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Abstract

Real estate development from raw land to completed structures is a multi-stage process. Given the current view of development as the exercise of a real option, the question arises whether development should be modeled as a compound option. This paper tests the validity of the compound option characterization by determining whether builders start units for which they have permits and then complete units started in a fashion consistent with the predictions of the real options model. To do so, we first identify a reduced form relationship between permits and starts and then between starts and completions. The parameters of this relationship indicate how well permits proxy for starts and starts for completions. Then, we determine whether controlling for this structural relationship, new information and uncertainty in returns affect permit exercise and completion rates as would be the case if these actions were the exercise of real options. We find that current and previous quarter permits forecast current single family starts, while multi-family starts require more quarterly lags of permits. More than one and two year’s worth of lagged starts numbers are needed to estimate current quarter completions for single and multi-family buildings respectively. The principal result is that once building permits have been obtained, the development process proceeds to completion. While there is no evidence that completion is the exercise of an option embedded in a start, some aspects of starts are consistent with builders treating them as an option for starts. However, even if they do, it takes large changes in market conditions to affect small changes in starts.
Introduction

Real estate development is now modeled as the exercise of a real option. The entire process of bringing raw land into developed use or redeveloping existing sites is not a single step, but a series of irreversible investments. Rather than a single option, this suggests modeling development as a compound option. While theoretically appealing this may not be realistic if the total cost of delay for some stages is higher than the benefit builders would get from doing so. In this paper we test the empirical support for compound options by determining whether builder timing of starts and completions is consistent with these activities as the exercise of distinct real options. To do so we first identify the reduced form relationships between permits and starts and between starts and completions separately for single and multi-family construction. This has the added value of indicating how effective permits and starts are as proxies for starts and completions.

The relationship between permits, starts, and completions is important for housing market research, analysis, and forecasting. Statistics on residential construction are subject to intense scrutiny because construction tends to lead both recessions and recoveries (Green 1997). Building permits and housing starts are used to gauge construction activity, yet they measure different phenomenons. Permits are the permission to build, while a start occurs with the beginning of construction, typically defined as when a foundation or slab is laid. The issuance of a permit is no guarantee that construction will occur. Starting construction does not ensure that construction will be completed in a timely manner. If the exercise and completion decisions are sensitive to market conditions, then the economic impact of building permits and housing starts will not be constant over the market cycle. For researchers these differences raise the question whether using permits
to proxy starts or either in place of completions introduces bias or extra noise in housing supply studies.¹

The results of the analysis presented here indicate that single family permits for the current and previous quarters do an excellent job of describing starts. Within three months, 95 percent of single family permits are exercised, although only 14 percent are exercised in the month of issue. In almost all cases, once a unit is started, it is completed. For single family construction, 41 percent of starts are completed within three months, and 99 percent within a year after that. The exercise rate for multi-family permits is slower: 8 percent of permits are exercised in the month of issue, after the same three months only 54 percent of permits have been exercised, and it takes 15 months to reach an exercise rate of 94 percent.² Construction time is substantially longer too: it takes 26 months to achieve a completion rate of 95 percent.

In this paper we study whether real estate development is best treated as a compound option. We assume that in total real estate development is the exercise of a real option, but investigate whether it is appropriate to interpret the final two stages of the development process, starting a unit for which a permit has been obtained or pulled and completing a unit that has been started, as the exercise of separate real options. We use two approaches for this test. The first is based on the fundamental result of the real options model that, controlling for the discount rate, increases in the volatility of returns slows option exercise. Because of potential problems with both the empirical application of this test and the quality of the measures for forward-looking uncertainty, we also use an indirect test. In a real options model, new information affects exercise behavior because the benefit of the option is the ability to delay until the flow of information reveals more about the
state of the world. We identify whether builders respond to shocks that occur after permits are pulled or units started by changing the timing of starts or unit completion as would be the case if these actions are the exercise of real options.

Our results are mixed. Uniformly, estimates of demand volatility have no effect on permit exercise or completions. In contrast, new information does affect the timing of starts, which is consistent with permits as real options. Even so, it takes large shocks to trigger small changes in starts. The inherent problems of using a backward measure of demand volatility to proxy for forward-looking uncertainty in returns, we place less analytical weight on the former result. There is no robust evidence from either approach that the completion of construction is the exercise of a real option. Given the strong evidence Holland, Ott, and Riddiough (2000) and Bulan, Mayer, and Somerville (2000) present that development is the exercise of a real option, our results indicate that the most important exercise decision occurs by the time a permit is obtained. The latter stages have option properties, but builder behavior indicates that the benefits to delay must be at best only slightly greater than the total cost of doing so.

The remainder of the paper is structured as follows. First, we outline the theoretical construct of the real options model and empirical specification used in this paper. Second, we review the existing literature on the relationship between permits, starts, and completions and the empirical application of real options theory in real estate. We then present the Canadian data and the empirical results, and finally conclude the paper with some thoughts on future research.

Testing Permits and Starts as Real Options
Over the last fifteen years there has been a tremendous volume of research on the application of option theory to investment in real assets under uncertainty. The basic real options model finds that increases in uncertainty in the future returns on an asset increase the value of the option to invest, delaying actual investment. For the model to hold the investment must be able to be delayed, at least partially irreversible, and uncertainty about asset values must be revealed over time. There are two approaches to determine the timing of individual investments, dynamic programming and contingent claims. The former imposes fewer restrictions, as the latter relies on complete markets and a no-arbitrage condition to achieve a solution. In both cases the solution depends on the uncertainty of future returns. In the absence of complete markets the solution requires a project specific discount rate and either the expected asset appreciation or the dividend (convenience) yield. With complete markets, the CAPM is used to replace the project specific returns with the risk-free rate of return, market price of risk, market uncertainty, and the asset’s beta.

There are a number of factors that can weaken or even reverse the basic investment activity and uncertainty relationship that are particularly pertinent for development. Bar-Ilan and Strange demonstrate that in either the presence of long lags (1996) or if investment process is characterized as a series of multiple options (1998) that uncertainty can actually increase investment activity. Grenadier (1999) presents a Cournot-Nash equilibrium where the option value falls with the number of competitors.

There are institutional factors specific to residential development that can limit the applicability of the real options model. The terms of construction loans impose a fixed duration and completion
must occur without excessive delay. While these are negotiable, in a repeat financing game the
signal and cost from violating terms may be high. Building and development permits typically
require that construction begin within a fixed interval following issuance and proceed at a
reasonable rate. While permits have the potential to be renewed, there is no guarantee. These
conditions limit the ability to or the returns from delay. Our data do not allow us to address all of
these complications, which limits the efficiency of our tests. However, we are able to observe if
builders respond to new information in starting and completing units, as required in the real
options model.

To start construction a builder must first obtain a building permit. If all permits are immediately
exercised by starting construction and all starts completed as expeditiously as possible, then the
start and completion decisions are not control variables, but technical steps in the housing
production process. In contrast, if builders treat these stages as the exercise of real options, then
depending on the evolution of market shocks, a builder with a permit in hand will choose to delay
or accelerate the start of construction, and a builder who has commenced construction will
accelerate or lengthen the construction process.

For both permits and starts there are arguments in favor of each framework. Though the permit
itself is typically inexpensive, many impact fees are paid and property taxes can rise at the time a
permit is drawn. Liquidity constrained builders are likely to wait until they are ready to
build to obtain permits. With a fixed life and renewal uncertain, there can be a high cost to
obtaining a permit too early. Alternatively, if there are time or fixed costs in applying for a permit
or uncertainties about how future development applications will be treated by the land use
regulatory process, then builders and developers have an incentive to bank permits and use them as market conditions dictate. Completions should occur promptly because an uncompleted unit is susceptible to weather damage, vandalism, and theft. Most builders are capital constrained, with tight cash flows, which limits their ability to hold unfinished units. To minimize agency costs, most construction loan contracts demand timely completion of units. On the other hand, completion clearly involves additional capital outlays and slowing construction or abandonment may well be the optimal strategy if the change in return from completing rather than abandoning or delaying does not outweigh the marginal cost of the action.

We test whether or not builders treat permits or starts. To do so, we determine whether contingent on the number of permits drawn (units started), starts (completions) fall with increased uncertainty in future real estate returns or change with new information on market conditions. The permit confers the right, but not the obligation to build so our prior is that builders do treat permits as options. For the decision to complete construction, our prior is that this is not a real option because holding costs and the terms of construction loans severely limit the ability to delay. In both cases, this ability is constrained, so any real options behavior should be modest at best. Below we present the empirical specification.

There is some vector $X$ that contains the market information that causes a builder to obtain a permit (start construction). In a starts (completions) regression, where current and lagged permits (starts) are on the right-hand side, the only component of $X$ that matters for starts (completions) is the information orthogonal to the decision to pull a permit (start construction). Current and lagged permits $pm_t$ to $pm_{t-k}$ (current and lagged starts $s_t$ to $s_{t-k}$) must embody market information and past
shocks. Discrete time ensures that $X_t$ will contain current period information that arrives after permits are pulled (units started). Thus, when $X$ is included along with current and lagged permits (starts) it will describe new information that affects the exercise decision because other relevant information is embodied in current and lagged permits (starts). As a more formal test we add measures of market volatility $F_t^2$ and the risk free rate of interest $r$, generating the following regression specifications:

$$s_t = \sum_{k=0}^{k} p m_{t-k} + \beta X_t + \gamma \sigma_t^2 + \eta r_t$$

$$c_t = \sum_{j=0}^{j} \delta_j s_{t-j} + \mu X_t + \lambda \sigma_t^2 + \kappa r_t$$

The explicit test for real options behavior is whether the coefficients on $F_t^2$ is statistically different from zero and negative. Our implicit test depends on the signs and significance of $\gamma$ and $\lambda$, which indicate whether builders update their decisions given new information.

The Existing Literature

The Relationship of Permits, Starts and Completions

The nature of the U.S. time series for housing starts makes precise estimates of the relationship between permits and starts hard to achieve. In the United States, the starts series is derived from samples rather than complete count data. The permit series is a complete count, but only for reporting jurisdictions, currently 8,500 for the monthly data and 19,000 for annual numbers.

Goodman (1986) proposes using information in the permits numbers to develop a more precise estimate of actual starts than is possible with the starts survey alone. One justification he uses for this approach is a set of relationships he derives from Census Bureau data to indicate that within
six months, 99 percent of the permits pulled in a given month eventually become starts. This paper revisits these relationships using Canadian metropolitan area data. These data have advantages over the U.S. series which we outline below in section IV. Other contributions here are that we estimate the structural relationships for permits, completions, and starts for both single and for multi-family construction.

Coulson (1999) applies an inventory framework to monthly time series of US national housing data to study the relationship between starts and completions. He concludes that unfinished units, those started but not completed, act as an inventory for housing production. This determines starts: as units are completed, they leave the inventory and new units are started to replace them. This has a very appealing intuition, treating residential investment like other types of inventory investment. Despite its conceptual appeal, the empirical research on manufacturing inventories has struggled to find empirical support for this approach.

The analysis here differs from Coulson’s work in goals, data, and methodology. First, this paper has the added goal of determining whether the permit exercise and construction completion decisions of builders are consistent with the real options model of real estate development. Second, we compare both permits with starts and starts with completions and extend the analysis to study both single and multi-family construction using metropolitan area panel data. One advantage of using data at the level of housing markets is that it avoids some of the aggregation problems identified in Goodman (1998). Finally, the characterization of construction in this paper is more consistent with the institutional framework of the development process.
It is hard to reconcile the inventory model with the standard terms of a construction loan. Treating homes under construction as inventory means that there are always a certain number of unfinished units waiting for sufficient demand, or their explicit purchase by consumers, to justify their completion. Yet, residential construction is a highly leveraged enterprise: builders obtain short-term construction loans for upwards of 75 percent of total project costs. It is a standard provision of these loans that the builder must complete construction expeditiously. Leaving units unfinished as part of an inventory works against the interests of lenders who experience higher default risk with no additional upside gain from project delays. While there are units for which construction is halted, the existence of such units is not itself evidence of delay in option exercise. Finally, it is not clear why inventory behavior should occur at the construction stage. Builders and developers with sufficiently deep pockets or vendor financing can develop an inventory of raw land, serviced lots, or in the case of urban environments, built-up properties suitable for redevelopment or developers may hold options on sites rather than purchasing them outright.\footnote{Empirical Studies of Real Options in Real Estate}{\footnote{Empirical Studies of Real Options in Real Estate}}

There is a well-developed theoretical literature on the application of real option models to different aspects of real estate development. Early applications include Titman (1985) and Williams (1991). This framework has been applied to city growth (Capozza and Helsley 1990), overbuilding in office markets (Grenadier 1995a), leases (Grenadier 1995b), and regulatory takings (Riddiough 1997), among other papers. In contrast, the empirical literature is quite sparse.\footnote{Using micro data on sales of undeveloped industrial land in Seattle, Quigg (1993) estimates the...}
development option to be worth 6 percent of site value. She uses hedonic regressions to estimate transaction values by parcel and backs out intrinsic values from rents. The option value is the difference between the two. One problem with her methodology is that even a small prediction bias in her hedonic specification can generate large errors in her estimates of the option value. As well, she only has a derived measure of volatility.

Holland, Ott, and Riddiough (2000) are the first authors using real estate data to find that aggregate investment, new construction, falls with higher levels of uncertainty in real estate prices or returns. They test all elements of the solution for real options under a complete markets assumption for each of several classes of investment real estate. Using two different measures of uncertainty, a forward-looking version derived from mortgage spreads, and the standard deviation of recent REIT returns. They find that new construction activity falls with the volatility of expected real estate asset returns. However, not all estimated coefficient signs and significance fit the CAPM framework, most likely because of the absence for real estate of complete markets.

Bulan, Mayer, and Somerville (2000) present a micro-data analysis of the real options model. Looking at the timing of individual developments in a duration model of development, they tie the empirical analysis to the fundamental prediction of the model, that increased uncertainty delays development, rather than stopping it completely. They find robust support for the model, higher volatility in returns lowers the hazard rate and the effect is significant. As noted above, the empirical analysis here differs from these papers because we focus only on whether it is appropriate to treat permits and starts as separate options, rather than testing if the development process in the aggregate reflects the exercise of a real option.
Data Description

This study uses an unbalanced panel of quarterly time series data for 15 Canadian census metropolitan areas (CMAs).\textsuperscript{11} CMAs in the data include all major Canadian metropolitan areas, but exclude several smaller CMAs with incomplete data, including St. Catharines-Niagara, Saint John, and St. John’s. Canadian data offer a number of advantages over similar series for U.S. metropolitan statistical areas (MSAs). First, permits, starts, and completions series are available for CMAs for more than twenty years. These quarterly series are formed from data reported by all jurisdictions in each CMA, though the monthly series use sampling for communities of less than 10,000 population for two out of three months each quarter. Third, these series are a census of all activity in a jurisdiction, rather than a sample, as they are in the United States. Finally, over the last twenty years the geography of CMAs changed less dramatically than has that of MSAs.

Table 1 presents the pooled means and standard deviations as well as the minimum and maximum CMA mean values. Permits, starts, and completions vary with the large differences in city sizes and growth rates. Overall, real house prices between the mid-1970's and mid-1990's have been essentially flat. The mean quarterly percentage increase in real house prices for single family units was -0.003 percent.\textsuperscript{12} This does vary widely by city: ranging from a low of -0.49 percent in Regina to a high of 0.92 percent in Vancouver (all cities experienced nominal price increases). The house price series are created from median sales prices reported by the national realtor Royal LePage for two storey mid-market single family units. Their brokers provide quarterly median sales prices for select cities by house type in major Canadian CMAs, creating a data set similar to the NAR median house price series in the United States. The alternative cross-CMA measure is the Statistics Canada new housing price index. Comparing both to a repeat sales house price
series for Vancouver demonstrates the superiority of the Royal Le Page data, principally because the Statistics Canada new house price series fails to adjust for changes in the location of new construction. Over the 1983-93 trough to peak for Vancouver prices, the real repeat sales index of single family house prices increased by 114 percent. This compares with 108 percent for the Royal LePage series and a decrease of 4 percent for the Statistics Canada series. The correlations with the real repeat sales index are 0.95 and 0.16 respectively.

The standard test for real options behavior is whether controlling for the discount rate, increases in uncertainty in asset returns lowers housing starts and completions. The volatility of the percentage change in house prices describes this uncertainty for geometric Brownian motion. We also use the volatility of the vacancy rate and the number of competed but unsold units to characterize the uncertainty facing builders because studies such as DiPasquale and Wheaton (1994) and Mayer and Somervielle (2000) have shown that prices are not a complete sufficient statistic for demand.

The commonly used measure of volatility, the standard deviation of recent returns, is problematic for our data. Papers using financial markets data such as Leahy and Whited (1996) and Holland, Ott, and Riddiough (2000) can use daily returns over the previous month or quarter to generate this type of measure of uncertainty. With quarterly data, a measure of forward-looking uncertainty in returns of this type would have to be based on quarterly returns over the past eight or more years. To obviate this problem we use a Garch conditional variance estimate for the percentage change in real house prices, vacancy rates, and the number of completed but unsold units. This measure is generated as follows. Let \( p_{it} \) be the percentage change in real house prices for period \( t \) in CMA \( i \). In the first stage of the Garch we estimate an ARMA(1,1) model for \( p_{it} \):
\( \% \Delta p_{it} = \alpha_{0i} + \alpha_{1i} \cdot \% \Delta p_{i,t-1} + \alpha_{2i} \cdot \varepsilon_{i,t-1} + \varepsilon_{it} \) \tag{2}

The vector of residuals \( \varepsilon \) from (2) is used to estimate the conditional variance itself. The maximum likelihood estimator of the conditional variance is a (1,1) process:

\[
\sigma^2_{i,t} = \beta_{0i} + \beta_{1i} \sigma^2_{i,t-1} + \beta_{2i} \mu_{i,t-1} + \mu_{it} \tag{3}
\]

Garch offers a particular set of advantages for our data. First, the Garch is a reduced form of Lo and Wang’s (1995) methodology for option pricing when asset returns have an auto-regressive component, which Case and Shiller (1989) and Quigley and Redfearn (1999) show applies to house prices. Second, uncertainty is a function of deviations from predicted values, which controls for the serial correlation in real estate values. Because this is not the standard deviation in future returns that is part of the explicit real options model, we cannot estimate model parameters. However, higher deviations from expected values, which yield higher Garch estimates of the conditional variance, are consistent with higher volatility in returns. The weakness of this approach is that our per CMA series size is too small for consistent estimation of a Garch model that is asymptotically accurate. With this in mind we find volatility measures vary dramatically across cities. For instance, mean house price volatility in Vancouver is 70 times the level in Saskatoon.

Our panel has up to 100 quarters of data for some CMAs, with no more than 15 cross-sectional observations. This difference can result in estimation problems because of the time series properties of the data. In Table 2 we present the results of Im-Pesaran-Shin (1997) panel unit root
tests and the number of CMAs for which a series is I(1) and I(0) based on individual by CMA augmented Dickey-Fuller tests. We find that variables that can increase without bound, such as real house and lumber prices and rents, are non-stationary. We would expect the stock of housing also to be non-stationary. Since starts, permits, and completions describe changes in the stock, they should be I(0), which they are in these data.\textsuperscript{14} Intuitively permits, starts, and completions should move together, but as stationary series they cannot strictly be co-integrated. The number of completed but unsold units is stationary, but with a lower level of confidence, the same is true with the vacancy rate. The former should follow starts, while the latter seems unlikely to be a variable that can increase without bound. Our empirical analysis uses only stationary series, so for any I(1) series we use differences in the regressions.

**Empirical Results**

*Structural Relationships*

We first identify the reduced for parameters for the structural relationship between permits and starts and between completions and starts for both single-family and multi-family construction. These tests are presented for both monthly and quarterly series. The monthly series allow a more precise identification of the relationship, are consistent with the data periodicity used by forecasters and market analysts, and generate results that allow a direct comparison with US parameters cited by Goodman (1986). Results for quarterly series are useful because most MSA-level housing market research uses quarterly data. As well, to test for behavior consistent with the real options model we need to have series that are of the same quarterly periodicity as the other variables in the data.
Table 3.1 summarizes the monthly starts-permits and completions-starts relationships for single and multi-family units in an unweighted pooled sample of fifteen CMAs between 1972 and 1998. Table 3.2 does the same for quarterly data. The structural relationships are identified with OLS regressions of starts on current and lagged permits and completions on current and lagged starts with monthly or seasonal dummies. The actual regression results are presented in Tables A-1 and A-2 in the appendix.

There are very clear differences between single family and multi-family construction. While 94 percent of single family permits are exercised within 90 days of being obtained (pulled), the corresponding figure for multi-family permits is only 55 percent. For the latter, it takes more than 10 months before 95 percent of permits obtained in a given month are exercised. A number of factors may contribute to this lag. Multifamily construction tends to be subject to far more rigorous land use regulation than is the case for single family units. As a result, builders may choose to take their permits as soon as possible to protect against any changes in the regulatory regime. Financing may also play a role in the longer lags. For strata-title (condominium) multi-family construction in Canada, permits must be obtained before units can be pre-sold, and a certain percentage of pre-sales are a condition for obtaining for financing. Depending on the rate of pre-sales there could be a non-trivial lag between obtaining permits and commencing construction. The quarterly data in Table 3.2 are consistent with these results. For single family permits approximately 100 percent are exercised in the quarter of issue or with a one quarter lag. Over the same period only 66 percent of multi-family permits are exercised.

Comparing the figures derived from Canadian metropolitan area data with those compiled for the
United States national series by Goodman (1986) reveals a number of differences. Goodman calculates that 56 percent of permits are started the same month of issue, and 80 percent with one month lag, and 94 percent with a three-month lag. From Table 3.1, the exercise rate in Canadian cities for both single and multi-family development in the month of issue is substantially lower than the figures calculated by Goodman, 14 and 8 percent respectively. For single family permits, the rate increases rapidly to 64 percent after a one month lag and essentially all permits are issued after a lag of three months. For multi-family construction, the exercise rate increases over time, but at 63 percent after a three-month lag, remains much slower than Goodman’s figures. Whether this difference is an artifact of the data, because we examine Canadian metropolitan areas, or because they represent actual counts rather than sampling is hard to determine. However, because they are based on complete counts rather than sampling, they should inspire more confidence than the figures reported by Goodman.

Single family units are completed much more quickly than multi-family units. Within 120 days of starting construction, 54 percent of single family units are completed, though it takes another 10 months for completions to reach 90 percent of starts. It takes one year before 50 percent of multi-family starts are completed, and another year on top of that to reach a 95 percent completion rate. The long construction periods are rather striking. Part of the long lag for single family construction may be because of contract construction, where an owner of a site contracts with a firm to custom-build a unit if builders are better able to keep contractors to schedule than are individuals. For multi-family construction, large buildings take time. The translation of starts into completions is not sufficiently quick to inspire confidence in using quarterly starts data to describe the evolution of the stock unless a large number of lagged values are included. This is an issue for stock-flow
models where researchers have tended to let current period starts or permits determine the evolution of the stock with few if any lags.

Testing for Real Options

This paper uses two approaches to test for real options behavior in the exercise of permits and completion of units. The first is the inclusion of measures of return volatility, described by the volatility of demand, and the risk-free rate to the regression specifications from Tables 3.1 and 3.2. If builders treat these stages as the exercise of real options, than the coefficients on both variables should be negative in both the starts and completions regressions. The second approach determines whether builder reaction to shocks reflects real options exercise.

These specifications both suffer from potential simultaneous equations bias. Market conditions are measured as the percentage change in real house prices and the number of completed but unoccupied units for single family activity, and the percentage change in real house prices, real rents, and the vacancy rate for rental units for multifamily units. All these measures are endogenous to new construction activity. We instrument for the market condition variables in every regression specification. Instruments include lagged values of percentage change in population and provincial employment, mortgage rates, and lagged own values. A comparison of regressions with and without instrumental variables, indicates that the IV methodology has the expected effect on coefficient values and increases standard errors.

Starts as the Exercise of an Option Embedded in Permits. Tables 4.1 and 4.2 present the analysis for determinants of quarterly single family and multi-family starts respectively. Both
tables included current and lagged permits issued and the number of lags of permits issued that are consistent with the structural results summarized in Table 3.2. For single family units, the regressions in Table 4.1 show that builders change their exercise rate of permits with new information on housing market conditions. Uniformly, controlling for permits drawn to date, starts rise with increases in the quarterly percentage changes in real house prices. The effect is statistically different from zero but quite small. Applying a two percentage point increase in the quarterly percentage change in real house prices in regression (4), equal to an annual real increase of 8.2 percent, raises starts by 27 units, or 3.1 percent of the mean. These effects are quite small, the price increase is 1/3 of a standard deviation while the effect on starts is only 2 percent of the same. Converting this to an elasticity for Vancouver yields a paltry 0.007.

In the presence of sticky prices, other variables must adjust to equilibrate the market. Following housing supply side work we use the number of completed but unsold units as an alternative measure of demand. Increases in this measure lower the exercise rate on permits. However, both the magnitude of this effect and the elasticity are also quite small: from regression (2), a one standard deviation increase in the number of completed and unsold units lowers quarterly starts by 37 units or 4.3 percent, an elasticity of only 0.038.

Changes in lumber prices have a positive effect on permit exercise, the reverse of our expectations that higher input costs reduce starts. One possible explanation is endogeneity: national lumber prices move with aggregate national construction and most CMAs move with the national cycle. We cannot easily correct for this endogeneity because we lack instruments for lumber prices that are independent of those used for the measures of demand.
The new information approach suggests that indeed builders treat permits as options. However, when we explicitly test the relationship between permit exercise and volatility, we find the demand uncertainty has no statistically meaningful effect on permit exercise. Adding estimated conditional variance measures to regressions (4)-(7) of Table 4.1, we find that while house price volatility affects the exercise of starts in the expected negative direction, the coefficient on volatility in the number of completed but unsold units has the “wrong” sign. In both cases the estimated coefficient is never statistically different from zero.\(^\text{18}\)

The risk free rate of return is part of a formal test of the real options model when there are complete markets. However, depending on assumptions about the relationship between the risk-free rate and other variables in the real options model, then increases in the risk-free rate can accelerate or delay option exercise. Uniformly the coefficient on the risk-free rate is not statistically different from zero, though it tends to be negative. One complication is that construction loans tend to have adjustable rates, so higher real rates will also mean higher project costs, which would make builders less likely to begin construction. This is not for option exercise reasons, but because construction costs, labor, materials, and financing costs, are now higher.

New information about market conditions also affects the decision to exercise multi-family permits. Contingent on permits issued, Table 4.2 shows that the effects of changes in real rents (regression 1), vacancy rates (regressions 4-5), and changes in real estate (house) prices (regressions 2-5) all have the expected signs, but only the coefficient on prices is statistically different from zero. This suggests that the future rent increases capitalized in prices are more important than current rents for builders, possibly because most multi-family starts since the mid-
1980's in Canada have been for condominiums rather than rental units.

As with single family starts, the effects are not large. A 2 percentage point increase in the percentage change in real house prices raises the number of multi-family starts by 69 units, or 11 percent, equivalent to an elasticity of 0.096 for Vancouver. These figures for multi-family starts are at least an order of magnitude higher than for single family starts. One possible explanation is that because for multi-family construction, incremental exploratory construction by building only a fraction of the units within a project is not possible. Consequently there is a greater gain to delay. Surprisingly, the coefficients on house price and vacancy rate volatility are positive, though always far from being statistically different from zero. As with single family starts, real interest rates have a negative but not statistically different from zero effect.

There are a number of reasons that may explain the failure of the uncertainty measures in these regressions. First, permit expiry limits the scope of builders to delay at this stage of the development process and uncertainty works directly through the ability to delay. Second, we include variables that describe market conditions, reflecting “new information” that should affect option exercise decisions. Consequently, there is less variance to be explained by uncertainty. Third, our measures of time varying variance of returns, number of unsold units, and the vacancy rate are not accurate measures of the relevant forward-looking uncertainty faced by developers and builders. Fourth, the nature of residential development, which includes the multi-stage development process and the limits on builder “monopoly power” because of competition from the existing stock and other new projects, may limit or reverse the standard effect of uncertainty. We do not have sufficient data to include all parameters of the real options model, raising the
possibility of left out variable bias.

Our conclusions from these results are that there is support for the argument that builders treat
starts as the exercise of a real option. They change their permit exercise decisions in light of new
information, a behavior consistent with permits as a real option. In contrast, the estimated
coefficients on the demand uncertainty variables lack statistical significance to support this claim.
We believe that problems with these variables are the likely explanation for their performance.
The reaction to new information approach is immune to this problem and inherently reflects the
option nature of the process, the ability to delay. Even so, the coefficient values on price changes
and the number of completed but unsold units are sufficiently small that new information has an
only modest effect on the speed with which permits are exercised.

*Completions as the Exercise of an Option.* Regressions of current completions on current and
lagged starts, new market information, and uncertainty measures find little support for the claim
that residential builders treat the completion of a unit already started as an option. Contingent on
current and past starts, neither the measures of uncertainty nor new information have a statistically
different from zero effect on completions. The regressions follow the same form and structure as
Tables 4.1-4.2: Table 5.1 presents the estimates of single family completions and Table 5.2 does
the same for multi-family completions.

Controlling for the number of current and lagged starts, the effects of shocks to price changes,
shocks to the number of completed but unsold units, and the degree of price volatility on single
family completions are not statistically different from zero. Comparing coefficient estimates, the
effects of price changes on the completions in Table 5.1 are 12-21% of the size of those on starts in Table 4.1. For house price volatility, the coefficient in Table 5.1 is less than 10 percent the size in absolute value of the estimate in Table 4.1. As with the other variables, the sign on the coefficient is wrong.

The results for multi-family completions are more intriguing. Unlike the case for starts in Table 4.2, house price changes in Table 5.2 have no discernable effect on the rate at which multi-family units are completed, controlling for two years worth of starts. However, the rate of completion does fall with the vacancy rate, with estimated coefficient values in regressions five and six that are twice those in Table 4.2. In the former regression the coefficient is statistically different from zero with 90 percent confidence, and close to that in the latter. Still, the magnitude of the effect is small. A one standard deviation increase in the vacancy rate results in a drop in completions of 41 units, or about 8 percent. As an elasticity this is quite low, 0.092. The sign on vacancy rate volatility has the wrong sign, though the estimated coefficients for price volatility are both larger than those for multi-family starts in Table 4.2 and of the correct sign.

There are a number of reasons that may explain why multi-family completion rates display weak evidence of real options behavior while single family rates do not. First, the longer construction process may allow builders more latitude to delay within the framework of their loans than is the case for single family construction. Second, single family completions include custom-built homes and speculative starts for which sales contracts have already been signed so that there is no option. While some multi-family units are pre-sold they are only a percentage of all units in a project, and custom-built multi-family projects do not occur.
Overall, the evidence is that once a unit has been started, builders finish construction. Completions occur independent of the evolution of housing market conditions. Consequently, the construction process does not have option properties. These results also reject the thesis that builders treat units under construction as an inventory for completed units, for if they were to do so, we would have to see evidence of counter-cyclical starts behavior.

**Conclusion**

This paper investigates two issues: where real options behavior occurs in the real estate development process and whether starts and permits are appropriate proxies for completions and starts respectively. We find that builders respond to new information in deciding whether or not to exercise permits, though it takes large changes in market conditions to generate small changes in permit exercise rates. While this behavior is consistent with the real option framework, we do not obtain the standard result, that uncertainty in returns itself is important. There is scant evidence of this type of options behavior by builders in the timing of completions. Overall, these results suggest that if developers and builders do treat development as a real option, the important stage is at or prior to the time of the decision to actually draw a building permit or obtain a development permit. Avenues of future research include a more developed analysis of the model, allowing feedbacks among the three variables in a VAR type framework. This would allow the estimation of current starts or completions while controlling any earlier decisions to exercise at a more rapid rate.

As a practical matter for evaluating housing market conditions and forecasting, the results of this
paper suggest that single family permits can proxy for starts. It is important to create the proxy using current and lagged values. For multi-family activity the number of lags needed is greater and the predictive accuracy lower. While starts do turn into completions, the very long lags needed to reach a point where 95 percent of starts become completions allows too much possibility for imprecision in a prediction to offer more than a very general insight. These results are important for metropolitan area analysis in the US, where reliable starts series are not available for most MSAs.
Bibliography


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Data Appendix

The permits, starts, and completions series are used to estimate the structural relationship between starts and permits and then completions and starts. We generate estimates of the coefficients in these structural relationships from OLS regressions of seasonally adjusted starts on current and lagged permits and completions on current and lagged starts. For monthly series these regressions are presented for both single family and multi-family units. Table A-1 shows the results using monthly series and Table A-2 for the quarterly series. One complication is that data series values change with new CMA definitions, but historic values are not adjusted to reflect these changes. The Canadian census occurs quinquennially, but with the exception of Ottawa-Hull, most CMAs have only one change. We construct adjusted series by altering values for years prior to new CMA geographic definitions by the percentage change resulting from any additions or subtractions in the year of the redefinition.
Endnotes


2. We use data series on apartment construction, buildings with six or more units, for multi-family. Both rental and condominium (strata-title) properties are included in the multi-family series. Single family series are for single detached units. Our breakdown excludes single family attached, row houses, and multi-family buildings with 3-5 units.

3. The theoretical foundations and applications of this model are covered in Dixit and Pindyck (1994), Pinches (1998), and Brennan and Trigeorgis (2000). Holland, Ott, and Riddiough (2000) provide a clear summary of the issues in applying the model to real estate.

4. By pulling a permit, the builder is assured of the right to build without delay or additional regulatory cost during the life of the permit (typically a year), even if there are changes in the regulatory environment or increases in impact fees. In most jurisdictions permits are transferable, and, subject to review, they may also be extended.

5. This discussion pre-supposes that all starts are speculative starts. In the US approximately 40 of starts are speculative.

6. This is not a problem for completions because of long construction times.

7. Goodman uses 1984 Construction Reports C20 data but does not explain his methodology.

8. Blinder and Maccini (1991) demonstrate that actual production is typically more volatile than sales in the manufacturing sector, implying that little smoothing occurs. The same is true for housing where starts are more volatile than sales.

9. Some large national US builders prefer to construct units only once they have a buyer. Pre-sales are quite common for condominium developments in Asia and Canada and are frequently part of a developer’s marketing strategy.

10. Capozza and Schwann (1989) is the first empirical treatment, but they have severe data problems.

12. Real series are developed using a smoothed inflation value, average of quarterly inflation over the current and previous three quarters with declining weights of 4, 3, 2, and 1.


15. For purposes of comparison we also estimated a starts-permits relationship for total permits. As the weighted average of single and multi-family estimates, the Canadian data again reveal a much slower initial exercise rate.

16. The Durbin-Watson statistics in Table 4.1 are rather high. AR(1) regressions yield an estimated $D$ of only -0.25 and the coefficient estimates are essentially unchanged. Consequently, we choose to keep the current specification and avoid the problems associated with IV estimation with a serially correlated error structure.

17. This is related to the median time to sale variable that Poterba (1984), DiPasquale and Wheaton (1994), and Mayer and Somerville (2000) find has significant effects on new construction in the aggregate U.S. data.

18. This result is robust across measures of demand volatility. Using the standard deviation of price changes over the previous eight quarters to measure uncertainty yields a qualitatively similar result to that presented in the tables using the Garch estimate of demand variance. As well we tried interacting volatility and price change to test for asymmetric effects, but did not obtain robust results.