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Economic efficiency of brownfield regeneration: study of South Moravian projects*
Efektywność ekonomiczna rewitalizacji terenów poprzemysłowych na przykładzie południowomorawskich projektów

Key words: brownfield, cost–benefit analysis, economic efficiency, regeneration
Słowa kluczowe: tereny poprzemysłowe, analiza kosztów i korzyści, efektywność ekonomiczna, rewitalizacja

Introduction

Regeneration of brownfields has become an important issue for many governments and cities. Revitalizing abandoned and often contaminated areas is motivated by several factors, such as increasing the attractiveness of urban public spaces, protecting the environment, creating employment opportunities, eliminating dangers to health, or reducing unnecessary land consumption (Chen Hipel, Kilgour and Zhu, 2009; Morio, Schädler and Finkel, 2013). Brownfield regeneration (BR) often represents a long-term financially and organizationally complicated process that concerns a large area (Schädler, Morio, Bartke, Rohr-Zänker and Finkel, 2011). Furthermore, BR usually faces conflicting goals arising from different environmental protection and economic points of view (Morio et al., 2013). Taking the above-mentioned into account, brownfields represent an important issue to be discussed, planned, and managed not just for local/governmental administration, but also for the research community from the perspective of creating practical support e.g. in relation to

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optimization, decisional support, and assessment of brownfields.

This study focuses on specific aspects of the efficiency of BR from an economic point of view. In particular, the aim of this research is to examine the economic efficiency of BR using the example of 14 projects located in the South Moravian Region (the Czech Republic), which has been selected as the study area. The paper is organized as follows: firstly, the research background is presented, then materials and methods are introduced. The next part of the paper presents and discusses the main results and the final section provides the main conclusions.

Research background

Limitation of greenfield use turns the focus back on formerly utilized areas. It is even considered a priority, especially if brownfield reuse contributes to the reduction of urban sprawl and if existing infrastructure can be taken advantage of (Jamecny and Husar, 2016). Because individual brownfields are of differing character, it is possible to classify them based on a specific sorting factor. This paper uses the following classification as defined by their original use (production, amenities, housing, commerce, services, administration, military, railway, and others) and also based on the target use (housing, recreation, greenery, missed use, amenities, business activities, and transport), as applied in Brno Brownfields 2015 (City of Brno, 2015).

Brownfield regeneration projects are very costly and risky, and that is why investors generally prefer to realize projects on greenfields (Černík, Kunc and Martinát, 2016). It is therefore important that investor is aware of probable costs related with planned construction activity (Plebankiewicz, Leśniak, Hromádka, Vítková and Kocourková, 2016). In relation to risks, Tedd, Charles and Driscoll (2001) identify three systems that can be at risk: the human population, the natural environment, and the built environment. All large projects typically have a high number of stakeholders involved. In order to achieve the main project goals, the activities of individual stakeholders should contribute to them. However, the regeneration process can be followed by the pursuit of dissimilar goals within the overall process by the parties involved, as reported by Alexandrescu, Rizzo, Pizzol, Critto and Marcomini (2016), thus this can be considered as another important risk factor.

Besides the influence of risk, it is also worth noting that the financial aspect is important, because BR is very costly. It is affected, by its very nature, by increased initial costs relating to the removal of the environmental burdens on the land that are frequently present or sometimes building facilities. These projects have a very large impact on the social environment and their socio-economic impacts are very important (MPO, 2008). Therefore, their efficiency is measured based on CBA and the basic outputs of the economic valuation include the economic net present value (*ENPV*) and economic benefit-cost ratio (*EBCR*). Taking all this into account, it is desirable to prioritize projects with regard to the available financial resources. Wang, Fang and Crawford-Brown (2011) mentioned the importance of governmental financial assistance and they con-

sider this incentive to be crucial for BR. Problems with balancing finances usually result in the stagnation of the project (Nijkamp, Rodenburg and Wagtendonk, 2002), therefore preventive measures should be implemented in order to prevent this unfavourable situation. A model examining a break-even point of cumulative tax revenues from redeveloped areas and expenditures of BR under different levels of funding availability was used by BenDor, Metcalf and Paich (2011).

In terms of performance, a BR project can be classified e.g. according to its efficiency and future needs as applied to the US (Chen et al., 2009). The authors have revealed that experts are more concerned about future brownfield redevelopment efforts than about the results and success of prior projects. Since restoration projects should create overall positive value (Bardos et al., 2016), their assessment should be considered from a broad perspective. Wedding and Crawford-Brown (2007) applied a system of 40 indicators of successful brownfield redevelopments covering the following areas: environment and health, financial indicators, social and economic indicators, and liveability indicators. For instance, it has been revealed that the size of a brownfield influences the extent of the decrement in property values (larger brownfields lower property values more than smaller brownfields) (Schwarz, Gill, Hanning and Cox, 2017).

Another approach focusing on the sustainability aspect was proposed by Chen et al. (2016). They allow determining the feasibility of sustainable redevelopment according to different land use scenarios by means of a brownfield sustainability index.

Skála, Čechmánková, Vácha and Horváthová (2013) make an important point in emphasising the need for stable identification and inventory of brownfields. With the support of modern tools, such as digital models (Danel and Neustupa, 2016), remote sensing, or BIM, this process will be easier to manage.

As many BR projects apply for public subsidy, it is important that the related documentation be free of errors (Juszczyk, Kozik, Lesniak, Plebankiewicz and Zima, 2014) and that they address relevant variables inclusive of socio-economic benefits that are to be evaluated by the respective subsidy decision-makers.

Material and methods

This study analyses a sample of 14 BR projects which have been undertaken in the South Moravian Region. The focus of this study was on the socio-economic benefits of these projects. The input data for the analysis were taken from CBA studies of projects by the Regional Council of the South-East Cohesion Region. These projects are characterized by their investment costs (*IC*), net present value (*NPV*), benefit–cost ratio (*BCR*), and economic *NPV* (*ENPV*) and economic benefit–cost ratio (*EBCR*), which are used to take into account the time value of money with a discount rate of 5.5%. Economic ratios mean that the socio-economic benefits are included.

In order to enable a relevant comparison of socio-economic benefits delivered by individual projects by extracting the effect of the project size from its financial perspective, the value of the economic

benefit–cost ratio (*EBCR*) was used. The following equation was applied:

$$EBCR = \frac{ENPV}{IC} + 1$$

Then, in the next step, the study seeks to examine the difference between the socio-economic and financial benefits delivered by individual projects. This is done by using the contribution of socio-economic efficiency to the total efficiency of projects based on *EBCR* (c_{ef}) computed by the following equation:

$$c_{ef} = EBCR - BCR$$

Finally, the expected value of *EBCR* was assessed by the Oracle Crystal Ball software, in order to determine the probable value of this criterion by simulations using the Monte Carlo method.

Results and discussion

Table 1 shows the basic characteristics of the research sample inclusive of calculated values of *EBCR* and c_{ef}. Individual projects are identified as P1–P14. The expected *EBCR* value was obtained by a Monte Carlo simulation with the Crystal Ball software. Considering that the extent of the sample is very small (only 14 projects are involved), the results have only an indicative value and should be later validated in a larger dataset. The resulting *EBCR* value is characterized by the probability distribution presented in Figure and the basic statistical characteristics of the random variable are shown in Table 2.

The data presented in Table 1 revealed that generally the socio-economic efficiency contributes significantly to the overall efficiency of these projects. More

TABLE 1. Characteristics of the research sample
TABELA 1. Charakterystyka próby badawczej

No Nr	*IC** [EUR]	*NPV** [EUR]	*BCR** [–]	*ENPV** [EUR]	*EBCR* [–]	c_{ef} [–]
P1	2,351,401	1,692,943	1.72	2,075,098	1.88	0.16
P2	2,556,190	–771,406	0.70	–1,277,899	0.50	–0.20
P3	1,198,303	444,023	1.37	2,834,814	3.37	2.00
P4	36,492,921	11,729,580	1.32	41,844,798	2.15	0.83
P5	669,006	–99,391	0.85	435,279	1.65	0.80
P6	490,424	–182,979	0.63	601,663	2.23	1.60
P7	439,020	–551,984	–0.26	448,141	2.02	2.28
P8	359,318	–444,165	–0.24	448,141	2.25	2.48
P9	2,296,611	–418,350	0.82	21,084	1.01	0.19
P10	3,223,725	–1,109,466	0.66	110,435	1.03	0.38
P11	1,467,143	–869,550	0.41	–276,340	0.81	0.40
P12	737,303	–199,198	0.73	–114,546	0.84	0.11
P13	187,071	–46,429	0.75	206,737	2.11	1.35
P14	36,019,389	–195,490	0.99	2,378,827	1.07	0.07

*Data taken from Regional Council of the South-East Cohesion Region projects – dane pozyskano z projektów Regionalnej Rady ds. Spójności Regionu Południowo-Wschodniego.

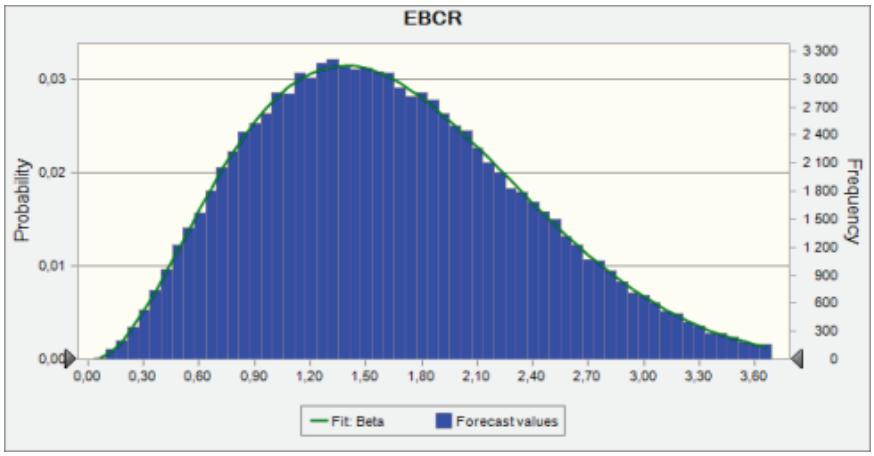

FIGURE. Probability distribution of random variable *EBCR*
RYSUNEK. Rozkład prawdopodobieństwa zmiennej losowej *EBCR*

TABLE 2. Descriptive statistics of the expected *EBCR* value
TABELA 2. Statystyki opisowe wartości oczekiwanej *EBCR*

Expected value Wartość oczekiwana	Results Wyniki
Mean	1.64
Median	1.57
Standard deviation	0.73
Average value	1.64

specifically, the results show that taking the socio-economic aspect into consideration helps to improve the overall evaluation of BR projects to be accepted. If projects are evaluated exclusively from their financial perspective, the resulting value of *BCR* (if negative) suggests about the inconvenience of the project, while their value of *EBCV* can be positive (P7 and P8, Table 1). However, it should be noted that the results also indicate one project (P2) with a negative value of c_{ef}. As detailed information about this project is not available, the next phase of this research should point out the reasons behind such a result in order to warn BR project planners and bodies responsible for decision-making on the allocation of public subsidies in order to succeed in implementing especially those projects that bring a positive c_{ef}, i.e. projects which, apart from a positive financial perspective, also contribute in terms of socio-economic benefits to society.

Furthermore, the Monte Carlo simulation has shown a mean value of the probable value of the projects' benefits (*EBCR*) of 1.64 (*SD* = 0.73); *EBCR* > 1 indicates satisfactory efficiency of the project in relation to *IC*. Based on this data, it can be stated that BR projects can be well assumed to bring positive socio-economic effects.

Conclusion

The issue of BR is a very relevant one in the scientific community, and this paper aims to contribute to broadening the current state of knowledge in this area. In particular, the objective of

this study was to address economic efficiency of BR projects on the example of the South Moravian Region. The presented results based on the analysis of 14 projects pointed out the importance of the socio-economic benefits that arise from these projects' realization in the context of their overall evaluation. Furthermore, the results show that BR projects can be well assumed to bring positive socio-economic effects.

The main limitation of this study is the sample size. Since the research examined merely 14 BR projects, the presented results cannot be considered to be statistically significant. However, the results provide an original insight into the examined topic and create the general background for further, more detailed research. In particular, future research could be directed towards a more in-depth analysis of BR projects from the point of view of their original and target use. Such research could help show the significance of the effect of project categorization on *EBCR* and *ENPV*.

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Summary

Economic efficiency of brownfield regeneration: study of South Moravian projects. The objective of brownfield regeneration is to increase the attractiveness and value of individual sites to a level where they can compete directly with the construction of a greenfield project. The aim of this paper is to examine the economic efficiency of brownfield regeneration. By using CBA outputs, the contribution of socio-economic efficiency to the total efficiency of individual projects based on *EBCR* was investigated on the basis of a sample of 14 projects located in the South Moravian Region. Furthermore, the expected value of *EBCR* was simulated by using the Monte Carlo method. The results reveal that socio-economic efficiency contributes significantly to the overall efficiency of these projects and therefore cannot be neglected during their evaluation. At the end of the paper, future research directions in this area are outlined.

Streszczenie

Efektywność ekonomiczna rewitalizacji terenów poprzemysłowych na przykładzie południowomorawskich projektów. Rewitalizacja terenów poprzemysłowych służy zwiększeniu atrakcyjności i wartości poszczególnych działek do takiego poziomu, aby mogły konkurować z terenami wcześniej niezagospodarowanymi. Celem niniejszej publikacji jest zbadanie efektywności ekonomicznej rewitalizacji terenów poprzemysłowych. Wykorzystując CBA (cost–benefit analysis), obliczono udział efektywności społeczno-ekonomicznej w porównaniu z całkowitą efektywnością poszczególnych projektów z zastosowaniem *EBCR* na przykładzie 14 projektów zlokali-

zowanym w kraju południowomorawskim. Ponadto wartość oczekiwaną *EBCR* symulowano metodą Monte Carlo. Wyniki pokazują, że efektywność społeczno-ekonomiczna w znaczący sposób przyczynia się do ogólnej skuteczności tych projektów, a zatem nie można jej pomijać podczas ich oceny. Na końcu artykułu wskazano kierunku dalszych badań w tej dziedzinie.

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