Sensitivity analysis within a chosen manufacturing company

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Abstract

Purpose of the article The aim of sensitivity analysis is to determine the effect of the selected financial criteria for firms to possible changes in the values of risk factors that influence the criterion in the selected company. Therefore, it represents an important tool for risk assessment and a decision-making aid for financial management.

Methodology/methods The methods used in this case study are the economic analysis, econometric, statistical and mathematical methods (single-factor analysis, multi-factor analysis, uncertainty index, sensitivity coefficient). Contribution of the paper is essentially a practical demonstration of the real data (from the company, which operates as a subcontractor of components for the automotive industry), their interpretation and subsequent discussion.

Scientific aim The aim of this contribution is to judge the sensitivity, rate of uncertainty, and to evaluate the expected development of chosen risky factors which influence reaching the planned economic result (before taxation) in a chosen manufacturing enterprise in 2017.

Findings Our sensitivity analysis has proven that key risk factors of fulfilling the target economic result in a chosen manufacturing enterprise include reaching at least the planned sales volume for 2017, growth of sale price at least in 2.955% as compared to 2016 and purchase material price which should decrease in 3% as compared to 2016.

Conclusions The contribution assessed the sensitivity, the degree of uncertainty and assessed also the expected of selected risk factors influencing the achievement of the planned profit.

Keywords: sensitivity analysis, risk, small and medium enterprises, financial management, enterprises development

JEL Classification: C19, D22, L29, M21

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Introduction

Sensitivity analysis is understood as a technique used to calculate the output variable – costs, revenues or profit – using different assumptions – sales price, sales quantity (Reilly, 2000). Kleijnen (2005) states that sensitivity analysis helps to predict and implement future changes in the economic environment. In practice, it serves in particular to verify, optimize and analyze the risks of simulation models (Yamwong, Kaotien, Achalakul, 2009).

Sensitivity analysis may be distinguished, according to Fotr, Hnilica (2014, p. 29) into single-factor and multi-factor analysis. While single-factor analysis ascertains the impact of isolated changes in individual risk factors on a chosen financial criterion and all other factors stay unchanged, multi-factor analysis enables ascertaining impacts of current changes in values of several risk factors on the value of the criterion of the analysed risky activity, profit in our case (Pang, 2009). Reilly (2000) states that, besides these differences, single-factor analysis does not respect any possible mutual dependency between some risky factors, and generally, assessing different rate of uncertainty in individual risk factors in both analysis variants. In our article, we have decided to use both types of analysis together with expanding indicators, thanks to which we will obtain a wider image and more probable results.

The aim of this contribution is to judge the sensitivity, rate of uncertainty, and to evaluate the expected development of chosen risky factors which influence reaching the planned economic result (before taxation) in a chosen manufacturing enterprise in 2017.

Profit rate is set as the difference of total revenue and total costs. With regard to the fact that the company owns a wide range of goods which is being sold all over the world in different currencies, we will set profit rate as a multiplication of accounts sold in a natural expression, and an approximate selling price in Euros. To allow an understanding of wider context we also indicate other risk factors in the analysis, necessary to be known, except those which are also used in calculations.

1 Key risk factors having impact on the chosen enterprise

Two main factor groups are included among the key risk factors, and at the same time among enterprise strategic success, according to Steinöcker (1998, p. 85):

- Factors of medium relevant company´s microenvironment (including social factors, environment factors, law and politics),
- Factors of directly relevant microenvironment of company´s tasks (including internal factors such as productivity, investment intensity, innovation range, product quality, factors related to customers, workers, marketing and vertical integration).
- Microenvironment factors are hardly and in a small extent influence able for the enterprise. In the article, we focus on internal factors which are measureable and thus usually available in every small or medium enterprise.

1.1 Single-factor sensitivity analysis

Frequently recommended method of sensitivity analysis is the above mentioned single-factor analysis, which determines the influence of the variable by degree (Webster, 1995). The lack of single-factor analysis is seen by Reily (2000) in that, it measures only the influence of one variable at a time and assumes the independence between the input variables.

The choice of risk factors is based on observed reality, whether the given factor the change of which will cause significantly greater changes in a chosen criterion, i.e. profit, and these are chosen for the analysis (Triantaphyllou, Sanchez, 1997). Changes in values in individual risk factors are characterised as deviations from the most probable values of certain range, for instance, +/- 10% (respectively of optimist and pessimist values, according to the probable development scenario).

The dependency of a monthly profit from production at single-factor sensitivity analysis on the influencing factors may be expressed, according to Fotr, Hnilica (2014, p. 30), as follows:

$$Z = P(cxm - sxk) - FN \qquad (1)$$

Where: Z = profit before taxation (in a yearly expression), P = sale, respectively production (in millions pcs/ year), we assume at this point that the amount of supplies of ready products will be kept at approximately constant rates, c = average selling price of products (Eur/piece), m = exchange rate (Euro/USD or / CZK), s = material consumption on production unit (in kg to piece, respectively an interesting perspective will be offered by the average material share in % on goods produced), k = purchase price of material (Eur/kg), FN = fixed costs (mill. Eur/year).

Table 1 Observed risk factors and their expression

Risk Factor	Unit
1. Sales	In mill. Pcs/year
2. Sale Price (average)	Eur/pcs
3. Exchange Rates	EUR/towards USD and CZK
4. Specific material consumption compared to performance	%
5. Specific average material consumption	kg/pcs
6. Material Purchase price	Eur/kg
7. Waste Purchase price (e.g. copper)	Eur/kg
8. FN- Fixed costs	mil. Eur/year

Source: own work

Due to better explanatory power of sensitivity analysis and the option of recognizing the current trend from the development of chosen indicators in the chosen enterprise we offer their overview for the observed period during the last three years (see the following table 2).

Table 2 Values of chosen indicators within an enterprise for the years 2013-2015

Yearly Expression	2014	2015	2016
1. Sale	11,4192	7,756362	9,4527
2. Selling price	0,8183	1,228	1,131001
3. Exchange Rates	1,328	1,329	1,11
4. Specific material consumption compared to performance	82,9	79	77
5. Specific average material consumption	0,143	0,136	0,133
6. Material Purchase Price	5,806	8,855	7,091
7. Waste Redemption Price	7,11	6,21	5,8
8. FN- Fixed Costs	2,7324	3,033	2,74266

Source: own work

If considering variables in a given enterprise during 2016 and we make them into two possible variants, one expecting that the observed risk factors will deteriorate in 5% as compared to 2016 and the second one expecting a careful improvement in risk factors in 3% as compared to 2016, and thus we will obtain single-factor sensitivity analysis (we will find out how sensitive the profit is to value changes in individual risk factors during an isolated transfer of values of each individual factor) represented in the following Table 3. The shortcoming to this analysis is the fact that we are still counting on the change of one risky factor, thanks to which we obtain information only about the most important factors of influencing the profit (Tian, Kouvelis, Munson, 2014).

Table 3 has proven that yearly profit reacts with most sensitivity to the reinforcement of exchange rate the evaluation of which reaches from EUR/USD 1.11 to EUR/USD 1.0545 leads to profit deterioration in 283.9%, which is not so fully true, the fact that the formula used for the calculation assumes that total production is used for exporting and is being recalculated via this rate, needs to be taken into account. This enterprise exports 92% of its production abroad, but approximately only 15% of sold goods is recalculated via the EUR/USD rate. The rest is being sold for less EURO, and perhaps in CZK, making this risk factor significantly weaker. Thanks to this fact, we may say with complete certainty that profit reacts most sensitively to sale price change. The enterprise we are observing produces amounts of tiny components in mass production, the prices of which move around low values per piece which may be also seen in Table 2. Even smaller changes in price (negative as well as positive) may create huge discrepancies in economic result. In case of decreasing taken amounts in numerous projects (at the total rate of 5% production) and impossibility to cover these volumes the enterprise would get into serious problems and its profit would drop in 170% (still assuming the immutability of other observed risk factors). Significant factors may also include material purchasing price because the share of material in products is very high and production is materially demanding. If the price grew in 5% it would cause a flat profit deterioration in

123%. This indicator, however, is very unspecific because production is differentiated and the materials too, proving a risk diversification connected to this factor.

Table 3 Sensitivity analysis results for the option of improving/deteriorating risk factors in the range of +/- 5 and 3%

	Risk Factor	Factor Value (Value expectation)		Profit deterioration during factor deterioration		Profit growth during factor improvement	
		Deterioration in 5%	Improvement in 3 %	Absolute (bill. Eur)	Relative in %	Absolute (mill. Eur)	Relative in %
1.	Sale	8,9801	9,7363	0,1476	70,6	0,0885	42,4
2.	Selling Price	1,0745	1,1649	0,5934	283,9	0,3560	170,4
3.	Exchange Rates	1,0545	1,1433	0,5934	283,9	0,3560	170,4
5.	Specific Average Material Consumption	0,1397	0,1290	0,4458	213,3	0,2675	128,0
6.	Material Purchase Price	7,4460	6,8787	0,4458	213,3	0,2675	128,0
8.	FN- Fixed Costs	2,8798	2,6604	0,1371	65,6	0,0823	39,4

Source: own work

The least significant risk factor is fixed costs at the growth of which the profit deterioration will be 65.6%. In case of this analysis it is necessary to think of certain ambiguity in understanding scenarios which may be understood differently (see Table 3). In our case we have used a negative scenario, risk factors deteriorating in 5% and improvement, thus a positive scenario, improving risk factors in 3%. In many cases the range of +/- 10% is used or each factor is guessed individually within the changes. With regard to shortcomings and limitations a multifactor sensitivity analysis should be created.

1.2 Multifactor sensitivity analysis in a chosen enterprise

Using this analysis we search for profit change sensitivity to current different changes in the value of sale price and amount of products sold (Dorcak, Markovic, Pollak, 2017). Thus, we have chosen two changing risk factors under the conditions of immutability of the rest of the four factors. The results are presented by Table 4, containing also data truly reached in 2016 in order to allow correctness checking. Multifactor sensitivity analysis allows us to check the fulfilment of the planned reached profit for the following year 2017. In case the planned sold amounts for 2017 is kept, being lower than in 2016 and the price does not grow further, the enterprise will reach loss numbers. If the enterprise has planned a profit of EUR 272830 for 2017, it will reach it only if the average sale price grows in 2.95%. Table 4 represents different mutual combinations of probable changes in the sold amounts of individual goods, and in the changes of average item prices together with the impact on economic result. The table emphasizes the fact that the enterprise should not decrease the average item price of its products because it will reach loss levels in 2017.

Table 4 The results of multifactor sensitivity analysis (in mill. Pcs/Eur)

		Further Decrease in 1 %		Plan 2017 of 10,193 %	Reality 2016	Growth in sold goods only in 1% (in EUR/pcs)				
		8,3203	8,4043	8,4892	9,4527	9,5472	9,6427	9,7391	9,8365	9,9349	10,0342
Price decrease in 10 % (reality)	1,017901	-1,189	-1,173	-1,15763	-0,97774	-0,96009	-0,94226	-0,92426	-0,90607	-0,88771	-0,86916
Price decrease in 5% (reality)	1,074451	-0,66691	-0,646	-0,62476	-0,38439	-0,36080	-0,33699	-0,31293	-0,28863	-0,26409	-0,23931
Individual Price (reality) 2015	1,131001	-0,14464	-0,11840	- 0,09189	0,20896	0,23848	0,26829	0,29840	0,32881	0,35953	0,39055
Price increase in 0,5 %	1,136656	-0,09242	-0,066	-0,03860	0,26830	0,29841	0,32882	0,35953	0,39056	0,42189	0,45353
Increase in average sale price always in 1% (EUR/pcs)	1,148023	0,01256	0,0404	0,06850	0,38756	0,41887	0,45048	0,48241	0,51466	0,54724	0,58014
	1,159503	0,11859	0,1475	0,17668	0,50802	0,54053	0,57336	0,60652	0,64001	0,67384	0,70800
Real Price Increase in 2,955 %	1,169706	0,21282	0,2427	0,27283	0,61508	0,64866	0,68257	0,71682	0,75142	0,78636	0,82165
	1,181403	0,32085	0,3518	0,38305	0,73781	0,77262	0,80777	0,84327	0,87913	0,91535	0,95193
Average sale price increase always in 1% (EUR/pcs)	1,193218	0,42996	0,46200	0,49438	0,86177	0,89782	0,93422	0,97099	1,00813	1,04563	1,08352
	1,20515	0,54016	0,5733	0,60681	0,98697	1,02427	1,06194	1,09998	1,13841	1,17722	1,21642
	1,217201	0,65146	0,6857	0,72037	1,11342	1,15198	1,19093	1,23026	1,26999	1,31012	1,35065

Source: own work

1.3 Other complementary items

Besides complex sensitivity analyses, according to Šimák, et al (2005) it is necessary to observe individual risk factors individually. It is suitable to complete single factor sensitivity analysis using uncertainty index which makes it clear to us what is the certain value chosen by us and assumed by us (Micu et al., 2014). The lower this value gets, the more reliable our guess is. And vice-versa, the higher it is, the higher the manager´s attention and reassessment have to be towards risk factor guess (Pang, 2009). In our manufacturing enterprise, the following uncertainty coefficient values have been the result – see Table 5. They move around the range of 7.53% in exchange rates up to 8.91% in sale volume. Sale volume is derived mostly from contractually agreed consumption of products in all projects during the total lifespan of a given product (often 3 to 7 years) which gives us some certainty that the planned expected value is real and it is not necessary to re-evaluate it additionally if consumers do not inform us about the changes in consumed volumes of products, or if there are no significant events, respectively problems production.

Table 5 The Index of expected value uncertainty in the used risk factor range (in %)

Risk Factor		Factor values (spread observed)		Spread of possible values	Value expected	Uncertainty Index in %
		Decrease in 5 %	Improvement in 3 %			
1.	Sale	8,9801	9,7363	0,7562	8,4892	8,91
2	Selling Price	1,0745	1,1649	0,0905	1,1697	7,74
3	Exchange rates	1,0545	1,1433	0,0888	1,1800	7,53
5	Specific average material consumption	0,1397	0,1290	0,0106	0,1330	8,00
6	Purchase material price	7,4460	6,8787	0,5673	6,8787	8,25
8	FN	2,8798	2,6604	0,2194	2,7340	8,03

Source: own work

Another indicator, thanks to which the enterprise´s dependency on individual risk factors is being ascertained is sensitivity coefficient. It informs us that the influence of risk factors on profit is different. A little change in one of the risk factors may cause a huge change in profit, and in another one a huge change influences the profit very little (Rabta, 2017). According to Ptáčková (2014) we may express the linear sensitivity character as follows:

$$CZ = a \times FAKTOR \quad (2)$$

In case of dependency linear character, the sharper the slope is the more sensitive the factor becomes, and the greater attention it needs, perhaps it is necessary to ensure oneself against any changes in this factor (e.g. In case of exchange rates it is possible to fix it for a given period of time). Sensitivity analysis thus expresses in what percentage the profit changes at the risk factor change in one percent – see Figure 1 (Derun, 2016). In our chosen manufacturing enterprise focused on car industry component production, the sensitivity coefficient has proved the following in individual risk factors, see Table 6. The table also contains the calculated spread[1] informing us about the rate of observed value variability. Its value in a chosen risk factor may be observed in Figure 1.

In case there is a change in the average selling price in 1% the profit will change in the average of 1.56%. The profit reacts with greatest sensitivity to changes in price, exchange rate and fixed costs. With greatest variability, sale values were developing, purchase material prices and, paradoxically, also fixed costs the change of which was caused by significant repairs done in 2014 and increased fixed costs.

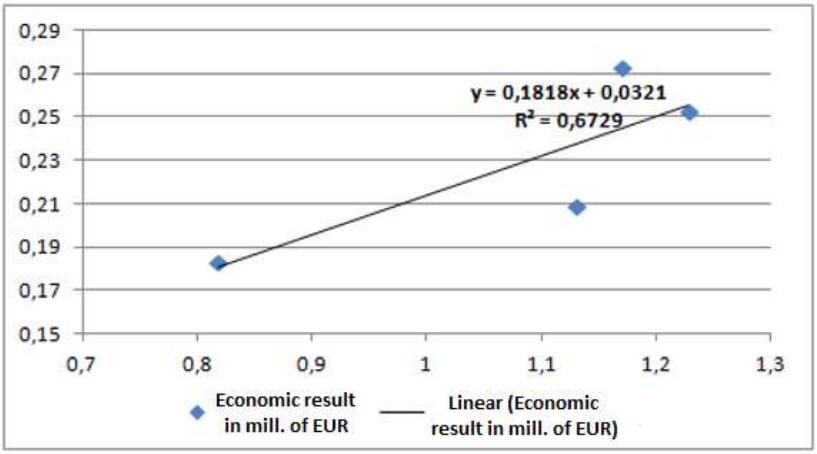
Table 6 Average sensitivity Coefficient (in %) and spread

Yearly expression		2014	2015	2016	2017	Average Sensitivity Analysis	Expected Sread
1.	Sale	11,4192	7,756362	9,4527	8,489198	-0,902	24,479
2.	Selling Price	0,8183	1,228	1,131001	1,169706	1,560	0,225
3.	Exchange Rates	1,328	1,329	1,11	1,18	212,050	0,296
5.	Specific average material consumption	0,143	0,136	0,133	0,133	0,425	0,003
6.	Purchase material Price	5,806	8,855	7,091	6,8787	0,815	14,399
8.	FN-Fixed Costs	2,7324	3,033	2,74266	2,734	2,478	1,913
10.	HV-in mill. EUR	0,183615	0,253156	0,208965	0,2727	1,000	0,001

Source: own work

Dependency between risk factors and profit is represented by regression curve in Figure 1 together with regression equation and determination index, which, being multiplied by 100 informs about the fact that the chosen regression curve explains variability, respectively profit variability at 67.29%, the rest represents inexplicable variability, the impact of other agents in a simplified conception.

[1] Spread is an arithmetic average of squares (second powers) in deviations of values detected in the xi K sign from the ẍ arithmetic average. It is marked as S^2. The standard deviation is $\sqrt{S^2}$.



Source: own work

Figure 1 Mutual linear dependency of selling price and profit

Conclusion

Business uncertainty means that more things may happen than really happens. Thus we should try to find out what exactly can happen whether within the company or its surroundings, and evaluate these options with a specific probability and risk. Sensitivity analyses are a tool for discovering possible influences of probable risk factor changes on the observed quantity, e.g. in our article about profit and its inclusion within expectations in the interest of prevention and securing oneself from problematic development. It is used very often in evaluation of introducing new projects, investment, and very often is understood, according to Brealey, Myers and Allen (2014, p. 322) as calculation of cash flow dependent on key variables with a subsequent calculation of impacts due to a wrong estimate in these variables or low quality prognoses. Besides advantages it also has its disadvantages, among which result ambiguity or the fact that input variables are probably not independent may be included. In this case, if variables are dependent, the evaluation of several probable scenarios may help.

The aim of this contribution was to evaluate the sensitivity, uncertainty rate, and to evaluate the expected development of chosen risk factors which influence reaching the planned economic result (before taxation) of a chosen manufacturing enterprise in 2017. Our sensitivity analysis has proven that key risk factors of fulfilling the target economic result in a chosen manufacturing enterprise in the amount of EUR 272 700 include reaching at least the planned sales volume for 2017, growth of sale price at least in 2.955% as compared to 2016 and purchase material price which should decrease in 3% as compared to 2016. Their changes influence most sensitively the economic result and their choice is confirmed by the reached sensitivity coefficient values. Fixed costs and unit material consumption is controlled by the enterprise in great amounts, and they do have a decreasing tendency, even though in 2015 a swing was noticed. Expected values of risk factor development are confirmed by a calculation of uncertainty index in moving around the range of 7.53% in all factors observed, up to 8.91% in exchange rates, thus our estimates are correct. The aim of this article has been fulfilled.

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