NBP
Narodowy Bank Polski

eFinanse
finansowy kwartalnik internetowy

QUASI-BETA INDEX: MULTIDIMENSIONAL COMPARATIVE ANALYSIS APPLICATION TO DETERMINE RISK INDEX FOR STOCK INVESTMENTS ON THE WARSAW STOCK EXCHANGE

Wiktor Cwynar[1]

Abstract

Cost of capital is the key parameter when evaluating a company's financial performance and valuing a firm or a project. The cost of equity calculation methods most commonly used in practice are based on market data. When such data is not available, classical methods used to determine required rate of return on equity capital are substituted with techniques based on accounting data. One of these techniques is multidimensional comparative analysis. This text shows an attempt to assess quasi-beta indices using multidimensional comparative analysis. Using five financial ratios calculated for companies from the Warsaw Stock Exchange indices WIG20, mWIG40 and sWIG80, risk coefficients were determined as taxonomic measures of development, and then they were compared to traditional beta indices. The final results are promising – the highest values of quasi-beta indices are assigned to companies that are characterized as above average in risk level.

JEL classification: G12, G15, G32
Keywords: CAPM, beta, cost of equity

Introduction

Cost of capital assessment in a company is part of the most important and key business analyses. Cost of capital is used to evaluate a company's performance, in the decision to accept or reject an investment project or in valuation of a business as a whole. There is one problematic aspect of cost of capital calculation emphasized in the literature. Namely it is cost of equity calculation for unlisted companies. For such companies classical models, based on market data like CAPM cannot be applied. In situations like this the literature suggests substitution of the classical CAPM model with techniques based on accounting data (e.g. financial ratios calculated based on the profit & loss statement and balance sheet). One such solution is the model based on multidimensional comparative analysis. Within this analysis a taxonomic measure of development is calculated and then used as a risk index (such a quasi-beta coefficient, obtained by converting taxonomic measure into a coefficient standardized around 1, is an equivalent of the traditional beta index). In this article such quasi-beta indices were calculated for almost 140 companies quoted on the Warsaw Stock Exchange based on

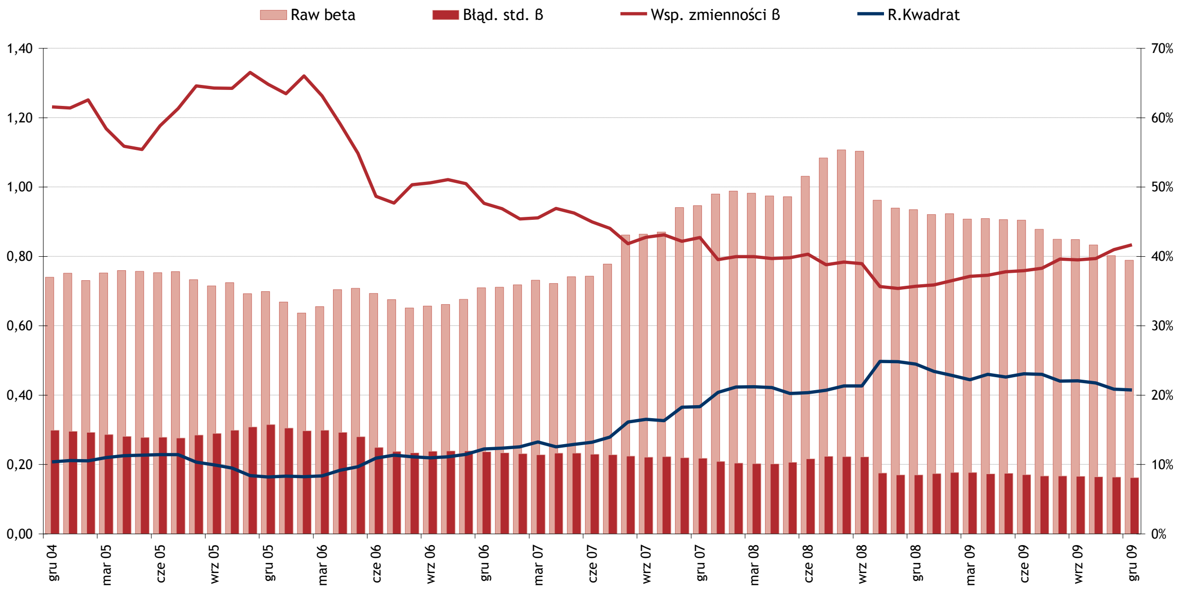
[1] Wiktor Cwynar, PhD, Finance and Accounting Chair, Wyższa Szkoła Biznesu – National-Louis University z siedzibą w Nowym Sączu, ul. Zielona 27, 33-300 Nowy Sącz, wiktor.cwynar@wsb-nlu.edu.pl.

five financial ratios and then they were compared with traditional beta coefficients evaluated for the same companies within the same period of time.

Imperfect CAPM

According to the results of many studies, the capital asset pricing model (CAPM) is the most frequently used method of assessing the cost of equity among companies. This applies to all markets. Referring to the results of research done by D. Zarzecki (2004), this is true for the Polish market as well. Almost 70% of managers from the biggest Polish companies when asked what method is used when evaluating the cost of equity, responded that it is CAPM. The key concept within CAPM methodology is a beta coefficient which measures the risk of a given investment related to the risk of the diversified market portfolio. Although the Polish stock market has been going through many positive changes recently (making the Warsaw Stock Exchange increasingly mature), evaluation of beta coefficient based on data derived from the Polish capital market is still problematic: beta indices for most companies are volatile over time, standard error of beta assessment is still high and the determination coefficient is low (it has even decreased recently) – see chart 1.

Chart 1: Beta coefficient for WSE all stocks and selected statistics describing its assessment



Source: Cwynar, W. *Zmienność* – dobra, czy zła? Analiza polskiego rynku kapitałowego. *e-Finanse*, *6*(2). 16-25.

An additional limitation of practical use of CAPM is that it is based on market data which means that this model cannot be used by companies that are not listed on stock markets. This forces analysts to look for alternative models of cost of equity evaluation in such cases. There are various techniques presented in the literature including the scoring model – like LEFAC (Górski, 2002), methods that try to assess investment risk based on ratings issued for a particular company or the economy as a whole – like the Erb-Harvey-Viskanta model (Erb, Harvey and Viskanta, 1996), models based on the analytical hierarchy (AHP) process[2] or the use of multidimensional comparative analysis. Among methods classified in the last group, a quite interesting procedure is presented by K. Byrka-Kita. The author presents a methodology of evaluation of a quasi-beta index that uses a synthetic measure of development based on taxonomy.

Multidimensional comparative analysis

Multidimensional comparative analysis is the method in which the objects being examined are described by various features. If market data of a certain company is not available to calculate market risk index (beta coefficient), risk of the investment can be described by various financial ratios that are commonly used to evaluate the financial condition of the company – profitability ratios, liquidity ratios, solvency ratios or turnover ratios.

The procedure of taxonomic measure of development can be split into the following steps:

Step 1 Selection of objects (companies) and features (variables, financial ratios) describing them – this is the preparation of a matrix of observations X:

$$X = [x_{ij}] \quad (i = 1,\ldots,n;\ j = 1,\ldots,m), \qquad (1)$$

where X = matrix of observations made on the variables (financial ratios) describing particular companies,
n = number of companies,
m = number of variables (financial ratios),

Step 2 Specification of the type of variables.

Depending on what is the impact of a given variable on the object being examined, one can differentiate stimulants, destimulants and nominants. Stimulants are those variables for which an increase has a positive effect on the object under examination (those variables whose high value is linked to a positive evaluation of the object examined). Destimulants are variables for which a decrease has a positive effect on the object under examination (destimulants include all the features whose low value results in a positive evaluation). Nominants is a feature typical for an object that is characterised by a feature approaching a defined value.

Step 3 Making all variables homogenous by transferring them into stimulants. In the case of destimulants it can be done based on one of the following formulas:

$$x_{ij}' = 1 - x_{ij}$$
$$x_{ij}' = \frac{1}{x_{ij}} \qquad (2)$$
$$x_{ij}' = - x_{ij}$$

where x_{ij} = initial, original destimulant values,

[2] The use AHP to assess the cost of equity was proposed among others by John S. Cotner, Harold D. Fletcher, Computing the Cost of Capital for Privately Held Firms, American Business Review 2000, June and R. Palliam, Application of a Multi-Criteria Model for Determining Risk Premium, The Journal of Risk Finance 2005, Vol. 6, No. 4

x_{ij}' = destimulant transferred into stimulant.

The first formula is usually used if a destimulant takes values from the range (0 – 1). The second one is used if a variable takes extremely high values. The last one is used in the case of some metrics like e.g. FLM (financial leverage multiplier), when values of such metrics – by definition – are relatively low. The dominant is transferred into stimulant by making it standardized at the same time (step 4 below) based on the formulas presented below.

Step 4 Making all diagnostic variables (stimulants and destimulants transferred into stimulants) comparable. It is done using a normalization procedure, usually based on standardization. In the case of stimulants the following formula is used:

$$z_{ij} = \frac{x_{ij} - \overline{x_j}}{S_j} \qquad (3)$$

where $\overline{x_j}$ = arithmetic mean for variable j,
S_j = standard deviation for variable j,

As mentioned above in the case of nominants the same one formula is used to transfer them into stimulants and in making them standardized:

$$z_{ij} = \frac{x_{ij} - min\{x_{ij}\}}{nom\{x_{ij}\} - min\{x_{ij}\}}, x_{ij} \le nom\{x_{ij}\}$$
$$z_{ij} = \frac{max\{x_{ij}\} - x_{ij}}{max\{x_{ij}\} - nom\{x_{ij}\}}, x_{ij} > nom\{x_{ij}\} \qquad (4)$$

where $max\{x_{ij}\}$ = maximum value of variable j,
$min\{x_{ij}\}$ = minimum value of variable j,
$nom\{x_{ij}\}$ = nominal value of variable j (nominal value is assumed to be a median calculated for all companies being examined)

Step 5 Defining weights assigned to particular diagnostic variables. B. Chorkowy and M. Drymluch say that "any formula that prefers most volatile variables can be used as a criterion that enables the definition of weights, because such variables differentiate objects being examined to the highest extent". To define a level of weights the following formula can be used:

$$w_j = \frac{V_j}{\sum_{j=1}^{m} V_j} \qquad (5)$$

where V_j = coefficient of volatility for variable j before standarization

$$V_j = \frac{s_j}{\bar{x}_j}$$

Step 6 Calculation of the distance from the model object. By doing it one uses Euclidean distance and weights defined in the previous step (since weights are based on coefficients of volatility, to calculate the distance one takes into account the different impact of particular variables on the object being examined).

$$d_i = \sqrt{\sum_{j=1}^{m} w_j (z_{ij} - z_{0j})^2} \qquad (6)$$

where w_j = weights assigned to particular diagnostics variables

z_{0j} = max $\{z_{ij}\}$ that is the so-called model object

Step 7 Taxonomic measure of development calculation. It is done by normalizing the distances calculated in the previous step so that they take values from range (0 – 1) and making sure their increase is favorable and beneficial for the object being examined.

$$z_i = 1 - \frac{d_i}{d_0} \qquad (7)$$

where z_i = synthetic, taxonomic measure of development for object i,

d_0 = norm providing z_i takes values from range (0-1)

$$d_0 = \bar{d} + 2 \times S_d \qquad (8)$$

where $\bar{d}$ = arithmetic mean for d_i variable,

S_d = standard deviation for d_i variable.

Step 8 The conversion of taxonomic measure of development into quasi-beta.

(9)

$$quasi - beta = \frac{\bar{z}_i}{z_i}$$

where $\bar{z}_i$ = average level of TMR for the market as a whole

The research

The analysis was focused on a total number of 140 companies whose shares are included in the WIG20, mWIG40 and sWIG80 indices of the Warsaw Stock Exchange. Financial ratios values were obtained from Bloomberg financial data services. Financial ratios were calculated for a one-year time horizon based on data for last two quarters of 2009 and first two quarters of 2010. For some of the companies the data was incomplete. In the situation when a given financial ratio value was not available for a particular company it was replaced with the average of this ratio calculated for the entire population of companies being analyzed. For three companies there were no financial ratios available. These companies were removed from the analysis. Finally, the sample was represented by 137 companies (n = 137). As diagnostic variables five financial ratios were used (m = 5):

a) ROA (*return on assets*)[3],
b) ROE_o (*operating return on equity*)[4],
c) CR (*current ratio*)[5],
d) FLM (*financial leverage multiplier*)[6],
e) FCFPS (*free cash flow per share*)[7].

Financial ratios were chosen from among a limited number of ratios provided by Bloomberg financial data services. These ratios (except for ROA) are the most commonly used financial metrics in such analyses (compare reports of IBnGR or papers by K. Byrka-Kita). ROA can distort the final results because of different capital requirements (the total assets base in the denominator) of various companies. Three of the above mentioned ratios are stimulants (ROA, ROE_o and FCFPS),one is destimulant (FLM) and one is nominant (CR).

1) Financial leverage multiplier (FLM) – an increase of this ratio means an increase in debt financing and at the same time an increase in financial risk and potential loss of control over a company's liquidity, which can lead to its bankruptcy. **Destimulant.**
2) Free cash flow per share (FCFPS) – it is the sum of free cash flow divided by the number of ordinary shares. It illustrates current potential to generate cash flows. The more cash available for each share, the better situation of investors. **Stimulant.**
3) Return On Assets (ROA) – a high level of this ratio shows that every unit of capital invested in the company's assets is effectively used. **Stimulant.**
4) Operating Return on Equity (ROE) – higher effectiveness of equity capital leads to a higher financial surplus which makes future dividend payments rise. **Stimulant.**

---

[3] ROA is the ratio of net profit to total assets.
[4] ROE_o is the ratio of EBIT to equity.
[5] CR is the ratio of current assets to current liabilities.
[6] FLM is the ratio of total assets to equity.
[7] FCFPS is the ratio of total free cash flow to number of ordinary shares.

5) Current ratio (CR) – values of this ratio should be included in the range (1,2 – 2,0). If the value is too high or too low, it is perceived that something is wrong. Low values of CR can be a signal of illiquidity, which means the situation in which a company is not able to repay its short term debt (now or in future) when it is due. And on the contrary, too high value of CR is the signal of overliquidity which means that a firm has too much liquid assets related to short-term liabilities or has receivables that are difficult to collect. **Nominant**.

Destimulant (FLM) was converted into stimulant by calculating its reciprocal (the idea of multiplying the destimulant by -1 was abandoned because values of FLM are always positive; when a positive destimulant is multiplied by -1, the destimulant converted into stimulant is negative and as a consequence the weight assigned to this diagnostic variable is negative). Then each diagnostic variable was standardized just to be comparable. The weights assigned to each variable were calculated in two ways. First they were based on coefficient of volatility determined for each variable. This approach overestimated some weights and underestimated the others (see table below). That is why further analysis was made for two cases – the first based on weights calculated using coefficients of volatility, and the second based on arbitrarily set equal weights (each of 20% due to the use of five variables).

Table 1: Weights based on coefficients of volatility calculated for each variable

Ratio	**ROA**	**ROE**	**CR**	**FLM**	**FCFPS**	**Sum**
Coefficient of volatility	7,43	4,66	3,12	0,98	10,24	26,43
Weight	28%	18%	12%	4%	39%	100%

Source: own study

Results

For most of the companies being analyzed values of quasi-beta coefficients are in the range (0,7-1,2). For three companies that close the ranking (the bottom 3) the quasi-beta index is below zero. Midas and Atlantis are among them.

Table 2: Ten companies having the lowest quasi-beta indices (weights based on coefficients of volatility)

Company	**Quasi-beta**
BZWBK	0,773
PBG	0,762
WAWEL	0,736
STALPROD	0,732
BUDIMEX	0,584
LPP	0,343
INGBSK	0,274
BRE	-0,445
ATLANTIS	-0,890
MIDAS	-5,568

Source: own study

Companies for which quasi-beta indices are below zero might be called "bankrupts". Let us recall that the taxonomic measure of development (z_i) for each company was calculated by converting the distance to the model object in a way such that they take values from the range (0-1) and their increase is viewed as beneficial from the analyzed object point of view. To do that, the following formula was used:

$$z_i = 1 - \frac{d_i}{d_0}$$

where d_0 represented norm making z_i took values from the range (0-1). The norm was determined by adding two times the standard deviation calculated for this norm to the average value of the distance set for the entire group of companies.

$$d_0 = \bar{d} + 2 \times S_d$$

Companies for which distance to the model object are not contained in such a range of values, are characterized by especially high volatility and in consequence extremely high risk. The detailed analysis of financial condition of the above mentioned companies confirms that these are firms having very poor financial standing. It has to be emphasized that expanding the above range of values to three times the standard deviation calculated for d_i (instead of two times), makes two of the three above mentioned companies still have negative value of the quasi-beta index (only for the Midas company did the quasi-beta increase to avalue slightly above zero). The other "bottom 10" companies from the rank based on quasi-beta values are firms that are characterized by low risk characteristics no matter what measure is used to express this risk – so called "defensive" companies (e.g. Stalprodukt or ING Bank Śląski). The "top 10" companies are characterized by a quasi-beta coefficient above 1,2. Five of these ten companies are firms having a risk index close to or above 2,0. They are: Bioton (1,8), Police (2,2), Petrolinvest (5,5), Centrozap (9,0) and Duda (22,2).

Table 3: Ten companies having the highest quasi-beta indices (weights based on coefficients of volatility)

Company	Quasi-beta
DUDA	22,209
CENTROZAP	8,977
PETROLINV	5,451
POLICE	2,242
BIOTON	1,810
LOTOS	1,468
SYGNITY	1,421
GRAJEWO	1,275
SKOTAN	1,263
RUCH	1,239

Source: own study

Again, high values of risk indices are characteristic for companies that are characterized by high volatility of investor's income, except for Bioton company for which the beta coefficient does not reflect actual risk level adequately. The complete specification of results calculated for each company is presented in the appendix at the end of this paper. The substitution of the originally assumed weights based on coefficients of volatility with equal weights did not change the results substantially. Two companies from the top 10 list (those with extremely high quasi-beta coefficients – Duda and Centrozap) have moved to the bottom 10 list (quasi-beta indices took on negative values after weights substitution).

Table 4: Ten companies having the highest quasi-beta indices (equal weights)

Company	Quasi-beta
POLICE	4,042
BIOTON	2,226
SYGNITY	1,640
SKOTAN	1,375
RUCH	1,329
OPTIMUS	1,328
GRAJEWO	1,297
MOSTALEXP	1,279
LOTOS	1,271
COGNOR	1,242

Source: own study

Table 5: Ten companies having the lowest quasi-beta indices (equal weights)

Company	Quasi-beta
WAWEL	0,724
STALPROD	0,708
BUDIMEX	0,590
LPP	0,379
INGBSK	0,321
BRE	-0,569
ATLANTIS	-0,677
MIDAS	-1,217
DUDA	-2,563
CENTROZAP	-5,285

Source: own study

Conclusions

Application of multidimensional comparative analysis to determine risk index as a taxonomic measure of development (so called quasi-beta), provided results that are very promising. These results coincide with traditional beta measurement for the same companies. In the next step, proper selection of financial ratios – based on which quasi beta was calculated – should be done. In this research they were taken from a limited set of financial ratios provided by Bloomberg.

References

Byrka-Kita, K. *Taksonomiczna miara rozwoju jako alternatywna miara ryzyka*

Chorkowy, B., & Drymluch, M.(2008). Wielowymiarowa analiza porównawcza banków notowanych na Giełdzie Papierów Wartościowych w Warszawie. In Kopycińska, D. (Ed.), Konkurencyjność podmiotów rynkowych (pp. 54-64). Szczecin: Katedra Mikroekonomii Uniwersytetu Szczecińskiego. Retrieved from http://mikro.univ.szczecin.pl/bp/pdf/89/5.pdf

Cotner, J.S., & Fletcher, H.D. (2000). Computing the Cost of Capital for Privately Held Firms, *American Business Review* 2000.

Cwynar, W. *Zmienność* – dobra, czy zła? Analiza polskiego rynku kapitałowego. *e-Finanse, 6*(2). 16-25.

Erb, C.B., Harvey C.R., & Viskanta T.E. (1996). Expected Returns and Volatility in 135 Countries. *Portfolio Management*. Spring.

Górski, D. (2002). *Dylematy wokół pomiaru wartości dla akcjonariuszy – koszt kapitału własnego banku*. Retrieved from www.gab.com.pl/rn/materialy/2002/Gorski-RN2002.ppt

Palliam, R. (2005). Application of a Multi-Criteria Model for Determining Risk Premium, *The Journal of Risk Finance*, *6(*4). 341 – 348.

Zarzecki, D. (2004). *Wieloczynnikowy model szacowania kosztu kapitału własnego – podejście operacyjne*. Uniwersytet Szczeciński 2001-2004, grant zespołowy KBN Nr 5 H02B00320.

Appendix

The complete specification of quasi-beta indices

Spółka	Quasi beta
DUDA	22,209
CENTROZAP	8,977
PETROLINV	5,451
POLICE	2,242
BIOTON	1,810
LOTOS	1,468
SYGNITY	1,421
GRAJEWO	1,275
SKOTAN	1,263
RUCH	1,239
PKOBP	1,231
MOSTALEXP	1,217
OPTIMUS	1,215
GTC	1,188
COGNOR	1,186
08OCTAVA	1,175
SWIECIE	1,165
BBIZENNFI	1,155
POLNORD	1,134
AZOTYTARNOW	1,125
KREDYTB	1,123
LCCORP	1,115

EMPERIA	1,110
BARLINEK	1,105
GETIN	1,097
CERSANIT	1,081
KOELNER	1,075
06MAGNA	1,072
KOPEX	1,070
PEKAO	1,068
ATMGRUPA	1,066
STALPROFI	1,066
BBIDEVNFI	1,064
IBSYSTEM	1,063
LENTEX	1,059
GASTELZUR	1,058
MIT	1,054
BORYSZEW	1,052
CHEMOS	1,052
PEKAES	1,048
ORBIS	1,045
NOWAGALA	1,042
FERRUM	1,041
BOGDANKA	1,038
HAWE	1,037
ALCHEMIA	1,035
STALEXP	1,032
BOMI	1,031
MILLENNIUM	1,030
IMPEXMET	1,029
HUTMEN	1,027
ATM	1,026
ACE	1,026
VISTULA	1,026
ENERGOPLD	1,025
IDMSA	1,022
ASSECOSEE	1,021
PGNIG	1,021
IZOJAR	1,020
NETIA	1,020
ELSTAROIL	1,019
GROCLIN	1,018
POLAQUA	1,016
ECHO	1,011
ARCTIC	1,010
CIECH	1,010
NFIEMF	1,009
JUTRZENKA	1,009
AGORA	1,004
AMREST HOLDINGS	1,000

FAMUR	0,999
RAFAKO SA	0,998
MCI	0,995
ZELMER	0,991
MMPPL	0,989
HANDLOWY	0,989
DOMDEV	0,989
POLIMEXMS	0,988
ASSECOSLO	0,979
POWSZECHNY ZAKLA	0,978
ARMATURA	0,977
SANOK	0,977
SYNTHOS	0,977
PAGED	0,977
MERCOR	0,973
MNI	0,971
TPSA	0,971
MOSTALZAB	0,970
ASSECOBS	0,968
CCIINT	0,962
NEUCA	0,956
FARMACOL	0,950
TRAKCJA	0,950
GANT	0,947
PEP	0,947
MOSTALWAR	0,946
PGE	0,945
RUBICON	0,943
PKNORLEN	0,940
QUMAKSEK	0,940
HBPOLSKA	0,937
JWCONSTR	0,936
TVN	0,933
ABPL	0,931
INTERCARS	0,931
APATOR	0,929
FORTE	0,927
EUROCASH	0,922
KOFOLA	0,919
ASSECOPOL	0,916
COMARCH	0,908
ASTARTA	0,899
KOGENERA	0,898
KERNEL	0,896
AMICA	0,889
SNIEZKA	0,884
KREZUS	0,884
CCC	0,883

COMP	0,869
CYFRPLSAT	0,836
PGF	0,824
DEBICA	0,824
PULAWY	0,820
ELBUDOWA	0,815
KGHM	0,813
ERBUD	0,807
KETY	0,775
BZWBK	0,773
PBG	0,762
WAWEL	0,736
STALPROD	0,732
BUDIMEX	0,584
LPP	0,343
INGBSK	0,274
BRE	-0,445
ATLANTIS	-0,890
MIDAS	-5,568

Source: author's own study