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HOW PERMITTING PROCESS LENGTH INFUENCES DEVELOPMENT COSTS AND REAL ESTATE PRICES

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ABSTRACT: The study presents a methodology which can be employed by a wide array of stakeholders in the urban real estate market: policymakers, developers, investors as well as individuals. The methodology is widely applicable globally, and various economic variables can be appropriately linked to its results in order to make the economic implications of the length of permitting processes more transparent and promote affordable housing development and sustainable urban development. Across a unique primary dataset of 189 development projects in Prague, we find significant differences in the time required to obtain permits and to undertake construction work for buildings of different functional types. We attribute these differences primarily to public resistance to certain types of development. Our research also quantifies the percentage increase in construction prices that results from delays in the pre-construction process. We find that residential and mixed-use developments face significantly longer permitting processes than industrial development. This is a surprising finding, as these functions generally don't give rise to as many externalities, necessitating stricter regulation. In addition, we also find that central locations face longer delays and greater price increases.

KEYWORDS: permitting process, real estate prices, construction costs, city development, externalities, Czech Republic

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Introduction

It is common knowledge that property prices, like all prices on free markets, are the result of an equilibrium between the number of buyers and the number of properties for sale (or, more precisely, between how much people are willing to spend and how many properties are available). Cities are attractive places to live and work, and large cities especially so, with millions of job opportunities and often the best schools in the country. It is no surprise that city populations have swelled, as they attract a steady influx of new residents. This exerts considerable pressure on property prices in major cities. In many there are simply not enough properties to buy, and prices have risen dramatically.

Property prices vary greatly across the world's cities. An 80 square metre apartment costs 2.1 average annual salaries in Houston, 10 in New York, and 19.3 in Prague. Other examples are Milan (19.6), Paris (19.4) and London (16.7) (Numbeo, 2024). Prague property prices, the focus of our study, are among the highest in Europe (relative to average earnings), resulting in a low level of home ownership affordability, which has been in decline over the last 20 years (Hromada et al., 2022). Striking examples of unaffordable housing can also be found in other European countries, such as Ukraine or Serbia, but these are examples of dysfunctional property markets, where housing is not distributed on market principles in general. Prague's property market has been shaped by the influences of mass privatisation and long-term regulation, but over the last 20 years, it has become more efficient and is now broadly comparable to the developed property markets in other major European cities. When we compare housing affordability across major cities where property markets are efficient, a fundamental question arises: "Why is privately owned housing in Milan, Paris, London or Prague far less affordable than in New York?" Intuition would suggest that the primary driver of price growth, i.e. high demand due to the attractiveness of big cities, should push up prices in Paris and New York to the same, or at least a similar, extent. Intuitively, the next question is: "Where do property prices come from, if not from the purchasing power of the population?" We are convinced that the main factor influencing housing affordability has to be sought on the supply side. Here, we found some interesting data to support the hypothesis that inflexible bureaucratic processes significantly increase construction time and investment costs and thus push up prices. In some localities, moreover, this phenomenon is even more evident. We show that residential real estate and mixed-use development require statistically significantly more time to obtain permits than other uses such as industrial real estate or infrastructure. This conclusion is intriguing because it cannot be argued that residential development, for example, is a source of more externalities than industrial development, thus potentially justifying a lengthy permitting process. We further show that a correlation exists between distance from the city centre and the length of administrative delays so that the extent of their reflection in property prices decreases with increasing distance.

Our contribution to this current discussion assesses the impact of an additional factor that influences both property prices and their volatility: delays in obtaining building permits. We anticipate that the longer it takes to obtain a building permit, the more rigid the supply side will be, so that the supply side will fail to respond quickly to changes in demand. Low elasticity of supply is correlated to higher volatility and cyclicity of property prices (as confirmed by Glaeser et al. (2008) or Evenson (2002)). Furthermore, this rigidity of the supply side is likely also to increase risks the developers need to bear, as housing completions can't be timed to coincide with periods of high demand. A long permitting process is also likely to result in higher costs, as developers have to wait long times before their investments can be turned into profits – an under-researched area, which this paper aims to address.

This paper is based on a dataset of construction permit requests, which are evaluated in the first instance based on environmental impact. We compare levels of environmental regulation in city construction – there are cities with high construction regulation and parks, but construction possibilities are very limited, and other social problems arise. We found some relevant results on the affordability of housing. Construction permit length has a significant environmental impact as the legislative barrier adverse the win-win agreement between the developer, municipality and local citizens. The higher the regulation, the less will to find an agreement. We show this mechanism using the construction permit length data.

The aim of this paper is to develop a simple and easy-to-understand methodology based on always fully comparable variables (building functions, distance and time), which will allow stake-

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holders in the urban real estate market to answer the following three questions: Which building types are most affected by the complexity of the permitting process? Is it more economically efficient to build closer or further away from the city centre? By what percentage do permitting processes make each type of building more expensive? This is so that the research results can be linked to other economic variables as needed – business cycle impacts, changes in interest rates, GDP, etc. We believe that macroeconomic forecasts must be based on solid microeconomic foundations.

Literature review

Property market equilibrium and dynamics are widely discussed research topics. Out of the vast range of studies, however, only a few focus directly on the relationship between administrative delays and property prices. Urban economists such as Cheshire and Hilber (2008) or Glaeser et al. (2005) have a simple solution: build more housing. By expanding city boundaries and allowing high-density housing such as high-rises and skyscrapers, the market is supplied with new properties and prices are kept in check.

The costs and consequences of *not* building are very high indeed. Supply restrictions have a disproportionate impact on the lower end of the income distribution (Bertaud, 2018), particularly for the least well-off and those at the start of their careers. Homelessness is also strongly associated with property prices (Glynn & Casey, 2018), i.e. when rents are high, it is more likely that an adverse event such as a divorce or job loss will leave a person on the street.

Property price differences can also be disguised. People generally spend around 30-40% of their income on housing, and when house prices rise out of step with income, people go on buying them, but they decrease in size. The average new dwelling in the UK has a floor area of 67.8 square metres, and this figure has been falling since 1970 (LABC Warranty, 2019). As a general principle, if housing becomes more expensive, we tend to consume less of it. This is a result of the extreme elasticity of demand in housing markets (Bertaud, 2018).

Building restrictions are justified to some extent. In the urban planning process, local residents are often given the right to object to development in their neighbourhood, as new construction always entails externalities. However, these do not have to be negative. If a city builds a new underground transport station within walking distance of your house, the price effect will be positive, and the same goes for a new park. These positive and negative externalities can also be attributed to the proximity of good schools, shopping facilities, or simply the local community. Parts of a city with a highly educated and high-earning population usually also have very low crime rates. It is generally the negative externalities that drive residents to object to new developments, and the reasons for this are clear. If someone has plans that will harm a neighbourhood and lower the price of houses, residents should have the right to object or, at the very least, be compensated. Previous research has even found that neighbourhoods are greener in areas with high local community participation. However, house prices in these neighbourhoods have also been found to be much higher (Cheshire & Vermeulen, 2009).

A house or apartment is often the biggest investment a person makes in their life. And it is a nerve-wracking experience to see property prices going up and up, just as you are about to buy. Equally distressing is needing to sell at a time when prices are tumbling. There is a general tendency to believe that real estate is a safe and stable investment, but although it *can* be a good investment, it is certainly not stable. In fact, real estate tends to gain or lose value depending on the economic cycle, and its volatility is substantial (Liow & Ibrahim, 2010). People tend to buy houses when the economy is humming, job security is high, and credit is readily available. They also frequently need to sell when times are bad and jobs are harder to find. Overall, however, real estate is arguably a less risky investment than stocks, and prices move in longer and smoother cycles (Liow & Ibrahim, 2010).

Housing markets are also plagued by irrationality. If people behaved rationally, housing prices would be determined by the opportunity cost of renting (Shiller, 2016). In this scenario, if it became cheaper to rent than own, people would stop buying houses and rent properties instead. However, this has not proven to be the case (Borgersen, 2022). Each of the options of owning or renting may be markedly cheaper in different cities (Strochak & Pardo, 2017), but people still prefer to buy even when renting is cheaper, either because of the traditional preference for ownership or for lifelong financial security (Hromada, 2021). In the final analysis, many instances of rising house prices are

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simply associated with a mania for higher prices, even when market fundamentals do not support them, especially in times of cheap money (Venhoda, 2022). This is the biggest difference between housing and all other markets: many people who do not understand the fundamentals are forced to participate. This is one reason why some housing booms become protracted and result in housing bubbles (Shiller, 2016). These factors can indirectly affect housing supply and demand by affecting employment opportunities (Lukavec & Kaderabkova, 2017) and migration patterns (Kurekova, 2022), thus the scope of housing construction and overall consumer confidence.

High property prices are not solely the product of insufficient supply and credit conditions, just as high volatility is not merely the result of the business cycle or irrationality. The elasticity of supply is also an important factor, although the impact of low elasticity on the price of housing is more nuanced. As noted above, residents have the right to object to development in their neighbourhood during the building permit process. This right has a clear rationale, namely to minimise or internalise an externality of the new buildings, either by finding a solution with a smaller impact on current residents' property or by providing them with compensation. This means the process of obtaining building permits should deliver an outcome which is more socially optimal (Cheshire & Vermeulen, 2009) and, as such, be value-creating.

Gete (2014) shows that to understand the patterns and functioning of real estate markets in different countries (or different cities within one country), it is not enough to monitor and evaluate one variable alone. The real estate market is always shaped by a combination of several factors, including legislative and environmental and administrative and institutional conditions (the laws in force, government regulations, municipal ordinances, etc.) (Bernat et al., 2023), time and distance, micro-economic variables such as stock of properties and new construction, economic fundamentals of changes in demand for properties discussed in details by vast range of literature, in relation to the region analysed by Cermakova et al. (2023), Kaderabkova and Řežábek (2023) or Macek (2023), and macroeconomic fundamentals such inflation, unemployment and migration, fiscal and regional policies (Krulicky & Schmallowsky, 2022) or external shocks. The COVID-19 pandemic has lately highlighted the role of external shocks to the property market either on the supply and demand side (a deeper discussion is offered by Zubikova et al. (2023), Jasova and Kaderabkova (2022) or Hromada (2021)) or in the form of transaction and energy costs (Grzebyk & Stec, 2023). We therefore consider it essential to look at a suitable combination of several of these factors simultaneously.

The implication of this is that we cannot simply compare the property prices in different countries or cities with the average time to obtain a building permit without knowing how much value has been created. We, therefore, developed our own new methodology and compiled a unique dataset as a means to find compelling arguments in support of our hypothesis. Our contribution to current research on property price formation consists of applying financial methods based on estimating the times to obtain permits and build and comparing these times against the financing costs involved in new development. We examine a sample of construction projects for which permit applications were made between 2002 and 2006 and compare the times required to complete projects with different purposes. We then take the land use with the shortest completion time as a benchmark and compare it with other land uses or functions to find statistically significant differences. We treat the differences found as a consequence of delays in the permitting process and calculate the cost of those delays by discounting the value of the investment at interest rates roughly equal to the financing costs faced by developers in the relevant period, time and location. Through this novel methodological approach, we aim to fill a gap in research, including the neglected fact that the different lengths of permitting processes can be a significant contributor to the uneven development of cities, regions and entire countries. We are not aware of any prior research in this area that has been carried out in this way and using the methodology we present. This specific quantification of the time delays in construction processes, along with our modelling of the cost increases associated with these delays, may also prove to be a valuable tool, e.g. for developers and other real estate market participants in the process of making financial sound decisions. The methodology is simple and can be applied almost anywhere, as time and distance are always fully comparable variables (unlike the legislative or economic conditions prevailing in different countries or cities). An interesting platform for extending the applicability of the methodology can be its appropriate integration into the Smart Cities concept as presented by (Dzurekova et al., 2023), which fits into the technological development of cities that contributes to a wider concept of sustainable development (Popescu, 2020).

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Methodology

This article aims to show how the time needed to obtain a building permit leads to higher property prices. To perform our assessment, we drew on data available on the public web portal CENIA (Czech Environmental Information Agency, n.d.). This portal contains a database of projects for which an EIA permit was required. As this is the first permit needed and a crucial step towards the other permits that follow (a planning permit, building permit and occupancy permit), we can treat the EIA application as the beginning of the whole process for a particular project. To some extent, this is a simplification, as projects differ, and an EIA may have been ordered by the authorities only after the project had already progressed to other stages, etc. However, in general, it provides a reasonable starting point from which to measure progress in obtaining permits.

Altogether, we identified 298 projects (individual buildings or complexes) which applied for an EIA between 2002 and 2006, of which 189 were completed before the end of 2018. The remaining 109 projects either met with refusal in the planning process or were suspended or changed by the developer.

For each project in our sample, we made a record of the start and completion date. Our timeframe was limited to 2002-2006, as many projects which applied after 2007 have yet to be completed. This five-year period was also the earliest in which applications were published on the CENIA portal. As exact completion dates were not available for most of the projects, we used the midpoint of the year in which each project was finalised. This introduces a measurement error in our analysis, but this is unlikely to have a major impact on the results, as the errors are most likely to cancel each other out at this sample size.

We grouped the projects by function into the following categories: office, residential, retail, mixed-use (i.e. projects with more than one purpose, such as a combination of offices and retail), infrastructure (including parking lots and multi-storey car parks), public projects (mostly athletic facilities), industrial (including warehouses) and other.

The fact that only finalised projects were included is a weak point of our analysis, as there could be additional projects that are still in the process of obtaining permits. However, this does not undermine our results, as the costs attributable to the length of the process and the statistical significance of our findings are both likely to be underestimated (although not substantially so, as only two projects in our sample were completed in 2018). We can, therefore, reasonably assume that the vast majority of the other 109 projects are not going to be built. Some of the projects will have been halted at the developer's own decision, while others will not have received a permit, so plans to build them were abandoned. We lack sufficient information to determine whether the latter cases were justified and constitute legitimate costs for the developer, and this is another possible cause of underestimation in our results.

One further source of underestimation may be that EIA applications are being made at a later stage, as mentioned above. As the data needed to correct for this are not publicly available, we must consider our findings to be underestimated and the impacts to be even larger than those actually found.

The location of each project was defined as its land registry district, and the commute time between that district and the centre of Prague was then used as an additional variable to locate the project in relation to the city centre.

The data above formed the input for two models, both based on multivariate regression. These were defined as follows:

- Model 1

$$lnTOPC = \beta_0 + \beta_1 off + \beta_2 res + \beta_3 ret + \beta_4 comb + \beta_5 inf + \beta_6 publ + \beta_7 rest + \varepsilon \tag{1}$$

- Model 2

$$\begin{gathered} lnTOPC = \beta_0 + \beta_1 off + \beta_2 res + \beta_3 ret + \beta_4 comb + \\ + \beta_5 inf + \beta_6 publ + \beta_7 rest + \beta_8 comtime + \varepsilon \end{gathered} \tag{2}$$

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where:
TOPC – time to obtain permits and finish construction,
off – dummy variable for office development,
res – dummy variable for residential development,
ret – dummy variable for retail development,
comb – dummy variable for mixed-use function development,
inf – dummy variable for infrastructure development,
publ – dummy variable for public buildings,
rest – dummy variable for other developments not included in the previous categories,
comtime – commute time from the land registry district where the project is located to the city centre, measured in minutes.

The industrial function was chosen as the missing dummy variable against which the other functions are compared because the time periods for this function were the shortest in our sample. This removed any arbitrariness in choosing the shortest possible period for completion of the permitting process and construction. We have assumed that the construction timeframes for different functions or land uses do not vary dramatically and, therefore, that the differences in the total time required to obtain permits and complete developments result primarily from the permit process itself. This approach has one major advantage, as it is not likely to be influenced by the business cycle. There is no reason to assume that the industrial function, for example, was less affected by the recessions of 2009 and 2012-13 than, say, the office segment. Indeed, both industrial and office markets experienced higher vacancy rates during those periods.

This method has its shortcomings, however. A reasonable objection can be made that industrial buildings can be constructed faster than others because they are rarely over one storey high. While that is true, industrial complexes also frequently require custom-built infrastructure such as wastewater and oil traps, as well as advanced HVAC systems. We also assume that the externalities that industrial complexes cause for their neighbours are relatively large compared to other structures, such as retail or office buildings. In theory, it should thus take longer for them to obtain permits than other functions. The average time taken to obtain permits and construct industrial buildings in our sample is 566 days, which appears to be a reasonable length of time against which other types of projects can be measured.

Cost estimation

To assess the cost impact of the time required to obtain building permits, we need to quantify the opportunity cost of capital. Development is financed by a combination of debt and equity, both of which have associated costs: debt in the form of interest and equity in the form of the opportunity cost of not investing in other projects or assets. We assume that developers have significant sunk costs in the form of land purchases and that the financing needs to be in place at the start of the construction process, as the time taken to obtain permits varies considerably and is thus difficult to predict. We therefore assume the opportunity cost of keeping funds available is equal to 100% of the project's costs.

To quantify the opportunity cost, we need to calculate the financing costs faced by developers. We assume these have two components: the risk-free cost of financing and a risk premium specific to developers. The risk-free premium can be approximated by the interest rate on interbank deposits (PRIBOR) published by the Czech National Bank (36), plus an added risk premium attached to real estate investments. To determine the size of this risk premium, we compiled a sample of negotiable bonds issued in 2018 by several large developers, namely CPI, FINEP and Trigema. We assume that these bonds were competitively auctioned so that the interest rate on them is equal to the developer's yield. We further assume that the difference between the average interest rate on these bonds and PRIBOR gives us the value of the risk premium. We hold this risk premium constant for the whole period of 2002-2018, although PRIBOR varies over time. We acknowledge that the risk premium would not have remained constant throughout that period and that this approach is, therefore, a simplification to some extent. However, we would expect the resulting error to be small (see Appendix 3, where the cost of capital is shown in the second row. This cost of capital will be used for discounting in the following chapter – see Figure 2).

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Analysis

Model 1 indicates very high statistical significance (F-significance <0.001). A fairly small share of the overall variance was explained ($R^2 = 0.1623$), which means that approximately 16.23% of the time required to obtain building permits can be attributed solely to the function the building serves. Even more interesting, however, is the interpretation of the coefficients for the various building functions.

The average time taken to obtain permits and build an industrial building is 566 days. For offices, development takes, on average, an additional 870 days (i.e. 1,436 days in total), which is 153% longer. This result is statistically significant at 99.9% ($P < 0.001$). For residential development, there quired time is 178.4% longer, i.e. 1,010 days more than for industrial development and 1,576 days in total.

This is a statistically significant finding, at $P < 0.001$. The longest permitting and construction times were found for mixed-use developments. On average, these take approximately 221.83% more time than industrial projects, requiring an additional 1,255.57 days. This finding is again significant at $P < 0.001$.

	Model 1			Model 2	
office development (off)	0.9312	***		0.6951	**
	(0.24)			(0.25)	
residential development (res)	1.0239	***		0.9704	***
	(0.22)			(0.21)	
retail development (ret)	0.0949			0.0417	
	(0.26)			(0.25)	
mixed-use development (comb)	1.1689	***		0.9864	***
	(0.27)			(0.26)	
infrastructure development (inf)	0.3271			0.1654	
	(0.23)			(0.23)	
public buildings (publ)	0.6407	*		0.4061	
	(0.26)			(0.27)	
other development (rest)	0.8032	*		0.7877	**
	(0.42)			(0.42)	
commuting time to the centre (comtime)				-0.0248	**
				(0.01)	
Intercept	6.012	***		6.78	***
	(0.13)			(0.25)	
Nr. of observations	189			189	
R2	0.1623			0.2031	
Robust standard error					
* p<0.1 **p<0.01 ***p<0.001					

Figure 1. Relationship between the length of time necessary to obtain permits and the development function

Source: authors' work based on Czech Environmental Information Agency (n.d.) and Google (2019).

In addition to these results, the development of public buildings also displayed a statistically significant difference when compared with industrial function, at 90% certainty. Retail, infrastructure and other development categories did not display statistically significant differences.

Model 2 is an extension of Model 1, with the added variable of commute time to Prague city centre from the land registry district where a sample development is located. The overall significance of

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this model is again very high (F-significance <0.001), and its explanatory value has increased to R2 =0.2031.

According to Model 2, the average office development takes 100.4% longer than industrial development, i.e. 568 additional days. This result is statistically significant at 99%. Residential development takes 163.9% more time to complete (927.7 additional days), also with a significance of 99.9%.

The mixed-use function once again requires the most time, in this case 168.17% more (952 additional days), and this finding is again statistically significant at 99.9%.The result for the commute time variable is revealing in itself. For every added minute of commute time from the centre to the approximate location of the development, we can expect the time needed to complete it to drop by 2.45% (statistical significance 99%).

This analysis shows that the time required to obtain permits and complete a building is 270 days shorter with a 10-minute commute than building in the centre itself.

To confirm the absence of multicollinearity, we have calculated the VIF scores (see Appendix 1) and prepared the residual plots and kernel densities of the residuals, to ensure that the regression analysis is not influenced by systematic errors or wrongly chosen variable transformations (see Appendix 2). As the condition of the error normality was not fully satisfied, we have employed robust standard errors in our analysis, so the statistical significance of the results are not impacted.

Figure 2 below displays the results of Model 2, i.e. how much extra time is needed for each of the development segments and our estimate of the resulting cost increase.

	Model 2		Extra time	Increase in costs due to extra time
office development (off)	0.6952		100.40%	9.55%
residential development (res)	0.9704		163.90%	16.49%
retail development (ret)	0.0417		4.26%	0.39%
mixed-use development (comb)	0.9864		168.17%	16.95%
infrastructure development (inf)	0.1654		17.98%	1.61%
public buildings (publ)	0.4061		50.09%	4.58%
other development (rest)	0.7877		119.83%	5.20%
commute time to centre (comtime)	-0.0248		-2.45%	-0.24%
Average (excl. commute time)	0.5790		89.23%	7.82%

Figure 2. Estimate of the extra costs caused by delays in obtaining building permits

Source: authors' work based on Czech National Bank (2019), CPI Group (2019), FINEP (2019), Trigema (2019), Czech Environmental Information Agency (n.d.), Google (2019).

In residential development, for example, the costs developers incurred were 16.49% higher due to the extra time needed for the permitting process. Other factors leading to higher property prices, such as credit conditions, population growth, or a shortage of development land, are not included in this estimation. This increase in prices due to the permitting process is most significant in the mixed-use segment (16.95%), residential development (16.49 %) and office development (9.55%).

Discussion of the results

The average time required to obtain a permit and construct an industrial building is 566 days, according to Model 1. This is the lowest figure for all the functions considered, and this may be linked to several factors. In terms of architectural complexity, industrial buildings are among the least demanding, and industrial sites are generally developed at the greatest distance from the city centre, primarily due to transport accessibility for their supply needs (connections to motorways and international routes). The outskirts of the city are not as densely developed as the centre, so the adminis-

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trative burden, particularly on central building authorities, can be expected to be lower. The construction of industrial buildings also took the shortest time according to Model 2.

According to Model 1, office buildings take an additional 870 days longer to complete than industrial buildings. This delay may result from the desire to develop this type of building closer to the city centre and further from the outskirts, where we encounter this type of building less often. Transport accessibility once again plays a key role, although in this case, it is not for goods but for the staff of the companies and institutions that occupy or carry out activities there. Shorter distances are an important factor here. Compared to industrial buildings, the completion time in Model 2 is 568 days longer, which is about one year less than in Model 1, due to the addition of the commute time variable in Model 2.

Approval and construction of residential property (total 1,576 days) takes 1,010 days longer than industrial development according to Model 1. We attribute the significant delay in these developments mainly to strong resistance from existing residents, who often actively oppose any new developments. The arrival of new residents leads to densification of the transport network, increased use of public transport, and other negative impacts. Compared to industrial development, the completion time in Model 2 is 928 days longer, which is 82 days less than in Model 1. New residential and office developments are also relatively more abundant in central locations, as compared to industrial development, for example. By controlling for commute times to the centre, this part of the unexplained variance is removed.

Mixed-use projects have the longest permitting and construction times, amounting to 1,256 days in Model 1. These are also the longest in Model 2 (952 days in total), although this result is 304 days shorter than in Model 1. In our opinion, development for this function has the highest value because of the complexity of the permitting process itself, in which permits have to be obtained from numerous specialised public sector agencies, whose opinions require expert assessments in areas such as water safety and pollution prevention, radiation, hazardous waste management and many others.

Permitting and construction times for public buildings also showed a statistically significant difference (when compared to industrial development) in Model 1, but this was not the case in Model 2. This is probably due to the fact that public buildings are generally constructed in central locations. When we control for the commute time to the centre in Model 2, the significance of the effect disappears. Other functions, such as the retail, infrastructure and 'other' categories, did not achieve statistical significance. The delay in the permitting process and construction compared with the industrial function is not large enough to be seen as significant.

Our finding is that the time taken to obtain permits and complete construction is 270 days shorter with a 10-minute commute, as compared to construction in the centre itself, which delivers a clear message for developers and their clients. It is more cost-effective to build and buy property further away from the centre, with the greatest savings being made by choosing the outskirts of the city. This incentive can be expected to result in increasing costs for Prague and the Czech state budget, as development of the outskirts of the city usually necessitates greater investment in infrastructure, in the form of roads, water and sewage systems, electricity supply lines, public transport and other requirements.

In our cost estimate (Figure 2), we looked at the increase in construction costs due to the extra time required to properly complete permitting processes. As residential development in Prague (more expensive by 16.49%) is competitive, and there are no signs of high market concentration, we can expect these costs to be passed on directly to consumers. These estimates of increased costs should, therefore, be considered equivalent to an increase in house and apartment prices, with the resulting conclusion that higher prices can only be attributed to the lengthy process of obtaining construction permits. Similarly, the increase in price for mixed-use development (16.95%) – half a per cent more than residential construction – and office buildings (9.55%) can also be explained by the extra time needed to obtain permits.

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Conclusions

Our results show that there is considerable variation in the length of time required to obtain pre-construction permits and complete construction. These differences depend on the function of the building involved and are primarily attributable to the time required to obtain permits. We confirmed the existence of an inverse relationship between the lengths of the permitting and construction processes and distance from the city centre.

To remedy this situation, solutions will have to be sought involving other measures, such as re-evaluation of the current level of legislative regulation, increasing the efficiency of the bureaucratic apparatus, or limitation of the potential for rent extraction by politicians and officials. Of course, if no new buildings are built in the city at all, the adverse effects of rising prices are obvious. The results of the research helped to identify in which locations and what types of buildings (according to their function) it is economically most advantageous to build and how long it will take to implement the construction (including building permits). From the point of view of both municipal and private developers, it is about removing some of the market uncertainty to facilitate their economic calculation in relation to the location and cost of buildings. Thus, more accurate decisions can be made about the allocation of public and private investment to meet the needs of the city or to make a profit.

Our results suggest that building regulation has a significant impact on the elasticity of real estate supply. As regulation increases, the supply of real estate becomes more rigid and less elastic. The combination of inelastic supply and the pass-through of final costs to consumers ultimately reduces the affordability of real estate and contributes to the gradual "depopulation of the city" (the departure of less economically successful residents and firms), which is first manifested in the central parts of the city; this trend increases the demand for real estate from "out-migrants". These processes ultimately create a strong precondition for uneven urban development, with prices significantly limiting housing affordability in some parts of the city. All property markets are pervaded by elements of regulation, which provides a necessary legal framework. When this regulation is framed by public authorities as a set of clear and simple rules that do not change too often, this increases market efficiency. If private entities operating on the market consider government regulation insufficient, they have the option to provide for their relationships under private law contracts. However, along with civic activism, these have a tendency to push up the prices of real estate locally, and not only new properties but also those already existing. This price increase will then be passed on to new buyers and is one of the factors making new properties less affordable. Simplification of the systems of the public authorities involved in pre-construction procedures, introduction of effective sanctions for any authorities that deliberately and unjustifiably prolong pre-construction procedures, and changes in the internal processes of specific authorities are all examples of steps that can help to speed up permitting processes.

This article, based on a new methodology, shows that reducing the length of permitting processes will reduce rigidity on property markets and increase the elasticity of real estate supply, and offers a data-driven breakdown of the factors that shape property prices. We found the length of the building permit process to be a key factor influencing those prices, regardless of the institutional or regulatory framework. We therefore recommend further research based on approaches similar to our data-driven analysis for Prague and look forward to seeing the results from property markets elsewhere. It would be interesting to carry out the research according to the same methodology over a longer period of time, segment the results according to individual city administrative districts or include other cities around Prague in the research. A possible limitation of the research is that the methodology does not consider the time necessary to change zoning plans, which can further prolong the permitting process. And lastly, more accurate outputs would be achieved by subtracting the amount of time by which the length of the permitting process is prolonged by the builder itself.

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The contribution of the authors

Conceptualization, V.Č., M.L. and K.Č.; literature review, V.Č. and M.L.; methodology, V.Č. and M.L.; formal analysis, M.L. and V.Č.; writing, V.Č., M.L. and K.Č.; conclusions and discussion, V.Č., M.L. and K.Č.

The authors have read and agreed to the published version of the manuscript.

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Appendices

Appendix 1. VIF scores (analysis of multicollinearity)

Variable	VIF	1/VIF
infrastruc~e	1.51	0.661335
office	1.51	0.661844
residential	1.34	0.744140
shopping	1.33	0.751020
mix	1.32	0.758210
public	1.24	0.806023
other	1.22	0.819077
commutingt~e	1.17	0.852771
Mean VIF	1.33	

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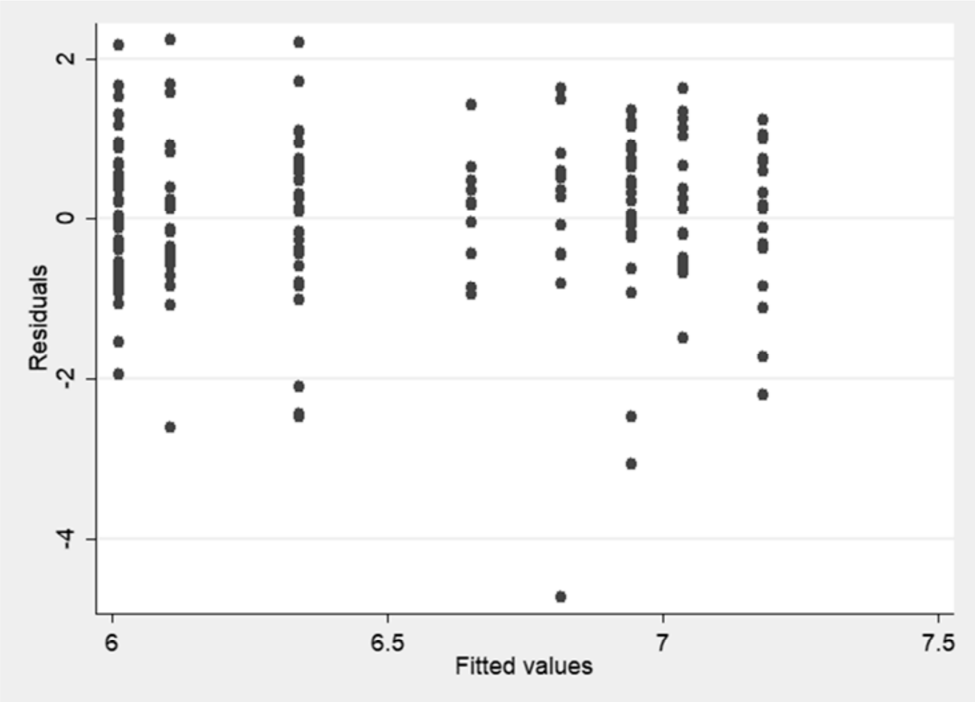
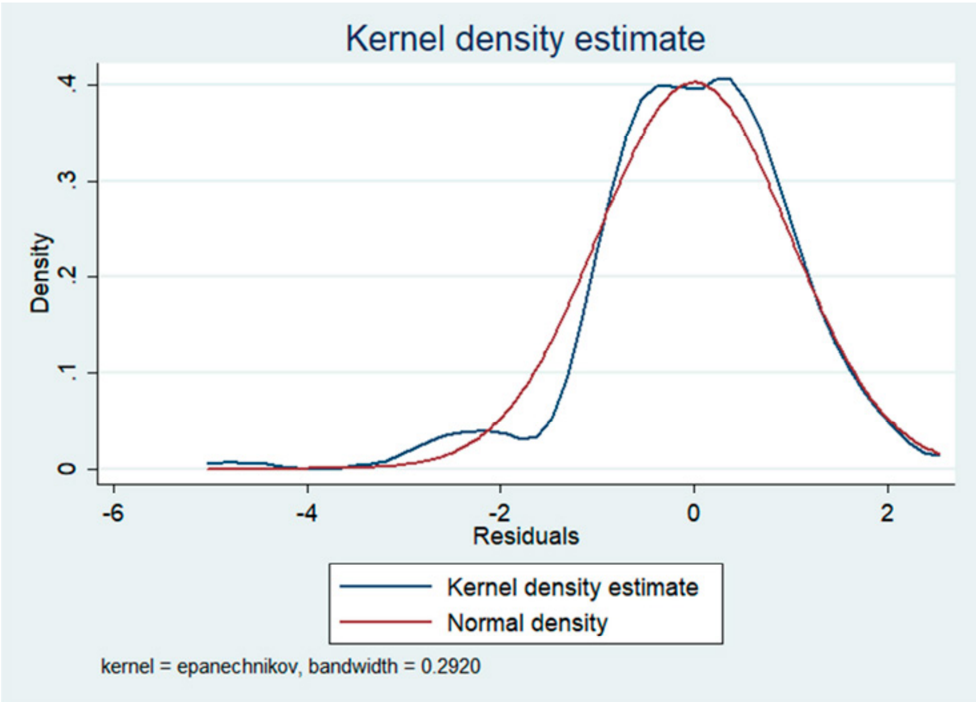
Appendix 2. Residual plots and kernel densities of residuals

- Model 1. Residual plot



- Model 1. Kernel density of residuals as compared with expected normal distribution



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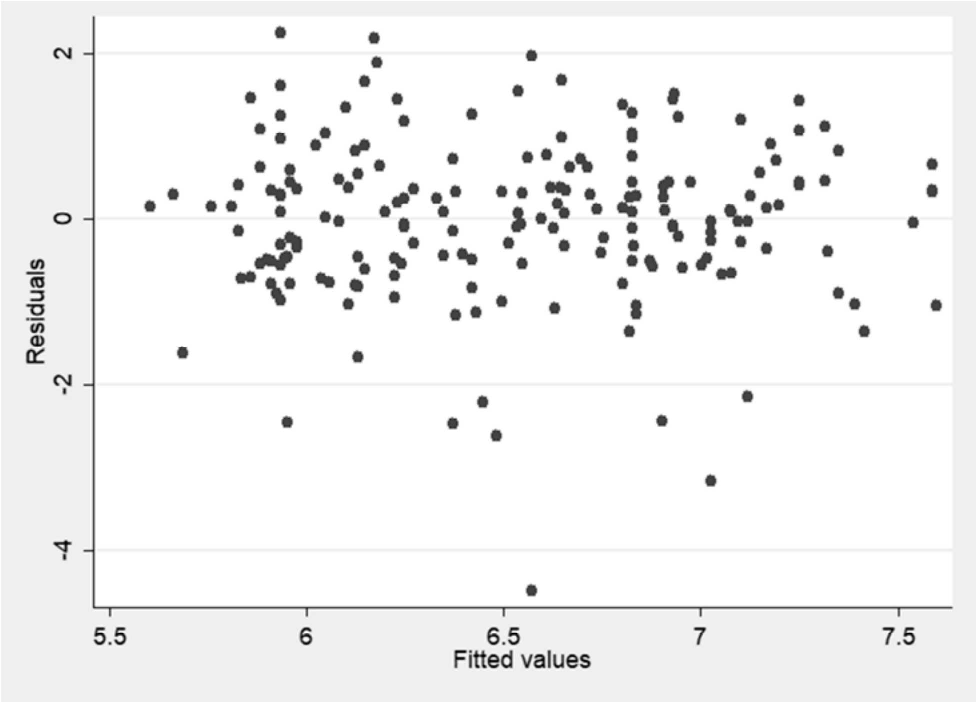
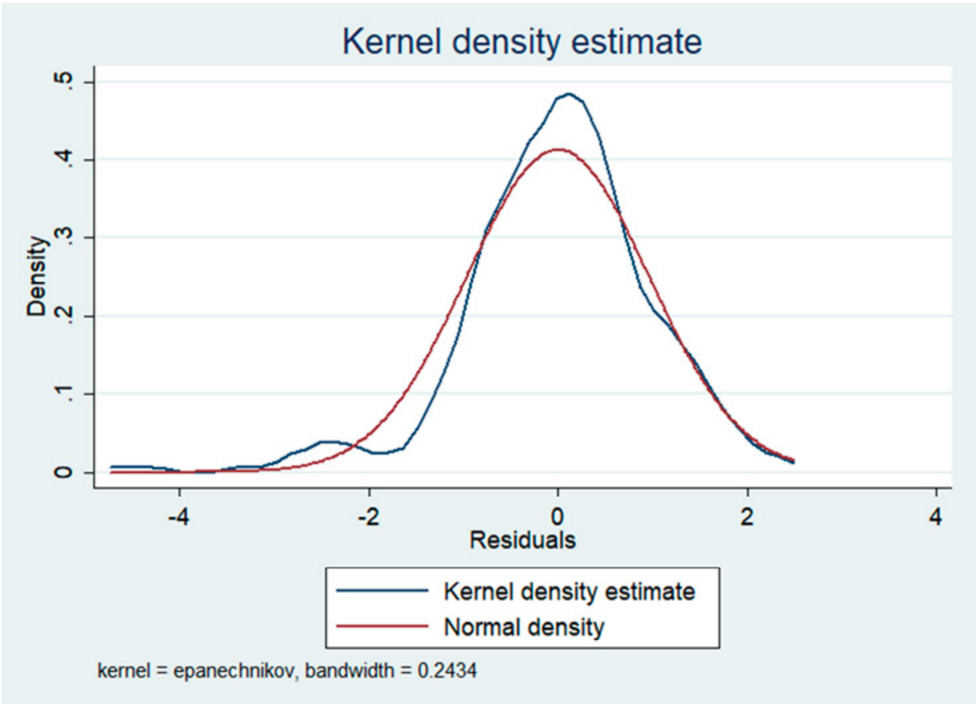
- Model 2. Residual plot



- Model 2. Kernel density of residuals as compared with expected normal distribution



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Appendix 3. Interest rates

	2002	2003	2004	2005	2006	2007	2008	2009	2010
PRIBOR (1 year)	3.62%	2.32%	2.71%	2.13%	2.65%	3.42%	4.20%	2.63%	1.86%
Risk Premium	3.58%	3.58%	3.58%	3.58%	3.58%	3.58%	3.58%	3.58%	3.58%
Estimated interest paid on bonds issued by developers	7.20%	5.90%	6.29%	5.71%	6.23%	7.00%	7.78%	6.21%	5.44%
Smoothed average (5 years)					6.27%	6.23%	6.60%	6.59%	6.53%
	2011	2012	2013	2014	2015	2016	2017	2018	
PRIBOR (1 year)	1.77%	1.48%	0.75%	0.53%	0.48%	0.45%	0.58%	1.48%	
Risk premium	3.58%	3.58%	3.58%	3.58%	3.58%	3.58%	3.58%	3.58%	
Estimated interest paid on bonds issued by developers	5.35%	5.06%	4.33%	4.11%	4.06%	4.03%	4.16%	5.06%	
Smoothed average	6.36%	5.97%	5.28%	4.86%	4.58%	4.32%	4.14%	4.28%	

Source: authors' work based on Czech National Bank (2019), CPI Group (2019), FINEP (2019), Trigema (2019).

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