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On the Timeliness of Price Discovery

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ABSTRACT

Price discovery is the process whereby value-relevant, private information becomes impounded or reflected in a stock's publicly-observable market price. The timeliness of price discovery refers to how quickly that process takes effect.

There is no reason to believe either that all private information is discovered equally quickly or that price discovery is equally speedy for all firms. The latter observation suggests it would be worthwhile knowing why the timeliness of price discovery differs across firms, even the more so in an environment where all listed companies by law must disclose most material price-sensitive information as soon as they become aware of it. The other observation, that not all private information is discovered equally quickly, implies we should focus on a material, periodic event when we compare timeliness across firms. A good candidate is the announcement of the company's annual results, since for many years is has been known that annual earnings alone captures at least half the value-relevant information released by the average firm over the 12 months leading up to this date.

We use various approaches to explore measures of timeliness and what they can tell us. We review a number of studies that have considered various aspects of timeliness in different countries and extend and contrast their findings. We also examine the relationship between the timeliness of price discovery and analogous measures based upon firms' formal disclosures to the share market and upon analysts' consensus earnings forecasts. Finally, we report on an issue of major concern to regulators and market operators, namely the influence of corporate governance on the timeliness of price discovery.

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On the Timeliness of Price Discovery[1]

Wendy Beekes[2] and Philip Brown[3]

1 Introduction

Timeliness is an old and important concept in accounting, where it refers to making information available to decision makers while it can still be used. In studies of financial markets, it has been applied when addressing the question, "How quickly is value-relevant information reflected in price?" Another strand of research, in the accounting literature, asks the reverse question,[4] "How quickly is information that is priced by financial markets recognized in the accounts?"

We explore timeliness in the first sense. We trace its development as an idea, mention settings where it has been estimated, and draw some interesting comparisons across studies. We also investigate its properties and relationships with analogous concepts based on corporate disclosures and analysts' earnings forecasts. Within an economy, timeliness is related to stock price volatility, to the firm's size, and to the quality of its corporate governance.

The next section outlines the key concepts of timeliness and price discovery. This is followed by a review of the related literature. Then there is discussion of our examination of the timeliness metric and the results obtained. The final section summarises our conclusions.

2 Basics

By price discovery we mean the process whereby value-relevant, private information becomes impounded or reflected in a stock's publicly-observable market price. The timeliness of price discovery refers to how quickly that process takes effect.

There is no reason to believe all private information is discovered equally quickly, neither is there any reason to believe price discovery is equally speedy for all firms. The latter observation suggests reasons for observing differences across firms could be interesting, perhaps the more so in a setting where firms are required by law to disclose any material price-sensitive information as soon as it becomes known.[5]

The former observation, that not all private information is discovered equally quickly, suggests that if we wish to compare differences across firms in the timeliness of price discovery,

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[4] See Basu (1997) et seq.
[5] For example, the Continuous Disclosure provisions of Australian company law apply equally to all listed companies.

we should focus on a material and periodic event. For most of our analysis in this paper, we choose the initial disclosure of a listed company's annual results, an event which we have known since Ball and Brown (1968) captures at least half the value-relevant information released by the average firm over the 12 months leading up to this date. We also need to measure speed over some time period. Given our choice of a company's annual results, we use an annual period (specifically, 365 days) ending 14 days after the announcement, to allow price to settle.[6] For simplicity, call this ending date the benchmark date and the stock price at the end of the benchmark date the benchmark price.

To illustrate our measure of timeliness, suppose we have an extreme case with two stocks A and B. Stock A's price begins at say $10 at the start of the first day of the tracking year. At the end of the first day, the price is exactly $20, where it remains until the end of the benchmark date because no further value-relevant information is discovered after the first day that year. Then we get the solid line as in Figure 1. Stock B's price begins at say $10 at the start of the first day of the tracking year where it remains until the start of the benchmark date (because no value-relevant information is discovered until the last day that year); and at the end of the benchmark day price is exactly $20, because previously-unavailable value-relevant information is discovered on the last day that year. Then we get the dashed line as in Figure 1. Note that the two stocks, A and B, are equally volatile. However, Stock A's price discovery is clearly more "timely" than Stock B's as it moves to the benchmark price more quickly.

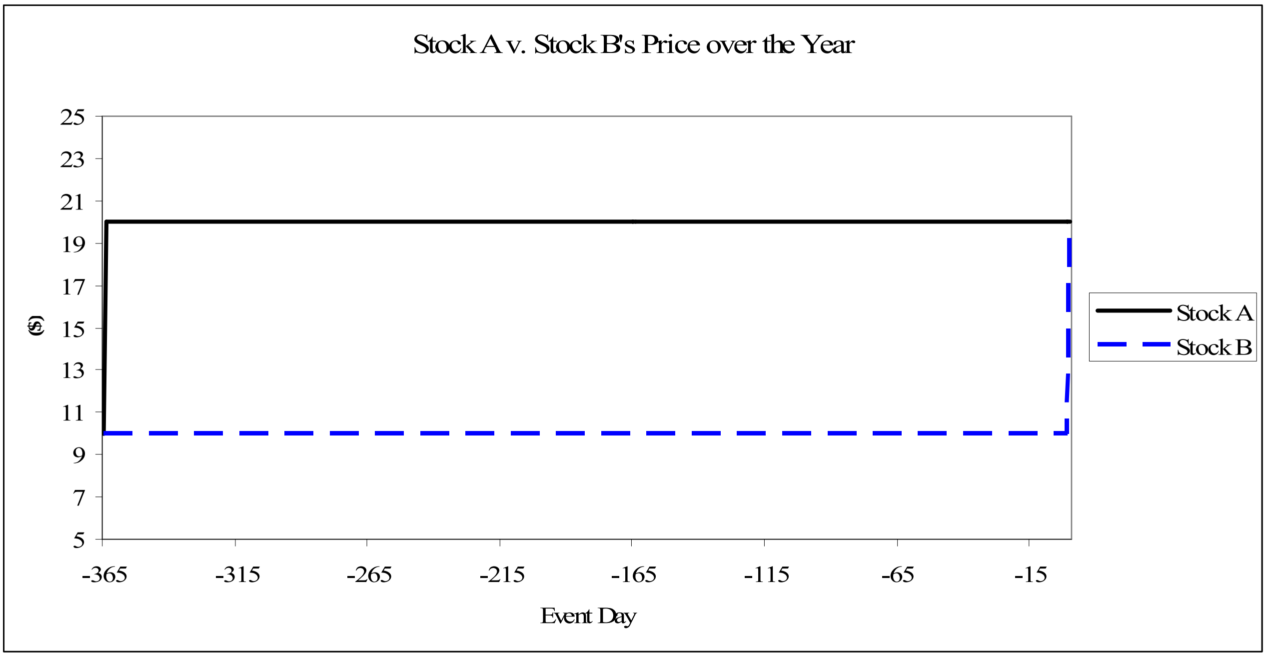

Figure 1

[6] Beaver (1968) was perhaps the first to point out that share prices are significantly more volatile for at least two weeks after a U.S. listed company releases its fourth quarter's financial results.

It is possible to construct a range of metrics for the timeliness of price discovery and in later sections we investigate some of them. For the time being we propose timeliness be measured as the average absolute difference between the log of price at the end of day t (beginning on day $t = -364$) and the log of price at the end of day 0, which we have defined as the release (announcement) day +14 days. Thus,

$$T_2 \equiv \sum_{t=-364}^{0} | \ln P_t - \ln P_0 | / 365. \qquad (1)$$

The subscript on T simply indicates this definition is the second of several definitions of timeliness we consider. For the two stocks, $T_2 = 0$ for Stock A and 0.7 for Stock B. Defined this way, the lower the value of T_2 the less time is taken to discover price, or equivalently, the more timely the price discovery. Clearly Stock A is more timely than Stock B, as indicated by T_2, but as mentioned above they are extreme cases.

We acknowledge that the reporting lag, which is the time lag from the close of the financial year to the reporting date, varies by firm and according to its circumstances. Comparisons across firms and over time can be complicated by the reporting lag, but we will ignore it in this paper.

The next section reviews the relevant prior literature and the timeliness concept.

3 Related Literature

The idea that prices adjust to information over time is not new. Seven papers, comprising four groups, are reviewed in this section: Fama, Fischer, Jensen and Roll (1969); Ball and Brown (1968), Alford, Jones, Leftwich and Zmijewski (1993), and Butler, Kraft and Weiss (2005); Brown, Taylor and Walter (1999); and Beekes and Brown (2006), and Beekes, Brown and Chin (2006). Fama et al. stands alone, because they began this literature when they studied the progressive adjustment of stock prices to value-relevant information associated with a stock split; Ball and Brown, Alford et al. and Butler et al. are grouped because they focus on the timeliness of price discovery in connection with accounting earnings information; Brown et al. is different to the extent that it deals with price discovery regardless of the nature of the information that is priced; and the remaining two papers consider the timeliness of price discovery as a product of the firm's corporate governance.

3.1 The Adjustment of Stock Prices to Information Associated with a Stock Split

Fama et al. (1969) (FFJR), on the adjustment of stock prices to new information, is a useful starting point. Focusing on stock price behaviour around stock splits, FFJR (pp. 1-2) ask two main questions: "(1) Is there normally some 'unusual' behavior in the rates of return on a split security in the months surrounding the split? and (2) if splits are associated with 'unusual' behavior of security returns, to what extent can this be accounted for by relationships between splits and changes in other more fundamental variables?" Their sample consists of 940 stock splits that occurred on the New Year Stock Exchange between 1927 and 1959. FFJR find that over the 29 months leading up to the month of a stock split, the average of the cumulative abnormal returns of stock splits rises rapidly at an increasing rate, but there is no further movement beyond the stock split month. Hence the market's expectations relating to the information associated with a stock split are on average fully reflected in the stock price by the end of the stock split month at the latest. In other words, stock prices rapidly adjust to this new information such that no abnormal trading profits can be derived from a stock split. If we use their estimates to calculate T_2 over the last 12 months leading up to their month 0, which is the month in which the split took effect, then $T_2 = 0.514$.[7]

3.2 The Timeliness of Price Discovery of Accounting Income Information

The real genesis of our paper, however, lies in Ball and Brown (1968). The initial objective of the Ball and Brown paper was "to assess the usefulness of existing accounting income numbers by examining their information content and timeliness" (p. 176.) For a sample of 261 firms studied over 1957-1965, Ball and Brown conclude that, although the annual earnings number is highly value-relevant, "the annual income report does not rate highly as a timely medium, since most of its content (about 85 to 90 per cent) is captured by more prompt media…" (p. 176). In particular, with reference to the Abnormal Performance Indices (APIs) plotted over time in Figure 1 (p. 169) in their paper, they note (p. 171) that "The persistence of the drifts … suggests not only that the market begins to anticipate forecast errors early in the 12 months preceding the report, but also that it continues to do so with increasing success throughout the year".

Figure 2 graphs the Ball and Brown estimates for good and bad earnings news portfolios over the 12 months leading up to the report month (see their Table 5, columns headed Earnings Per Share [EPS]). To make the two time series comparable, the estimates have been re-scaled to range between 0 and 1. Note that the line for bad news mostly lies above that for good news, indicating price discovery was faster for bad news. This property is reflected in the timeliness metrics, which are 0.470 for good and 0.438 for bad news respectively.

[7] We use the cumulative abnormal return averaged over all splits (Column 9 in their Table 2).

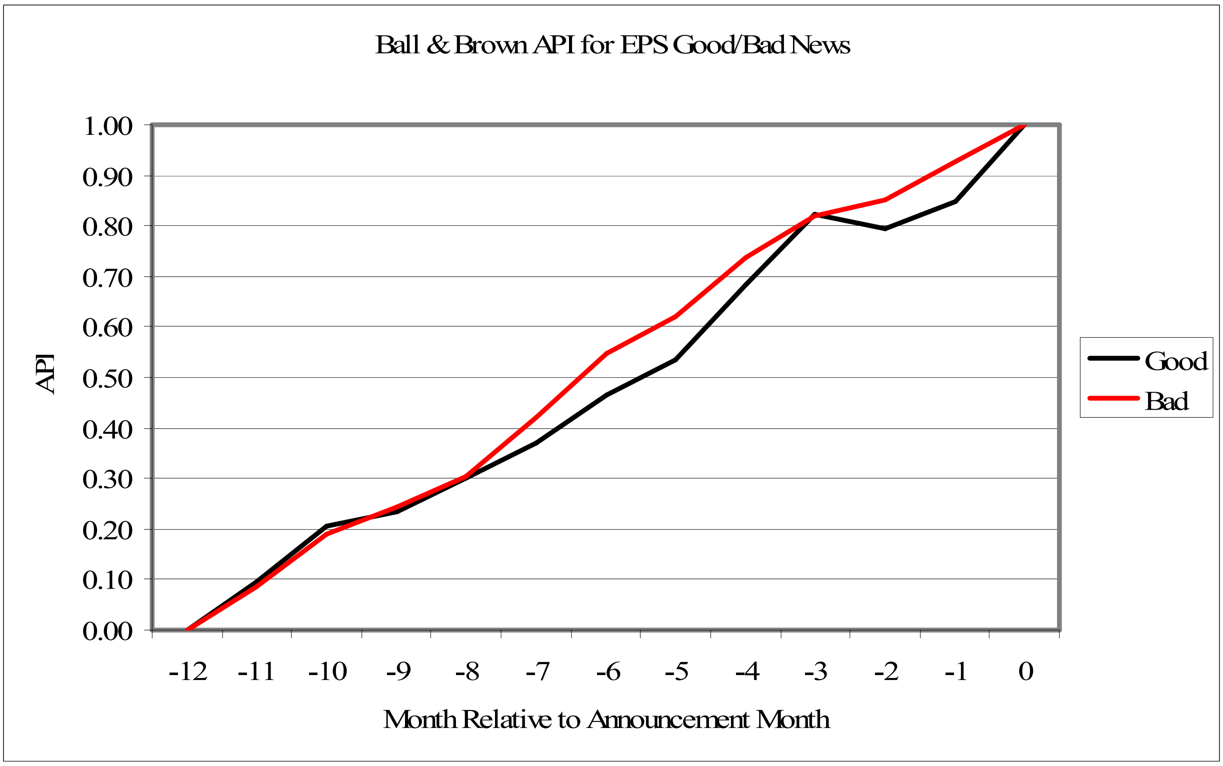

Figure 2

Nichols and Wahlen (2004) replicate the Ball and Brown (1968) estimates using more current data. Their sample comprises 31,923 reports by firms listed on the NYSE, AMEX, and NASDAQ stock exchanges and made between 1988 and 2001. They find similar results to Ball and Brown in that annual stock returns are strongly related to the sign of annual income changes. The relationship appears to be even stronger than in the Ball and Brown study period, as they find that the sign of the earnings change is associated with an average 35.6% difference in the abnormal returns of the good and bad earnings news portfolios, compared with Ball and Brown's earlier estimate of 16.8%. Leaving that particular difference aside, we can apply the same re-scaling procedure to the results in Nichols and Wahlen's Table 2 (p. 273). We can then see some other interesting differences in the two sets of estimates. The re-scaled results are graphed in Figure 3 (Nichols and Wahlen estimates for good and bad news), Figure 4 (Ball and Brown v. Nichols and Wahlen for good news) and Figure 5 (Ball and Brown v. Nichols and Wahlen for bad news).

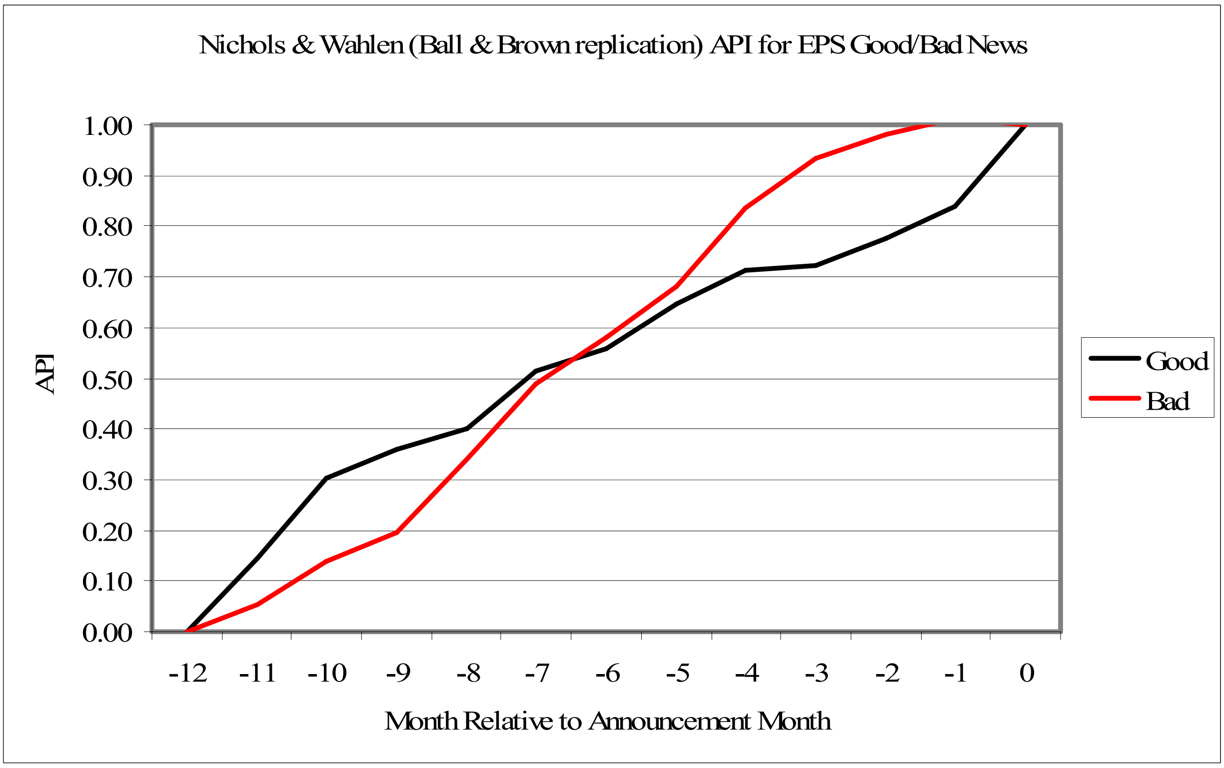

Figure 3

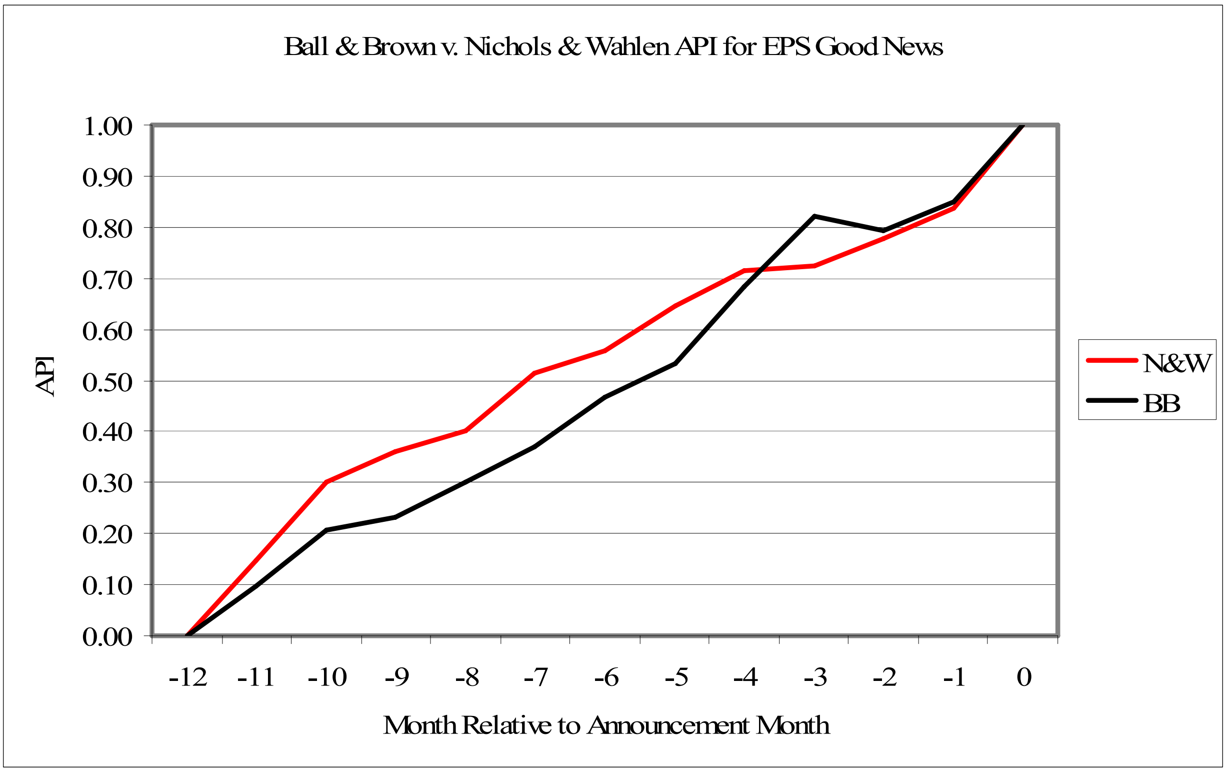

Figure 4

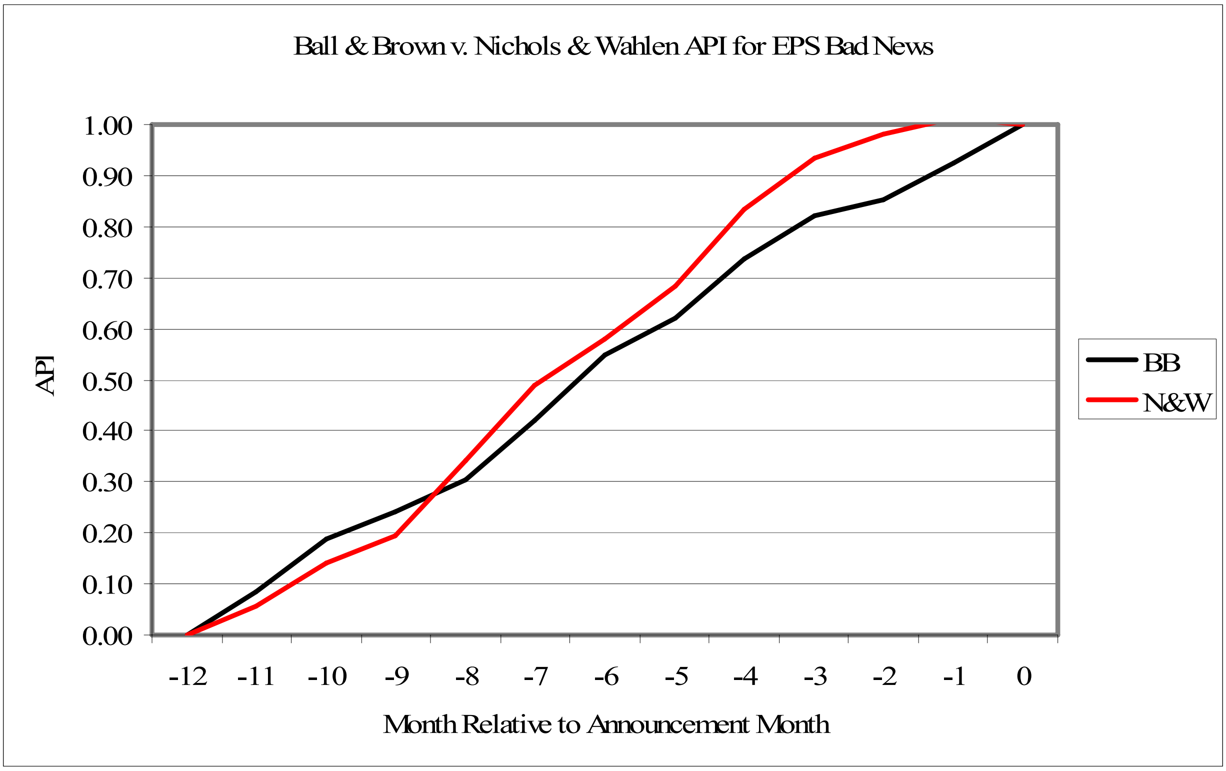

Figure 5

We can draw a number of conclusions from these prior studies.[8] First, there is a cross-over in the timeliness of good and bad earnings news in the USA in the later period studied by Nichols and Wahlen. Good earnings news has become timelier in the first half of the year, although bad news remains timelier in the second. Second, both good and bad news have become timelier in the later period, which could be for any number of reasons such as more frequent mandatory or voluntary corporate disclosures, increasing sophistication of financial analysts, speedier price discovery by market agents, and so on.

Nichols and Wahlen were by no means the first to replicate the Ball and Brown study[9] and with due respect to them they are unlikely to be the last. Among the many replications, the first to be published probably was Brown (1970), who found similar results for 118 Australian companies reporting between 1959 and 1968. There was, however, a noteworthy difference between Brown's results and those of Ball and Brown: as regulators world-wide so often seem to believe,[10] good news in Australia was "getting out" earlier than bad, as can be seen clearly in Figure 6. For completeness, the corresponding metrics are 0.525 for good news and 0.594 for bad.

8 We have not conducted any tests to see whether the conclusions are statistically reliable.

9 The honour, if we can call it that, belongs to a University of Chicago MBA student who, in a term paper, replicated their result for non-December 31 firms.

10 See, for example, comments below on the relationship between corporate governance and timeliness.

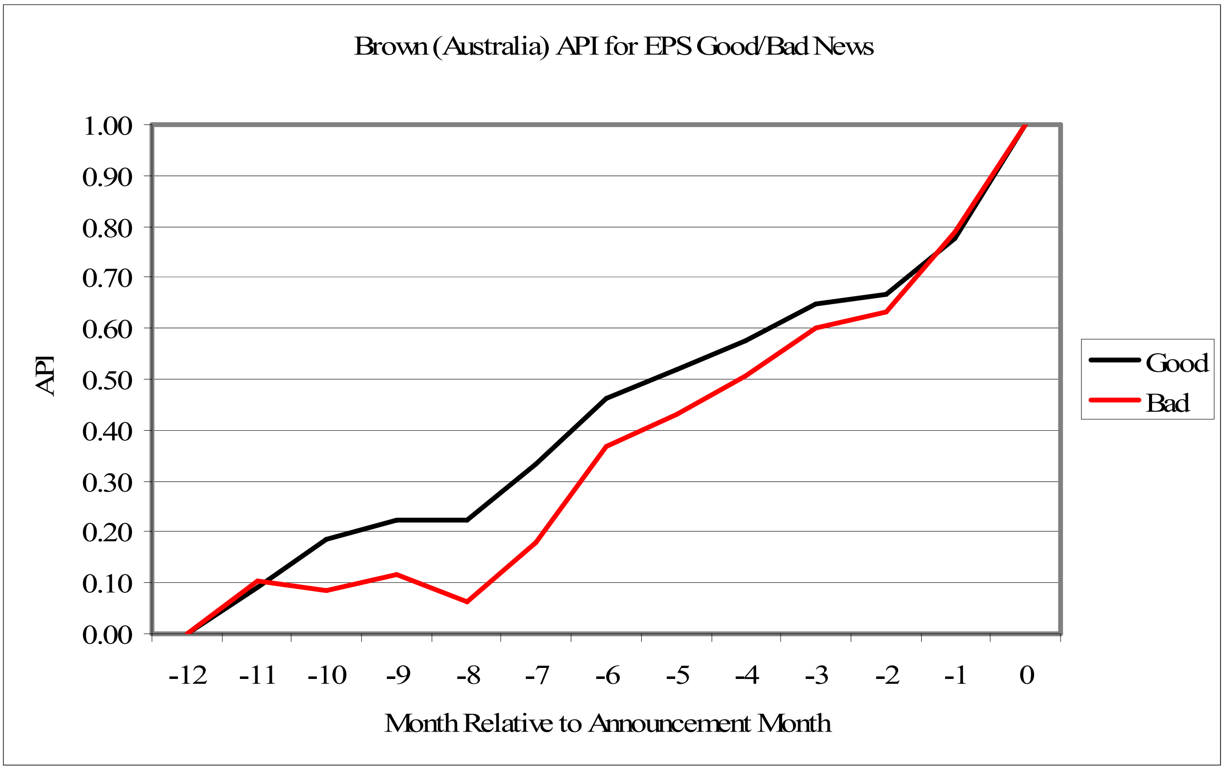

Figure 6

A more germane international replication is that of Alford et al. (1993), a large part of which is based on Ball and Brown (1968). They extend the Ball and Brown notion of timeliness to a comparison of the timeliness of accounting (GAAP) earnings reported between 1983 and 1990 in 17 countries**:** Australia, Belgium, Canada, Denmark, France, Germany, Hong Kong, Ireland, Japan, the Netherlands, Norway, Singapore, South Africa, Sweden, Switzerland, the United Kingdom and the United States. To measure timeliness, Alford et al. (1993) construct two hedge portfolios for each country. The first, which they term the "earnings-based" hedge portfolio, is an equally-weighted portfolio long in firms with the highest 40% of income changes ("good news" firms) and short in firms with the lowest 40% of income changes ("bad news" firms) in that country sample. The second hedge portfolio, the "returns-based" hedge portfolio, is an equally-weighted portfolio long in firms with the highest 40% of 15-month market-adjusted returns ("good news" firms) and short in firms with the lowest 40% of market-adjusted returns ("bad news" firms) in that country sample. For both portfolios, a 15-month time horizon ending 3 months after a firm's fiscal year end is used to calculate returns. Scaling the earnings-based portfolio cumulative return by the returns-based hedge portfolio 15-month return "measures the proportion of all information impounded in stock prices that is captured by accounting earnings" (p. 200) and is used to control for cross-country differences.

Alford et al. (1993) construct three measures of timeliness from these two hedge portfolios. The first measure is the ratio at the end of each month of the firm-level mean cumulative market-adjusted earnings-based hedge portfolio return to the corresponding return at the end of month 15. For any given month, this measure represents the proportion of the 15-month earnings-based portfolio return that has been earned by the end of that month, and thus will equal 1 for month 15. The second measure is the ratio at the end of each month of the firm-level mean cumulative market-adjusted earnings-based hedge portfolio return to the cumulative market-adjusted return-based hedge portfolio at the end of month 15 (i.e., the "perfect foresight" cumulative return). The advantage of this metric over the first is that it adjusts for the information content of the accounting income number, and thus measures value-relevance as well. The third measure is a simple extension of the second. It sums the second measure over the 15 month time horizon. The larger the sum, the timelier and more value-relevant is the information. They find that Australia, Canada, France, Ireland, the Netherlands and the U.K. are at least as timely as the U.S. benchmark, with each country outperforming the U.S. on at least one of the above measures. The timeliness of GAAP in Germany, Norway, South Africa, and Switzerland is similar to U.S. GAAP while GAAP in Belgium, Denmark, Hong Kong, Japan, Singapore, and Sweden all generate less timely information than U.S. GAAP, according to most of the metrics.

Butler, Kraft and Weiss (2005) look at whether regulation has influenced earnings timeliness, where timeliness relates to the concept in Ball and Brown (1968) and as applied by Alford et al. (1993). Butler et al. study the effect of varying financial reporting frequency – particularly for the case of voluntary increases – upon the speed with which accounting information is reflected in price. They treat the concept of "timeliness" in two ways: *intraperiod* timeliness, which is based on Ball and Brown (1968) and Alford et al. (1993), and *long-horizon* timeliness, which is related to the reverse regression question addressed by Basu (1997) and subsequent literature. Butler et al. (2005) describe these two terms as follows: "Intraperiod timeliness measures the speed of earnings-based price formation during a specific period (e.g., a year) … Long-horizon timeliness, in contrast, represents the extent to which accounting income lags economic income … Long-horizon timeliness is closely linked to the concept referred to in the literature as valuation (or value) relevance." (pp. 7-8.) The first measure is more relevant to this paper. We leave the relationship between the Ball and Brown and Basu notions of timeliness to a separate paper.

In order to measure intraperiod timeliness, Butler, Kraft and Weiss use two metrics. The first is similar to the Alford et al. (1993) metrics. It requires construction of a hedge portfolio comprising long positions in firms in the top 27% of scaled earnings changes and short positions in the bottom 27%. The timeliness metric is thus based upon the speed at which hedge portfolio returns are earned over the 12-month fiscal-year, i.e., the ratio of the earnings-based portfolio return at the end of each month to the hedge portfolio 12-month return. The metric is calculated as the area under the graph of the above ratio plotted over the 12-month period. The second metric is referred to as “an individual intraperiod timeliness statistic for each firm (IPT)” (p. 13) and roughly mirrors both the construct of Beekes and Brown (2006) and our own T_2 metric defined previously. Their metric is calculated as:

$$IPT = \sum_{m=1}^{11} \frac{BH_m}{BH_{12}} + 0.5, \qquad (2)$$

where BH_m represents the stock’s buy-and-hold return from month 1 through to month *m*.

For a sample of 28,824 reporting-frequency observations from 3,702 NYSE and AMEX-listed firms over the period 1950-1973, Butler, Kraft and Weiss find little difference in the intraperiod timeliness for firms reporting on a quarterly basis compared to those reporting on a semi-annual basis. Although they note that, for the first timeliness metric, firms reporting quarterly exhibit a larger timeliness figure (6.21) compared to firms reporting semi-annually (5.82), the difference is not statistically significant. Further, these results hold even after controlling for the fact that firms self-select their reporting frequency. Butler, Kraft and Weiss also found firms that *voluntarily* increased their reporting frequency displayed significant improvements (at the 10% level for their IPT regressions) in intraperiod timeliness, which is consistent with findings reported later in this paper (we find timeliness is increasing in the number of documents weighted by their price impact). Meanwhile firms that increased their reporting frequency following changes to mandatory reporting requirements imposed by the SEC in 1970 exhibited only insignificant improvements in intraperiod timeliness. This finding contrasts with an earlier paper by Brown, Taylor and Walter, to which we now turn.

3.3 The Timeliness of Price Discovery of Wider Information Sets

A key difference between the papers discussed in Section 3.2 and Brown, Taylor and Walter (1999) is the classification of “good” and “bad” news. Alford et al. (1993), for example, make this classification based on an accounting signal (size of the change in income) and rank the results to construct a hedge portfolio for each country. Brown et al. (1999), however, use a cumulative return measure over a one-year horizon and preserve the overall nature of the news.

Brown et al. find the passage of Australian legislation encouraging increased disclosure was followed by timelier price discovery for smaller firms, many of which were, arguably, the target of the legislation. From a methodological viewpoint, the significance of their paper was its extension of the information set from information about earnings (as in Ball and Brown and following papers) to any information that is priced. The extension is important, especially in the Australian environment, because GAAP earnings are but one, albeit price sensitive, component of the annual release.[11]

Their research question is the effect of "significant statutory civil and criminal sanctions on both the quantity and timeliness of voluntary disclosures made by firms listed on the Australian Stock Exchange" (p. 138). The sample consists of 1,474 ASX-listed firms, over the period 1992-1996. The choice of this time period makes use of the 1994 legislative changes that imposed new statutory civil and criminal sanctions to reinforce pre-existing ASX disclosure rules, which allows a comparison of the pre- and post-sanctions environments. Brown, Taylor and Walter employ a number of indicators of the richness of the firm's information environment, including: the frequency of corporate disclosures; the extent of disagreement among, and accuracy of, analysts' consensus earnings forecasts; the relationship between corporate disclosures and share price volatility; and the level of anticipation in share prices of the information content of periodic reports.

Brown, Taylor and Walter use this last indicator to measure "timeliness". A feature of their analysis is that interim reports are also considered. That is, the timeliness of both Preliminary Financial Statements (PFSs) and Half-Yearly Reports (HYRs) is examined, with returns calculated over a 12 month time horizon leading up a to PFS release date and a 6 month time horizon leading up to a HYR release date. Their timeliness metric is calculated as the ratio of the average cumulative market-adjusted return from time $t = -12$ ($t = -6$ for half-yearly reports) up to time t, to the average cumulative market-adjusted return to time $t = 0$, for their portfolios. The faster this metric approaches "1" the more timely the information; i.e., the faster the price discovery. Their experimental design involves constructing hedge portfolios that are long in good news firms and short in bad news firms, where the nature of the news is based upon the sign of the market-adjusted return over the relevant time horizon. They do not specifically examine the timeliness of good news compared to bad news. Two separate portfolios are constructed: one consisting of firms that reported prior to the 1994 legislative changes, i.e., a "pre-sanctions" portfolio, and the other of firms that reported after the legislative changes, i.e., a "post-sanctions" portfolio.

Referring to Table 5 of their paper, Brown, Taylor and Walter find that the legislative change relating to disclosure sanctions had little if any impact on the timeliness of the half-yearly report, since there was no significant difference between the amount of information reflected in post-sanctions prices compared to the amount of information reflected in pre-sanctions prices for any

[11] As Beekes and Brown (2006, p. 9) note, "Australian listed companies make extensive disclosures in their Preliminary Final Statements. For example, they include standard form Income Statements, Balance Sheets, Statements of Cash Flows, dividend announcements and details of any completed or planned capital raisings."

given month leading up to the release date. In the case of PFSs, however, information was impounded into share prices significantly faster after month -9, as the amount of information reflected in post-sanctions prices was greater than the amount of information reflected in pre-sanctions prices for any given month leading up to the release date (~10-20% of the total information) and the probability of this being a chance result was negligible (<0.008 after month -9).[12] Hence the annual earnings information became timelier following the imposition of statutory criminal and civil sanctions for non-disclosure. Further investigation revealed the effect was mainly restricted to smaller firms. Their hedge portfolio results for PFSs are reproduced in Figure 7.

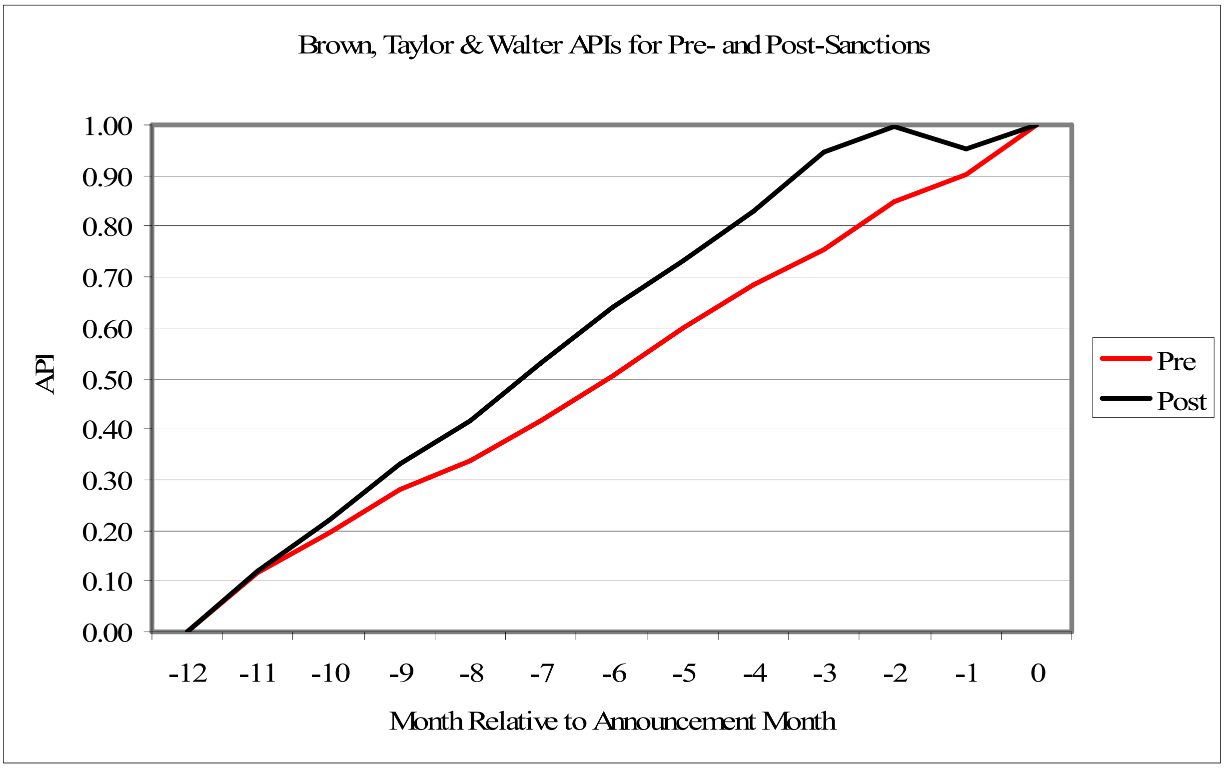

Figure 7

3.4 Timeliness and Corporate Governance

Beekes and Brown (2006) and Beekes, Brown and Chin (2006) explore the relationship between corporate governance and various indicators of the firm's information environment, including its disclosure practices, properties of analysts' consensus earnings forecasts, and timeliness as measured by T_2 (defined above). The first paper employs Australian data, and the second replicates the first for a sample of Canadian companies. Both papers essentially ask the same question: "Do better governed firms make more informative disclosures?" Focusing on the "timeliness" indicator, Beekes and Brown (2006) construct a timeliness metric ("intrayear" in

[12] Brown, Taylor and Walter (1999) employ a non-parametric re-sampling test. See their Table 6 for detailed results on PFSs.

Butler, Kraft and Weiss's terminology) that is based upon Ball and Brown (1968) and Brown, Taylor and Walter (1999), and describe the metric as being designed to capture the average speed of price discovery throughout the year. In the first paper, their metric tracks a firm's share price over 250 ASX trading days, ending 10 trading days after the release of the firm's PFS. Formally, the Beekes and Brown (2006) metric is defined (p. 431) as:

$$M_c = \left(\sum_{t=-249}^{0} | \, ln(P_0) - ln(P_t) \, | \right) / \, 250, \tag{3}$$

where P_t is the market-adjusted share price at time t, and time $t = 0$ corresponds to 10 trading days after the earnings announcement. This is almost identical to our own construct, T_2, the sole difference being whether we work in calendar or trading days.

As noted in both papers, the M_c metric can be interpreted as follows. The longer it takes for a firm's share price to impound information and tend to the "final" price P_0 (which reflects all value-relevant information discovered during the year), the longer the absolute value term in M_c will remain large, thereby inflating M_c. In particular, if the share price simply tracked the market index[13] from day -249 to day -1, and fell from P_{-249} to P_0 on the last day, then the speed of adjustment is at its slowest and M_c will be "close to"' the absolute value of the market-adjusted return over the 250 trading days. But if the share price changed to P_0 on the first trading day (day -249) and then simply tracked the market index for rest of the trading period, the speed of adjustment will be at its maximum and M_c is zero. Beekes and Brown remark that the presence of excessive share price volatility complicates the use of their metric. This relationship with volatility is explored further, below.

The Beekes and Brown (2006) timeliness analysis sample consists of 1,226 PFS observations accumulated from the set of 250 Australian firms rated in the Horwath (2002) Corporate Governance Report. They find that value-relevant information is incorporated more rapidly into share prices when a firm has a better corporate governance structure, and they note that timeliness and the nature of the news are also statistically related, such that good news is reflected in share prices earlier than bad news.[14] These results hold when the timeliness metric is scaled by a volatility-measure, to reduce the effects of noise in the sample. Beekes and Brown (2006) further incorporate a "good news-CGQ" interaction term into their analysis, to account for the ASX

[13] Beekes and Brown (2006) use both observed and market-adjusted prices and find market-adjustment makes little difference to their results.
[14] A 'good news' firm is defined to be one that outperforms the market index over the 250 trading day period during which timeliness is measured.

Corporate Governance Council's belief that better governed firms are more "balanced" in their disclosure of good and bad news. They find that this variable is statistically related to the timeliness metric, suggesting that "better governed firms are more balanced in the extent to which good and bad news are reflected in share prices on a timely basis" (p. 441).

Beekes, Brown and Chin (2006) largely replicate the Beekes and Brown (2006) timeliness analysis using evidence from Canada between 2000 and 2005. Their sample consists of the set of Canadian firms rated in the in the 2004 Clarkson Centre for Business Ethics and Board Effectiveness Corporate Governance Report. They find similar results to Beekes and Brown (2006), namely that CGQ is directly related to the speed with which value-relevant information is priced by the market. Interestingly, the relationship between the nature of the news and timeliness is not significant for the "raw" timeliness metric. However, for the volatility-deflated timeliness metric, similar results to Beekes and Brown's are found with respect to both CGQ and the nature of the information released (good vs. bad). Extending their analysis to account for the possible interaction between CGQ and the level of "balance" in the nature of the news disclosed, they find, as did Beekes and Brown, that the "good news-CGQ" interaction term is statistically related to timeliness, suggesting "managers of better governed firms are not as quick to release good news to the market, despite the incentive to do so" (p. 18).

Finally, Beekes and Brown (2006) also report on the relationship between corporate governance and the timeliness of price discovery for a sample of U.S. firms whose corporate governance was rated by Brown and Caylor (2004). Once again, timeliness is found to be associated with the quality of a firm's corporate governance. The overall findings (for the USA, Australia and Canada) are summarised in Table 1. As can be seen from Table 1, firms with good news, larger firms and firms with better corporate governance are more timely. It is interesting to note that corporate governance appears to have a larger impact on timeliness in Australia than in Canada or the USA.

3.5 Summary

The above literature suggests the existence of some observable relationships between the timeliness of price discovery and characteristics of a financial market's reporting and information trading environment. The nature of earnings information, the strength of reporting regulations, and the quality of corporate governance have all been investigated in prior literature in relation to timeliness. Prior studies have yielded sometimes contrasting results. They provide a strong motivation to examine the properties of the timeliness metric in greater detail, which is the focus of this paper.

Table 1: Beekes and Brown's estimates of the relationship between timeliness and the "quality" of corporate governance for three countries

	USA			AUSTRALIA			CANADA		
Variable	*Coeff.*	*t-stat.*	*prob.*	*Coeff.*	*t-stat.*	*prob.*	*Coeff.*	*t-stat.*	*prob.*
Constant	0.291	107.35	<0.001	0.219	33.87	<0.001	0.203	32.89	<0.001
Good News	-0.017	-6.01	<0.001	-0.029	-4.54	<0.001	0.035	0.56	0.578
Size	-0.054	-19.24	<0.001	-0.043	-7.09	<0.001	-0.067	-7.65	<0.001
Resource Ind.				0.003	0.60	0.550			
CGQ	-0.016	-6.09	<0.001	-0.035	-4.90	<0.001	-0.022	-3.96	<0.001
R^2 (Adj.)	0.062			0.095			0.168		
N	8,664			1,226			694		

Sources: Beekes and Brown (2006); Beekes, Brown and Chin (2006).

4 Further Examination of the Timeliness Metric

This section of the paper discusses the tests conducted on the timeliness metric evaluating its ability to capture information timeliness, the influence of share price volatility on the metric and the ability of the metric to detect changes in the timing of firms' disclosures. The sample comprises firms listed on the Australian Stock Exchange (ASX) between 1 January 1995 and 31 December 2005 and with sufficient data for conducting the tests. In Section 4.1 we consider relationships between the timeliness metric calculated in three related settings: prices, earnings forecasts and corporate disclosures. In Section 4.2 we consider the metric's time-series properties. In Section 4.3, we discuss the connection between timeliness and volatility, while Section 4.4 contains a Monte Carlo analysis of the metric's ability to detect managerial intervention in timing the release of price-sensitive disclosures.

4.1 Timeliness in Three Analogous Settings

The timeliness metric, as we have defined it, looks at pricing outcomes and pays no attention to the means by which price discovery occurs. In this section, we investigate the association between the timeliness of prices, and analogous measures of the timeliness of corporate releases to the share market and of analysts' forecasts. In brief, we find that, despite the noisy character of the timeliness measures and the fact that not all value-relevant information is sourced from the company itself, the timeliness of stock prices, of analysts' consensus earnings forecasts and of corporate disclosures are positively correlated.

Prices. For the metric based on prices, we measure timeliness by T_2, as previously defined, except that prices are adjusted for market movements.[15] The sample of firms is all companies listed on the ASX with (1) at least a year's daily returns data, and (2) PFS announcement dates available from ASX's Signal G, which is a "same day" commercial, electronic data feed containing an edited text version of all company announcements to ASX. The date range is from 1 January 1995 (which is the first full calendar year for which the relevant announcement dates are available electronically) to 31 December 2005, which is the end-date of the edition of SIRCA's CRD that we use.[16] The ASX All-Ordinaries Accumulation Index, sourced from Datastream, is used to calculate the market-adjusted price series.

Analysts' consensus earnings forecasts. Data requirements for this timeliness measure, which is based upon analyst earnings forecasts, are consensus EPS forecasts, forecast dates, actual EPS and their announcement dates, and stock prices relative to the forecast dates. We source all of these data from the I/B/E/S summary database. To be included in the sample, the first forecast date must be between 365 and 425 days before the report date, and the last forecast date must be between 1 and 60 days before the report date. This ensures that there are sufficient consensus forecasts available to calculate the timeliness metric. Median analysts' forecasts, deflated by the last available stock price reported by I/B/E/S up until day -365 to express them as a rate of return, are used to measure the consensus forecast. These (deflated) forecasts are then forward filled from day -365 to day 0,[17] and the timeliness metric calculated in a manner analogous to T_2. Hence,

$$T_2^{EPS} \equiv \sum_{t=-364}^{t=0} \left| DF_t - DF_0 \right| / 365, \qquad (4)$$

where DF_t is the median forecast EPS on day t divided by the base price. This measure of timeliness, T_2^{EPS}, examines how quickly to the consensus earnings forecast converges on the actual earnings, as reported by I/B/E/S. Therefore $t = 0$ in this timeliness measure is the date on which the earnings are released as reported by I/B/E/S, in contrast with the T_2 measure based on prices. As with T_2 based on prices, smaller values of T_2^{EPS} indicate that there is greater timeliness (i.e. there is quicker convergence of the forecast to the actual earnings).

[15] This is done to be consistent with Beekes and Brown (2006). However, they point out that market-adjustment makes little difference to their results.
[16] SIRCA is an established acronym for the Securities Industry Research Centre of Asia-Pacific; CRD is the acronym for SIRCA's Core Research Database.
[17] Forward filling refers to carrying forward the previously-reported deflated consensus forecast up until the current forecast date. This procedure accommodates irregular time intervals between successive I/B/E/S cut-off dates and between the last available forecast date and the actual reporting date.

Corporate disclosures. Australian law requires listed companies to notify ASX first when making a public disclosure. ASX then releases the disclosure document to the market. For ASX listed firms between 1 January 1995 and 31 December 2005 with at least one document earlier than $t = -350$ and one document later than $t = 13$, which ensures sufficient disclosure history, we collect data on the document releases to the ASX. We use ASX's Signal G to identify the days on which each listed company released a document. We then weight that document-day by the absolute value of the stock's log return that day, which reflects the price sensitivity of the documents. The daily time series of returns (which are zero on days when there is not any information released to the market) are cumulated so that all days in the series have a cumulative value. The log return is again sourced from SIRCA's CRD. The timeliness measure is calculated as follows:

$$T_2^{Docs} \equiv \sum_{t=-364}^{t=0} (CD_0 - CD_t)/365, \qquad (5)$$

where CD is the cumulative value of returns. In this timeliness measure, T_2^{Docs}, $t = 0$ is the date on which the firm's annual results are released according to ASX Signal G plus 14 days (as in T_2). The timeliness metric for disclosures is analogous to the metric for price discovery: it measures how quickly the firm releases its price-sensitive documents to the share market over the course of the year. As previously, smaller values of T_2^{Docs} are associated with greater timeliness.

Table 2 contains descriptive statistics for the three timeliness measures (of stock prices, analysts' EPS forecasts and corporate disclosures), while Table 3 contains the simple (product-moment) correlations between these three variables.

Table 2:
Descriptive statistics for the three timeliness metrics (prices, disclosures and analysts' EPS forecasts) for ASX listed firms 1995 - 2005

	Prices	EPS forecasts	Disclosures
Mean	0.26	0.05	0.48
Median	0.18	0.01	0.48
Maximum	3.03	2.00	1.00
Minimum	0.01	0.00	0.00
Std. Dev.	0.26	0.17	0.15
Observations	8,696	3,002	8,405

Table 3:
Product-moment correlations between the three timeliness metrics
for ASX listed firms 1995 - 2005

	Prices	EPS forecasts
EPS forecasts	0.32	
Disclosures	0.14	0.03

The minimum values of the timeliness of prices, EPS forecasts and disclosures are either zero (the lower bound) or “close to” it. The maximum values of the timeliness of prices and EPS forecasts exceed 1, while the maximum value of the timeliness of disclosures is exactly one, which is its upper bound. There is some skewness apparent in the timeliness of prices and especially EPS forecasts, suggesting a more thorough investigation should take this into account, particularly for EPS forecasts. In terms of how the metrics are statistically related to one another, while the simple correlation between the timeliness of corporate disclosures and of consensus EPS forecasts is weak, both variables are more strongly correlated with the timeliness of prices. Moreover, all three correlation coefficients are positive, which is the expected sign. Our timeliness metric, T_2 examines the outcomes and pays little attention to the means of price discovery. Nevertheless, our results suggest that our concept of timeliness, T_2, calculated using market-adjusted prices does capture important information. Despite the fact that not all of the value relevant information is being released by the company, there are positive correlations between T_2 and the analyst earnings forecasts and also between T_2 and the returns on days of corporate releases.

4.2 Serial Dependence in the Timeliness of Prices

If the timeliness of prices is driven by factors such as corporate governance attributes as well as by underlying volatility, seasonalities and so forth, and if the underlying drivers evolve over time, then we should observe (1) positive serial dependence in the timeliness of price discovery and (2) declining autocorrelation functions for timeliness at the firm level.

Table 4 contains year-by-year bivariate correlations for the timeliness metric T_2. The correlations reflect all cases where there are sufficient daily returns on SIRCA’s CRD and corresponding PFS release dates on Signal G for ASX listed firms between 1 January 1995 and 31 December 2005.

Table 4: Year-by-year bivariate correlation matrix for the timeliness metric T_2

	T2 1995	T2 1996	T2 1997	T2 1998	T2 1999	T2 2000	T2 2001	T2 2002	T2 2003	T2 2004
T2 1996	0.267									
T2 1997	0.253	0.249								
T2 1998	0.214	0.213	0.340							
T2 1999	0.334	0.179	0.321	0.251						
T2 2000	0.252	0.188	0.334	0.329	0.353					
T2 2001	0.174	0.088	0.340	0.258	0.357	0.331				
T2 2002	0.168	0.137	0.237	0.205	0.117	0.178	0.254			
T2 2003	0.204	0.116	0.367	0.244	0.353	0.316	0.370	0.213		
T2 2004	0.333	0.125	0.342	0.243	0.387	0.313	0.279	0.264	0.284	
T2 2005	0.123	0.201	0.317	0.289	0.182	0.217	0.249	0.243	0.288	0.344

Apart from the significant positive correlation ($r > 0.1$) between the timeliness metric T_2 for any two given years, there is evidence of some weakening in the correlations as we increase the time lag between the years. Thus the correlation between T_2 in adjacent years is higher than in non-adjacent years by a ratio of 2:1. Similarly, the correlation is higher for T_2 two years apart than for T_2 more than two years apart (by a ratio of 2.6:1), while the corresponding ratios for three and more than three, and for four and more than four years apart, are 1.3:1 and 2:1. However, the size of the effect is evidently not large.

4.3 Timeliness and Volatility

Volatility is not unrelated to the metric we use to measure the timeliness of price discovery. The core idea behind our measure, however, is that the sequence of prices matters. The formal relationship is explored in the appendix, for a closely-related timeliness measure. The conclusion can be summarised as follows. When timeliness is measured by the mean squared deviation of the daily price from the benchmark (terminal) price, there is a simple relationship between the volatility of *price* (specifically, not return) and the timeliness of price discovery: timeliness is the volatility of *price* plus the square of the bias in price relative to the benchmark price. That is why the sequence of prices matters in our measure of timeliness.

We can also examine this relationship empirically. To do so, volatility is calculated as the standard deviation of daily log return, sampled over the same 365 day time period, and using the same share price and market index data as that used to calculate timeliness metric T_2. We can see evidence of this relationship between timeliness and share-price volatility in the year-by-year bivariate correlations for an 11-year time period (see Table 5). As expected, the timeliness metric is strongly positively correlated ($0.5 < r < 0.7$) with volatility for each timeliness-volatility pair. Hence it is reasonable to expect excessive share price volatility to inflate the timeliness metric for an individual firm, as indicated by the derivation in the appendix and by Beekes and Brown (2006).

Table 5: Year-by-year bivariate correlations for timeliness metric T_2 and volatility

	Timeliness										
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Volatility	0.682	0.545	0.600	0.571	0.606	0.639	0.679	0.606	0.636	0.715	0.672

4.4 How Accurately Does the Timeliness Metric Identify Managerial Intervention?

The assumption in Beekes and Brown (2006), and Beekes, Brown and Chin (2006), is that management intervention affects the timeliness of price discovery. Therefore corporate governance could have a key role in determining the timeliness of information released to the market. We employ a simulation model to investigate how well the metric identifies an intervention that affects the sequence of otherwise random stock returns.

We assume log return is independently and Normally distributed with mean 12% p.a. and daily standard deviation 2%.[18] In the simulation, we assume management intervenes in the disclosure process twice, once in the first half of the year and once in the second (with the effect of shifting returns by the same amount). We preserve the volatility of return in our simulation as explained below. We vary just two parameters: the size of each of the two returns that are the subject of managerial intervention, and the number of days the value-relevant information is moved forward.

It is assumed that management intervenes in the disclosure process twice per annum to make releases on a more timely basis: once in the first half and once in the second half of the year. The amount of the intervention ranges from -25% to +25% in increments of 0.5%. The amount of intervention is set by the delta. The annual delta is divided by 2, since the same amount of manipulation is assumed in both halves of the year (i.e., the combined effect of the intervention, delta, ranges from -50% to +50%). Note that the release day, day t, must occur after the maximum amount of lag (the number of days by which the information may be moved forward by the manager). This lag or time which information may be moved forward is assumed to range from 1 to 61 days and is assumed to be the same for both halves of the year. When the delta and day t have

[18] We do not need to run Monte Carlo simulations to understand the behaviour of our timeliness metric in this initial setting. However, we intend to introduce greater complexity, e.g., via stochastic volatility, and a simulation approach will facilitate this aspect of our future work. (The bumps in the surfaces of Figures 9–11 reflect the finite number of trials in the Monte Carlo analysis.)

been set, we retain one set of returns at this point as the 'unmanaged' benchmark set of returns over the year. This enables calculation of T_2 for the unmanaged returns.

For the managed set of returns, we choose the lag and determine the new release date for the information (calculated as day t − lag). We then switch the return on the release date with the return on the new, earlier release date to preserve the volatility of returns. The same procedure is then carried out in the second half of the year, assuming the same lag and delta. The timeliness metric for the managed returns is then calculated and compared with the unmanaged case. If our metric is able to correctly identify management intervention in the disclosure process, we would expect the managed case T_2 to be smaller than for the unmanaged case.

The results from 10,000 trials per size-lag combination are graphed in Figures 8–10. Figure 8 gives the overall rate at which the timeliness metric, T_2, correctly identifies the intervention. Figures 9 and 10 graph the accuracy rate where the cumulative return for the year is negative (bad news) and non-negative (good news).

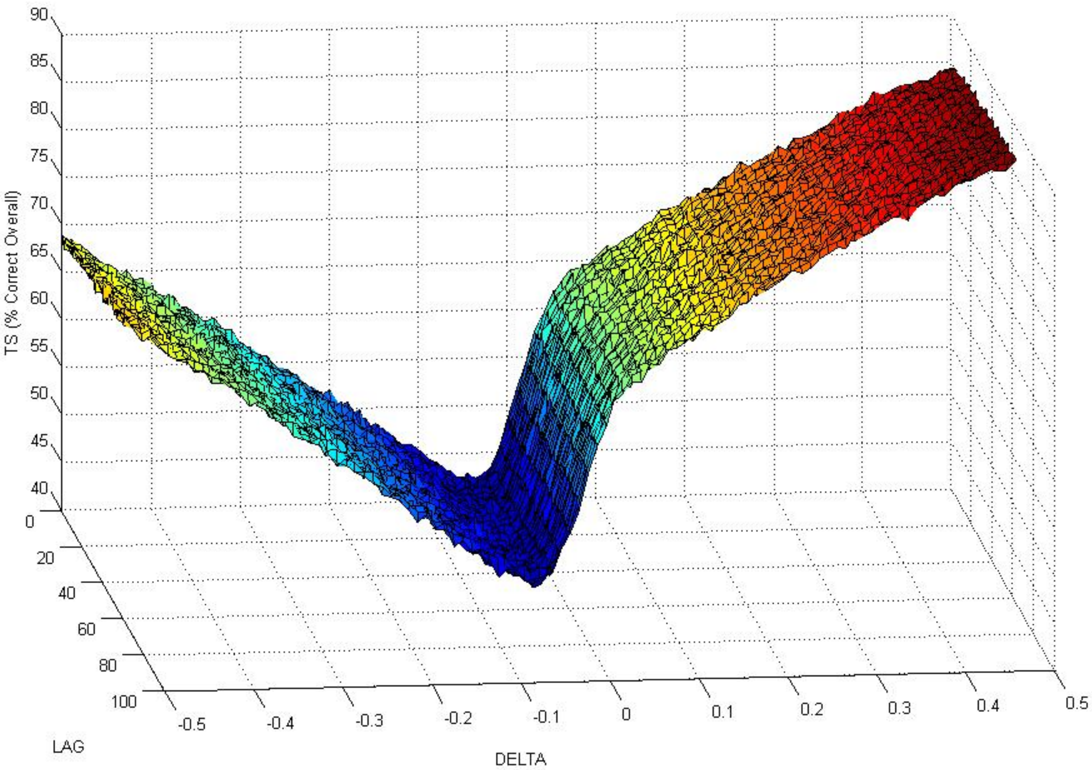

Figure 8

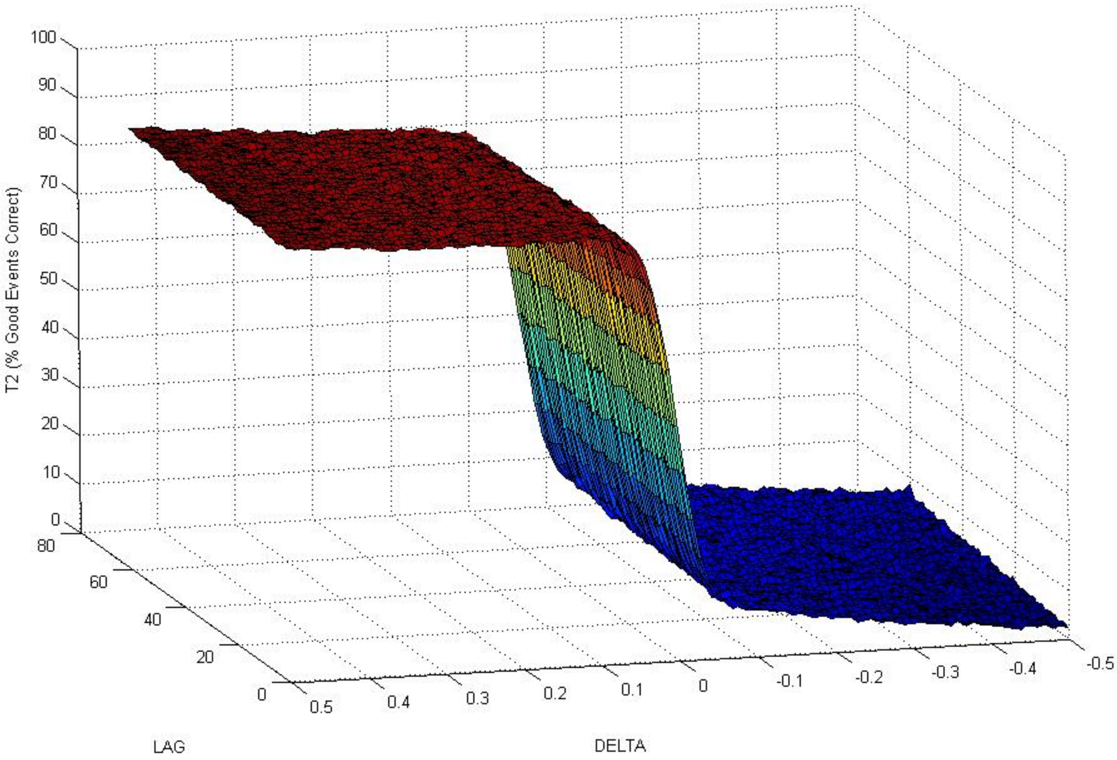

Figure 9

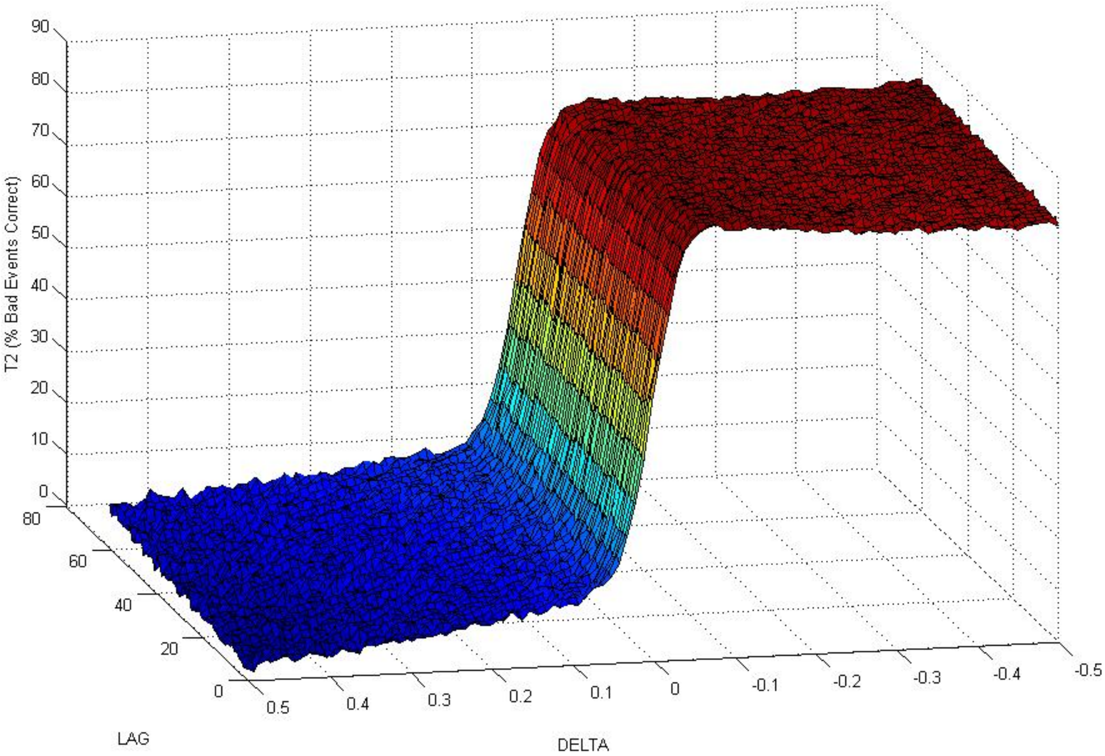

Figure 10

Clearly the metric is by no means perfect as there is not 100 per cent accuracy. Nonetheless accuracy improves with the size of the return that is subject to managerial intervention (delta). When there are two interventions aggregating to +50% (i.e., delta = +50%), the metric correctly identifies the interventions about 85% of the time. However, when they aggregate to -50%, the accuracy rate falls to about 68%. The reason for the fall in the accuracy rate becomes clear when we turn to Figure 9 (where the year's return is non-negative, i.e., when $P_0 \geq P_{-364}$) or to its bad news counterpart, Figure 10. When the intervention shifts a return with sign opposite to the aggregate return for the whole year, the accuracy rate of the metric falls sharply. The number of cases with delta <0 in Figure 9 or delta >0 in Figure 10 declines rapidly as delta becomes larger, which explains why the overall accuracy rate of the metric (Figure 8) exceeds 50% for all but those cases where the absolute value of delta is of the order of 2%, which is the volatility parameter in the simulation model.

An alternative metric is to calculate the time series of the absolute value of the daily log return, and to use this time series to calculate timeliness. The result from simulations calculated using the absolute value of daily log return is shown in Figure 11. While this metric performs extremely well in Monte Carlo analysis – its accuracy rate is about 100% for delta ≥ 5% in absolute value – the alternative metric makes no allowance for the fact that most price changes during a year are offsetting.[19]

[19] Ball and Brown (1968) estimate 75% of *monthly* returns are mutually offsetting.

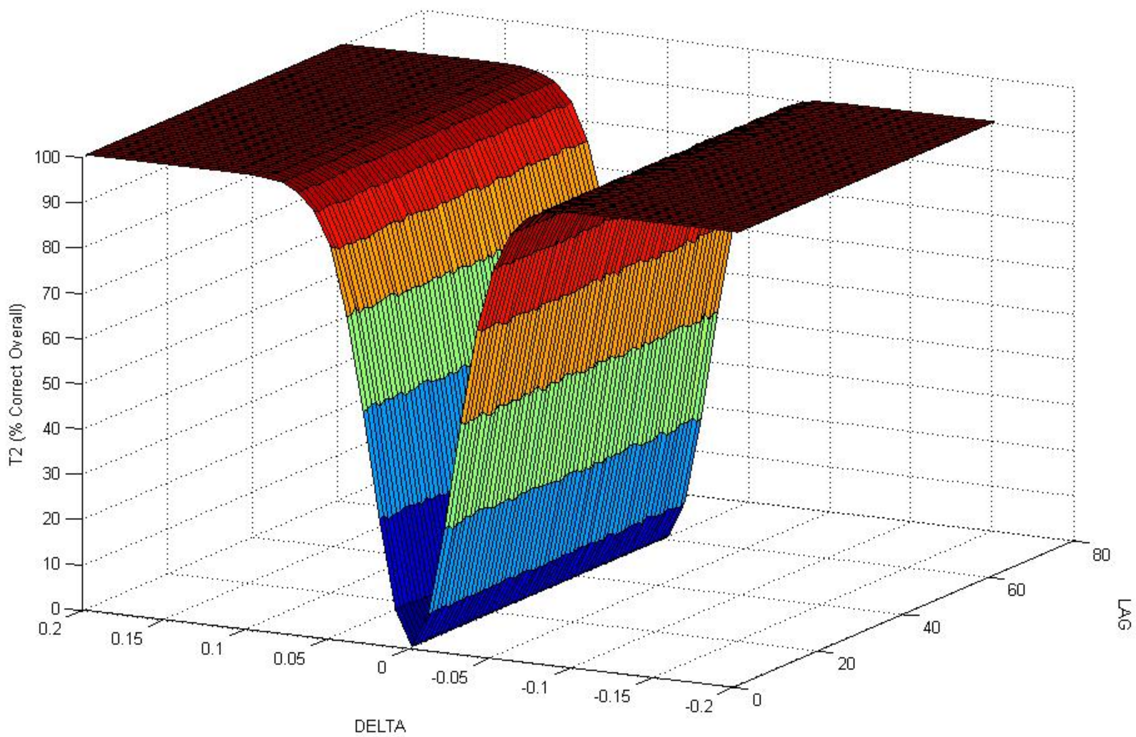

Figure 11

6 Summary

The notion of timeliness we have explored is not new. It began with Ball and Brown (1968) but it has been used only sparingly, in a variety of settings, over the intervening 40 years. Although our timeliness metric, T_2, is clearly a noisy measure, it nonetheless does capture some systematic differences in the pattern of price discovery and it manifests several properties consistent with our intuition.

In this paper, we have shown that the timeliness of price discovery is related to analyst earnings forecasts and corporate disclosures. In addition there appears to be serial dependence in timeliness which declines over time. However, the timeliness metric is also found to be affected by the volatility of the share price, which inflates our metric. In simulations, where we explicitly control for volatility, T_2 appears to perform well with up to 85 per cent of interventions in the disclosure process being correctly identified. However, our results also show that T_2 is unreliable in settings of greatest regulatory interest: where managers privy to impending bad news bring forward whatever credible good news they can find. An alternative metric, based on the absolute value of the daily log return, does not suffer from the same disability in that, in a controlled setting, it can accurately identify cases where management has intervened in the disclosure process.

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Appendix: Timeliness and Volatility

We define three timeliness metrics, where the second is the one we work with while the first and third help with the intuition. The three metrics are:

$$T_1 \equiv \sum_{t=-364}^{0} \left(\ln P_t - \ln P_0\right) / 365$$

$$T_2 \equiv \sum_{t=-364}^{0} |\ln P_t - \ln P_0| / 365$$

$$T_3 \equiv \sum_{t=-364}^{0} \left(\ln P_t - \ln P_0\right)^2 / 365$$

where P_t is the share price at the end of each trading day t and day 0 is 14 days after the public announcement of the company's profit (net income) for the year.

Relationship with Volatility

The easiest way to see the relationship with volatility is to observe that a stock's log *price* volatility – specifically, *not return* volatility, although they are directly related – over that same time period is approximately (i.e., ignoring the degrees of freedom issue) given by:

$$s^2 = \sum_{t=-364}^{0} \left(\ln P_t\right)^2 / 365 - \left(\sum_{t=-364}^{0} \ln P_t / 365 \right)^2 .$$

T_3 (which is similar to T_2) can be expressed as:

$$T_3 = \sum_{t=-364}^{0} \left(\ln P_t\right)^2 / 365 - 2 \ln P_0 \sum_{t=-364}^{0} \ln P_t / 365 + \left(\ln P_0\right)^2$$

so that:

$$T_3 = s^2 + \left(E\left(\ln P\right) - \ln P_0\right)^2$$

where:

$$E\left(\ln P\right) = \sum_{t=-364}^{0} \ln P_t / 365 .$$

Thus we have:

$$T_3 = s^2 + T_1^2 .$$