RELATIONSHIP BETWEEN IT COMPANIES’ QUOTATIONS AND WIG-INFORMATYKA INDEX

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Summary
The situation of companies depends mainly on the situation in the sector with which they cooperate. Hence, it is extremely essential to determine the connection between WIG-Informatyka index and particular IT companies. Article investigates the relationship between WIG-Informatyka index and IT companies’ quotations on the basis of correlation treated as coefficient comparing the directions of two vectors.

Słowa kluczowe: stock exchange, time series analysis, vector calculus

1. Introduction
WIG-Informatyka index is one of sector indexes that allows to determine the extent to which investing in IT companies is profitable. It takes into account income from dividends and salary. Furthermore, it refers to companies that belong to the “IT” sector and WIG index. A detailed description of this subindex is available on the website of Warsaw Stock Exchange. Although WIG-Informatyka index refers to IT companies, it does not describe each of them equally precisely. This is particularly the case with companies offering IT services to firms functioning in a particular sector. It may be useful to compare the aforementioned index with companies’ quotations. The relationship is examined with the use of correlation coefficient that enables one to determine the extent to which the shape of one graph affects the shape of the other graph. As far as the analysis of stock exchange quotations is concerned, the coefficient is used for examining the connection between indexes, between indexes and turnover, as well as between average annual rates of return on stock exchange indexes and GDP growth rate etc. The present article investigates the relationship between WIG-Informatyka index and IT companies’ quotations on the basis of correlation treated as coefficient comparing the directions of two vectors.

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2. Correlation as a method for comparing two vectors

In order to compare vectors, one should first of all decide what aspects this comparison is going to involve, namely what is crucial and ought to be taken into account, and what should be omitted. Therefore, it is vital to decompose a given vector in a proper way in order to separate important information from unimportant one. The simplest decomposition involves dividing vector \( \vec{A} \) into \( \vec{A}_{sr} \) and changeable \( \vec{A}_{zm} \). If vectors describe a given object, information about the size of this object (\( \vec{A}_{sr} \)) is separated from information about its specialization (if vector’s coordinates determine, e.g. share in particular branches). As for coordinates that describe the object, it is very difficult to interpret the result of decomposition (the interpretation depends on the character of data). Still, in the case of time and space series it is much easier to interpret the decomposition of vector \( \vec{A} \) into \( \vec{A}_{sr} \) and \( \vec{A}_{zm} \), and such interpretation is uniform. Vector \( \vec{A}_{sr} \) is responsible for translating the diagram showing the coefficient of series relative to ox axis, and vector \( \vec{A}_{zm} \) describes the shape that coefficients have formed or surface defined by the coefficients.

Every vector has its direction and absolute value. These two elements may be employed for determining the similarity of vectors. All vectors \( \vec{A}_{sr} \) are characterized by identical coordinates, which entails they have the same direction and may differ in senses. Hence, there is no point in comparing the directions of these vectors. Still, one may compare their absolute values that define the translation of the diagram relative to ox axis. If we assume that the coordinates of vector describe the profit made in consecutive months during which a given product was being sold, then the higher the absolute value of vector \( \vec{A}_{sr} \), the more favorable the situation. Coordinates of vector \( \vec{A}_{sr} \) represent the value around which the profit fluctuates; it is the average profit made.

Vector \( \vec{A}_{zm} \) represents changeability, in this case – changeability of profit. Its absolute value depends on how high the oscillation around the mean value is. The longer the vector \( \vec{A}_{zm} \), the higher the oscillation. Hence, in the aforementioned case, the absolute value should be as low as possible since this guarantees the smallest profit fluctuations. Comparing the vectors representing the profit from the sale of different products, one should choose the longest \( \vec{A}_{sr} \) and the shortest \( \vec{A}_{zm} \). The direction of vector \( \vec{A}_{zm} \) represents the shape of the graph. When the directions of two vectors \( \vec{A}_{zm} \) are the same, the graphs are also the same, yet this does not determine the oscillation. The more different the directions of vectors, the less similar the shapes of graphs representing these vectors.
Having substituted unit vectors obtained from vectors $\vec{A}$ and $\vec{B}$ into the scalar product formula, one obtains the following:

$$
\mathcal{c}_\text{norm} = \frac{\vec{A} \cdot \vec{B}}{\sqrt{\langle A, A \rangle} \sqrt{\langle B, B \rangle}} = \frac{\langle A, B \rangle}{\sqrt{\langle A, A \rangle} \sqrt{\langle B, B \rangle}}
$$

(1)

After substituting the coordinates of vectors $\vec{A}$ and $\vec{B}$:

$$
\mathcal{c}_\text{norm} = \frac{\sum_{k=1}^{n} a_k b_k}{\sqrt{\sum_{k=1}^{n} a_k^2} \sqrt{\sum_{k=1}^{n} b_k^2}}.
$$

(2)

As a rule, one does not compare vectors $\vec{A}$ and $\vec{B}$, but their variable components $\vec{A}_{zm}$ and $\vec{B}_{zm}$. In the case of vectors under consideration, the aforementioned formula is as follows:

$$
\mathcal{c}_\text{norm(zm)} = \frac{\sum_{k=1}^{n} (a_k - \bar{a})(b_k - \bar{b})}{\sqrt{\sum_{k=1}^{n} (a_k - \bar{a})^2} \sqrt{\sum_{k=1}^{n} (b_k - \bar{b})^2}}.
$$

(3)

Coefficient $\mathcal{c}_\text{norm(zm)}$ is called Pearson’s correlation coefficient. Coefficients $\mathcal{c}_\text{norm}$ and $\mathcal{c}_\text{norm(zm)}$ may be interpreted similarly to projection coefficient, which stems from the fact that the scalar product of unit vector onto itself equals one. If we assume that vectors $\vec{X}$ and $\vec{Y}$ are unit ones, the following equalities are true:

$$
\langle \vec{X}, \vec{Y} \rangle = \frac{\langle \vec{X}, \vec{X} \rangle}{\langle \vec{X}, \vec{X} \rangle} = \frac{\langle \vec{X}, \vec{Y} \rangle}{\langle \vec{Y}, \vec{Y} \rangle}.
$$

(4)

Hence, coefficient $\mathcal{c}_\text{norm}$ is a component of vector $\vec{A}$ along vector $\vec{B}$ or (which is tantamount to the above) a component of vector $\vec{B}$ along vector $\vec{A}$ (Fig. 1). Coefficient $\mathcal{c}_\text{norm(zm)}$ may be interpreted in a similar way. The component equals 1 when the absolute values, senses and directions of both vectors are the same. It has been assumed that the absolute values of vectors are always the same, and thus the component is never higher than 1. It equals -1 when absolute values and directions are the same, whereas senses are opposite. Due to the fact that the absolute value of vectors is constant, it cannot be lower than 1. Therefore, correlation coefficient takes values in the range $[-1, 1]$, where 1 implies that vectors are identical, -1 indicates they are identical yet their senses are opposite, and 0 – that they are perpendicular and very different. The component is a measure of the absolute value of one vector along the other vector and depends on their absolute values and directions. When the absolute values of vectors are the same, it depends only on their directions and senses.

Using the following formula\(^7\):
\[
\langle \vec{A}, \vec{B} \rangle = \frac{\vec{A} \cdot \vec{B}}{\| \vec{A} \| \cdot \| \vec{B} \|} = \cos \angle \{ \vec{A}, \vec{B} \}
\] (5)

**Figure 1. Comparison between the directions of vectors**

The cosine of angle between vectors \( \vec{A} \) and \( \vec{B} \), may be calculated as follows:
\[
\cos \angle \{ \vec{A}, \vec{B} \} = \frac{\vec{A} \cdot \vec{B}}{\| \vec{A} \| \cdot \| \vec{B} \|} = \left( \frac{\vec{A} \cdot \vec{B}}{\| \vec{A} \| \cdot \| \vec{B} \|} \right)
\] (6)

where \( \| \vec{A} \| \) and \( \| \vec{B} \| \) are absolute values of vectors \( \vec{A} \) and \( \vec{B} \). Thus, coefficient \( c_{\text{norm}} \) may be interpreted similarly to the cosine of angle between vectors. If angular measure makes sense for chosen variables describing the vector, one may calculate the angle between two vectors for a known value of \( c_{\text{norm}} \) coefficient. Coefficient \( c_{\text{norm}} \) does not depend on absolute values of vectors, but on the angle between them (Fig. 2).

**Figure 2. \( c_{\text{norm}} \) and the angle between vectors \( \vec{A} \) and \( \vec{B} \)**

\(^7\) K. Borsuk, Geometria analityczna w n-wymiarach, Spółdzielnia Wydawnicza „Czytelnik”, Warszawa 1950.
If one states that vectors with coefficient $c_{norm}$ higher than a given threshold value are similar to vector $\vec{A}$, this threshold value will determine a hypercone in space. The hypercone will include ends of vectors similar to vector $\vec{A}$ that share the origin with vector $\vec{A}$ (Fig. 3).

Figure 3. Domain of vectors similar to $\vec{A}$ for $c_{norm}$

3. Investing the relationship between WIG-Informatyka index and IT companies’ quotations

The investigation of the relationship between WIG-Informatyka index and IT companies’ quotations is one way of analyzing the connection between two series. Many IT companies want to cooperate with large firms from different branches. Hence, their financial results will depend on the situation in particular branches within which their customers function. If a given IT company has a lot of clients who are quite evenly “distributed” among all the branches, one would expect that its quotations will largely depend on WIG-Informatyka index. However, if this IT company has one or several strategic clients from one branch or specializes in attending the customers from one branch, its stock exchange quotations will mainly depend on financial results achieved by strategic clients and thus on stock exchange index reached by the branch within which its customers function.

In practice, the situation may be much more complex. IT company may address its offer to customers functioning within two or more branches, and its cooperation with clients from a particular branch may depend on the overall economic situation. The better the situation in a given branch over a certain period of time, the closer the cooperation with customers from this branch. Thus, strategic clients may change and so may the index on which a given company’s quotations depend. Table 1 presents the relationship between IT companies’ quotations and WIG-Informatyka index in the period 2005–2008. It should be emphasized that quotations for the year 2008 were analyzed from 1st January to 30th July. One may easily notice that in 2008 the quotations of most IT companies depended largely on the aforementioned index. Simple S.A., Talex S.A., ATM S.A., Betacom S.A. and Qumak-Sekom were exceptions. Nevertheless, this connection may stem not only from a direct relationship with WIG-Informatyka index, but also from indirect relationship. Indirect relationship results from the correlation with the index on which company’s quotations depend, namely WIG-Informatyka index. This correlation does not have to be the same and hence one should analyze it taking into account a given span of time, e.g. a year. As shown in Table 1, the relationship between stock exchange quotations and WIG-Informatyka index is strong and relatively stable for many IT companies. In the case of some companies, e.g. Invar&Biuro System
S.A., one may easily notice that the connection in question was subject to decline over a given period of time. One of possible reasons behind such a state of affairs may be a temporary weak financial situation of the company. Still, in the case of some companies the correlation with WIG-Informatyka index is exceptional. For instance, Betacom S.A. displayed a strong relationship with WIG-Informatyka index only in 2007. This may indicate that this company may have strategic clients who function within one or more branches. Very often it is difficult to determine who is a strategic client as this may be kept secret. On its official website, Betacom S.A. has listed 109 clients from the following four branches: financial, industrial, telecommunications and public. However, it is not known which clients are strategic to the company under consideration. In 2005, the relationship between Betacom’s quotations and WIG-Informatyka index amounted only to 0.19, but the connection with WIG-Banki index stood at 0.92, while the relationship between WIG-Informatyka index and WIG-Banki index amounted to 0.16. This implies that firms functioning within the banking sector were the most important customers of the company in 2005.

Table 1. Relationship between IT companies’ quotations and WIG-Informatyka index

<table>
<thead>
<tr>
<th>Company</th>
<th>$c_{norm(2008)}$</th>
<th>$c_{norm(2007)}$</th>
<th>$c_{norm(2006)}$</th>
<th>$c_{norm(2005)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asseco Poland S.A.</td>
<td>0.98</td>
<td>0.51</td>
<td>0.74</td>
<td>0.49</td>
</tr>
<tr>
<td>Novitus S.A.</td>
<td>0.93</td>
<td>0.78</td>
<td>0.77</td>
<td>-</td>
</tr>
<tr>
<td>Asseco Slovakia S.A.</td>
<td>0.93</td>
<td>0.42</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Teta S.A.</td>
<td>0.93</td>
<td>0.82</td>
<td>0.84</td>
<td>-</td>
</tr>
<tr>
<td>Procad S.A.</td>
<td>0.92</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sygnity S.A.</td>
<td>0.92</td>
<td>0.47</td>
<td>0.13</td>
<td>0.43</td>
</tr>
<tr>
<td>Infovide-Matrix S.A.</td>
<td>0.90</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Invar&amp;Biuro System S.A.</td>
<td>0.90</td>
<td>0.77</td>
<td>-0.15</td>
<td>0.77</td>
</tr>
<tr>
<td>Comarch S.A.</td>
<td>0.90</td>
<td>0.69</td>
<td>0.75</td>
<td>0.84</td>
</tr>
<tr>
<td>Macrologic S.A.</td>
<td>0.87</td>
<td>0.40</td>
<td>0.54</td>
<td>0.45</td>
</tr>
<tr>
<td>ABG S.A.</td>
<td>0.87</td>
<td>0.45</td>
<td>-0.43</td>
<td>0.19</td>
</tr>
<tr>
<td>Techmex S.A.</td>
<td>0.85</td>
<td>0.21</td>
<td>0.85</td>
<td>0.35</td>
</tr>
<tr>
<td>Wąsko S.A.</td>
<td>0.85</td>
<td>0.22</td>
<td>0.74</td>
<td>0.49</td>
</tr>
<tr>
<td>Internet Group S.A.</td>
<td>0.84</td>
<td>0.51</td>
<td>0.54</td>
<td>0.35</td>
</tr>
<tr>
<td>Zakl. Urządż. Komp. Elzab</td>
<td>0.83</td>
<td>0.24</td>
<td>0.84</td>
<td>0.16</td>
</tr>
<tr>
<td>Comp Safe Support S.A.</td>
<td>0.83</td>
<td>0.78</td>
<td>-0.15</td>
<td>-</td>
</tr>
<tr>
<td>Optimus S.A.</td>
<td>0.82</td>
<td>0.70</td>
<td>-0.52</td>
<td>0.45</td>
</tr>
<tr>
<td>B3System S.A.</td>
<td>0.81</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>LSI Software S.A.</td>
<td>0.81</td>
<td>0.72</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wola Info S.A.</td>
<td>0.79</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Asseco Business Solutions</td>
<td>0.78</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

4. Conclusions

The majority of companies under consideration proved that there was a strong correlation between WIG-Informatyka index and stock exchange quotations. In the case of some companies, this relationship was subject to temporary break, e.g. Invar&Biuro System S.A. that did not observe such a connection in 2006. Furthermore, there were also companies in the case of which the relationship in question was occasional, e.g. Betacom S.A. that experienced a strong connection only in 2006. However, in the case of this company there was a strong relationship with WIG-Banki index, which might indicate that companies functioning in the banking sector were its strategic clients.

Bibliography


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ZALEŻNOŚCI POMIĘDZY NOTOWANIAMI FIRM Z SEKTORA IT
A INDEKSEM WIG-INFORMATYKA

Streszczenie

Notowania firm na giełdzie zależą przede wszystkim od sytuacji w sektorze, w którym działają. W analizach notowań istotne też jest określenie związku pomiędzy kursami poszczególnych firm a indeksem WIG-Informatyka dedykowanym dla branży IT. W artykule zbadano związek notowań a indeksem WIG-Informatyka na podstawie korelacji i współczynników kierunków dwóch wektorów.

Keywords: notowania giełdowe, rachunek wektorowy

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