Reducing Uncertainty: Implementation of Heisenberg Principle to Measure Company Performance

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ABSTRACT

The paper addresses the problem of uncertainty reduction in estimation of future company performance, which is a result of wide range of enterprise's intangible assets probable efficiency. To reduce this problem, the paper suggests to use quantum economy principles, i.e. implementation of Heisenberg principle to measure efficiency and potential of intangible assets of the company. It is proposed that for intangibles it is not possible to estimate both potential and efficiency at a certain time point. To provide a proof for these thesis, the data on resources potential and efficiency from mid-Russian companies was evaluated within deterministic approach, which did not allow to evaluate probability of achieving certain resource efficiency, and quantum approach, which allowed to estimate the central point around which the probable efficiency of resources in concentrated. Visualization of these approaches was performed by means of LabView software. It was proven that for tangible assets performance estimation a deterministic approach should be used; while for intangible assets the quantum approach allows better quality of future performance prediction. On the basis of these findings we proposed the holistic approach towards estimation of company resource efficiency in order to reduce uncertainty in modeling company performance.

Keywords: Quantum economics, Heisenberg principle, Company Performance, Uncertainty, Intangible assets.

1. INTRODUCTION

Measuring company performance has been one of the major issues of management theory and practice throughout the period of its development, which lead to diverse studies of approaches, methods and instruments aiming to reduce uncertainty in evaluation of companies' performance and thus provide higher quality of decision making. At the same time the origins of uncertainty in socio-economic systems still remain unclear: some of the authors claim that uncertainty is the result of financial and real sectors misbalance [5], difference in institutional development level [8], irrational behavior and decision making [1], and a number of other reasons. The situation is relevant not only to macrolevel, but for micro- and meso level as well: hence estimating company efficiency for a forthcoming period becomes a challenge since efficacy and efficiency of certain resources remains unclear.

One of the problems that lead to increased uncertainty of future company performance is the difference in predicting efficacy of different resources – the range of possible efficiency of these varies from a relatively small one normal for tangible assets, and a wide one that appears in case of intangible assets, especially human, organizational or cultural capital. Hence the purpose of this research is to suggest a tool to reduce uncertainty in measuring company performance by implementing instruments from natural sciences that are used to measure discrete performance of elements. To achieve this goal we check the possibility of using Heisenberg principle to evaluate uncertainty of company's intangible assets performance by using wavelet transformation to capture their efficiency and performance.

2. LITERATURE REVIEW

Estimation of uncertainty level in order to improve quality of economic and managerial predicting models had for a long while been one of the major problems of business research. Analysis of existing literature reveals that the main tools used to reduce uncertainty in measuring company performance include: use of factor analysis and definition of the main factors affecting the result variable [15], defining predictors of economic agents' behaviour [9], implementation of smoothing and buffering [14], estimation of shocks to define probable uncertainties [12], use of appropriate statistical distribution [22] or external forecasters [4]. Still, the suggested instruments, as it is proven by mentioned authors, can be used only in certain cases – while in the other situations they don't provide any effect in reducing uncertainty.

As mentioned in our previous works [20], analysis of global economic system development in last 40 years shows that a number of fundamental principles of classical political economy, such as, for example, deterministic laws of supply and demand [10] do not explain facts provided by empirical evidence. This was outlined by a number of researches, who tried to develop an alternative model of economic growth on the basis of quantum principles [6, 17, 23]; and on the basis of their research we make

the following proposal: classical political economy is based on deterministic principles, while modern economy has a quantum nature – therefore main principles of classical theory are proven in modern world only with a certain probability. As all the above mentioned statements are considered for macroeconomic level of study, we assume the same situation occurs, in our opinion, on microlevel as well, but the origins of uncertainty at this point of measurement are different.

The main factor of uncertainty on a firm level is possible efficiency and efficacy of resource use – the range of their efficiency, as indicated by scholars, can be the result of resource allocation [13], quality of resource management [3], or ensuring productivity [21]. However, though these finding shed lights onto possible predictors of company performance, the instruments used does not allow to define an approach to reduce uncertainty in the majority of cases – thus in this paper we evaluate the possibility of using quantum tools to evaluate resources' performance to reduce uncertainty.

3. HEISENBERG PRINCIPLE: AN OVERVIEW AND ADAPTION TO ECONOMIC ENVIRONMENT

Heisenberg principle states that "the position and the velocity of an object cannot both be measured exactly, at the same time, even in theory" [11], and is considered by physicists to be a consequence of wave/particle duality that appears on microlevel of physical world (an illustration of this principle can be seen on Fig. 1).

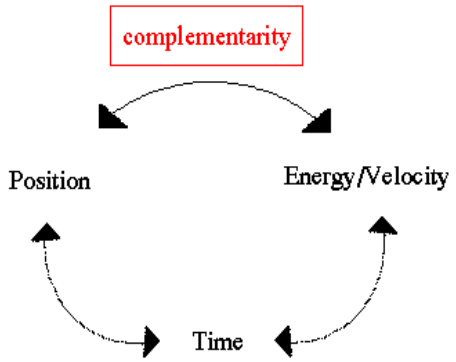

Fig. 1. Visualization of Heisenberg principle [24]

In physics this principle applies to estimation of position and velocity of electron, and an analogue can be found in socio-economic systems when we try to measure potential (an analogue of energy/velocity) and efficiency (actual position) of companies' intangible assets. In this paper we assume that at a certain moment of time we can either measure efficiency of intangibles, or their potential. This can be formalized in the following way (see Eq. 1):

$$\Delta p * \Delta e \geq c \qquad (1)$$

p – potential of intangible asset (per unit), points; e – efficiency of intangible asset, currency units per unit of assets; c – constant.

Potential of intangible asset is measured in points as a result of expert estimation, unless theory suggests certain units to measure intangible's potential. Definition of the constant requires evaluation of big amount of data that had not been done up to date, so for the purpose of the study we assume that it is a constant, and do not aim to define its value. Thus, we propose that in a certain time one can either define the potential of intangible in terms of influencing company performance, or its efficiency; and this becomes the main reason for high uncertainty of intangibles' performance which leads to low quality of predicting models defining company performance.

4. MAIN FINDINGS

To conduct this study we measured performance of tangible and intangible assets at 15 companies from mid-Russian region during 5 month. The dataset was tested for consistency, and the graphs for potential and efficiency for each asset were drawn in LabView. As proposed, both potential and efficiency were changing throughout the period, but no exact pattern was detected (see an example for human resources – an intangible asset - on Fig. 2, alone the proposed timeline measured daily). Similar results were found for the other types of resources investigated in this study.

Based on the results from Fig. 2 we can state that there is high uncertainty in potential of human resources. The same type of graphs that do not reveal any pattern, were acquired for the other types of intangible assets; hence high level of uncertainty was estimated for these types of assets.

Methodology: wavelet transform

In order to estimate the range of efficiency for resources performance on the basis of acquired data, we performed wavelet transformation on the basis of original signal. According to the recommended procedure [2, 7, 16], continuous wavelet transform is carried out by convolution of the analyzed signal (function) from two-parametrical wavelet function (se Eq. 2).

$$W(a,b) = \int_{-\infty}^{\infty} f(t) \cdot \psi^{*}_{a,b}(t)\, dt \qquad (2)$$

$\psi^{*}_{a,b}(t)$ is a complex interfaced volume.

The basis of wavelet transform is derived from the mother wavelet by means of scaling and shifting (see Eq.3).

$$\psi_{a,b} = \frac{1}{\sqrt{a}} \psi \left(\frac{t-b}{a} \right), \qquad (3)$$

a – the large-scale coefficient defining the width of a wavelet, b – the shift parameter defining the provision of a wavelet on an axis t.

Wavelet transform allows to analyze thin structure of signals as the mobile time-and-frequency window, which equally well marks out low frequency and high frequency signal components and thus has a big advantage over the analysis of signal's local features – the latter is absent at Fourier's transformation.

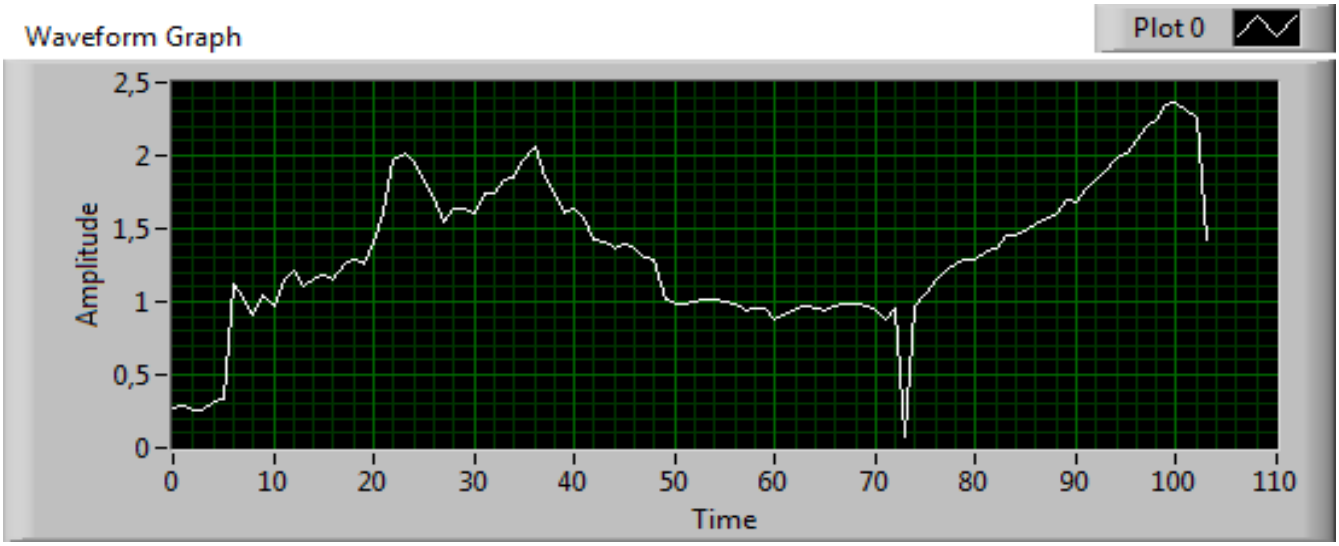

Fig. 2. Waveform graph for human resources potential (averaged on 5-point scale)

For the purposes of this study we have chosen Morlet wavelet, which has narrow spectral range and considerable duration in a time domain (see Eq.4):

$$\psi(x) = e^{-x^2/2} \cdot \cos(5x) \qquad (4)$$

This mother wavelet suits best the basic purpose of the study as it allows evaluating long periods of time and narrow range of the basic independent variable.

Results of wavelet analysis

Produced wavelet analysis of the described database acquired form Russian companies, for the efficiency of human resources use, acquired with LabView visualization tools, can be seen on Fig. 3.

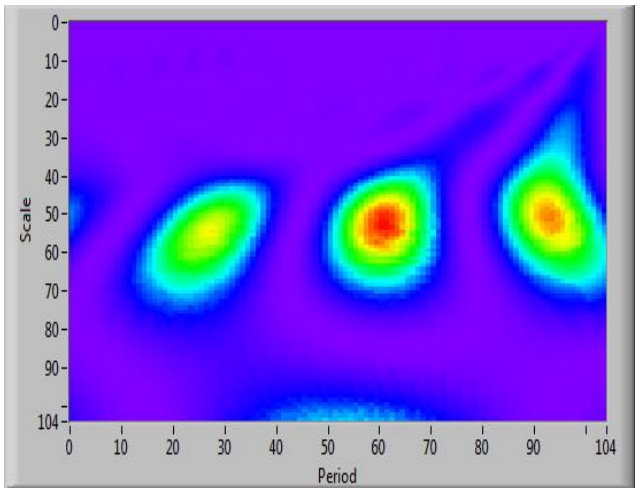

Fig. 3. Scalogram of human resources efficiency for the chosen database

Fig. 3 indicates, that efficiency of human resources is concentrated around certain levels, and becomes more intensive alone the timeline – this supports the idea of cyclical efficiency of resources and suits the findings in Russian literature which assume that efficiency of resources use increases by the ends of projects (project-based management is the most spread type) [17, 18]. For this certain intangible we have the full amount of data, as this type of efficiency was measured daily – unlike in case of other intangible assets.

The scalogram for organizational resources efficiency after wavelet transform can be found on Fig. 4.

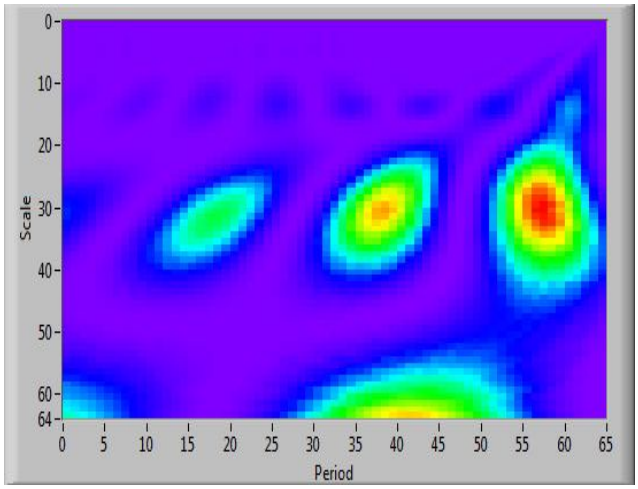

Fig. 4. Scalogram of organizational resources efficiency for the chosen database

Fig. 4 indicates a similar behavior of organizational resources, which efficiency is again concentrated around certain points around timeline – though in this case we had a shorter timeline

due to limitations of the study. This findings are also in line with the literature [17].

The two types of assets, featured in Fig. 3 and Fig. 4, are intangibles, and for the purposes of this study we have also studied behavior of tangible assets alone the same timeline. An example of tangible assets efficiency evaluation by using wavelet transform can be seen on Fig. 5 (for efficiency of technical resources).

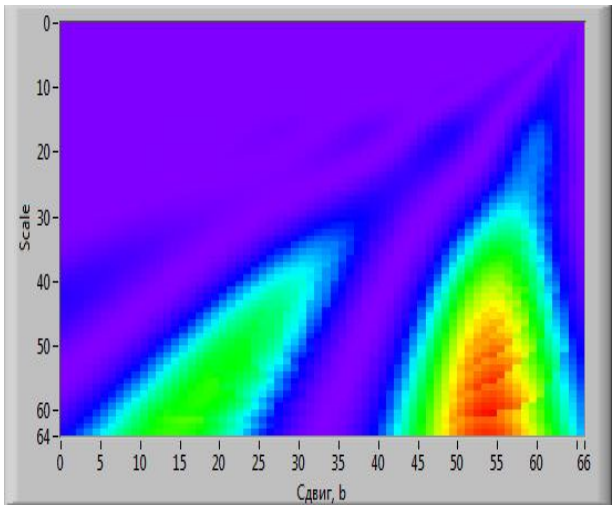

Fig. 5. Scalogram of technical resources efficiency for the chosen database

As it can be derived from the figures 3-5, the behavior of tangible and intangible assets is different, and efficiency of tangible assets, as our analysis had shown, is more predictable, and its trends are stable. At the same time, intangible assets potential and efficiency have unpredictable patterns (as shown on Fig. 2)., but application of wavelet transform allows to define trends and hence reduce uncertainty in predicting intangible assets efficiency.

Fig. 3 and 4 illustrate that efficiency of intangible assets can be achieved (a) under certain circumstances – for example, for human resources these can be stimulus programs of a company – and (b) exact efficiency and potential can not be defined at a certain moment. Unlike in case of tangible assets, which efficiency is relatively well-determined (see Fig. 5), intangibles tend to differentiate around certain maximum efficiency (marked red on Fig. 3 and 4). In case of human resources maximum efficiency is achieved for the frequency of 50, while for organizational resources the optimal frequency is 30; on the other levels efficiency of these resources is much lower – and this fact provides indirect proof of a hypothesis that intangible assets efficiency can be predicted only as a range, not as a determined value.

Heisenberg principle implementation in predicting company performance

Since the possibility of implementing Heisenberg principle to define the range of efficiency and potential of intangibles was defined by above presented analysis, we propose the following way to estimate company resources' efficiency (see Eq. 5):

$$K_{Ef} = \sum w_i * eti + \sum w_j * eit_j \psi^2 \qquad (5)$$

w_i, et_i – the part of i-th tangible asset in total share of tangible assets of all company assets, and its efficiency, correspondingly; w_j, eit_j – the part of j-th intangible asset in total share of intangible assets of all company assets, and its efficiency, correspondingly; ψ^2 – squared wave function defining distribution of intangible assets efficiency during certain amount of time.

Implementation of this equation allows defining assets efficiency taking into account probability with which intangible assets may be used. In accordance with Heisenberg principle, alongside the timeline of company performance, probability of higher efficiency increases.

Thus Eq. 5 should be implemented in predicting models used by the companies to indicate future performance in order to reduce uncertainty that appears from uncertain performance of company's intangible assets, while tangible assets can be evaluated using traditional tools. As in case of physical idea of quantum mechanics, quantum principles in estimation of economic systems performance can be used only for the elements that demonstrate high level of uncertainty in their performance. Such approach would allow reducing risks of future company performance estimation by means of higher quality prediction models.

5. DISCUSSION

The findings of the paper support existing literature in several directions. First, it appeared that the level of efficiency of intangible assets is quite unstable alone the timeline, which support the results of quantitative evaluation performed by different authors on the same research question. In our opinion, such behavior is the result of quantum nature of intangible assets, since their efficiency can't be estimated as deterministic constant at certain time point, but can be defined only with a certain level of probability. Such propositions were made on the macroeconomic level by several researchers [6, 10], but our research also finds that the same trend is supported on microlevel.

Second, we have proven that regular visualization instruments does not allow to find the trend in intangible assets performances, while wavelet transform indicates such pattern exists on a certain level of resource concentration. The evaluation carried out for companies' intangible assets reveal that the findings of Russian researcher which insisted on project type of company management in this country [17, 18] are supported by our results. As research indicates, we have found patterns that indicate concentration of intangible assets efficiency around the deadlines of micro projects performed in the companies from our database; after the end of the project concentration remains for a while and than decreases substantially. Hence to estimate probable efficiency of intangible assets at a certain time point we can define both potential and efficiency only with a certain level of probability, which again supports the proposed quantum approach to estimate intangible assets performance – and this finding fully reflects possible implementation of Heisenberg principles for the purposes of management studies and company performance estimation.

Third, our analysis has also revealed that tangible assets demonstrate behavior, different from intangibles (visualized

after wavelet transform), and this type of assets in fact does not demonstrate the quantum type of behavior, so the tendencies of tangible assets efficiency can be predicted by means of regular deterministic instruments. This is also in line with existing literature that demonstrates good examples of modeling tangible assets performance, which is again not the case for intangibles. Hence we can state, that development of models that describe company assets' performance should include both deterministic modeling and quantum modeling. In this direction our research contributes by defining areas where different types of models can be implemented.

The fourth problem raised by achieved results is the fact that resources efficiency performance can't be measured at a certain time point in case of intangibles – for this type of resources we have to state interdependency of resource potential and efficiency, but we can only evaluate the probability of certain performance, not the exact efficiency. This contributes to the existing literature by outlining the limits of deterministic modeling on company performance.

6. CONCLUSIONS

Our research indicates dual nature of company resources performance, and reveals that efficiency of intangible assets is of quantum nature, while efficiency of tangible assets can be determined by regular analytical and estimation approaches. This finding allowed us to propose an equation which estimates the relationship between potential and efficiency of resource use in case of intangibles, derived from the Heisenberg principle in quantum physics. This paper provides evidence on possibility of uncertainty reduction by implementing this principle, which leads to higher quality of modeling in case of company performance evaluation.

Introduction of proposed approach in the practice of company management would provide them with a tool for uncertainty reduction in short-term and mid-term prognosis – which is one of the important unsolved problems in current management.

7. LIMITATIONS AND FUTURE RESEARCH

The study is based on a short-term study of a limited number of companies, all of them a Russian-based. Though the results seem to be in line with existing literature, the use of such sample can possibly lead to result distortion, and our findings might appear to be relevant only to a set of Russian enterprises. Thus future research should be focused on testing the proposed hypothesis on a larger sample – in turn, this task is quite complicated taking into account the number of measurements that are necessary for this type of analysis.

The second limitation is derived from the proposition on possibility of joining quantum principles and deterministic principles in one model – it might appear that there is a certain "dividing point" between these two, which is not considered in this study despite of its highly probable importance. Hence future research should also aim to define such point, which is also an important part of uncertainty reduction procedures on a company level.

The third direction of future research should be focused on evaluation of possible influence that higher quality company performance models have on actual enterprises performance. As described in literature, there is always a problem whether the knowledge on how economic agents are supposed to act is actually affecting their performance. In our opinion, this reason might one of the most important when we try to evaluate uncertainty in intangible resource efficiency, and one of the main reasons for appearance of Heisenberg principle in the studied area – but this research does not evaluate this possibility hence leading to a third important limitation of the study that should be eliminated by future research.

7. ACKNOWLEDGEMENTS

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