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Performance Measurement Of eProcurement Solution With Dynamic Pricing Aspect

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Abstract

One of the biggest problems by decisions in the e-business investments is unclear ROI and uncertainty about how to measure results. In this paper we present some aspects of research in measuring the impact of web based B2B procurement. Presented approach is focused on ROI indicator, which we have adjusted to e-commerce specifics, especially to procurement with dynamic pricing transactions. This measuring is performed by accepting structural ROI decomposition by the level of quantification of complexity of attributes used in this indicator. It is expressed by ROI added, i.e. value added for enterprise due to implementation of e-procurement / commerce solution. Finally, we present a conclusion of our research performed on Slovak mining enterprise.

1 Introduction

As we can see in statistics and different studies, e-business is still progressing and expanding. The dominant model for the future will be business-to-business (B2B) with 87% share as presented in e-marketer B2B report. In this model, investments in e-procurement are growing faster than investments in any other e-business solution (Chuck 2001). Electronic markets, as outsourced e-commerce services with community added value (Bain 2000, GoldmanSachs 1999) will also gain on importance, by providing aggregation and integration to the participants. Dynamic pricing mechanisms, especially auctions and exchanges will dominate other transaction mechanisms (Kannan, Praveen 2001).

However these solutions will also give a rise to significant complications, such as managers uncertainty about financial results indicators, inability to quantify actual savings and they are uncertain about results measuring (McCullough 2001, Mogolon, M., Raisinghani, M. 2003). Providing solutions to these problems could strongly encourage e-business investments decisions.

2 Methodology Of Measuring eBusiness Impact

In measuring e-business we can see some specifics. E-commerce is solutions complex with various functions and focus. Some solutions as e-auction is element of procurement as well as tool for planning, forecasting, replenishment, supports cooperation in this area (Seifert 2002), etc. they have their own specifics and measurement methodology. On the other hand we must focus on process aspect, in order to be able to identify relationships between e-solutions and business processes. By examining different e-commerce solution combinations as solution portfolios, we could be able to identify marginal efficiency of such portfolios or most effective portfolio for examined process. Hereby, if we focus only on specific industry or segment we could identify marginal efficiency of specific portfolio. If firms in specific industry realize all possible benefits from specific portfolio, they could compare it.

Research, done in this filed, could help by e-business solutions investments decision making. This study presents mainly B2B procurement process solutions and the way for its measurement. Considering abovementioned facts, one of the biggest problems by e-business solution investing is unclear ROI (Return on Investment) and quantifying solutions impact. It is essential to provide managers simple and clear methods applicable in practice. Presented approach to design applicable method for measuring B2B procurement was developed in the framework of VEGA (2002) project (national grant project).

2.1 Methodology For Complex eProcurement Measuring

If we take the OECD (OECD, 1999) methodology for measuring e-commerce, we see the logical system used on macro-environment level measuring. But we can also use this system on micro-environment level (for enterprise). OECD layers (readiness, intensity and impact) are well applicable to measuring the e-commerce/e-business impact on enterprise performance. These three areas are in fact areas of specific indicators. The next scheme based on Subramaniam & Shaw study (Figure 1) was designed for better identification of e-procurement impact We have integrated all aspects of attributes with OECD (macro)methodology, using modified intensity and readiness indicators (as shown in Table 1).

Table 1: *Examples Of Indicators*

Readiness indicators	Intensity indicators
Online access	Percentage of revenue generated online,
User's accessibility	Percentage of online MRO procurement
Online submitting and modifying orders	Percentage of existing customers doing business online.
Automation of document processing	
Automation of control and monitoring	
Authorization	
Dynamic transaction mechanisms	
Staff knowledge	

Readiness can express about staff knowledge – as important success factor (Doucek 2002), level of solution complexity, etc. Intensity represents the rate of application, exploitation, etc. (Barua at al. 2001). Examples of such indicators are in the Table 1.

Impact can be measured by traditional measurement methods as return on investments and other financial methods (e.g. real option).

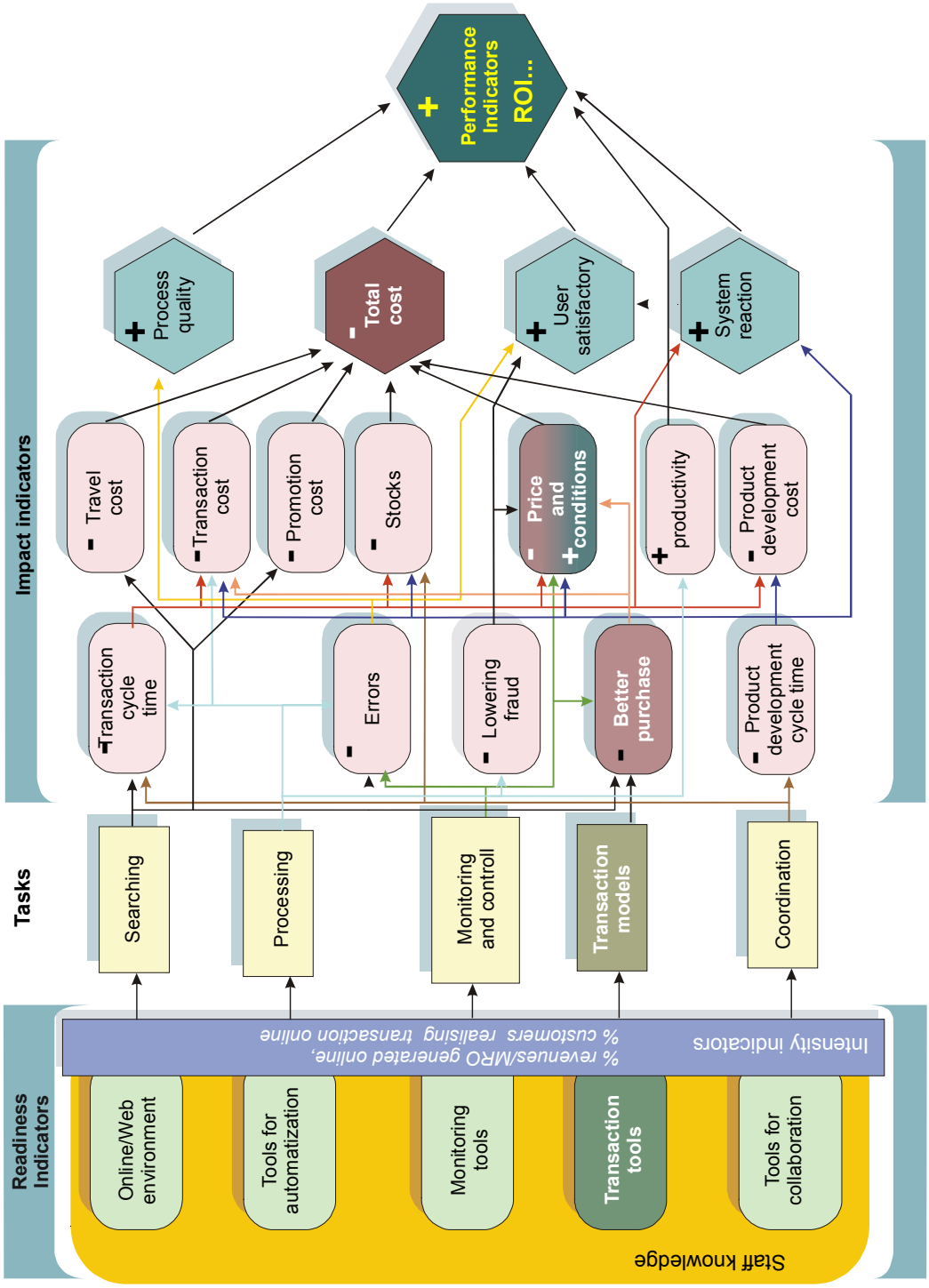

Figure 1: *Impact Of Web Based Procurement (Delina 2003)*

3 Methodology For ROI Value Measurement

When deciding on e-commerce solution application, savings can be achieved by this solution and costs needed for its implementation can be defined. If we calculate ROI as share of revenue to total assets, we must adjust both of these attributes by adding relevant values. Firstly, we use the revenue before taxes figure. ROI adjusted by traditional processes (ROI_c) is expressed as follows:

$$ROI_c = \frac{P + C_r + I_v - D_e - C_c}{A + I + C_r - S - D_e + (TP_e + IP_e - S_i)}, \quad (1)$$

where:

P is profit before taxes by traditional processes (without solution implementation),

C_r is value of identified cost reduction, (more about attributes see Delina 2003), by assets, this cost reduction increases money on bank accounts,

C_c is solution-carrying costs,

D_e is value of solution depreciation,

A is value of assets without solution implementation,

S is value of stock reduction (material prices and units in warehouse),

TP_e is saved value of tangible solution assets as computers, accessories etc.,

IP_e is saved value of intangible property, purchased or developed software solution,

S_i is the installment on credit in year I,

Interest (I_v) is defined as difference between benefit (I_b) and loan interest (I_l). Benefit interests include interest for savings (I_s) (deposits) and interest for better-negotiated maturity date (I_{md}). We can also use lost interest for not investing in solution instead of loan interest (I_l). Then complex interest (I) is expressed as:

$$I = I_b - I_l = (I_s + I_{md}) - I_l, \quad (2)$$

We only use TP_e and IP_e in the case of debt financing.

For purpose of this study we will define Cr as savings from dynamic pricing models and we will use two factors, purchasing price and maturity date. Savings in purchasing prices are expressed as difference between catalogue prices and prices achieved through dynamic pricing solution.

In the previous part we have presented the case, where profit and assets by traditional processes without implementing e-business solution was known. It could be used for decisions about implementing the solution.

In this way we are able to deduce added ROI by implementing e-business solution. This can be expressed as follows (ROI_t is ROI of traditional processes):

$$\Delta ROI = ROI_c - ROI_t, \quad (3)$$

then

$$\Delta ROI = \frac{P + Cr + I_v - D_e - C_c}{A + I + C_r - S - D_e + (TP_e + IP_e - S_i)} - \frac{P}{A}, \quad (4)$$

This indicator represents ROI added by implementing e-business solution.

In the case of existing evaluation solution a complex profit (Pc) and assets (Ac) (with implemented solution) can be used. Then:

$$\Delta ROI = \frac{P_c}{A_c} - \frac{P_c - Cr - I_v + D_e + C_c}{A_c - I + S - Cr + D_e - (TP_e + IP_e - S_i)}, \quad (5)$$

Expressing ROI from e-solution:

$$ROI_e = \frac{I_v + Cr - C_c - D_e}{A_e}, \quad (6)$$

where

A_e is value of solution assets:

$$A_e = TP_e + IP_e + I_v + Cr - S - D_e, \quad (7)$$

These ROI indicators can be used for measuring performance and efficiency of the enterprise, which is implementing e-commerce solutions. This value as we have mentioned by the ROI's structure is not absolute complex. Soft measured benefits are missed. But in many cases it is sufficient for making performance estimation or decision. On the other hand, for taxes and depreciation allowance purposes, Cash ROI (CROI) expression is more suitable:

$$CashROI = \frac{(P + Cr + I_v - D_e - C_c)(1-d) + D_c}{A + I_v - S + Cr - D_e + (TP_e + IP_e - S_i)}, \quad (8)$$

where

d is tax rate,

D_c is value of complex depreciation.

In the case of added CashROI (ΔCROI), the expression is modified:

$$\Delta CashROI = \frac{(P + Cr + I_v - D_e - C_c)(1-d) + D_c}{A + I_v - S + Cr - D_e + (TP_e + IP_e - S_i)} - \frac{P(1-d) + D_t}{A} \quad (9)$$

where

D_t is value of depreciation in traditional processes without e-business solution.

This methodology (principle) of indicator adaptation for e-commerce specifics can be used the same way also for another measurement and indicators, such as rate of ROI/profit growth, pay-back period, cash flow, NPV, real option and other.

The performance analysis can be specified by using the dynamic pricing models. These models (Delina 2003) enable the estimation of the whole financial yield and involve aspect results from opportunity to negotiate better maturity date.

3.1 Financial Yield From Dynamic Pricing Models

Previously, we used modification of some traditional indicators. Adjusted indicators are based on identification of financial yield from specific solution. In our case, it is dynamic transaction solution (reverse e-auction).

As we said previously, we use two factors for evaluation of dynamic pricing models. It is savings in purchasing prices and maturity date. In the procurement case, where enterprise invites potential business partners to some kind of B2B auction, two factors mentioned above are taken as key evaluating factors.

In the case of B2B reverse auction, which is used very often for industrial procurement (Emiliani & Stec 2002), wefirstly need to identify savings for each auction. For thess savings we can calculate interests, as secondary financial yield.

When auction j is performed in day k, auction price is P_0, negotiated price is P_d and interest rate is i, then financial yield can be defined as follows:

***Table** 2: Identification Of Price Savings From eProcurement*

k1	k2	. .	kn	financial yield
(P_{0k1} - P_{dk1})				$(P_{0k1} - P_{dk1}) \cdot \left(1 + i\frac{365 - k_1}{365}\right)$
	(P_{0k2} - P_{dk2})			$(P_{0k2} - P_{dk2}) \cdot \left(1 + i\frac{365 - k_2}{365}\right)$
		..		...
		. .		...

Then total financial yield (V_u) from purchasing prices savings can be expressed as:

$$V_u = \sum_{j=1}^{n} (P_{0kj} - P_{dkj}) \cdot (1 + i\frac{365 - k_j}{365}), \tag{10}$$

where

n is number of procurement auction

k_j is the day in the year, when auction j is performed

Second aspect of dynamic transaction model is opportunity to negotiate better maturity date. Due to more favorable maturity date a longer maturity interest can be added to the financial yield. For simplification purposes, we can assume that interest after end of the year is equal to interest from the previous year. When maturity date is d, P_{dkj} is achieved price in day k by auction j, and then we can express interest from the savings (I_{md}) as follows:

$$I_{md} = \sum_{j=1}^{n} (P_{dkj} \frac{d_{dkj} - d_{0kj}}{365}) \cdot i \tag{11}$$

Complex savings (or financial yield) (V) from dynamic transaction solution can be expressed as:

$$V = V_u + I_{md} = \sum_{j=1}^{n}(P_{0kj} - P_{dkj}) \cdot (1 + i\frac{365 - k_j}{365}) + \\ + \frac{i}{365}\sum_{j=1}^{n}\left[P_{dkj}(d_{dkj} - d_{0kj})\right] \tag{12}$$

If we want to express only amount of interests from the savings (I_v), from previous results:

$$I_v = I_s + I_{md} = \\ = i\left[\sum_{j=1}^{n}(P_{0kj} - P_{dkj})\frac{365 - k_j}{365} + \sum_{j=1}^{n}(P_{dkj}\frac{d_{dkj} - d_{0kj}}{365})\right] \tag{13}$$

In many cases we must take into account the possibility, that maturity date is not the same as date of performing the auction. In this case we must modify the money availability time. Then

$$I_v = I_s + I_{md} = \\ = i\left[\sum_{j=1}^{n}(P_{0kj} - P_{dkj})\frac{365 - k_j - d_{dkj}}{365} + \sum_{j=1}^{n}(P_{dkj}\frac{d_{dkj} - d_{0kj}}{365})\right] \tag{14}$$

$$V = V_u + U_{md} = \sum_{j=1}^{n}(P_{0kj} - P_{dkj}) \cdot (1 + i\frac{365 - k_j - d_{dkj}}{365}) + \\ + \frac{i}{365}\sum_{j=1}^{n}\left[P_{dkj}(d_{dkj} - d_{0kj})\right] \tag{15}$$

4 Application of Methodology

4.1 The Background Of Research

Our research was realized on one of the Slovak mining company request. They have implemented reverse auction model in procurement process (not integrated in information system).

At the beginning of a year, the company only traded 1% of commodities purchased through the e-solution. In that year the company sales through electronic auction accounted for 2,5% of total sales. In the near future they plan to increase that portion to 80%. Nowadays, the company has included the monopolistic suppliers into e-auctions, however the price settings are given by bilateral agreements. That means that e-solutions only serve the needs of buying process automation. Concrete requirements for material supply with parameters of supply term and term of expiration are performed on-line through e-auction, as it is required. Actual realization of material supply through e-auction is only performed in 60% of all business partners of the mentioned company.

Operational purchase for cash is excluded from the system. From the cash position point of view it's not material amount.

The costs of hardware that was purchased for the needs of electronic commerce solutions were in amount of 600 000 Sk (Slovak Crown). Software costs amounted to 1.5 mil. Sk. Costs of the maintenance for the first year were not paid according to the system guarantee. Currently there is a discussion about the conditions of service and maintenance of the system, which are based on a developing service agreement. Licenses are in an abeyance. There were 5 user licenses bought and included in the basic payment. Business partners are not the system users.

In the part of solution applying, an impact evaluation of electronic commerce solution was also mentioned, but only from the efficiency and possible correction point of view.

The above-mentioned solution is based on the principles of dynamic pricing. It is evaluated from the point of 2 attributes – price and maturity date. Other attributes were stated as minimum requirements for invited suppliers but not evaluated. The prices in e-solutions are the prices of purchased materials which include the costs of transport. In the following lines we will refer to this solution as to the e-auction.

After finishing research enterprise has integrated this solution with information system, so another issue that came up, was how to measure other benefits from automation. This is the subject to our next research.

The most important issue for managers implementing this solution was how to measure effectiveness and performance of this e-commerce solution. They have requested only traditional indicators as ROI, Cash Flow or payback period as most understandable results. Nevertheless, the principle we used in this research can be used also for other performance measurement indicators and investment measures. Abbreviated research with application is presented in the next chapters.

4.2 Approach To Application

The investigation of possibilities of acquisition cost decrease is the first step for the impact of the solution detection. It is possible to identify the savings in two ways. First is the rough calculation when the first price in auction is considered as the one we would pay if we used the regular way of purchasing – by catalogue. The second way of solution impact evaluation is exact research of the real catalogue price at the time of the auction performance.

In accordance with the psychological aspect, there is a valid assumption that the first price offered in auction would be higher than the real catalogue price. The participant doesn't have anything to lose if he mounts the price higher. In case of breakdown by another offer he's still able to reduce his own offer. But in case of low auction attendance, he can achieve a higher price than the catalogue one.

Valorization of the savings is the second step that needs to be performed from the aspect of better conditions (achieved more favorable maturity date). It is uniform and very easy to use from the auction data.

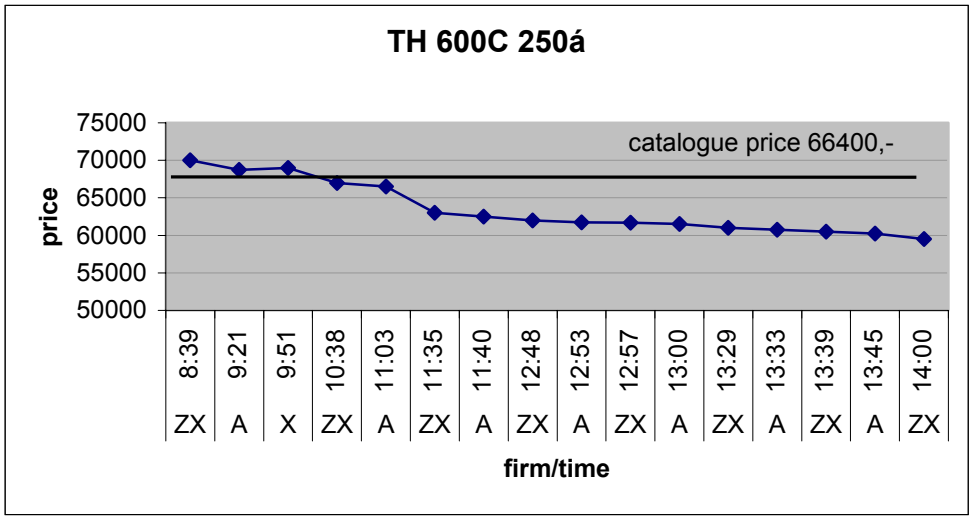

Figure 2: *Example Of Price Development*

In this figure, price development in e-auction is presented. Maturity date savings was from initial 30 to final 50 days. These savings are the main benefits from this e-solution. Only problem could represent catalogue prices identification (with 1 year delay) but in connection with procurement, we have found that managers would be able to estimate catalogue prices at the time of e-auction realization without any problem. We measure complex impact on performance in next chapter in line with metrics mentioned above.

4.3 Method Application

In our case, the staff costs are not relevant due to the same number of personnel employed before and after the solution implementation. During the next implementation phase and in accordance with the development of the metrics for labor savings indicator calculation, it will become clearer that there is some savings which could be solved by positions reduction or by changing the workload. On the other hand there will be much higher qualifying requirements set for the employees who would be allotted to the department of the electronic commerce. Of course it goes hand in hand with a higher salary. That means that the staff cost savings will be equal to the saved staff costs for redundant employees and the increase of the salary for the employees at the department of electronic commerce caused by their higher qualification. In case, that these employees are transferred on other job or function, secondary effect of increased productivity will be taken into account. This problem is a topic of our further research.

The first point in the evaluation process is auction recalculation; sum up the price and maturity savings. These data are presented in appendix by the dates of e-auctions. That means that we will proceed to the ROI analysis with two attributes (the price and maturity date).

Presented methodology was applied in the mining company, which have adopted B2B electronic auction for procurement processes. For ROI calculation of e-solution two methods can be used:

- First method is based on accepting only relevant costs. For example, in case of the mining company, we used purchase cost because it changed but we ignored

personal cost, because this firm couldn't accept redundancies. Hereby we cannot use investment cost because the assets show transfer from money to fixed assets.

- For second method we will reflect all relevant attributes, also personal cost, because e-solution enabled also time savings. In this case we have used model case, where we can take the situation of virtual enterprise, which offers such a solution as outsourced service. Here we must take also personal, investment, maintenance and other costs.

From input data the results were calculated, based on indicators mentioned herein.

Results are presented in the table 3 in two ways. Column of 2.5% procurement intensity show real status of intensity in our company. Column of 80% intensity is status, which our company wants to achieve in 1 year.

Table 3: *Results Of ROx*

Indicators	2,5% intensity	80% intensity
ROI_e / $CROI_e$	26,74% / 33,64%	95,08% / 68,49%
ROI / CROI	1,14% / 7,54%	2,13% / 8,8%
ROI_t / $CROI_t$	1,12% / 7,52%	1,12% / 7,52%
ΔROI / ΔCROI	0,02% / 0,022%	1,017% / 0,66%
ROC / CROC	45,63% / 57,4%	2414,5% / 1739%
In the model case		
ROI_e/$CROI_e$	-15,12% / -	92,3% / 66,5%
ROC/CROC	-25,8% / -	2343% / 1688,6%

Where ROC is return on cost calculated in the same way as ROI and ROI_t is ROI if the e-solution was not implemented. CROI is CashROI.

After examination of previous results we have found that it is necessary to calculate other indicators (significance of Δ(C)ROI, profit or CF growth and other), but especially level of e-assets and level of virtuality.

Table 4: *Result Of Other Indicators*

	2,5% intensity	80% intensity
Level of e-assets	0,06%	1,07%
Level of virtuality	0,046%	0,67%

Level of assets shows the share of assets generating online processes (A_e) on total assets (A_c). In other words it is percentage of total capital invested into e-solution. This indicator is useful only for companies owned and carry on this e-solution (See Table 4).

$$M_{vA} = \frac{A_e}{A_c}, \tag{16}$$

For allowance of other attributes, such as value of telework, value of digital products and other, it is used level of virtuality. This indicator represents share of financial flows

related to e-solution (O_e) on total financial flows (O_c) on input and also output side (costs + returns). In this case we can also reflect the depreciation of fixed assets generating online processes. This indicator is also suitable for firms participating on outsourced electronic markets where this indicator includes also values of e-services.

$$M_o = \frac{O_e}{O_c}, \tag{17}$$

Together with this we must also examine ROI. If one of these indicators is low, it could cause lower ROI added.

In our case, we see these indicators as very low. It is because of mining industry specifics (assets are very high through ownership of real estates such as mines).

For the investment evaluation in time, we have assumed, the first year the enterprise procure online with 2.5% intensity (it was reality), other 3 years of depreciable life 80% intensity (as planned by managers).

We have calculated Internal rate of return (IRR) using backsolver function in MS Excel. This and other indicators, shown in the next table, are very positive and show how dynamic transaction solution in electronic commerce could be effective for enterprises.

Table 5: *Effectiveness Of Investment Into eSolution*

Investment effectiveness for 4 years (stated by depreciation plan)				
IRR	401,16%			
N_e	1,02			
	1th year	2th year	3th year	4th year
Cf_e (in Sk)	1320180,4	36341944	40882120	40882120
NPV10% (in Sk)	87773208			

5 Conclusion

It is obvious that ROI_e/$CROI_e$ is very high at the same time ROI added is very low. This effect is caused by very high value of total assets and low value of indicator of intensity, which is 2,5%. When we compare both indicators values (2,5% and 80%), we see, that ROI added has considerably increased. In fact, the percentage on total ROI is still low. It is one of mining industry specifics, where most of the assets don't relate to the procurement processes. That is the reason for other indicators inclusion – level of e-assets and virtuality, which enabled better results understanding. This indicator also enabled better demonstration of the effect of digital products value or value of teleworking (using e-technology).

We have identified also another very important fact. When we calculate ROI with total assets, we come to the benefit paradox. With increasing of savings from e-solution implementation, this savings determine increasing total assets by increasing financials (cash) - we save money and thus achieve additional interest. In that case, every additional savings mean that rate of ROI growths slower. That is the reason for our recommendation not to use the total assets in the ROI calculation. The better choice, in this case is to use only use fixed assets instead of total assets, which express return on

actually invested funds without adverse effect of increased cash. Other choice is using only cost per year (ROC). In both cases we can calculate real added value to our ROI, which enables us to better understand the e-procurement impact.

In whole research we have tried to identify "added value" gained from implementation of the e-solution. In this case, we didn't include the personnel costs in the indicators calculation (because in our case human potential stayed unchanged). On the other hand, ensuring e-procurement's efficiency and effectiveness indirectly crated the need for redesign of the company's procurement / purchase as a whole. The results (added value) coming from e-procurement implementation should be more favorable should the company be willing to reduce employment in accordance with redesigning the process.

By calculating ROI_e and ROC_e in the case of 2.5% and 80% intensity it is obvious, that by 2.5% level the solution is not effective. But as this indicator increases, the effectiveness of this solution rapidly grows.

For this reason it is appropriate to use backsolver functions for calculating necessary amount of procurement to be effective. Using these methods managers are able to find amount of procurement, and decide if it is more efficient to choose outsourced solution as electronic markets than implementing into the firm.

Considering the research and application outcomes we can underline following conclusions:

- For application into existing environment the expression of added ROI (ROC) is useful, using savings as particular revenue – cash, the firm doesn't need to pay. We don't need to calculate whole personal costs (as by mentioned model case) only the savings. The same approaches can also be used for calculating other financial indicators as payback period, NPV, cash flow etc.
- According to amount of e-procurement we can calculate the margin indicated in which case it is appropriate to choose outsourced solution for e-procurement or using the internal solution.
- For some specifics allowance it is necessary to use also other indicator as level of e-assets and virtuality for better understanding of results (especially if the result are extreme values – very high or low as in the mining company where the total assets are very high because of real estates property).
- The methods for measuring performance was also used by the mining company, specifically pay-back period, financial yield and CROIe. According to this metrics the company is going to develop datamining solution to automatically measure performance of this e-procurement solution in a real time.

By applying of the presented approach and measurement methods, managers will be able to evaluate and measure their investments into procurement and different e-business solutions. This research is wider and is focused on more areas as mentioned above, but for purpose of this study we have outlined at least basic results from area of the e-business measurement.

Benefits of this research were also in following issues: the main metrics for financial yields are usable also for intelligent agent in e-procurement solution for automatic choice of best offer. On the other hand, implementing this metrics into solution in datamining system can help to evaluate savings in time to examine other aspects of these dynamic transactions.

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