Splitting up Beta's change

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Working Paper

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In this paper we estimated IBM beta from 2000 to 2013, then using differential equation mathematical formula we split up the annual beta's change attributed to the volatility market effect, the stock volatility effect, the correlation effect and the jointly effect of these variables.

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I. INTRODUCTION

Beta is usually defined as a measure that compares the risk of an asset against the risk of the market.

As nasdaq.com investing glossary pointed out, beta is a measure of co-movement, not volatility.

The standard estimation of beta and its use as an input in the Capital Asset Pricing Model, with its limitations (e.g. Ramachandran, 2012), still is a worldwide tool used to evaluate an investment.

Beta is usually calculated using regression analysis of stock returns against market returns.

The beta of the stock corresponds to the slope of the regression, expressed as:

$$\beta = \frac{\sigma_i * \rho_{im}}{\sigma_m}$$

where σ_i is the standard deviation of the stock returns, σ_m is the standard deviation of the market returns, and ρ_{im} is the coefficient of correlation between stock returns and market returns.

Beta estimations are not consistent. Beta values for the same company can be very different. Computations can differ due to the use of a different index (e.g. S&P 500 vs NYSE Composite), the number of years for calculation (e.g. 3 years vs 5 years), and the return time frame input (e.g. weekly returns vs monthly returns) (Coppedge et. al., 2012).

Additionally, see Damodaran (1999) comments related with the choice of the market index, the time period, and the return interval.

II. IBM BETA ESTIMATION

The beta of a firm is determined by three variables: the type of business the firm is in, the degree of operating leverage in the firm, and the firm's financial leverage (Damodaran, 1999).

Firm's business and leverage change over time and market fluctuates in due course as well, therefore beta varies over time.

We estimated IBM beta from 2000 to 2013 using the S&P 500 index, a 3 years' time horizon and monthly returns calculated with monthly historical prices downloaded from Yahoo Finance.

Next table summarized beta estimations and its main inputs for calculation:

Period	Std.Dev.S&P	Std.Dev.IBM	Correlation	Beta
2013-2011	3.486	4.293	0.510	0.629
2012-2010	4.408	4.148	0.660	0.621
2011-2009	5.484	4.174	0.506	0.385
2010-2008	6.554	6.614	0.691	0.698
2009-2007	5.925	6.738	0.660	0.751
2008-2006	4.648	6.566	0.763	1.078
2007-2005	2.243	5.761	0.621	1.595
2006-2004	1.979	5.464	0.658	1.816
2005-2003	2.592	5.350	0.540	1.114
2004-2002	4.381	9.365	0.789	1.687
2003-2001	5.332	11.507	0.755	1.629
2002-2000	5.467	12.637	0.775	1.792
2001-1999	4.897	10.620	0.550	1.193
2000-1998	5.152	9.925	0.547	1.053

III. IBM BETA'S CHANGE SPLIT UP

For a variable

$$X = A*B$$

we have that

$$X_t - X_{t-1} = (A_t - A_{t-1})*B_t + (B_t - B_{t-1})*A_t - (A_t - A_{t-1})*(B_t - B_{t-1})$$

so

$$\Delta(A*B) = \Delta A*B_t + \Delta B*A_t - \Delta A*\Delta B \qquad [1]$$

then for a variable

$$X = (A*B)*C$$

we have that

$$\Delta X = \Delta(A*B)*C_t + \Delta C*(A_t*B_t) - \Delta(A*B)*\Delta C \qquad [2]$$

substituting [1] in [2]

$$\Delta X = [\Delta A^*B_t + \Delta B^*A_t - \Delta A^*\Delta B]^*C_t + \Delta C^*(A_t^*B_t) - [\Delta A^*B_t + \Delta B^*A_t - \Delta A^*\Delta B]^*\Delta C$$

so

$$\Delta(A^*B^*C) = \Delta A^*B_t^*C_t + \Delta B^*A_{t^*}^*C_t - \Delta A^*\Delta B^*C_t + \Delta C^*A_t^*B_t - \Delta A^*B_t^*\Delta C - \Delta B^*A_t^*\Delta C + \Delta A^*\Delta B^*\Delta C$$

therefore, defining $A = \sigma_i$, $B = \rho_{im}$, and $C = \frac{1}{\sigma_m}$

we have that

$$\Delta\beta = \underbrace{\Delta\sigma_i * \rho_{imt} * \frac{1}{\sigma_{mt}}}_{\text{stock volatility effect}} + \underbrace{\Delta\rho_{im} * \sigma_{it} * \frac{1}{\sigma_{mt}}}_{\text{correlation effect}} - \underbrace{\Delta\sigma_i * \Delta\rho_{im} * \frac{1}{\sigma_{mt}}}_{\text{join stock volatility \& correlation effect}} + \underbrace{\sigma_{it} * \rho_{imt} * \Delta\frac{1}{\sigma_m}}_{\text{market volatility effect}}$$

$$\underbrace{-\Delta\sigma_i * \rho_{imt} * \Delta\frac{1}{\sigma_m}}_{\text{join stock volatility \& market volatility effect}} - \underbrace{\sigma_{it} * \Delta\rho_{im} * \Delta\frac{1}{\sigma_m}}_{\text{join correlation \& market volatility effect}} + \underbrace{\Delta\sigma_i * \Delta\rho_{im} * \Delta\frac{1}{\sigma_m}}_{\text{join stock volatility, correlation \& market volatility effect}}$$

Next table summarized beta's change split up effects:

		Effect						
Period	β Change	Market Volatility	Stock Volatilty	Correlation (Mk.Vol.,Stock Vol.)	Join Mk.Vol. & Stock Vol.	Join Mk. Vol. & Correlation	Join Stock Vol. & Correlation	Join Mk. Vol., Stock Vol. & Correlation
2013-2012	0.008	0.132	0.021	-0.184	-0.004	0.038	0.006	-0.001
2012-2011	0.235	0.122	-0.004	0.144	0.001	-0.028	0.001	0.000
2011-2010	-0.312	0.063	-0.225	-0.141	0.037	0.023	-0.082	0.013
2010-2009	-0.053	-0.074	-0.013	0.031	-0.001	0.003	0.001	0.000
2009-2008	-0.327	-0.206	0.019	-0.117	0.005	-0.032	0.003	0.001
2008-2007	-0.517	-1.156	0.132	0.201	0.142	0.215	-0.025	-0.026
2007-2006	-0.221	-0.213	0.082	-0.094	0.011	-0.013	0.005	0.001
2006-2005	0.702	0.429	0.038	0.325	-0.009	-0.077	-0.007	0.002
2005-2004	-0.573	0.455	-0.836	-0.515	0.342	0.210	-0.387	0.158
2004-2003	0.058	0.301	-0.386	0.074	0.069	-0.013	0.017	-0.003
2003-2002	-0.162	0.040	-0.160	-0.043	0.004	0.001	-0.004	0.000
2002-2001	0.599	-0.208	0.286	0.520	0.033	0.061	-0.083	-0.010
2001-2000	0.140	0.059	0.078	0.007	-0.004	0.000	0.000	0.000

Next table summarized beta's change split up effects as a percentage:

		Effect as Percetage						
Period*	β Change	Market Volatility	Stock Volatilty	Correlation (Mk.Vol.,Stock Vol.)	Join Mk.Vol. & Stock Vol.	Join Mk. Vol. & Correlation	Join Stock Vol. & Correlation	Join Mk. Vol., Stock Vol. & Correlation
2012-2011	100.0%	51.7%	-1.6%	61.3%	0.3%	-12.0%	0.4%	-0.1%
2011-2010	100.0%	-20.1%	72.2%	45.1%	-11.8%	-7.4%	26.4%	-4.3%
2010-2009	100.0%	139.2%	24.5%	-58.9%	2.6%	-6.2%	-1.1%	-0.1%
2009-2008	100.0%	63.0%	-5.8%	35.8%	-1.6%	9.8%	-0.9%	-0.3%
2008-2007	100.0%	223.5%	-25.6%	-38.8%	-27.4%	-41.6%	4.8%	5.1%
2007-2006	100.0%	96.6%	-37.2%	42.4%	-5.0%	5.7%	-2.2%	-0.3%
2006-2005	100.0%	61.2%	5.4%	46.4%	-1.3%	-11.0%	-1.0%	0.2%
2005-2004	100.0%	-79.5%	146.0%	89.9%	-59.6%	-36.7%	67.5%	-27.6%
2003-2002	100.0%	-24.8%	98.6%	26.7%	-2.4%	-0.7%	2.6%	-0.1%
2002-2001	100.0%	-34.8%	47.7%	86.9%	5.6%	10.1%	-13.9%	-1.6%
2001-2000	100.0%	42.2%	55.9%	5.2%	-2.8%	-0.3%	-0.3%	0.0%

*We excluded 2012-2011 and 2004-2003 period because in that cases effects as percentage rised up to high (e.g.>500%).

IV. CONCLUSION

Using the described formula you can split up beta's change in a time period and use that detailed information for an accuracy explanation of variations.

References

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