

## EQUITIES

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### Coordinator's message

By Alison Harrington

Justin Scattini is a long term supporter of AIA and an in depth, informed, presenter on a range of share market topics. In this bulletin he outlines the conditions for favourable economic growth and the possible threats to that growth. He argues that a company's earnings recovery and a better matched dividend to cash earnings policy give good markers to individual company's accurate valuations.

Jodi Ellis discusses the shrinking sharemarket software provider industry and argues that investors will not benefit from a total loss of this sector as they provide informed broad based analysis not available elsewhere. He also comments on the psychology of investors who disappear when the market is down which is when they should be looking for advice to know when to buy! AIA has been well supported by this industry and has relied heavily on their broad expertise of the market so their loss also has ramifications for information events held by AIA.

Robert Vagg continues his detailed intellectual analysis of investing in the stock market. The media can be said to dumb down financial information and rely on fear and drama to sell their products. It is a pleasure to read articles like Robert's which presume a level of intelligence and logic from the reader. As always, Robert's articles are well researched and logically presented and make you think.

The newsletter is longer than normal but the quality of the articles are such we could not delay them to the next newsletter.

Thank you to Brian Matthews who has coordinated this bulletin with considerable insight for the past five issues.

*Alison Harrington is an AIA Councillor and Chair of the AIA Queensland Committee.*

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# Australian equities – earnings certainly will be rewarded

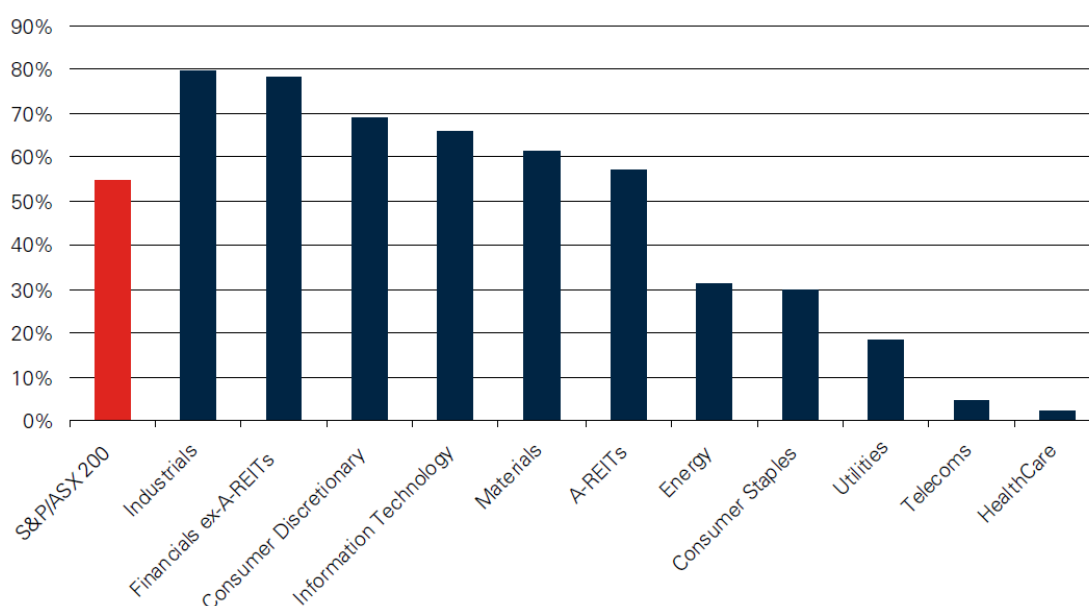
By Justin Scattini

The 2009 year was one of dramatic contrasts. It carried the unflattering distinction as the first year since the Second World War in which the global economy ended the year smaller than when it began it. However, policy makers across the world did an admirable job in hauling their economies back from the brink and avoiding a fate similar to the dreadful decade preceding the War. The corollary of this effort delivers the contrast, with stock markets around the world staging some of their strongest returns as they looked ahead to the budding economic recovery.

The Australian market provides an interesting case, with the S&P/ASX 200 index up 31% over the calendar year and 55% above its March nadir. Meanwhile the Australian economy grew by what we expect will be a paltry 0.9% over 2009. Admittedly it is a much better outcome than most other developed economies, but weak nonetheless. The prospect of 3.0% growth in 2010 provided the carrot to the market.

Within the market's rebound, it is evident the sectors that have staged the strongest recoveries to date are those providing exposure to economic recovery – banks, transport, building materials, consumer discretionary, construction & engineering. Those areas that have lagged are mostly defensive - consumer staples, healthcare, telcos and utilities (**Chart 1**).

**Chart 1:** Market performance since March 2009



**Source:** Datastream, Ord Minnett Research. Performance measured from 6/3/09 to 20/1/10.

Within each sector, the dispersion of returns of individual stocks was low. This meant that as long as the sector call was right, it didn't matter as much which stock(s) within the sector you held to gain that performance, they all tended to move in line. Our view for 2010 is that we will see sector performance become less of a differentiator than it was for most of 2008 and 2009. Instead stock performance within sectors will become more dispersed. We think there are good reasons why broader economic drivers of returns will play a lesser role and why the gap between winners and losers within sectors will become wider.

## Conditions favour ongoing recovery

Some commentators question the sustainability of the recovery, but we believe a number of important conditions for the next phase of the recovery are in place:

- Credit markets have stabilised;
- Emerging Asia leads the way in the recovery –helpful for Australia;

- Industrial production is solid, with capital expenditure the next step after re-stocking of inventories;
- US housing is bottoming out;
- Labour markets are turning;
- Core inflation remains subdued, despite some impact of higher commodity prices.

Of course, the economic passage is not assured, so investors need to remain vigilant over factors such as:

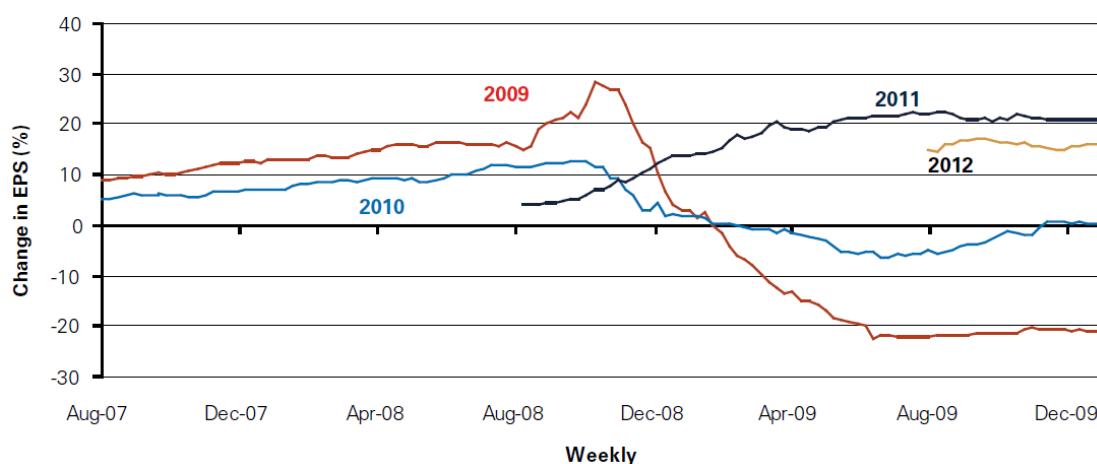
- Currency volatility;
- The effects of withdrawing the huge amount of stimulus around the world over the next 12 - 24 months;
- Loss of confidence in governments' creditworthiness and the prospect of rising bond yields;
- Fiscal drag as governments control deficits;
- Rebalancing of Chinese growth to head off inflationary pressures;
- Regulatory intervention.

As far as Australia is concerned, a scenario often raised is that the economy will provide a positive surprise. We're not convinced that this is a risk worth tilting a portfolio towards. Bearing in mind that consensus points to 2.8% GDP growth this year, the economy has to work through fiscal drag and rising interest rates and Australia doesn't have the early cycle "bungee" effect of other economies, we would argue that there are risks on both sides of current thinking.

## Earnings outlook

Over half way through the 2010 financial year and consensus expectations point to flat earnings per share for the Australian market. This follows a 21% contraction in earnings per share in the 2009 financial year. This is markedly better than the experience of most other developed economy stock markets, reflecting the relatively stronger position of the Australian economy through the global recession (**Chart 2**).

**Chart 2:** Australian Consensus Earnings per Share Growth Expectations



**Source:** Datastream, Ord Minnett Research. Chart measures consensus earnings per share expectations for the S&P/ASX 200 Index on a financial year basis.

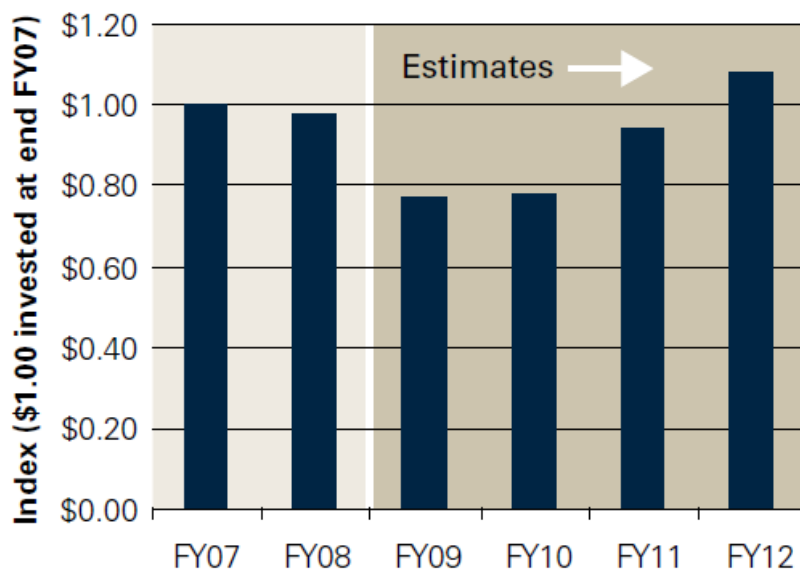
This reporting season will help analysts firm their full year profit expectations. Admittedly, early on in the earnings recovery phase profit numbers might feel "low quality" as revenue growth remains stunted. Instead, many companies rely on cost cutting to eke out any profit growth.

Nonetheless, investors will reward growth, as we've seen with positive reactions to profit upgrades from the likes of Commonwealth Bank, Computershare and Flight Centre. On the flip side, any

earnings shortfall is still dealt with harshly, such as has happened to Foster's Group, Telstra and Worley Parsons following profit warnings.

The reason that this year's earnings are critical is that they represent the path to restoring company profitability to pre-crisis levels and provide support for the market's valuation. Consensus estimates currently peg 2012 as the year that Australian earnings per share will again match pre-crisis levels, a five year cycle of impairment and reparation. Part of the reduction in earnings per share reflects a fall in profitability from the economic downturn, but it also entails the impact of myriad dilutive capital raisings worth \$100bn that have occurred over the last two years (**Chart 3**).

**Chart 3:** Earnings per share movements

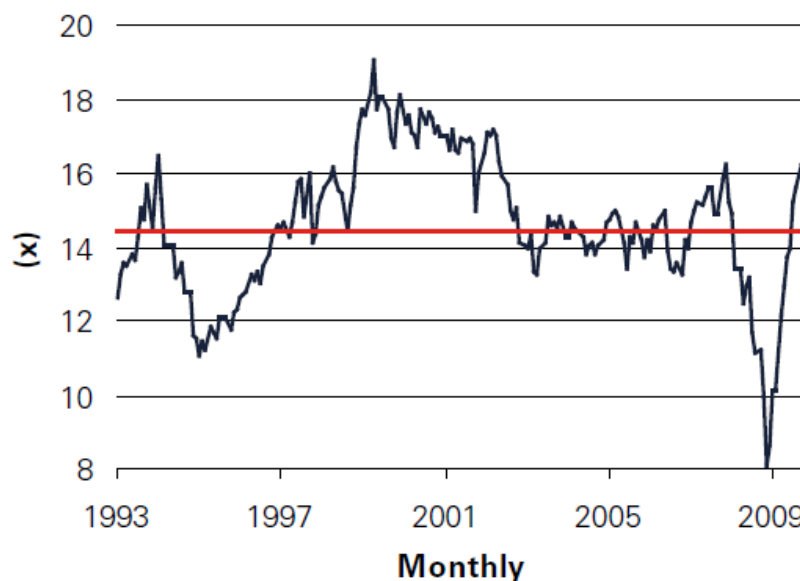


**Source:** Datastream, Ord Minnett Research.

## Valuations matter

The pace and size of the earnings recovery obviously have a direct bearing on the market's valuation. Looking at a relatively simple measure such as Price/Earnings, the market is trading at 15.2 times earnings for the next 12 months, slightly ahead of the long-term average of 14.6 times, but within fair value range. On this basis we enter 2010 with the expectation that market returns will be more measured than the 2009 roller coaster ride (**Chart 4**).

**Chart 4:** Price/Earnings Ratio – S&P/ASX 200 Index



**Source:** Datastream, Ord Minnett Research.

This chart measures the prospective consensus earnings for the market on a 12 month rolling basis.

The market's dividend yield is another handy measure of value. Fortunately, given the repairs that many companies have made to their capital structures, and the changes that boards' have made to company dividend policies (including better matching dividends with cash earnings), we have much greater confidence surrounding forecasting dividends.

The following table gives our estimates for the Australian market's dividend yield. The 2010 financial year sees a slight movement down to 3.8% and a material pick up in 2011. This compares with the market's historic average dividend yield of 3.7%. On this indication the market has some valuation headroom; although expected interest rate rises this year will remove some relative valuation support. (**Table 1**)

**Table 1:** Dividend estimates for the ASX 200

	FY08A	FY09E	FY10E	FY11E	Historic Average
Dividend Yield	5.6%	4.0%	3.8%	4.4%	3.7%
Franking Level	77%	75%	74%	75%	n/a
Implied Gross Yield	7.4%	5.2%	5.1%	5.9%	n/a
Payout Ratio	75%	65%	65%	64%	59%

**Source:** Ord Minnett Research, IRESS. Dividend yield is calculated using share prices as at 15 January 2010.

Justin Scattini is a private client adviser and representative of Ord Minnett Limited, AFS licence 237121. This article contains general financial advice only and does not consider your personal circumstances. Justin can be contacted on 07 3214 5529 or [jscattini@ords.com.au](mailto:jscattini@ords.com.au).

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# Software and data industry going the way of gas street lighters?

By Jody Elliss

Every year we can look at the top 200 ASX index close of the year from the December options Thursday ie the middle Thursday in December and then compare it with the last day of trade in January. This has traditionally been as good an indicator as any of a bullish or bearish year, hence the old saying "UP in January, Up for the year! Down in January, down for the year!" XJO finished December at about 4650 and despite good initial gains, finished January below 4650, leaving us all with the unpleasant thought that we are in for a depressed 2010.

Fund managers, financial planners, investors, speculators, and virtually everyone involved in the financial markets (FM) was looking for any sign of even a slightly bullish 2010. The huge bullish run from May to October 2009 saw a recovery of fortunes for many but the market has since been retracing those gains, leaving the FM industry struggling to recover from the GFC.

The last two years has seen the "culling" of nearly 50% of active traders from the stock market. Comsec, Etrade, and other large organisations are all reporting significant cuts to trading revenue. All the major CFD providers are reporting a large attrition of "active" accounts in the market. This has made the broking industry far more aggressive in its fossicking for clients, increasing products and services to the point that broker execution platforms include, charting, technical analysis, fundamentals, and recommendations as part of a service to attract clients.

This has impacted directly on the stock market data industry and it has seen many smaller companies just disappear. The data industry has been long hamstrung by ASX costs to supply individuals live or delayed data. However, this same data is now being provided free to "active" clients by brokers to promote any sort of market activity.

Generic data companies that provide ASCII and Metastock data are unofficially reporting renewals of data services of below 30%. This has been the case for two years now and by definition, this leaves these companies with an active client base of around 15% that of 2007.

Proprietary data companies have fared better where their clients have been able to use proprietary information to their advantage. Both Lincoln Indicators (Stock Doctor) and Investor Centre (IC-I) are still claiming over 70% renewal rate for existing clients. Both these organisations supply charting, fundamentals, and portfolio management information to their clients and these clients have not been eliminated from the market. However, new business is very rare and both organisations are unofficially reporting a shortage of new business.

It is an industry oddity that the most NEW business is written the month after any market high. Even though the real time to take advantage of these packages is when the market is near or at a low point, interest is generated as a factor of greed. With the market down or sideways, the call to action for new clients is at a low point. With the hope of an aggressively bullish 2010 quickly disappearing, it takes with it the future of many Australian and international software and data companies.

This has in turn affected the Financial Market trade shows which has gone from more than 18 shows Australia wide in 2007 to just 3 for 2010, after the Traders Expo again cancelled Perth for the third year in a row due to lack of exhibitors. This has also seen data and software exhibitors at the yearly ATAA and AIA conferences consequently diminish to the point of nonexistence.

The 2009 World Traders and Investor Expo (held in Las Vegas) saw more than 1,000 exhibitors from all over the world – up on 2008. However, data and software providers were noticeably lacking from this show. It was dominated by real-time execution platforms offering everything from "at call" fundamental market reports to advanced "Elliott Wave" and "Gann" forecasts, all based on tic and 1 minute charts.

Even the “strategic” platforms were based on intraday data and information. Equis (Metastock) and Omega (Tradestation) had no ‘end-of-day’ software available for sale and were both promoting proprietary data execution platforms for the US market. Rumours have been abounding for more than two years that Equis intends to kill off its end-of-day business as it is deemed ‘non-profitable’.

We know there is still a call for software and data solutions. The Canning College TAFE in Western Australia runs a stock market investment course once every 3 months and it continues to run to capacity. David Barnes, the Dean of Studies, continues to train students with the IC-I software and reports that they still see the value of standalone software fed by up-to-date data, with more than 80% of students attending, purchasing the software.

As Lincoln Indicators and Investor Centre continue to provide useful services to investors and traders, they continue to hold on in an ever shrinking market. This market is seeing the natural attrition of people who are just not making money in a difficult financial market and very few NEW investors arriving to take their place.

The resultant is an obvious turn towards internet based advisory services or the operation of managed funds and the extinction of end-of-day data and stand alone software as we know it. There, unfortunately, can be no long-term future for this industry that many argue has been in its death throws since the GFC struck.

Investor Centre has a vested interest in continuing its services as we derive an enormous amount of useful investment information from seeing corporate buying patterns (Elliss Big Money Index). As Investor Centre runs its own fund and continues to rely heavily on this information, it will continue to factor costs of the information to its client base and in-turn provide useful services.

However, the once great data industry is now in its twilight hours. Amazingly, the ASX has worked towards this end, with only those correctly licensed, forced to pay royalties. Unless 2010 breaks into a bullish year with an aggressive breach above 5000, we can expect to see very few FM software and data providers still standing in 2011.

*Jody Elliss is the CEO of the Investor Centre. He will be presenting at the AIA National Investors Conference from 25 to 28 July 2010 at the Surfers Paradise Marriott Resort <http://www.investors.asn.au/events/national-conference/>.*

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# Market maths: compound growth and the log scale

By Robert Vagg

*"The most powerful force in the universe is compound interest"* is a quote that has been attributed, perhaps unjustifiably, to Albert Einstein. Although surely something of an overstatement, it does hint at the wide occurrence and importance of compound (or exponential) growth that is evident throughout our natural world. This includes that related to the many human activities shaped by population growth, a major driver of growth in financial markets. This article looks at the importance to investors of understanding compound growth, particularly when represented numerically or in share price charts, and attempts to cover some of the mathematical basis for that understanding.

## Growth of an investment

Compounding of an investment is a repetitive process by which new earnings are continually added to the total capital available so as to form a larger base on which future returns may accumulate. By this means, the reinvested earnings are able to generate their own earnings. Since public company earnings compound by this same process, so also will their associated share prices, as they grow by ever increasing increments. The meaningful interpretation of share price growth displayed in price charts therefore requires some understanding of the concept of compounding.

Examples of growth occurring at different compounding rates are shown in Table 1. This displays the effects of different compound growth rates (rates of return) on initial capital of \$1,000 taken at different stages of a long-term investment.

**Table 1.** Growth of a \$1,000 investment at different annual growth rates

Year	Compound Growth Rate						$\log_{10}$ 30%
	5%	10%	15%	20%	25%	30%	Value *
0	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	3.0000
1	\$1,050	\$1,100	\$1,150	\$1,200	\$1,250	\$1,300	3.1139
2	\$1,103	\$1,210	\$1,323	\$1,440	\$1,563	\$1,690	3.2279
3	\$1,158	\$1,331	\$1,521	\$1,728	\$1,953	\$2,197	3.3418
4	\$1,216	\$1,464	\$1,749	\$2,074	\$2,441	\$2,856	3.4558
5	\$1,276	\$1,611	\$2,011	\$2,488	\$3,052	\$3,713	3.5697
6	\$1,340	\$1,772	\$2,313	\$2,986	\$3,815	\$4,827	3.6837
7	\$1,407	\$1,949	\$2,660	\$3,583	\$4,768	\$6,275	3.7976
8	\$1,477	\$2,144	\$3,059	\$4,300	\$5,960	\$8,157	3.9115
9	\$1,551	\$2,358	\$3,518	\$5,160	\$7,451	\$10,604	4.0255
10	\$1,629	\$2,594	\$4,046	\$6,192	\$9,313	\$13,786	4.1394
15	\$2,079	\$4,177	\$8,137	\$15,407	\$28,422	\$51,186	4.7092
20	\$2,653	\$6,727	\$16,367	\$38,338	\$86,736	\$190,050	5.2789
25	\$3,386	\$10,835	\$32,919	\$95,396	\$264,698	\$705,641	5.8486
30	\$4,322	\$17,449	\$66,212	\$237,376	\$807,794	\$2,619,996	6.4183
35	\$5,516	\$28,102	\$133,176	\$590,668	\$2,465,190	\$9,727,860	6.9880
40	\$7,040	\$45,259	\$267,864	\$1,469,772	\$7,523,164	\$36,118,865	7.5577

\*  $\log_{10}$  of \$ values given in the 30% growth column

The Table demonstrates the importance of maximising the compound growth rate for an investment. Viewed along the bottom line, the results of achieving an additional 5% annual growth over an investment lifetime are striking, particularly at the higher rates. They provide a compelling argument for the reinvestment of distributed earnings (*i.e.* dividends) by an investor, which would increase the compounding effect by approximately this amount, equivalent to compounding

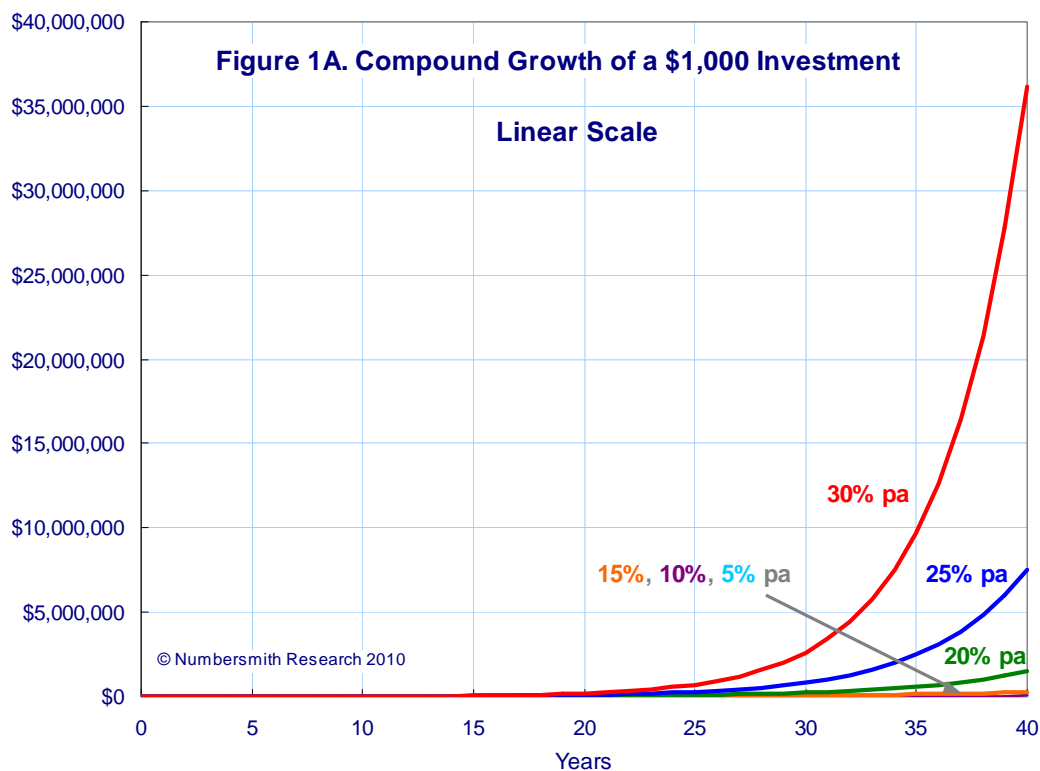


interest. That is, the result of capital growth of 15% p.a. plus a net 5% p.a. dividend consistently reinvested would be identical to that obtained from 20% p.a. capital growth alone. The data in the Table also demonstrate the importance of becoming an investor as early as possible so as to take advantage of compounding over an extended time period.

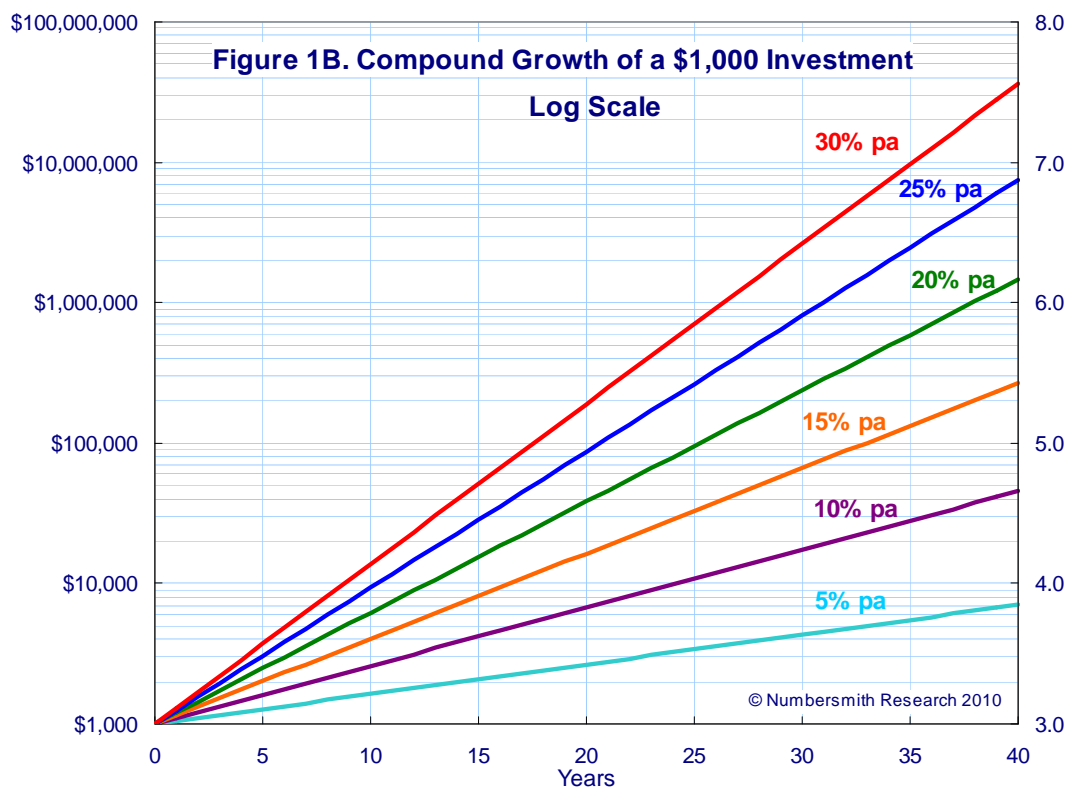
## Charting price growth

The determination of long-term growth rates for financial data, whether they be price, earnings, dividends, *etc*, is crucial to informed investment decisions. This type of information generally may be obtained more readily from graphical representations of price plotted against time rather than from tables of numeric data, if available. In order to reach a decision based on the performance of two alternative investments, charts that allow ready comparison of each are almost indispensable. An informed decision requires that growth rates be readily determined from these charts.

An important alternative exists when choosing the most appropriate type of price chart. That choice, available in all charting software packages, is between the use of a linear or a log scale, and the latter is always appropriate for a value that displays compound growth. As a general guide, if it is not practical for the parameter being charted to have a negative value, then the correct choice is a log scale. This is necessary, in particular, when identifying or comparing trends in share prices and indices.



When the data contained in Table 1 are plotted on a normal linear scale (Figure 1A), very little information of value is obtained. In fact a false impression, that little or no growth in the first 25 years is followed by sudden rapid growth, is likely to result. Importantly, no quantitative determination may be made of each of the different growth rates, and of the lower ones in particular, simply from this chart. Growth at 5%, 10% or 15% rates is not even discernable when placed on this common scale. When plotted on a log scale, however, the six different growth rates may be readily compared (Figure 1B) and all data are observable.



The different growth rates now are apparent from straight-line plots whose gradients increase with each higher rate. The gradient of each line is determined solely by its growth rate. The mathematical reason for this is outlined in detail in the Appendix section later, but some discussion is included below. If this proves to be confusing, then readers may wish to skip forward to the section on Price Charts.

From an inspection of the \$ values shown in the 30% column of Table 1, it may be seen that each annual value is generated by multiplying the previous year's value by a factor of 1.30 (the *growth multiplier* – here 1.00 + 30%). The final column of Table 1 lists values (*log\$*) that are each the logarithm (to base 10) of the dollar values shown in the previous 30% growth column<sup>1</sup>. It might be noted that these *log\$* values display an annual increment of 0.11395, beginning at 3.0000 (1,000 is  $10^{3.0000}$ ) and ending at 7.5577 (36,118,865 is  $10^{7.5577}$ ) after 40 years. These *log\$* values correspond to the units shown on the right-hand axis of Figure 1B. Following the red straight-line plot, it may be seen there that it is in fact the *log\$* values<sup>2</sup> that are being plotted in the chart. The resulting straight line is caused by the repetitive addition of this constant annual increment.

The magnitude of each increment is determined solely by the growth rate. The antilog of 0.11395 (i.e. 10 to the power of 0.11395, or  $10^{0.11395}$ ) equals 1.300 – the growth multiplier. The corresponding growth rate then remains after subtracting 1.000 from the resultant growth multiplier ( $1.300 - 1.000 = 0.300$  or 30%).

This exercise is of potential value to an investor, since it would allow calculation of an effective rate of return averaged over any time period for an investment, or when wishing to compare investment alternatives. The time period may be in fractional years. An example is given here.

**Q:** A \$1,000 investment grows to \$4,300 over 8.0 years. What is the effective annual rate of return?

**A:** The increase in *log\$* is calculated as  $[\log(4300) - \log(1000)] = [3.6335 - 3.0000] = 0.6335$  over 8 years. Each 1-year increment therefore is  $0.6335 / 8.0 = 0.07919$ .

<sup>1</sup> A logarithm definition is available at <http://en.wikipedia.org/wiki/Logarithm>.

<sup>2</sup> Each of these *log\$* values represents an **exponent** of 10 (see <http://simple.wikipedia.org/wiki/Exponent>). Growth represented by addition of these exponents is referred to as **exponential**.

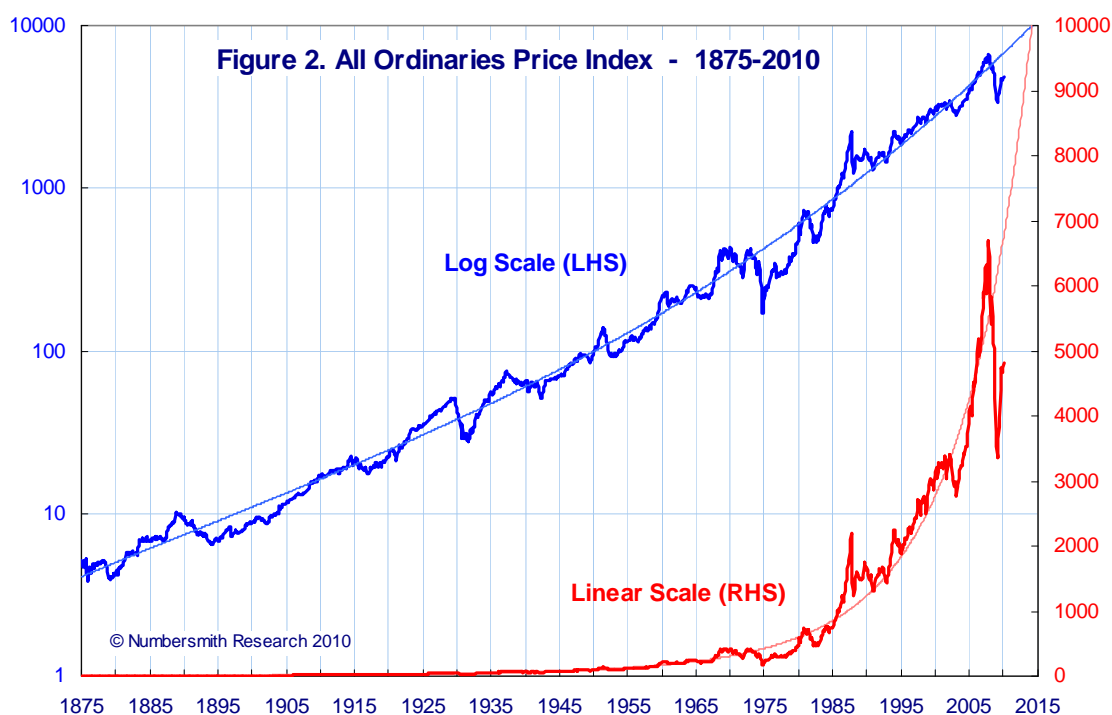
The growth multiplier calculates as  $10^{0.07919} = 1.200$ . The averaged annual growth rate then is **20.0%** ( $1.200 - 1.000$ ).

This result may be compared with data in the 20% growth column of Table 1.

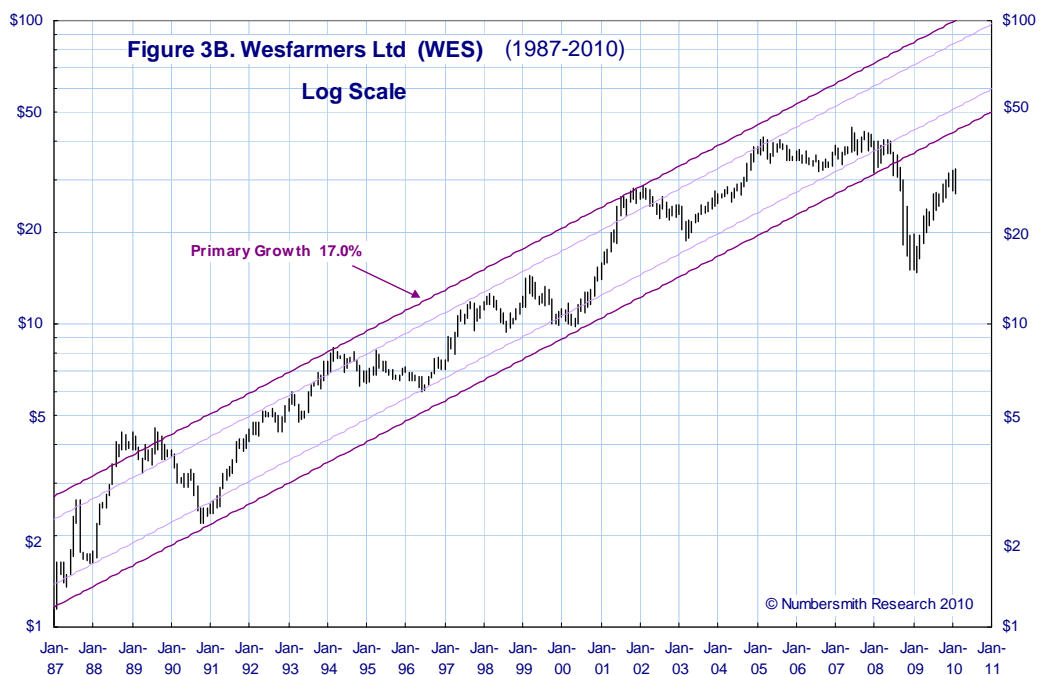
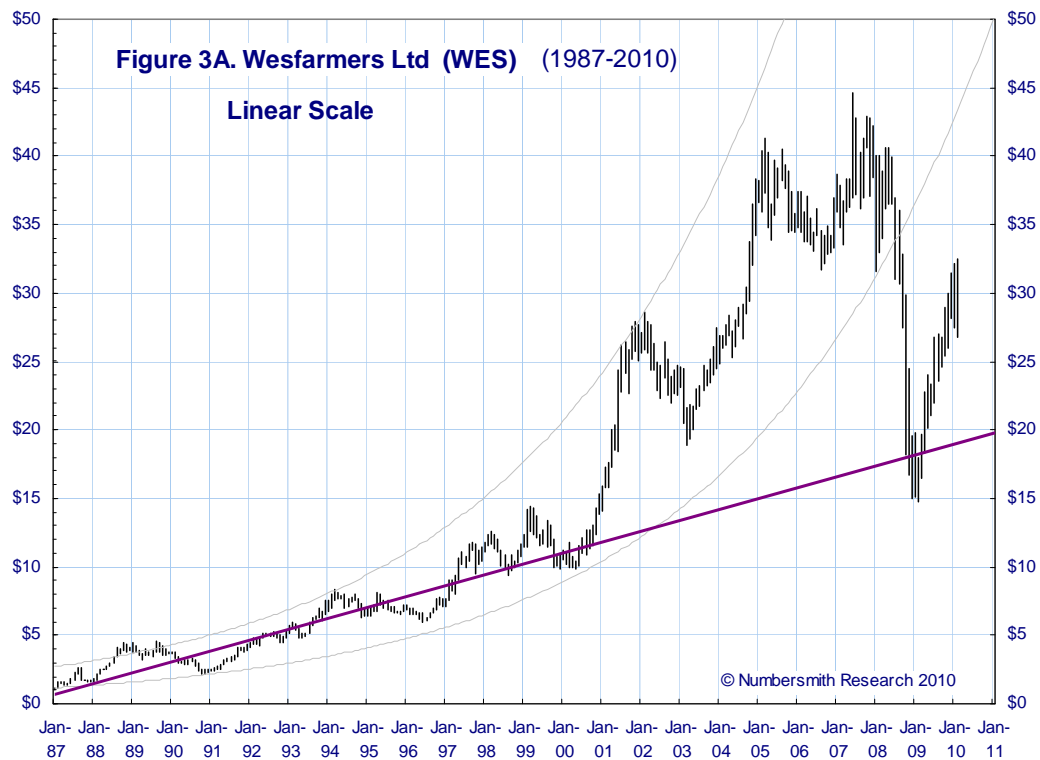
## Price charts

Trendlines are very commonly included in charts of financial markets to quantify periods of (compound) growth. When doing so, it is important that the correct choice of a log scale be made. As demonstrated above, straight trendlines would have no theoretical basis unless they are drawn on log-scale plots. In fact, drawing a straight line on a chart with a linear scale may easily lead to misinterpretation of the price action represented. Drawn on a linear scale, a compounding trendline should not be a straight line but should show exponential curvature.

Figure 2 shows the All Ordinaries Index plotted on a linear scale (red). This provides very little information, and its shape easily might be likened to that of a hockey stick. No growth at all is apparent until the middle of the twentieth century, and an impression of sudden rapid growth with the possible formation of a massive bubble over the last few decades might be incorrectly concluded. Also shown are the same Index data plotted using a log scale (blue). The latter plot is far more informative. All Index values are observable, and trend growth and relative changes in volatility are apparent. Recent growth now is seen as being consistent with the Index's 135-year history. A primary trendline, and its likely future direction, becomes obvious.



Similar caution is required when interpreting trends in the price history of individual shares. As an example, the 23-year price history of Wesfarmers Ltd shares is displayed in Figures 3A & 3B. If compound growth is not recognised, a trendline similar to that in Figure 3A could be drawn and likely be interpreted as representing long-term fair value for this stock. The period 2000-2007 then would be viewed as indicating considerable bubble formation that corrected with the GFC declines. A correct interpretation is permitted by Figure 3B, which shows that the company's share price had been contained within a well-defined trend channel compounding at 17% p.a. until mid-2008, when it then plummeted well below that trend to levels from which it is yet to recover. The lack of validity of the linear trendline suggested in Figure 3A may be confirmed by realising that its extension back prior to 1986 would require the stock to have had a negative share price. The trend channel in exponential form also is shown here.



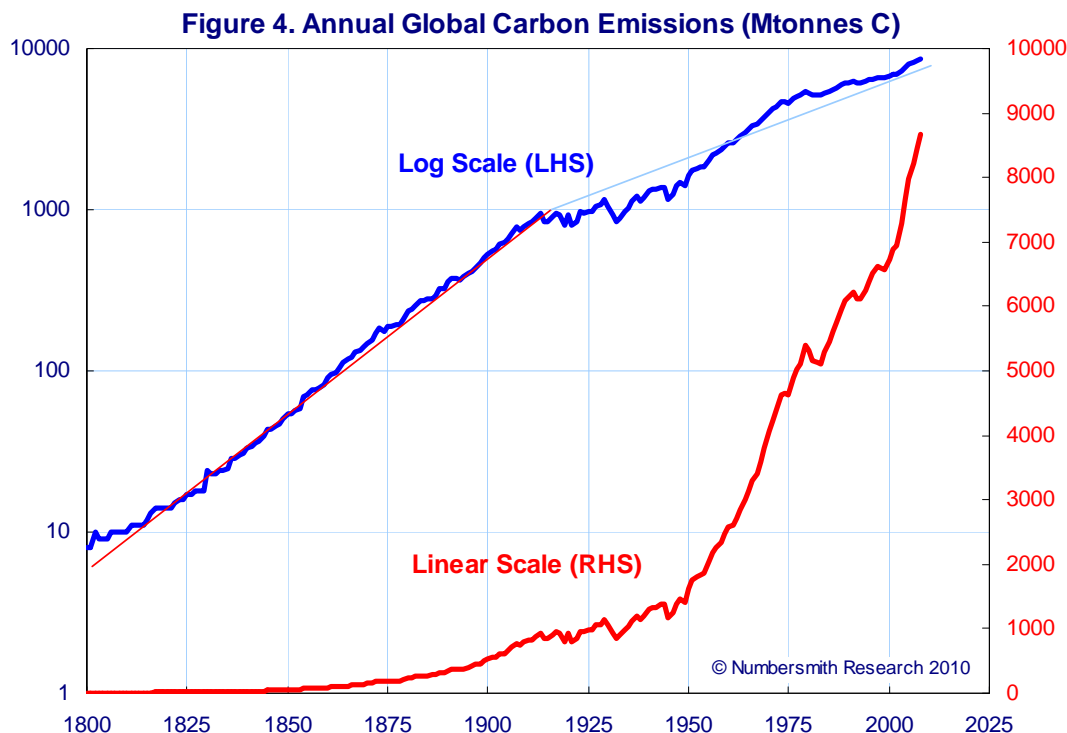
## Carbon trading markets

Many market-traded securities whose prices are influenced by population growth display compound growth, of particular relevance to commodities and futures markets. A very topical example, of considerable importance to investors, is the variety of proposed carbon-trading schemes arising from the anthropologically-derived emission of carbon into the atmosphere.

Figure 4 displays carbon emissions over the last two centuries<sup>3</sup>. The linear plot (red) again gives the impression of little growth during the nineteenth century followed by particularly rapid increases in growth rate in the second half of the twentieth. From a value of ca 1,500 MtC p.a. reached in 1950 the growth rate of emissions appears to have exploded suddenly, resulting in a six-fold

<sup>3</sup> Data source: [http://cdiac.esd.ornl.gov/trends/emis/tre\\_glob.html](http://cdiac.esd.ornl.gov/trends/emis/tre_glob.html) .

increase by 2008.<sup>4</sup> Presented as a log plot (blue) however, a less alarming overall impression results. This shows the growth rate of emissions generally to be decreasing with time. Average growth in 1800-1910 emissions is represented by a well-defined trendline of gradient corresponding to a growth rate of 4.4% p.a. For the period 1910-2010 this growth rate averages 2.3% p.a. For the last four decades growth has averaged 1.8% p.a., consistent with global population growth<sup>5</sup>. Similar to share price charts, different perceptions may be determined by the provider's choice of a linear or a log scale. The latter is the more informative.



It is intended that in a future article the basis for the well-known 'Rule of 72' also will be ascribed to *"the most powerful force in the universe"*.

## Appendix: mathematical background

The following description is provided for readers wishing to look further into the mathematical basis of compound growth, and its graphical representation.

Compound price growth occurs when price increases by application of a growth multiplier at constant time intervals. For normal compound growth the value of the growth multiplier, and its inherent growth rate, remains constant throughout.

If the initial price ( $P_0$ ) of a financial asset were to increase over a year by a measured effective growth rate ( $E$ ), then the annual growth multiplier ( $G$ ) is equal to  $1+E$  and the new price at the end of the year ( $P_1$ ) is calculated simply as  $P_1 = P_0 G$  or  $P_0 (1+E)$ . Growth for a second year would be determined by applying the same growth multiplier to the new price  $P_1$ , such that  $P_2 = P_1 G = P_1(1+E)$ . Alternatively,  $P_2$  may be expressed as either  $P_0(1+E)(1+E)$  or as  $P_0(1+E)^2$  or  $P_0G^2$ . Similarly, after a third year of growth the new price  $P_3$  could be calculated as  $P_2(1+E)$  or  $P_0(1+E)(1+E)(1+E)$  or  $P_0(1+E)^3$ . Thus, compound price growth after  $n$  years may be described by the general expression (a1):

$$(a1) \quad P_n = P_0 G^n = P_0 (1+E)^n \quad \text{where } n = \text{number of years}$$

<sup>4</sup> Australia's carbon emissions contribution in 2008 was 151 MtC p.a. (1.73% of global emissions), equivalent to 0.0178% of the total CO<sub>2</sub> content of this atmospheric "pollutant". A 10% emissions reduction by Australia therefore would represent an annual decrease of 0.0018% in the atmosphere's natural CO<sub>2</sub> reservoir.

<sup>5</sup> Per capita emissions from developed countries have been in steady decline during this period, offset by increases from developing countries.

$P_0$  = initial price

$P_n$  = price after  $n$  years

$G$  = annual growth multiplier

and  $E$  = effective annual growth rate.

This mathematical description **(a1)**, employing an effective growth rate, is applicable if the prices achieved are considered only at the end of each year. In practice, price changes on financial markets, and hence growth, is essentially continuous. The relevant time interval for price change therefore approaches zero, and continuously compounding growth occurs. In such case, growth is exponential and is better described by application of a nominal growth rate, as described by the expression **(a2)**:

$$\begin{aligned} \text{(a2)} \quad P_n &= P_0 e^{Nn} \quad \text{where} \quad n = \text{the growth period expressed in years} \\ N &= \text{nominal compounding annual growth rate} \\ \text{and} \quad e &= \text{the natural growth base (2.718281828...)}^6. \end{aligned}$$

The relationship between the effective annual growth rate  $E$  and the nominal rate  $N$  is given by **(a3)**:

$$\text{(a3)} \quad E = e^N - 1.$$

The differences between these two growth rate descriptions may be explained by example. A security priced at \$10.00 and displaying annual compound growth for three years at an effective rate of 15.0% p.a. would result in a price of \$15.21 { \$10.00 x 1.15<sup>3</sup> }. This is equivalent to a continuous nominal rate of 14.0% p.a. Alternatively, continuous compounding at a nominal 15.0% p.a. rate would see the price increase to \$15.68 over this period, an effective annual rate of 16.2% p.a.

Compound growth rates may be determined graphically by mathematical manipulation of the formulae above. Since relative price growth remains constant throughout, the plot requires price to be displayed on a relative scale. This may be achieved simply by plotting price on a logarithmic scale against time. In logarithmic form, relationship **(a1)** becomes

$$\text{(a4)} \quad \log_{10} P_n = \log_{10} P_0 + n \log_{10} G = \log_{10} P_0 + n \log_{10} (1+E),$$

whereas formula **(a2)** becomes either

$$\text{(a5)} \quad \ln P_n = \ln P_0 + N n$$

$$\text{or} \quad \text{(a6)} \quad \log_{10} P_n = \log_{10} P_0 + 2.3026 N n.$$

Each of these relationships **(a4-6)** has the common linear equation form of  $y = ax + b$  which, when plotted, generates a straight line of gradient (annual increment)  $a$  and a y-axis intercept of  $b$ . Using **(a4)**, as an example, a linear plot of  $\log_{10} P_n$  ( $\equiv y$ ) against  $n$  ( $\equiv x$ ) has an intercept of  $\log_{10} P_0$  ( $\equiv b$ ) and gradient of  $\log_{10} (1+E)$  ( $\equiv a$ ). Taking the antilogarithm of the measured gradient gives  $1+E$ , thereby allowing determination of the effective annual compound rate  $E$ . A similar plot from equation **(a6)** would have a measurable gradient corresponding to  $2.3026N$ , allowing easy calculation of the nominal compounding rate of return  $N$ . Either analysis may be applied in practice, with equation **(a3)** allowing inter-conversion between the resultant nominal and effective rates of return.

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\* \* \* \* \*

<sup>6</sup> An explanation of  $e$  (Euler's Number) is given at: [http://en.wikipedia.org/wiki/E\\_\(mathematical\\_constant\)](http://en.wikipedia.org/wiki/E_(mathematical_constant)).

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