TEMPORAL LINKS BETWEEN PRICE INDICES OF STOCK MARKETS WITH OVERLAPPING BUSINESS HOURS*

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ABSTRACT

This article analyzes the way in which international stock markets transmit information around the world. We are able to decompose the influenced of one market on another one in two elements: the capability of one market to exercise influence on any other market and the sensitivity of every market to information coming from other stock markets. We extend previous work including markets with overlapping operating schedules. The prediction accuracy of the proposed model is favourably compared with alternative models.

KEY WORDS: Transmission of stock market information, international linkages.

RESUMEN

En este trabajo se analiza la forma en la que los mercados bursátiles transmiten su información a lo largo y ancho del mundo. Se consigue descomponer la influencia ejercida por un mercado sobre otro en dos partes: la capacidad de un mercado para influir a todos los demás y la sensibilidad de cada mercado a la información procedente del resto. Como novedad en relación a trabajos anteriores se incluyen mercados cuyos horarios se solapan. La capacidad predictiva del modelo propuesto mejora la de los modelos alternativos.

PALABRAS CLAVE: Transmisión de información de mercados bursátiles, relaciones internacionales.

1. INTRODUCTION.

In previous work[1] we developed and estimated a model of international linkages between stock markets whose working hours did not overlap. We were able to identify two different features present in every capital market: first, the capacity of one market to exercise influence on other markets through the generation and transmission of information; in principle, this *informational power* should be the same independently of the market receiving such influence. The second feature of each market was its *sensitivity* to the information flow generated and transmitted by other markets. According to this scheme we estimated a system of three equations formed by daily returns for three stock markets -New York, Tokyo and Frankfurt. Log differences on daily closing prices were used and cross restrictions imposed to keep invariable the features of each market in all regression equations. Consequently, the influence exercised by one market as well as its sensitivity were evaluated using the information contained *in all three* regression equations in which such market appeared, either as a dependent or as an explanatory variable.

After testing for the absence of any predictive power in current stock closing prices we assumed market efficiency. According to this, asset prices would only change as a result of new information revealed after the closing of the market in the previous day. Hence, we assumed -as we will throughout this article- that only innovations change prices.

Figure 1 shows how the different business hours of the stock markets are distributed over a 24 hour period. Above the time line we find the trading hours of three *non-overlapping* markets Tokyo (T), Frankfurt (F) and New York (N). Three hours after a new date (International Date) has begun in the world, the Tokyo market opens for a six hour trading period with a two hour break in between. Four and a half hours after Tokyo closes, Frankfurt opens trade for a short two hour trading session. And two hours after Frankfurt closes New York opens for a six and a half hour trading period, which ends exactly twenty four hours after the new date started. Below the time line we find the hours of trading corresponding to two other markets whose business hours overlap with those of Frankfurt and New York, namely, London and Madrid. Both markets open three hours after Tokyo's

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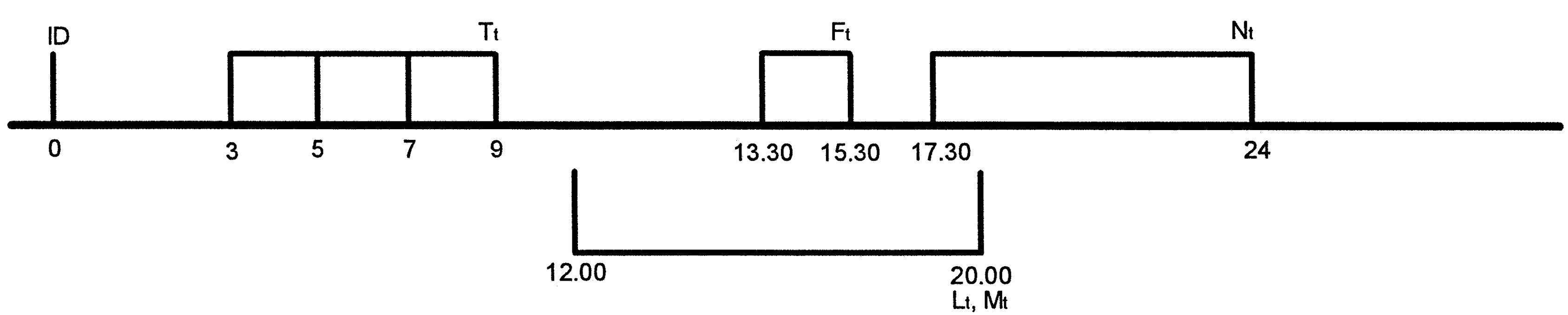
[1] See Peiró et al. (1993).

Figure 1: BUSINESS HOURS AROUND THE CLOCK



ID: International Date Change
T, F, L, M, N: Daily returns on closing times for the stock markets in Tokyo, Frankfurt, London, Madrid and New York.

closing and 1.5 hours before Frankfurt's opening, and close 2.5 hours after New York has opened trade on the same date. Thus, we consider two stock markets of significant size difference but identical business hours to check if the importance of a market as an influencing power lies in its size or rather in its time location.

In our present work we generalize our previous model to treat information on closing prices of stock markets whose trading hours do overlap. Contrary to the previous case, there is a period of trading hours during which new information moves prices of two markets simultaneously. Introducing *overlapping markets* we can check our earlier results and see if there is a change in the estimated parameters for informational power and sensitivity. Section 2 reviews previous work, section 3 introduces the new model, section 4 carries out correlation analysis, section 5 presents regression results, section 6 shows the forecasting performance of the model and, finally, section 7 presents some concluding remarks.

2. NON-OVERLAPPING TIME-FRAMES.

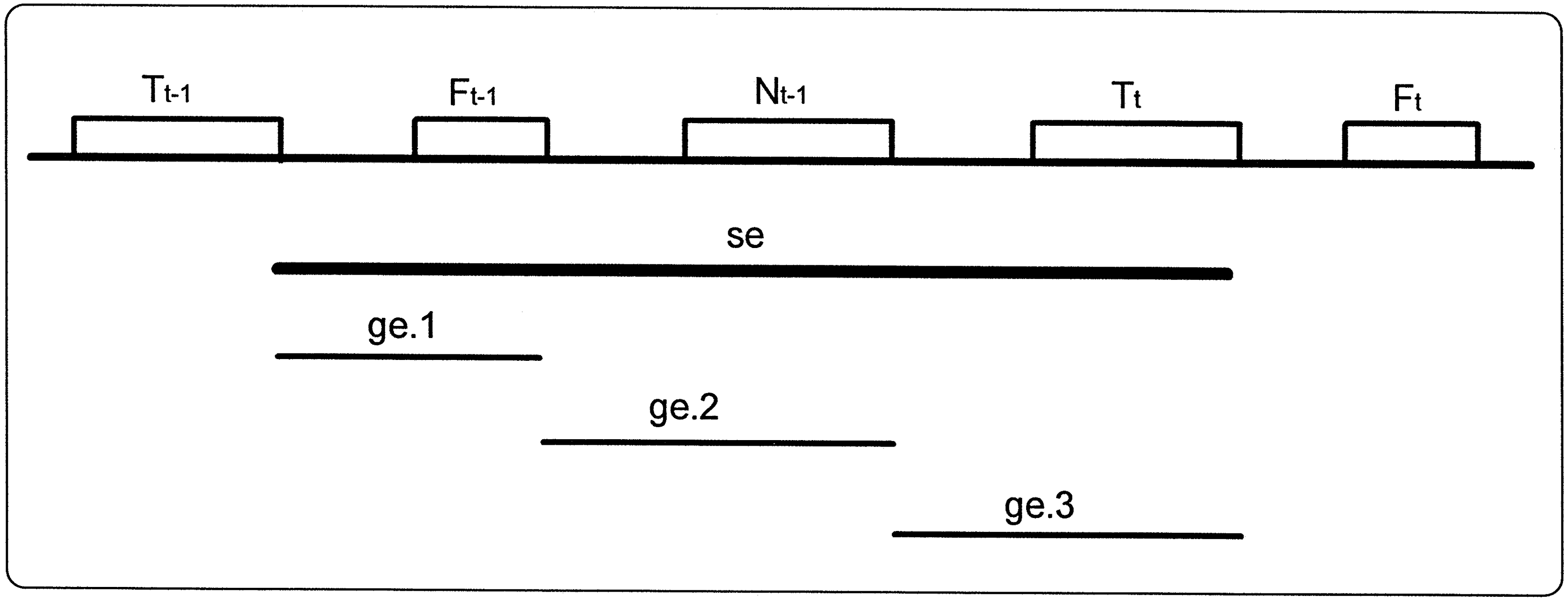
In our model we distinguish two sources of information, (i) *global innovations:* news generated around the world and captured by stock prices in *all* markets. (ii) *specific innovations*: information generated during a twenty four hour period that only affects the prices *in one particular* market. Once a market is closed for the day, innovations cannot be reflected until the next day of operation. In the meantime, global innovations change prices in the stock markets that are open for trade, while the first market remains closed. So, part of the accumulated information that will influence the prices of the market of reference will already be reflected in the closing prices of the preceding markets -the so called influence exercised by one market. Contrarily, the accumulated specific information produced during the last twenty four hours shows up exclusively in the closing prices of the corresponding market.

One meaningful difference between our estimated model and those found in the literature is that we do not treat each market separately. On the contrary, when we estimate the parameters of informational power and sensitivity for each market, we use the information provided by each market in each regression equation. Our results clarify the way information flows between different stock markets around the world. If we take Tokyo as a reference market, its daily return can be regressed on the observed daily returns of the two preceding markets, New York and Frankfurt (see equation [1]). According to the efficiency market hypothesis we should not expect any influence of the lagged endogenous variable (T_{t-1}) on the current rate of return, since all the information available up to the end of the previous session should have been incorporated in the closing price at t-1. This assumption was tested and confirmed for all analyzed markets. We would also expect a value close to zero for the constant, meaning an absence of any trend in market price levels for the period considered in the sample. New York's influence on Tokyo is assumed to depend on two parameters. β_1 is the parameter measuring the power of New York to influence other markets: it measures the power of the information signalled by New York's closing prices on any other market around the world. A similar interpretation applies to the parameter γ_1 in relation with Frankfurt. Thus, β and γ are parameters measuring the *power of influence* of New York and Frankfurt respectively. A different interpretation receives the parameter λ_{11}. It is associated with Tokyo's sensitivity to the influence of a foreign market, either New York or Frankfurt. Thus, the influence generated by any foreign market is filtered by Tokyo's market through the value of the parameter λ_{11}.

$$T_t=\alpha_{1T}+\beta_1\lambda_{11}N_{t-1}+\gamma_1\lambda_{11}F_{t-1}+u_{1Tt} \qquad (1)$$

To see how the information generated over a twenty four hour period affects Tokyo's daily return we refer the reader to figure 2. (i) (se) represents the specific effect (se) of Tokyo, that is, the news arrived during the last 24 hours that only affects this market. The global effect (ge) is splitted into three different time periods. (ii) (ge.1), the information generated from the closing of Tokyo until the closing of Frankfurt: the global information generated during this period is captured by Frankfurt's rate of return but, also, by New York's return closing a few hours later. (iii) (ge.2) the amount of information generated between the closing of Frankfurt and the closing of New York captured by this market return together with the global effect (ge.1). (iv) (ge.3) the global effect not incorporated in previous market returns and which will be first reported by Tokyo's current return. Undoubtedly, market influencing power greatly depends upon the amount of information

Figure 2: NON OVERLAPPING MARKETS



generated during this last time interval.[2] According to this information model, the addition in a regression equation as an explanatory variable of a market that closes immediately ahead of one that is already present would deprive this last variable of most of the previous explanatory power. According to this informational decomposition we can argue that $u_{1Tt,}$ the error term in equation [1] contains two types of information: global effects revealed since the closing of the New York market (ge.3) and the specific effects (se).

3. OVERLAPPING TIME-FRAMES.

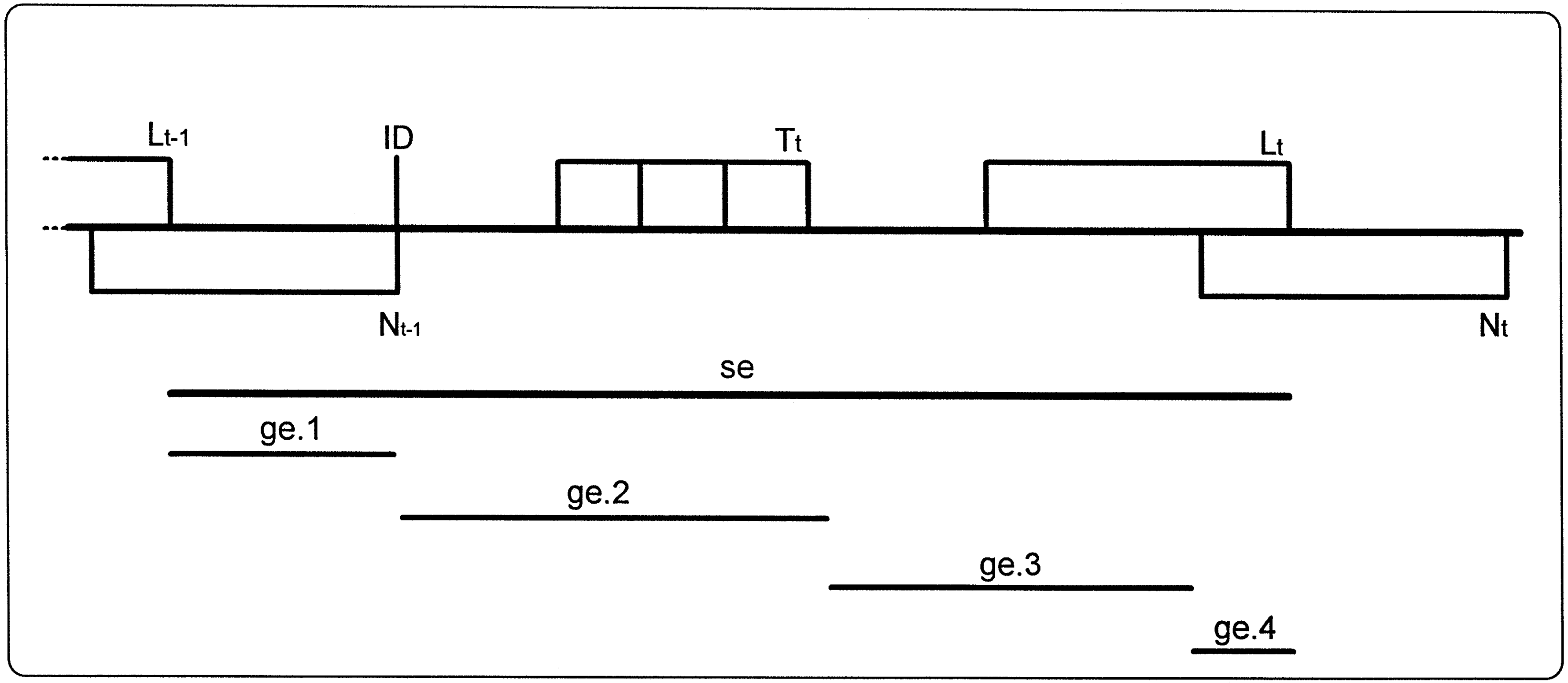
As mentioned above, previous research dealt with non-overlapping markets. It was interesting to see whether the treatment of information carried out in the previous model could be used to analyze causality. For that purpose we included the markets of London (L) and Madrid (M) with identical operating hours but very different sizes, both markets overlapping with the New York Stock Exchange for a period of two and a half hours[3]. Consequently, the closing prices of Madrid and London are influenced by information generated by New York on the same day. This fact ought to change the values of the estimated parameters of the original model.

The substitution of London for Frankfurt leaves unchanged the information time-frame developed in section 2, if we take either Tokyo or New York as the reference market. However, if we take London as the reference market (see figure 3) the informational flows arriving since the closing of the previous day must be decomposed in a different way. First the specific effects (se) generated during the previous 24 hours. Secondly, the global effects which can be divided in turn into *four* different elements. ge.1: global effects corresponding to the period between the closing of London in the previous day and the closing of New York. ge.2: global effects generated in the period between the closing of London on the

[2] The quantity of news produced during such an interval will be high if it coincides with day light time in industrialized countries like Europe or the United States, when a lot of other news is being announced. It will also be high, if the period is sufficiently long.

[3] See figure 1 above.

Figure 3: OVERLAPPPING MARKETS
(Effects on London)



previous day and the closing of Tokyo on the same day. ge.3: global effects produced between the closing of Tokyo and the opening of New York. ge.4: global effects on London corresponding to the first two and a half hours of trading in New York on the same day.

By looking at figure 3, it is easy to see that when we regress L_t on the other markets we must include as regressors not only N_{t-1} and T_t but also N_t, for it contains explanatory power of the endogenous variable. However, as it is clearly seen in the diagram, N_t also contains information that should never have affected L_t, since it arrives after the London market has closed its doors for the day. The residuals of this equation would incorporate the specific effects plus global information generated since Tokyo's closing.

4. CORRELATION ANALYSIS.

The introduction of two additional markets, London and Madrid, allowed us again to carry out a correlation analysis between returns on different markets to see if our results of the previous work were still valid. We were able to test if two markets operating at similar business hours are good substitutes as transmitters of information. We ran crossed correlations between London and Madrid on New York and Tokyo. Except for only two coefficients we have found the expected results (see table 1).

4.1. London crossed correlations.

According to figure 3, above, London returns L_t, should be correlated only with New York's returns on t-1 and t, and with Tokyo's returns on t and t+1. No correlation between L_t and L_{t+i}, $(i>0,\ i<0)$ should be found. Surprisingly, we find London returns negatively related with Tokyo's returns on the day before (-.08) and even two days earlier (-.10) (see table 1). This finding clearly contradicts the assumption of market efficiency, since the information contained in the last day of Tokyo's return (T_{t-1}) should have been incorporated in the closing price of London on the day before (L_{t-1}): this would be even more true of the

Table 1: CROSS CORRELATIONS

	N_{t+2}	N_{t+1}	N_t	N_{t-1}	N_{t-2}
L_t	.03	.01	.33**	.19**	-.01
M_t	.01	.07	.31**	.24**	.01
	T_{t+2}	T_{t+1}	T_t	T_{t-1}	T_{t-2}
L_t	-.01	.11**	.32**	-.08*	-.10*
M_t	-.04	.12**	.40**	.00	-.04
	M_{t+2}	M_{t+1}	M_t	M_{t-1}	M_{t-2}
L_t	.01	.04	.48**	-.02	.02

N, T, L, M: Stock market index daily rates of return in New York (Dow Jones), Tokyo (Nikkei), London (Financial Times 100) and Madrid (Indice General de la Bolsa). Sample: 1/5/90-10/30/92.
* indicates statistical significance at the 5 per cent level
** indicates statistical significance at the 1 per cent level

information contained in T_{t-2}. We do not have a rational explanation for these results, since this systematic behaviour of returns for London and Tokyo should be exploited by market agents seeking good guesses on the market direction. However, as expected, we find London returns on t positively correlated with Tokyo's on t (.32) and less significantly related with Tokyo's return on the next day (.11).

As was expected, London and NYSE returns on the same day are strongly and positively correlated (.32), as are those of London with the New York returns on the day before. The remaining crossed correlation coefficients for London are not statistically significant, as predicted by the theory.

Since London and Madrid share the same business hours their returns should be strongly correlated for the same day because the same news affect both markets and only specific effects will differ. Again, if efficient markets incorporate all available information into prices, we should expect no correlation between London's return and Madrid's return for the day before or the day after. As expected, our results show positive crossed correlation only for the same day (.48), with all other coefficients showing no significance.

4.2. Madrid crossed correlations.

Except for specific effects, Madrid and London should behave in a similar way since they are open during the same hours of the day. Substituting London for Madrid in figure 3 we would expect Madrid to be correlated with Tokyo on the same day and on the following day but not with any other positive or negative lag. Our results confirm these predictions, a positive crossed correlation (.40) with Tokyo's return for the same day, and a weaker relationship (.12) with the next day's return, values in relation with those obtained for London (.32) and (.107). All other coefficients are found insignificant.

We would also expect Madrid returns to be correlated with those of New York on the day before and, besides, with New York's return on the same day since their business hours overlap daily for 2.4 hours. The data show a strong positive correlation with New York on the same day (.315), very similar to the corresponding one for London (.325). There is also a weaker correlation of Madrid with New York on the day before (.24), again quite similar to the corresponding one for London (.195). All other coefficients are found not significant.

5. REGRESSION ANALYSIS.

5.1. Single equation estimation.

We start by regressing returns for Madrid and London on previous market returns without imposing any cross-equation restriction. When we regress London and Madrid returns including New York's on the same day we find very similar coefficients in size (.38 and .36) as well as in significance (see table 2). The predicted positive values for Tokyo's return on the same day and for New York's on the day before are also found, but no other positive or negative lag with statistical significance. We also find the constant term not significantly different from zero, meaning an absence of any trend in prices. The similarity of the estimated coefficients for Madrid and London can be interpreted as evidence of the essential role of a stock market as a transmitter of information. Accordingly, as for the relevance of markets, their business hours seem more important than their share of total transactions. This result reinforces the findings of our previous research.

Table 2: SINGLE EQUATION ESTIMATION (LS)

	L_t	M_t
Constant	.00001	-.0002
	(.03)	(-.51)
N_t	.36	.38
	(7.83)	(7.73)
N_{t-1}	.17	.19
	(3.59)	(3.82)
T_t	.15	.22
	(6.75)	(9.15)
R^2	.22	.28
SSR	.06	.06
DW	2.07	2.07

* t-statistics in parenthesis
Sample: 1/9/90-10/30/92
L, M, N, T: Daily returns on the stock market indices of London, Madrid, New York and Tokyo.

5.2. Simultaneous equation estimation.

In order to check the effects produced by the substitution of a non-overlapping market like Frankfurt with one that overlaps with New York and Tokyo -either London or Madrid- we have nested the three complete models (TFN, TLN, TMN) in the following model:

$$T_t=\alpha_{1T}+\beta_1*\lambda_{11}*N_{t-1}+\gamma_1*\lambda_{11}*F_{t-1}+u_{1Tt} \quad (2)$$

TFN

$$F_t=\alpha_{1F}+\delta_1*\lambda_{12}*T_t+\beta_1*\lambda_{12}*N_{t-1}+u_{1Ft} \quad (3)$$

$$N_t=\alpha_{1N}+\gamma_1*F_t+\delta_1 T_t+u_{1Nt} \quad (4)$$

$$T_t=\alpha_{2T}+\beta_2*\lambda_{21}*N_{t-1}+\gamma_2*\lambda_{21}*L_{t-1}+u_{2Tt} \quad (5)$$

TLN

$$L_t=\alpha_{2L}+\delta_2*\lambda_{22}*T_t+\beta_2*\lambda_{22}*N_{t-1}+u_{2Lt} \quad (6)$$

$$N_t=\alpha_{2N}+\gamma_2*L_t+\delta_2*T_t+u_{2Nt} \quad (7)$$

$$T_t=\alpha_{3T}+\beta_3*\lambda_{31}*N_{t-1}+\gamma_3*\lambda_{31}*M_{t-1}+u_{3Tt} \quad (8)$$

TMN

$$M_t=\alpha_{3M}+\delta_3*\lambda_{32}*T_t+\beta_3*\lambda_{32}*N_{t-1}+u_{3Mt} \quad (9)$$

$$N_t=\alpha_{3N}+\gamma_3*M_t+\delta_3*T_t+u_{3Nt} \quad (10)$$

In this model we normalize the parameters making New York's sensitivity equal to one. For this reason, all other sensitivity parameters must be interpreted as values relative to those of New York. Notice that we allow for different power and sensitivity parameters for New York and Tokyo in each of the three submodels. Thus, this is a model estimated without forcing all β-parameters (nor the δ- and γ-parameters) to be the same. With this procedure we are able to test for the equality of such parameters across the three 3-equation models.

Non-linear LSQ estimation of the model produced the results reported in table 3. The nine constants are not significant at the 5% level, and only those corresponding to equations

Table 3: NON-LINEAR LEAST SQUARE ESTIMATION OF THE COMPLETE MODEL

	Coefficient		Coefficient
α_{1T}	-.00099 (-1.86)	α_{2L}	.00004 (.08)
β_1	.203 (3.12)	δ_2	.106 (4.02)
λ_{11}	2.313 (3.07)	λ_{22}	1.553 (3.45)
γ_1	.061 (2.56)	α_{2N}	.00023 (.45)
α_{1F}	-.00024 (-.46)	α_{3T}	-.00072 (-1.36)
δ_1	.107 (4.21)	β_3	.093 (2.5)
λ_{12}	1.6802 (3.75)	λ_{31}	4.812 (2.406)
α_{1N}	0.0002 (.51)	γ_3	.025 (1.805)
α_{2T}	-.00097 (-1.87)	α_{3M}	-.00012 (-.23)
β_2	.145 (2.49)	δ_3	.102 (3.73)
λ_{21}	3.143 (2.44)	λ_{32}	2.478 (3.48)
γ_2	.044 (1.96)	α_{3N}	.00022 (.43)
R^2	.09		
SSR	.91		
DW	2.06		

t-statistics in parenthesis
See equations (2)-(10) for the meaning of the estimated parameters.
Sample 1/9/90-10/30/92

[2] and [5] are significant at the 7% level, with values very close to zero. All the other coefficients appear significant and they have the expected sign. Estimated equations [2]-[4] show that the most influencing market is New York, followed by Tokyo and Frankfurt in this order ($\beta_1 > \delta_1 > \gamma_1$; .203 > .107 > .06). They also show Tokyo as the most sensitive market,

followed by Frankfurt and New York ($\lambda_{11} > \lambda_{12} > \lambda_{13}$; $2.31 > 1.68 > 1$). These two ordernations do not change when we substitute London and Madrid for Frankfurt (equations [5]-[10]), which indicates that New York is more influential but less sensitive than Tokyo regardless of the third market included. This result can be interpreted as evidence in favor of the way we have hypothesized the international linkages of stock market price variations around the globe.

Next, we compare the values of the estimated coefficients for New York's and Tokyo's power and sensitivity parameters obtained when introducing London or Madrid as the third overlapping market (see table 4). We cannot reject the hypothesis that the values of both types of parameters are equal. This result means that these parameters adequately capture the influence exercised by each market as well as its sensitivity to information generated in external markets. For those markets whose timetables are identical we cannot reject the hypothesis that their influence is also identical.

Table 4: F-STATISTICS CORRESPONDING TO THE TEST OF EQUALITY OF SENSITIVITY AND INFLUENTIAL POWER PARAMETERS

	λ_T		β	δ	
	TLN	TMN	TLN	TLN	TMN
TFN	.31*	1.36*		.009*	.02*
TMN	.49*		.56*	.01*	
TFN and TMN	.74*			.01*	

λ_T: Tokyo's sensitivity parameter
β: New York's influential power parameter
δ: Tokyo's influential power parameter
The equality of the parameters estimated in the different models cannot be rejected. The usual significance levels.

Comparing the values of the parameters corresponding to the three equation systems including New York, Tokyo and Frankfurt or London, we cannot reject the hypothesis that such parameters are equal. Only when comparing the systems formed by New York, Tokyo and Frankfurt or Madrid, the value of the F statistic indicates a lower degree of confidence in not rejecting the hypothesis that the New York and Tokyo sensitivity parameters remain unchanged. Notice that in this case we refer to the replacement of one market by another that does not operate exactly during the same hours. Additionally, it seems that the New York influencing power coefficient would be higher when Frankfurt and not London or Madrid are present. This would be reasonable because London and Madrid get some credit for the first two and half hours of global news generated after the opening of New York, which are good advanced indicators. Frankfurt, instead, closes much earlier -4.5 hours- so that the global news generated during that period is attributed to New York.

Finally, we have estimated the Tokyo-London-New York, model including in the equation corresponding to London both the New York returns on the preceding day and those corresponding to the present day (results reported in table 5). This estimation was carried out in two different ways. First (equations [11]-[13]) we set, in the equation for London, the coefficient on New York's return on the same day as $\gamma^*\lambda_2$, where γ is the power coefficient for London, and λ_2 is London's sensitivity coefficient. In this way we want to take into account the fact that the influence exercised by New York on the same day must be the same as the influence exercised by London on the other markets, since both markets are open simultaneously for a period of two and half hours. The second procedure (equations [14]-[16]) does not impose any restriction on the coefficient corresponding to New York on the same day. We should notice that the residuals of the equation including New York's current return have all the information specific to this market, as well as the global information produced since the closing of Tokyo.

RESTRICTED MODEL

$$T_t=\alpha_T+\beta*\lambda_1*N_{t-1}+\gamma*\lambda_1*L_{t-1}+u_{4Tt} \qquad (11)$$

$$L_t=\alpha_L+\delta*\lambda_2*T_t+\beta*\lambda_2*N_{t-1}+\gamma*\lambda_2*N_t+u_{4Lt} \qquad (12)$$

$$N_t=\alpha_N+\gamma*\lambda_3*L_t+\delta*\lambda_3*T_t+u_{4Nt} \qquad (13)$$

UNRESTRICTED MODEL

$$T_t=\alpha_T+\beta*\lambda_1*N_{t-1}+\gamma*\lambda_1*L_{t-1}+u_{5Tt} \qquad (14)$$

$$L_t=\alpha_L+\delta*\lambda_2*T_t+\beta*\lambda_2*N_{t-1}+\theta*N_t+u_{5Lt} \qquad (15)$$

$$N_t=\alpha_N+\gamma*\lambda_3*L_t+\delta*\lambda_3*T_t+u_{5Nt} \qquad (16)$$

Results are presented in table 5. Except for the constant terms, all coefficients are significant and have the expected sign. The unrestricted model gives Θ the value of .38, somewhat higher than the restricted model which gives New York, on the current period power of influence, a value of .256 = .17*1.458 ($\gamma*\lambda_2$).

Table 5: T-L-N MODEL ESTIMATION

	RESTRICTED MODEL	UNRESTRICTED MODEL
α_T	-.00094 (-1.85)	-.0097 (-1.90)
β	.22 (3.63)	.27 (2.83)
λ_1	1.34 (3.96)	1.58 (2.94)
γ	.17 (4.7)	.10 (2.86)
α_F	-.00001 (-.02)	-.00003 (-.06)
δ	.086 (4.15)	0.106 (4.23)
λ_2	1.45 (4.52)	.987 (3.35)
α_N	.0002 (.44)	.0002 (.47)
λ_3	1 (-)	1 (-)
Θ	$=\gamma.\lambda_2$	.379 (6.42)
R^2	.095	.10
Standard Error of the Dependent Variable	.01	.01
SSR	.29	.29
D.W.	2.07	2.06

Endogeneous variables are daily rates of return in the markets of Tokyo, London and New York.
Restricted ($\Theta=\gamma*\lambda_2$) and unrestricted T-L-N model estimation.
See equations (11)-(16) for the meaning of the parameters.

6. FORECASTING.

To test the predictive power of our basic model we estimated the original Tokyo-Frankfurt-New York model using data for the subsample jan/3/90 - dec/30/92. Using the estimated model we forecasted returns for the nov/1/92 - sept/30/93 period. These forecasts were compared with those obtained by regressing the returns of each of the markets on the returns of the other two preceding markets without imposing any cross restrictions between equations.

Table 6 shows the average absolute errors and the average quadratic errors of all these forecasts. For Frankfurt and New York, the complete model gives lower statistics, being superior according to both criteria. For Tokyo, the complete model gives lower values for the average quadratic error but, on the contrary, a higher absolute average error. The differences between both forecasts are highest for New York (3-5%).

Table 6: FORECASTING PERFORMANCE

		Quadratic Average Error	Absolute Average Error
TOKYO	single	.0001452	.00862
	complete	.0001450	.00864
FRANKFURT	single	.0000813	.00619
	complete	.0000803	.00614
NEW YORK	single	.000030	.0042
	complete	.000029	.0040

We should emphasize the better forecasting performance of the complete model in spite of the cross equation restrictions introduced by our proposal of a constant particular bundle of parameters measuring the power and the influence of each market.

7. CONCLUDING REMARKS.

The results reached in this paper confirm the treatment of linkages between international stock markets that we proposed in our former research. We extended our previous results to include two additional markets, Madrid and London, which operate simultaneously. The substitution of one market by another having identical business hours did not change its explanatory power. This may mean that almost any market serves the purpose of transmitting information to other markets. The trading hours of these two additional markets overlap with those of New York, requiring a detailed analysis of the way and order in which information reaches their respective closing prices. Previous correlation analysis confirmed our hypothesis. In that respect, when we analyzed stock markets whose business hours overlap we confirmed the influence of the market that closes later on the closing price of the leading market. This might be due to the fact that during a period of time, innovations were influencing both market returns: those of the preceding market as well as those of the following market. Focusing the analysis of the temporal links between National Stock Price Averages as a simultaneous model allows us to identify for each market two parameters that measure two different features: the power of influencing other markets and the sensitivity towards influence coming from foreign markets. We find New York as the most influencing power and Tokyo as the most sensitive one. The ordernation between different markets is quite robust to changes in the markets included in the model. All parameter values must be interpreted as relative values.

Finally, we check the predictive power of our model in relation with a pure unrestricted one. The forecasts made outside of the sample of estimation by our model are better than those derived from the alternative one in two (New York and Frankfurt) of the three markets, and there is mixed evidence about the predictive power on Tokyo's market. These extensions provide additional evidence in favor of pursuing the problem of the transmission of information between international markets with the approach we initiated in our previous work.

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