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METALLURGY IN THE CZECH REPUBLIC: A SPATIO-TEMPORAL VIEW

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The objective of this paper is to introduce the stochastic input-output model of the impact of metallurgy sector on the Czech economy. Contrary to original input-output model, which is of deterministic nature, we reckon with interval estimates of the development of metallurgy sector. They help us to surpass deterministic impediments when analyzing and forecasting the possible developmental tendencies of metallurgy sector in various economies.

Key words: metallurgy sector, interval estimates, input-output, probability distribution, Czech Republic

INTRODUCTION

Albeit metallurgy as well as other economic branches bear a distinct spatial-functional dimension, it is debated only rarely. Despite its relative simplicity, input-output model represents rather useful instrument for grasping spatial-economic structures and interrelations. In case of the Czech Republic, which is relatively small and open economy, usage of such model finds its rationale.

The traditional version of input-output model reckons with deterministic inputs and outputs [1, 2, 3]. Apart from this fundamental type of the model we can utilize also its stochastic counterpart. Its pivotal attributes have been discussed elsewhere [4, 5]. It should be mentioned qualitative broadening of original input-output model allows its wider application not only within economic-spatial studies but also practical calculations.

Metallurgy represents an important and at the same time also interesting sector, which traditionally played a prominent role within Czech economy and remained rather relevant so far [6]. Thus, the objective of the paper is to introduce the stochastic input-output model of the impact of metallurgy sector on the Czech economy. In spite of its usefulness, stochastic modification of input-output is hitherto much less utilized. At the same time, it is indispensable for the analysis and forecasting the possible developmental trajectories of economic sectors. Czech metallurgical sector can serve as an appropriate stuff for the application of stochastic version of input-output model.

THEORETICAL FUNDAMENTALS OF INPUT-OUTPUT AND ITS STOCHASTIC BROADENING

There exists ample literature on the issues related to the traditional version of input-output model [7, 8]. Input values and results obtained from the traditional version of structural input-output model have deterministic character. They can be therefore regarded as point estimates in terms of statistical theory. In order to overcome limitations of deterministic inputs and results, it is necessary to enter input values that are based on interval estimates. These estimates have a greater explanatory power compared to deterministic point estimates. Then it I would be possible to model and forecast the impact of the metallurgy sector scenarios on the Czech economy.

To build up stochastic version of input-output model, input parameters of the model, i.e. the elements of the vectors X and Y, and matrix A respectively, must be entered in the form of random variables. These variables are expected to follow a given probability distribution with its parameters. In order to overcome limitations of deterministic model and get a stochastic model, there shall be at least one of the model inputs specified as a random or stochastic variable.

Thus, it is necessary to accept the hypothesis that input data for calculation of structural input-output model are random variables. To get expert estimates of inputs, it is possible to use some suitable probability distribution. For the purpose of our stochastic model, we should accept an assumption that expert estimates will follow some of commonly used probability distributions. In addition to this, the type of distribution will be selected by an expert.

In general, some unimodal probability distributions that are defined on a finite interval of random variable, for instance triangular distribution or beta distribution come into consideration [9]. Theoretically, there can be applied also other probability distribution like Gaussian distribution.

For the purpose of entering the input values, the triangular distribution was chosen. The triangular distribution belongs to the group of continuous probability distributions with lower limit a, upper limit c and mode b. It holds that $a < c$ and $a \leq b \leq c$.

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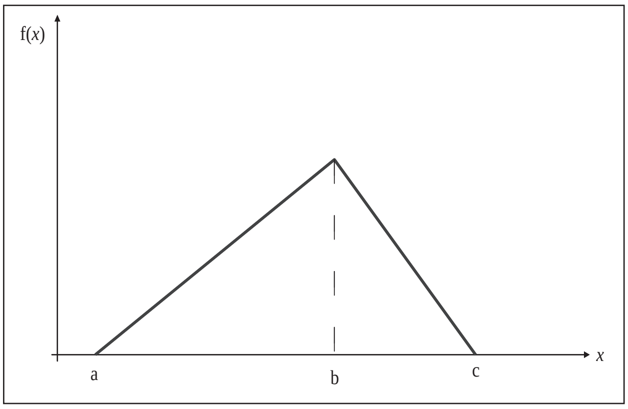

Figure 1 Probability density function of triangular distribution

In this distribution, the probability density is not constant for a given interval. It has a triangle shape, i.e. initially increases linearly to its optimum value (the mode of the distribution), and then decreases linearly to zero as shown in Figure 1.

The probability density function for the triangular distribution can be analytically written as follows:

$$f(x)=\begin{cases} 0 & x \le a \\ \dfrac{2(x-a)}{(b-a)(c-a)} & a < x \le b \\ \dfrac{2(c-x)}{(c-a)(c-b)} & b < x \le c \\ 0 & x > c \end{cases} \qquad (1)$$

The parameters of triangular distribution have in terms of expert estimation the following meaning:

a – minimum value, lower or pessimistic expert estimate,

b – optimal or expected value, the mode of probability distribution,

c – maximum value, upper or optimistic expert estimate.

The value of mode usually corresponds to point estimate of given sector production. The triangular distribution will be applied in our stochastic input-output model to describe expected development of total production in the metallurgy sector. In the next step of our procedure the Monte Carlo simulation will be applied [10]. In this manner, we can get a dynamization of originally deterministic input-output model.

Due to linearity of applied stochastic input-output model it expected that all outputs of our model including vector of final consumption will also have the triangular distribution. However, when using more stochastic elements in input-output model, some of the output parameters would not have followed the triangular distribution. In accordance with central limit theorem, a probability distribution of output should increasingly resemble the Gaussian distribution when applying increasing number of stochastic inputs.

RESULTS AND DISCUSSION

When creating stochastic input-output model, we intentionally focused on the metallurgy sector. This sector can be considered a key one from the point of view of the export base theory in Moravian-Silesian region. However, our model will be applied on the whole Czech economy since it is impossible to get detailed and correct data sample on NUTS3 level. To verify the methods of stochastic simulations, we have created input-output model of nine aggregated sectors of the Czech economy and exclusive imports in those sectors.

For the purpose of our stochastic input-output model, we chose a relatively small number of aggregated sectors and thus a relatively high degree of aggregation. In this manner, we can easily and clearly identify potential impacts and effects of various expert estimates of metallurgy sector on a possible development of various sectors of the Czech economy. Czech Statistical Office publishes input-output tables relatively irregularly. The input-output tables of Czech economy were published last time in 2015 year. Expert scenarios of development of metallurgy were obtained by experts from Hutnictví železa Ltd.

Further, there have been used three points estimation (a = minimum estimated value, b = the most probable value, c = maximum estimated value). With a help of these three values we constructed triangular distribution of metallurgy sector possible development. For the purpose of this paper, the most probable value or the mode of triangular distribution corresponds to real value of metallurgy sector production in the Czech Republic in 2015 year. The value of real production in 2015 decreased by 10% was set as the lower limit of the interval (pessimistic estimate), while the upper limit of the interval (optimistic estimate) represents the same value increased by 20%. In this manner, it can be estimated practically all the elements of matrix A as well as the values of input vector X or vector of final consumption Y respectively.

Our stochastic input-output model was created with a help of Visual Basic programming language and it is available using MS Excel spreadsheet. Simulations are carried out by Monte Carlo method, i.e. by repeated generation of input values using generator of random values in MS Excel. Results of simulations can be interpreted as an impact of possible stochastic effects on the whole Czech economy that was caused by metallurgy sector only. When a simulation is finished, we can get basic statistical characteristics like mean value, standard deviation and variance coefficient for every generated element of the vector of outputs.

Table 1 shows an example of the stochastic input-output model that calculates or estimates the value of final consumption Y for a given total production X according to equation $Y = (I – A) X$ after 10 000 iterations. The values presented Table 1 are given in current prices in millions CZK. The metallurgy sector is shown in the 2nd row. Total production of metallurgy sector was estimated by experts while other sectors were imputed just in the form of point estimates on the basis of data from Czech Statistical Office. The same is true for coefficients of structural matrix A.

Since 17 items of vector of inputs X have a deterministic character and only metallurgy sector input has

Table 1 **Example of stochastic simulation in input-output model using real data from Czech economy**

	A	B	C	D	H	J
1	**Stochastic Matrix *X* -> *Y***	**Lower *X***	**Mode *X***	**Upper *X***	**Mean of *Y***	**St. Deviation of *Y***
2	1st Sector	78 973	78 973	78 973	8 323	249
3	**2nd Sector (Iron Metallurgy)**	**145 570**	**161 745**	**194 094**	**116 579**	**5 962**
4	3rd Sector	399 902	399 902	399 902	235 800	964
5	4th Sector	304 196	304 196	304 196	205 413	29
6	5th Sector	291 457	291 457	291 457	209 514	5
7	6th Sector	305 161	305 161	305 161	73 335	469
8	7th Sector	539 311	539 311	539 311	230 528	66
9	8th Sector	47 236	47 236	47 236	7 221	119
10	9th Sector	3 445 504	3 445 504	3 445 504	1 712 031	3 069
11	10th Sector	59 242	59 242	59 242	-1 312	214
12	11th Sector	45 944	45 944	45 944	16 480	39
13	12th Sector	188 816	188 816	188 816	71 848	592
14	13th Sector	215 244	215 244	215 244	81 268	79
15	14h Sector	111 852	111 852	111 852	57 202	18
16	15th Sector	2 266	2 266	2 266	501	7
17	16th Sector	8 600	8 600	8 600	221	9
18	17th Sector	2 314	2 314	2 314	33	8
19	18th Sector	685 567	685 567	685 567	108 571	1 724

a stochastic nature with the triangular distribution, particular items of vector of final consumption Y should also have the triangular distribution.

Results of our simulations can be interpreted as a potential impact of stochastic effects caused by metallurgy industry on the other aggregated sectors of the Czech economy. The results of these simulations and forecasts cannot be considered to be truly representative but rather illustrative for the method used because of relatively high and unbalanced degree of aggregation of input data sample. When aggregating the values of the vector of final consumption Y we can get an estimate of the total size of the final use of the Czech economy, which represents an approximation of the GDP of the Czech economy.

CONCLUSIONS

The input-output analysis represents very powerful instrument for analysis of intersectoral relationships in economy. In this paper, originally deterministic input-output model of the Czech economy was transformed into stochastic one with a help of Visual Basic programming language. In general, there exist three basic types of tasks that can be solved by our stochastic input-output model. This paper investigated possibilities of using stochastic simulation input-output model applying real data inputs of Czech economy and expert estimations. Within this paper, the construction and derivation of stochastic input-output model was described in a simple manner.

The objective of the paper was to introduce and apply the stochastic input-output model of the impact of metallurgy sector scenarios on the Czech economy final consumption. The results of our simulations can be considered just an illustrative example. However, our approach can be practically applied on any data sample so that the economic implication of our findings could be very universal and easy applicable.

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