Time to develop

A quantitative analysis on the effect of price uncertainty on development timing in the Netherlands

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Preface

Before you lies my Master's thesis on the influence of price uncertainty on the development timing of residential development plans in the Netherlands, with which I conclude my Masters in Spatial Planning at the Radboud University in Nijmegen.

The process of conducting this research had been a very challenging but educating experience. Because of a personal situation and the surge of a global pandemic which hit ground in the Netherlands by February 2020, the research progress in the first few weeks was rather slow. During the first national lockdown and the start of my Internship at Stadkwadraat BV, the majority of efforts was aimed at understanding the financial models of options theory and shaping the research design. As it concerned a topic which had been scarcely discussed in the Spatial Planning discipline, it required some time to establish an adequate understanding of the material to build up this research.

One of the largest challenges in this research project was the data preparation for analysis, which turned out to be more complex and time-consuming than initially thought. I take this opportunity to express my gratitude to my thesis-supervisor Huub Ploegmakers, who had been very helpful in organising and preparing the data for analysis. His aid and helpful advice have had a considerable impact on how this research has been shaped. Besides Ploegmakers, I worked alongside Job Wevers; a fellow master student who conducted his study within the same theme of subject. Through countless discussions we attempted to better understand the material at hand and organise the provincial plan capacity inventories, for which I am thankful for his commitment and motivation. A special appreciation for Babak Firoozi Fooladi, who helped us tremendously with the coding and transformation of the raw data to amenable datasets.

I also want to thank Stadkwadraat BV for giving me the opportunity to do an Internship and make use of their resources and expertise. Especially my internship-supervisor Christian van der Blonk had been very helpful in reflecting on the process of my research, for which I thank him. He always let me see the bigger picture, which is something that is important to keep in mind whilst conducting research. Doing the internship at Stadkwadraat BV had been a really educating and exciting experience during which I gained a lot of information from a financial perspective on real estate development and I am definitely grateful for the opportunity to start my career here.

Last but not least, I would like to thank the province of Noord-Holland and Watson+Holmes for providing the datasets which were used in this research.

I hope you enjoy reading this research.

Pim Beckers
Utrecht, March 2021

Summary

The real house prices in the Netherlands have reached new records by 2020 and they still reflect no signs of stopping. Demand is high, but the supply of housing remains behind. It has been a prevailing topic in politics for over a few years now, but the housing shortage has not yet been halted. According to plan capacity inventories there should be enough development plans to provide an answer to the growing demand. However, the reality is that not all proposed plans are eventually implemented. Even more so, many development plans are systematically delayed, which has given rise to the concept of implementation gap in scientific literature.

Irrevocable plan status does not guarantee construction, as there are numerous factors that are theoretically expected to influence development timing. One of these factors is price uncertainty. The idea of price uncertainty influencing the decision to invest is derived from financial option pricing theories but has increasingly been applied on real estate development where it is referred to as *real options*. Having the option to delay investment can be valuable for the developer and uncertainty over prices influences this value. There are already some studies on the relation between price uncertainty and development timing, but evidence for this relation in the Dutch housing sector is still underdeveloped. This study therefore investigates the effect of price uncertainty on development timing, aimed at answering the main research question:

> *How does price uncertainty influence the development timing of residential development plans in the Netherlands?*

Besides price uncertainty, other market conditions and plan-specific factors are included in the analysis to also examine their relation on development timing. Within this study, a proportional hazard analysis is applied on a large collection of development plans from the province of Noord-Holland from 2008 to 2019. The duration of a development plan is defined as the time taken in years from the year that a development plan is defined as irrevocable till the year that construction is started. The hazard in this context is the event of construction.

The results of proportional hazard models suggest that price uncertainty systematically delays development timing of residential development plans, implying that real options are present. If price uncertainty increases with one standard deviation, the rate of construction decreases with 5,65 – 9,48%. The results from the analysis also suggest that other variables systematically related to development timing, as increases in house prices will result in an increase in the construction rate, whilst increases in construction costs will decrease development activity. There is an urgent need for more houses in the Netherlands, but uncertainty prices seems to be an important component to consider when evaluating the current development cycle.

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1. Introduction

1.1. Research problem statement

Early 2020, the average real house prices in the Netherlands surpassed € 326.000, the highest it has ever been (NVM, 2020a). Especially new-build supply is becoming unaffordable as these prices are (on average) twenty percent higher than the real house prices of homes of the existing stock of supply (NVM, 2020b). These high prices are not only true for the more economically active Randstad-region, but they are present throughout the Netherlands with current price-levels exceeding the previous peak in 2008. This has great implications for the affordability of owner-occupied housing in the country. Especially people from the lower- to middle socioeconomic segment and starters experience an increasingly difficult market to enter upon. Moreover, the national housing shortage is expected to grow beyond 330.000 houses by 2020 and due to the anticipated increase in the number of households, the forecast for the year 2025 is that the housing shortage will be exceeding 400.000 houses (Ministry of the Interior and Kingdom Relations, 2020).

One of the most important components of the housing market is the rate of housing construction, which is ordinarily placed in direct association with issues of demand and supply. In 2018, a coalition of private developers, construction companies, civil representatives, housing corporations and the three levels of the Dutch government set up the National Housing Agenda 2018 – 2019, in which the pressing challenges of the Dutch housing market were addressed and possible solutions to these challenges were presented (Ollongren, 2018). The main decision derived from this document is the increasing of the rate of housing construction to combat the prevailing housing shortage. This ambition was translated into an annual target of 75.000 new housing units (including conversion projects) until at least 2025. This annual construction rate was deemed necessary to comply with the need for over 700.000 housing units in total by the end of 2025 (Ollongren, 2018).

Unfortunately, the annual threshold of 75.000 housing units has proven (historically) to be difficult to achieve. Corrected for demolition and other supply-stock mutations, the year 2019 was the first year since 2013 in which an annual production of 75.000 housing units[1] had been reached (Statistics Netherlands, 2020a). However, despite 2019 sounding promising for successive years, that same year also experienced a significant drop in the number of granted building permits for new residential developments, troubling efforts to reach the desired annual housing construction rate in successive years (Ministry of the Interior and Kingdom Relations, 2020). It is the insufficient rate of housing construction which is often argued as the fundamental reason for the imbalance at the Dutch housing market,

[1] According to Statistics Netherlands (2020a), 76.872 housing units had been created that year.

eventually driving up real house prices even more (Michielsen, Groot, & Maarseveen, 2017; Buitelaar & van Schie, 2018; De Graeff & Hildebrand, 2018; Manshanden & Koops, 2019).

There have been substantial attempts by the Dutch government to speed up housebuilding. In January 2019, minister Ollongren of Interior and Kingdom Relations, being responsible for the housing sector, mediated *housing deals* with several urban regions (Mannekes, 2019; Ollongren, 2019). These deals included regional arrangements to stimulate the uptake of residential development plans and preparatory measures to combat barriers to effectuate development. These housing deals portray a desire for a stronger governmental control on housing construction, but it is not a guarantee that these deals are implemented (Obbink, 2020). The continuation of these efforts was eventually rendered into the national *Housing Impulse*[2], which was presented by the Dutch government in May 2020. This funding scheme entailed a one-billion euro's financial package for municipalities to accomplish their residential construction programmes[3] (Ollongren, 2020).

Important to mention is that the designated funds are only distributed to municipalities which submitted valid development proposals with financial substantiations. Once granted, a municipality may only use the funds for the public section of the proposed housing development, which includes preparatory measures such as soil remediation and infrastructure. It can therefore not be seen as funds to initiate or force true housing construction, which therefore still raises concerns over the lagging rate of housing construction and the increasing gap between supply and demand of housing.

This gap is a consequence of the market's cyclicality and the inelasticity of new construction (Michielsen et al., 2017). Inelasticity implies that changes in demand only trigger a limited response of new construction in the short term. So if there is a positive shift in demand, the response of new construction is minimal, resulting in a growing imbalance between supply and demand, which will be converted into higher real house prices. This justifies the focus on housing construction rates and specifically on what factors influence the low response of housing construction.

A prevailing discussion revolves around plan capacity and especially the lack of ready-to-implement development plans. Provincial inventories of the plan capacity show that the number of development plans have increased substantially throughout the years (Groenemeijer & Van der Lelij, 2020). According to ABF Research reports, the *net* plan capacity for the period 2019 – 2030 comprises a housing production rate of 83.000 housing units a year, which is 8.000 higher than the threshold set in the Housing Agenda 2018 – 2019. However, although the net plan capacity appears sufficient to meet demand, it does not imply that every planned housing units will be constructed.

[2] Translated from Dutch: *Woningbouw impuls.*
[3] Only programmes that involve more than 500 housing units.

Development plans move through various judicial phases and each phase varies in terms of stringency. Plans that are in a later judicial phase often have a higher change of implementation as more requirements are met. Although there are some differences in the denomination between provinces, in general, development plans will receive the plan status *irrevocable* once the land-use plan in effect is confirmed of altered and the development is granted (Groenemeijer & Van der Lelij, 2020). However, only a slight majority of the net plan capacity in the inventories is categorised as irrevocable (Feijtel, 2018), which evidently demonstrates the consideration with which these plan capacity inventories should be interpreted.

Bearing the judicial denomination of irrevocability is predominantly based on the feasibility of the plan and the anterior agreements in place. But even development plans that are defined as irrevocable plan capacity are not guaranteed to be implemented. This leads to the contention that although an irrevocable plan status is indeed a necessary requisite for housing development, it is not an all-encompassing guarantee for construction (Buitelaar & van Schie, 2018; Bayer & Baggerman, 2020). This is the premise of what Bramley (1993a) defines as the *implementation gap*, referring to the discrepancy between planned developments with granted building permissions and true housing construction rates.

Among others, the Dutch Real Estate Developers Association (NEPROM) refers to issues of production capacity of the construction sector as an important reason for the implementation gap (Leeuw, 2019; NEPROM, 2019). The labour market for the construction sector is one which is characterised by its high volatility (Buitelaar, 2019). This volatility implies that many people may lose their job during an economic depression, whilst the number of vacancies is relatively high in times of economic prosperity. Precisely this volatility has positively fuelled the production-capacity of the construction sector since 2014. Reports of the Economic Institute for Construction (EIB) show that the production capacity in 2018 had reached levels of prior to the economic recession of 2008 and that the sector is still experiencing rising production levels and increasing profit-margins (EIB, 2019). The EIB further estimates a production rate of twenty percent above normal levels by 2030. So whilst the production capacity of the construction sector might be a limiting factor to overall housing construction, the above implies that there are other factors that explain the lagging rate of housing construction.

In scientific literature, this implementation gap is often addressed through an economic perspective in which a developer has the option to start or delay construction, based on the available information of market conditions. Once permission for construction is granted, there still exists a lot of uncertainty for the developer as it is difficult to precisely predict future market conditions and prices This uncertainty over future prices has regularly been linked to development timing, especially at the moment when construction can be initiated (Bramley, 1993b; Michielsen, Groot, & Veenstra, 2019). By examining the relation between price uncertainty and development timing, one can gain a better understanding of this implementation gap.

1.2. Research design

Considering the political and societal pressure on speeding up the rate of housing, there is little to no research on development timing and the implementation gap in the Netherlands. There is an increasing understanding of the magnitude of the imbalance of the housing market and the insufficient supply of new houses. However, existing research on housing construction in the Dutch context has been predominantly focused on examining and explaining aggregated supply elasticities (Michielsen et al., 2017) and the effect of planning regulations on land values (Levkovich, Rouwendal, & Brugman, 2018). This research adopts an economic perspective on housing construction as put forth by scholars such as Cunningham (2006) and Bulan, Mayer and Somerville (2006). In these studies, the prevailing factor influencing development timing is uncertainty. When converted into a main research question for this study, it follows:

> *How does price uncertainty influence the development timing of residential development plans in the Netherlands?*

For the purpose of this research, proportional hazard models are applied on an extensive provincial plan capacity of Noord-Holland which contains detailed information on individual residential development plans. Alongside the effect of price uncertainty, changes in house prices and construction costs are also examined. In addition, various covariates that are provided in the plan capacity inventory are included in the model to test their effect on the development timing.

1.3. Relevance

There is an extensive body of empirical research on the supply side of housing, albeit being concerned with a rather diversified set of research approaches and associated methodologies (DiPasquale, 1999). The prevailing method to examine housing supply dynamics has been to uncover the responsiveness of construction rates to changes in demand, more commonly referred to as the *supply elasticity* or construction elasticity. From a macroeconomic perspective, changes in demand for housing can either result in changes in the rate of housing construction or changes in house prices. When the change of the rate of housing construction is not parallel to the change of demand, the increased scarcity of housing is captured in the price for housing (Michielsen et al., 2017). Precisely this matter is a fundamental factor in the issues of housing affordability in many countries such as the Netherlands.

Diverse methodological methods have produced a varying degree of estimated supply elasticities. Muth (1960) and Follain (1979) approached supply elasticity from a mainstream econometric perspective, but both failed to produce significant relations between construction rates and real house prices through reduced-form equations, concluding that new the construction of housing is fully elastic. DiPasquale and Wheaton (1996) offer a dynamic macroeconomic model incorporating four submarkets of the total market for housing, in which a stock-adjustment process complements the assumed long-run equilibrium. They found long-run elasticities of new construction of 1.0 to 1.2, much lower than the full elasticities found by Muth and Follain.

In contrast to previously mentioned studies, Poterba (1984) argued that opportunity costs are also important in defining the allocation of investments in housing and eventually estimated new construction elasticities ranging from 0.5 to 2.3. However, his model failed to incorporate future asset prices in current investment decisions, which is exactly where Topel and Rosen's (1988) investment model adds its value. Topen and Rosen found new construction elasticities of 1.2 to 1.4, which is narrower range than Poterba's estimates. Both their studies suggest that investment options are important in determining new construction rates. Nonetheless, as Topel and Rosen failed to identify credible values for the effect of the time it takes to the sale of the real estate, its valuation was adopted by Mayer and Somerville (2000a), who included the variable 'median months to sale'. They found an elasticity of 6.3 within the same quarter of the change of house prices and an elasticity of 3.7 in the long run as it includes the lagged response of construction.

Table 1: Overview of new construction elasticities

Model	Approach	New construction elasticity
Muth (1960)	Reduced form	∞
Follain (1979)	Reduced form	∞
DiPasquale & Wheaton (1996)	Stock-adjustment	1.0 – 1.2
Poterba (1984)	Investment model	0.5 – 2.3
Topel & Rosen (1988)	Investment model	1.2 – 1.4
Mayer & Somerville (2000a)	Stock-adjustment	6.3 (within 1 quarter) – 3.7 (within 1 year)

In summary, the discussed empirical works on housing supply produce rather low elasticities implying that housing construction fails to adequately respond to changes in demand, eventually resulting in higher house prices. There is an extensive scientific debate on the justification of these low construction elasticities, which have adopted varying approaches culminating a diversified set of explanations.

Planning regulations

Several studies have examined the effect of planning regulations on the rate of construction. The general consensus from these studies is that more extensive planning regulations result in lower rates of housing construction and a more stringent development process, eventually leading to even a lower rate of housing construction, which would explain the low supply elasticities (Gyourko & Molloy, 2015). The relation between planning regulation and the rate of housing construction has been addressed through various conceptions and methods, but the main concerns around (1) land availability and (2) regulatory processes.

The first concern refers to the amount of land available for (residential) development (Adair, Berry, & McGreal, 1991; Glaeser & Gyourko, 2003). As land is inelastically supplied, planning restrictions affecting the amount of land which is suitable for residential purposes will only further limit the supply of housing. Turner, Haughwout and Van der Klaauw (2014) refer to this relation as the *supply effect*, referring to the increasing scarcity of developable land. This is why Glaeser and Gyourko (2003) argue that zoning in particular is responsible for increasing house prices, as the artificial scarcity of developable land will increase the value of land which actually is destined for residential purposes. The reverse is also true, which was demonstrated by Adair, Berry and McGreal (1991), who found that an excess of zoning land (*over-zoning*) for housing in Northern Ireland resulted in more supply of housing and higher construction rates. The recurrent conception in these works in that the availability of developable land correlates with housing construction rates. More stringent planning regulations will eventually lead to less land available for development, driving up the prices for land and real estate (Gyourko, Mayer, & Sinai, 2013).

Others have delved into the relation between regulatory processes and the supply of housing, where regulatory processes are a derivative of the policy or stance of governmental bodies towards spatial planning, Through the means of surveys, various scholars have developed indices on regulatory processes, which represent the level of stringency of the land use regime (Gyourko & Molloy, 2015). A very detailed index is provided by Glaeser, Schuetz and Ward (2006), who were able to accurately estimate the potential housing supply in the greater metropolitan area of Boston. However, the specificity of their model meant that the index could not easily be applied on other regions, which is why the more generic index of Gyourko, Saiz and Summers (2008) offers a better understanding of the relation between regulatory processes and housing supply. Through their model, they found that development plans in regions which maintained more stringent regulatory practices would experience more delays in projects (expressed in the approval delay index within their model).

Implementation gap

However, Gyourko and Molloy (2015) argue that planning regulation alone remains an unsatisfactory factor in estimating construction rates. A statement which also put forth by Bramley in 1993, when he examined the impact of planning regimes on housing supply in Britain. As he coined the term *implementation gap* to describe the discrepancy between the planned capacity for housing construction and the real construction rate, he emphasized the idea that not planners, but developers are the ones responsible for the realisation of development plans (Bramley, 1993a). Whilst planners do acknowledge and react to changes in demand for housing, the effect on housing construction is marginal (Bramley, 1993b). He confirmed his theory in his later collaboration with Watkins, where they modelled the effect of 40 percent annual increase of granted planning permissions on the number of housing completions, which only adjusted with 11.9 – 18.2 percent (Bramley & Watkins, 2016).

When examining unimplemented planning permissions in the UK, McAllister, Street and Wyatt (2016) developed a similar understanding. They encountered a considerate gap between the number of granted planning permissions and actual construction rates, which comprised over 70.000 stalled housing units, dispersed over 1.331 individual development plans. With no clear regional differentiation, results of their analysis show that the number of *stalled sites* corelated with land values and house prices (McAllister et al., 2016). In combination with a more in-depth inquiry on selected schemes, they found that changing market conditions proved an important factor in relation to stalled sites and argued that the investment behaviour of developers is an essential element in understanding actual construction rates. This portrays developers as rational actors who make strategic decisions to develop based on provided information on market conditions.

Investment behaviour of developers

Whilst confirming the contention that the investment-decisions by a developer is a central component in real estate markets, Antwi and Henneberry (1995) have offered a more behaviouralist approach towards developer's decisions and claim that the way developers respond to changes in demand and supply is one that reflects non-linearity. Developers would not only react to price signals but are also influenced by non-priced variables (such as individualised habit-persistence and risk-aversion), which suggests that not all developers respond the same to changing market conditions. Consequently, the investment behaviour of developers remains to be considered a key factor influencing the development process. This inevitably gave rise to the debate on *real options* in the real estate, as the decision to invest conforms strategic business-like opportunities that capture the uncertainty and the associated risk with investing in housing (Baldi, 2013).

Real option theory

Being one of the first to acknowledge the importance of the real options approach in real estate development, Titman (1985) concluded that an increase in price uncertainty raises the value of vacant sites in urban areas and decreases development activity, as having the option to start construction has a higher value than starting construction at that very moment. Williams (1991) extended Titman's line of reasoning by incorporating the scale and density of proposed development plans as determinants of the value of future cash flows. Another contribution on his part is the inclusion of stochastic development costs in the model, which eventually turned out to influence the optimal time to develop.

Quigg (1993) provides the empirical contribution by combining the model of Williams and the theoretical assumptions of Titman. She finds that the option to wait has a value resembling six percent of the land value, therefore accepting the premise of the existence of real options in real estate. Later empirical contributions include topics such as the relation between true housing construction, building permits and expected future economic conditions (Somerville, 2001), the effect of idiosyncratic uncertainty and competition on the development timing (Bulan et al., 2006) and the relation between future price uncertainty and the urban-rural gradient (Cunningham, 2007). They all confirm the presence of real options in real estate development, as the value of having the option to start or delay construction influences the individual decision to develop.

However, the studies referred to in this paragraph mainly examine housing supply dynamics in the US and the UK context. As Ball (1998) argues, the institutional context shapes the way actors are related and how they operate, which in turn influences the way the development process is being organized. Land positions, land-use planning, and market conditions can vary across countries, and they are key to understanding how the development process takes form (Needham, 2006; Caldera & Johansson, 2013; Hilber & Schöni, 2016). This asserts the scientific relevance of this study, as empirical analysis on this matter in the Dutch context are scarce.

Furthermore, the majority of scientific works on housing supply apply macro- or regional levels of analysis and although they produce interesting insights into the extent of the proclaimed implementation gap, there is still a lot to examine to better understand the influence of market conditions on development timing. As many scholars have delved into the relation between land availability (as a result of planning regulations) and actual construction rates, the contention that delaying construction has value for the developer has received less attention. This study complements the later empirical works that apply housing supply equations on a microscale by using panel data on individual development plans. The latter is of relevance to understanding construction rates and combine the macro-economic with the particular.

1.4. Reading guide

The remainder of this study is structured as follows. Chapter 2 discusses the theoretical framework and provides a review of approaches to real estate markets, theories on investment and introduces the real options theory in relation to real estate. This is followed by the contextual framework in Chapter 3, where a conceptualisation of the development process is provided as well as a brief discussion of the Dutch context of spatial planning. Chapter 4 follows with the methodological framework which presents the research philosophy and the methodological choices that are made in this study. Chapter 5 defines the model and discusses the various datasets and associated variables that are used for the analysis. The results of the statistical analysis are presented in Chapter 6, which is then followed by conclusions and recommendations in Chapter 7. This study ends with a critical reflection in Chapter 8 after which the Appendices are provided.

2. Theoretical Framework

2.1. Approaches to real estate markets

The real estate market is a complex construct which can be approached from various theoretical angles and corresponding methodological frameworks (Ball, Meen, & Nygaard, 2010; Adams & Tiesdell, 2013). The elected theoretical perspective not only determines the assumptions on how the real estate market behaves, but it also pertains to the weight attributed to the components included in this study. This section therefore discusses the dominant perspectives in explaining the workings of the real estate market and justifies the theoretical stance taken.

2.1.1. Mainstream economics

It is the economy of land and the structures on land that make real estate market an interesting market for many (Needham, 2006). Studies on the housing market often revolve around economic principles which refer to the economic market forces that shape market dynamics (Drane, 2013). It is the theoretical perspective of neo-classical economics which is predominantly focused on the structure of price-mechanisms. Models from the neo-classical paradigm are often identified as structure- or equilibrium models where the relevant actors possess a certain rationality in regard to the available information on the market. The price of goods or assets on the market then equalizes the forces of supply and demand, more commonly referred to as the workings of the invisible hand of Adam Smith.

The actors in a market make their decision rationally and independent from others (Adams & Tiesdell, 2013). Theoretically, any influence from social, behavioural or other sentiments is neglected. In an effort to mathematically model market dynamics and predict future construction rates, there are five assumptions that represent a perfect market in the eyes of a neo-classical economist (Adams & Tiesdell, 2013, pp. 50-51):

- Plentiful buyers and sellers to develop market prices
- Homogeneous goods
- Ease of entry and exit
- Frequent transactions to eliminate surpluses and shortages
- Full information so rational decisions can be made

In practice, these five assumptions will never hold, as markets are – to a certain extent – always imperfect. Especially the real estate market is known for having a small number of buyers and sellers, heterogeneous goods and, above all, no transparent information on the market, leading to high levels of uncertainty (Cunningham, 2006). Every location is different and entails various qualities which can alter the price that buyers are willing to pay for the real estate developed on that specific location (Needham, 2006). Additionally, the real estate market is known for its transaction costs which limits free trade of goods and assets (Buitelaar, 2004). Despite these market imperfections, the neo-classical perspective does provide a fruitful foundation for many empirical analyses of the real estate market. Increasingly, studies in the neo-classical paradigm have acknowledged the market imperfections and have shifted the focus on attempting to explain the presence of e.g. surpluses and shortages in markets, so too in the market for housing (Adams & Tiesdell, 2013).

Closely linked to neo-classical economics and also under the mainstream economics umbrella, welfare economics focuses heavily on these market failures and how individual preferences and successes persevere in imperfect market conditions. The concept of resource efficiency is key here, reflecting the inevitable scarcity of goods and services and the reallocation of these resources to individuals. The renowned construct of Pareto efficiency is a good example of how welfare economics perceive markets. Pareto (1896) supposes that society cannot attain a higher level of welfare if an increase in one's welfare results in the decline of the welfare of someone else. The situations where resources and welfare are allocated to the maximum efficiency is referred to as Pareto optimality. Applied to the theme of housing construction, Pareto optimality thus revolves around the challenge on allocating the resources at our disposal as efficient as possible in order to construct enough houses in a market deemed partially imperfect operating without governmental interventions.

2.1.2. Institutional economics

In addition to mainstream economics, institutional economics questions the workings of the market as assumed by neo-classical economists and introduces the importance of transaction costs in markets and link it to decision-making of rational actors. One of the key scholars in this regard is Ronald Coase (1937), who challenged the basic assumptions of mainstream economics and argued that simple transactions and market price-mechanisms are not the sole factors in attaining an effective allocation of resources. He refers to a gap between the assumptions of mainstream economics and the influence of entrepreneurial decisions and organisations on transactions (1937, p. 389) and introduces the concept of transaction costs. The basic price-mechanisms of neo-classical economy would then not fully explain the occurrence of transactions, as transaction costs (contracts, inquiry, communication etc.) and institutions (who can make *the rules of the game*) also influence the decision to buy or sell (Buitelaar, 2004; Adams & Tiesdell, 2013).

Whilst broadening the scope of market price-mechanisms, Coase can also be considered as a welfare economist as his intentions reflect the pursuance of maximum effective allocation of resources. The way institutional economists look at governmental intervention reflects the desire to minimize uncertainty and internalize transaction costs within the price-mechanisms. Stronger institutional frameworks providing better arrangements and would reduce transaction costs as private decision-makers gain more certainty over future contracts (Adams & Tiesdell, 2013). Moreover, institutions and laws can better manage the negative externalities caused by individual decisions.

2.1.3. Behavioural economics

Both mainstream- and institutional economics depict the market as a place where its actors make rational decisions which are based on the information available. Contrastingly, powered by insights from psychology, behavioural economics questions this rationality of the actors (Adams & Tiesdell, 2013). Behavioural economics can be considered as a subfield of economics which directs its focus on the social-psychological and the emotional factors that influence decision-making. In other words, the focus is more on the how markets operate in reality. The benchmark for the behaviouralist approach is *bounded rationality*, which means as much as that the availability of information to the actors is limited (Buitelaar, 2004; Adams & Tiesdell, 2013). Through the eyes of a behaviouralist, uncertainty will cause people to make irrational decisions. This becomes abundantly clear when looking at financial markets. Various price signals or framing techniques will leave some traders to make irrational decisions based on falsely perceived information, giving rise to “noise trading” (De Long, Shleifer, Summers, & Waldmann, 1990).

These assumptions are only making analysis of real market dynamics a lot more complex, as it is often difficult to grasp the true intentions and irrationality of the actors in question (Adams & Tiesdell, 2013). It is clear that the effective allocation of resources-approach is not of utmost importance here since market- *and* actor imperfections will limit the effectiveness of markets.

2.1.4. Application to this study

This study is not an exact application of one of the discussed market perspectives. It is rather a combination of perspectives. However, considering the goal of this study to estimate the effect of price uncertainty and other factors on development timing, the mainstream economic approach forms the foundation for the analysis. Additionally, the neoclassical economic paradigm poses a good fit in terms of mathematical analysis, often derived from studies on financial markets (Adams & Tiesdell, 2013).

Whilst classical economic theory generally indicates that pure market forces would produce perfect market equilibrium as the price-mechanisms would produce ‘market prices’, the neoclassical economic perspective acknowledges the presence of market imperfections. Especially uncertainty remains an important factor in the imperfection of the housing market (Anenberg, 2016).

Information in markets is crucial (Stigler, 1961), but housing markets are generally understood as markets were information is scarce and asymmetric, resulting in the very imbalance which has led to market imperfections. Developers are the actors making decisions to invest in housing supply in order to answer to busts of demand. Whilst developers are humans and are likely influenced by the bounded rationality and institutions in place as institutional- and behaviouralist economists would argue, this study treats those developers as rational decision-makers, where readily available market information forms the basis for decision-making. In doing so, this study attempts to estimate the causal effect of price uncertainty on development timing.

2.2. Traditional theories on investment

The housing sector has distinctive features that differentiate this sector from other goods or services. Firstly, housing as a product is considered highly durable and therefore investment in housing is often associated with the notion of irreversibility (Bulan, 2005; Cunningham, 2006, 2007; Paciorek, 2013). Existing structures are only redeveloped once they are deemed economically or technically deprived, which ordinarily happens over a long period of time (Williams, 1991). At the forefront of housing construction, developers cannot simply disinvest and retrieve the capital spent for housing construction (Pindyck, 1990; Paciorek, 2013), hence the irreversible character of housing investment.

This construct leads to the second distinctive feature of housing investment, which is the ability of developers to alter the timing of development. Whether referred to as 'managerial flexibility' (Baldi, 2013), 'entrepreneurial flexibility' (Lucius, 2001) or plainly 'flexibility' in the development process (Gore & Nicholson, 1991), it resembles the decisions that developers have to make within the development process (hereafter the term *managerial flexibility* will be used).

An important incentive for developers to invest in housing is (economic) profit. The expected profitability of development schemes is often found to correlate with the rate of development (Antwi & Henneberry, 1995). The profitability of investment decisions has been – and still is – an important question in aggregate and sectoral empirical economics (Pindyck, 1990; Belanová, 2014). It is the desire to explain a firm's investment behaviour that has fuelled many scholars to produce models that attempt to expose the underlying conditions that trigger investment. The following paragraphs will discuss the most prevailing methods to determine the decision to invest.

2.2.1. DCF Method

An important element in the developer's decision to invest in housing is economic feasibility. The prevailing theoretical method to determine the economic feasibility of a proposed development plan is the Discounted Cash Flow method (DCF). This method has a rather deterministic character as it assumes a single trajectory with the desired realisation of the development as outcome (Sing, 2001). The potential profits and expected costs (cash flows) are discounted back to the present through the use of a valuation formula (Baldi, 2013), which eventually generates the Net Present Value (NPV). The NPV defines the economic value of the investment. The formula for the NPV analysis is as follows:

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+IRR)^t} - C_0 \qquad (1)$$

where t is the number of periods, C_t represents the cashflow during period t, IRR refers to the *Internal rate of return* (IRR) and C_0 reflects the Opportunity Costs of Capital (OCC).

When the DCF method is applied, the developer justifies his investment decision on the outcome of the NPV analysis (Lister, 2007). When the rate of projected returns on the investment are equal to the OCC, the NPV generates a value of null. If the rate of projected returns exceeds the OCC, the NPV will be positive and, according to the DCF standards, the developer in question should invest. Whenever the rate of expected returns falls below the OCC, the NPV will generate a negative value and the developer should defer or cancel investment. The construct of OCC is linked to the IRR, otherwise known as a speculative discount rate (Lister, 2007). This discount rate is a metric used to estimate the investments' profitability based upon the expected growth of the value of the asset and the associated risk (Bulan et al., 2006).

Whilst simple in its form, the DCF method is not entirely adequate in estimating the economic feasibility of development plans, as it lacks trustworthiness and explanatory power. An important premise for the DCF method to accurately determine the NPV for an investment is that most parameters are known or can be estimated with precision at the time of making the analysis (Lister, 2007). This is a troublesome premise in this context, as real estate development projects often follow alternative paths to the one projected at first (Lister, 2007), which inevitably influences the parameters used in the NPV analysis.

As the DCF method assumes a fixed discount rate (and thus a constant level of risk over time), this is arguably an underestimation of the probable alterations in a development's rate of return and associated risks, which are in direct relation with the managerial flexibility present at investment decisions (Pindyck, 1990; Bulan, 2005; Baldi, 2013). Having said this, in reality, many developers do not apply a DCF method to their investment decision, but rather calculate the balance between expected profits from the real estate and the expected construction costs.

Conclusively, the DCF method underestimates the influence of risk and flexibility on the economic feasibility of development plans, which eventually administered more interest in investment theories that better account for flexibility.

2.2.2. Q theory

An alternative approach to estimating investment decisions is the neoclassical *q* theory, led by the efforts of Tobin (1969). Compared to the DCF method's relatively simple relation between OCC, expected rate of return and a fixed discount rate, the *q* theory encompasses a standard of marginality (Pindyck, 1990), which sharpens the analysis to the particular and makes it more suitable for estimating housing construction rates. In short, a developer will decide to develop a new house (an additional unit) when the expected price for that house exceeds the costs for developing (adjustment costs).

The relation between the price for the additional unit and the adjustment costs is expressed through the *q*-ratio, which can also be called the *rate of investment* (Bulan, 2005). If *q* is less than unity, a developer should not invest as the adjustment costs outweigh the expected future cash flows from the investment. If *q* equals unity, a developer should still defer investment as the expected gains are not exceeding the adjustment costs. Only when *q* surpasses unity, the developer should invest, as the expected gains outweigh the adjustment costs.

In theory, there is not a uniform entity called *q*. There is a difference between marginal *q* and average *q* and it has to do with how these constructs are related to existing capital stock and how they incorporate uncertainty within the equation (Hayashi, 1982; Bulan, 2005). *Marginal q* expresses the ratio of the market value of an additional unit of capital in relation to its adjustment costs. However, as this reflects future-based transactions of capital, there exists a degree of uncertainty which is difficult to incorporate within the *q*-ratio.

Within empirical research, it is *average q* which is generally used. This is because average *q* is the observable variant and reflects the ratio of the market value of existing units of capital. The latter is observable because it uses data from existing sources valued at existing values of capital. We can merely attempt to predict marginal q, whilst we can observe the average q ratio (Hayashi, 1982). This poses a problem for estimating true investment rates, as uncertainty over future prices can only be captured by marginal *q* and is thus neglected in the usage of average *q*.

Only when assuming perfect market conditions which include perfect competition and linear homogeneous production and adjustment costs, marginal *q* will equal average *q*, which is often not the case. This conception is supported by Yoshikawa (1980), as an alignment of average *q* and marginal *q* failed to capture expectations on future profits by investors. This only asserts the importance of the inclusion of other variables that can better explain investment behaviour of developers.

There have been several empirical studies which have applied *q* theory to estimate housing supply elasticities (Poterba, 1984; Topel & Rosen, 1988; Mayer & Somerville, 2000a). Both Poterba (1984) and Topel and Rosen (1988) found that the price of housing is a strong determinant of construction rates, whilst at the same time finding that cost measures are weak determinants. The latter is because of the omission of land as input, say Mayer and Somerville (2000a), who also argued that precisely because house prices and construction costs are non-stationary variables, the stationary *q*-ratio would fail to produce trustworthy estimates for housing construction rates. Grimes and Aitken (2010) extend this reasoning and assume in their *q* theory-based model that the profits from housing construction are stationary over time. They find evidence that including land in the equation for costs improves the results of construction rates estimates.

Whilst the application of *q* theory produces some useful insights in the relation between house prices, adjustment costs and construction rates, it fails to adequately incorporate measures of uncertainty and flexibility into the equation.

2.3. Option Theory

2.3.1. Financial option valuation

The fundamental relations between (the value of) risk, uncertainty and managerial flexibility are derived from option-pricing techniques (OPT) which were put forth by Black and Scholes (1973) and Merton

(1973), who examined the valuation of financial assets whilst including the unaccounted risk factor in their models. Within the financial market, OPT were used to answer questions on ambiguous relations between risk-structures, interest rates and speculation (Merton, 1973). Having the option to invest can be compared to having a call-option to trade an asset on a financial market: a broker is not obliged to invest in an asset but he or she has the right to exercise that option (Williams, 1991). The price paid at the moment of investment is called the *exercise price* (Merton, 1973).

Having the right to exercise an option adds value to the asset in question as uncertainty over future-expected returns on the investment can greatly increase the value of that same asset. To illustrate, a broker has the option to invest at $t = 0$, but it might be worthwhile to defer investment as the broker intends to gain more information over future market conditions, which might increase the potential pay-off in the future. Hence, the broker delays investment, even when the investment at $t = 0$ might seem favourable in light of the DCF method or q theory.

2.3.2. Black & Scholes Model

A classic real-options model is the Black-Scholes Model[4] (BS-Model) which assumes ideal market conditions and no transaction costs (Black & Scholes, 1973). The Nobel-prized model was created in order to estimate the equilibrium price for a *European stock option*[5], whilst assuming the financial assets (stock prices) to have a lognormal distribution of prices as these cannot drop below zero[6]. The BS-Model conforms asset prices following a geometric Brownian motion process, which can be interpreted as a stochastic variation of prices (Quigg, 1993; Sing, 2001), that is:

$$dP/P = \mu dt + \sigma dz \qquad (2)$$

where dz represents an increment of a standard Wiener process, μ is the constant drift and σ is the constant variance. To better compute the investment behaviour of risk-neutral investors, the market rate of interest is considered constant over time and known, i.e. risk-free, which is an important sidenote as it lowers the risk factor in the model.

The BS-model measures option prices as a function of semi-observable variables. The first variable is the time till the expiration of the right to exercise the option (t), which is relevant as Merton (1973) argued that the value of a mature option is systematically larger than an option which is relatively new. The second variable is the exercise price (P), representing the price which is eventually paid for the (financial) asset at the time of exercising the option. The third and fourth variables are the asset's current price (s) and the risk-free rate of interest (r), respectively. The latter is the interest rate whilst assuming

[4] With an acclaimed contribution of Merton (1973).
[5] A European option can only be exercised at the specified expiry date. American options can be exercised at any given time until the date that the option expires (Black & Scholes, 1973).
[6] Black and Scholes (1973) further assume that the value of assets cannot drop below the stock price minus the exercise price (p.638).

that investors are risk-neutral and that the volatility of risk is constant over time (Black & Scholes, 1973). The fifth and only non-observable variable in the BS-model is the instantaneous variance of the rate of return of the asset (v). This last variable is about the income from an investment as a share of the initial investment. The dependent variable is the premium for the option in question (ω). The BS-model is then denoted as follows:

$$\boldsymbol{\omega} = sN(d_1) - Pe^{-rt}N(d_2) \tag{3}$$

where N is the cumulative normal distribution function and where:

$$\boldsymbol{d_1} = \frac{Log\frac{S}{P} + rt}{\mathrm{v}\sqrt{t}} + \frac{\mathrm{v}\sqrt{t}}{2} \tag{4}$$

$$\boldsymbol{d_2} = d_1 - \mathrm{v}\sqrt{t} \tag{5}$$

Whilst this model is a valuable tool to measure prices of European purchase stock options, it remains a fairly theoretical construct producing some empirical flaws, which Black and Scholes (1972) also argued themselves. There exists an underestimation of the influence of transaction costs on options pricing (Black & Scholes, 1972). This would also have implications for applying the BS-model on the real estate market, as these markets are characterized by high transaction costs (Buitelaar, 2004). Additionally, as the BS-model is focused on European options it fails to capture the managerial flexibility of developers, who are able to exercise the 'option to develop' at any given time until a specified expiry date.

2.3.3. Real options

The option-pricing models as discussed above slowly spread to other disciplines, including the real estate sector. Whilst the conception that the value of an option is embedded within an investment opportunity is maintained – especially in the real estate sector – the strategies concerning real options and their economic values are diversified. The standard 'invest or delay' decision is only one category in a list including more options that regard various aspects of the development cycle. Based on the categorisation of Trigeorgis (1995), Table 2 below presents a simplified collection of real options in the real estate development.

Table 2: Overview of real options

Category	Description
Option to wait	The developer holds the lease (or the option to buy) land which is suitable for construction and has the flexibility to wait to see how prices evolve which can justify constructing houses.
Option to abandon	The developer can choose to withdraw from the development plan as market conditions have declined drastically. Already paid expenses are taken as losses or assets are sold for lower margins.

Option to scale	The developer may choose to increase or decrease the number of houses in the plan through enlarging the plan-area or increasing the housing density of the plan. The same goes for shrinking the plan-area or lowering the density of the plan when the market conditions are less favourable.
Option to switch	The majority of developments have a certain programming which defines the mix of housing to be constructed and the share of land which is reserved for public space. A developer may change the programming to suit market conditions or better utilize plan-specific opportunities.

2.3.3.1. Theoretical models on real options

Titman (1985) first applied the idea of option valuation to the real estate sector, specifically on the value of vacant lands. His motive for applying the option-pricing framework as proposed by Black and Scholes (1973) and Merton (1973) was based on the desire to explain why some private land owners deliberately chose to keep their land vacant or underutilized.

The model produced by Titman (1985) demonstrated that deferring investment in real estate can be seen as economically viable as it reduces the chances of building a suboptimal structure. It is the amount of uncertainty about the type of building which is deemed optimal on the plot of land, which is an important determinant of the value of vacant land (Titman, 1985). Uncertainty is defined as a combination of future price volatility and rental rates within a risk-free free portfolio. The higher the amount of uncertainty, the higher the value of the vacant plot, which ultimately leads to a decrease in development activity. In this regard, the plot of land can be viewed as an *option* on which the landowner can purchase (develop) a range of possible buildings. Although this might seem to refer to the option to switch, Titman's primary discovery is that having the option to wait is of value to the developer.

In his paper on the valuation of greenfield real estate projects, Williams (1991) extended the model of Titman (1985) through emphasizing optimal development timing as an outcome, based on estimated parameters. He further assumed that both the expected future returns and the development costs evolve stochastically through time, driven by a Wiener process. Williams' article shows the relevance of assuming negative net cash flows when a plot of land remains vacant. He illustrates that undeveloped land may produce negative cash flows as e.g. maintenance costs exceed rental incomes. This provides the incentive to exercise the option to *abandon* the development, which eventually correlates with the optimal development ratio as well. Whilst this study focuses on the option to delay construction, William's contribution remains relevant as it highlights the importance of expected cash flows on investment behaviour.

2.3.3.2. Empirical models on real options

Quigg (1993) combines the theoretical propositions of Titman (1985) and Williams (1991) and provides an empirical perspective on the real options approach by examining 2.700 real estate transactions of undeveloped land in the city of Seattle, US. The market transactions of undeveloped land are relevant in this matter, as it is the land which is viewed as an option. Quigg finds that for most properties, the development ratio (building price to development costs) is less than the optimal development ratio, which implies that developers would exercise the option to wait with development.

More interestingly, in comparing the results from the intrinsic valuation model and the option-based model, she found a mean percentage difference of six percent. Considered as the *option premium*, this six percent represents the option to wait to invest as a share of the theoretical value of land. But although Quigg's model produces significant results, it fails to capture any lag between construction and completion of the real estate, as data on actual construction is missing.

Whilst using aggregate data on commercial real estate, Holland, Ott and Riddiough (2000) are among the first to demonstrate the relationship between uncertainty, aggregate investment and construction rates. Other variables in their model include the interest rate, construction costs, expected growth rate of asset cash flow, systematic risk and prices of existing stock. Holland *et al*. (2000) conclude that investors in commercial real estate capitalize the option to wait, and therefore suggest that irreversibility and delaying investment are important factors in developer's investment behaviour. Although their study conforms a different level of analysis, it does confirm the relevance of option-based modelling of investment.

Somerville (2001) contributed to the empirical literature on real options by examining both the presence of option-values in starts and building permits and the phase of development where real options would be present. Based on data from fifteen Canadian Metropolitan Areas, he affirms the presence of real options in new construction, as developers adapt their investment decisions based on available information on future market conditions. His model includes the parameters of permits, starts, market volatility, risk-free rate of interest, completions and the vacancy rate, with the latter only having a minor effect. Albeit overall significant, the model coefficients are low, which lead Somerville to conclude that increases in uncertainty and market volatility only have a minor effect on the rate of investment. He does argue that real options are predominantly present from the time a building permit is obtained, which is also assumed in this study.

Through applying proportional hazard modelling on micro real estate data from Seattle, Cunningham (2006) produced some interesting conclusions. The first is that price uncertainty positively influences the value of vacant land, which is consistent with previously discussed empirical works. Secondly, he found that price uncertainty negatively influences construction activity; a one standard deviation increase in price uncertainty reduces construction rates by 11.3%. Thirdly, by including a measure of distance to the CBD, Cunningham found that the degree of urbanisation stands in relation to the significance of the real option to wait with construction. In other words, urbanisation interacts with uncertainty, which produces varying results in option premiums in land values.

Another contribution was provided by Bulan, Mayer and Somerville (2006), who used microdata on 1.214 individual real estate projects in Canada to also claim a significant negative relation between price uncertainty and investment in housing. Their contribution to the appliance of the option-model in real estate development revolves around the distinction between idiosyncratic risk and market-based (systematic) risk and the addition of competition as a variable. The latter is considered to have an influence on the relation between idiosyncratic risk and investment. Through their proportional hazard model they find that a one standard deviation increase in idiosyncratic volatility reduces the rate of investment ("hazard") by 13%, fairly similar to Cunningham's (2006) estimate. In addition, competition is shown to reduce the negative effect of idiosyncratic uncertainty on the rate of investment, which implies that developers delay investment when faced with greater competition.

These empirical works differ greatly in their approaches and their included variables, but they produced similar results for the effects of price uncertainty on development activity. This is an essential theoretical understanding and an assumption which has influenced the analysis as presented in this chapter. This study does not include all individual variables that are mentioned above, but rather focuses on price uncertainty as the centre variable. The efforts of the works above provide support for the hypotheses formed in Chapter 5.

3. Contextual framework

3.1. The development process

Real estate development in itself is a complex assemblage of organisational systems which combine the necessary input to create the desired real estate product, often with an increase in value. The process of real estate development is inherently different from other production-processes, as it includes *land* as a factor of production, ultimately linking the market for land and associated property rights with the market for real estate (Needham, 2006). It is the desire and (often) the need to transform places fit for change to desired real estate structures, that drives developers, private investors and governmental bodies to invest labour, capital and land into the development process.

Drane (2013) defines the development process as: *"…a particular state of transition or change in the form of real estate toward a different state with an associated change in potential or real value"* (p. 2). From this definition, one could deduce that development is a linear motion from state A to state B over time. However, such a simplification would negate the complex and dynamic reality of the process we call real estate development. In the words of Baldi (2013, p. 187): "*No model can capture the constant repositioning that occurs in the developer's mind or the nearly constant renegotiation between the developer and the other participants in the process*". Still, a model on the real estate development process produces a contextual framework that can be generalised to a certain extent, which helps to define the practice and place empirical findings in perspective.

3.1.1. Modelling the development process

There have been several contributions from the 1970s onwards to conceptualise the development process, which have formed the foundation for review articles by Healey (1991), Gore and Nicholson (1991) and Ball (1998). These articles presented fairly similar, but slightly varying categorisations of approaches to modelling the development process. In respect of their efforts, the following categorisation of approaches has been drafted and will be elaborated on in this paragraph:

- Sequential models
- Behaviouralist models
- Structure-based models
- Production-based models

3.1.1.1. Sequential models

Sequential models project the development process as a series of phases that are interrelated and often displayed in a flow-diagram. This rather pragmatic approach provides the tools to identify relevant actors and events in a logically organized development process where time is an important element (Gore & Nicholson, 1991). The attractiveness of this type of model comes from its flexibility and the possibility of incorporating sequential (horizontal) and parallel (vertical) variation. Not only can extra actors or parallel events be incorporated, but the overall process can be made shorter or lengthier by removing (simplifying) or adding events in the modelled development process.

Nevertheless, a considerable dilemma in designing sequential modelling is maintaining a balance between comprehensiveness and simplicity (which is often the case with designing models). Another source of criticism concerns the non-cyclical character of these often-linear models, which negates the complete cycle of real estate which also includes deterioration and redevelopment of existing property (Gore & Nicholson, 1991).

A useful theoretical model on the development process that provides an answer to these dilemma's is the development-pipeline of Barrett et al. (1978), which can be observed in **Fout! Verwijzingsbron niet gevonden.**. The myriad of development activities have been grouped together into three sets of events, whilst also integrating cyclicality into the model by linking the beginning and end-phase of the development process, giving the model its recognizable triangular shape.

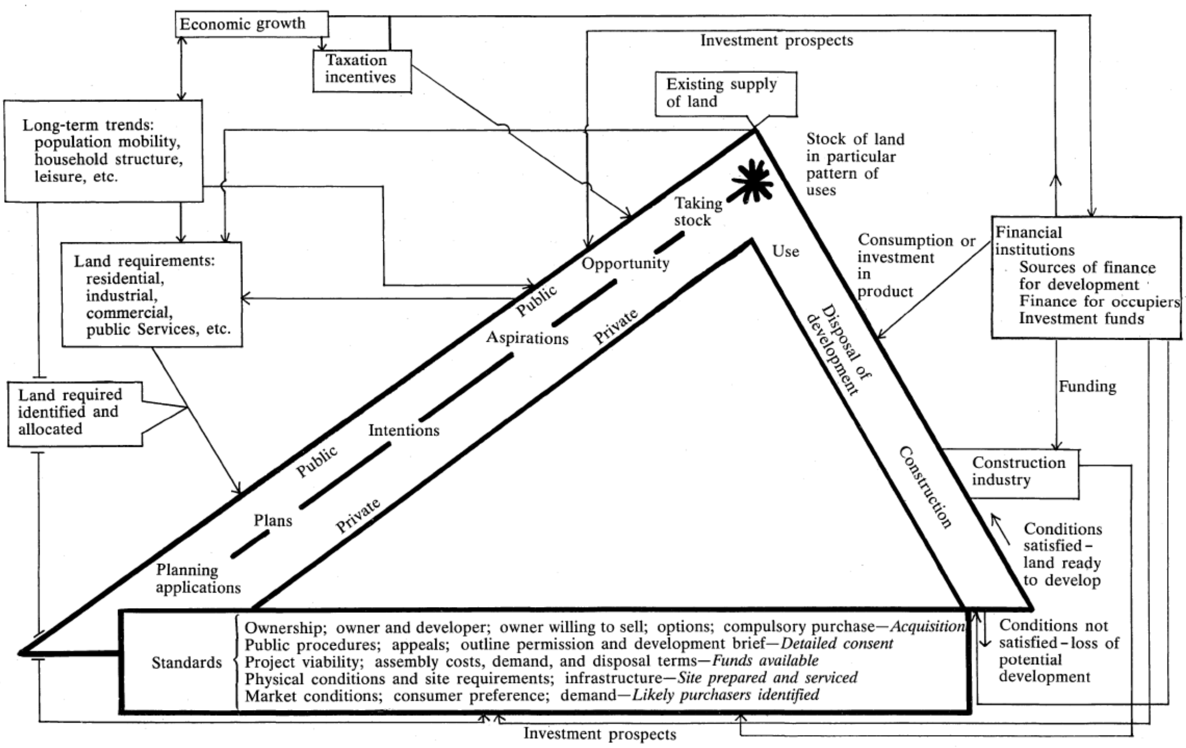

Figure 1: Development-pipeline by Barrett et al. (1987) as presented in Gore & Nicholson (1991, p.710)

The development-pipeline comprises three main phases: (1) development pressure and plan making (prospecting), (2) development feasibility tests and (3) the implementation. These phases are not rigid or predetermined but are rather flexible and plan specific. Nevertheless, they intent to follow a certain chronological order:

- **[Phase 1]** The first phase starts at the top of the triangle at “Existing supply of land”. When the housing market is not in equilibrium (demand ≠ supply) it opens up opportunities for new investment in housing, where a development plan can be drafted for a specific site.
- **[Phase 2]** The proposed development plan enters the phase of feasibility tests, which lends its value on limiting risks by preventing any unwanted developments and protect the anticipated financial investments in property development (Ball, 2011). Barrett *et al*. (1978) define five specific tests of development feasibility: (1) ownership, (2) public procedures, (3) project viability, (4) physical conditions and (5) market conditions. It is in this phase where development plans are often altered to make them more feasible or acceptable, which would ensure development opportunity. When the development plan successfully endured the feasibility tests, official building permits or legal approvals can be obtained, gratifying the next phase.
- **[Phase 3]** This concerns the implementation phase. The developer can choose to commence construction. However, the choice to invest is not straightforward and can depend on a multitude of factors that are exogenous to the development process and which are unfortunately excluded from the development-pipeline model as presented in this paragraph.

Within this model, there is an implicit indication of time as it assumes a chronology of events. Much of the scientific literature on investment behaviour assumes a direct transition from investment to structures. However, obtaining a building permit does not necessarily implicate immediate construction. Whilst some authors do account for a standardized factor of delay in between obtaining a building permit (phase 2) and construction (phase 3), they often fail to endorse the versatility of the temporal length of the development process. Also, albeit providing valuable pragmatic insight in the development process, sequential models have a predominantly descriptive character, which impairs their use in analytical studies where the goal is to *explain* why certain phenomenon occur.

As this research intents to expose factors influencing investment behaviour of developers, the transition from phase 2 to phase 3 in the development pipeline is contextually important. This is where the implementation gap of Bramley (Bramley, 1993a, 1993b) applies, as the actual rate of housing construction (implementation: phase 3) fails to correlate with the rate of granted planning permissions (development feasibility: phase 2). It is these development plans that are not implemented, but where developers do have the permission to proceed which are referred to as *stalled sites* McAllister *et al*. (2016).

3.1.1.2. Behaviouralist models

In emphasizing the behaviour of relevant actors in the development process, behaviouralist models offer a better understanding of the decision-making processes within real estate development (Gore & Nicholson, 1991; Healey, 1991). Ordinarily, the developer, the planner and the landowner are considered the key actors in the process and they are accompanied by a larger array of secondary actors, interests and (sometimes) events.

There are several contributions to behaviouralist modelling of the development process and these can be divided into individualist approaches and interactive models. Individualist approaches treat the relevant actors as autonomous entities, who make decisions based on their own preferences and intentions, neglecting other actors in the process (Gore & Nicholson, 1991). Interactive models do include the interaction of actors and often also their decisions. In this sense, decisions made by secondary actors have the ability to influence the decision made by the actor in question, which is an important extension of the individualist approach as development processes are seldom individual ventures (Baldi, 2013).

Behaviouralist models often adopt a chronological depiction of events, which is similar to the sequential modelling as discussed in paragraph **Fout! Verwijzingsbron niet gevonden.**. The difference here, is that behaviouralist models accentuate decision-making dynamics of actors and use the sequential phases of the development process as a framework for building a logical model. A good example to illustrate the purpose of including development phases in depicting the behaviour of actors can be seen in **Fout! Verwijzingsbron niet gevonden.**, which is an interactive model presented by Goodchild and Munton (1985).

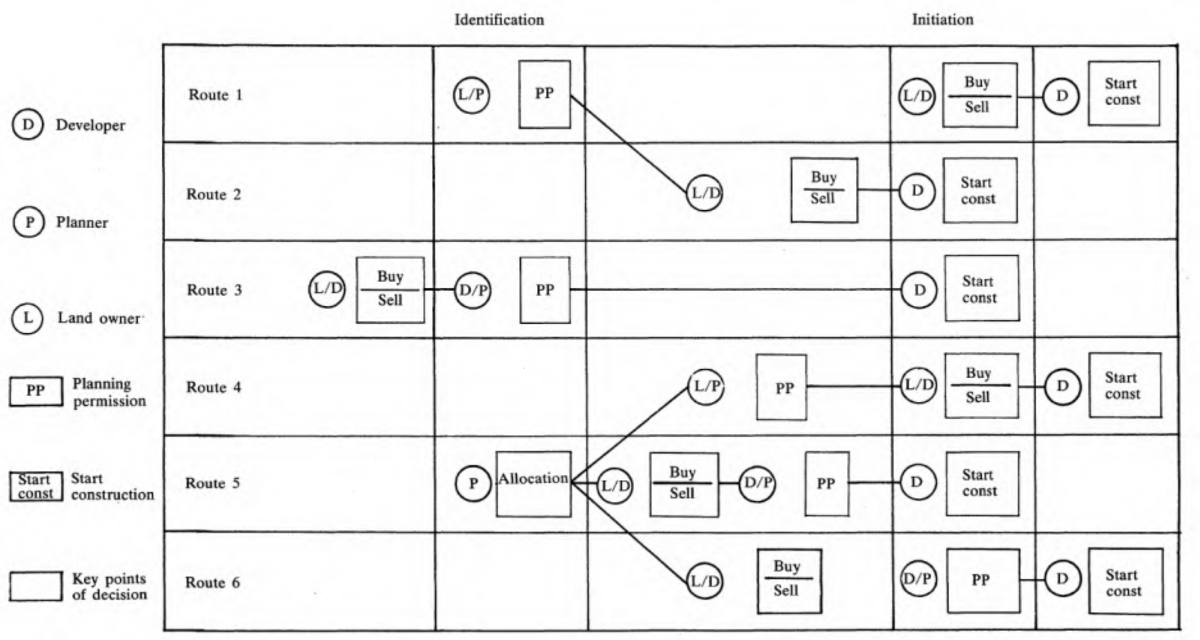

Figure 2: Behaviouralist model of development (Goodchild & Munton, 1985)

The model presented above portrays six different routes in the development process, whilst revolving around two important decision-making points, namely: (1) the identification of developable land and (2) the initiation of construction. Especially the decision to start construction is of importance, as in every route a decision regarding construction is being made by either the developer or the developer in combination with the planner or the landowner (Goodchild & Munton, 1985).

Considering the fact that this model is applied on the British context, this model asserts the important role of the developer in the implementation phase of development. Neglected in this model (and often in other behaviouralist models as well) is the influence of external linkages. Besides macro-economic conditions and governmental policies, behaviouralist approaches tend to disregard the workings of the market, whilst supply and demand variables are known to be crucial in understanding development activity. Decision-making processes within the development cycle are rarely a product of solely individual interests.

3.1.1.3. Structure models

Structure models accredit the institutional perspective on the development process and provide an extension to the previously mentioned sequential and behaviouralist models. As important contributors to structure models, Harvey (1985) and Ball (1998) have stressed the important links between the development of built property, financial investments and public policy. Also called *structures-of-provision*, these models incorporate internal and external pressures on the development process that are either fuelled by conflict or collaboration (Gore & Nicholson, 1991). But applying these relations on a site-specific level proved difficult. Institutional perspectives alone often lack the capacity to explain local developments in the built environment (Ball, 1998). Although promising in offering a grander theoretical framework for analysing the workings of the real estate industry, structure models lack a sufficient approach to investigate the particular, which is an approach deemed favourable when assessing the development timing for individual development schemes.

3.1.1.4. Production models

The fourth type of modelling concerns the macroeconomic dynamics of demand and supply within the housing market. These production-based models, or equilibrium models, are founded on the premise that an increase in demand eventually leads to an increase in development activity, whereas the development itself is regarded as relatively unproblematic (Healey, 1991, p. 222).

The primal focus of these models is the flow of capital and the outputs these flows produce, mainly in the arrangement of built property (Gore & Nicholson, 1991). Production models often include the origins of funding in relation to the costs of development, which provides insight in how generic development would be made financially feasible. The main criticism on these models revolves around the simplification of the development process and therefore the ignorance of the complex and uncertain nature of particular real estate development projects (Ball, 2011) and the strong deterministic character of the system in which there is little room for managerial flexibility (Gore & Nicholson, 1991).

A well-known production model of the housing market which follows a direct function of house prices is provided by DiPasquale and Wheaton (1996). Their dynamic model of the housing market revolves around stock-adjustment and assumes a long-term equilibrium of the market. The model incorporates three submarkets (see Figure 3), namely: (1) the consumer market for space (top-right corner), (2) the asset market for property (top-left corner) and (3) the construction market (bottom-left corner). These

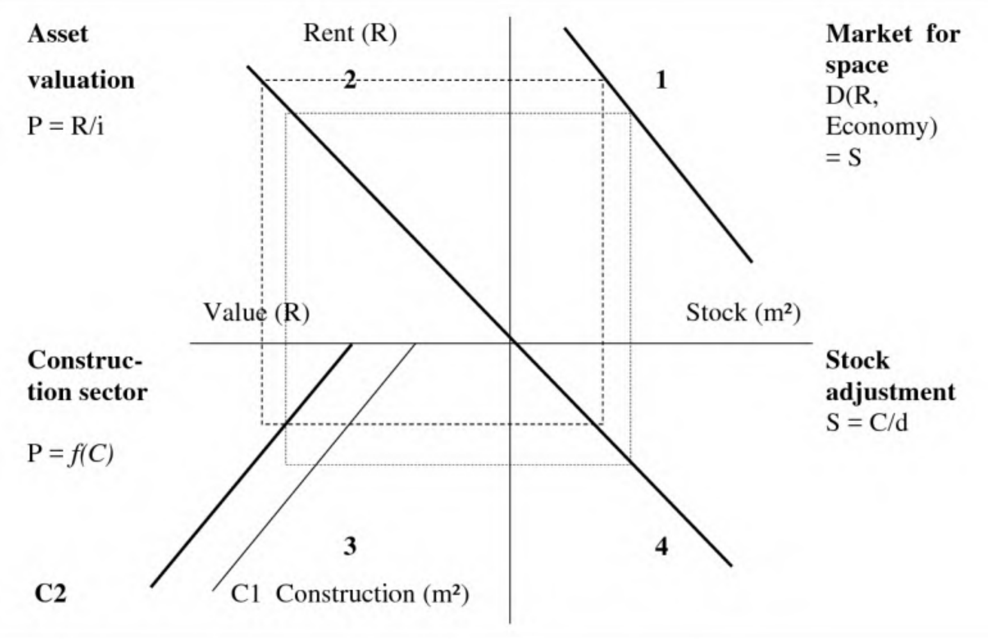

Figure 3: Production model of DiPasquale and Wheaton (1996) as presented in Toit & Cloete (2004)

submarkets are then linked to the entity of housing stock (bottom-right), which is a stock-variable influenced by flows of new construction and withdrawals.

The dynamics of the DiPasquale and Wheaton model indicate a cyclical character: when the demand for space increases, rents increase which means that property assets gain a higher value. Not the new *level* of asset valuation, but the *change* of asset valuation influences the level of construction. This is an important distinction, as it simulates the assumption of absolute house prices reflecting market equilibrium on the long run. This produces the important assumption that construction is a function of a *change* in house prices (Mayer & Somerville, 2000a; Ball et al., 2010). It also works the other way around; when house prices are not subjective to change, it implies that the housing market is in a phase of equilibrium. To finish the cycle: the construction of new houses increases the stock of housing in order to comply with the new levels of demand in the market for space, creating a new equilibrium.

The reason why market equilibrium is only expected in the long run, is because of the inelasticity in the short term and the heterogeneity of the housing market (DiPasquale & Wheaton, 1996; Toit & Cloete, 2004). Shocks in market demand do not immediately result in new construction. In their supply equations, Mayer and Somerville (2000a, p. 99) therefore include variables that relate to delays (in time) of land acquirement, gaining housing permits and builders' expectations on future housing prices. The latter is important as construction only commences when the marginal expected gains (connected to house prices) is higher than the investment in housing (such as interest rates and production capital).

This reflects the concept of *q* theory as explained in 2.2.2, in which the marginal profitability influences the decision to invest.

3.1.2. Application to this study

This study adopts some of the assumptions that are presented above. An important assumption is that construction is a product of changes in market conditions. Especially the production model by DiPasquale and Wheaton (1996) illustrates this, as changes in demand are directly linked to changes in prices and eventually construction. This provides the contextual foundation for including market conditions as an important derivative for construction rates in the housing sector. An essential nuance to the DiPasquale and Wheaton model is that it implies perfect market dynamics, which is often not the case in the Netherlands. Caps on rents and initial yields, transaction costs and regulatory processes such as land-use plans disturb the dynamics as predicted by the model in Figure 3.

Another important takeaway is that it is the changes in house prices rather than the levels of those prices which influence construction. The sequential and behaviouralist perspectives illustrate the relevance of seeing the developer as a conscious actor who is able to influence the development process at various stages, from which the initiation of construction is the primal focus of this study.

3.2. The Dutch context

Much of the scientific literature on housing supply and the development process presented above is concentrated on the planning contexts of the UK or the US, which cannot be translated to the Dutch context without any interpretation. As Ball (1998) would argue, institutional contexts shape the way actors are related to each other and how they operate, which in turn influences the way the development process is being organized. Land ownership, land-use planning, and property rights systems can vary across countries, and they are key to understanding how the legal system shapes development practices (Needham, 2006).

3.2.1. Basic principles of Dutch spatial planning

The Netherlands is widely known for its comprehensive and strongly institutionalized planning system in which the majority of governmental bodies exemplify an active stance towards land-use development in a system well documented in a legal framework (Needham, 2014; Buitelaar & Bregman, 2016). This is accurately described by Needham in his book 'Dutch Land-Use Planning: The Principles and the Practice' (2014), where he says:

> *"The rules for spatial planning and related aspects are extremely carefully thought out, so as to be consistent with each other and with other rules too. There is an impressive construction of laws, both in private law and in public law, and it is the aim of the lawyers, civil servants and politicians that the rules for changing and using land be fully coherent with the more general rules…" (p. 14).*

This established legal framework for spatial planning in the Netherlands is the product of how the Dutch view land and its eventual use, which can be summarised with three key principles.

The first is that all land is ought to be used (Needham, 2014). Every single square meter of land will be designated with a function which is often the outcome of an extensive and thorough evaluation of interests of relevant landowners and interested parties. All land that is left 'open' on purpose, will be labelled with an ecological development function, as also nature is managed within the Dutch spatial planning context.

The second principle revolves around a business-like perspective on land ownership. Landowners are likely to co-operate in land-use development schemes when business-cases prove economically profitable or attractive in the broader sense (Needham, 2014). In addition, and especially after the commencement of the new Act on Spatial Planning (hereafter referred to as Wro)[7] in 2008, local governments gained more responsibility which increased the business-like relationships between local governments, property developers and housing corporations (Buitelaar, 2010) As a result, local governments increasingly rely on the co-operation of private enterprises to develop real estate. However, there still exists a level of mutual dependency as private developers always need to cooperation of the government in order to initiate development.

The third principle is about value, and most notably about *value-creation*. As previously explained in paragraph 3.1, real estate development is about producing or transforming a new structure on land, almost always with an increase in value. This increase in value will not be roamed off through taxes but is instead used to increase the quality of the proposed development plan (Needham, 2014). In light of the focus of this study development timing, this last principle displays the link between the decision to invest and the quality of the proposed development plan.

3.2.2. Spatial administrative instruments

The Dutch spatial planning system revolves around an array of spatial administrative laws. As these laws are extensive in nature, this paragraph will only discuss the most relevant aspects that relate to the context of this study. These aspects involve the (1) land-use plan, (2) the development permit and (3) the financial[8] or development plan, which are all important in respect to the judicial plan status discussed later (see Paragraph **Fout! Verwijzingsbron niet gevonden.**).

3.2.2.1. Land-use plan

A spatially relevant judicial instrument for municipalities is the *land-use plan*, of which its protocols concerning procedure and contents are laid down in article 3.1 Wro. Every municipality is obliged to establish a land-use plan for its territory, whether it contains numerous smaller land-use plans or one larger global plan. It is a powerful legally binding tool that influences the zoning, and thus the interest

[7] Translated from Dutch: "*Wet op Ruimtelijke Ordening (Wro)"*
[8] Translated from Dutch: "*Exploitatieplan"*

in – and the value of – land. This evidently determines the possible locations for housing construction in the Netherlands (Michielsen et al., 2017). The function of a land-use plans can be threefold (Nijmeijer, van Buuren, Gier, & Robbe, 2010). It can entail (1) a planning-function, (2) a development-function or (3) an assessment-function.

The first concerns the 'control' on the specified area on which the land-use plan is effective. The plan contains the expected spatial developments for the future and functions as a framework for the municipality to govern on. The second function is especially relevant to the context of this study as it regards the acting of municipality or developers (or a combination) in the realisation of structures on the land. Whenever it concerns a development of some sort, the land-use plan in question must be accompanied by a financial substantiation in the form of a financial plan or anterior agreement (Nijmeijer et al., 2010). The last function is interesting from a judicial perspective, as the land-use plan in effect will function as a framework for assessing and evaluating future development plans and construction works.

Based on article 3.1 Wro, land-use plans can be altered by municipalities, but only after careful consideration that follows a legal procedure that takes a minimum of 26 to 31 weeks, provided that there are no appeals (Nijmeijer et al., 2010). The time taken for the land-use plan procedure is actually highly variable and is also dependent on the complexity of the proposed plan. If the land-use plan receives appeals on those moments where appeals are allowed, the procedure for just a single plan can take up to 3 years to complete (Kubiek Ruimtelijke plannen, 2020).

Whilst legally binding, the land-use plan on itself is not an instrument of commandment, often referred to as *admission planning*[9]. The land-use plan does not oblige the landowners and/or developers to initiate construction. It merely sets the framework to which future developments must comply (Nijmeijer et al., 2010). This produces the condition where landowners, developers or the municipality thus have the 'option' to start the process of attaining a development permit, reflecting the managerial flexibility in real estate development. In the new Environmental and Planning Act[10], where land-use plans are to be replaced by environmental plans for the entire municipality, there is also no stringent period laid down in which the development plan must be realised, which means that the concept of admission planning is still applicable for the foreseeable future.

3.2.2.2. Development permit

For the majority of activities that concern construction, renovation, demolishing or any other activity in the physical domain, one needs a permit under the Wabo Act[11] (for simplicity hereafter referred to as *development permit*). The Wabo Act prohibits any activities from happening without a development

[9] Translated from Dutch: *"toelatingsplanologie*"
[10] Scheduled for implementation in 2021.
[11] Translated from Dutch: *"Wet Algemene Bepalingen Omgevingswet (Wabo)"*

permit. Obtaining a permit is once again dependent on whether there are any appeals to the proposed development, which, if there are appeals and court proceedings included, the procedure could take up more than 2 years (Kubiek Ruimtelijke plannen, 2020). The relevance of the development permit in this context is derived from article 2.10 Wabo, which states that a granted development permit may never be in conflict with the land-use plan effective for that specific area. This legally binds the development permit and the allocation of the land-use plan (Nijmeijer et al., 2010).

3.2.2.3. Financial- & development plans

As mentioned in Paragraph **Fout! Verwijzingsbron niet gevonden.**, the establishment of a land-use plan must be accompanied by a financial substantiation. Articles 6.12 and 6.24 Wro state that this financial substantiation can be enacted through either private or public law. Municipalities, landowners and developers can voluntarily come to an agreement on how the costs for development are appropriated between the associated parties in the form of an anterior or posterior agreement (Nijmeijer et al., 2010). The legal basis for these development plans through private law are laid down in article 6.24 Wro.

When the associated parties do not come to an agreement voluntarily, a financial plan must be enforced, which is a public instrument to ensure that the municipality can appeal to market parties to account for plan-related costs. The legal basis for a financial plan are laid down in article 6.12 Wro. Both public- and private law plans are regarded as 'development plans' in this study and are important in relation to the phase of the development project. Composing the development plan is a procedure legally aligned with the planning decision (Nijmeijer et al., 2010). This ensures that no plan can be considered operative before the accountability for development costs is settled.

3.2.3. Plan capacity

In regard to gaining insight in housing market mutations and in order to compose effective policy on housing, provinces are expected to document residential development plans in their region and disclose them to the national government on a twice-yearly basis (Groenemeijer & Van der Lelij, 2020). The documentation of these development plans is done in provincial plan capacity inventories. Whilst provinces are obliged to register the individual development plans, there is not a standardized format for these inventories which leads to differences between provinces in how they document each development plan. Albeit these differences, some key variables must always be present, including plan status, gross- and net plan capacity.

3.2.3.1. Plan status

Real estate development is a process which goes through various phases: from the initial opportunity to the eventual implementation of the development plan. The same line of reasoning can be applied to the development plan itself. Not all development plans are in the same status of being implemented. Development plans also move from early phases where an idea is pitched towards the phase where more elaborated plans are tested on their feasibility after which the change of being implemented has grown considerably. The status of development plans in the Netherlands is linked to their judicial status

(Scheele-Goedhart & Reijden, 2008), which is based on the planning decision as discussed in Paragraph **Fout! Verwijzingsbron niet gevonden.**.

A decisive juncture where a development plan receives a more stringent status (namely *irrevocable*) is when the land-use plan is altered or drafted (Buitelaar & van Schie, 2018). Thus, whenever one speaks of the readily available plan capacity in the Netherlands, they generally imply those plans that are denoted as irrevocable. However, within the Dutch context, many generally refer to 'hard' plans, which also contain those plans that are approved or certified by the municipality (Scheele-Goedhart & Reijden, 2008). For the remainder of this study the denotation of irrevocable plan status is leading, as these plans are expected to be implemented in the near future, therefore assuming that the land-use plan is altered.

An overview of the various plan statuses can be found in **Fout! Verwijzingsbron niet gevonden.**. This classification depicts three unique irrevocable plan statuses. For the analysis in this study, only development plans with 1A or 1C are included, as plans with 1B and an obligation to elaborate further are usually global land-use plans that require substantially more time to develop. The individual plan statuses as provided by the province are the primary derivative of the phase of the plan. The Wro act does allows for higher tiers of government to establish development plans which usually fulfil structure visions or masterplans (Nijmeijer et al., 2010), but these are not taken into account in this study as data on these plans are not provided.

Table 3: Overview of plan statuses

<table>
<tr><td>1A: Irrevocable capacity*</td><td rowspan="3">Land-use plan is altered</td></tr>
<tr><td>1B: Irrevocable capacity with obligation to elaborate further</td></tr>
<tr><td>1C: Irrevocable capacity with ability to alter the plan*</td></tr>
<tr><td>2: Approved plan</td><td rowspan="4">Phase prior to alteration of land-use plan</td></tr>
<tr><td>3: Certified plan</td></tr>
<tr><td>4: Plan in preparation/design</td></tr>
<tr><td>5: Potential capacity</td></tr>
</table>

**included in the analysis*

3.2.3.2. Gross- & net plan capacity

Another important distinction within the plan capacity inventories concerns the relation between newly built houses and demolition, expressed in values for gross plan capacity and net plan capacity that are registered for each development plan (Scheele-Goedhart & Reijden, 2008). The gross plan capacity reflects the number of houses that are to be added to the overall housing supply when the development is realised. The net plan capacity reflects the gross plan capacity minus the planned demolished housing units. In a situation where no former structures need to be demolished, the gross plan capacity will be the same as the net plan capacity.

As the goal of this study is to examine the relation between price uncertainty and development timing, where the outcome of the decision to invest is additional housing supply, the gross plan capacity is selected as a variable of interest for analysis.

4. Methodological framework

4.1. Research philosophy

The following paragraphs are structured conforming the *research onion* (**Fout! Verwijzingsbron niet gevonden.**) as presented by Thornhill, Saunders and Lewis (2009). Whether constructing a new grand theory or investigating a small case, doing research always entails doing assumptions. These assumptions are the derivative of the research philosophy which the researcher has embodied. In this sense, the research philosophy can best be described as a "*system of beliefs and assumptions about the development of knowledge"* (Thornhill et al., 2009, p. 130). The underlying assumptions will evidently shape the research questions, the methods used, and the conclusions drawn.

The questions of research philosophy relate to the nature of reality (ontology), the relation between the research and the 'what can be known' (epistemology) and how the researcher can go about finding this reality (methodology).

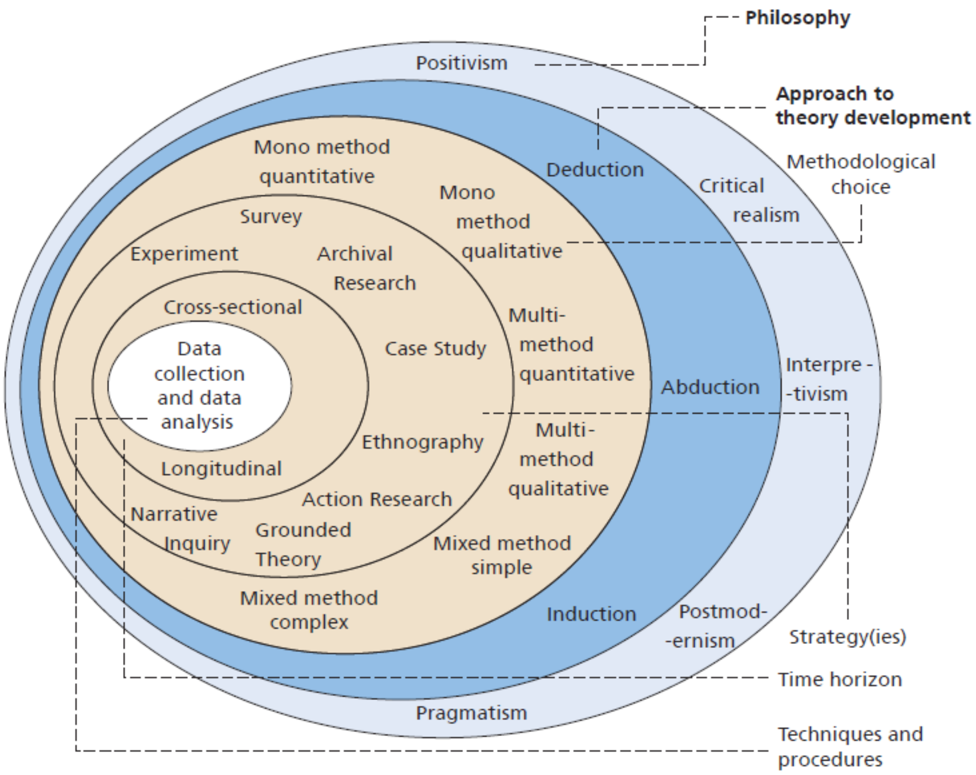

Figure 4: The "Research Onion" (Thornhill et al., 2009)

4.1.1. Positivism & post-positivism

This research is set within an empirical-analytical research tradition, which is linked to the research philosophies of *(post-)positivism*. Positivism has its roots in the natural sciences in which reality is perceived as an observable entity, where the purpose of doing research is to produce law-like generalisations (Thornhill et al., 2009). An important element in the positivist philosophy is the separation of objective data and human interference. This implies conducting research in a value-free setting, where the researcher purposely distances him- herself from the research objects and the data used. With a focus on objectivity, systematic analysis and a strong methodology, positivist researchers pursue replicability, which is eventually also a measure of truthfulness (Guba & Lincoln, 1994). As repeated analyses produce identical results, a-priori hypotheses may be accepted and shaped into generalised theories.

Maintaining a true positivist philosophy has been proven difficult as human constructions are present in the majority of observable entities (Thornhill et al., 2009). Additionally, in neglecting any qualitative values, the research might ignore important factors that influence the analysis. These critiques have piqued interest in the post-positivist tradition. Important characteristics of post-positivism are its "reductionist, logical, empirical, cause-and-effect oriented and deterministic" approach towards conducting research (Creswell & Poth, 2016, p. 24). By following logically defined and well-documented steps, the researcher aims to test a-priori hypotheses that are deductively derived from the study of existing scientific literature, much like in the positivist tradition. Through the testing of hypotheses, the researcher aims to come closer to reality. Once the results show that a hypothesis is false, it is rejected. This reflects the post-positivistic principle of *falsification*: replicated research results are generally not perceived as being completely true and are only accepted until proven otherwise (Thornhill et al., 2009). This rather critical stance towards the relation between human knowledge and reality compliments the often-complex nature of reality.

4.1.2. Application to this study

Conforming the aim of this study to test a-priori hypotheses through objective systematic analysis and produce generalized statements on the relation between selected variables and the development timing in the Netherlands, this research fits best with the post-positivist approach.

In terms of the approach to theory development, this research is conducted in a deductive manner. Based on existing scientific literature, a collection of variables is selected to be tested in statistical analysis. Another important principle adhered to in this study is the distance between the researcher and the units of study. The analysis is based upon secondary existing material which is produced by various institutions and governments and *not* by the researcher. Ordinarily, analysis on secondary material involves statistical data (Van Thiel, 2014), which is also the case in this study. Statistical data is most suitable for deductive hypothesis-driven research. Equally important is the repeatability of the study, especially from a (post-)positivistic perspective. In order to facilitate proper replication of the analysis presented in this study, the methodology is transparent and carefully structured. This also contributes to the overall reliability of this study.

This study cannot be considered an in-depth research. Whilst aimed at exposing causality between independent and dependent variables, the mere focus on quantitative dynamics does not allow the researcher to explain *why* certain causal relations occur (Lin, 1998). It is important to acknowledge this shortcoming to prevent faulty conclusions on causality in later stages of the research. The time horizon of this study is bound to the availability of the data, which is thirteen years (2008 – 2019). As the residential development plans are compared on the basis of their characteristics over a long period, this study can be categorised as a panel study. Within a panel study, the researcher investigates a fixed group of units which are traced in a longitudinal context (Van Thiel, 2014). Instead of measuring at a single interval, the researcher can conduct multiple measurements over time, which helps to see how the independent variables can influence the dependent variable of interest.

4.2. Methodological choice

In accordance with the research design principles of Thornhill *et al.* (2009), the primary question on methodology is the nature of the data to be investigated; whether it be qualitative, quantitative or mixed. In general, post-positivist philosophies often entail quantitative data, as it lends itself more to examining relationships between variables in a systematic and naturalist approach. Moreover, whenever causalities are to be found, they can be more easily generalised through aggregation of data, which is easier with quantitative than with qualitative datasets. In terms of collection techniques, this study entails the mono-method quantitative study, indicating that only one technique for gathering data has been used. Although multiple data-sources have been combined, they are all approached as secondary datasets.

4.3. Research strategy

Whilst often confused with research methods, a research strategy refers to the translation of the research philosophy to the research methods (Van Thiel, 2014). The strategy resembles the logical way of reasoning from the objective of the research and the underlying assumptions to the methods applied. It is important that the research design and the methods are aligned to ensure the research's internal validity. Alongside the research objective, there are other factors that influence the choice for a certain strategy, for example the body of available literature on the topic at hand and the number of observable units of study that can be included in the analysis (Van Thiel, 2014).

The research strategy applied in this study can be referred to as an *experiment*. As mentioned before, the objective of this study is to test a-priori hypothesis which involve causalities between various independent variables and a dependent variable (development timing). The ultimate purpose of an experiment is to accept or reject the hypothesised relation between two variables (Thornhill et al., 2009). At the basis is the null hypothesis, which represents the situation where there is no significant relation between the observed variables. Through a statistical analysis a probability is produced, which provides an indication of the compatibility of the data with the null hypothesis. If the probability (p) of the relation falls below a certain threshold, the data proves incompatible and the alternative hypothesis is accepted. Once the probability of that relations exceeds the threshold, the null hypothesis is accepted, and the alternative hypothesis is rejected. This can be repeated for multiple variables in the same model.

4.4. Research ethics

Conducting research is not without ethical considerations. The concept of research ethics refers to the behaviour of the researcher in relation to the units of study and everyone affected by the research (Thornhill et al., 2009). This behaviour is not only influenced by the researcher's social norms, but also by the overall research design, the availability and the nature of the units of study and external developments. In general, qualitative research will bring about more ethical concerns because the gathering and analysis of qualitative data is less straightforward and requires more interpretation by the researcher than with quantitative data. Nonetheless, quantitative research also encompasses important ethical concerns linked to the various phases of conducting research: from the initial phases of designing the research to reporting the findings of analysis (Thornhill et al., 2009). Especially data protection and data management require well-justified measures in order to conduct the research in an ethical and lawful manner.

Data protection revolves around data which can lead to the identification of individuals (Thornhill et al., 2009). Since the implementation of the General Data Protection Regulation EU (GDPR), the use of personal data has been heavily restricted, and all processes related to personified data have to comply with EU regulations. Within this research, no personal data – or data that can be used to identify individuals – is used, bypassing any ethical concerns revolving personified data or privacy in line with the GDPR.

Notwithstanding the former, there are still ethical concerns regarding the received plan capacity inventories from the provinces. These provincial inventories are received on the condition that they are not shared with third parties nor made public through publication of this research. To comply with these requests, the results of this study are presented in a way constraining any person to trace back individual development plans or consolidated plan capacity on a municipal level. Data on residential transactions, retrieved from Watson+Holmes (2020), is non-public and are therefore not disclosed in detail. The data is solely used in the analysis to produce measures for price changes and price uncertainty. The remaining source for data is Netherlands Statistics[12], which is a publicly available database and is therefore treated as such.

4.4.1. Reliability

According to Van Thiel (2014), reliability refers to functions of accuracy and consistency with how the variables in the study are measured and analysed. When these functions of reliability are sound,

[12] *"Centraal Bureau van de Statistiek (CBS)"*

repeating the analysis should produce the same results. Accuracy concerns how variables are measured and if this method truly reflects the intention of the researcher. Despite the ambiguity of the term, 'accuracy' asserts the weight of a proper research design. On the other hand, consistency refers to the stability of the measurements used and the repeatability of the analysis by using the same methods. Through careful and thorough documentation in associated log-files[13], the procedure for the analysis in this study is made clear for others to repeat the analysis provided they can utilize the same datasets.

4.4.2. Internal- & external validity

Validity is concerned with the cogency of the research, referring to the effectiveness of the analysis in relation to the intention of the researcher (Van Thiel, 2014). It therefore concerns the appropriateness of the measures used in the research and the eventual generalisability of the results, or more commonly referred to as *internal* validity and *external* validity.

First, internal validity relates to the extent to which the research results can be ascribed to the units of study themselves instead of existing flaws in the research design (Thornhill et al., 2009). In other words, a research is deemed internally valid, when the results truly represent what the researcher intended to investigate. If the research results are the product of false assumptions or unobserved variance, the research loses its internal validity. The testing of hypotheses will be done through significance testing which are available in the statistical analysis program Stata.

Province	**Number of housing units per km^2 (2019)**	**New starts per 1000 housing units in 2019**	**Number of housing units per km^2 (2009)**	**New starts per 1000 housing units in 2009**	**Percentual change in housing density 2009 – 2019**	**Percentual change in new starts 2009 - 2019**
			Included for analysis			
Noord-Holland	501	11.0	453	8.9	+ 10.6%	+ 23.6%
			Excluded from analysis			
Zuid-Holland	621	10.4	553	9.6	+ 12.3%	+ 8.3%
Utrecht	390	12.1	361	12.2	+ 8.0%	- 0.8%
Gelderland	182	10.1	162	11.6	+ 12.3%	- 12.9%
Limburg	247	4.0	232	5.9	+ 6.5%	- 32.2%
Noord-Brabant	230	10.4	206	11.6	+ 11.6%	- 10.3%
Drenthe	84	4.7	78	7.5	+ 7.7%	- 37.3%
Friesland	90	7.8	84	4.6	+ 7.1%	+ 69.6%
Zeeland	105	5.8	98	7.8	+ 7.1%	- 25.6%
Overijssel	152	9.8	138	7.6	+ 10.1%	+ 28.9%
Groningen	120	8.5	108	7.6	+ 11.1%	+ 11.8%
Flevoland	120	17.7	105	17.6	+ 14.3%	+ 0.6%

[13] These are do-files that contain the coding used in the statistical program Stata.

			National average			
Netherlands	232	9.8	211	9.6	+ 9.9%	+ 2.1%

Secondly, external validity concerns the extent to which the results in the study can be generalised to other a broader extent (Thornhill et al., 2009; Van Thiel, 2014). As housing markets are regional markets, results from a single province are likely to be different from other provinces. Provided that this study only includes one province weakens the external validity and undermines the ability to draw conclusions on a national level.

Fout! Verwijzingsbron niet gevonden. presents a comparison of the Dutch provinces and the national average based on information on housing stock mutations of 2009 and 2019 (Statistics Netherlands, 2020b). Solely based on the number of housing units per square kilometres, Noord-Holland belongs to the upper category when compared to the other provinces and to the national average. This implies that the exclusion of other provinces might lead to skewed results. In regard to the data on new starts per 1.000 housing units, Noord-Holland is relatively close to the national average, but there is a significant variance between provinces, as Drenthe has a value of 4.7 in 2019 compared to 17.7 of Flevoland.

Noord-Holland is also compared to other provinces based on the house price index for existing houses (Statistics Netherlands, 2020c). **Fout! Verwijzingsbron niet gevonden.** displays the indices for 2005 to 2020[14] for each of the twelve provinces. Noord-Holland and the national index are highlighted and show that house prices have risen harder in Noord-Holland than in other provinces. The difference between the provinces is, once again, relatively large between outliers (Noord-Holland and Zeeland) varying 22,6 points. The preceding contentions support the argument that the results of this research cannot simply be generalized to other provinces, meaning that the results of this study only apply to the province of Noord-Holland.

[14] 2015 = 100

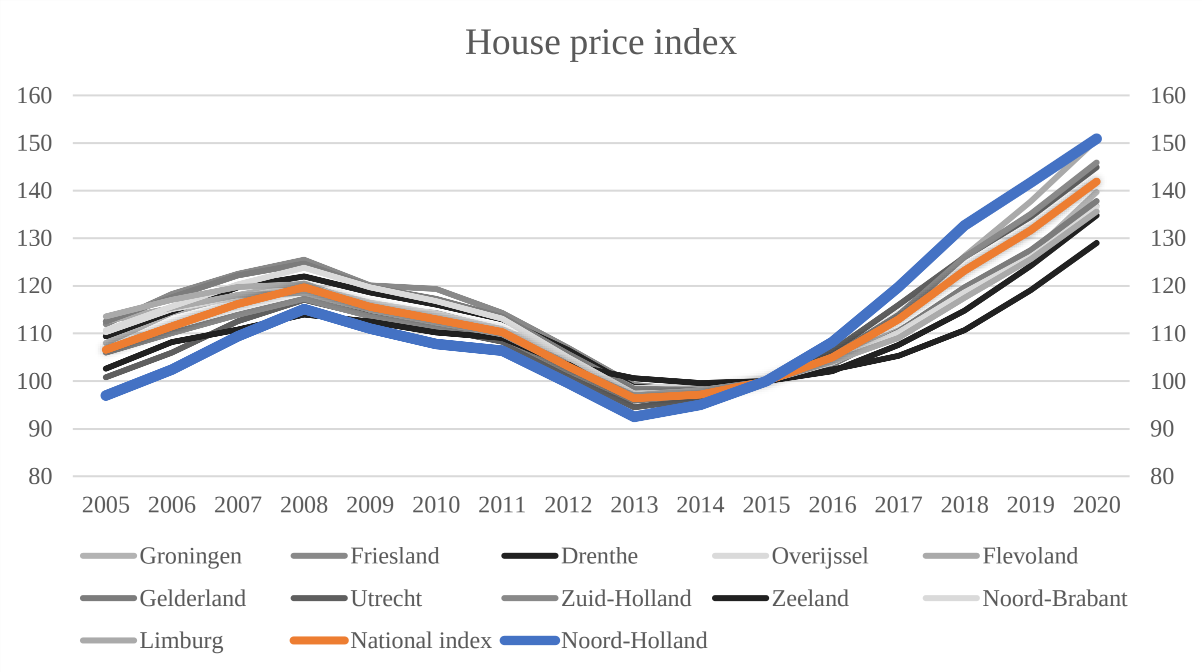

Figure 5: House price indices over time (Statistics Netherlands, 2020c)

5. Empirical specification

This section provides the empirical specification of this study through constructing the model for the analysis. First, the basics of proportional hazard modelling will be discussed after which the choice for a Weibull parametric specification is justified. Secondly, the various covariates of the hazard function will be elaborated on by discussing the datasets and the specific estimations of the covariates.

5.1. Proportional hazard model

The main objective of this study is to test whether price uncertainty influences development timing, for which the latter is approached as the timing of construction. With this in mind, this study applies an empirical approach called survival analysis, where the main concern is the time taken for a certain one-time event to occur, or in other words: the *survival time* (Foster, Barkus, & Yavorsky, 2006). Basic survival functions produce survival curves, which reflect the probability of surviving until the unit of study experiences the event in question. This *event* can be referring to various types of exits in which the unit of study is eliminated from further analysis. In this context, the event denotes to the start of construction after the development plan has been labelled as irrevocable. Explicitly, the basic survival function reflects the probability (P) of surviving longer than a specified time of interest (t):

$$S(t) = P(T > t) \tag{6}$$

where T reflects the survival time. As this study is less concerned with survival time, but rather with the probability of the start of construction, the inverse of a survival curve is applied, otherwise known as a hazard function. A hazard function shifts the attention to estimating the probability of event-occurrence, making it a better fit for the empirical analysis in this study. Henceforth, a proportional hazard model can be constructed where one can examine the hazard rate (alias probability of failing) as a function of selected determinants. Conform the works of Bulan *et al.* (2006) and Cunningham (2006, 2007), the following model is specified:

$$h(t) = h_0(t)\exp(X'\beta) \tag{7}$$

where $h_0(t)$ denotes the hazard baseline specification and X' is a vector of covariates which are shaped by the vector for estimated coefficients β. The second component of the proportional hazard model is determined through the following covariates function (4):

$$X'\beta = x_1 p_{jt} + x_2 C_t + x_3 \sigma_{jt}^2 + \Gamma'_i + J_{FE} \tag{8}$$

The explanatory variables in the covariates function include variables for house price changes (p), construction costs (C), price uncertainty (σ^2) and a collection of dichotomous variables on plan level (Γ') including the gross plan capacity, whether there are issues with financial feasibility, soil contamination or devaluation, whether the plan is initiated by a private party and whether the plan is located on a greenfield location or an infill site. The last denotation of Eq. (7) defines the municipal fixed effect (J_{FE}). The subscripts i and j denote the development plan and municipality respectively, whereas subscript t denotes the time expressed in years.

Important to address is that the covariates are not all denoted by the same denominator, as house price changes, construction costs and price uncertainty all vary by year t, from which house prices and price uncertainty also vary per municipality j. The remaining variables are plan-specific and therefore vary per plan i. Each covariate will be discussed in paragraph **Fout! Verwijzingsbron niet gevonden.**.

Applying the logic of real option theory as discussed in paragraph 2.3.3, this model attempts to provide insight in the presence of real options in the housing sector for Noord-Holland. As real options concerns uncertainty over future expected returns, the variable on price uncertainty is the key variable to examine. Theoretically, an increase in price uncertainty should lower the probability of construction and thus lower the hazard rate. Put into a formal hypothesis to be tested in the empirical analysis:

> H_0 *: price uncertainty does not systematically influence development timing*
> H_1 *: price uncertainty does systematically delay development timing*

The null hypothesis shall be accepted when $x_3 = 0$. The one-tailed alternative hypothesis H_1 will be accepted when $x_3 < 0$. This study therefore does not assume the analysis to produce a value for x_3 larger than 0, as theory and empirical studies provide convincing evidence that price uncertainty unlikely accelerates construction rates.

Besides price uncertainty, this study also incorporates two other variables reflecting market conditions, namely house price changes and construction costs. Based on existing empirical works on development timing, the following two hypotheses are set up:

For house price changes:

H_0 : Changes in house prices do not systematically influence development timing
H_1 : An increase in house price changes speeds up development timing

For construction cost changes:

H_0 : Changes in construction costs do not systematically influence development timing
H_1 : An increase in construction cost changes delays development timing

The rules for accepting and rejecting these hypotheses is the same as for the hypotheses on price uncertainty, except they apply on the estimates for x_1 for house price changes and x_2 for construction costs in Eq. (8).

5.2. Parametric Weibull specification

In general, there are two approaches to statistical analysis: non-parametric and parametric analysis (Foster et al., 2006). The difference between the two revolves around the assumption on the distribution of the data. Whereas non-parametric techniques allow the data itself to demonstrate the effect of selected variables on the hazard probability and are thus *distribution-free*, parametric methods entail a particular assumption on the distribution of data and test the data on its contiguousness with a normal distribution. This latter assumption is important as it provides the condition to include explanatory variables into the equation (Foster et al., 2006). Through probability testing, it can then be tested whether any existing variance in the scores of the dependent variable can be attributed to chance or the presence of certain factors. With non-parametric models this is more difficult as variance is assumed to exist heterogeneously.

For the baseline hazard function a Weibull parametric specification is applied, which is in line with the empirical contributions of Bulan *et al.* (2006) and Cunningham (2006), who applied parametric Weibull hazard functions in estimating the effects of various explanatory variables on development timing. In assuming that the probability of starting construction increases with time (after the development plan is labelled irrevocable), the Weibull model poses a better fit as the advantage of using a parametric model is that the base model is fully specified and the baseline hazard rate h_0 is assumed to increase or decrease monotonically with time (Bulan et al., 2006). The Weibull baseline hazard specification has the following functional form:

$$h_0(t) = \rho t^{\rho-1} \tag{9}$$

When the Weibull parameter $\rho > 1$ the baseline hazard is monotonically increasing over time. If $\rho < 1$ the baseline hazard is monotonically decreasing over time and whenever ρ equals 1, the baseline hazard is a constant (Bulan et al., 2006). This latter condition can also be referred to as an exponential distribution model.

5.3. Data description

This section presents an overview of the various datasets used in this study and the associated modifications to the variables in order to properly include them in the proportional hazard model of Eq. (7). First, the main dataset containing the individual development plans will be discussed after which the covariates and their sources will be presented in the order of how they are included in Eq. (8). This section concludes with an overview of the descriptive statistics of the various covariates.

5.3.1. Provincial dataset on plan capacity

This study has its analysis primarily built on data retrieved from detailed records on individual development plans which are gathered and monitored in annual provincial plan capacity inventories of Noord-Holland. On a national level these provincial inventories may vary in their documentation as there is no nationwide system for monitoring plan capacity (Groenemeijer & Van der Lelij, 2020). Prior to conducting the analysis, the retrieved plan capacity inventories for each year (either .xls(x)- or .dta-format) from Noord-Holland had to be modified and merged in order to produce one comprehensive and coherent dataset, hereafter referred to as the *master dataset*. The performed modifications to the original datasets are documented in log-files in Stata.

The master dataset is complete for 2006 to 2019, whereas it also contains development plans from 2005 of the northern part of the province of Noord-Holland. This means that the master dataset includes fifteen years of data. The information from the additional development plans from 2005 are used to help track the development plans over time, which is why they are maintained in the master dataset.

Besides the main information regarding the individual development plans, such as the name of the plan, the municipality where the plan is situated and the gross plan capacity, there is a bulk of other variables which further describe the plan in detail. As not all variables will be of relevance to the empirical analysis presented in this study, only the relevant variables are discussed. The variables used to build up the analysis are presented in Table 4 below.

Table 4: Overview of selected variables from master dataset

Name in Stata	Translation	Explanation
final_plan	Plan ID	Each individual development plan has received a unique plan ID in order to track the plan through time.
gemeentecode_oud	Municipal code	Each municipality has a unique code.
planstatus	Plan status	The plan status as explained in paragraph 3.2.3.1.

plancap_bruto	Gross plan capacity	The number of houses to be built (including demolition).
vertr_particulierinitiatief	Private initiative	Whether the development plan is initiated by a private party.
vertr_financiële_haalbaarheid	Financial feasibility	Whether the development plan entails issues with financial feasibility.
vertr_bodemverontreiniging	Soil contamination	Whether the development plan entails issues with soil contamination.
vertr_planschade	Devaluation	Whether the development plan results in the devaluation of nearby real estate.
binnen_bebouwd_gebied	Infill site	Whether the development plan is located in an existing urban region or in a greenfield location.

5.3.2. House price changes

The first covariate in Eq. (8) reflects a measure for house prices for which sale prices per square meter are used as a proxy variable. The data is derived from a combined dataset containing references of individual transactions in the residential property market, which are retrieved from databases held by Watson+Holmes[15] (2020). To align the data on residential transactions with the master dataset, the dataset on residential transactions entails all references from the available municipalities[16] from 1-1-2005 to present. As the references regard transactions rather than sales, the selection also encompasses references with transaction dates after 31-12-2019. The combined dataset contains 264.269 individual transactions.

To control for bias in property transaction prices as a result of the size of the property in question, the sale price per square meter of gross floor area (GFA) is used (hereafter referred to as €sqm). To account for the variation in transaction prices as a result of the age of the property or the surface in square meters (sqm), the selection is further specified to only include references that:

- have a construction date later than 1990;
- have a minimal surface of 80 and a maximum of 300 square meters GFA.

The remaining references are then checked for outliers. Properties with transaction prices below €25.000 and above €1 million are removed, as well as properties having €sqm below €500 and above €10.000. Any properties where the €sqm is unknown are removed from the selection. After preparation, 114.369 references were removed (43,3% of the total dataset), leaving the dataset with 149.900

[15] Watson+Holmes is a private organisation specialised in real estate market analysis and big data management. They hold an extensive dataset of property transactions in the Netherlands.
[16] For an overview of the selected municipalities included in the analysis, see Appendix Table 1

individual transactions (56,7%). The dataset is then collapsed based on municipal code and year and a value for mean €sqm is computed.

Instead of adding the absolute values of sale prices to the master dataset, this study adopts the reasoning of Mayer and Somerville (2000a, 2000b) and considers the probability of construction as a function of house price changes, rather than levels. Whilst the dataset contains information on a daily basis, an annual percentual change in house prices (p) is computed as the master dataset only contains information on an annual level. This measure is derived through a basic formula for relative change:

$$p_{j,t} = \frac{\phi_{j,t} - \phi_{j,t-1}}{\phi_{j,t-1}} \tag{10}$$

where ϕ denotes the annual mean €sqm in municipality j. The computed values are then lagged for one and two years to end up with three values for each year. The annual change (and the lagged values) in €sqm are then merged with the master dataset based upon the municipality code and year variables.

5.3.3. Construction cost changes

Often considered an important determinant of investment behaviour in classical economic theory, construction costs are regularly included into studies on investment decisions and development timing. Whilst Antwhi and Henneberry (1995) argue that the investment behaviour of developers is influenced by both house prices and construction costs, many have failed to find truly significant relations between construction costs and development timing (Poterba, 1984; Topel & Rosen, 1988; DiPasquale, 1999; Caldera & Johansson, 2013).

In order to respect classical economic theory and maintain consistency with previous works on this matter, this study also includes measures for construction costs. The dataset is derived from Statistics Netherlands (2020d) which audits national annual indices for construction costs. The annual indices are merged with the master dataset on the basis of the respective year.

As data on construction costs on a municipal level is lacking, this equation only differentiates in years. Many of the previously mentioned studies assume constancy across regions in the level of construction costs, which would result in bias in the estimations (Gyourko & Saiz, 2006). However, the majority of these studies are concerned with the situation in the US, where the inter-state differences are high. Although the dataset used in this study also involves aggregated national means, this study assumes minimal variance between municipalities in terms of construction cost indices.

5.3.4. Price uncertainty

In order to test the main hypothesis and examine the presence of real options in the real estate market in a Dutch context, a measure for price uncertainty σ^2 is included in the proportional hazard model Eq. (8). Whilst it is difficult to truly grasp the uncertainty that developers have concerning future prices (Cunningham, 2006), it generally involves measures on the volatility of asset prices. The higher the volatility of the asset price, the higher the uncertainty over future asset prices, which is assumed to influence the value of the option to delay investment, eventually reducing the incentive to exercise the option to invest at time *t*. Whilst Bulan (2005) distinguishes between industry-wide uncertainty and firm-specific uncertainty, this study will solely involve industry-wide uncertainty because of data availability. Industry-wide being price uncertainty regarding property assets in the selected regions.

To estimate price uncertainty, the variance method is applied on the dataset containing transaction references used for the measure on house price changes[17]. The equation to compute the variance as a measure for price uncertainty is as follows:

$$\hat{\sigma}^2 = \sum (x_i - \mu)^2 / (n - 1) \qquad (11)$$

Before applying this equation on the dataset, lags on the mean €sqm are created. By computing lags for up to four years back, the variation over three and five years can be calculated. The reason for including both three (Var3) and five (Var5) years is that in computing the variation for five years, the number of observations will be declining as data on individual residential transactions only entails the years 2005 till 2020. Therefore, the covariate for price uncertainty measured over five years cannot include the years 2005 till 2009.

Additionally, to test whether historical price uncertainty has any influence on the decision to start construction, the computed variances of three and five years are also lagged with one and two years. So in total, six covariates for price uncertainty per year are included in the analysis. As this measure concerns the price uncertainty of real estate property in the recent past, this study assumes the behaviour of the developer to be consistent in regard to their response to price uncertainty in the past. Following the line of reasoning by Cunningham (2006), the confidence of developers (and thus their investment behaviour) is generally dependent on their former success in estimating house prices, justifying this assumption.

5.3.5. Additional covariates

The remaining covariates are derived from the provincial plan capacity inventories themselves. These inventories contain a bulk of information on each individual development plan, describing the plan in more detail. Unfortunately, the extent to which the variables are present in the datasets differs between years and not every variable is tracked with consistency, therefore some observations could not be included in the analysis. The ones that were interesting to test within the context of this study and were eventually included in the analysis are briefly described below.

[17] The dataset from Watson+Holmes is also trimmed to the same extent as presented in paragraph 5.3.2.

The first is the gross plan capacity per plan, which provides information on how many houses are intended to be built within the development plan. This variable does not correct for demolition as it conforms the same reasoning explained in paragraph 3.2.3.2. All development plans that contain no gross plan capacity are removed, leaving the dataset for analysis with development plans containing a value for plan capacity between 1 and 2.920 houses (see Table 5). For the analysis, the gross plan capacity is divided by a unit of ten in order to better interpret the potential effect on the hazard rate.

The remaining five variables are all dichotomous variables meaning that they contain either a value of 1 or a value of 0. Each development plan is checked whether they have a value of 1 at some point in time. If a plan contains a value for 0, but it had a value of 1 somewhere along the years, the development plan is coded as having a value of 1 for all observations of that plan. This is to guarantee that the effects of these variables are taken into account.

If a plan has a 1 for financial feasibility, it implies that there are issues with the financing of the plan. When the plan has a value of 1 for soil contamination, it means that the soil has to be remediated as it is (possibly) contaminated. The variable private initiative indicates whether a development plan is initiated by any party other than the government. If this is the case, the plan has a value of 1 for this variable. Devaluation concerns the situation where the proposed development plan has a negative impact on the value of real estate in the vicinity. If this is the case, the plan has a value of 1. Last but not least, there is an indication of whether the development plan is located in a greenfield location (value = 0) or an infill site (value = 1). There is some debate on whether building on an infill site is significantly slower than building in greenfield locations (Buitelaar, 2018). Although it is not the primal scope of this study, it is included in the analysis to test its effect on development timing.

All variables presented in the preceding paragraphs are summarized in Table 5, which also provides insight in the means and standard deviations of the variables. The latter is important to understand how to interpret the results of analysis presented in the next chapter. Development plans are included if they contain at least one unit for gross plan capacity, omitting two plans in the process.

Table 5: Summary of explanatory variables

Variable	Obs	Mean	Std. Dev.	Min	Max
House price changes	1.056	6,29	5,69	-13,64	27,58
Price uncertainty (Var3)	1.056	45.808.90	56.545,53	122,72	284.929,90
Price uncertainty (Var5)	826	78.329,06	94.766,89	872,51	536.864,00
Construction cost changes	1.056	2,09	1,32	0,15	4,59
Gross plan capacity	1.056	82,26	228,84	1	2920
Financial feasibility	1.039	0,18	0,38	0	1
Soil contamination	1.039	0,05	0,21	0	1
Private initiative	1.039	0,15	0,35	0	1
Devaluation	1.039	0,04	0,19	0	1

	Infill site	911	0,89	0,31	0	1

6. Empirical results

This chapter will present the results of the analysis which provide the foundation for the conclusions as presented in chapter 7. Paragraph 6.1 first presents a non-parametric estimation of the time taken till the start of construction. This is followed by paragraph 6.2, which discusses the results of the first regressions from the parametric base specification. Paragraph **Fout! Verwijzingsbron niet gevonden.** extends these regressions by incorporating the results of the estimates for the additional variables that are discussed in paragraph 5.3.5 in the previous chapter and a municipal fixed effect. This chapter concludes with paragraph 6.4 presenting three measures of robustness on the analysis.

6.1. Non-parametric estimation

With the purpose of gaining a better insight in the data, a non-parametric Kaplan-Meier (KM) curve is produced. This model provides a visual plot of the survivor function by estimating the probability in which the unit of observation survives at time t (provided it has survived up and until $t = 0$). The KP-model is applied on all development plans with a minimum of 1 gross plan capacity and where the event of construction has occurred. This comprises over 1.056 plans in Noord-Holland covering the years 2008 till 2019 (see Table 6).

Table 6: Descriptive table of time taken from irrevocable till construction in years

Time in years	Frequency	Percent	Cum. Percent

1	577	54,64%	54,64%
2	250	23,67%	78,31%
3	122	11,55%	89,87%
4	47	4,45%	94,32%
5	14	1,33%	95,64%
6	22	2,08%	97,73%
7	13	1,23%	98,96%
8	8	0,76%	99,72%
9	3	0,28%	100,00%
Total	**1.058**	**100%**	

Figure 6: Kaplan-Meier survival curve on plans involving construction visually presents the estimates for the survival curve. The survival plot visualizes the time taken from the year a development plan is defined as irrevocable till the year construction is commenced. Based on the survival curve, we can conclude that construction will start within one year for more than 54% of all the development plans in the sample. After the first year, the probability flattens, and delays are more apparent, which is examined more in-depth through the parametric survival models. The curve as depicted in Figure 6: Kaplan-Meier survival curve on plans involving construction is not surprising, as the majority of the plans that receive irrevocable plan status are expected to have construction within a short time (Buitelaar & van Schie, 2018). The results are also identical to the survival curve as presented in Schoone (2020), who investigated the effects of market conditions and competition on development timing in the Netherlands.

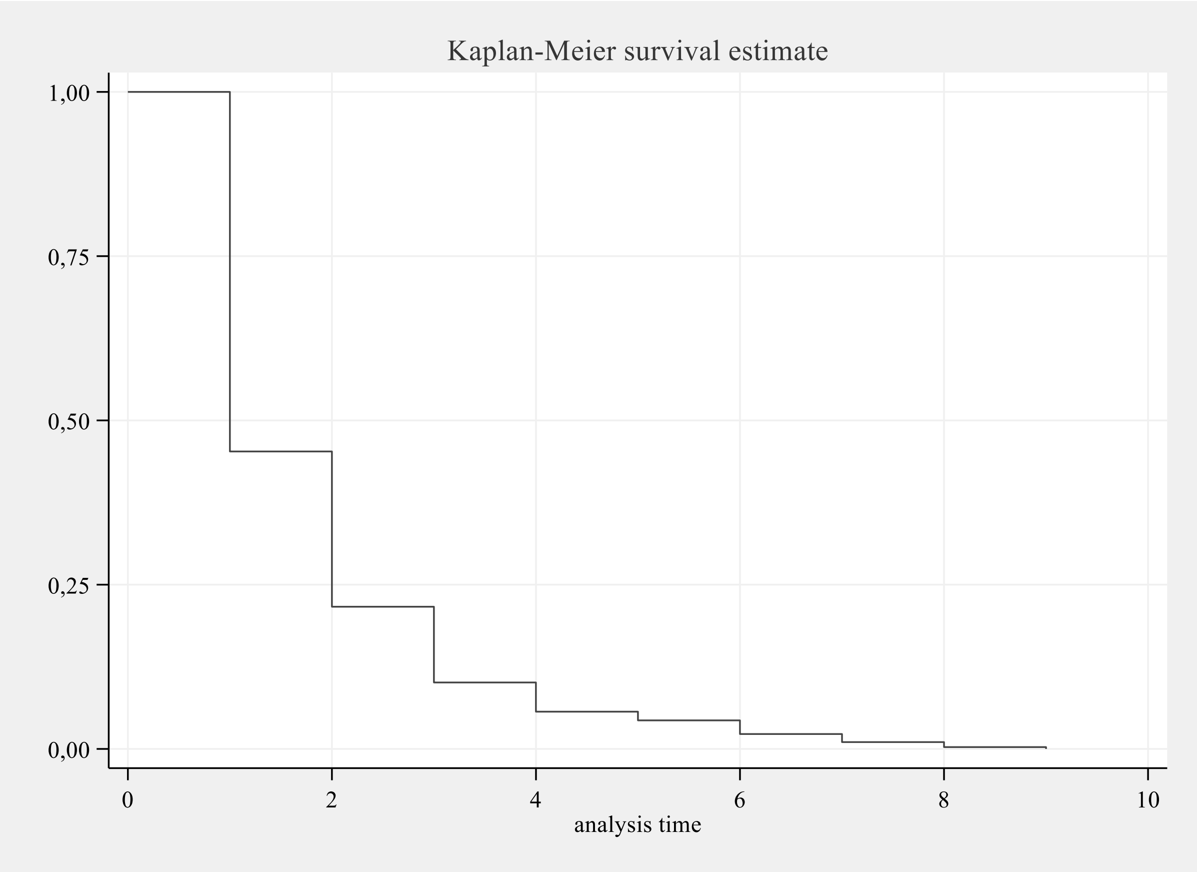

Figure 6: Kaplan-Meier survival curve on plans involving construction

This curve also displays the monotonicity of the probability of construction over time, as the survival ratio gradually decreases over time, implying that the hazard rate is at its highest shortly after the development plan is defined as irrevocable and at its lowest after several years in the period of observation. This justifies the choice for a parametric Weibull specification.

6.2. Base specification

For the base specification, the effects of the explanatory variables on the probability of construction are estimated. As explained in the contextual framework, (residential) real estate development is a time-consuming process and the decision to develop is influenced by market conditions and expectations on future prices. As the decision to start construction might also be founded on market conditions from the past, the base specification includes two types of lag to test whether certain market conditions in the past are influential in the decision to start construction at year *t*. These lags are applied on the variables that represent market conditions, namely: house price changes, price uncertainty and construction cost changes. These lagged variables are then also included in the model together with the base values for the other variables.

The first year included in the analysis is 2008, because the price uncertainty computed over three years (Var3) is only possible for development plans that are tracked for at least three years. As the dataset for *price uncertainty (see paragraph 5.3.4) only includes transactions from 2005 onwards, the first year that a valid measure for Var3 can be included is thus 2008. However, in order to compare the estimates based on Var3 and Var5, the two models need to have identical samples from the dataset. That is why the base specification with Var3 only includes development plans from 2010 onwards. Table 7 provides an overview of the number of development plans per year, where it becomes clear that from 2010 onwards, the analysis involves 826 (1.056 minus 230) plans. After that, as each lag requires data from prior to the period of analysis, the number of observations decreases for each extra year lagged. This explains why in the regression outputs in*

Table 8, column (1) has 826 observations, whilst column (3) has 732 observations.

Table 7: Overview of development plans with construction per year

Year	Frequency	Percent	Cum. Percent
2008	145	13,73%	13,73%
2009	85	8,05%	21,78%
2010	67	6,34%	28,13%
2011	27	2,56%	30,68%
2012	60	5,68%	36,36%
2013	46	4,36%	40,72%
2014	114	10,80%	51,52%
2015	94	8,90%	60,42%
2016	111	10,51%	70,93%
2017	75	7,10%	78,03%
2018	37	3,50%	81,53%
2019	195	18,47%	100,00%
Total	**1.056**	**100%**	

Table 8: Parametric Weibull base specification estimates

	Price uncertainty over 3 years			Price uncertainty over 5 years		
	(1) Base model	(2) 1-year lagged	(3) 2-year lagged	(4) Base model	(5) 1-year lagged	(6) 2-year lagged
House price changes	1.02585***	0.99154	0.99930	1.02066***	0.98963	1.00152
	(0.0079)	(0.0079)	(0.0074)	(0.0073)	(0.0076)	(0.0075)
Price uncertainty	0.99999***	0.99999***	0.99999***	0.99999***	0.99999***	0.99999***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Construction cost changes	0.88544**	0.87257**	0.82244***	0.86367***	0.89475**	0.81000***
	(0.0507)	(0.0474)	(0.0447)	(0.0487)	(0.0502)	(0.0429)
Weibull parameter	1.57519	1.54506	1.54564	1.56830	1.54395	1.54596
	(0.0386)	(0.0396)	(0.0408)	(0.0384)	(0.0395)	(0.0407)
Municipality fixed effects	No	No	No	No	No	No
Log likelihood	-839.04	-795.29	-770.88	-852.06	-795.07	-769.30
Observations	826	759	732	826	759	732

Exponentiated coefficients; Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Alongside the lags, two measures for price uncertainty are included. As explained in paragraph 5.3.4., price uncertainty is defined as the variance in mean prices over time. The value of the variance is dependent on the computed mean, which is further influenced by the number of time periods included in the calculation.

Both the differentiations in lags and the measure for price uncertainty produce six models for the base specification as presented in

Table 8, where each model is represented by a column. Columns (1), (2) and (3) provide the estimates for the effects on the hazard for construction, where price uncertainty is computed over three years, whilst columns (4), (5) and (6) include the measure on five years. The estimates in

Table 8 depict hazard ratios instead of regression coefficients, which means that they reflect the predicted change in the hazard rate associated with a unit change in the explanatory variables.

If the estimated β for the hazard rate equals one, a change in the associated explanatory variable does not significantly affect the hazard for construction. If the hazard ratio is greater than one it reflects a positive relation where if the value for the explanatory variable were to increase, the hazard for construction would increase also. On the occasion that the hazard ratio is below one, it reflects a negative relation between changes in the value of the explanatory variable and the hazard ratio, where an increase in the value of the explanatory variable significantly decreases the hazard for construction. The standard errors for the estimates are displayed in parentheses below the hazard ratios.

6.2.1. House prices estimates

For the base models in column (1) and (4) the variable for house prices changes comes out as highly significant. This implies that for every one unit increase in house prices in the year when the plan becomes irrevocable, the hazard rate for construction is 1.03 (1) or 1.02 (3) times higher. Translated to percentual effects, a one standard deviation increase of 5,69 in house prices results in an increase of 14,71% (1) or 11,76% (4) in the hazard for construction. The estimates for house price changes lose their significance in the lagged models, implying that house price changes in one or two years prior to year *t*, do not affect the decision systematically. Based on the results of the base model the null hypotheses for house price changes will be rejected, and the alternative hypothesis will be accepted as an increase in house prices systematically increases the hazard for construction.

6.2.2. Price uncertainty estimates

The hazard ratio estimates for price uncertainty are all negative and highly significant in all models. Although the estimated effects on the hazard ratio are all significant, the effects on the hazard for construction remain marginal, as a one unit increase in price uncertainty will result in hazard rate for construction of 0.000001 times smaller. Important to note however, is that the computed variance (and thus the values for standard deviations) for price uncertainty contain high values. When translated to percentual effects, a one standard deviation change of 56.545,53 (Var3) or 94.766,89 (Var5) of price uncertainty lowers the hazard for construction with either 5,65% (Var3) or 9,48% (Var5). This provides ground (based on the base specification) to reject the null hypothesis for price uncertainty and accept the alternative hypothesis which states that an increase in price uncertainty systematically delays development timing.

6.2.3. Construction costs

The estimated hazard ratios for construction costs are also significant for all models, although with varying levels of significance. Models (3), (4) and (6) are significant at a $p < 0.01$ level, while the other three models contain estimates significant at the $p < 0.05$ level. For the base models, a one standard deviation increase in construction costs results in a 15.13% (1) or a 17,99% (4) decrease in the hazard rate for construction. This is in line with the theoretical reasoning that the financial feasibility of a development plan is one of the most essential elements of a success implementation of development. Higher costs for construction might trouble the financial feasibility of proposed plans and therefore developers might delay construction or cancel the development all together (Barrett et al., 1978). Based on these estimates, the null hypothesis for construction cost changes can also be rejected, as increases in construction costs, also for previous years, systematically decrease the hazard for construction and thus delay development timing.

Also displayed is the Weibull parameter, which is specified as the baseline hazard of the models that are presented in

Table 8. This parameter is consistently greater than one with values ranging between 1,54 and 1,58, which implies that the baseline hazard ratio is monotonically increasing over time.

6.3. Extended specification

In addition, to estimating the effects of the variables included in Eq. (8), a selection of dichotomous variables has been added to the models. These variables indicate whether a development plan is confronted with certain barriers that eventually ‘stall’ a development. These barriers include: (1) the financial feasibility of the designated plan, (2) whether the site has contaminated soil, (3) if the development has been initiated by a private party and (4) whether the plan has a negative effect on the value of real estate in the vicinity of the proposed plan. McAllister, Street and Wyatt (2016) refer to these as issues of general viability, site issues and landowner and developer issues which they found were also important in explaining the stalled sites in their research. However, their study still proved market conditions to be the most influential factor, which in this study would imply that the price and cost measures would be having the greatest effect on the hazard for construction.

Additionally, the extended specification includes the variable which denotes whether the development plan is located either within urban boundaries (infill site) or in a greenfield location. The estimates for the hazard ratios can be observed in Table 9, which also includes the distinction between the lagged-models and the two measure for price uncertainty as seen in the regression results of the base specification.

6.3.1. Market conditions

Firstly, house price changes remain significant and even gain significance for the one-year lagged models. The base models portray that a one unit increase in house prices will result in a 1.03 times higher hazard for construction. This translates in a percentual increase of 17,68% (1) or 15,18% (4) in the hazard for construction when house prices increase with one standard deviation of 5,69. Interestingly, the one-year lagged models for both Var3 and Var5 produce negative β for the hazard ratio that are significant. This implies that a one unit increase in house prices in the year prior to the decision to construct, results in a hazard rate of 0.98 times lower. Translated into percentual changes, a one standard deviation increase in house prices, results in an 8,55% (1) or 8,92% (4) lower hazard for construction. This means that the null hypothesis for price uncertainty for the one-year lagged models is maintained.

The effects of price uncertainty on the hazard for construction are slightly different from the base specification as the significance levels for the lagged models is lower, becoming only significant at $p < 0.05$. So the conclusions on the effects of price measures on the hazard for development still hold, although with nuances to their significance levels.

Table 9: Parametric Weibull extended specification estimates

	Price uncertainty over 3 years			Price uncertainty over 5 years		
	(1) Base model	(2) 1-year lagged	(3) 2-year lagged	(4) Base model	(5) 1-year lagged	(6) 2-year lagged
House price changes	1,03108***	0,98497*	0,99519	1,02667***	0,98432**	0,99651
	(0,0081)	(0,0079)	(0,0075)	(0,0076)	(0,0077)	(0,0077)
Price uncertainty	0,99999***	0,99999**	0,99999**	0,99999***	0,99999**	0,99999**
	(0,0000)	(0,0000)	(0,0000)	(0.0000)	(0.0000)	(0.0000)
Construction cost changes	0,79555***	0,90441*	0,90052*	0,78478***	0,92214	0,88177**
	(0,0472)	(0,0497)	(0,0510)	(0,0459)	(0,0521)	(0,0488)
Gross plan capacity	1,00145	1,00067	1,00046	1,00104	1,00049	1,00025
	(0,0015)	(0,0015)	(0,0015)	(0,0014)	(0,0015)	(0,0015)
Financial feasibility	0,60871***	0,63477***	0,64104***	0,60052***	0,63876***	0,66466***
	(0,0609)	(0,0650)	(0,0667)	(0,0598)	(0,0655)	(0,0702)
Soil pollution	0,96726	0,94274	0,96882	0,96205	0,94281	0,97327
	(0,1618)	(0,1661)	(0,1735)	(0,1611)	(0,1662)	(0,1743)
Private initiative	0,70214***	0,66817***	0,72058***	0,69849***	0,66830***	0,73261***
	(0,0764)	(0,0786)	(0,0851)	(0,0760)	(0,0787)	(0,0865)
Devaluation	1,24491	1,28134	1,25831	1,27442	1,27797	1,24637
	(0,2761)	(0,3119)	(0,3050)	(0,2826)	(0,3111)	(0,3032)
Infill site	0,54622***	0,49412***	0,47857***	0,53761***	0,48432***	0,46623***
	(0,0718)	(0,0657)	(0,0648)	(0,0705)	(0,0641)	(0,0629)
Weibull parameter	1,65452	1,62964	1,61775	1,65212	1,62977	1,61394
	(0,0412)	(0,0426)	(0,0431)	(0,0411)	(0,0426)	(0,0429)
Municipality fixed effects	No	No	No	No	No	No
Log likelihood	-796.15	-743.19	-733.73	-797.21	-742.55	-734.56
Observations	809	742	725	809	742	725

Exponentiated coefficients; Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Construction costs show some variation compared to the base specification, and the estimated β for the hazard rates are more diverged. Where the base models now imply that a one unit increase of *construction costs will result in a 0.80 (1) or 0.78 (4) times lower hazard for development, these estimates revolved around 0.89 (1) and 0.86 (4) in the base specification presented in*

Table 8. So, the size of the effect of construction costs on the hazard for development has declined, but it remains significant for most models, therefore maintaining the alternative hypothesis as posed in paragraph 5.1.

6.3.2. Additional variables

The variable of financial feasibility has a highly significant and strong negative effect on the hazard for construction for all base and lagged models. Whenever issues of financial feasibility are present for a development plan, the hazard rate of construction is 0.61 (1) to 0.60 (4) times lower in the base models, which translates into percentual declines of construction of 39% and 40% respectively. These effects remain extensive in the lagged models, implying that issues with financial feasibility are an important factor in explaining why certain development plans are consistently delayed. This effect is expected, as tests on financial feasibility of a development are an essential element of the real estate process, as explained asserted by Barret *et al.* (1978) and Adams and Tiesdell (2013).

Another variable showing significance is the one which denotes whether a development plan is initiated by a private party. Here too, the estimated β for the hazard rates are significantly smaller than one for all the models, implying that if a development plan were to be initiated by a private party, the probability of construction decreases with 33% (2) to 27% (6).

The last variable that turned out (highly) significant is the location of the development plan. Each model produces estimates for the variable Infill site with significance levels of smaller than $p < 0.01$. The effects on the hazard for construction are also evident. If a development plans is located within the existing urban boundary, the hazard for construction (in the base models) decreases by 0.45 (1) and 0.46 (4), suggesting that developments in greenfield locations are generally realised faster.

The remaining variables have estimates that are not defined as significant on levels smaller than $p < 0.1$, which leads to the conclusion that these do not systematically influence the hazard for construction. Here too, the Weibull parameters are displayed for each model, which are fairly similar but higher to the ones in the base specification. As the parameters fall between 1,61 (6) and 1,65 (1), the models entail a baseline hazard that is monotonically increasing over time, justifying the model-fit of a parametric Weibull specification on this data.

6.3.3. Fixed effects

To control for unobserved heterogeneity in the model regressions, fixed effects are included in the models of the extended Weibull specification, for which the output is presented in Table 10. These fixed effects correct for any unobserved heterogeneity between municipalities in the province of Noord-Holland. Including fixed-effects for geographical regions is in line with existing empirical works, such as Somerville (2001), Bulan *et al.* (2006) and Cunningham (2006, 2007).

The results in Table 10 show some differentiation in comparison to the specifications without fixed effects. Although the effects for the base models are fairly similar, the significance of the estimates for the lagged models is lower. Price uncertainty remains significant with a small estimated β for the hazard rate, but house price changes lose their significance in the one-year lagged models. This implies that there are indeed some unobserved effects that influence the relation between house price changes and the hazard for construction. Based on these results, the alternative hypothesis for price uncertainty is only rejected for the two-year lagged model with Var5 (column 6). The alternative hypotheses for house price changes and construction cost changes remained accepted for the base models and for construction costs also the one-year lagged models.

Additionally, the Weibull parameters for each model have increased to values higher than 1.85, implying that the hazard rate curve is actually steeper than in the previous models. These values are closely related to the Weibull parameters found by Bulan *et al*. (2006). Once again, these parameters justify the use of a Weibull parametric analysis.

Table 10: Parametric Weibull extended specification with municipal fixed effects

	Price uncertainty over 3 years			Price uncertainty over 5 years		
	(1) Base model	(2) 1-year lagged	(3) 2-year lagged	(4) Base model	(5) 1-year lagged	(6) 2-year lagged
House price changes	1.03419***	1.01088	0.98273	1.02856***	1.00503	0.97856*
	(0.0097)	(0.0112)	(0.0113)	(0.0092)	(0.0103)	(0.0110)
Price uncertainty	0.99999**	0.99999***	0.99999***	0.99999**	0.99999***	0.99999
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Construction cost changes	0.73449***	0.82452***	0.99004	0.74281***	0.85031**	0.96860
	(0.0530)	(0.0542)	(0.0685)	(0.0542)	(0.0573)	(0.0667)
Gross plan capacity	1.00032	0.99864	0.99830	0.99954	0.99852	0.99907
	(0.0018)	(0.0018)	(0.0018)	(0.0018)	(0.0018)	(0.0018)
Financial feasibility	0.58915***	0.63694***	0.61522***	0.58859***	0.63163***	0.63372***
	(0.0721)	(0.0840)	(0.0827)	(0.0721)	(0.0836)	(0.0846)
Soil pollution	0.96379	0.92152	0.93589	0.95119	0.91042	0.93330
	(0.1787)	(0.1761)	(0.1821)	(0.1761)	(0.1740)	(0.1812)
Private initiative	0.74855**	0.77727*	0.82690	0.74889**	0.77869*	0.85160
	(0.0994)	(0.1119)	(0.1182)	(0.0995)	(0.1123)	(0.1216)
Devaluation	1.21904	1.10005	1.14904	1.22350	1.11457	1.13707
	(0.3282)	(0.3368)	(0.3494)	(0.3291)	(0.3411)	(0.3450)
Infill site	0.55557***	0.53717***	0.52988***	0.55020***	0.53085***	0.52758***
	(0.0846)	(0.0821)	(0.0837)	(0.0829)	(0.0810)	(0.0836)
Constant	0.28382***	0.25002***	0.20100***	0.28783***	0.24228***	0.20037***
	(0.1051)	(0.0946)	(0.0756)	(0.1058)	(0.0919)	(0.0756)
Weibull parameter	1.87191	1.86238	1.85833	1.87261	1.86099	1.85056
	(0.0470)	(0.0493)	(0.0499)	(0.0470)	(0.0492)	(0.0497)
Municipality fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Log likelihood	-702.03	-650.52	-638.86	-701.65	-650.56	-641.79
Observations	809	742	725	809	742	725

Exponentiated coefficients; Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

6.4. Robustness of findings

6.4.1. Test for multicollinearity

Tests for multicollinearity have been conducted on the explanatory variables included in both the base- and the extended specification. Multicollinearity implies that the explanatory variables are correlated, therefore masking the true effects on the hazard for construction. The correlation matrices for the base and extended specifications are presented in Appendix III. The highest correlation exists between house price changes and construction cost changes, which is logical concerning their relation in market dynamics. This still has to be taken into consideration when interpreting the results. As the majority of values for the other variables are below 0.1, they are no reason for concern.

6.4.2. Alternative price measures

Important factors that influence the results are the quality and quantity of the observations in the utilized datasets. For the variables that are associated with price changes and price uncertainty, this study employed a dataset derived from the Watson+Holmes inventory on individual transactions in the residential real estate market in Noord-Holland. Although the data is very specific and extensive, it is not all-encompassing and lacks data of prior to the year 2005. In order to compute valid estimates for price uncertainty computed over five years in addition to the two-year lagged models for 2005 up and until 2012, data on price levels from before 2005 are needed.

For the base specification, development plans are only included when these measures could be fully computed, resulting in a decreasing number of observations when the lags are applied. To test the significant relations between house price changes and price uncertainty on the hazard for development found in the models, another model has been computed which includes data derived from Statistics Netherlands (2020c; 2020e). The results are shown in Appendix IV.

The number of observations is equal for every model (895) and the Weibull parameter is relatively stable between 1,85 (2) and 1,89 (4), indicating a monotonically increasing baseline hazard. Where this particular specification is distinctly different than the previously presented specifications, is the significance of explanatory variables. Based on these results, one may conclude that the decision to initiate construction is influenced by house price changes of one and two years prior to the year of making that decision. Price uncertainty is also not significant in the base model with Var3, whilst being significant for all other models. The variables that show consistency in their significance are the dichotomous variables denoting financial feasibility and infill site.

However, the dataset for house prices by Statistics Netherlands entails absolute house prices and thus do not correct for the size of the house. Additionally, no distinction is made for the age of the buildings. Therefore this dataset loses can be considered less valid and thus less applicable to the context of this study.

6.4.3. Cox proportional hazard model

The main models presented in this study are Weibull parametric models, which entail certain assumptions on the shape of the baseline hazard function (Mills, 2010). As explained in paragraph 5.2, the parametric model has the preference as the baseline hazard is expected to be monotonically increasing over time, which is empirically tested by others (Bulan, 2005; Cunningham, 2006, 2007). If time progresses, development plans in the pipeline should be more prone to the start of construction. The non-parametric Kaplan-Meier curve as presented in paragraph 6.1 supports this assumption. To further test the correctness of the Weibull parametric model, a Cox proportional hazard model is applied on the variables that are included in the extended specification with fixed effects as presented in paragraph 6.3.3. The results are displayed in Appendix V.

The value for the log-likelihood provides a measure for comparing the model fit. In general, the closer the value of the log-likelihood is to zero, the better the model fit. Where the log-likelihoods for the parametric Weibull models remained between the minimum of -638.86 (extended specification with fixed effects, column 3) and a maximum of -852.06 (base specification, column 4), the log-likelihoods for the Cox PH models are much greater in the range between -4205.77 (3) and -4790.90 (1). This implies that the parametric Weibull models are a much better fit on the datasets used in this study.

7. Conclusions and recommendations

7.1. Conclusions

This chapter will present the conclusions from the results of this study and answer the main research question:

> *How does price uncertainty influence the development timing of residential development plans in the Netherlands?*

Developers have a certain managerial flexibility when it comes to the real estate development process. Initiating construction entails costs which the developer in question hopes to earn back through profits made from selling the constructed real estate assets. And once the structure is completed, the cycle can start over. It is the progression from phase to phase, where developers have to make decisions on how to proceed with the proposed development. As Bramley (1993a) would argue, it is the phase from feasibility tests finalizing a plan to the start of construction where there is a proclaimed *implementation gap*. Not all readily available plans that are shovel-ready are immediately implemented, which raises concerns on what the causes are for the delay of development plans when they are deemed irrevocable, also in the Dutch context (Buitelaar & van Schie, 2018).

Existing research on the effects of various factors on housing construction rates have embraced an economic perspective on housing supply and included the concept of real options as ‘having the option to start construction’ is linked to an economically interesting decision involving an irreversible investment. The prevailing factor included in these studies is the uncertainty over prices, which also formed the centre of this study. Price uncertainty is commonly defined as the volatility of asset prices and its volatility is then related to the true construction rates in hazard regression modelling. With this in mind, this study applied a hazard analysis through parametric Weibull models on 1.056 development plans, where the effects of price uncertainty and associated factors on the hazard for construction are computed.

The results of this study suggest that price uncertainty systematically influences the development timing for development plans in Noord-Holland. If price uncertainty increases with one standard deviation, the rate of construction decreases with 5,65 – 9,48%. Besides proving significant in the base specifications, these effects also prove significant in the extended parametric models. Cunningham (2006) and Bulan *et al.* (2006) found effects of respectively 11,3% and 13%, which means that the estimates presented in this study are slightly lower. The difference in the estimates may be ascribed to the method used for computing price uncertainty. Both Cunningham and Bulan *et al.* estimate price uncertainty over future periods through GARCH models and include a measure for price uncertainty over past periods as a robustness check. For this study, adding an estimate for future price uncertainty would be an interesting addition to fully capture price uncertainty.

Moreover, the institutional context may explain the differences in estimated effects of price uncertainty on the development timing, as the Dutch context is different than the context of Vancouver, Canada (Bulan et al., 2006) or Seattle, US (Cunningham, 2006). Research on the effects of price uncertainty on development timing in the Netherlands is still underdeveloped, so a comparison cannot be made.

Besides price uncertainty, this study also examined the effect of other variables on development timing, including changes in house prices and construction costs. Mayer and Somerville (2000a) suggest that changes rather than the levels of house prices better explain new construction. Bulan *et al*. (2006) also include the change in prices instead of the average price of real estate, as it control for changes in the quality of the real estate. In applying this line of reasoning in this study, the results of the base models of this study imply that an increase in house prices systematically increases the hazard for construction. A one standard deviation increase in house prices will result in an increase in the construction rate of 11,76% to 17,68%. These estimates are much greater than the estimates found by for example Schoone (2020). This may be explained due to the level of analysis as Schoone used monthly price changes based on yearly moving averages. Within this study, the individual transaction prices are aggregated to annual means, which are then used to compute annual percentual changes. This was necessary as the duration of development plans was provided in years, instead of months.

Whilst others have failed to find significant relations between development costs and development activity at higher levels of aggregation (Poterba, 1984; Topel & Rosen, 1988; Caldera & Johansson, 2013) or chose to leave out costs (Bulan et al., 2006; Cunningham, 2006)[18], the results in this study indicate that construction costs are indeed of influence on development timing. For most models in this study, construction costs proved significant. The base models with variance computed over three years proved that a one standard deviation increase in construction costs would result in a systematic decrease in construction with 15,12% - 35,%, whereby the latter percentage is given for the extended parametric model with fixed effects. This variation in estimated effects is not unexpected, as construction costs is often denoted as a difficult variable to include in analysis as it is very dependent on location and actors involved (Bulan et al., 2006).

Finally, the results show three more variables systematically influencing the development timing. The first being financial feasibility, an important element in Barret et al.'s (1978) development pipeline, proved highly significant for all extended models. This supports the findings by McAllister, Street and Wyatt (2016), who found that the financial feasibility is the primary driver of stalled sites. The probability of construction can decrease with as much as 41% if issues of financial feasibility occur. Another systematic negative relation was found for development plans that are initiated by private parties. This might be the result of the strong governmental presence in the spatial planning paradigm

[18] Cunningham (2006) explained he lacked a good measure for construction costs, therefore including year fixed effects to account for changes in construction costs.

of the Netherlands. Residential developments, in all sorts, need an updated land-use plan and these procedures are time-consuming and the responsibility lies with the municipality. This dependency might delay development timing if municipalities and private developers are not well aligned. Furthermore, providing input for the discussion on whether construction within existing urban boundaries is more time-consuming, this study found that development plans on infill locations are systematically slower realised than development plans in greenfield locations. However, these effects are to be interpreted with much deliberation, as these results are merely based on the denotations in the provincial datasets. To properly control for the effect of urban environments and density on development timing, classifications such as in Broitman and Koomen (2019) are needed.

In conclusion, the results of this study support the hypothesis that price uncertainty delays the development timing of residential development plans in Noord-Holland. This study therefore implies that the real options approach is a concept to consider when examining development cycles and ways to speed up residential development.

7.2. Recommendations

The results as presented in this study are the product of methodological decisions and the datasets used for analysis. Changes in either the methods applied, or the datasets can influence the results. One important impediment of this study is the unit of time to analyse the development timing. The provincial datasets, although extensive in specific information on plan characteristics, only include estimates for construction on an annual basis. An analysis on a monthly basis might provide better insight in the true effects of the covariates, as it would control for any aggregation-related biases. Sometimes plans might only take a few months from irrevocable plan status to construction, but if these span the months of November till February, an analysis on an annual level will denote this specific plan as having a duration of a full year. Further research on monthly basis might therefore offer a more detailed perspective on the relation between selected factors and development timing.

Additionally, the estimates of the extended specification with fixed effects as presented in this study vary considerably in relation to the models without fixed effects. This implies that there are some unobserved effects on the relation between selected variables and development timing that are not included in the models. Especially the estimates for the price measures and construction cost are affected by the fixed effects. Follow-up research on additional market conditions, such as interest rates and measures for demand might provide answers to these changes. Also, fixed effects on a regional level might be interesting to include, as house markets are usually defined as regional markets

This study follows the prevailing method to include uncertainty over prices to examine the presence of real options in the real estate market. However, uncertainty does not only apply to house prices. Uncertainty over construction costs, demand for housing, regulatory procedures or politics might all be of importance for the developer to initiate development. Additional research on uncertainty on various aspects of the development cycle would help to get a better understanding in where policy can be aimed at to reduce uncertainty and prevent intentional delays in development timing. Especially uncertainty over construction costs might provide a more thorough understanding of how asset prices and costs are connected and how they are valued by the developer in making the decision to develop.

An important process within the Dutch spatial planning regime is the attainment of a building permit. This process might take up a few months, but with delays because of appeals, this process might easily be extended with a few months more. For maintain the scope of this study, these potential delays in attaining a building permit is simplified, but further research on the effect of regulatory processes on development timing in the Dutch context might provide useful information to shape the spatial planning system. Especially with the new Environmental and Planning Act, where the aim is to better manage spatial practices and provide more streamlined regulatory processes.

As this study is built on quantitative methods, it neglects a qualitative reflection of the real estate developers themselves. From a behaviouralist perspective, this might provide useful insights in how price uncertainty might be perceived and how it influences the decision to develop. Real estate development is – and probably will stay – a sector full of uncertainties. The question is how these uncertainties define the behaviour of actors.

8. Critical reflection

This chapter includes a reflection on the process and the results of this study, which is a fundamental component of conducting research (Van Thiel, 2014). Throughout the research, many decisions have been made and developments have occurred that have had their impact on the outcomes (or a part thereof) of the study.

The results of this study provide an insight in the presence of real options in residential real estate development in the province of Noord-Holland, the Netherlands. Without the intent to discredit the results of the analysis and the eventual conclusions presented in this study, a critical reflection on the research conduct is necessary in order to correctly interpret the results and conclusions.

The results of this study cannot be generalised to a national context. Although the underlying motive for conducting this study is to understand development timing in the Netherlands as a whole, this study only includes data on individual development plans from a single province (Noord-Holland). Issues concerning data availability and especially the quality of the datasets have led to the sole inclusion of this province. Nonetheless, other provincial datasets are still being moderated and transformed to include them in associated studies on plan capacity in the Netherlands. Albeit the lower level of external validity, this study attempts to provide inciting intel for the discussion on real options in the Dutch real estate market.

The master dataset containing the individual development plans had not been monitored consistently throughout the years, which led to various interpretations of raw data. Especially because each year was provided in a separate Excel file. Not only did the set of variables change through the years, sometimes the values themselves were altered for which a clear motivation was lacking. Through manual data checks and recoding in Stata – which is all documented in the log-files – numerous missing values and errors were corrected according to the interpretation of the researcher. There is a chance that some interpretations are inadequate, but because of the size of the complete master dataset, the effects on the eventual analysis and the conclusions are ought to remain marginal. This does remain an issue for other provinces as well, which is an important remark for future studies that utilise provincial plan capacity inventories.

Survival analysis is all about timing and event-occurrence (‘failure’). The smaller the unit of time, the more precise the analysis (and thus the results) can get. The datasets used in this study are on – or are transformed to – an annual level, which, given the assumption that construction can be completed in twelve months, is relatively high. Moreover, a variable that denotes the start of construction had not been provided in the dataset and had therefore needed to be created based on the expected delivery of houses for each development plan. As the development plans are tracked on an annual basis, the actual start of construction might occasionally be delayed or postponed and not been corrected for in the inventory. Whilst assuming that these incidences are rare, it is necessary to justify how the unit for event-occurrence is computed.

For the measure on price uncertainty, a measure for variance on the sale price per square meters is used. In the analysis a further distinction is made between a variance computed over three and five years, however both are measures that are focused on the past. This is not an unusual method[19], but it contradicts with the supposition that uncertainty over prices reflects future estimations. As Cunningham (2006) explicitly mentions in his work, there is no perfect measure for uncertainty. Real options theory concerns a theoretical approach to market forces and investment behaviour and is strongly dependent on rather unpredictable future developments. Having said this, the results in this study are theoretical and should therefore be treated as such.

[19] See e.g. Bulan (2006) who use it as an alternative method for measuring price uncertainty

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Appendices

Appendix I

Selection of municipalities in Watson+Holmes for the residential transaction references and location of Noord-Holland in the Netherlands.

Aalsmeer	Haarlemmermeer	Purmerend
Alkmaar	Heemskerk	Schagen
Amstelveen	Heemstede	Stede Broec
Amsterdam	Heerhugowaard	Texel
Beemster	Heiloo	Uitgeest
Bergen (NH.)	Den Helder	Uithoorn
Beverwijk	Hilversum	Velsen
Blaricum	Hollands Kroon	Waterland
Bloemendaal	Hoorn	Weesp
Castricum	Huizen	Wijdemeren
Diemen	Koggenland	Wormerland
Drechterland	Landsmeer	Zaanstad
Edam-Volendam	Langedijk	Zandvoort
Enkhuizen	Laren (NH.)	Opmeer
Gooise Meren	Medemblik	Ouder-Amstel
Haarlem	Oostzaan	

Appendix II

Overview of the recoding for plan statuses in the provincial plan capacity inventory of Noord-Holland.

2005	2006	Coded to
1	1A	1A Onherroepelijk
1b	1B	1B Onherroepelijk (uitwerkingsplicht)
n/a	n/a	1C Onherroepelijk (wijzigingsbevoegdheid)
2	2	2 Goedgekeurd plan
3	3	3 Vastgesteld plan
4	4	4 In voorbereiding
5	5	5 Potentiëel
0	-	Status onbekend
2007	2008	Coded to
1A	1A onherroepelijk	1A Onherroepelijk
1B	1B onherroepelijk uit	1B Onherroepelijk (uitwerkingsplicht)
n/a	n/a	1C Onherroepelijk (wijzigingsbevoegdheid)
2	2 Goedgekeurd	2 Goedgekeurd plan
3	3 Vastgesteld	3 Vastgesteld plan
4	4 in voorbereiding	4 In voorbereiding
5	5 potentieel	5 Potentiëel
Niet ingevuld	onbekend	Status onbekend
2009	2010	Coded to
1A	1A	1A Onherroepelijk
1B	1B	1B Onherroepelijk (uitwerkingsplicht)
n/a	n/a	1C Onherroepelijk (wijzigingsbevoegdheid)
n/a	n/a	2 Goedgekeurd plan
2	2	3 Vastgesteld plan
3	3	4 In voorbereiding
4	4	5 Potentiëel
n/a	-	Status onbekend
2011	2012	Coded to
1A onherroepelijk	1A onherroepelijk	1A Onherroepelijk
1B onherroepelijk uit te werken	1B onherroepelijk uit te werken	1B Onherroepelijk (uitwerkingsplicht)
n/a	n/a	1C Onherroepelijk (wijzigingsbevoegdheid)
n/a	n/a	2 Goedgekeurd plan
2 vastgesteld	2 vastgesteld	3 Vastgesteld plan
3 in voorbereiding	3 in voorbereiding	4 In voorbereiding
4 potentieel plan	4 potentieel plan	5 Potentiëel
Onbekend/n.v.t.	Onbekend/n.v.t.	Status onbekend
2013	2014	Coded to
1A onherroepelijk	1A onherroepelijk	1A Onherroepelijk
1B onherroepelijk uit te werken	1B onherroepelijk uit te werken	1B Onherroepelijk (uitwerkingsplicht)
n/a	n/a	1C Onherroepelijk (wijzigingsbevoegdheid)

n/a	n/a	2 Goedgekeurd plan
2 vastgesteld	2 vastgesteld	3 Vastgesteld plan
3 in voorbereiding	3 in voorbereiding	4 In voorbereiding
4 potentieel plan	4 potentieel plan	5 Potentiëel
Onbekend/n.v.t.	Onbekend/n.v.t.	Status onbekend

2015	2016	Coded to
1A onherroepelijk	1A onherroepelijk	1A Onherroepelijk
1B onherroepelijk uit te werken	1B onherroepelijk uit te werken	1B Onherroepelijk (uitwerkingsplicht)
n/a	n/a	1C Onherroepelijk (wijzigingsbevoegdheid)
n/a	n/a	2 Goedgekeurd plan
2 vastgesteld	2 vastgesteld	3 Vastgesteld plan
3 in voorbereiding	3 in voorbereiding	4 In voorbereiding
4 potentieel plan	4 potentieel plan	5 Potentiëel
Onbekend/n.v.t.	Onbekend/n.v.t.	Status onbekend

2017	2018	Coded to
1A onherroepelijke	1A Onherroepelijk	1A Onherroepelijk
1B onher. met uitwerkingsplicht	1B onhr + uitwerkingsplicht	1B Onherroepelijk (uitwerkingsplicht)
1C onher. met wijzigingsbevoegdheid	1C onhr + wijzigingsbevoegdheid	1C Onherroepelijk (wijzigingsbevoegdheid)
n/a	n/a	2 Goedgekeurd plan
2 vastgesteld plan/besluit	2 Vastgesteld plan/besluit	3 Vastgesteld plan
3 plan/besluit in voorbereiding	3 plan/besluit in voorbereiding	4 In voorbereiding
4 potentiele woninbouwlocatie	4 potentiele woningbouwlocatie	5 Potentiëel
Status onbekend	Status onbekend	Status onbekend

2019	Coded to
1A Onherroepelijk	1A Onherroepelijk
1B onhr + uitwerkingsplicht	1B Onherroepelijk (uitwerkingsplicht)
1C onhr + wijzigingsbevoegdheid	1C Onherroepelijk (wijzigingsbevoegdheid)
n/a	2 Goedgekeurd plan
2A Vastgesteld plan/besluit	3 Vastgesteld plan
3 plan/besluit in voorbereiding	4 In voorbereiding
4A potentiele locatie in visie	5 Potentiëel
Status onbekend	Status onbekend

Appendix III

Correlation output for variables in base specification

	House price changes	Price uncertainty Var3	Construction cost changes
House price changes	1,0000		
Price uncertainty Var3	0,4034	1,0000	
Construction cost changes	0,4361	0,2587	1,0000

Correlation output for variables in the extended specification

	House price changes	Price uncertainty (Var3)	Construction cost changes	Gross plan capacity	Financial feasibility	Soil pollution	Private initiative	Devaluation	Infill site
House price changes	1,0000								
Price uncertainty (Var3)	0,4062	1,0000							
Construction cost changes	0,5138	0,4070	1,0000						
Gross plan capcacity	-0,0043	0,1092	0,0108	1,0000					
Financial feasibility	-0,0338	-0,0206	-0,0666	-0,0056	1,0000				
Soil pollution	-0,0065	-0,0520	-0,0540	-0,0003	0,2011	1,0000			
Private initiative	0,0053	-0,0504	-0,0467	-0,0518	0,4122	0,1800	1,0000		
Devaluation	-0,0359	0,0171	-0,0411	-0,0207	0,2572	0,1765	0,2650	1,0000	
Infill site	0,0514	0,0979	0,0763	-0,0507	0,0419	-0,0205	-0,0189	-0,0178	1,0000

Appendix IV

Parametric Weibull extended specification with municipal fixed effects and data from Statistics Netherlands (2020c; 2020e)

	Price uncertainty over 3 years			Price uncertainty over 5 years		
	(1) Base model	(2) 1-year lagged	(3) 2-year lagged	(4) Base model	(5) 1-year lagged	(6) 2-year lagged
House price changes	1.00149	0.98578***	0.98243***	0.99992	0.98574***	0.98377***
	(0.0063)	(0.0053)	(0.0056)	(0.0062)	(0.0052)	(0.0056)
Price uncertainty	0,99999	0,99999**	0,99999**	0,99999**	0,99999***	0,99999***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Construction cost changes	0.72491***	1.04641	1.22151***	0.75956***	1.06818*	1.23003***
	(0.0391)	(0.0410)	(0.0461)	(0.0445)	(0.0421)	(0.0464)
Gross plan capacity	0.99948	0.99926	0.99947	0.99912	0.99871	0.99887
	(0.0018)	(0.0018)	(0.0018)	(0.0018)	(0.0018)	(0.0018)
Financial feasibility	0.61183***	0.60664***	0.61217***	0.61205***	0.58744***	0.59919***
	(0.0697)	(0.0699)	(0.0696)	(0.0696)	(0.0686)	(0.0688)
Soil pollution	0.90571	0.87881	0.89769	0.90979	0.90111	0.90875
	(0.1613)	(0.1569)	(0.1604)	(0.1620)	(0.1608)	(0.1624)
Private initiative	0.74162**	0.82482	0.79574*	0.74207**	0.83013	0.79300*
	(0.0916)	(0.1019)	(0.0981)	(0.0913)	(0.1028)	(0.0980)
Devaluation	1.20191	1.28550	1.21791	1.18284	1.30450	1.22344
	(0.2797)	(0.2982)	(0.2855)	(0.2743)	(0.3032)	(0.2874)
Infill site	0.48715***	0.45273***	0.40555***	0.49505***	0.46042***	0.40248***
	(0.0649)	(0.0593)	(0.0539)	(0.0659)	(0.0604)	(0.0535)
Constant	0.30810***	0.21762***	0.16194***	0.30284***	0.21836***	0.17023***
	(0.0887)	(0.0664)	(0.0485)	(0.0872)	(0.0666)	(0.0512)
Weibull parameter	1.89049	1.85451	1.88254	1.89267	1.85974	1.88345
	(0.0452)	(0.0447)	(0.0456)	(0.0452)	(0.0447)	(0.0456)
Municipality fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Log likelihood	-768.31	-788.03	-777.23	-766.19	-784.16	-776.19
Observations	895	895	895	895	895	895

Exponentiated coefficients; Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Appendix V

Semi-parametric Cox PH model with municipal fixed effects

	Price uncertainty over 3 years			Price uncertainty over 5 years		
	(1) Base model	(2) 1-year lagged	(3) 2-year lagged	(4) Base model	(5) 1-year lagged	(6) 2-year lagged
House price changes	1.02161**	1.00341	0.98700	1.01739*	1.00072	0.98462
	(0.0096)	(0.0106)	(0.0113)	(0.0092)	(0.0099)	(0.0111)
Price uncertainty	0.99999*	0.99999*	0.99999**	0.99999*	0.99999*	0.99999
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Construction cost changes	0.82235***	0.87661**	0.98395	0.83194**	0.89486*	0.96801
	(0.0578)	(0.0562)	(0.0663)	(0.0595)	(0.0587)	(0.0647)
Gross plan capacity	1.00021	0.99933	0.99907	0.99976	0.99922	0.99949
	(0.0017)	(0.0018)	(0.0018)	(0.0017)	(0.0018)	(0.0018)
Financial feasibility	0.70265***	0.72150**	0.70588***	0.70047***	0.71837***	0.72275**
	(0.0835)	(0.0924)	(0.0922)	(0.0833)	(0.0922)	(0.0940)
Soil pollution	0.95682	0.92457	0.94062	0.95122	0.92059	0.93740
	(0.1749)	(0.1748)	(0.1807)	(0.1736)	(0.1739)	(0.1800)
Private initiative	0.86984	0.87894	0.91309	0.87187	0.88059	0.92597
	(0.1122)	(0.1226)	(0.1271)	(0.1125)	(0.1229)	(0.1289)
Devaluation	1.13676	1.08517	1.10623	1.13977	1.08977	1.09681
	(0.2937)	(0.3171)	(0.3218)	(0.2942)	(0.3184)	(0.3186)
Infill site	0.75101*	0.73682**	0.73830**	0.75024*	0.73183**	0.73150**
	(0.1109)	(0.1091)	(0.1132)	(0.1101)	(0.1081)	(0.1123)
Municipality fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Log likelihood	-4790.90	-4322.90	-4205.77	-4790.59	-4322.68	-4207.26
Observations	809	742	725	809	742	725