.003547	0.014185	0.010638	0.749947	0	0.003547	0.003547	1	0.007091	0.499894
5	8	0	0	0	NA	0	0	0	NA	0	NA
5	9	0	0	0	NA	0	0	0	NA	0	NA
5	10	0	0	0	NA	0	0	0	NA	0	NA
6	1	2.287804	2.500175	0.212371	0.084942	2.270616	2.526744	0.256128	0.101367	-0.04376	-0.0934
6	2	1.296995	2.288172	0.991177	0.433174	1.241806	2.270288	1.028483	0.453019	-0.03731	-0.01847
6	3	0.336032	1.267249	0.931217	0.734833	0.324971	1.346492	1.021521	0.758654	-0.0903	-0.04624
6	4	0.056738	0.36795	0.311213	0.845802	0.063829	0.33474	0.27091	0.809315	0.040303	0.069235
6	5	0.007092	0.106852	0.099759	0.933618	0.014184	0.070922	0.056738	0.800006	0.043021	0.2749
6	6	0.003546	0.014184	0.010638	0.75	0	0.007092	0.007092	1	0.003546	0.2
6	7	0	0.003547	0.003547	1	0	0	0	NA	0.003547	1
6	8	0	0	0	NA	0	0	0	NA	0	NA
6	9	0	0	0	NA	0	0	0	NA	0	NA
6	10	0	0	0	NA	0	0	0	NA	0	NA
7	1	2.343438	2.711665	0.368227	0.135794	2.335298	2.741844	0.406546	0.148275	-0.03832	-0.04946
7	2	0.99162	2.286609	1.294989	0.566336	0.983317	2.351417	1.368099	0.581819	-0.07311	-0.02745
7	3	0.237189	1.012999	0.77581	0.765855	0.209287	0.998057	0.788771	0.790307	-0.01296	-0.00828

Table 2: Commodity Spot and Stock Markets

Bins	Block	NCDEXAGRI (Y) to NIFTY(X)					NIFTY(X) to NCDEXAGRI(Y)				
		h(X,Y)	h(X)	T(Y->X)	REA(Y->X)	h(Y,X)	h(Y)	T(X->Y)	REA(X->Y)	NIF(Y->X)	NDI(X,Y)
7	4	0.039007	0.250973	0.211966	0.844577	0.028368	0.208819	0.180451	0.86415	0.031515	0.08031
7	5	0.003546	0.059414	0.055868	0.940317	0	0.031915	0.031915	1	0.023953	0.272866
7	6	0	0.014185	0.014185	1	0	0.003547	0.003547	1	0.010638	0.599932
7	7	0	0	0	NA	0	0	0	NA	0	NA
7	8	0	0	0	NA	0	0	0	NA	0	NA
7	9	0	0	0	NA	0	0	0	NA	0	NA
7	10	0	0	0	NA	0	0	0	NA	0	NA
8	1	2.292738	2.881165	0.588427	0.204232	2.312346	2.940391	0.628046	0.213593	-0.03962	-0.03257
8	2	0.780281	2.240476	1.460195	0.651734	0.721894	2.328055	1.606161	0.689915	-0.14597	-0.0476
8	3	0.160042	0.825438	0.665397	0.806114	0.125451	0.739737	0.614285	0.83041	0.051112	0.039941
8	4	0.039006	0.158304	0.119298	0.753601	0.024822	0.104175	0.079352	0.761718	0.039946	0.201087
8	5	0.007092	0.031915	0.024822	0.777753	0.003547	0.024823	0.021276	0.857108	0.003546	0.076923
8	6	0	0	0	NA	0	0	0	NA	0	NA
8	7	0	0	0	NA	0	0	0	NA	0	NA
8	8	0	0	0	NA	0	0	0	NA	0	NA
8	9	0	0	0	NA	0	0	0	NA	0	NA
8	10	0	0	0	NA	0	0	0	NA	0	NA

Table 3: Commodity Derivatives and Stock Markets

Bins	Block	FUTEXAGRI(Z) to NIFTY(X)					NIFTY(X) to FUTEXAGRI (Z)				
		h(X,Z)	h(X)	T(Z->X)	REA(X->Z)	h(Z,X)	h(Z)	T(X->Z)	REA(Z->X)	NIF(Z->X)	NDI(X,Z)
2	1	0.997228	0.999846	0.002618	0.002618	0.991442	0.996298	0.004856	0.004874	-0.00224	-0.29944
2	2	0.992949	0.999359	0.006411	0.006415	0.989496	0.996026	0.00653	0.006556	-0.00012	-0.0092
2	3	0.981955	0.998531	0.016576	0.0166	0.98562	0.995399	0.009779	0.009824	0.006797	0.257902
2	4	0.957798	0.989682	0.031884	0.032216	0.971564	0.989756	0.018192	0.01838	0.013692	0.273424
2	5	0.916538	0.970726	0.054189	0.055823	0.948591	0.986449	0.037858	0.038378	0.016331	0.17742
2	6	0.815618	0.938004	0.122387	0.130476	0.855233	0.955284	0.100051	0.104734	0.022336	0.100414
2	7	0.619467	0.832155	0.212688	0.255587	0.675426	0.869514	0.194089	0.223215	0.018599	0.045723
2	8	0.376094	0.61525	0.239156	0.388714	0.410683	0.644433	0.23375	0.362722	0.005406	0.011431
2	9	0.204877	0.377139	0.172262	0.45676	0.199518	0.361839	0.162321	0.4486	0.009941	0.029712
2	10	0.109529	0.192894	0.083364	0.432175	0.075808	0.179582	0.103774	0.577864	-0.02041	-0.10906
3	1	1.568259	1.579512	0.011253	0.007124	1.565479	1.581231	0.015751	0.009961	-0.0045	-0.16657
3	2	1.5223	1.547676	0.025377	0.016397	1.536649	1.571639	0.03499	0.022263	-0.00961	-0.15924
3	3	1.357121	1.493361	0.136239	0.09123	1.364861	1.511138	0.146278	0.0968	-0.01004	-0.03553
3	4	0.891093	1.318121	0.427029	0.323968	0.912951	1.360366	0.447415	0.328893	-0.02039	-0.02331
3	5	0.468936	0.887578	0.418642	0.471668	0.425045	0.866797	0.441752	0.509637	-0.02311	-0.02686
3	6	0.204405	0.444979	0.240574	0.540641	0.170681	0.424867	0.254186	0.598272	-0.01361	-0.02751
3	7	0.088653	0.181789	0.093137	0.512336	0.067376	0.148067	0.080691	0.544963	0.012446	0.0716
3	8	0.042553	0.070922	0.028369	0.400003	0.017731	0.056738	0.039007	0.687493	-0.01064	-0.15789
3	9	0.003547	0.021277	0.017731	0.833341	0.007092	0.021276	0.014184	0.666667	0.003547	0.111139

Table 3: Commodity Derivatives and Stock Markets

Bins	Block	FUTEXAGRI(Z) to NIFTY(X)					NIFTY(X) to FUTEXAGRI (Z)				
		h(X,Z)	h(X)	T(Z->X)	REA(X->Z)	h(Z,X)	h(Z)	T(X->Z)	REA(Z->X)	NIF(Z->X)	NDI(X,Z)
3	10	0	0.007092	0.007092	1	0	0.003546	0.003546	1	0.003546	0.333333
4	1	1.939575	1.977431	0.037855	0.019144	1.942383	1.988591	0.046208	0.023237	-0.00835	-0.09937
4	2	1.701593	1.912159	0.210566	0.11012	1.718065	1.947945	0.229879	0.118011	-0.01931	-0.04385
4	3	1.011594	1.636838	0.625244	0.381983	0.993785	1.723981	0.730196	0.423552	-0.10495	-0.07743
4	4	0.405329	1.014262	0.608933	0.600371	0.322364	0.998184	0.67582	0.67705	-0.06689	-0.05206
4	5	0.104175	0.434276	0.330101	0.760118	0.08069	0.383113	0.302423	0.789383	0.027678	0.043758
4	6	0.0461	0.140974	0.094874	0.672989	0.024823	0.086445	0.061622	0.712846	0.033252	0.212478
4	7	0.003547	0.024822	0.021276	0.857143	0.003547	0.017731	0.014184	0.799955	0.007092	0.2
4	8	0.003547	0.010639	0.007092	0.666604	0	0	0	NA	0.007092	1
4	9	0	0	0	NA	0	0	0	NA	0	NA
4	10	0	0	0	NA	0	0	0	NA	0	NA
5	1	2.17804	2.272418	0.094378	0.041532	2.185691	2.300939	0.115247	0.050087	-0.02087	-0.09955
5	2	1.573561	2.16092	0.587359	0.27181	1.569372	2.185847	0.616475	0.28203	-0.02912	-0.02419
5	3	0.600539	1.569467	0.968927	0.617361	0.554512	1.603141	1.048629	0.654109	-0.0797	-0.0395
5	4	0.13522	0.608822	0.473602	0.777899	0.104176	0.546949	0.442774	0.809534	0.030828	0.033641
5	5	0.031915	0.147842	0.115928	0.784134	0.031915	0.156496	0.124581	0.796065	-0.00865	-0.03598
5	6	0.010638	0.052322	0.041684	0.796682	-0.000001	0.024823	0.024824	1	0.01686	0.253503
5	7	0	0.014185	0.014185	1	0	0.007092	0.007092	1	0.007093	0.333365
5	8	0	0	0	NA	0	0	0	NA	0	NA

Table 3: Commodity Derivatives and Stock Markets

Bins	Block	FUTEXAGRI(Z) to NIFTY(X)					NIFTY(X) to FUTEXAGRI (Z)				
		h(X,Z)	h(X)	T(Z->X)	REA(X->Z)	h(Z,X)	h(Z)	T(X->Z)	REA(Z->X)	NIF(Z->X)	NDI(X,Z)
5	9	0	0	0	NA	0	0	0	NA	0	NA
5	10	0	0	0	NA	0	0	0	NA	0	NA
6	1	2.266243	2.500175	0.233932	0.093566	2.332613	2.551707	0.219094	0.085862	0.014838	0.032753
6	2	1.293224	2.288172	0.994948	0.434822	1.314047	2.37573	1.061683	0.446887	-0.06673	-0.03245
6	3	0.343639	1.267249	0.923609	0.72883	0.318525	1.280855	0.962329	0.751318	-0.03872	-0.02053
6	4	0.068715	0.36795	0.299235	0.813249	0.061623	0.284623	0.223001	0.783496	0.076234	0.145976
6	5	0.014185	0.106852	0.092667	0.867246	0.003547	0.053191	0.049644	0.933316	0.043023	0.302317
6	6	0.003547	0.014184	0.010637	0.749929	0.003547	0.010638	0.007092	0.666667	0.003545	0.199955
6	7	0	0.003547	0.003547	1	0	0.003547	0.003547	1	0	0
6	8	0	0	0	NA	0	0	0	NA	0	NA
6	9	0	0	0	NA	0	0	0	NA	0	NA
6	10	0	0	0	NA	0	0	0	NA	0	NA
7	1	2.335739	2.711665	0.375926	0.138633	2.361566	2.767436	0.405869	0.146659	-0.02994	-0.0383
7	2	0.983408	2.286609	1.303201	0.569927	0.922678	2.318683	1.396005	0.602068	-0.0928	-0.03438
7	3	0.210156	1.012999	0.802843	0.792541	0.176905	1.009968	0.833063	0.824841	-0.03022	-0.01847
7	4	0.03546	0.250973	0.215512	0.858706	0.039007	0.193296	0.154289	0.798201	0.061223	0.165557
7	5	0.007092	0.059414	0.052321	0.880617	0.010638	0.042554	0.031916	0.750012	0.020405	0.242233
7	6	0	0.014185	0.014185	1	0	0	0	NA	0.014185	1

Table 3: Commodity Derivatives and Stock Markets

Bins	Block	FUTEXAGRI(Z) to NIFTY(X)					NIFTY(X) to FUTEXAGRI (Z)				
		h(X,Z)	h(X)	T(Z->X)	REA(X->Z)	h(Z,X)	h(Z)	T(X->Z)	REA(Z->X)	NIF(Z->X)	NDI(X,Z)
7	7	0	0	0	NA	0	0	0	NA	0	NA
7	8	0	0	0	NA	0	0	0	NA	0	NA
7	9	0	0	0	NA	0	0	0	NA	0	NA
7	10	0	0	0	NA	0	0	0	NA	0	NA
8	1	2.289794	2.881165	0.591371	0.205254	2.327457	2.930249	0.602792	0.205714	-0.01142	-0.00956
8	2	0.716939	2.240476	1.523537	0.680006	0.726304	2.324353	1.598049	0.687524	-0.07451	-0.02387
8	3	0.121036	0.825438	0.704403	0.853369	0.130335	0.743926	0.613591	0.824801	0.090812	0.068902
8	4	0.010638	0.158304	0.147666	0.9328	0.014185	0.116153	0.101968	0.877877	0.045698	0.18306
8	5	0.003547	0.031915	0.028368	0.888861	0.003546	0.01773	0.014184	0.8	0.014184	0.333333
8	6	0	0	0	NA	0	0.003547	0.003547	1	-0.00355	-1
8	7	0	0	0	NA	0	0	0	NA	0	NA
8	8	0	0	0	NA	0	0	0	NA	0	NA
8	9	0	0	0	NA	0	0	0	NA	0	NA
8	10	0	0	0	NA	0	0	0	NA	0	NA

Table 4: Commodity Spot and Stock Derivatives Markets

Bins	Block	NCDEXAGRI(Y) to NIFTYFUTURES(W)					NIFTYFUTURES(W) to NCDEXAGRI(Y)				
		h(W,Y)	h(W)	T(Y->W)	REA(Y->W)	h(Y,W)	h(Y)	T(W->Y)	REA(W->Y)	NIF(Y->W)	NDI(W,Y)
2	1	0.998617	0.999927	0.00131	0.0013101	0.985202	0.991233	0.006031	0.0060843	-0.004774	-0.64565
2	2	0.993279	0.995009	0.00173	0.0017387	0.981162	0.988932	0.00777	0.007857	-0.006118	-0.63761
2	3	0.9782	0.99004	0.011839	0.0119581	0.975436	0.986098	0.010662	0.0108123	0.001146	0.050319
2	4	0.957498	0.984083	0.026585	0.027015	0.955416	0.979216	0.0238	0.0243052	0.00271	0.052803
2	5	0.915452	0.964795	0.049343	0.0511435	0.911662	0.955616	0.043954	0.0459955	0.005148	0.052997
2	6	0.7994	0.913338	0.113938	0.124749	0.811278	0.911569	0.100291	0.1100202	0.014729	0.062737
2	7	0.636474	0.828501	0.192027	0.2317764	0.597195	0.803198	0.206003	0.2564785	-0.024702	-0.05059
2	8	0.391212	0.673079	0.281867	0.4187725	0.376552	0.581538	0.204987	0.3524912	0.066281	0.085939
2	9	0.191087	0.40533	0.214243	0.5285644	0.245216	0.398074	0.152858	0.3839939	0.14457	0.158423
2	10	0.102837	0.228356	0.12552	0.5496681	0.156965	0.270216	0.113251	0.4191129	0.130555	0.134762
3	1	1.56078	1.574393	0.013614	0.0086471	1.533412	1.552344	0.018932	0.0121958	-0.003549	-0.17026
3	2	1.502048	1.54285	0.040802	0.0264459	1.478738	1.523794	0.045056	0.0295683	-0.003122	-0.05574
3	3	1.310653	1.482014	0.171361	0.1156271	1.308904	1.457905	0.149001	0.1022021	0.013425	0.061631
3	4	0.864838	1.30168	0.436842	0.3355986	0.897192	1.272292	0.3751	0.2948223	0.040776	0.064681
3	5	0.436081	0.881298	0.445217	0.5051833	0.433721	0.929889	0.496169	0.5335787	-0.028395	-0.02734
3	6	0.182656	0.470918	0.288261	0.6121257	0.144519	0.47675	0.332232	0.6968684	-0.084743	-0.06474
3	7	0.086444	0.172022	0.085578	0.4974829	0.070052	0.221264	0.151212	0.6834008	-0.185918	-0.15744
3	8	0.03546	0.074468	0.039008	0.5238223	0.01773	0.08999	0.07226	0.8029781	-0.279156	-0.2104
3	9	0.01773	0.028369	0.010639	0.375022	0.007092	0.028368	0.021276	0.75	-0.374978	-0.33331

Table 4: Commodity Spot and Stock Derivatives Markets

Bins	Block	NCDEXAGRI(Y) to NIFTYFUTURES(W)					NIFTYFUTURES(W) to NCDEXAGRI(Y)				
		h(W,Y)	h(W)	T(Y->W)	REA(Y->W)	h(Y,W)	h(Y)	T(W->Y)	REA(W->Y)	NIF(Y->W)	NDI(W,Y)
3	10	0.003546	0.007092	0.003547	0.500141	0.003547	0.014185	0.010638	0.7499471	-0.249806	-0.19983
4	1	1.940895	1.978524	0.037629	0.0190187	1.909778	1.96928	0.059502	0.0302151	-0.011196	-0.22741
4	2	1.671878	1.895475	0.223597	0.1179636	1.705417	1.918674	0.213257	0.1111481	0.006815	0.029747
4	3	1.02444	1.651441	0.627001	0.379669	1.016831	1.685279	0.668448	0.3966394	-0.01697	-0.02186
4	4	0.389338	1.060836	0.671497	0.6329885	0.380036	1.010551	0.630515	0.6239319	0.009057	0.007205
4	5	0.106852	0.398638	0.291786	0.7319573	0.103305	0.398413	0.295108	0.7407088	-0.008751	-0.00594
4	6	0.039007	0.116621	0.077614	0.6655234	0.039007	0.114815	0.075808	0.6602622	0.005261	0.003968
4	7	0.014185	0.03546	0.021276	0.6	0.007092	0.024822	0.01773	0.7142857	-0.114286	-0.08696
4	8	0	0.007092	0.007092	1	0	0.007092	0.007092	1	0	0
4	9	0	0	0	ND	0	0.007092	0.007092	1	ND	ND
4	10	0	0	0	ND	0	0	0	ND	ND	ND
5	1	2.168036	2.258545	0.09051	0.0400745	2.181944	2.28875	0.106805	0.0466652	-0.006591	-0.07598
5	2	1.553097	2.108916	0.555819	0.2635567	1.580246	2.149866	0.56962	0.264956	-0.001399	-0.00265
5	3	0.613586	1.5374	0.923813	0.6008931	0.562295	1.555506	0.993211	0.6385131	-0.03762	-0.03035
5	4	0.168005	0.672675	0.50467	0.7502434	0.130336	0.658754	0.528419	0.8021492	-0.051906	-0.03344
5	5	0.031915	0.170679	0.138764	0.8130116	0.014185	0.139636	0.125451	0.8984144	-0.085403	-0.0499
5	6	0.014185	0.045231	0.031046	0.6863877	0.003547	0.024822	0.021276	0.8571429	-0.170755	-0.11063
5	7	0.007092	0.014184	0.007092	0.5	0	0.003547	0.003547	1	-0.5	-0.33333
5	8	0	0.003547	0.003547	1	0	0	0	ND	ND	ND

Table 4: Commodity Spot and Stock Derivatives Markets

Bins	Block	NCDEXAGRI(Y) to NIFTYFUTURES(W)					NIFTYFUTURES(W) to NCDEXAGRI(Y)				
		h(W,Y)	h(W)	T(Y->W)	REA(Y->W)	h(Y,W)	h(Y)	T(W->Y)	REA(W->Y)	NIF(Y->W)	NDI(W,Y)
5	9	0	0	0	ND	0	0	0	ND	ND	ND
5	10	0	0	0	ND	0	0	0	ND	ND	ND
6	1	2.342093	2.508913	0.166821	0.0664913	2.297071	2.526744	0.229674	0.0908972	-0.024406	-0.15507
6	2	1.306556	2.301215	0.994659	0.4322321	1.260465	2.270288	1.009823	0.4447995	-0.012567	-0.01433
6	3	0.395559	1.269804	0.874245	0.6884881	0.362708	1.346492	0.983784	0.7306274	-0.042139	-0.02969
6	4	0.070053	0.372831	0.302778	0.8121052	0.049644	0.33474	0.285095	0.8516909	-0.039586	-0.02379
6	5	0.010638	0.078483	0.067844	0.864442	0.010637	0.070922	0.060285	0.8500183	0.014424	0.008413
6	6	0.003547	0.021277	0.017731	0.8333412	0	0.007092	0.007092	1	-0.166659	-0.0909
6	7	0	0	0	ND	0	0	0	ND	ND	ND
6	8	0	0	0	ND	0	0	0	ND	ND	ND
6	9	0	0	0	ND	0	0	0	ND	ND	ND
6	10	0	0	0	ND	0	0	0	ND	ND	ND
7	1	2.339589	2.682836	0.343248	0.1279422	2.334929	2.741844	0.406915	0.1484092	-0.020467	-0.07406
7	2	0.992113	2.276255	1.284142	0.5641468	1.022913	2.351417	1.328504	0.5649802	-0.000833	-0.00074
7	3	0.177774	1.093244	0.91547	0.8373885	0.200856	0.998057	0.797201	0.798753	0.038636	0.023614
7	4	0.031915	0.236719	0.204804	0.8651777	0.028368	0.208819	0.180451	0.8641503	0.001027	0.000594
7	5	0.007092	0.038138	0.031046	0.8140437	0.003546	0.031915	0.028369	0.8888924	-0.074849	-0.04395
7	6	0.003547	0.007092	0.003546	0.5	0	0.003547	0.003547	1	-0.5	-0.33333

Table 4: Commodity Spot and Stock Derivatives Markets

Bins	Block	NCDEXAGRI(Y) to NIFTYFUTURES(W)					NIFTYFUTURES(W) to NCDEXAGRI(Y)				
		h(W,Y)	h(W)	T(Y->W)	REA(Y->W)	h(Y,W)	h(Y)	T(W->Y)	REA(W->Y)	NIF(Y->W)	NDI(W,Y)
7	7	0	0	0	ND	0	0	0	ND	ND	ND
7	8	0	0	0	ND	0	0	0	ND	ND	ND
7	9	0	0	0	ND	0	0	0	ND	ND	ND
7	10	0	0	0	ND	0	0	0	ND	ND	ND
8	1	2.287748	2.87128	0.583531	0.2032303	2.3223	2.940391	0.618091	0.2102071	-0.006977	-0.01688
8	2	0.784158	2.238132	1.453974	0.6496373	0.668162	2.328055	1.659893	0.7129956	-0.063358	-0.0465
8	3	0.121906	0.794285	0.672379	0.8465211	0.144988	0.739737	0.594748	0.8039993	0.042522	0.025763
8	4	0.021276	0.187542	0.166266	0.8865534	0.021276	0.104175	0.082899	0.7957667	0.090787	0.053965
8	5	0.003546	0.034593	0.031047	0.8974937	0.003547	0.024823	0.021276	0.8571083	0.040385	0.023017
8	6	0.003547	0.007092	0.003546	0.5	0	0	0	ND	ND	ND
8	7	0	0	0	ND	0	0	0	ND	ND	ND
8	8	0	0	0	ND	0	0	0	ND	ND	ND
8	9	0	0	0	ND	0	0	0	ND	ND	ND
8	10	0	0	0	ND	0	0	0	ND	ND	ND

Table 5: Commodity Derivatives and Stock Derivatives Markets

Bins	Block	FUTEXAGRI(Z) to NIFTYFUTURES(W)				NIFTYFUTURES(W) to FUTEXAGRI(Z)					
		h(W,Z)	h(W)	T(Z->W)	REA(Z->W)	h(Z,W)	h(Z)	T(W->Z)	REA(W->Z)	NIF(Z->W)	NDI(W,Z)
2	1	0.997801	0.999927	0.002126	0.002126155	0.986926	0.996298	0.009372	0.009406824	-0.007280669	-0.631291246
2	2	0.992383	0.995009	0.002626	0.002639172	0.98652	0.996026	0.009506	0.009543928	-0.006904755	-0.566748664
2	3	0.982693	0.99004	0.007347	0.007420912	0.982853	0.995399	0.012546	0.012603991	-0.005183079	-0.25883164
2	4	0.959266	0.984083	0.024817	0.025218401	0.967351	0.989756	0.022405	0.022636892	0.002581509	0.053944063
2	5	0.920955	0.964795	0.04384	0.045439705	0.938277	0.986449	0.048172	0.048833746	-0.003394041	-0.036002090
2	6	0.817355	0.913338	0.095983	0.105090339	0.832357	0.955284	0.122927	0.128681104	-0.023590765	-0.100913803
2	7	0.638975	0.828501	0.189527	0.228758927	0.652629	0.869514	0.216886	0.249433592	-0.020674664	-0.043235023
2	8	0.427945	0.673079	0.245134	0.364197962	0.382788	0.644433	0.261645	0.406008072	-0.04181011	-0.054284319
2	9	0.214171	0.40533	0.191158	0.471610786	0.192426	0.361839	0.169414	0.468202709	0.003408077	0.003626334
2	10	0.106384	0.228356	0.121972	0.534130918	0.086446	0.179582	0.093136	0.518626588	0.01550433	0.014727352
3	1	1.567186	1.574393	0.007207	0.004577637	1.561753	1.581231	0.019478	0.012318251	-0.007740614	-0.458135941
3	2	1.51612	1.54285	0.02673	0.01732508	1.527859	1.571639	0.04378	0.02785627	-0.01053119	-0.233087094
3	3	1.321483	1.482014	0.160531	0.10831949	1.353414	1.511138	0.157724	0.104374319	0.00394517	0.01854859
3	4	0.884546	1.30168	0.417134	0.320458177	0.915404	1.360366	0.444963	0.327090651	-0.006632473	-0.01024243
3	5	0.488828	0.881298	0.39247	0.445331772	0.409231	0.866797	0.457566	0.527881384	-0.082549612	-0.084821718
3	6	0.234111	0.470918	0.236807	0.502862494	0.170681	0.424867	0.254186	0.59827193	-0.095409436	-0.086646493
3	7	0.093538	0.172022	0.078484	0.456243969	0.06383	0.148067	0.084237	0.568911371	-0.112667402	-0.109902761

Table 5: Commodity Derivatives and Stock Derivatives Markets

Bins	Block	FUTEXAGRI(Z) to NIFTYFUTURES(W)				NIFTYFUTURES(W) to FUTEXAGRI(Z)					
		h(W,Z)	h(W)	T(Z->W)	REA(Z->W)	h(Z,W)	h(Z)	T(W->Z)	REA(W->Z)	NIF(Z->W)	NDI(W,Z)
3	8	0.0461	0.074468	0.028368	0.38094215	0.017731	0.056738	0.039007	0.687493391	-0.306551241	-0.28691599
3	9	0.014184	0.028369	0.014185	0.500017625	0.007092	0.021276	0.014184	0.666666667	-0.166649042	-0.142839878
3	10	0.003546	0.007092	0.003547	0.500141004	0	0.003546	0.003546	1	-0.499858996	-0.333208008
4	1	1.945941	1.978524	0.032584	0.016468842	1.920436	1.988591	0.068155	0.03427301	-0.017804168	-0.350877372
4	2	1.728668	1.895475	0.166807	0.088002743	1.703233	1.947945	0.244712	0.125625724	-0.03762298	-0.176114076
4	3	1.041555	1.651441	0.609886	0.369305352	0.989481	1.723981	0.7345	0.426048779	-0.056743427	-0.0713436
4	4	0.375156	1.060836	0.685679	0.646357213	0.310854	0.998184	0.68733	0.688580462	-0.04222325	-0.031629379
4	5	0.107721	0.398638	0.290916	0.729774883	0.077145	0.383113	0.305968	0.798636434	-0.06886155	-0.045054332
4	6	0.036799	0.116621	0.079822	0.684456487	0.024823	0.086445	0.061622	0.712846318	-0.028389831	-0.020317594
4	7	0.014185	0.03546	0.021276	0.6	0	0.017731	0.017731	1	-0.4	-0.25
4	8	0.003547	0.007092	0.003546	0.5	0	0	0	ND	ND	ND
4	9	0	0	0	ND	0	0	0	ND	ND	ND
4	10	0	0	0	ND	0	0	0	ND	ND	ND
5	1	2.148082	2.258545	0.110463	0.048908921	2.203171	2.300939	0.097768	0.042490479	0.006418443	0.070224121
5	2	1.573364	2.108916	0.535553	0.253947051	1.582342	2.185847	0.603505	0.276096634	-0.022149583	-0.041788221
5	3	0.672647	1.5374	0.864753	0.56247756	0.608351	1.603141	0.99479	0.620525581	-0.058048021	-0.049068358
5	4	0.189752	0.672675	0.482924	0.717915784	0.111268	0.546949	0.435681	0.796566042	-0.078650258	-0.051932124

Table 5: Commodity Derivatives and Stock Derivatives Markets

Bins	Block	FUTEXAGRI(Z) to NIFTYFUTURES(W)				NIFTYFUTURES(W) to FUTEXAGRI(Z)					
		h(W,Z)	h(W)	T(Z->W)	REA(Z->W)	h(Z,W)	h(Z)	T(W->Z)	REA(W->Z)	NIF(Z->W)	NDI(W,Z)
5	5	0.050983	0.170679	0.119696	0.701293071	0.024822	0.156496	0.131674	0.841388917	-0.140095847	-0.090813173
5	6	0.010639	0.045231	0.034592	0.764785214	-0.000001	0.024823	0.024824	1.000040285	-0.235255072	-0.13330217
5	7	0	0.014184	0.014184	1	0	0.007092	0.007092	1	0	0
5	8	0	0.003547	0.003547	1	0	0	0	ND	ND	ND
5	9	0	0	0	ND	0	0	0	ND	ND	ND
5	10	0	0	0	ND	0	0	0	ND	ND	ND
6	1	2.302188	2.508913	0.206725	0.082396241	2.352071	2.551707	0.199636	0.078236255	0.004159986	0.025897535
6	2	1.335702	2.301215	0.965513	0.41956662	1.328024	2.37573	1.047706	0.441003818	-0.021437198	-0.024910451
6	3	0.337417	1.269804	0.932388	0.734277101	0.293525	1.280855	0.98733	0.770836668	-0.036559567	-0.024290235
6	4	0.049645	0.372831	0.323186	0.866843154	0.062961	0.284623	0.221663	0.778795108	0.088048046	0.053503889
6	5	0.003546	0.078483	0.074937	0.954818241	0.003546	0.053191	0.049645	0.933334587	0.021483654	0.011378133
6	6	0	0.021277	0.021277	1	0	0.010638	0.010638	1	0	0
6	7	0	0	0	ND	0	0.003547	0.003547	1	ND	ND
6	8	0	0	0	ND	0	0	0	ND	ND	ND
6	9	0	0	0	ND	0	0	0	ND	ND	ND
6	10	0	0	0	ND	0	0	0	ND	ND	ND
7	1	2.272805	2.682836	0.410032	0.152835283	2.392713	2.767436	0.374722	0.135404035	0.017431249	0.060474916
7	2	0.994042	2.276255	1.282212	0.563298927	0.939806	2.318683	1.378877	0.594681119	-0.031382191	-0.027100805

Table 5: Commodity Derivatives and Stock Derivatives Markets

Bins	Block	FUTEXAGRI(Z) to NIFTYFUTURES(W)				NIFTYFUTURES(W) to FUTEXAGRI(Z)					
		h(W,Z)	h(W)	T(Z->W)	REA(Z->W)	h(Z,W)	h(Z)	T(W->Z)	REA(W->Z)	NIF(Z->W)	NDI(W,Z)
7	3	0.206142	1.093244	0.887102	0.811440081	0.203933	1.009968	0.806035	0.798079741	0.01336034	0.008300823
7	4	0.039007	0.236719	0.197712	0.835218128	0.049644	0.193296	0.143652	0.743171095	0.092047033	0.058317069
7	5	0.003547	0.038138	0.034592	0.907021868	0.010638	0.042554	0.031916	0.75001175	0.157010118	0.094753731
7	6	0	0.007092	0.007092	1	0	0	0	ND	ND	ND
7	7	0	0	0	ND	0	0	0	ND	ND	ND
7	8	0	0	0	ND	0	0	0	ND	ND	ND
7	9	0	0	0	ND	0	0	0	ND	ND	ND
7	10	0	0	0	ND	0	0	0	ND	ND	ND
8	1	2.326355	2.87128	0.544924	0.189784347	2.320284	2.930249	0.609965	0.208161491	-0.018377144	-0.046180012
8	2	0.826444	2.238132	1.411688	0.630743852	0.712814	2.324353	1.611539	0.693327993	-0.06258414	-0.047266423
8	3	0.128999	0.794285	0.665286	0.837591041	0.111267	0.743926	0.632659	0.850432704	-0.012841663	-0.007607513
8	4	0.014185	0.187542	0.173357	0.924363609	0.017731	0.116153	0.098422	0.847347895	0.077015715	0.04346967
8	5	0	0.034593	0.034593	1	0.003546	0.01773	0.014184	0.8	0.2	0.111111111
8	6	0	0.007092	0.007092	1	0	0.003547	0.003547	1	0	0
8	7	0	0	0	ND	0	0	0	ND	ND	ND
8	8	0	0	0	ND	0	0	0	ND	ND	ND
8	9	0	0	0	ND	0	0	0	ND	ND	ND
8	10	0	0	0	ND	0	0	0	ND	ND	ND

Table 6: Mutual Information (MI)

Delay	niftyfutures-MI	nifty-MI	ncdex-MI	futex-MI
1	1.558594	1.476563	1.390625	1.296875
2	1.417969	1.410156	1.375	1.480469
3	1.527344	1.476563	1.300781	1.546875
4	1.421875	1.382813	1.464844	1.265625
5	1.386719	1.363281	1.476563	1.367188
6	1.523438	1.40625	1.292969	1.441406
7	1.507813	1.410156	1.304688	1.429688
8	1.417969	1.535156	1.378906	1.261719
9	1.410156	1.429688	1.46875	1.382813
10	1.535156	1.359375	1.214844	1.355469
11	1.355469	1.429688	1.371094	1.421875
12	1.527344	1.386719	1.359375	1.441406
13	1.496094	1.410156	1.402344	1.460938
14	1.464844	1.367188	1.402344	1.3125
15	1.410156	1.464844	1.457031	1.425781
16	1.464844	1.375	1.433594	1.410156
17	1.402344	1.324219	1.460938	1.4375
18	1.371094	1.34375	1.34375	1.40625
19	1.335938	1.472656	1.492188	1.417969
20	1.414063	1.480469	1.421875	1.359375

Annexure I

Indian Commodity Derivatives Market – A Brief History

The history of organised commodity derivatives market in India dates back to the nineteenth century with the establishment of the first derivatives market in the form of the Cotton Trade Association where cotton futures contracts were traded in 1875, barely about a decade after trading in commodity derivatives started in Chicago. Subsequently, derivatives trading started in oilseeds at Mumbai from 1900, in raw jute and jute goods at Kolkata from 1912, in wheat at Hapur from 1913 and in bullion at Mumbai from 1920. Later in 1939, in order to restrict speculative activity in the cotton market, options contracts in cotton were prohibited and in 1943, forward trading in commodities including oilseeds, food-grains, spices, vegetable oils, sugar and cloth was prohibited. After Independence, the government enacted the Forward Contracts (Regulation) Act, 1952 which regulated forward contracts all over India in commodities which are defined as any movable property other than security, currency and actionable claims. The Act prohibited options trading in goods and cash settlement of forward trades, which severely affected the growth of the commodity derivatives market. Further the Act allowed only those associations / exchanges which were recognized by the Government, to organise forward trading in approved commodities and also provided for three-tier regulation - the exchange which organizes forward trading in commodities to regulate trading on a day-to-day basis; the Forward Markets Commission to provide regulatory oversight under the powers delegated to it by the Government and the Ministry of Consumer Affairs, Food & Public Distribution, the Government of India to be the ultimate regulatory authority. Consequent to repeated defaults on forward contracts during the 1960's, forward trading was banned in many commodities. Subsequently, during the 1970's and the 1980's the Government relaxed forward trading rules for some commodities, however the market did not flourish.

During the liberalization era, the Government set up the K.N. Kabra Committee in 1993 to examine the role of commodity futures trading. The Committee recommended allowing futures trading in 17 commodity groups, strengthening of the Forward Markets Commission, and certain amendments to the Forward Contracts (Regulation) Act, particularly allowing options trading in goods and registration of brokers with the Forward Markets Commission. The Government accepted most of these recommendations and trading in futures contracts was permitted in all recommended commodities. Further, the SEBI (Securities and Exchange Board of India) appointed the Ramamoorthy Committee which recommended fruitful cooperation between the commodity derivatives market and the stock market towards convergence of the two markets in terms of infrastructural facilities and regulatory environment. Since 2002, the commodities futures market in India experienced an unprecedented boom with the setting up of multi-commodity exchanges which provide for electronic trading, the rapid increase in the number of commodities in which derivatives trading has been facilitated and the huge growth in trading volumes. On account of such developments, the commodity derivatives market in India has become as matured as the highly developed stock market in India. In this background, the interactions in terms of price dynamics, if any, between the two markets in India merit qualitative and quantitative analysis.

Annexure II

Transfer Entropy - A Short Note

Transfer entropy quantifies the degree to which a dynamical process affects the transition probabilities i.e. the dynamics of another. Transfer entropy has the properties of mutual information and also takes the dynamics of information transport into account. If X and Y are stochastic processes and k and l denote the number of past observations included in the variables X and Y for the estimation of future observations, then

$T_{Y \to X}(k,l)$ = transfer entropy from Y to X

= (Information about future observation x_{n+1} gained from k and l past observations of X and Y respectively) - (Information about future observation x_{n+1} gained from k past observations of X only)

= Information flow from Y to X

If H(X) denotes the entropy of X, then $0 \leq T_{Y \to X}(k,l) \leq H(X)$.

Also $T_{Y \to X}$ is asymmetric and takes into account only statistical dependencies originating in the variable Y and not those deriving from a common input signal. Transfer entropy quantifies the exchange of information between two systems, separately for both the directions and conditional to common input signal.

$T_{Y \to X}(k,l)$ is a non-increasing function of the block length k of the series X, since inclusion of more number of past observations in the variable X is likely to result in reduction of flow of information from Y in the estimation of the next value of X. The parameter k is to be chosen as large as possible in order to find an invariant value for $T_{Y \to X}$, however due to the finite size of time series available in practice, it is required to find a reasonable compromise between unwanted finite sample effects and a high value for k. An appropriate value of k is such that the mutual information of the time series X with delay k viz. I(k) is small where I(k) is the mutual information between a time series $\{x_1, x_2, \ldots, x_n)$ and itself with a delay of k i.e. $\{x_{k+1}, x_{k+2}, \ldots, x_n\}$ and measures the information carried over by the delayed time series from the original time series. It may be noted that Fraser and Swinney (1986) have suggested that the time delay that produces the first local minimum of the mutual information of a time series may be used in the construction of multidimensional phase portrait from a scalar time series. Also, the choices for l are l = k or l = 1 and, for computational reasons, l = 1 is preferred usually.

Annexure III

Measures For Interpreting Transfer Entropy Values

(a) Net information flow $NIF_{Y \to X} = T_{Y \to X} - T_{X \to Y}$

If this is positive, the variable Y may be said to influence the variable X.

(b) Normalised directionality index NDI(X,Y) =

$$\frac{T_{Y \to X} - T_{X \to Y}}{T_{Y \to X} + T_{X \to Y}}$$

The index varies from -1 (in case of uni-directional causality from X to Y) through 0 (in case of equal feedback between the two variables) to +1 (in case of uni-directional causality from Y to X), with intermediate values corresponding to bidirectional causality between the two variables X and Y.

(c) Relative explanation added $REA_{Y \to X}(k,l) = T_{Y \to X}(k,l) \ / \ h_K(X)$

$$REA_{X \to Y}(k,l) = T_{X \to Y}(k,l) \ / \ h_k(Y)$$

$REA_{Y \to X}$ measures how much of x_{n+1} is additionally explained when the past values of X are already known and then the last value yof Y_n is taken into account. The ratio varies from 0 (in case of no information flow at all from a variable to the other) to 1 (in case of all the information in the current value of one variable being transferred from past values of the other variable) with intermediate values corresponding to the amount of information in one variable caused by the other variable.

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[1] Literature characterizes that these firms are likely to focus on larger risks and leave the smaller ones unattended. They are likely to hedge when it is relatively easy to monitor and the benefits are manifold. These firms are unlikely to have an elaborate risk management set-up.

[2] Theory implies that such firms consider the market behaviour, conduct detailed analysis of possible outcomes and then cover themselves against more unacceptable and risky outcomes.