On the dynamics of international stock market efficiency

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Abstract:
The Granger causality procedure is used to assess the dynamics of market efficiency of 17 international stock indices. These indices are based on relatively smaller firms. The reference of market efficiency is a stock index, from the same economy, which is based on relatively larger firms. There is evidence that market efficiency increases over time at a decreasing rate.

JEL classification: G14, G15

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Market efficiency, International, Stock indices, Panel model, Granger causality
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1. Introduction

This paper explores an alternative approach to the examination of the dynamics of market efficiency. The Granger (1969) causality procedure (see, for example, Wickremasinghe, 2011) is used to assess market efficiency. Except for a structural break analysis or a recommendation for it in some cases (see, for example, Karim and Majid, 2010; Narayan and Narayan, 2007), most authors stop short of exploring the dynamics of the Granger causality coefficient. Using a panel data regression model, we examine the way that the relative market efficiency of 17 international stock indices evolves over a period of 21 years. The focus is on stock indices based on relatively smaller firms. The corresponding stock index based on relatively larger firms is used as the gauge of market efficiency. The words ‘big’ and ‘small’ are used to differentiate between the two classes of index.

In an international study of the Monday effect in 50 stock indices, Keef, Khaled and Zhu (2009) make three observations. First, the degree of anomalous price behavior decreases over time. They equate anomalous behavior with market inefficiency. Using $ME$ to represent the level of market efficiency, this observation can be represented by

$$ ME = ME(t), \quad ME'(t) > 0. $$

This is called Hypothesis 1.

Second, the rate of the temporal reduction of the anomalous behavior is larger for less developed economies. Third, the level of economic development goes hand in hand
with market efficiency. These observations can be represented as $ME'(t) = f(ME)$, where $f_{ME} < 0$. The implication of this, under Hypothesis 1, is that market efficiency increases at a decreasing rate:

$$ME'(t) = f_{ME}ME(t) < 0.$$  

This is called Hypothesis 2.

Our research question relates to the degree that these between-country results also occur within a country, i.e., between two indices from the same country. The subjects in this study are a big index and a small index from 17 countries. The term ‘GC coefficient’ is used to represent the degree to which the returns of the big index Granger-cause the returns of the small index. As conceptual framework, we posit that the GC coefficient is a measure of the inefficiency of the small index using the big index as the reference.

We examine the temporal change in the GC coefficient on non-Mondays and on Mondays. Under the assumption that the market efficiency of the big index is stable over time, there is support for Hypothesis 1 if the GC coefficient on non-Mondays, or Mondays, decreases over time. If one is prepared to accept that the market efficiency of the big index increases over time, then the decline of the GC coefficient provides support for Hypothesis 2. There is extensive evidence that stock index returns on Mondays are anomalous. Our conjecture is that the GC coefficient on Mondays will also be anomalous. There is further support for Hypothesis 2 if two conditions are met. They are: (i) at the start of the data in 1990, the GC coefficient on Mondays is larger than the GC coefficient on non-Mondays, and (ii) the GC coefficient on Mondays declines at a faster rate compared to non-Mondays.
2. Methodology

The stock index price series are obtained from Datastream. Our search isolated 17 countries where: (i) index price data for two indices are available for a period of 21 years (1 January 1990 to 31 December 2010) and (ii) we could reliably classify one index as being ‘big’ and other index as being ‘small’. Our sample of countries is constrained by data availability. There are 89,230 possible trading days in the period. After missing values are taken into account, there are 86,316 cases available for analysis. Table 1 provides details of the indices.

Unreported preliminary analyses use four lags of the returns of both indices and the panel approach as described below. There are three important results. First, the returns of the small index do not Granger-cause the returns of the big index. Second, the returns of the big index Granger-cause the returns of the small index. These results are not exceptional. Third, with the latter result, the first lag of the big index is the only statistically non-zero estimated coefficient.

We do not fit the same empirical model (i.e., estimated coefficients) to all countries. Rather, we allow each country to have their unique empirical model in the framework of a panel regression. We finesse the ‘average’ of the 17 estimated coefficients for each independent variable. A Kronecker combination of the one-lag Granger model with the temporal variable and the Monday variable gives
\begin{align*}
    r_{i,t}^S &= \sum_{i=1}^{17} \alpha_{0,i} D_i + \sum_{i=1}^{17} \beta_{0,i} D_i Y_i + \sum_{i=1}^{17} \gamma_{0,i} D_i M_t + \sum_{i=1}^{17} \delta_{0,i} D_i M_i Y_i + \\
    &+ \sum_{i=1}^{17} \alpha_{1,i} D_i r_{i,t-1}^S + \sum_{i=1}^{17} \beta_{1,i} D_i r_{i,t-1}^B + \sum_{i=1}^{17} \gamma_{1,i} D_i r_{i,t-1}^B M_t + \sum_{i=1}^{17} \delta_{1,i} D_i r_{i,t-1}^B M_i Y_i + \\
    &+ \sum_{i=1}^{17} \alpha_{2,i} D_i r_{i,t-1}^B + \sum_{i=1}^{17} \beta_{2,i} D_i r_{i,t-1}^B Y_i + \sum_{i=1}^{17} \gamma_{2,i} D_i r_{i,t-1}^B M_t + \sum_{i=1}^{17} \delta_{2,i} D_i r_{i,t-1}^B M_i Y_i + \\
    &+ e_{i,t} 
\end{align*}

where \( r_{i,t}^S \) and \( r_{i,t}^B \) are the daily rates of return of the small indices and the big indices, respectively, with subscript \( i \) representing the country, \( Y_t \) is a temporal indicator (= 0 in 1990 through to 20 in 2010) and \( M_t \) is a dummy variable which takes on a value of 1 if day \( t \) is a Monday, otherwise zero. The constant is suppressed and \( D_i \) \((i = 1 \ldots 17)\) represents 0,1 dummy variables -- one for each country. The average of the 17 coefficients for each independent variable is denoted with an ‘overbar’. As an illustration, the average coefficient of the Constant \( \bar{\alpha}_0 \) is

\[
    \bar{\alpha}_0 = \frac{\left( \sum_{i=1}^{17} \alpha_{0,i} \right)}{17} .
\]

The averages and their corresponding standard errors are calculated by the use of linear restriction tests within the panel regression.

The coefficients in the first row of equation (1), i.e., those with a subscript of 0, measure the Monday effect and the temporal effect in the returns of the small index. The coefficients in the second row, i.e., those with a subscript of 1, are mandated by the Granger causality test. Since they are control variables, the estimated coefficients in row one and row two are reported without comment. The primary focus is on the four sets of coefficients in row three – those with a subscript of 2. When converted to an average of the 17 countries, they capture the average magnitude of Granger causality –
hereafter, they are called the $GC$ coefficients with the unwritten connotation of ‘average’. The conventional interpretation is: (i) coefficient $\alpha_2$ is the $GC$ coefficient on non-Mondays in 1990 (i.e., when $Y_t = 0$), (ii) coefficient $\beta_2$ measures the temporal slope of the $GC$ coefficient on non-Mondays, (iii) the $GC$ coefficient on Mondays in 1990 is given by $\alpha_2 + \gamma_2$ and (iv) the temporal slope of the $GC$ coefficient on Mondays is given by $\beta_2 + \delta_2$.

Equation (1) is estimated by the panel EGLS method using cross-section weights and panel corrected standard errors. This provides control for heteroscedasticity and contemporaneous correlation of the errors across countries. The lagged rates of return provide control for serial correlation.

3. Results and Discussion

The panel regression results are presented in Table 2. In 1990, the $GC$ coefficient on non-Mondays is significantly positive ($\hat{\alpha}_2 = 0.1468, p < 0.001$). This strong Granger causality declines at a statistically significant rate ($\hat{\beta}_2 = -0.0069, p = 0.04$). This provides support for Hypothesis 1 under the assumption that the market efficiency of the big indices, on average, does not change over time. As suggested earlier, these results also support Hypothesis 2 if this latter assumption is changed to allow the market efficiency of the big indices to systematically increase over time.

In 1990, there is weak statistical evidence that the $GC$ coefficient is greater on Mondays compared to non-Mondays ($\hat{\gamma}_2 = 0.1263, p = 0.10$). However, in economic terms the
difference is of practical importance. The estimated $GC$ coefficient on Mondays

$\hat{\alpha}_2 + \hat{\gamma}_2 = 0.2731$ is almost twice the size of the coefficient on non-Mondays. The $GC$

coefficient declines at a faster rate on Mondays compared to non-Mondays

$\hat{\delta}_2 = -0.0136, p = 0.07$. Again, the statistical evidence is weak but the difference in

the temporal slope is of economic importance. The slope on Mondays,

$\hat{\beta}_2 + \hat{\delta}_2 = -0.0205$, is almost three times the slope on non-Mondays. In terms of slope

and intercept, the $GC$ coefficient results on Mondays dominate non-Mondays -- thus

there is stronger support for Hypothesis 1. The results for Mondays also provide weak,

in a statistical sense, support for Hypothesis 2. In a practical dimension, the support is

far stronger.

4. Conclusions

Based on a pair of stock indices from 17 countries, the conclusion is reached that

market efficiency increases over time (Hypothesis 1) at a decreasing rate (Hypothesis

2). The sample of countries can be classified as being highly developed. The study

raises two issues. First, an interesting question is the degree that the results apply to

less developed countries. Ceteris paribus, these countries are expected to provide

stronger support for the hypotheses. Second, researchers into stock market anomalies

and/or market efficiency should take into account the degree that the magnitude of the

anomaly (e.g., Marquering, Nisser & Valla (2006) and/or the level of market efficiency

evolves over time.
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Table 1

Countries and their Stock Indices

| Country   | Big                        | Small                     |
|-----------|----------------------------|---------------------------|
| Australia | S&P/ASX 20                  | S&P/ASX Small ord         |
| Austria   | DS Market (50 firms)        | HSBC Smaller              |
| Denmark   | OMXC 20                     | S&P Small                |
| Finland   | DS Market (50 firms)        | OMXH                      |
| France    | CAC 40                      | DS Market (250 firms)     |
| Germany   | DAX 30                     | CDAX General              |
| Hong Kong | Hang Seng                   | Hang Seng Small cap       |
| Ireland   | DS Market (50 firms)        | S&P Small                |
| Italy     | Milan COMIT 30              | Milan COMIT General       |
| Japan     | NIKKEI 225 Average          | NIKKEI 500                |
| Korea     | SE Large-sized              | SE Small-sized            |
| Netherlands | AEX Index                  | Midkap                    |
| Singapore | FTSE W Singapore           | S&P Small                |
| Spain     | IBEX 35                     | IBEX Medium cap           |
| Sweden    | OMXS 30                     | DS Market (70 firms)      |
| UK        | FTSE 100                    | FTSE All share            |
| USA       | Dow Jones Industrials       | NYSE Composite            |
### Table 2
Small Index Effects (equation 1)

| Variable          | Coefficient | Estimated Coefficient$^{(a)}$ | Standard Error | $t$  | $p$  |
|-------------------|-------------|------------------------------|----------------|------|------|
| **Panel A: $M_t$ and $Y_t$ effects on $r_{i,t}^S$** |             |                              |                |      |      |
| Constant          | $\alpha_0$  | 0.0318                       | 0.0259         | 1.23 | 0.220|
| $Y_t$             | $\beta_0$   | -0.0011                      | 0.0022         | -0.50| 0.614|
| $M_t$             | $\gamma_0$  | -0.1211                      | 0.0582         | -2.08| 0.037|
| $M_tY_t$          | $\delta_0$  | 0.0063                       | 0.0050         | 1.27 | 0.206|

| **Panel B: $r_{i,t}^{S-1}$ effects on $r_{i,t}^S$** |             |                              |                |      |      |
| $r_{i,t-1}$       | $\alpha_1$  | -0.0553                      | 0.0373         | -1.48| 0.138|
| $r_{i,t-1}Y_t$    | $\beta_1$   | 0.0039                       | 0.0037         | 1.06 | 0.287|
| $r_{i,t-1}M_t$    | $\gamma_1$  | 0.1887                       | 0.0863         | -2.18| 0.029|
| $r_{i,t-1}M_tY_t$ | $\delta_1$  | -0.0065                      | 0.0085         | -0.77| 0.444|

| **Panel C: $r_{i,t}^B$ effects on $r_{i,t}^S$** |             |                              |                |      |      |
| $r_{i,t-1}$       | $\alpha_2$  | 0.1468                       | 0.0326         | 4.50 | < 0.001|
| $r_{i,t-1}Y_t$    | $\beta_2$   | -0.0069                      | 0.0033         | -2.10| 0.035|
| $r_{i,t-1}M_t$    | $\gamma_2$  | 0.1263                       | 0.0763         | 1.66 | 0.098|
| $r_{i,t-1}M_tY_t$ | $\delta_2$  | -0.0136                      | 0.0076         | -1.79| 0.074|

Note:
(a) These are averages over the 17 countries.