Compound annual growth rate

Compounded Annual Growth rate (CAGR) is a business and investing specific term for the smoothed annualized gain of an investment over a given time period.[1] CAGR is not an accounting term, but remains widely used, particularly in growth industries or to compare the growth rates of two investments because CAGR dampens the effect of volatility of periodic returns that can render arithmetic means irrelevant. CAGR is often used to describe the growth over a period of time of some element of the business, for example revenue, units delivered, registered users, etc.

Formula

$$\mathrm{CAGR}(t_0, t_n) = \left(\frac{V(t_n)}{V(t_0)}\right)^{\frac{1}{t_n - t_0}} - 1$$

- $V(t_0)$: start value, $V(t_n)$: finish value, $t_n - t_0$: number of years.
- Actual or normalized values may be used for calculation as long as they retain the same mathematical proportion.
- The CAGR can also be calculated as the geometric mean of 1 plus each year's return (i.e. +3% becomes 1.03 and -2% becomes 0.98), minus 1.[2]

Example

Suppose the revenues of a company for four years, V(t) in above formula, have been:

Year	2004	2005	2006	2007
Revenues	100	115	150	200

$t_n - t_0$= 2007 - 2004 = 3

Then the CAGR of revenues over the three-year period from the *end* of 2004 to the end of 2007 is:

$$\mathrm{CAGR}(0, 3) = \left(\frac{200}{100}\right)^{\frac{1}{3}} - 1 = 0.2599 = 25.99\%$$

Verification:

If you multiply the initial value by (1 + CAGR) three times (because we calculated for 3 years) you will get exactly the final value again. This is:

$$V(t_n) = V(t_0) \times (1 + \mathrm{CAGR})^n$$

For n = 3:

$$= V(t_0) \times (1 + \mathrm{CAGR}) \times (1 + \mathrm{CAGR}) \times (1 + \mathrm{CAGR})$$
$$= 100 \times 1.2599 \times 1.2599 \times 1.2599 = 200$$

For comparison:

- the Arithmetic Mean Return (AMR) would be the sum of annual revenue changes (compared with the previous year) divided by number of years, or:

$$\mathrm{AMR} = \bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i = \frac{1}{n}(x_1 + \cdots + x_n) = \frac{15\% + 30.4\% + 33.3\%}{3} = 26.26\%.$$

In contrast to CAGR, you cannot obtain $V(t_n)$ by multiplying the initial value, $V(t_0)$, three times by (1 + AMR) (unless all annual growth rates are the same).

- the Arithmetic Return (AR) or simple return would be the ending value minus beginning value divided by the beginning value:

$$\mathrm{AR} = \frac{V_f - V_i}{V_i} = \frac{200 - 100}{100} = 100\%.$$

Applications

These are some of the common CAGR applications:

- Calculating and communicating the average returns of investment funds[3]
- Demonstrating and comparing the performance of investment advisors[3]
- Comparing the historical returns of stocks with bonds or with a savings account[3]
- Forecasting future values based on the CAGR of a data series (you find future values by multiplying the last datum of the series by (1 + CAGR) as many times as years required). As every forecasting method, this method has a calculation error associated.
- Analyzing and communicating the behavior, over a series of years, of different business measures such as sales, market share, costs, customer satisfaction, and performance.

References

[1] http://www.investopedia.com/terms/c/cagr.asp
[2] http://www.buzzardsbay.org/geomean.htm#negative_values
[3] http://www.12manage.com/methods_cagr.html

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