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
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Article

The Impact of Brownfields on Residential Property Values in Post-Industrial Communities: A Study from the Eastern Part of the Czech Republic

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Abstract: Dilapidated, neglected, or abandoned sites and buildings (so-called brownfields) are frequently neither visually attractive nor aesthetically valuable. Indeed, neglected brownfields contribute to the emergence of both objective and subjective barriers to the social, economic, and environmental development of communities. We also know that the occurrence of decayed brownfields affect the prices of residential housing in their vicinity. In our paper, we seek to better understand the impact of brownfields on the perceived value of neighbouring properties. We are also keen to shed more light on the factors behind the allegedly undesirable impact of brownfields on property values. Our research is based primarily on data obtained from a survey of 1,152 respondents in ten municipalities situated at the eastern part of the Czech Republic, where neglected brownfields frequently occur. The findings are complemented by an analysis of sales of residential properties located in proximity to brownfield sites, to further confirm our preliminary survey results. The results confirmed that neglected brownfields tend to negatively affect the value of neighbouring residential properties. Our results also signal that the concentration of socially unacceptable behaviour is considered a key issue for distorting property prices around brownfields. Our analyses have confirmed that distance from a particular brownfield is one of the factors significantly influencing property prices. We claim that neglected brownfields create negative externalities that require public sector interventions and better planning. We urgently need more systematic support for brownfield regeneration to improve the quality of life of residents in affected communities.

Keywords: brownfields; property prices; perception of place; post-industrial regions; Central Europe



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1. Introduction

The occurrence of brownfields is undoubtedly a consequence of the manifestations of former anthropogenic activities in urban and rural landscapes. Our understanding of brownfield sites includes abandoned buildings and premises that no longer serve their purpose and are completely or partially unused. Alker et al. [1] or Yount [2] define a brownfield as the real estate property that is insufficiently utilized, neglected, and might also be contaminated. Many existing brownfields are the remains of former industrial, agricultural, military, transport, religious or community activities that lost their recent way of economic utilization [3,4]; yet, brownfields still form an integral part of urban and rural space, and thus must be seriously taken into account when planning development [5,6]. It is indisputable that brownfields are perceived as significant, yet a highly specific element of spatial planning in post-industrial communities [7]. To live or own a property in

the immediate neighbourhood of brownfield brings about its specifics, which are not always perceived positively. The occurrence of these sites is frequently related to plenty of undesirable effects followed by social, environmental, economic, health, or safety issues [1].

This paper is primarily focused on a more in-depth understanding of the impact of abandoned brownfield sites on the values of neighbouring properties. It is evident that the impact of brownfields on the price of neighbouring properties is variable and depends on the stage of the life cycle in which the particular brownfield is found. It is also without a doubt that neglected and abandoned properties or buildings have the potential to contribute to a reduction in the property prices in their neighbourhood. On the other hand, it may be assumed that brownfields intended for regeneration will be a driver for an increase in the neighbouring property value [8]. At the same time, even though the property may be located in the proximity to a brownfield, the crucial influence on its price lies in its central or peripheral location within communities or regions [9]. Provided that this influence is negative, it presents a negative externality for the owners of neighbouring properties, and consequently, the owner tends to reduce or remove such an externality [10]. Our findings thus represent a space for strong argumentation concerning the more thought-out and coherent public support of urban regeneration processes. We believe that positioning the public sector as a driving force for reducing and mitigating social-economic failures is consistent with its core mission. Support is urgently needed, especially in the post-communist space, where an unprecedented high incidence of abandoned brownfields significantly affects the quality of life and wellbeing of the population.

The aim of this paper is to deepen our knowledge and understanding of the attitudes towards the impact of neglected brownfields on the values of neighbouring properties. Additionally, we explore the willingness of the population to live in the neighbourhood of the brownfield sites. Our endeavour is to define the principal factors that determine this complex and multilayer relation. As model case study areas, post-industrial municipalities and cities in the eastern part of the Czech Republic were selected. The selection of the municipalities was based on a criterion that neglected abandoned brownfields are to be found within the settled parts of given municipalities.

This approach was in the latter stage confronted with the outcomes of analyses of changes in residential property prices in the proximity to selected brownfields. The analysis was fed by data from the residential property market. At this stage, we were interested in the effects of distance of the relevant property from the respective brownfield and in how the prices are changing in their neighbourhoods.

The paper is divided into the following chapters. After the chapter focused on the literature review reflecting the general situation of brownfields in Central Europe and the brownfield regeneration potential, we focus on the literature retrieval on the impact of brownfields on the value of neighbouring properties. In the next part, the methodology of the research is explained in detail and the data utilized for the research are presented. The following part of the paper presents the results of the findings from the survey and the analysis of real estate prices in the context of the localization of the selected brownfields. The final part summarizes the most fundamental findings resulting from the conducted research and critically discusses the topic of the impact of brownfields on the value of neighbouring properties in relation to other studies. Finally, several policy recommendations were defined.

2. Literature Review

2.1. Brownfields in Central Europe

In our understanding, non-regenerated brownfields are represented by neglected, and abandoned, as well as frequently technically fragile and aesthetically not-so-attractive buildings and sites of which the emergence constitutes a burden for the sustainable development of cities. At the same time, the insufficient utilisation of brownfields surely limits local entrepreneurial opportunities and thus, also reduces local development potential. It is without a doubt that the decision making of investors in brownfields is among other factors

also influenced by the visual aspect, attractiveness, and the aesthetics of the site. On the other hand, plenty of entrepreneurial opportunities are closely associated with the potential given by the location of brownfields [11]. We urgently need to identify the driving forces of the occurrence of abandoned brownfields within economic, social, and environmental factors that are embedded in sectoral changes and cycles of economic activities. This is especially true in post-communist Central Europe, where a dramatic economic transformation has been experienced since the 1990s [12–15] and caused the occurrence of plentiful brownfields of various types.

In addition, the expulsion of the Germans, the political changes after the Second World War, and the subsequent nationalisation of land under the communist regime led to uncertainty with land ownership in the early 1990s [16]. The decline of entire sectors of the economy and the regional concentration of uncompetitive state-owned industrial enterprises brought about the quick emergence of abandoned brownfield sites in this period. Consequently, numerous abandoned brownfields started to appear on the real estate market. The problem started to further expand in the middle of 1990s, when too many brownfield sites appeared on the market at the same time, and these could not be absorbed by the market [17]. In other words, an enormous number of brownfields simply stayed abandoned and unused, as investors did not find them attractive, and rather focused on greenfield developments. Additional driving forces emerged when the existence of regional or local concentrations of abandoned brownfields occurred. These clusters of brownfields were predominantly situated in highly industrialized regions and contribute to a situation, where a large number of brownfields competed for regeneration investment, making the brownfield situation even worse. As a result, abandoned and neglected brownfields can be detected in the post-industrial regions much longer than in other regions. It can surely be stated that brownfield sites represent a significant environmental, economic, and social issue in post-communist space. Whether the issue is solved or not reflects the social-cultural and economic maturity of these regions [18–20]. The regeneration of brownfields strengthens the ability to extend the life cycle of territorial units, respectively their recovery from the phase of decline and stagnation to the phase of development [21,22]. Brownfield regeneration in Central Europe belongs to the crucial tasks that urgently need to be addressed when planning the sustainable development of post-industrial regions.

2.2. Impact of Brownfields on the Value of Neighbouring Properties

One of the many impacts of neglected brownfields is their effect on the value of neighbouring properties. Plenty of studies have already focused on this topic and analysed the relation between the occurrence of brownfields and the impact on the value of residential properties located in their immediate neighbourhood [23–28]. In particular, we may mention the study [26], which analysed the value of more than 6800 properties in the City of Cincinnati (Ohio, USA) located within 2000 feet (about 610 m) from brownfields. They found out that the property value depreciated nearly by 0.1%, with each percent of the residential property being located nearer to the brownfield. Conversely, a one percent increase in distance from the closest brownfield corresponded to a nearly 0.1% increase in market value. The authors also pointed out that, with the overall decrease in the value of properties resulting from their proximity to brownfields, the city experiences a decrease in the property taxes (in their study, they quoted 2.2 million US dollars annually). With properties at a 2000-foot distance, the impact of brownfields on the property value started to be insignificant. Gibilaro et al. [28] claim, in their study, that the existence of brownfields has a negative impact on the property market, as it leads to a drop in demand for houses, flats, and other properties [29], and at the same time, it reduces the rental value. As a result, the owners of the affected properties are the unintentional recipients of the loss caused by this undesirable effect (a negative externality) and their rental revenues are lower than they could potentially be. Another highly relevant finding in their study reveals that the higher the number of brownfield sites in the district, the lower the property price. If abandoned and derelict brownfield sites are concentrated around the centre (in the ring of

0.5 km around the centre), an even stronger decrease in property prices is visible. Indeed, it seems that it is not only the proximity to one brownfield that can determine the value of its neighbouring properties, but also the number of abandoned sites in the neighbourhood.

De Sousa et al. [8] attempted to quantify the impact of brownfield on the property value using a reversed approach, i.e., by analysing the impact of brownfield regeneration on the property value of the neighbouring residential properties in Milwaukee (WI, USA) and Minneapolis (MN, USA). They discovered that, due to the redevelopment of neighbouring brownfields, the net housing prices increased by 11.4% and 2.7%, respectively. This finding can be supported by conclusions from the research [30] which stated that brownfield regeneration leads to housing price increases from 5.1% to 12.8%. Another study [31] claims that it is 5% to 15% for real estate; no more than three-quarters of a mile away from the brownfield site. A more recent study by Haniger et al. [32] proved that brownfield regeneration has a statistically significant and positive but highly localized effect on housing prices. The study reports that, after the regeneration and clean-up of brownfields, real estate value increased from 5% to 11.5%. This range falls within the range of estimated impacts (3% to 36%) based on multiple previous studies [26,33–36].

It is highly relevant to add at this point that if the cost–benefit analysis is applied [37], the benefits resulting from brownfield regeneration exceed the costs needed. This study also highlights that the general clean-up and regeneration of brownfield sites increased the value of the neighbouring housing and positively influenced the well-being of the local community [38].

It is not only the existence of a nearby brownfield itself that influences the value of neighbouring properties. According to the literature, it is predominantly the character of the local property market [39], the demand for other properties [40], or the way the inhabitants perceive particular localities [41]. Plenty of aforementioned studies also reflect the importance of the distance of relevant properties from brownfields, or the distance from the settlement core. Baxter and Lauria [42] draw our attention to the finding that a negative impact of brownfields on the average property value within the neighbourhood implicates a modification in the average income of the inhabitants (its decrease), or alternatively, a change in the social or cultural status of inhabitants in the relevant locality, as these properties will be traded at a cheaper price, or will be rented for less. This way, the properties will become more attractive for less affluent citizens who may gradually move into the area. The concentration of such groups of people may become deeper and stronger over a long course of time, and in an extreme case, it may give cause to the formation of the areas of poverty.

A psychological phenomenon that is employed by many studies on the perception of abandoned brownfields is the stigmatization of entire areas in which these sites are located. Coffin in his study [43] emphasises that concerns over brownfields result from a lack of information about the condition of the relevant site (its safety, contamination). Trouw et al. [44] and Chen et al. [45] prove such a hypothesis, and at the same time, they discuss the uncertainty related to brownfield regeneration projects that are reflected in the prices of the neighbouring properties, as well as in the brownfield itself. The stigma of the contamination and potential health issues can be removed only by intense communication with the locals and a consistent information campaign.

McCan [46] states that the spatial distribution of brownfields causes a decrease in the values of residential properties irrespective of the urban zone they are localized in (city centre, inner city or suburban zone). As you can see from Figure 1, it is typical for the bid–rent curve that its growing shape positively correlates with a growing distance from the hypothetical brownfield. Naturally, the bid–rent curve may be distinct in the proximity to brownfields, but nevertheless, its finding corresponds with other study results (please see [47]).

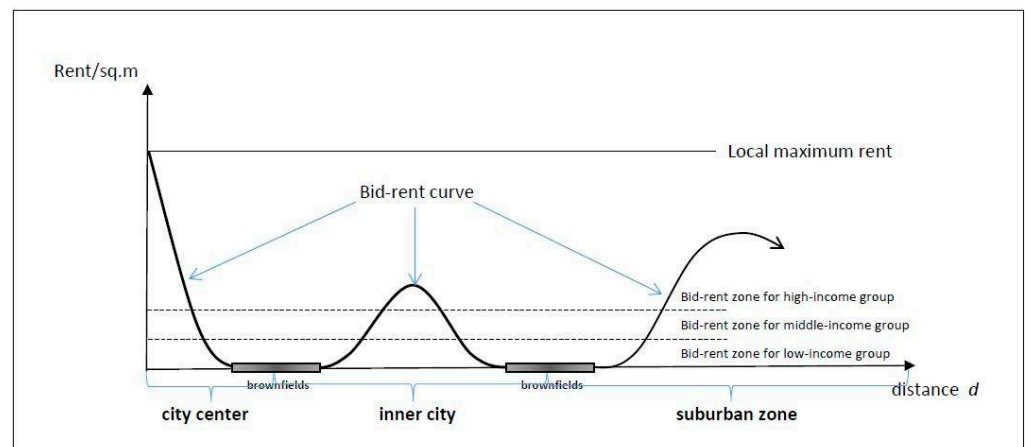


Figure 1. Hypothetical effects of brownfields on the bid–rent curve in urban space. Source: authors processing (inspired by McCaen [46], p. 128).

Property values in the brownfield neighbourhoods are determined by a wide range of additional internal and external factors and surely also by the uniqueness of the socio-cultural space around the individual brownfield. In general, it can be assumed that there is a negative correlation between the location of abandoned and dilapidated brownfields and the value of the neighbouring properties.

Indeed, the redevelopment of the brownfield site seems to be the right solution when dealing with the negative effects that brownfields usually generate in their neighbourhood. As most of these abandoned sites are located within urban areas, it is essential to regenerate in line with the sustainability principles (Brown [48] or Bartke and Schwarze [49]) and respect urban planning [5,50]. There is a significant opportunity for the public sector to intervene and support brownfield regeneration processes, as it has numerous essential preconditions at its disposal as financial resources, bargaining power, suitable tools and, in particular, motivation for action driven by the interests and attitudes of citizens [51,52]. The re-use and regeneration of brownfields enhance the quality of life, contribute towards the improvement of the environment, causes an increase in the value of the land [53], protect against unwanted urbanization effects [54], inhibit the undesirable development of the locality [55], weaken the interest in greenfields [56], or hinder socio-pathological phenomena (see Mihaescu and vom Hofe [26]). Moreover, the EU Cohesion Policy promotes an integrated development approach and the reuse of brownfield sites in preference of greenfields. In this context, brownfield regeneration can address health, ecological and economic threats from site contamination, and helps to cope with the rising population in urban areas and avoiding urban sprawl [57].

An element of microeconomic consumer theory is surely worth mentioning. It argues that the actual price of the property is not decisive at all, but instead, it is the perceived value that seems to be the key factor. This value can significantly differ from the actual price, and at the same time, the perceived value partly determines the objective property price [58]. Price is crucial for consumers when deciding on property value.

3. Methods and Data

The study on the impact of brownfields on the perceived value of neighbouring properties was carried out in two ways: (1) by collecting data through a questionnaire survey on the perceived impact of brownfield sites on neighbouring property prices; and (2) by analysing secondary data obtained from the local residential property markets to better understand specificities occurring in brownfield neighbourhoods.

The main objective of our research is to determine how brownfield sites influence the price of properties located in their vicinity, both subjectively by the inhabitants of the post-industrial communities and objectively, based on the analysis of the residential

property prices gathered from local real estate markets. The findings from the two above-mentioned streams of our research were contrasted to support and verify our assumptions. Additionally, a partial objective was to define the factors that have the greatest potential to affect the impact of brownfields on the price of neighbouring properties.

To operationalize our research, two hypotheses were defined.

Hypothesis 1 (H1). *In the proximity to brownfields (up to 100 m), the price of real estate tends to be reduced by 15%.*

Hypothesis 2 (H2). *The main explanation for the decrease in the price of real estate in brownfield neighbourhoods is the real or perceived contamination of brownfields.*

Hypothesis 1 (H1) was defined to reflect the key findings of the previous brownfield studies (please see Section 2.2). Hypothesis 2 (H2) principally refers to the most common definitions of brownfields, where real or perceived contamination is highlighted among the basic characteristics of these sites [1,2].

A survey was carried out in 10 post-industrial communities in the eastern part of the Czech Republic in the period between autumn 2017 and spring 2019. The communities for our survey were selected based on the following principles: (i) abandoned brownfield sites form an integral and at the same time visible section of the settled parts of the communities, (ii) local population is aware of these sites and brownfields constitute important development issue, (iii) there is an existing housing real estate market in the brownfield neighbourhoods (people are reflecting on how the proximity to brownfield sites affects the property prices). The sample included 1,152 people older than 18 years, specifically 158 successfully completed questionnaires in Karviná, 120 in Orlová, 69 in Dětmárovice, 50 in Stonava, 102 in Životice, 203 in Bohumín, 120 in Olomouc, 80 in Skrbeň, 100 in Studénka, and 150 questionnaires in Zlín. Altogether, 1800 people were asked to complete the questionnaire, which makes the rejection rate 64 %.

The questionnaire included 12 closed questions, out of which 6 were directly focused on the brownfield issue. We asked to what extent and what are the reasons behind the impacts of brownfields on the prices of properties. Further questions were focused on the basic characteristics of individual respondents, such as gender, age, education, and social status. The survey included 522 males (45%) and 630 females (55%). We aimed to gather a balanced sample of the population of all ten surveyed communities (please see Table 1 for the segmentation of our respondents). The respondents were selected randomly on the streets of the surveyed communities (every fifth person older than 18 years was asked to complete the questionnaire). It took no longer than 15 min to complete one questionnaire. All respondents were informed about the aim of the research and consent was given by all participants. The principle of anonymity of individual respondents was strictly applied. The collected data were transcribed, and a database of replies was created that was stored in an offline repository to prevent any misuse.

The evaluation of the survey was conducted in the SPSS software. We applied the correlation analysis (Pearson correlation analysis, [59]) to explore mutual relations between responses of respondents and their segmentation.

The second research study was focused on monitoring the development in the prices of the real estate properties (specifically houses and flats) in the proximity to brownfields. This part of our research was conducted between September 2017 and May 2019. Seven quarterly periods were covered (namely autumn 2017, winter 2018, spring 2018, summer 2018, autumn 2018, winter 2019, and spring 2019). This part of our research was carried out in four post-industrial communities (Brno, Zlín, Olomouc, and Karviná). The total number of observations of individual prices exceeded the number 7500. We were specifically interested in the price recalculated to square metres (CZK per square meter) of the properties located in the immediate proximity to brownfield (up to 100 metres) and of the properties located at 450–550 metres distance (zones between 100 and 450 metres were not taken

into consideration). In the immediate proximity to brownfields (up to 100 m), 144 real estate properties were included in the analysis, whereas in the distance of 450–550 metres, 876 real estates were analysed. The real estate website www.ceskereality.cz was the source of the property prices. Brownfields whose neighbourhoods were analysed, were selected to be as similar as possible concerning their size, current condition, and the location within the community. Unfortunately, just in the case of four out of the originally ten surveyed communities, a sufficient number of advertised real estate properties were detected to enable reasonable analysis.

Table 1. Basic segmentation of respondents from surveys in 10 municipalities.

Variable/Municipality/Number of Questionnaires		Karviná	Orlová	Dětmarovice	Olomouc	Skrbeň	Stonava	Životice	Studénka	Bohumín	Zlín	Total	
		158	120	69	120	80	50	102	100	203	150	1152	100%
Gender	Female	80	46	42	49	35	22	40	44	93	71	522	45%
	Male	78	74	27	71	45	28	62	56	110	79	630	55%
Age	18–25 years	24	16	15	38	40	4	6	21	28	40	232	20%
	26–45 years	72	61	33	47	25	19	57	41	100	72	527	46%
	46–65 years	52	36	17	25	15	17	26	22	62	26	298	26%
	65 and over	10	7	4	10	0	10	13	16	13	12	95	8%
Education	Elementary	7	8	5	14	5	3	11	14	23	0	90	8%
	Secondary without final exam	38	20	16	42	14	19	29	25	49	15	267	23%
	Secondary with final exam	89	68	36	44	55	25	47	43	116	88	611	53%
	Tertiary	24	24	12	19	6	3	15	18	15	47	184	16%
Social status	Employees	95	63	41	52	40	24	26	52	124	76	593	51%
	Students	14	10	9	31	25	4	20	10	34	52	209	18%
	Entrepreneurs	19	6	7	5	0	3	24	7	17	14	102	9%
	Unemployed	4	9	1	5	0	0	9	8	0	3	39	3%
	Retired persons	19	22	7	11	0	15	15	15	19	0	123	11%
	Persons on maternal/parental leave	7	10	4	17	15	4	8	8	9	5	87	8%

Source: survey (n = 1152).

In Brno, an abandoned site of ABB EJF factors was selected for our research, located between Sportovní and Poděbrady Street, with former engineering sites that had been demolished in 2011 (production buildings, warehouses, offices). The site is officially declared to be without any ecological burden; minor self-seeding trees and shrubs can be found here. In Zlín, a brownfield located in the Jižní Svahy city district met our criteria. There used to be an unfinished shopping centre which was subsequently removed, and the site was left unused. Karviná is represented by a brownfield site of a former Kovona in Karviná Hranice city district, which used to be located in wireworks, screw works, and a carriage factory, and eventually a manufacturing factory for components in the construction industry. In 2004, the site was abandoned, and in 2012, unutilized buildings were demolished, and the rubble was removed. The site is currently overgrown by self-seeding plants and trees and is unused. The final city involved in the secondary research is Olomouc. Here, three brownfields were researched, of which only one was already regenerated. The choice of three brownfields—two of them unused and one of them regenerated—in one city was deliberate, as we aimed to prove how the price of the neighbouring properties of two abandoned sites in one city reacts and at the same time, what is the situation at the property market in the proximity to already regenerated brownfield. In order to perform the comparison, an assumption was made that the regenerated brownfield will not have any negative impact on the price of neighbouring residential buildings, unlike with non-regenerated brownfields, where this was expected. The first non-regenerated site in Olomouc is a former military repair factory (VOP) located in the proximity to the city centre. The buildings and halls of this site were demolished in 2016. The second site in Olomouc is a former military warehouse in the Nové Sady city district. The only regenerated brownfield covered by our research is Gallery Šantovka, a former food processing factory Milo Olomouc. New housing and administration units are continuously being developed

within this shopping centre. An overview of the selected characteristics of the analysed brownfields is shown in Table 2.

Table 2. Basic characteristics of the brownfields whose neighbourhoods were selected for our research.

Municipality/Characteristics of Brownfield	Brownfield	Area [m ²]	Ownership	Previous Use
Brno	Former area of ABB factory	52,700	Private	Industrial
Zlín	Unfinished shopping centre	53,200	Public	Civic amenities
Karviná	Abandoned part of the former Kovona	122,000	Private	Industrial
Olomouc	Former military repair factory	125,000	Private	Military
Olomouc	Former military warehouse	170,000	Private	Military
Olomouc	Former food factory Milo (Šantovka)	24,000	Private	Industrial

Source: authors' processing.

4. Results

4.1. Respondents' Attitudes to the Impacts of Brownfields on the Value of Neighbouring Properties

The first section of our primary research conclusions relates to the respondents' willingness to live in the neighbourhood of an abandoned and unutilised brownfield site. A total of 852 respondents (74%) do mind living in the proximity to brownfields, even though 743 respondents, i.e., 64%, actually live within half of a kilometre. This implies that, even if people do not have direct personal experience with living in the proximity to a brownfield, they still perceive its negative impacts on the quality of life. This statement is obvious from Figure 2, as only in three municipalities (Orlová, Studénka and Skrbeň) are people more responsive to living in the proximity to brownfields. The graphical projection (Figure 2) shows that, as regards the willingness of living in the proximity to brownfields, the respondents from various localities share a similar opinion. The individual opinions within the answer "yes" oscillated between 63% and 94%.

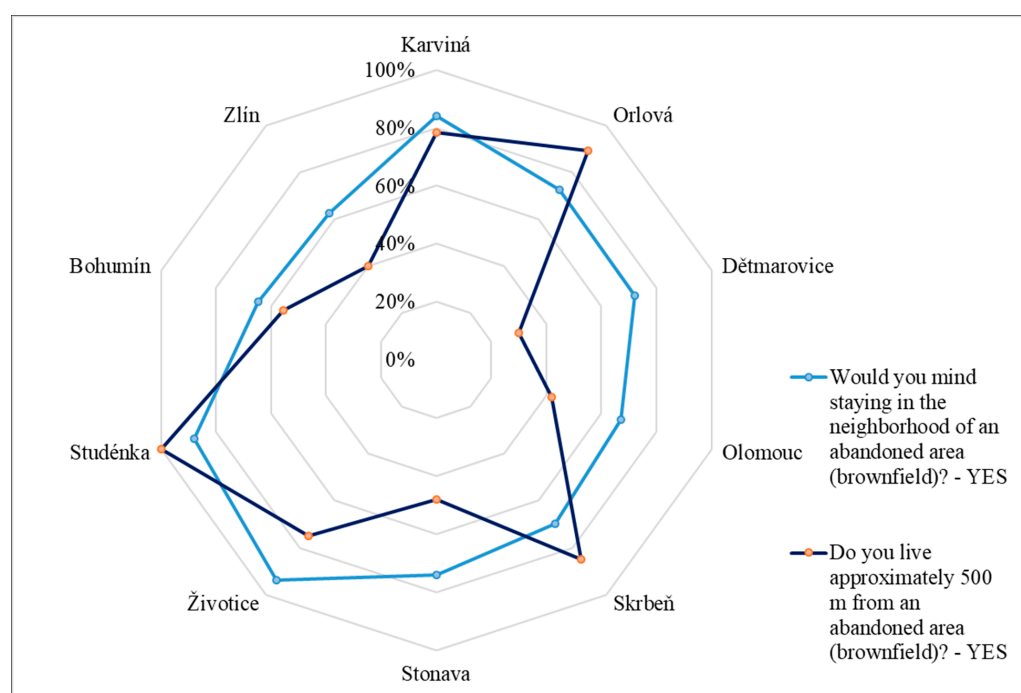


Figure 2. The actual situation and willingness to live in the neighbourhood of brownfields in 10 surveyed communities. Source: own survey (n = 1152). Note: original data are presented in Appendix A.

The following figure (Figure 3) refers to the issue of how brownfields influence the prices of neighbouring properties from the point of view of the respondents in two different ways. The first information is that 801 respondents (69.5%) would not buy a property in an immediate neighbourhood of a brownfield (up to 100 m), even if its price was 20% lower than the usual price for the locality and the period. In total, 351 respondents (30%) would theoretically make such a purchase. Another inquiry was focused on understanding the level of reduction in the price of property that are expected in the proximity to a brownfield. More than one-fifth of respondents (22%) believe that the occurrence of brownfields reduces the property value by more than 50%, while 32% of the respondents assume a reduction between 10% and 50%. A price reduction of less than 10% was expected by 31%. Only 14% of the respondents (160) do not agree with the suggestion that abandoned brownfield sites influence the price of the neighbouring properties. After summarizing all these partial results, we can say that 86% of the respondents (992) unanimously agree (using a weighted arithmetic mean) that abandoned brownfields have a negative impact on the value of neighbouring properties (on average by 27%).

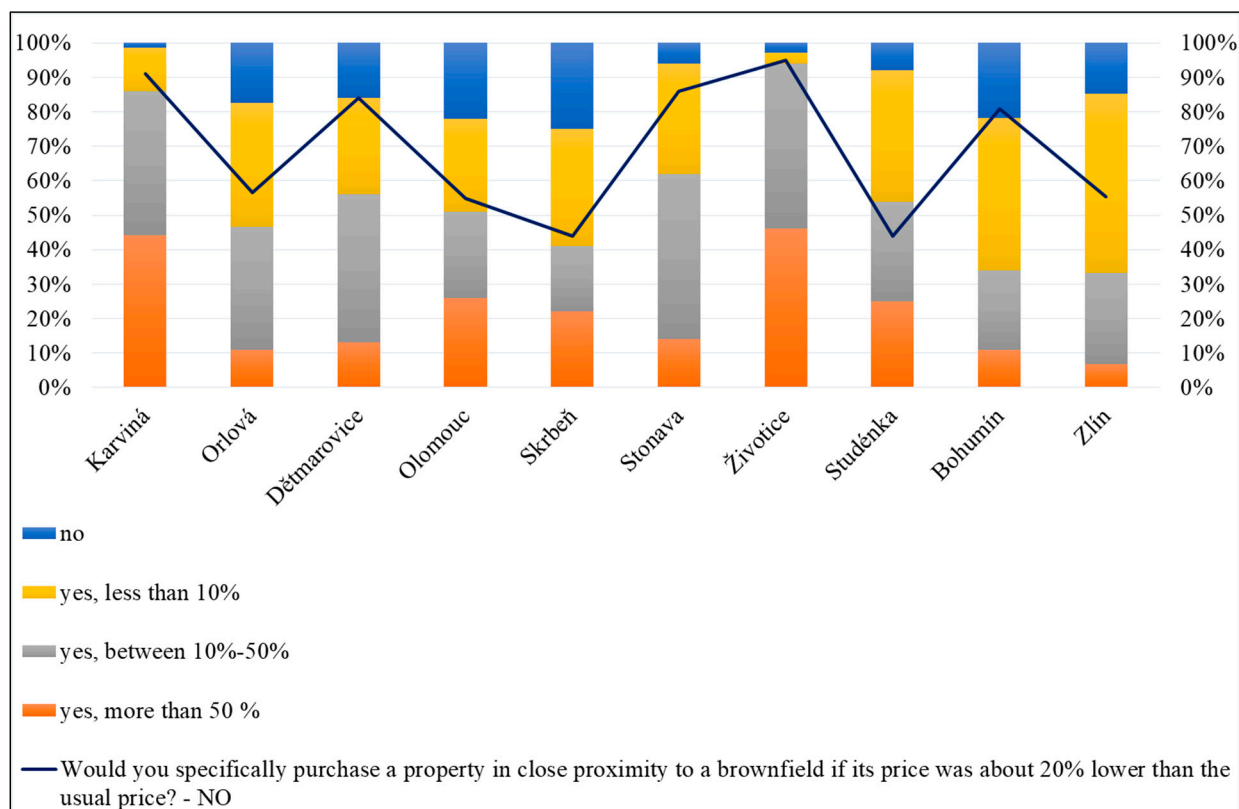


Figure 3. Respondents' attitudes to the influence of brownfields on the price of neighbouring real estate. Source: own survey (n = 1152).

The abovementioned attitudes of respondents to the replies could not be correlated with any particular group of respondents. It seems that these findings are independent of age, sex, occupation, education, and type of housing, and independent of type and size of the municipality where the survey was implemented. The only dependence across the answers can be detected with the combination of the question on a property purchase at a lower price and the locality where the survey was implemented. The respondents from Olomouc, Skrbeň, Studénka, and Zlín would be more interested in the purchase of the concessionary property compared to the respondents of other surveyed communities (approximately by one-third).

The reasons for negative attitudes towards brownfields, as far as the influence on the price of the neighbouring properties is concerned, can be observed in Figure 4. Here, the

partial results for individual communities are shown, and an average value is assigned to the defined factors presented. The respondents could select from six predefined options, assigning each one value at a scale from 1 to 6, with the value 1 being the “key—the most fundamental”, while the value 6 is “insignificant”. Taking into account the number of answers and their weight, a certain significance in percentage was assigned to each option. The following options represent the reasons chosen by the respondents: (1) the brownfield is usually dangerous as far as its construction and technical condition are concerned; (2) there is no certain future use of the brownfield; (3) the brownfield is aesthetically unsightly; (4) the brownfield is dangerous due to the possible contamination and pollution that threatens health; (5) the brownfield blocks the development of the city, and finally (6) social-pathological phenomena are concentrated in the brownfield.

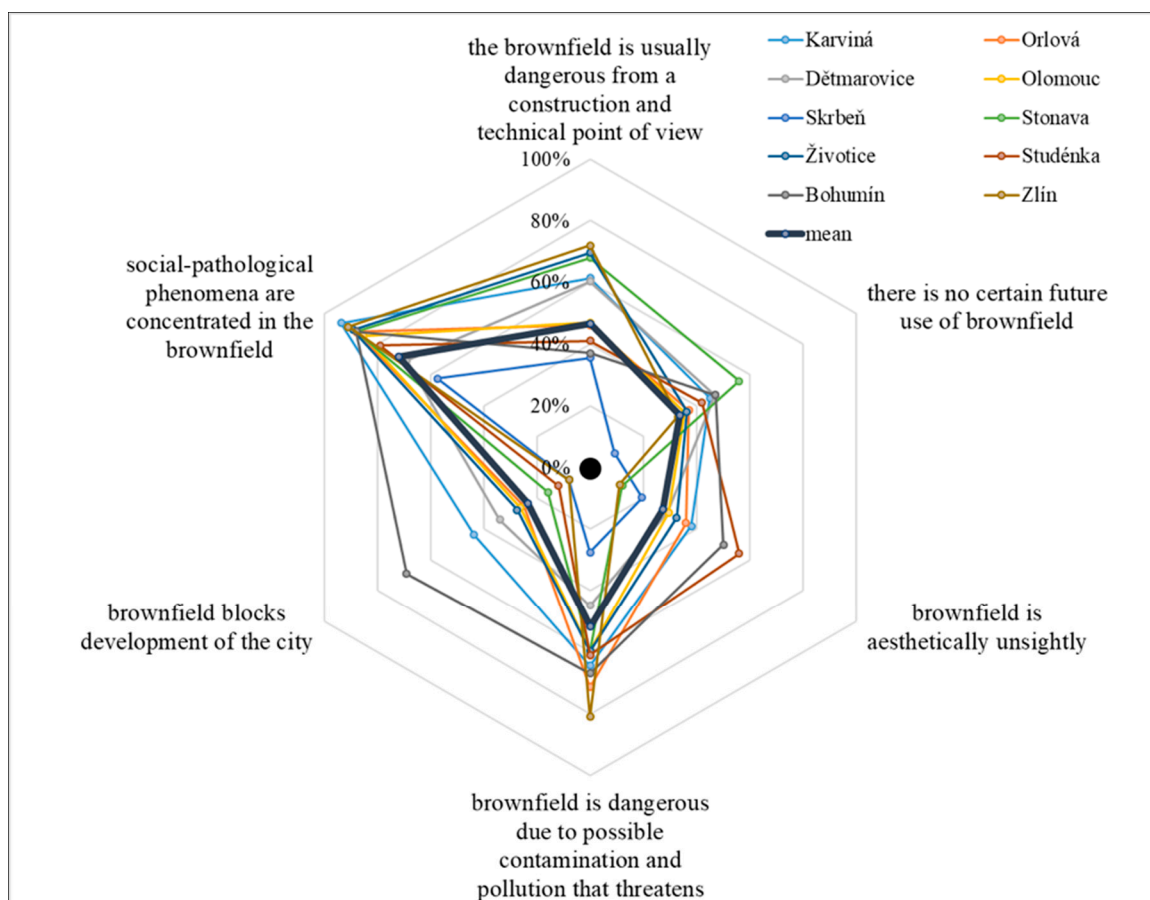


Figure 4. Reasons why brownfields have a significant influence on the property values. Source: own survey (n = 1152).

The majority of the respondents (72%; 829 answers) believe that an abandoned site is problematic and dangerous (and thus reducing the value of a neighbouring property) due to the concentration of socially unacceptable behaviour, such as drug dealing, vandalism, etc. The second most frequent argument expressing the negative impact of brownfields on the prices of neighbouring properties (52%; 597) is the threat and harmfulness of such a site as far as the potential soil contamination along with general contamination of soil and buildings is concerned. This issue truly seems to represent a danger to the inhabitants residing in the proximity to an abandoned brownfield site. The level of the redevelopment of these sites is largely a relative minor issue and considerably uncertain. A factor that is similarly compelling (assessed positively in 47%; 538) is the risk that brownfields are usually dangerous due to their constructional and technical aspects, and are poorly secured against the breaking and entering of third parties. In other words, there is a risk of injury

related to poor building statics, the disrupted structure of buildings, the disruption of the stepping surface (paving), and considerably desolated condition due to neglected maintenance, corrosion, and other issues.

Another potential reason why brownfields have a negative influence on the value of neighbouring properties is the uncertainty associated with the future use of an abandoned brownfield site (with 34%; 388 answers), as there is no certainty of what exactly will be built in the locality and in what way the site will be used in future. Just 27% of the respondents (313) associate the lower property prices in the proximity to brownfields with the aesthetics of these sites. These abandoned and underused buildings are unsightly, with chipped plaster, and are ruined, overgrown with weeds, covered with graffiti, etc. The smallest number of respondents (23%; 269) perceive the negative aspect of the existence of brownfields in the fact that the further development of the city is limited. The potential for the contemporary and future development of the city to be positively perceived is low and reduces the demand for living in such a city, indirectly reducing the value of the intangible property of its inhabitants.

The last presented finding for a survey is represented by the respondents' replies to the question of whether and at what distance from the existing brownfield they would consider buying a new property. Overall, 23% of the respondents (262) would buy a property in the neighbourhood of a brownfield, of which 164 respondents (14%) would only buy it provided the brownfield could not be seen from their property. In contrast, 77% (890) of the respondents would not buy a property in the proximity to the brownfield. Furthermore, 17% of the respondents would change their opinion provided that the property is at 100–200 metres distance from the brownfield, 27% of the respondents on condition that the distance is between 200 and 500 metres, and 33% of the respondents would buy the property only on condition that it is located at more than 500 metres distance from the brownfield. The respondents' replies based on the municipalities are demonstrated in Figure 5. The answers do not correlate with the size of the municipality but with its location within the region. Respondents who are more benevolent concerning the property purchase in the neighbourhood of brownfields are from Olomouc, Skrbeň, or Zlín, which are all municipalities outside the Moravian-Silesian Region (Silesia). This can be explained by the long-term concentration of heavy industry in this region and the large quantity of mainly industrial brownfields that are typical for their large area and size. Moreover, the Moravian-Silesian Region is characterized by above-average unemployment and an incidence of socio-pathological phenomena. As a result, this region shows a more critical attitude towards the existence of abandoned sites and buildings.

The next step was based on the findings from the correlation analysis that we use to detect additional relevant coherences. The key findings can be summarised in the following points: (1) inhabitants who live in proximity to brownfields (not more than 500 m or 5 min walking distance) realise their negative impact on properties; (2) inhabitants who live in proximity to the brownfield are bothered by this effect; (3) when considering a real estate purchase, the proximity to brownfields taken into account if the price was lower by 20%; (4) inhabitants would oppose living in proximity to brownfields and they would consider this fact when deciding on the purchase of real estate (5) inhabitants younger than 65 years are bothered the most to live in the brownfield neighbourhoods and are the most aware of a negative impact of brownfields on neighbouring real estate properties. The results of the correlation analysis are summarised in Table 3.

For all five above-mentioned statements, we detected the high values of the correlation coefficient. This finding indicates the high relation between analysed data and confirms the causality.

The first statement (see Table 3) was confirmed in 84.7% of cases. These are primarily inhabitants who have everyday experience with life in proximity to brownfields. These people realise a negative impact of brownfields on the price of neighbouring properties.

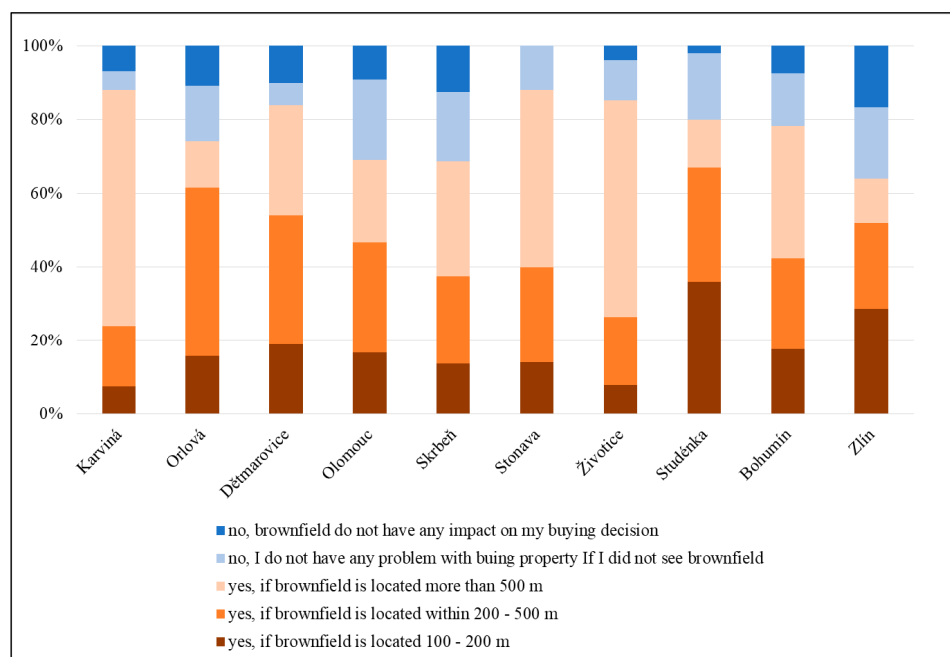


Figure 5. Influence of distance of brownfields on real estate purchase behaviour of respondents. Source: own survey (n = 1152).

Table 3. Pearson correlation coefficient values calculated for the statements in the survey.

Statement no 1	Inhabitants who live in the proximity to brownfields and realise their negative impact on neighbouring real estate.	0.8470
Statement no 2	Inhabitants who live in proximity to brownfields and are bothered by this fact.	0.7626
Statement no 3	Inhabitants who considered proximity to brownfield when purchasing their real estate (if the price was lower by 20%).	0.9473
Statement no 4	Inhabitants would be bothered by living in the brownfield neighbourhood. The occurrence of brownfields would be a factor when thinking about purchasing real estate.	0.9622
Statement no 5	Inhabitants younger than 65 years are the most bothered by living in proximity to brownfields, and at the same time, they acknowledge the negative impact of brownfields on neighbouring real estate.	0.9395

More than three quarters of the respondents (76.3%) who live in proximity to brownfields, are bothered by this fact. These people would prefer not to live in the brownfield neighbourhoods, as they feel undesirable externality impacts (for more see [60] or [61]). A negative attitude towards living in proximity to brownfields can also be confirmed by other relations: almost 95% of respondents to our survey expressed that the occurrence of brownfield would be a decisive factor when thinking about the purchase (even if it was lower by 20% than usual). Similarly, 96% of respondents are bothered by living in brownfield neighbourhoods. When considering a purchase of real estate, the proximity to brownfields is seriously considered. It seems that the inhabitants younger than 65 years (94%) have more distinct and negative opinions about living in proximity to brownfields (in the case of people older than 65 years old, the attitude was not so strong (51%), as well as in the case of the younger population (26%)). An interesting finding was also revealed in the case of unemployed people (20%).

If we conclude the results of the primary research, then we can state that, for 74% of respondents, living in proximity (up to 100 m) to brownfield presents a problem, and 70% of the respondents would not buy a property even if the price was 20% lower than is the common price for the relevant locality, and at the same time, only 9% of the respondents do not perceive living in the proximity to brownfields as a problem. Only 14% of the respondents believe that the proximity to brownfields does not influence the price of the neighbouring properties. The rest of the 86% of the respondents claim that the localization of brownfields negatively influences the price of the neighbouring properties, reducing their value by 27.1% on average, the reason mainly (in 72%) being that socio-pathological phenomena are concentrated in these abandoned sites and buildings. With reference to the above, the established hypotheses can be evaluated: H1 (the proximity to brownfields (up to 100 m) reduces the price of real estate by 15%) is not rejected, and the hypothesis is accepted. The second hypothesis (H2) was defined as follows: the reason why brownfields reduce the price of surrounding properties is their contamination. H2 is rejected.

4.2. Analysis of Real Estate Prices in the Context of the Localization of the Selected Brownfields

The second research study based on the secondary data from the property market was performed in order to (1) find the objective picture of the property prices and their localization in relation to brownfields, and at the same time, (2) to verify the discrepancy between reality and the subjective opinions of the respondents on the same issue.

Table 4 summarizes the average price of properties during seven periods of time in CZK per square metre in relation to the distance of the marketed properties from brownfields. In 94%, the price of the properties at 100 metres distance from abandoned brownfield was lower than that of those located at 500 metres distance from brownfields. This confirms our assumption that properties located in the proximity to abandoned brownfields are of a lower value than those located at a greater distance. Based on the obtained data, it was found that the prices of the properties located at 500 metres distance from non-regenerated brownfields are 17% higher than those located at 100 metres distance. It seems that the property price (of marketed real estate) increases objectively with an increasing distance from the abandoned brownfield. With the regenerated brownfield of Gallery Šantovka, the situation was reversed, even though the available data are only for one group of observations (summer 2018). The logical implication here is that a properly regenerated brownfield makes the locality even more attractive, and the value of neighbouring properties reflects this reality (in our case, the property price in proximity to regenerated brownfields is higher, by 3.4%). The aforementioned statements are evident in Figure 6, where average property prices in CZK/m² are displayed for the whole monitored period and for individual brownfields.

Table 4. The average price of real estate (in CZK/m²) according to the distance from the analysed brownfield.

Time Period/Distance/Brownfield	Autumn 2017		Winter 2018		Spring 2018		Summer 2018	
	100 m	500 m	100 m	500 m	100 m	500 m	100 m	500 m
Brno—Former area ABB EJF	49,286	57,646	49,265	64,726	53,359	60,925	49,276	54,198
Zlín—Former unfinished shopping mall	30,665	32,716	34,033	38,455	34,872	38,917	32,926	36,407
Karviná—Abandoned part of the former Kovona	9836	11,834	10,841	10,946	10,298	11,069	10,384	10,540

Table 4. Cont.

Olomouc—Former VOP	-	41,314	42,412	39,372	42,087	44,312	37,856	42,502
Olomouc—Former military warehouses	42,224	47,333	42,421	40,648	34,833	82,353	-	44,296
Olomouc—Gallery Šantovka (regenerated brownfield)	-	46,244	-	43,695	-	47,679	42,793	41,350
Time period/distance/brownfield	Autumn 2018		Winter 2019		Spring 2019		Mean	
	100 m	500 m	100 m	100 m	500 m	100 m	500 m	100 m
Brno—Former area ABB EJF	45,640	55,950	47,980	53,898	52,912	65,533	49,674	58,982
Zlín—Former frame	33,276	34,139	32,191	35,483	38,655	39,184	33,803	36,472
Karviná—Abandoned part of the former Kovona	10,953	12,215	10,238	11,389	9653	12,247	10,315	11,463
Olomouc—Former VOP	37,414	39,251	41,860	43,695	43,526	44,961	35,022	42,201
Olomouc—Former military warehouses	40,323	63,415	43,899	44,839	40,684	43,476	34,912	52,337
Olomouc—Gallery Šantovka (regenerated brownfield)	-	69,966	-	40,954	-	47,290	42,793	41,350

Source: own processing based on www.ceskereality.cz (2017–2019). Note ¹: data are graphically presented in Appendix B.

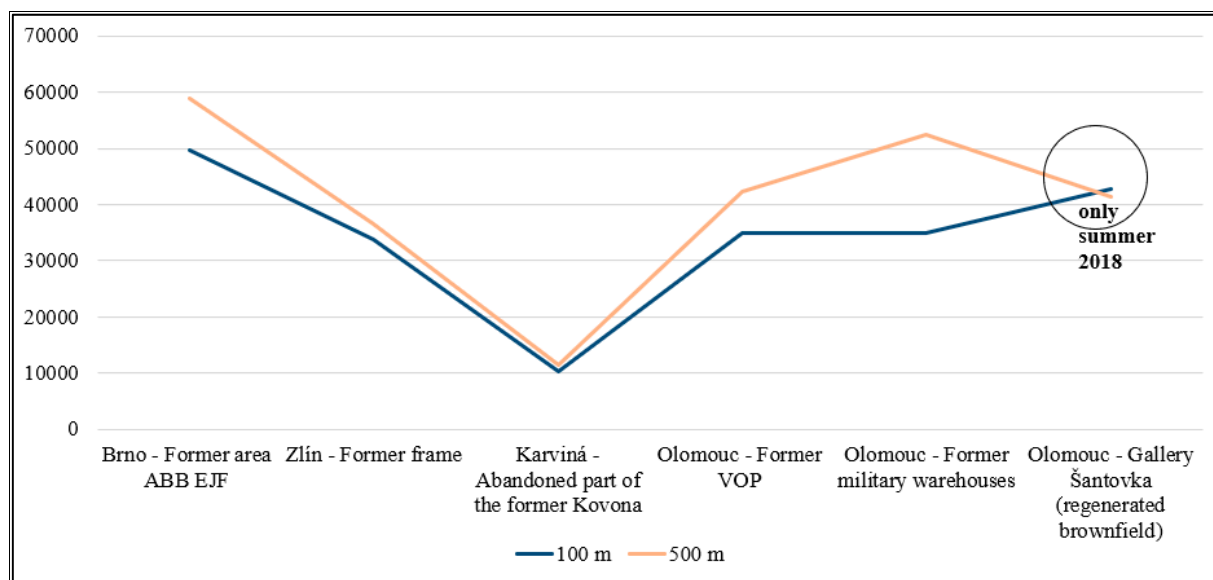


Figure 6. Average real estate prices (in CZK/m²) in the neighbourhoods of the surveyed brownfields. Source: own proceeding-based data from www.ceskereality.cz (accessed between 4 February 2017 and 7 December 2019).

5. Discussion

It is well known that the location of a house, flat, or estate is highly important for the prospective buyer or the current owner, and it is among the key factors that determine the value of the relevant property. In this contribution, we were investigating the impact of brownfield sites on the prices of properties located in their proximity.

Our study on the impact of brownfields on the price of neighbouring properties confirmed that brownfields truly reduce (devalue) property value in their neighbourhood (please see, for example, Bond and Cook [62]). Primary (4.1) and secondary (4.2) research performed in the selected municipalities and regions of the Czech Republic proved analogous findings that had already been detected in numerous studies ([26]: Cincinnati, Ohio; [28]: Milan; [8]: Milwaukee and Minneapolis [18], New Jersey; [34]: Illinois; [63], Atlanta and Cleveland [40]: Chicago). However, such studies on Central European towns

and cities are still quite rare. We are filling this gap. In other words, our study thus broadens the portfolio of the current brownfield research related to the issue of their impact on the price of neighbouring properties and promotes its relevance. Moreover, we are adding the knowledge of specific regional and local contexts in Central Europe which are inevitable for a better understanding of the factors and specificities behind the change in property prices in brownfield neighbourhoods.

The concrete findings of the research performed in the selected regions of the Czech Republic also reflect the results of the abovementioned studies through which we can demonstrate their relevance and substantiality. Our survey revealed that 86% of the respondents believe that brownfields significantly reduce the value of neighbouring properties. For a 100-m zone around brownfields, it was believed that reductions in the price are more than one quarter on average. This conclusion correlates with further a finding that states that 70% of the respondents would not buy a property in proximity to a brownfield, even if it was cheaper by 20% compared to the usual price. We can say that the ascertained average value corresponds with the generally accepted price reduction interval between 3% and 36% (please see Section 2.2 for a more in-depth view of previous studies).

At the same time, we detected that the main cause of the unwillingness to live in the vicinity of brownfields or buy a property here at a real price is the fact that, in these abandoned and underused sites, socio-pathological phenomena are concentrated. It is thus supposed that the quality of life and wellbeing in brownfield neighbourhoods are reduced. This finding is in line with results from the seminal study by Watkins [64]. By employing the analysis of a residential property market in non-regenerated brownfield neighbourhoods, we also found out that the prices are higher by 17% in a 500-m distance from the brownfield than in a 100-m distance. This finding proves distance as a key factor when forming residential prices around brownfields, and is also in line with previous studies.

In contrary, the value of properties in the neighbourhood of a regenerated brownfield was higher by 3.4% than in locations without any brownfields. Provided we apply this result from the conclusion of a study by Mihaescu and vom Hofe [26], our result can be objectively defended. However, we must recalculate their results for our purposes, as their results are different for properties that are located at different distances from brownfields: reducing the distance from 1000 to 0 feet, the residential property values decrease by 21.93%, while the distance from 1000 to 900 feet devalues a property by 0.76% (this value was applied with a recalculation at the distance over 1000 feet). When converted to percentage and distance, the property value at a 500 metres distance from the brownfield should be approximately higher by 13.4% than the value of the property located at a 100 metres distance. In our case, the property value was higher by 17% on average, and after excluding the extreme values of Olomouc, it was higher by 12.5%.

Finally, we discovered that a regenerated brownfield raised the price of properties located within a 500 metres distance by 3.4%. Similar results were confirmed by the study by De Sousa et al. [8] performed in Minneapolis (2.7%); other studies quote a higher bottom value of dispersion (e.g., [30], quote the value of 5.1%).

The results of our research should predominantly support or accelerate the public, or more precisely, the private sector in the area of support of sustainable brownfield regeneration processes, as a range of undesirable effects are connected with their occurrence. In our case, this directly and specifically concerns the reduction of both objective and subjective wealth of the property owners, including the reduction of the quality of life in the vicinity of brownfields, reduction in property tax income or personal income from the sale of such properties, and undesirable discrepancies in the property market. Indirectly, we may argue that by failing to look for the solution to this issue, it may result in gentrification, resettlement, cultural and social transitions, a local economic slump, and social exclusion of the relevant locality ([38]). We may add that, regarding the arguments that support the adoption of the strategies for regeneration processes, it is essential to reflect the location of brownfields [65] within the area of cities or municipalities (city centre, inner city, suburban zone) (see McCan [46]), and at the same time, within the city and countryside [66].

Finally, as brownfields may be considered to be a hindrance or a threat to the future development of localities and an urban hindrance to the development of human settlements (Ganser and Williams [67] or Pacione [68]), at the same time, they can be regarded as a potential opportunity for increasing the property value (Adams et al. [69]). The argument that regenerated and utilized sites contribute to the increase in the prices of the neighbouring properties is highly relevant. A systematic brownfield regeneration undoubtedly contributes towards the improvement of the quality of life [70], increase in the value of the area, and the support of local development. It is without a doubt that the brownfield regeneration is topical, socially desirable, and essential [71–73], and can be seen as an innovation of the territorial product [21,74].

6. Conclusions

The objective of the paper was to ascertain how brownfields affect the price of properties located in their neighbourhoods. We focused on the post-industrial communities situated in the eastern part of the Czech Republic. Two research streams were applied to enable a more in-depth understanding of the topic. The survey was conducted in ten communities, where brownfield sites are visibly represented and an analysis of changing prices of real estate in the brownfield vicinity was carried out.

We defined two hypotheses. With Hypothesis 1, we expected that, in the proximity to brownfields (up to 100 m), the price of real estate tends to be reduced by 15%. This assumption was based on a set of previous studies. We found in our cases that the price was on average reduced by 17% in the immediate proximity to brownfields. Hypothesis 1 (H1) was rejected. With Hypothesis 2 (H2), we searched for the reason behind the decrease in the price of real estate in brownfield neighbourhoods. We suppose that the main reason is the real or perceived contamination of these sites. This hypothesis was confirmed.

The key findings of our research include the following pieces of knowledge: (1) inhabitants who live in proximity to brownfields (not more than 500 m or 5 min walking distance) realize their negative impact on properties; (2) inhabitants who live in proximity to brownfield are bothered by this effect; (3) when considering a real estate purchase, the proximity to brownfields taken into account if the price was lower by 20%; (4) inhabitants would oppose living in proximity to brownfields and they would consider this fact when making a decision about the purchase of real estate (5) inhabitants younger than 65 years are the most bothered about living in the brownfield neighbourhoods, and are the most aware of a negative impact of brownfields on neighbouring real estates.

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Appendix A. Data

Table A1. Data tables for selected graphs.

Municipality/Questionnaire Response		Karviná	Orlová	Dětmorovice	Olomouc	Skrbeň	Stonava	Životice	Studénka	Bohumín	Zlín	Respondents	Mean
Would you mind staying in the neighbourhood of an abandoned area (brownfield)?—YES		84%	73%	72%	67%	70%	74%	94%	88%	65%	63%	852	74%
Do you live approximately 500 m from an abandoned area (brownfield)?—YES		78%	89%	30%	42%	85%	48%	75%	100%	56%	40%	743	64%
Would you specifically purchase a property in close proximity to a brownfield if its price was about 20% lower than the usual price?—NO		91%	57%	84%	55%	44%	86%	95%	44%	81%	55%	801	70%
In general, you think that brownfields reduce the value of the surrounding properties?	yes, less than 10%	13%	36%	28%	27%	34%	32%	3%	38%	44%	52%	367	32%
	yes, between 10%–50%	42%	36%	43%	25%	19%	48%	48%	29%	23%	27%	373	32%
	yes, more than 50 %	44%	11%	13%	26%	22%	14%	46%	25%	11%	7%	252	22%
	No	1%	17%	16%	22%	25%	6%	3%	8%	22%	15%	160	14%
From what distance from brownfields would you be willing to buy a property?	100–200 m	8%	16%	19%	17%	14%	14%	8%	36%	18%	29%	205	17%
	200–500 m	16%	46%	35%	30%	24%	26%	19%	31%	25%	23%	308	27%
	more than 500 m	64%	13%	30%	23%	31%	48%	59%	13%	36%	12%	377	33%
	no, if I did not see brownfield	5%	15%	6%	22%	19%	12%	11%	18%	14%	19%	164	14%
	no, without any conditions	7%	11%	10%	9%	13%	0%	4%	2%	7%	17%	98	9%
Determine the reasons why the proximity to brownfields negatively affects the value of real estate?	brownfield is usually dangerous from a construction and technical point of view	61%	46%	60%	47%	36%	68%	70%	41%	37%	72%	538	47%
	there is no certain future use of them	45%	37%	47%	36%	9%	56%	36%	42%	47%	33%	388	34%
	brownfield is aesthetically unsightly	38%	36%	29%	30%	20%	12%	32%	56%	50%	11%	313	27%
	brownfield is dangerous due to possible contamination and pollution that threatens health	65%	71%	45%	60%	28%	60%	60%	61%	67%	81%	597	52%
	brownfield blocks development of the city	44%	25%	34%	26%	8%	16%	28%	12%	69%	8%	269	23%
social-pathological phenomena are concentrated in the brownfield		94%	88%	69%	85%	58%	88%	89%	79%	88%	91%	829	72%

Appendix B



Figure A1. Property prices near brownfields by distance and period (in CZK/m²). Source: own proceeding based on www.ceskereality.cz (accessed between 4 February 2017 and 7 December 2019).

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