

**THE LEAD-LAG RELATION BETWEEN STOCK EXCHANGES: THE
INTERESTING CASE OF ISRAEL AND NEW ZEALAND**

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Abstract

Based on the background of stock market integration, studying the diffusion process of stock prices around the world has become attractive.

Different from much of the literature focusing on the case of overlapping trading time in different stock markets, our paper pays attention to the case of non-overlapping trading time in global stock markets.

We have selected the US, New Zealand and Israel stock market as a case study.

As we conjecture, we find that Israel index's performance on Sunday has a significant correlation on New Zealand index's performance on Monday, while no significant relation is found on other weekdays.

Keywords: Time Zone; Global Stock Market; Stock Price Index; Lead-lag relation

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Table of Contents

Approval.....	1
Abstract.....	2
Acknowledgements.....	3
Table of Contents	4
List of Figures	5
List of Tables	6
1: Introduction.....	7
2: Literature Review	9
3: Data	11
3.1 Data Collection.....	11
3.1.1 Stock Index Selection.....	11
3.1.2 Data Period Selection.....	12
3.2 Data Processing	13
4: Methodology	15
5: Result.....	17
6: Conclusion	21
Bibliography	22

List of Figures

Figure 1. Stock Price Index of NZSE,TA and SP over period 1996-2015	13
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List of Tables

Table 1. International Timeframe of New Zealand, Israel and the US market	12
Table 2. Daily Return of Stock Price Indices of the US, New Zealand and Israel Market.....	14
Table 3. Regression Results for Equation a) and b).....	17
Table 4. Regression Results for Equation c), d) and e).....	错误! 未定义书签。

1: Introduction

During the past 20 years, and especially past 10 years, stock markets have become more and more integrated. Anca Munteanu, Angela Filip, Andreea Pece (2014) present a high degree interconnection between the emerging European countries and the US stock market by conducting a study in the period 2005-2013. Events occurring in one country's financial market diffuse to other markets, which is clearly evident in the ripple effect of the financial crisis of 2008.

With the development of technology, accessing information and investing in other countries' stock markets has become more easily available for investors. By investing in different countries' stock markets, investors can better diversify risk with a global perspective. Furthermore, some arbitragers employ the price spread in different countries of similar assets to make money. Related to this, one possible investment strategy is utilizing the lead-lag relation of global events – in the sense that because of the different operating time of different stock markets – it is possible that stock price movement in one stock market lag behind another stock market.

Because time zone difference exists, the stock markets in different countries open and close at different times. This time-zone difference means that events occurring in the world would immediately affect prices in countries whose stock market is open at the time, but will affect closed stock markets only with a lag, once these markets open. In other words, a lead-lag relation is expected in the global financial markets due to information transmission delay (Sergey K. Aityana, Alexey K. Ivanov-Schitz, Sergey S. Izotov, 2010).

In this paper, we have selected three stock markets with almost no overlap in trading time, the US, Israel, and New Zealand stock markets. Among these three stock markets, the US and New Zealand markets are open during weekdays (Monday to Friday), but Israel market operates from Sunday to Thursday. This feature allows us to analyze the lead-lag relation more closely, and generate a testable hypothesis about the degree of stock market integration.

The idea is as follows. On every calendar day, the first stock market to open is that of New Zealand; a few hours after the New Zealand market closes, the Israeli market will open (except for Fridays), and that would be followed by the US market (there is an overlap of 1.5 hours between the US and Israel, but that won't influence our analysis). Of the three markets, it is obvious that the US market is the most important, because it accounts for approximately 25% of

the world in GDP. Therefore, it should be clear that changes that occur in the US day would have an effect on New Zealand and Israel on the following calendar-day in which trade occurs. The effect of Israel on New Zealand should basically be almost completely muted on regular trading-days because the US market is bigger and closes later than Israel. Thus, the New Zealand market should be affected by the US market much more than Israel not only because of the US importance but also because it is the last market to close before the opening of New Zealand market. Interestingly, for Monday trading in New Zealand market, the last market to close prior to New Zealand market open is Israel market because trading takes place there on Sunday. This would suggest that on Monday (New Zealand time) we should find a positive and significant relation between stock market return in Israel (on Sunday) and stock market return in New Zealand (on Monday). This is what we test in this paper.

After analyse the regression result, our first finding supports that stock market is more integrated in the recent 10 years. Moreover, we also proved that the US stock market has a stronger influence on the other two stock markets. The most important finding is that Israel stock market more significantly affects New Zealand stock market on Monday than other days. To summarize, our findings are consistent with our conjecture.

This paper will be organized as following sequence: the second part describes the past researches on globalization and time zone effect of stock markets; the third part displays both data selection and processing; the forth part describes the methodology applied in this paper; the fifth part analyzes the result by using the data and methodology mentioned in the third and forth part; the final part shows the conclusion based on the analysis in the fifth part.

2: Literature Review

Base on the background of global economy integration, an increasing number of researches pay their attention to the importance of time zone in different businesses and investments.

Ernesto Stein and Christian Daude (2007) prove that global bilateral foreign direct investment (FDI) is negatively influenced by time zone differences, and the effect increases over time. Toru Kikuchi and Sugata Marjit (2010), Biswajit Mandal and Sugata Marjit and Noritsugu Nakanishi (2015) also put forward that time zone difference positively impact business services trade.

Similarly, with rapid globalization, stock markets integration has entered the focus of many researchers in latest decades.

By measuring the performance between major European Countries and the United State, Hans Schöllhammer and Ole Sand (1985) find that global economic interdependence and awareness of constructing a global portfolio lead to a higher degree synchronization of different countries stock price indices. However, prior to this research, many papers indicate that different countries' stock indices only have a weak correlation. G Bua, C Trecroci (2016) also shows that the correlation of global stock markets has enhanced since 1990s. After entering the 21st century, the interconnection of different stock markets becomes stronger (Anca Munteanu, Angela Filip, Andreea Pece, 2014).

The higher and higher degree of stock markets integration raised investors' awareness to construct global portfolios. Many researchers have begun to study the relationship between time zone difference and stock markets.

George M. von Furstenberg, Bang Nam Jeon, N. Gregory Mankiw and Robert J. Shiller (1989) selected the largest four stock markets in the world and analyzed the correlation of stock price indices from each markets by following the stock price indices daily movements. Because these four stock markets operating in different time, the researchers have taken the time zone difference into consideration.

Pamela C. Moulton and Li Wei (2009) studied the market performance of European cross-listed stock on a time zone basis as well. They conclude that the spread of European cross-listed stock is higher in non-overlapping time than in overlapping time.

As researches listed above, global stock market integration has increasingly concentrated researchers' attention to relationship between stock markets and time zone. However, we find that most of researches focus on overlapping trading time of different stock markets. So, in this paper, we decided to take a look at the case of non-overlapping trading time of different stock markets.

3: Data

3.1 Data Collection

3.1.1 Stock Index Selection

All the data in this paper is obtained from Bloomberg, covering three countries' stock markets index. The three indices respectively come from New Zealand, the US and Israel.

New Zealand stock market is one of our research objectives due to its special geographical location. The only registered stock exchange of New Zealand is located in Wellington, whose time zone is UTC+12. This time zone is special because it is the earliest one to change on any given calendar day. The trading time of New Zealand stock exchange is from Monday to Friday, 10:00-17:00.

Israel stock market trading time is Sunday 9:30-16:30 and on Monday to Thursday (9:30-17:30), which is not usual pattern of other stock markets which tend to operate on Monday to Friday. Tel Aviv Stock Exchange belongs to UTC+2 time zone. Considering that Israel stock market's Sunday performance may directly influence other stock markets' Monday performance without a weekend cumulative Monday effect (from Friday's to Monday' s close), it is meaningful to contain this market when do a analysis based on time zone difference. There will be more detailed analysis in the later part of this paper.

The reason to choose US is that its stock market is one of the largest stock markets in the world. Many researches have proved that US stock market has a significant impact to other countries' stock market. Given that New York stock exchange is one of the most influential stock exchanges in US, it would work as a representative in US market in this paper. In addition, the New York time zone falls into UTC-5, which satisfies our attempt that there is no significant overlap of trading time among our selected markets. New York stock exchange is open at 9:30 and close at 16:00.

Crossing the International Date Line to the western side, the date will be added one day. In the whole world, time zone difference keeps a 24-hour range at any moment. As showed in Table 1, the three selected markets are sequenced in a 24-hour period. But, it should be noticed that there is no absolute sequence relation.

These three countries' trading time of stock markets almost cover the whole periods within a 24-hour.

Table 1. International Timeframe of New Zealand, Israel and the US market

Item	New Zealand	Israel	US
Local time	10:00-17:00	09:30-17:30 09:30-16:30 ^a	09:30-16:00
Coordinated Universal Time (UTC)	22:00-05:00	07:30-15:30 07:30-14:30 ^a	14:00--21:00
Local time equivalent			
Noon New Zealand	<u>12:00</u>	02:00	19:00 ^b
Noon Israel	22:00	<u>12:00</u>	05:00
Noon US	05:00 ^c	19:00	<u>12:00</u>

a. Sunday's trading time in Israel

b. On the date previous to the date at noon in New Zealand and Israel

c. On the date following the date at noon in US

To measure New Zealand stock market's performance, we have used New Zealand All Ordinaries Index (NZSE), a capitalization-weighted index, which developed from a base value of 1000 as of July 1,1986. This index contained all domestic stocks listed on the New Zealand Exchange without any foreign companies' stocks.

Tel Aviv 100 Index (TA-100), as the name implies, consisted of the most highly capitalized 100 stocks traded in the Tel Aviv Stock Exchange, and developed from a base value of 100 as of January 1, 1992.

Standard & Poor's 500 Index (S&P 500) measures the US market's performance. It is composed of 500 capitalization-weighted companies traded in New York Stock Exchange. S&P 500 is well known for the best representative of the stock market in US.

3.1.2 Data Period Selection

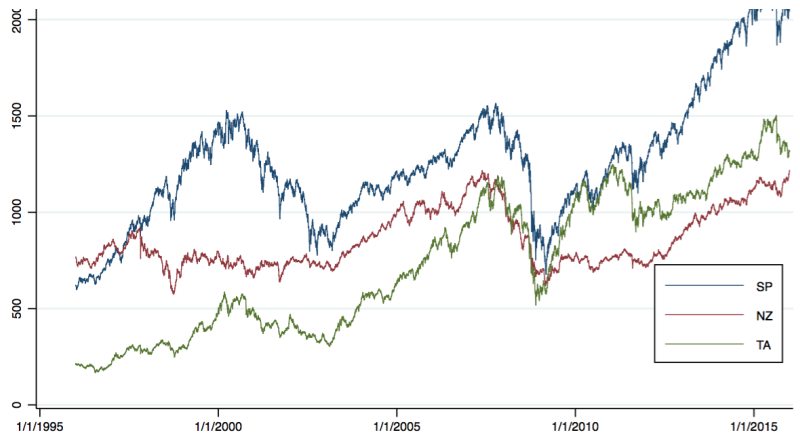
We choose the whole period of 1996-2015 in total 20 years due to economic globalization during this period. Because relationship of global stock markets is getting stronger in the later 10 years, we also do subperiod: The first 10 years (1996-2005) and the second 10 years (2006-2015).

In this paper, we analyze the relationship among stock markets' performance of three countries (Israel, America and New Zealand) in both the whole period and two sub-periods.

3.2 Data Processing

As discussed previously, the raw data on a daily basis in this paper is collected from three stock indices. Selected data period is 1996-2015, and total 6179 data are collected. The sample size would be smaller in later analysis due to missing data of holiday. However, the missing data could be ignored considering the large number of our sample data.

Figure 1. Stock Price Index of NZSE,TA and SP over period 1996-2015



After obtaining the raw data, we firstly calculated the daily return of each market based on a simple return calculation formula:

$$R_t = (P_t / P_{t-1}) - 1$$

Where, R_t is daily market return at date t ; P_t is daily closing prices for each index at date t ; P_{t-1} is daily closing prices for each index at date $(t-1)$. The line chart below shows simple return of each index during 1996-2015 period.

Then we do the regression using the calculated return on a whole 20-year period (1996-2015) and on two sub-periods of 10-year (1996-2005 and 2006-2015).

Table 2. Daily Return of Stock Price Indices of the US Market, New Zealand and Israel (Except number of trading days, all information is given in percentages).

Statistic	S&P 500			NZSE			TA-100		
	1996-2015	1996-2005	2006-2015	1996-2015	1996-2005	2006-2015	1996-2015	1996-2005	2006-2015
Number of trading days	6177	3086	3088	6176	3085	3087	6178	3087	3090
Mean	0.026	0.028	0.022	0.010	0.012	0.008	0.036	0.051	0.021
Std. Dev.	1.113	1.043	1.180	0.689	0.753	0.617	1.116	1.148	1.083
Minimum	-9.035	-6.866	-9.035	-12.099	-12.099	-4.764	-9.861	-9.861	-7.199
Maximum	11.581	5.732	11.581	9.609	9.609	5.480	10.276	7.996	10.276
p5	-1.723	-1.705	-1.780	-1.061	-1.149	-1.006	-1.741	-1.798	-1.706
p50	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
p95	1.660	1.680	1.637	1.025	1.125	0.948	17.597	1.868	3.058

Note that, the data selection bias could not be completely eliminated due to a relatively small number of stock markets analyzed and a limited period of time selected.

4: Methodology

In order to examine the relationship between the three countries' stock markets and the influence of time zone difference, we analyze the following regression models for three countries' stock markets index's performance over the period of 1996-2015:

- a) $SP_t = TA_{t-1} + NZ_t$
- b) $TA_t = NZ_t + SP_{t-1}$
- c) $NZ_t = Mon + TA_{t-1} + SP_{t-1} + NZ_{t-1} + InterTA$
- d) $NZ_t = Mon + TA_{t-1} + SP_{t-1} + NZ_{t-1} + InterSP$
- e) $NZ_t = Mon + TA_{t-1} + SP_{t-1} + NZ_{t-1} + InterTA + InterSP$

Where, SP_t represents the daily return of S&P500 index at day t ; TA_t represents the daily return of TA-100 index at day t ; NZ_t represents the daily return of NZSE index at day t ; Mon represents the control variable, where on Monday, $Mon = 1$, otherwise $Mon = 0$; $InterTA$ represents the control variable, $InterTA = TA_{t-1} * Mon$; $InterSP$ represents the control variable, $InterSP = SP_{t-1} * Mon$; t represents the day t ; $t-1$ represents the day $t-1$.

In equation a), we try to interpret the S&P500 index's daily returns by using Israel's returns and New Zealand's returns. We do time-series test based on equation a). To eliminate the influence of overlap from Israel index on the same day, we use the previous day returns of Israel index. There is no influence of overlap from New Zealand index because of the time zone difference, we use the same day returns for S&P500 index and New Zealand index. Therefore, the result could allow us to see if that S&P500 index was influenced by the two stock market's performance which happened before its market opening.

In equation b), we try to interpret the Israel index's daily returns by using S&P500's returns and New Zealand index's returns. We do time-series test based on equation b). Because the opening time of the Israel's stock market is earlier than the US's, and there is no overlapping opening market time between New Zealand's stock market and Israel's on the same day, we use the same day returns for New Zealand and the previous day returns for the US. Therefore, the result could allow us to examine whether or not that the performance of S&P500 index of

previous day and the performance of New Zealand index of the same day could interpret the performance of Israel index's performance.

The first two equations are related regular, we mainly used them to test whether the globalization is getting stronger during the recent years and to testify the relationships between these three indices. The most special model, which could reflect the lead-lag relation on different countries' stock markets, is whether the Israel's index affects NZ's index on Monday but no other days or affects more on Monday. So we add three variables (Mon, InterSP and InterTA) to develop three equations, which could specify the performance of Israel index on Monday, and the performance on other days.

In equation c), we specify the performance of Israel's stock index on Monday compared with other days through adding a control variable Mon. Also we add InterTA and InterSP which was controlled by the variable Mon. In this way, we could express the specific influence on New Zealand index on Monday by using InterTA and InterSP, compared with the influence on regular days using TAt-1 and SPt-1. We do time-series test based on equation c). Because of the influence of the time zone difference, New Zealand is the first stock market to open on the same day, we use previous day returns of Israel index and S&P500 index to interpret the New Zealand's performance on regular days. Also, Israel's stock market is the only one which would open on Sunday, and New Zealand's opening time is earlier than the US's, so the New Zealand index's performance on Monday is correspond to the performance of Israel index on Sunday and S&P500 index's on last Friday. In the meantime, we add NZ_{t-1} to control the influence of the performance on the previous day. Therefore, the result could allow us to test if that the performance of S&P500 index of previous day and the performance of Israel index of the previous day could interpret the performance of New Zealand's index. Especially on Monday, to see whether or not the influence of Israel index would be larger than it on other days.

In Equation d), we replace the variable InterTA to InterSP to see if there is more significant influence of S&P 500 index's performance on last Friday compared with the performance on other days. In Equation e), we add all control variables together and to test if the conclusion from the results of last two regressions would stay the same.

5: Result

We divided the whole period into two sub periods, using the daily returns to do the time-series regressions and try to focus on the coefficients, t value and P value of independent variables as follows:

Table 3. Regression Results for Equation a) and b)

Panel 1 Regression Result for Equation a) $SP_t = TA_{t-1} + NZ_t$									
	1996 - 2015			1996 - 2005			2006 - 2015		
	R Squire			R Squire			R Squire		
	Coef.	t value	P value	Coef.	t value	P value	Coef.	t value	P value
NZ _t	0.006	0.25	0.804	0.009	0.32	0.749	0.0012	0.03	0.976
TA _{t-1}	0.009	0.66	0.509	0.008	0.46	0.645	0.010	0.44	0.66
cons	0.0003	1.69	0.091	0.0003	1.37	0.171	0.0003	1.02	0.31
Panel 2 Regression Result for Equation b) $TA_t = NZ_t + SP_{t-1}$									
	R Squire			R Squire			R Squire		
	Coef.	t value	P value	Coef.	t value	P value	Coef.	t value	P value
NZ _t	0.212	6.89	0	0.263	6.85	0	0.098	1.88	0.06
SP _{t-1}	0.207	10.91	0	0.238	8.38	0	0.199	7.64	0
cons	-0.0001	-0.54	0.586	-0.0001	-0.2	0.838	-0.0002	-0.53	0.594

In Panel 1, we used the previous day's return of Israel index to eliminate the overlap influence on S&P500 index, we could find that t value of New Zealand's performance and Israel's performance are pretty small, which means there is no significant evidence to say Israel index and New Zealand index could influence S&P500 index. The t value and coefficients of intercepts are all relatively small, which show an insignificant level.

In Panel 2, we could see that the t value and P value of S&P500 index always show a significance, which means S&P500 index could interpret the performance of Israel index during these three periods. Combining the coefficients of these three periods, we could find that the influence of S&P500 index lightly decreased. For the New Zealand index, we find that during the whole period and The first 10 years, t value and P value show a significant relationship between the New Zealand index and Israel index, from the coefficients, we could also know during this

two periods, New Zealand index interpret the performance of Israel index better than S&P500 index. But the t value and P value decrease to a level not that significant as before during the recent 10 years. The influence of New Zealand index on Israel index is getting weak. Still, there is no significant influence of the intercept on Israel index in this regression.

We divided the whole period into two sub periods, using the daily returns to do the time-series regressions and try to focus on the coefficients, t value and P value of independent variables as follows:

Table 4. Regression Results for Equation c), d) and e)

Panel 1 Regression Result for Equation c) $NZ_t = \text{Mon} + TA_{t-1} + SP_{t-1} + NZ_{t-1} + \text{InterTA}$									
	1996 - 2015			1996 - 2005			2006 - 2015		
	R Squire	0.2089		R Squire	0.1469		R Squire	0.3082	
	Coef.	t value	P value	Coef.	t value	P value	Coef.	t value	P value
Mon	-0.0008	-3.38	0.001	-0.0013	-3.38	0.001	-0.0003	-1.06	0.291
TA_{t-1}	0.013	1.36	0.173	0.013	0.87	0.384	0.015	1.2	0.231
InterTA	0.153	9.19	0	0.136	5.25	0	0.171	8.39	0
SP_{t-1}	0.286	32.93	0	0.282	18.82	0	0.289	29.53	0
NZ_{t-1}	-0.014	-0.98	0.326	-0.049	-2.38	0.017	0.041	2.21	0.027
_cons	0.0002	1.54	0.123	0.0003	1.62	0.105	0.00005	0.37	0.708
Panel 2 Regression Result for Equation d) $NZ_t = \text{Mon} + TA_{t-1} + SP_{t-1} + NZ_{t-1} + \text{InterSP}$									
	R Squire	0.2131		R Squire	0.1604		R Squire	0.3004	
	Coef.	t value	P value	Coef.	t value	P value	Coef.	t value	P value
Mon	-0.0007	-2.91	0.004	-0.0012	-3.11	0.002	-0.0002	-0.73	0.467
TA_{t-1}	0.042	5.1	0	0.033	2.57	0.01	0.555	5.36	0
InterSP	0.214	10.59	0	0.262	8.32	0	0.159	6.41	0
SP_{t-1}	0.279	32.59	0	0.278	18.83	0	0.278	28.73	0
NZ_{t-1}	-0.022	-1.55	0.122	-0.055	-2.7	0.007	0.032	1.71	0.088
_cons	0.0002	1.51	0.131	0.0003	1.6	0.11	0.00005	0.38	0.704
Panel 3 Regression Result for Equation e) $NZ_t = \text{Mon} + TA_{t-1} + SP_{t-1} + NZ_{t-1} + \text{InterSP} + \text{InterTA}$									
	R Squire	0.2175		R Squire	0.1622		R Squire	0.3108	
	Coef.	t value	P value	Coef.	t value	P value	Coef.	t value	P value
Mon	-0.0008	-3.24	0.001	-0.0013	-3.29	0.001	-0.0003	-0.99	0.321
TA_{t-1}	0.013	1.37	0.17	0.0133	0.88	0.38	0.015	1.2	0.231
InterTA	0.098	5.4	0	0.065	2.35	0.019	0.14	6.21	0
InterSP	0.166	7.53	0	0.232	6.84	0	0.085	3.1	0.002
SP_{t-1}	0.286	33.11	0	0.282	18.99	0	0.289	29.58	0
NZ_{t-1}	-0.014	-0.99	0.324	-0.049	-2.4	0.016	0.041	2.22	0.027
_cons	0.0002	1.55	0.121	0.0003	1.64	0.102	0.00005	0.38	0.707

In Table 4, we mainly focus on the regression results on the compare between TA_{t-1} and InterTA, also the compare between SP_{t-1} and InterSP. The t values and coefficients of all intercepts show an insignificant level that we will not influence our regression results. Although the t values of our control variable Mon are relatively big in the 1996 – 2015 and 1996 – 2005 periods, the coefficients of them are pretty small, which would also not affect the relationship between the main variables.

From Panel 1, the t value and P value of interTA always show a big significance which means there is significant relationship between the performance of Israel index on Sunday and the performance of New Zealand index on Monday. But for regular days excluded Monday, the t value and P value for TA_{t-1} become much smaller and not significant anymore, which means Israel index's performance have much more influence on New Zealand on Monday through its Sunday's performance compared with its regular days' influence.

From Panel 2, both InterSP and SP_{t-1} show a significant level between them and New Zealand index performance, which means even the return of S&P 500 index on last Friday, still have significant influence on Israel index the on first day of next week. But combining the coefficients of these two variables, we could find that the regular day's performance of S&P index has more influence on Israel index than the last Friday's performance.

From Panel 3, after we consider all the control variables, we could still conclude that the performance of Israel index on Sunday have much more influence on the performance of New Zealand index on Monday compared with other regular days during all these three periods. And S&P500 index have more influence during regular days compared with the last Friday's performance.

For all the regression results above, the t values of the variable NZ_{t-1} all show an insignificant level, which means although we controlled the influence of the previous day of New Zealand Index in order to control the influence of the S&P500 Index. The performance of S&P500 Index on last Friday on the performance of New Zealand Index on the next Monday still show a significant level.

The result from the equation c) has tested our hypothesis that the influence of Israel index performance on Sunday on New Zealand index on Monday much more significant than the influence on regular days. But the result from the equation d) and e) is a little different from our hypothesis: we assumed the New Zealand index performance would be mainly influenced by the performance of Israel index on Sunday, that the influence of S&P500 index should be less

significant. The followings are supposed to be the reasons: 1) The S&P500 index always have big influence on the New Zealand index, no matter on the next specific day or on the next Monday after the weekend, the influence would be always significant. 2) During the weekend that the stock markets close, investors of New Zealand still concentrate more on the news of the trends of S&P500 index and other big news from the US, which lead to the big influence of the US index even after the closing weekend time. But we do not have a good accurate explanation for why the interaction term with SP is significant.

Our main model is comprised of these three equation, the result shows a strong evidence the time zone difference makes the influence of Israel index performance on Sunday on New Zealand index on Monday much more significant than the influence on regular days.

6: Conclusion

Overall, we could conclude that the stock market has become more globally connected during the recent period 1996-2005 than the period 2006-2015. S&P500 index has significant influence on New Zealand index and Israel index, and there is no significant influence of other two indices on S&P500 index. However, New Zealand index has a weaker influence on Israel's index during the last 10 years.

Moreover, we find out that Israel index's performance has much more significant influence on New Zealand index's performance on Monday than other days through examining the main model of New Zealand Index. The reason is that the special opening time of Israel stock market on Sunday. Also, the time zone difference makes it happen that New Zealand stock market opens just after a couple of hours after Israel's stock market closing on Sunday. This factor leads to the significant lead-lag relationship between Israel index's performance on Sunday and New Zealand index's performance on Monday.

In practical application, our data analysis provides investors and stock markets with the empirical evidence about how the globalization influences the worldwide stock markets. Also, this research provides support for investors to utilize lead-lag relation of different stock indices to learn more about the index's performance by combining different stock markets. Especially for the cross-listed equities, this method would help investors to evaluate equities more accurate, to make better investment decisions and to earn more possible returns.

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