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VERIFICATION OF OVERALL EFFECTIVITY OF BROWNFIELD REGENERATION BASED ON MATHEMATICAL MODEL

Introduction

A lot of definitions of the word "brownfield" well known, but in some cases, they are very different. Brownfield view is very unlike main in European and in American conception (Ferrber, 2012). However, no definition is received by professional public in general. Definition made within the project CABERNET (Petríková, 2012) is used in the Czech views the most often. This definition says, that brownfields are these areas which:

- have been affected by former uses of the site or surrounding land;
- are derelict or underused;
- are mainly in fully or partly developed urban areas;
- require intervention to bring them back to beneficial use;
- may have real or perceived contamination problems.

Brownfields are very important problem in our cities' structures. Revitalization of them is very factual and time consuming and also economically disadvantageous in the most cases. New development originates on the edge of the city and its extent is still wider and wider (so called urban sprawl). This situation causes reduce overall compactness of development and its economy as-well, because transport and technical infrastructure is still overspreading and transport distances are much longer, e.g. brownfields occupy about 10% of built-up area in Czech city Ostrava (Havránek, 2012). It means, if Ostrava realized its development only on brownfield sites, its built-up area would be 10% smaller and all city standards would be conserved.

Apart from urban problems, brownfields causes also social problems. Mainly, brownfields are unsightly chipped buildings and areas, which are not secured satisfactory and these zones entice some homeless, squatters, metals pickers etc. Combination of uninviting surroundings, higher criminality and concentration of these problem occupants causes overall social locality decline and this could be followed by land value reduction.

Brownfield regeneration and their restoration of meaningful use are more than desirable for the above reasons. Lack of finance is the most common argument defending brownfield regeneration. In general, it is stated, that brownfield regeneration is approximately 1,5 – 2,0 times more expensive than greenfield development (Bergatt, Jiřina, 2004). However, these considerations take to account only prime investment costs needed for construction erection. Nevertheless, brownfields can bring many financially invaluable benefits to their surroundings (e.g. better area condition, higher employment in particular place, re-use of existing infrastructure, overall place renewal, etc.) These benefits take shape right in long-term horizon of several years (Kuda, Smolová, 2007). This long-term development in the case of brownfield regeneration is possible to model thanks to mathematic modeling tools.

MODIFIED DYNAMIC MODEL

Modified dynamic model (MDM) is one of very suitable tool for this modeling. It is a software tool, which was created by experts from Czech Technical University in Prague. This tool enables long-term development simulation on a basis of stochastic model defined by user. MDM was program as a MS Excel supplement (Dlask, Beran, 2012).

The basis of this model is fact, that all development accompanying actions has some cause and some result and all of them are connected one another. Then, finding and defining of these development accompanying elements is main task for user of MDM. Subsequently, connections between particular elements and their values scaled from -1 to 1 have to be determined, accordingly how the elements affect one another. MDM is able to calculate and then graphically display qualitative running of each element standard after task of initial conditions. The calculation runs on a basis of equations (Beran, Dlask, 2005):

$$X(t+1) = X(t) + X'(t+1) \quad (1)$$
$$X'(t+1) = AX(t) \quad (2)$$

where: X = element standard; A = matrix of particular connection values; t = 1,......, r has r cycles.

It is obvious, that all connections can not be evaluated completely objectively, so it can be a problem. Then, we can have situation, that the influence of one element on the second one is evident, but very hard evaluable. In this case, we have to estimate this value and consult it with experts at particular fields and make the whole model more objective this way. In this situation, it is also possible to use „Values parameterization“, which is one of useful tools of MDM and this tool enables to assign values in some range to one ore more values with user defined number of iteration. Then, the calculation is made separately for each iteration and according to results fluctuation we can find, how big mistake we do, if we estimate value of some connection.

Apart the parameterizations, MDM enables to use many others tools for further making more accurate models, such as connections intervention or external intervention. By using connections intervention, it is possible to change value of each connection in the case, when user expect, that these values are not constant all time. External interventions are useful, if we want to affect a particular element during the calculation (Dlask, 2011).

Practical example

Quite extensive abandoned area in the land of Silesian Ostrava, particularly former mine Petr Bezruč, was chosen for practical show of land development simulation. Whole area covers about 10ha and mine service was stopped at 1993. Since this, whole mine is empty, idle and dilapidating (Fig. 1).

Fig. 1. Current state of former mine Petr Bezruč (Petríková, 2012).

Fig. 2. Visualization of future usage of the area (Petríková, 2012).

Many studies and area development proposals were made during last 20 years. Currently, the city vestry tries hard to repurchase the whole grounds and to build residential centre of Silesian Ostrava including administrative and sport areas there. Conservation of mine tower is also component of this proposal (Fig. 2), because a part of the mine history of place should be conserved.

Brownfield regeneration

Seven development accompanying elements were chosen for future development model, these are:

- Brownfield regeneration.
- Area conditions – land value increases and whole area quicken by brownfield regeneration.
- Environment – environment is rather negatively affected by brownfield regeneration and its subsequent operation, amount of harmful substances in the air increases.
- Employment – some jobs will be created thanks to brownfield regeneration
- Transportation – traffic load increases thanks to regeneration and overall quicken of the area.
- Transport infrastructure – transport infrastructure is worn down by construction and subsequent operation of the new objects.
- Technical infrastructure – existing infrastructure is used, particular media consumption increase without need of any other investment and on the other hand, thanks to increased operation at the area, overall wear is quicker.

So called mental model was created on the basis of these elements. On this model, all connections and their values are obvious (Fig. 3). These values were regularly consulted with experts, who solve brownfield issue.

From this mental model, so called matrix A was created. This is matrix of all connections values (Fig. 4). When we compare Fig. 3 and Fig. 4, we can find, that values stated at the matrix equal values of connection from element in row of matrix to element in column of matrix.

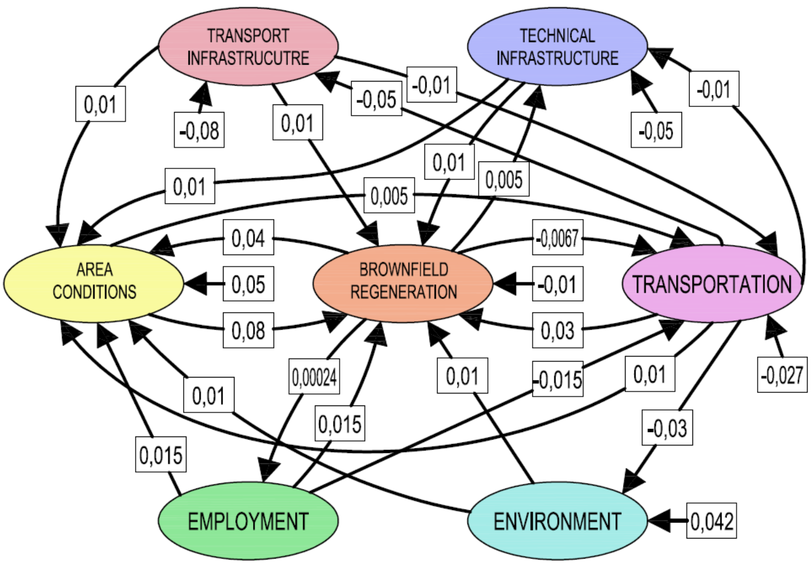
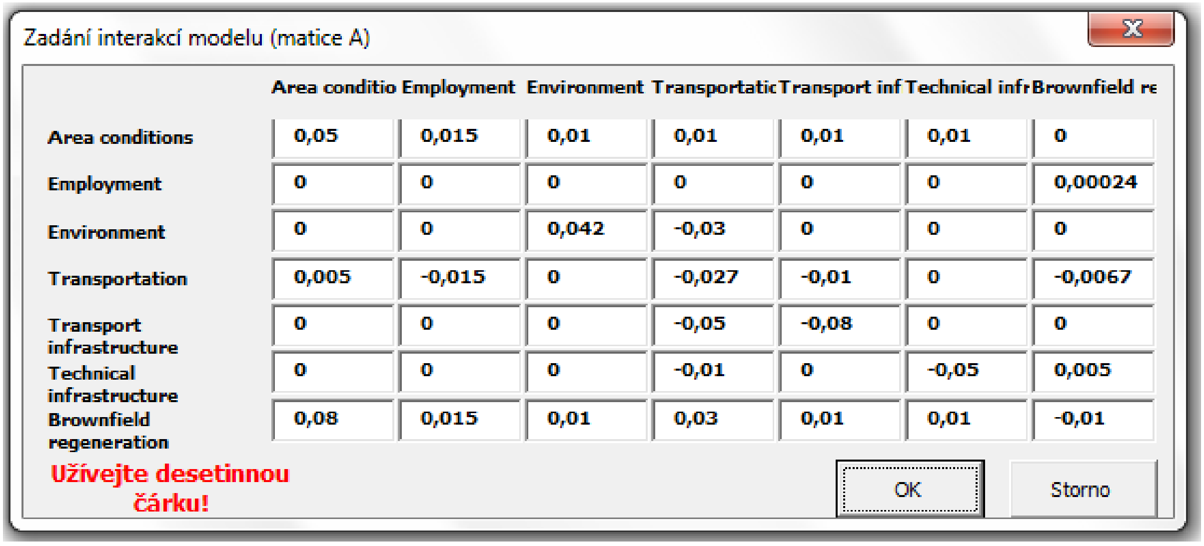


Fig. 3. Mental model.



	Area conditio	Employment	Environment	Transportatic	Transport inf	Technical infr	Brownfield re
Area conditions	0,05	0,015	0,01	0,01	0,01	0,01	0
Employment	0	0	0	0	0	0	0,00024
Environment	0	0	0,042	-0,03	0	0	0
Transportation	0,005	-0,015	0	-0,027	-0,01	0	-0,0067
Transport infrastructure	0	0	0	-0,05	-0,08	0	0
Technical infrastructure	0	0	0	-0,01	0	-0,05	0,005
Brownfield regeneration	0,08	0,015	0,01	0,03	0,01	0,01	-0,01

Fig. 4. Matrix A of area development in the case of brownfield regeneration.

After initial conditions specifying, the software calculated qualitative standards process for each element (Fig. 5).

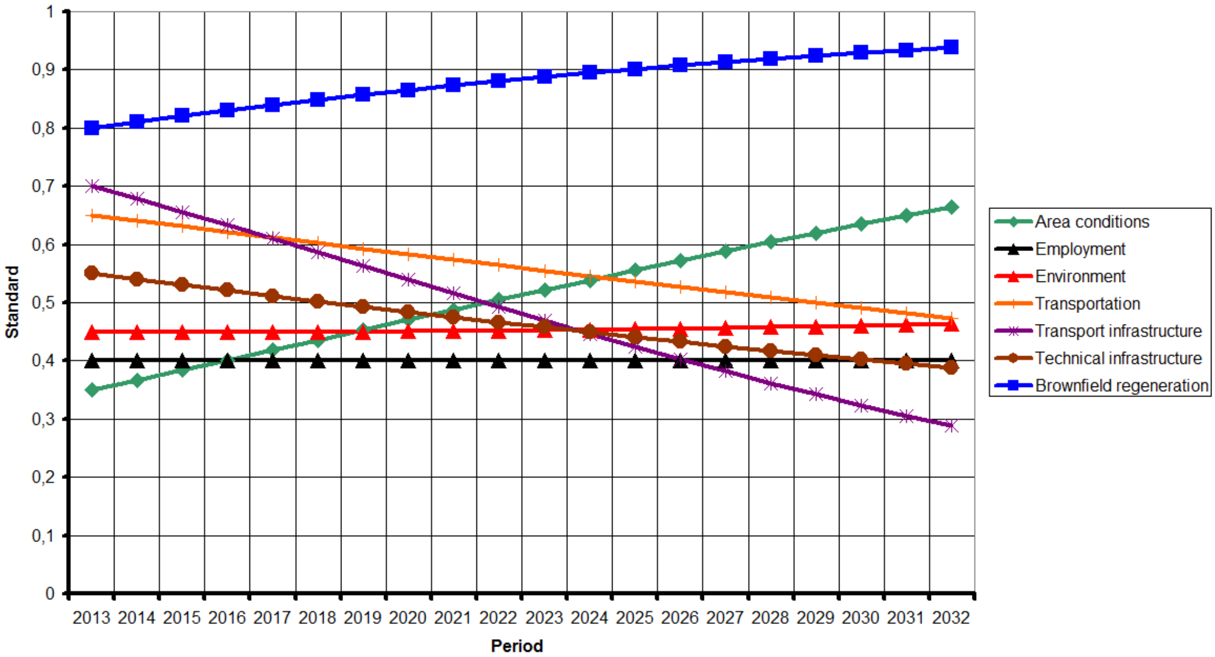


Fig. 5. Qualitative standard running of each element in the case of brownfield regeneration.

Increase of elements “Brownfield regeneration” and “Area conditions” is clearly evident from the graph. So based on results, we can expect, that possible brownfield reconstruction would be successful, project would operate and overall area image would really raises.

Element “Environment” also shows temperate increase. This increase is caused by constant gradual reduction of discharged exhalations amount. These exhalations are discharged by local industrial plants, which use still better and better filters and technologies.

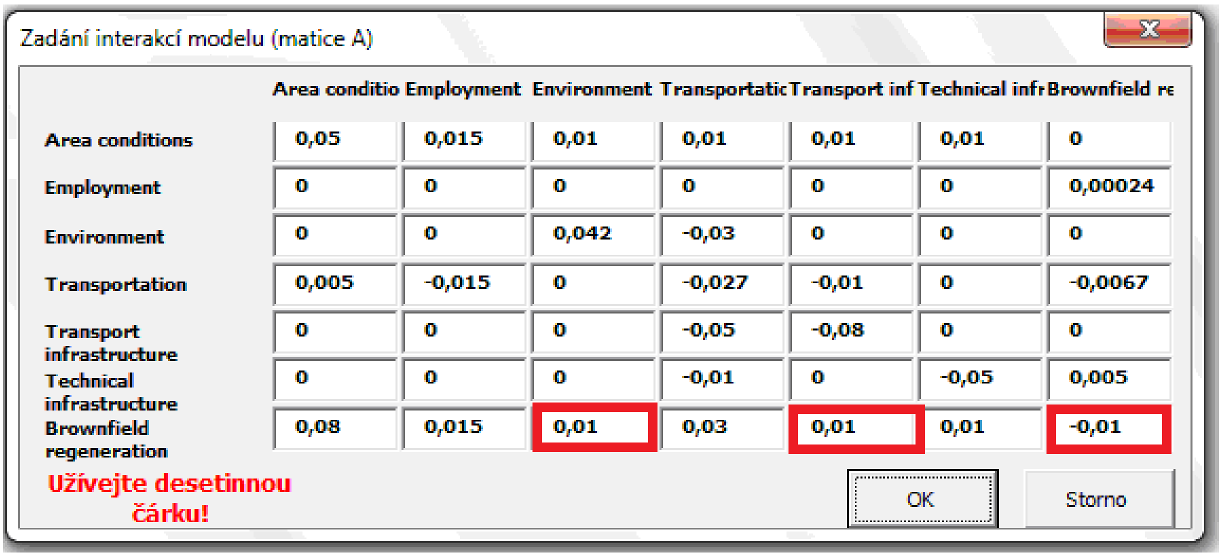
Element “Employment” shows quite constant running, because overall amount of new created jobs is very small, if we compare it with overall number of unemployed people in the city.

However, we notice temperate decrease at the element “Transportation”. We can interpret this decrease as an increase of number of cars going throw the area per one day. This increase is caused firstly by brownfield regeneration and overall renewal of the area, secondly by constant increase of overall amount of cars in our cities.

Decreases of elements “Transport infrastructure” and “Technical infrastructure” are caused by detrition of these elements during time. From the graphs, it is obvious, qualitative standard of transport infrastructure decreases quicker than standard of technical infrastructure. So, we can assume that transport infrastructure will degrade faster and we will have to reconstruct it more often.

Thanks to the model, it is also possible to predict moments, in which it will be necessary to reconstruct the infrastructure, if we state a minimum standard, when the reconstruction is needed.

Some values of connections of this model cannot be evaluated completely objectively. So, the tool “Values parameterization” was used. Particularly, influence of elements “Environment”, “Technical infrastructure” and “Transport infrastructure” on element “Brownfield regeneration” were parameterized. Parameterized values are highlighted by red color on the Fig. 6. Minimal positive influence of these elements on regenerated brownfield is obvious (e.g. without transportation infrastructure, the new building cannot operate), but it is difficult to measure it. For the parameterization, the limit values from 0,005 to 0,05 with 20 iterations were set. Parameterization results and running of element “Brownfield regeneration” are showed in the Fig. 7. Running of other elements are not affected by this parameterization significantly.


Zadání interakcí modelu (matice A)

	Area conditio	Employment	Environment	Transportatic	Transport inf	Technical infr	Brownfield re
Area conditions	0,05	0,015	0,01	0,01	0,01	0,01	0
Employment	0	0	0	0	0	0	0,00024
Environment	0	0	0,042	-0,03	0	0	0
Transportation	0,005	-0,015	0	-0,027	-0,01	0	-0,0067
Transport infrastructure	0	0	0	-0,05	-0,08	0	0
Technical infrastructure	0	0	0	-0,01	0	-0,05	0,005
Brownfield regeneration	0,08	0,015	0,01	0,03	0,01	0,01	-0,01

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Fig. 6. Connections under consideration for parameterization.

Axis “Standard” and “Period” exactly correspond with axis of graph 1, the third axis shows particular iterations of parameterization. From the graph it is obvious, that qualitative standard running of element “Brownfield regeneration” is changed only in hundredths thanks to iterations and this situation does not affect the overall results significantly. In this case, we can say, that these connection values can be evaluated by expert estimate.

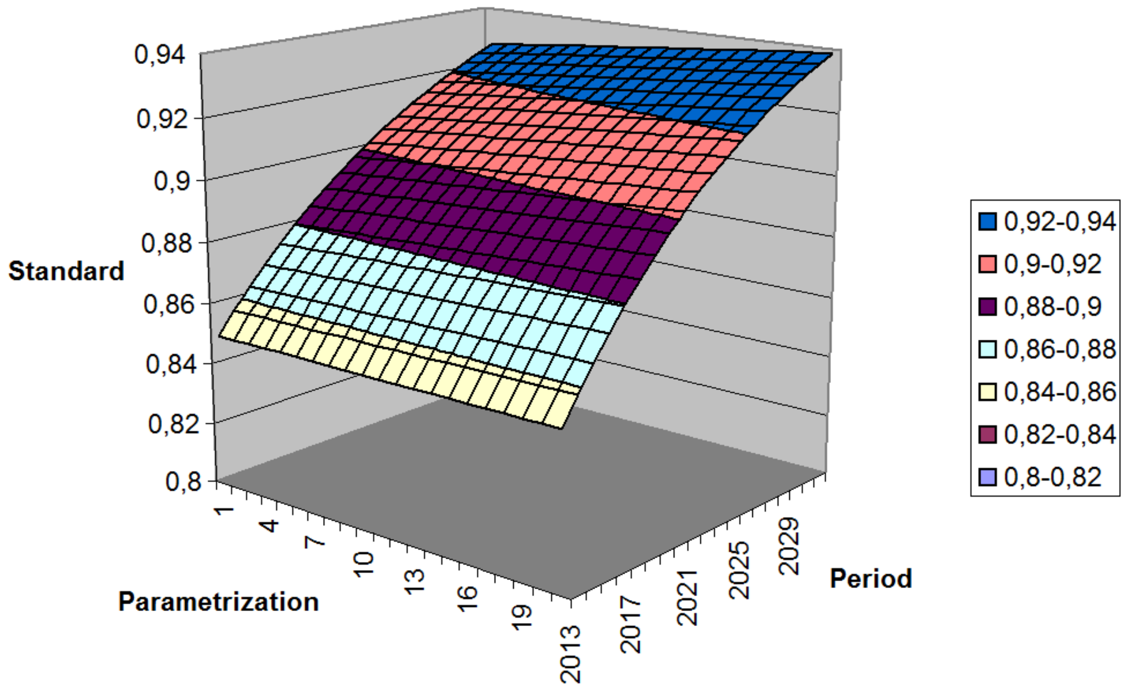

Fig. 7. Qualitative standards running of element “Brownfield regeneration” by undertaken parameterization.

State without regeneration

For a comparison, the situation without brownfield regeneration was also modelled. All elements were taken from previous model; only the element “Brownfield regeneration” was renamed to “Brownfield”. Matrix A of this situation is showed in the Fig. 8 and the qualitative standard running of each element is obvious form the Fig. 9.

Zadání interakcí modelu (matice A)

	Area conditio	Employment	Environment	Transportatic	Transport inf	Technical infr	Brownfield
Area conditions	0,05	0,015	0,01	0,01	0,01	0,01	-0,2
Employment	0	0	0	0	0	0	0
Environment	0	0	0,042	-0,03	0	0	-0,08
Transportation	0,005	-0,015	0	-0,027	-0,01	0	0
Transport infrastructure	0	0	0	-0,05	-0,08	0	0
Technical infrastructure	0	0	0	-0,01	0	-0,05	0
Brownfield	0	0	0	0	0	0	-0,05

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Fig. 8. Matrix A of area development in the case without brownfield regeneration.

We notice some changes if we compare graphs 1 and 3. We can see the difference mainly in running of standard of element “Environment”, which decrease in this case it means it has exactly reverse trend then in the previous model. Connected to this fact the element “Area conditions” increases much slower. We can interpret this situation as prompting the development of the area by investment processes nevertheless brownfield will be still very significant obstacle impeding the overall development.

Fig. 9. Qualitative standards running of each element in the case without brownfield regeneration.

The element “Transportation”, conversely, shows better standard running in the case of leaving the area in current state. So, we can assume, that traffic situation will be worse and worse in the case of brownfield regeneration. It means, some measures, which can compensate this trend (e.g. car lots, better public transport etc.) will have to be realized much earlier.

Conclusion

MDM is very suitable tool for long-term area development modeling. These models can be used by administration or by potential investors when they decide about particular brownfield regeneration. Possible of including financially invaluable element to the model is significant advantage of this tool. Model stated here is the evidence of this, because they reflect about the presumed development in outlined situations quite exactly, but some results can be relatively surprising. Financial aspects were not be included into this accounts, because it is quite easy to compile brownfield regeneration budget or plan of deriving and compare this budget with brownfield retaining costs. So, this aspect is not necessary in the models.

In this example, we can see that brownfield regeneration does not bring expected benefits in the whole range, but it can also cause some complications for particular areas. In this case, quicker increase of traffic load and the necessity of some measures realizing is this complication. However, each brownfield is unique in a way and model for each brownfield would like differently.

At the end, it is necessary to state, that brownfield regeneration is always desirable in each condition, at least in urban terms. Tools of mathematic modeling can help with decision about this regeneration or they can show some problems, which brownfield regeneration can bring.

Acknowlengment

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