Economic Valuation of Tax Deed and Warranty Deed Theory and Empirical Verification

Elli Kraizberg[1,*]

[1]*Bar Ilan University, Ramat Gan, 52900, Israel*

Abstract: A property sold and recorded as a Warranty Deed (WD) is valued differently from an otherwise identical property sold and recorded as a Tax Deed (TD). This observation supports the common view that winning bids in TD auctions are lower than prices observed in market transactions recorded as WD. This paper develops a rational theoretical framework to explain and quantify the valuation differences between WD and TD properties. Using data on TD sales in Florida, governed by Florida §197, from two periods (2011–2012 and 2021–2025), the analysis confirms that winning bids for TD-recorded properties are generally lower than or equal to those for WD-recorded sales. However, when TD prices are properly adjusted for the theoretical differences identified in this paper, the adjusted TD prices indicate overpricing.

Keywords: Tax deed, warrantee deed, valuation, optimal timing for development, real estate auctions.

JEL Classification: R30, R32.

1. INTRODUCTION

In 2021, the average time a residential property remained on the market in Florida was 87 days. That is, a property owner typically had to wait nearly three months before a single buyer was willing to offer an acceptable price. In contrast, during the same period, as many as 300 buyers participated in Tax Deed auctions held in Florida, all bidding on a single day at a specific time. This stark difference suggests that the strong appeal of Tax Deed (TD) auctions may stem from the widespread belief that properties conveyed through TD are priced significantly below comparable properties conveyed through Warranty Deeds (WD). This paper examines whether such beliefs are valid and financially rational.

A property sold and conveyed by a Warranty Deed (WD) and the same property sold and conveyed by a Tax Deed (TD) constitute fundamentally different assets. These differences arise from legal constraints that, in turn, generate differences in their financial values. A WD is a real estate instrument that provides the highest level of protection to the purchaser, as it guarantees that the seller holds a clear title to the property, free of any liens, mortgages, or other encumbrances. Accordingly, the price agreed upon in a transaction recorded as a WD is likely to reflect the property's market value, incorporating financial risk but largely excluding legal risk, since the title is insurable. Because a WD involves minimal legal risk, the value of a property conveyed through a WD can be considered a close approximation of its market value.

Given the uniqueness of real estate—no two properties are perfectly identical—the notion of market value reflects the price that the buyer with the highest valuation is willing to pay for a specific property. In contrast, the sale of real estate through a forced process initiated by a tax certificate holder and recorded as a Tax Deed (TD) is likely to command a lower price for several reasons. For example, title insurance companies are often reluctant to insure such titles, limiting opportunities for immediate resale ("flipping," in practitioners' terminology) or prompt development of vacant land. In addition, the original tax-delinquent owner may retain the right to reclaim the property for a period of up to four years following the TD sale.

Two intertwined questions emerge from the definitions above: (i) Are prices in TD auctions rationally discounted relative to WD sales? (ii) What is the appropriate difference between the economic values of WD and TD properties? To address these questions, we first develop a theoretical model to quantify the value difference, and then test it empirically.

In this paper, we focus on undeveloped residential land properties conveyed either by WDs or TDs. Accordingly, we adopt a valuation model for undeveloped land that corresponds to the market value reflected in a WD transaction. The literature offers a variety of approaches to estimate the rational market value of vacant land. Shaup (1970) and Ratcliff (1972) employ a simple present-value approach, embedding uncertainty within the discount rates. Titman (1985) applies option-pricing theory, treating the value of vacant land as a derivative of a single source of uncertainty—the potential value of developed space. Pindyck (1998), building on the Samuelson-McKean (1965) framework, generalizes this approach by modeling an infinite-horizon real option with an irreversible initial investment, conceptualized as the option's exercise price.

Williams (1991) further extends this framework by incorporating factors such as density, abandonment likelihood,

*Address correspondence to this author at the Bar Ilan University, Ramat Gan, 52900, Israel; Tel: US: 1845-4290066 IL +972544618896;
E-mail: ekraizberg@gmail.com

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and uncertainty regarding future construction costs. Arnott and Lewis (1979) and Capozza and Helsley (1987) examine the value of agricultural land convertible into urban use, developing dynamic models over a continuous infinite time horizon with a single type of housing. Their models highlight the impact of uncertainty on the timing of development, with the optimal rule being to convert land to urban use once observed rents reach a critical threshold; otherwise, conversion should be deferred. Capozza and Li (1994) expand this framework to account for multiple potential uses and variable housing and office densities. Clarke and Reed (1988) address a similar land development problem, where landowners face uncertain future rents and development costs; they demonstrate that the optimal capital intensity can be determined independently from the optimal timing due to the recursive structure of the problem. Finally, Eddie et al. (2008) and Grovenstein et al. (2011) provide empirical tests of real options theory applied to land development.The above studies imply a critical conclusion for our analysis; a piece of undeveloped land will rationally be held undeveloped indefinitely, as long as the carry costs are nil. Anderson (1986) and Williams (1991) point out that a positive property tax may lead to an optimal decision to develop or abandon the land.

Allen, Faitcloth, and Nejadmalayeri (2004) model property tax liens within a continuous-time framework and empirically find that buyers' bids for redemption penalty rates are negatively correlated with the assessed values of the underlying properties. Their dataset extends only until 2000; more recent data indicate that 99.8% of winning bids occurred at a rate of 0.25%. This pattern reflects both the historically low interest rates in the U.S. economy in recent years and the fact that, regardless of the bid, the minimum redemption penalty rate is fixed at 5%. Jarrow and Tyagi (2007) develop and test a simple pricing model for tax liens, which are legal claims on unpaid real estate taxes issued by state counties and auctioned to the public. Under this system, the property owner retains the option to redeem the tax lien certificate before foreclosure by paying the overdue taxes plus penalties and interest. They argue that the tax lien auction mechanism is inherently unfair, producing non-zero net present values (NPVs) for participants.

While Allen, Faitcloth, and Nejadmalayeri (2004) and Jarrow and Tyagi (2007) develop methods for valuing tax certificates sold to the public, this paper focuses on establishing a valuation model for Tax Deed (TD) sales—that is, for properties where the tax certificates have not been redeemed, and the certificate holder has initiated a Tax Deed action.

TD sales should not be classified as distressed sales. While there is a substantial literature on distressed sales (see Immergluck et al., 2006; Harding, 2009, 2012; Campbell et al., 2011; Depken et al., 2015; Doerner et al., 2016; Donner, 2020, among others), TD sales differ in important respects. Neither the original property owner nor the certificate holder is under a binding time constraint. The certificate holder has up to seven years to decide when to initiate a TD sale, and the original owner retains the right to redeem the property for up to four years after the sale. Furthermore, the legal environment governing TD sales is fundamentally different from that of foreclosure sales, for example, in the types of liens that survive the closing of each transaction. These distinctions make TD sales legally and economically distinct from conventional distressed sales.

2. THE LEGAL ENVIRONMENT: THE TD PROCESS, TITLE INSURANCE, AND ZONING

In this section, we outline the legal framework governing the tax deed (TD) process in Florida, based on the relevant statutes, since the data used in this paper were collected in that state. We also describe the basic zoning rules incorporated into our model.

Sections Florida §197.502–197.532 pertain to the application process, while Florida §197.542 governs the auction mechanism. The sections most relevant to this study are §197.552 (tax deeds), §197.562 (immediate right to possession), §197.573 (survival of covenants and restrictions), and §197.602 (litigation risk).

Florida § 197.552 clearly states that tax deeds are issued without warranty and may contain title defects. Moreover, in Texas, Georgia, and Illinois, the property owner retains the right to redeem the property even after the tax deed sale. In any state, an owner may seek to set aside the sale or pursue post-sale remedies if the process is shown to be defective.

2.1. Tax Deed Process

1. Ad valorem property taxes are assessed for calendar year t and become due and payable on November 1 of that year. Taxes become delinquent if not paid by April 1 of year t+1.
2. If taxes remain unpaid, the tax collector is required to sell a tax certificate at public auction (typically by June 1 of year t+1) pursuant to Florida law. The certificate represents a first lien on the property and includes unpaid taxes, interest, costs, and charges. Bidders compete by offering the lowest rate of interest (from 0 to 18 percent) they are willing to accept upon redemption.
3. From the date of issuance until the expiration of two years (but before the issuance of a tax deed), the property owner or other interested parties may redeem the tax certificate. The redemption amount includes the face value of the certificate, interest at the bid rate (subject to a statutory minimum of 5 percent), and any additional costs and fees.
4. In mid $t+3$, but not later than mid $t+8$, if the certificate was not redeemed, the certificate owner may apply for a tax deed which will be publicly auctioned. The opening bid includes:

- The amount required to redeem the certificate, including interest and fees (for properties qualifying for a homestead exemption, an additional amount equal to one-half of the assessed value is included, as required by statute); and,
- The value of all outstanding tax certificates that were issued against this property.

5. The certificate holder applying for a tax deed must pay all applicable costs and charges associated with

the application and sale, including any additional amounts needed to meet the opening bid. Proceeds from the tax deed sale are distributed according to statutory priority: governmental liens, homeowners' association liens, and public utility liens are satisfied before any surplus is remitted to the former property owner. If the sale proceeds are insufficient to satisfy these liens, the remaining balance continues as a lien on the property. All other junior liens are extinguished upon issuance of the tax deed title[1].

6. The property is awarded to the highest bidder at the tax deed sale; if no higher bids are received, the certificate holder obtains title to the property. The successful bidder receives a tax deed. The former owner retains the right to challenge the tax deed through legal action; if such a challenge is successful, the tax deed holder is generally entitled to reimbursement for the purchase price, costs, and the value of any authorized improvements made to the property.
7. Title to property acquired through a tax deed is often considered unmarketable by title insurance companies. As a result, resale of the property typically requires the issuance of a warranty deed backed by title insurance. This can be achieved either by initiating a quiet title action to clear defects in the title or by waiting the statutory period (generally four years from the date of the tax deed sale), after which title insurers may be willing to provide coverage.

2.2. Embedded Development Zoning

The zoning constraints incorporated into the model include permitted land uses, maximum residential density (i.e., allowable units per parcel), building height limits, setback requirements and maximum lot coverage, as well as access to municipal water infrastructure. Collectively, these regulatory constraints define the feasible development envelope and are used to compute the maximum allowable buildable floor area.

3. THE MODEL

A real estate transaction recorded as a title-insured warranty deed (WD) is assumed to be legally risk-free. In contrast, a transaction resulting from a tax deed (TD) sale is not immediately insurable. The model aims to identify the valuation differential between WD and TD transactions.

1. There exists a risk that the sale price at a TD auction will be insufficient to cover the total value of recorded liens that survive the sale. In such cases, the TD purchaser may remain liable for the outstanding balance.
2. A purchaser at a TD sale cannot resell the property as a title-insured WD transaction within the statutory period (typically four years), as the title is not insurable during this interval.

The first risk is not expected to be quantitatively significant, as information on surviving liens is publicly available. A prospective bidder can therefore avoid participating in tax deed auctions where the value of such liens exceeds their reservation price. Accordingly, the model focuses on the second friction—namely, the requirement that the purchaser must hold the property for a statutory period (approximately four years) before the title becomes insurable.

The second risk is economically significant and represents a true market risk, as it cannot be diversified or avoided. The mandatory holding period before the title becomes insurable exposes the TD purchaser to potential opportunity costs and liquidity constraints, distinguishing it from the relatively risk-free WD transaction.

Let $L(i)$ be the size of a vacant or partially built[2] plot, given use i, net of setback and/or maximum land coverage requirements.

Let q denote the number of units permitted by zoning regulations that can be built on a vacant parcel, or the additional units that can be added to a partially developed property. Let s represent the size of each unit. The optimal values, s^* and q^*, are to be determined (see below). Let γ denote the annual carrying cost rate for undeveloped land, including property taxes, drainage, and code enforcement obligations. The annual borrowing rate, r^b, is assumed to exceed the risk-free rate, r^f.

Let $V(i, s^*, q^*)$ denote the market price of undeveloped land recorded as a warranty deed (WD), and let $P(i, s^*, q^*)$ represent the value of the property with optimal unit size and use after construction. Following the standard approach in the literature:

If $V(i, s^*, q^*) = P(i, s^*, q^*) - C(s^*, q^*)$,(1)

then the optimal time to develop the land is immediately.

If $V(i, s^*, q^*) > P(i, s^*, q^*) - C(s^*, q^*)$,(2)

then it is not rational to undertake development at the present time. Here, $C(V(s^*, q^*)$ denotes the construction cost associated with building the optimal units.

It is assumed that all participants are rational and face the same risks, though they may differ in their investment horizons. To support our empirical analysis, we consider two types of participants in tax deed (TD) auctions. The first type, short-term participants—such as builders or "flippers"—have a very short investment horizon and will submit bids only if condition (1) is satisfied, *i.e.*, if it is optimal to develop the land immediately.

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[1] However, a title acquired through a tax deed is not risk-free. The purchaser is responsible for conducting due diligence by reviewing public records for potential issues, including environmental liabilities, flood zone designations, access restrictions, bankruptcy proceedings, and zoning regulations. Some of these risks may also arise in transactions involving a warranty deed.

[2] A partially developed plot is one in which the existing construction occupies less than the maximum buildable area permitted under the applicable zoning regulations.

The second type, long-term participants or end-users, has a longer horizon. These participants may purchase vacant land even when condition (2) holds, as they (i) do not plan to sell within the four-year period before the title becomes insurable, and (ii) are protected in the event that the former owner attempts to reclaim the property. This group also includes speculators who intend to hold the property and sell it at a later date. End-users are therefore willing to make offers under both conditions (1) and (2).

Preposition 1

A builder's rational offer, *V'*(*i*, *s**, *q**) for vacant land with the size L*s*(*i*) and a TD-recorded piece, is,

$$V'(i, s^*, q^*) = \begin{cases} [P(i, s^*, q^*) - C(s^*, q^*)]e^{(r^f - r^b)4} & if\ P(.) > C(.) \\ [V(i, s^*, q^*)]e^{(r^f - r^b)4} & if\ P(.) < C(.) \end{cases} \quad (3)$$

and for the second type of bidders in TD auctions (if abandonment is costless),

$$V'(i, s^*, q^*) > MAX[[P(i.s^*, q^*) - C(s^*, q^*)]e^{(r^f - r^b)4}), 0] \quad (3A)$$

Proof.

At the time of the TD auction, two possible states of nature exist, as described in equations (1) and (2). In state (1), it is optimal to develop the vacant parcel immediately, so that *V*(*i*, *s**, *q**) = *P*(*i*, *s**, *q**) * *C*(*s**, *q**). A WD-recorded transaction allows a builder to purchase the land, develop it, and subsequently resell the property. Consequently, *V*(.) represents the rational price a builder would be willing to pay for WD-recorded vacant land.

If, however, a builder wishes to bid in a TD auction, a builder can mimic the payoff of a WD-recorded deal as follows:

- The builder may purchase vacant land in a TD-recorded transaction at a price of *V'*(*i*, *s**, *q**) provided that the builder submits the highest bid. However, an end-user participating in the auction with a horizon longer than four years is likely to submit a higher bid.

The builder can then sell a forward contract to deliver the vacant land through a WD-recorded transaction at time *t**=*t*+4. The agreed-upon forward price must satisfy

$$F(t^* = t + 4) = [P(s^*, q^*) - C(s^*, q^*)]e^{(r^f + \gamma)4}$$

- Simultaneously, the builder can borrow at the present time at an interest rate r^b, using the vacant land, its acquisition cost, and the carry costs as collateral. The loan repayment at time *t* + 4 is therefore *V'*(*i*, *s**, *q**)*e*(r^b + *y*)4. This strategy is riskless, and since the initial net outlay is zero, the payoff at time *t* + 4 must also be zero; that is,

$$[P(s^*, q^*) - C(s^*, q^*)]e^{(r^f \mp \gamma)4} - V'(i, s^*, q^*)e^{(\gamma + r^b)4} = 0 \quad (4)$$

Thus, the price that a builder will be willing to pay in a TD-recorded deal is:

$$V'(i, s^*, q^*) = [P(i, s^*, q^*) - C(s^*, q^*)]e^{(r^f - r^b)4} \quad \text{(QED).}$$

Note, however, that in periods in which *P*(*i*, *s**, *q**) < *C*(*s**, *q**), V'(.) represents only a theoretical price. In such cases, a short-term bidder—such as a builder—would avoid participating in TD auctions.

We now refine the builder's decision rule for the optimal bid in a TD auction, incorporating additional institutional parameters. The minimum opening bid in the auction is equal to the value of the tax certificate plus associated fees at the time of sale, denoted by CER, plus one-half of the assessed property value, denoted by HX (with HX = 0) for non-homestead properties). This minimum bid excludes the value of publicly recorded surviving liens, denoted by LEIN. Then, the builder's decision rule is therefore as follows:

$$\begin{cases} V'(i, s^*, q^*)\ if\ [P(i, s^*, q^*) - C(s^*, q^*)]e^{(r^f - r^b)4} > Max[CER + HX, LIEN] \\ Max\{V'(i, s^*, q^*) - [LIEN - CER - HX], 0\}\ if\ LIEN > CER + HX \end{cases} \quad (6)$$

A type 2 bidder in TD auctions may outbid the builder if her investment horizon exceeds four years. In a state of nature as described in Eq. 1, this type of bidder may rationally bid as high as

P(*i*, *s**, *q**) - *C*(*s**, *q**)

Because

$$E_t[V_{t+4}(\cdot)] = E_t[V'_{t+4}(\cdot)],$$

i.e., the expected values at *t* + 4 of the vacant land, whether TD- or WD-recorded, are the same.

If the state of nature described in (2) prevails, this type of bidder becomes the sole bidder, since *V*(*i*, *s**, *q**) > max[*P*(*i*, *s**, *q**) - *C*(*s**, *q**),0] assuming that property abandonment is costless.

The above implicitly assumes that, for all t' such that

t < *t*' < *t* + 4, *V*(*i*, *s**, *q**) = max{ *P*(*i*, *s**, *q**) - *C*(*s**, *q**),0}.

This condition is always satisfied when land carrying costs are zero. In that (unlikely) case, the values of vacant land—whether TD- or WD-recorded—are identical. However, suppose there is a positive probability that at some time *t*', *V*(*i*, *s**, *q**) = *P*(*s**, *q**) - *C*(*s**, *q**). In that case, the holder of a TD-recorded claim can replicate the payoff of a WD-recorded claim by entering into a forward contract at time t' for delivery at *t* +4, while borrowing to cover land costs if and when the equality holds. The difference between the values of WD- and TD-recorded deals can therefore be interpreted as the difference between American and European options to exchange the risky variable *C*(*i*, *s**, *q**) for the risky variable *P*(*s**,*q**), that is, an option with a stochastic exercise price. We analyze this below under the assumption of constant interest rates, and we further assume that *s** and

q*, representing the optimal choices, remain unchanged from their current values.

3.1. The builder's optimization regarding optimal construction

The next step in our analysis considers the builder's optimization problem once title has been obtained and the developer determines the optimal scale of construction. This stage is essential for our empirical assessment of the valuation differences between WD- and TD-recorded properties.

We adopt a set of assumptions that differs from those in Sheridan Titman and Sherman Williams. One key assumption in their framework is the convexity of construction costs—that is, costs increase at an increasing rate as the number of units expands. We believe this assumption is not realistic.

In practice, the developer's optimization problem is more complex (as discussed below), and construction costs may exhibit both concave and convex regions. In addition to specifying a cost function that more accurately reflects actual construction behavior, it is also necessary to account for variation in the value of identical structures across different locations.

Let L_s denote the size of vacant land, net of setback requirements. Let q be the number of separate units (e.g., the number of kitchens in residential use), and let s denote the size of each unit in square feet. Define $P(i, q, s, l)$ as the market price per square foot of a structure, given s, q, and the location variable l. Let $C(q, s)$ denote the construction cost per square foot for a structure, given s and q. We normalize these variables by the size of the land:

$p(\cdot) = P(\cdot)/L_s$ and $c(\cdot) = C(\cdot)/L_s$.

We now introduce the following assumptions, consistent with observed practice, regarding the behavior of construction costs:

$$\frac{\partial C}{\partial q} \; and \; \frac{\partial C}{\partial s} > 0 \; but \; \frac{\partial^2 C}{\partial q^2} \geq 0 \; and \; \frac{\partial^2 C}{\partial s^2} \leq 0 \quad (7)$$

The number of units q may be constrained by zoning regulations. For example, a lot designated for single-family residential use typically implies $q \in \{0,1\}$. The maximum buildable square footage per unit, given Ls, may also be restricted, either explicitly through regulation or implicitly through physical constraints. In particular, the size of the lot may limit total buildable square footage due to setback requirements and maximum allowable building height. Even in the absence of formal air-rights restrictions, height may still be constrained by technological considerations that render additional height prohibitively costly. Let Q denote the maximum total buildable square footage on a given lot, where Ls represents the net land area after accounting for setback requirements.

$$Q = f_l L_s \quad (8)$$

Where f_l denotes the number of floors, as implied by any applicable height restriction. For example, a 0.25-acre lot (80×125 feet) designated for single-family residential use in Florida typically allows for a maximum buildable area of approximately 3,500 square feet. l is the location parameter that is reflected in the price per square foot, such that $\frac{\partial P(l)}{\partial l} > 0, but \; \frac{\partial^2 P(l)}{\partial l^2} < 0$, i.e., $P(l)$ is a concave function in l with a limit, $\lim_{l \to \infty} P(l) = Pmax$.

We can derive the following proposition under the above assumptions.

Proposition 2

The developer optimization problem regarding the optimal structure is:

$$ARG\,MAX_{q,s}\; p(s,q,l)sq - c(s,q)sq \;, \forall s,q \in Q, sq \leq Q, p \leq \hat{p} \to s^*, q^* \quad (9)$$

with the solutions:

$$q^* \leq \sqrt{Q\left(\frac{\partial p(.)}{\partial s} - \frac{\partial c(.)}{\partial s}\right) / \frac{\partial c(.)}{\partial q}} \quad (9a)$$

$$s^* \leq \sqrt{\frac{Q\frac{\partial c(.)}{\partial q}}{\left(\frac{\partial p(.)}{\partial s} - \frac{\partial c(.)}{\partial s}\right)}} \; or \; Q/q^* \quad (9b)$$

(9a) and (9b) become equalities if

$$\forall\, q, s, sq = Q, \frac{\partial p(.)}{\partial l} > 0$$

Proof.

(9a) and (9b) are the solutions for the following two equations, given $Q \geq sq$:

$$\frac{\partial p(.)}{\partial s} sq + p(.)q - \frac{\partial c(.)}{\partial s} qs - c(.)q = 0 \quad (10)$$

$$\frac{\partial p(.)}{\partial q} sq + p(.)s - \frac{\partial c(.)}{\partial q} qs - c(.)s = 0 \quad (11)$$

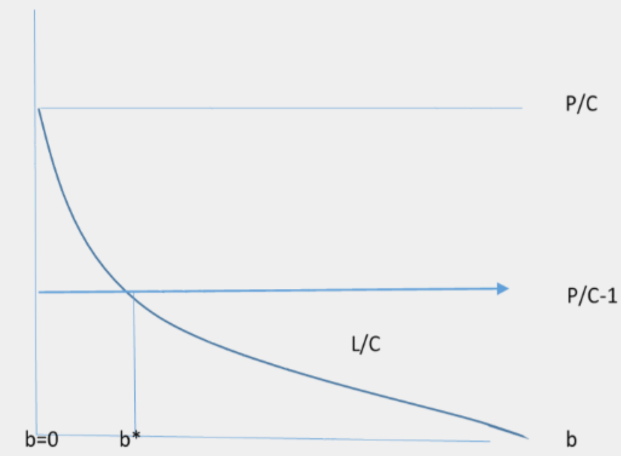
If at $Q = sq \; \forall \; q, s$ the market can absorb higher prices, *i.e.*, $\frac{\partial p(.)}{\partial l} > 0$, and the builder will select the maximum size, Q.

The above derivations will be taken to the data in the empirical section below. Before doing so, however, we must account for the fact that, in practice, a developer may choose between two alternative sales strategies:

1. The developer constructs the structure and subsequently offers it for sale. In this case, we assume that the probability of sale is a function of the price; that is, there exists a known distribution function $f(P)$, strongly correlated with location l, which governs the likelihood of a sale. The optimization algorithm becomes,

$$ARG\,MAX_{q,s}\, f(p)[p(s,q,l)sq - c(s,q)sq]\delta,$$

$$\{\forall s, q \in Q, sq \leq Q, p \leq \hat{p}\} \to s^*, q^* \quad (12)$$



Graph 1

The current value of vacant land, L, given rf, the risk free opportunity costs, as a function of b the carrying costs of the undeveloped land. P is the value of the optimal structure/use and C is the costs of constructions. At b* develop now.

where δ is the certainty equivalent factor, $\delta < 1$. If we employ risk-adjusted probabilities in *f(P)*, then $\delta = 1/1 + r^f$ where r^f is the risk-free rate of interest.

2. The developer offers a menu of building plans with varying sizes. The buyer selects the preferred design and unit size, after which the developer applies for a building permit, undertakes construction, and delivers the completed unit.

The buyer may select a unit size that is suboptimal from the developer's perspective, that is, relative to the developer's profit-maximizing choice. Nevertheless, the developer seeks to preserve the same level of profit that would have been obtained under the optimal size. Accordingly, the developer sets the price as follows:

$$P'(j(s,q)) - c(s,q)s_i q_j\{\forall\, i, j\; q_i s_i \le Q\} = p(s^*, q^*, l)s^* q^* - c(s^*, q^*)s^* q^* \quad (13)$$

where $j(s,q)$ denote the customer's choice, and let $p'(\cdot)$ represent the developer's price. The publicly reported transaction price, $P'(j)$, may not reflect the true market price, even if it is reported as an arm's-length transaction. For example, according to (13), if *j*(*s*, *q*) is smaller than the developer's optimal size (*s**, *q**), the reported price per square foot will exceed the actual market price.

3.2. Land Evaluation

An undeveloped piece of land can be viewed as a perpetual real option, whose value can, in principle, be derived under risk-neutral valuation in a continuous-time framework, provided a strong set of assumptions. However, most existing valuation models require the estimation of unobservable parameters—unlike financial options, where such parameters can often be inferred from market data. Moreover, aspects such as the developer's optimization are typically oversimplified, potentially leading to inaccurate estimates of vacant land value. We adopt a compromise approach that relies on a framework requiring fewer measurable parameters while explicitly incorporating the developer's optimization process.

A key concept in land valuation as an option to develop is that the option becomes effectively perpetual if carrying costs are zero, as first noted by Paul Samuelson. In this case, the value of the perpetual option equals the value of the underlying asset—in our context, the developed structure. By framing the problem as an option to exchange one risky asset for another—that is, the developed structure for stochastic construction costs, following Margabe—we can confirm this result, as illustrated in Graph **1**. The time horizon of the option warrants further analysis, as the option's value is highly sensitive to the difference between the opportunity cost of capital, r^f, and the rate of carrying costs, *b*. Graph 1 clearly illustrates this relationship.

The graph shows that for various values of $r^f - b$, the time horizon of the option can be effectively zero—meaning that, under these conditions, it is rational to develop the land immediately. For some values of $r^f - b$, the option is worthless, reflecting abandonment. The only scenario in which the option is truly perpetual occurs when $b = 0$.

Empirically, we can identify periods in which these dynamics are observable. For example, in 2021, $r - b$ was sufficiently low that the value of undeveloped land was exactly equal to the difference between the current value of the optimally developed structure and current construction costs—i.e., the option premium above intrinsic value was zero. In contrast, in 2011, construction costs exceeded the value of the developed structure; in this case, regardless of $r^f - b$, the value of undeveloped land corresponded to an out-of-the-money option to exchange one risky asset for another.

Accordingly, for the 2021–2025 period, we employ a land valuation model under the following assumptions:

Let $p(i, s, q, l)$ be the value of the underlying structure per square foot, normalized by the size of the lot, and reflecting a location *l*. It is reasonable to assume that *q* is a linear multiplier of *p* as,

$$\frac{\mathrm{p(i,s,nq,l)}}{\mathrm{p(i,s,q,l)}} = np(i, s, q, l) \quad (14)$$

i.e. units with the same use, size, and location have the same value[3].

We assume that the stochastic behavior of $p(\,s_{/q^*,\hat{l}}\,)$ is governed by a geometric Brownian motion,

$$\frac{dp(.)}{p} = \mu_p dt + \sigma_p dZ \quad (15)$$

$c(s, q)$ is the cost of development per square foot, normalized by the size of the lot. It has two sources of uncertainty, $c(s, q^*)$ *and* $c(s^*, q)$ that follow a GBM,

$$\frac{dc(\,s,q\,)}{c(s,q)} = (\mu_c - b)dt + \sigma_s dZ_s + \sigma_q dZ_q \quad (16)$$

Where $\mu_c = w\mu_s + (1 - w)\mu_q$ and *w* is the portion of the costs attributed to the size of the developed unit. *b* is an assumed constant.

Empirically, we cannot disentangle the variabilities of the two components; therefore, we adopt the following simplifying assumption: $\sigma_c dZ_c = \sigma_s dZ_s + \sigma_q dZ_q$.

We are effectively dealing with an option to bear stochastically evolving construction costs in exchange for the stochastically evolving price of the developed property. A unique feature of this option is that, as long as it remains unexercised, the holder incurs carrying costs. It is reasonable to assume that *b* depends on the value of the developed property—for example, through property taxes—which in turn are influenced by the type of development, its location, and maintenance standards.

Following Richard Roll and Margabe, and applying Itô's lemma along with the concept of a self-financing portfolio, the value per square foot of size-adjusted vacant land, $v(\cdot)$, satisfies the following partial differential equation (PDE):

$$\frac{\partial v}{\partial t} - bp(.)\frac{\partial v}{\partial p} + .5\left[\frac{\partial^2 v}{\partial p^2}\sigma_p^2 p^2 + \frac{\partial^2 v}{\partial c^2}\sigma_c^2 c^2 + \frac{\partial^2 v}{\partial p \partial c}\sigma_p \sigma_c \rho_{cp} cp\right] = 0 \quad (17)$$

Subject to free boundary conditions that at some finite $t^*, v(.) = p(.) - c(.)$, as $b \neq 0$. The solution can be derived numerically by incorporating the free boundary condition.

4. METHODOLOGY

Our goal is to examine how winning bids in TD auctions correspond to comparable WD-recorded market prices, while incorporating the insights derived from Propositions 1 and 2.

4.1. Data

The dataset consists of 620 observations with complete information on TD sales in Florida, covering two periods: 2011–2012 and 2021–2025, in counties where data were available. These periods were chosen for their distinct market conditions. In 2011, there was essentially no new construction, and construction costs exceeded the market price of developed properties, making the condition in Eq. (2) applicable. In contrast, during 2021–2025, the condition in Eq. (1) was satisfied. The following parameters were available:

4.1.1. Land Parameters

Physical parameters: Location, size, overgrown plantation, quality of the access road, city water/well, and electric service.

Zoning: permitted use, setback and/or maximum land coverage requirements[4], maximum height, and driveway permit.

4.1.2. Market Prices of Developed Properties[5]

Builders' offering prices for various property sizes were used as proxies for the market value of developed properties. These offerings differ in both size and profit margins. In most cases, the builders owned the underlying vacant land, which supports our assumption that, regardless of the sizes offered, they aim to preserve the same level of profit. This assumption allows us to compute the optimal buildable size (see Section III.1). In other words, the underlying premise is that builders set prices for suboptimal unit sizes so that the net profit equals what would have been achieved had the optimal size been built. Finally, the typical sizes of nearby structures serve as an additional constraint on feasible offerings.

4.1.3. Construction Costs

Various professional publications provide estimates of construction costs per square foot (SQF) for single-family homes of different sizes. The data support our assumption that costs per SQF decline with size (i.e., exhibit a negative second derivative). We adjust the baseline construction costs

[3] Obviously, in an elevator-multi-dwelling structure, higher floors command higher values, but in this empirical study, we focus on properties with a maximum height of two floors.

[4] Size-dependent as per Florida **§** 304-VI

[5] Offering prices of builders for various sizes within 5 miles of the location, and or, Zillow reports of WD-recorded sales within 1 mile of the location.

to account for several factors: plantation density (which may require clearing), lack of access to municipal water, absence of nearby electrical infrastructure, and driveway permitting requirements.

In practice, builders' margins were approximately 15–20% in 2021–2025. Margins in 2011–2012 are unknown, as no actual development was observed during that period. We use equations (9a) and (9b) to determine the builders' optimal margin, assuming that the land was acquired at market price prior to construction.

Additionally, we employ an iterative procedure to validate construction cost estimates. Our dataset includes listing prices for newly constructed single-family homes. For a given property size, we solve for construction costs per built SQF under the assumption that the builder already owns the land. Specifically, we set an initial land value, v, per built SQF and iteratively solve the following equation:

$$c(s,q) = p(s,q)(1-g) - v \quad (18)$$

where g denotes the builder's optimal margin. We then apply our model to compute the land value. This land value is incorporated into equation (18), and construction costs, $c(\cdot)$, are recomputed. The procedure is repeated iteratively until convergence is achieved.

In the relatively rare cases where the end user provides the land, the analysis is more straightforward, as construction costs can be inferred directly.

4.1.4. Carrying Costs

The carrying costs of vacant land include property taxes, stormwater drainage fees, and maintenance required by code enforcement regulations. These costs are modeled as a proportion of the market value of the fully developed property.

4.1.5. Liens Search

Active governmental liens, as reported in Florida public records and/or identified through title searches attached to the TD sales documentation.

4.1.6. Other Parameters

The risk-free interest rates are proxied by Treasury yields with maturities as specified in Section IV.3. Borrowing rates are assumed to equal the prime rate plus 2%. Estimating the standard deviation presents a challenge that has been addressed in the literature. We adopt the view that the best proxy for single-family home price volatility is the return volatility of a publicly traded firm specializing in the construction and sale of single-family homes in Florida. Accordingly, we use D.R. Horton (DHI), the largest such firm operating in Florida.

Similarly, we use the return volatility of CRH plc to proxy for construction cost volatility. We then adjust the estimated equity volatility, σ_e, to obtain the corresponding asset volatility, using the following relationship:

$$\sigma = \sqrt{(1-LEV)\sigma_e^2 / \frac{\partial E}{\partial AS}}$$

where *LEV* is the firm's leverage, *AS* is the total balance sheet assets, and *E* is the equity.

4.2. TD-Auction Parameters

We control for TD auction parameters that may influence winning bids. Our dataset allows us to isolate the effects, if any, of the following variables:

• the number of bidders;

• the initial bid (reservation price);

• the time interval between the bids of the two highest bidders;

• the identity of the winning bidder (business entity or individual).

Following Proposition 1, the last variable is of particular importance.

4.3. Timing

Solving equation (17) for the case specified in (2) requires defining the time horizon of the option to exchange one risky asset (the expected value of construction costs) for another risky asset (the developed property), while incorporating carrying costs. Although land can, in principle, remain undeveloped indefinitely, it is unreasonable to assume that buyers of vacant land perceive the horizon in this way. Instead, buyers form expectations about the earliest date at which development becomes optimal.

Accordingly, we adopt the following key assumption: when condition (2) prevails, the relevant time horizon for the buyer coincides with the expected time at which condition (1) is expected to prevail.

We employ an empirical approach to estimate this parameter. Condition (1) is more likely to prevail during periods of strong real estate market activity. Accordingly, we make the following assumptions:

- In the 2011-2 period: the time horizon, τ, is $\tau = 18 - (t - 2007)$ in localities in which the land vacancy rate was less than 20% while in localities in which the land vacancy rate was between 20% and 40%, $\tau = 24 - (t - 2007)$.

- In the 2021-25 period: We set $\tau = 1$;[6] although, in theory, the option should be exercised immediately given positive carrying costs, we account for the time required for construction and/or the period until a buyer is secured.

5. RESULTS

We begin by presenting the summary results for each period. Table **1** reports the results for 2021–2025.

[6] The peaks in the real estate market in Florida were in 1987, 2007, and 2022. The average cycle, therefore, is assumed to be 18 years. We assume that in a densely populated area with a land vacancy rate of less than 20% the horizon is one cycle, while in a less dense area, the horizon is 2 cycles.

2021-2025	% of all buyers	Averge winning bids	WD- value (market)	% winning bids to WD	TD- value Proposition 1	% wining bids to TD
All buyers	100%	24210.13	28570.62	84.7%	21421.98	113.0%
Individual buyers	27.8%	21354.55	24356.53	87.7%	19532.79	109.3%
Business entities	72.2%	25312.28	30197.12	83.8%	22151.15	114.3%
Certificate holders	0.0%	n/r	n/r	n/r	n/r	n/r

Table 1 - Summary results
n/r - not relevant as all certificates were sold to a third party

Table **2** presents the results for 2011–2012. During this period, the value of a WD-recorded transaction was equivalent to that of a TD-recorded transaction, as construction costs exceeded the market value of the developed property. A substantial share of sales was acquired directly by the tax certificate holders, meaning no third-party bids were placed. In cases where TD titles were granted to the certificate holders, the premiums of market prices over the minimum auction prices (i.e., the prices at which the titles were transferred to the certificate holders) were significantly higher than the winning bids in other cases (see further explanation below).

Several observations emerge from a comparison of these tables.

3. In the 2021–2025 period, the average winning bid in TD-recorded auctions was 84.7% of the market price (had the sale been WD-recorded). However, when applying Proposition 1, TD-recorded sales were on average 13% above market prices, primarily due to bids placed by end-users. This finding supports our assertion that, for end-users—as opposed to short-term buyers such as builders, the difference between TD-recorded and WD-recorded transactions is relatively minor. In the 2011–2012 period, the average final bid in the auctions was 66.2% of the market price. The larger discount (33.8%) reflects the fact that, during this period, construction costs exceeded the expected value of the completed structures, and builders anticipated a development horizon longer than four years[7] waiting period.
4. In the 2021–2025 period, we anticipated that auction participants purchasing for their own use would be willing to pay higher prices than builders, as they perceive similar values for TD-recorded and WD-recorded transactions. Indeed, they did pay more, 87.7% of market prices compared with 83.8% for builders, but the difference was smaller than predicted by Proposition 1. According to Proposition 1, builders were expected to bid 26.66% below the market price (WD-recorded), yet in practice they bid only 16.2% below market price. This suggests that competition with end-users compelled builders to submit higher bids.In the period 2021-25, builders dominated the scene as 72% of the TDs were granted to builders, while only 53% in the period 2011-12. In 2011-12, immediate construction was unlikely as construction costs exceeded the value of the structures and builders were willing to buy at a very deep discount.
5. In the period 2021-25, all TDs data in the sample[8] were purchased by third-party bidders (i.e., bidders other than the underlying tax certificate holders). In contrast, during 2011–2012, TD titles for 26% of sales were granted directly to the certificate holders, as no third-party bidders participated. Interestingly, the average price—defined as the opening bid, which includes the face value of the certificates and additional fees—was lower than the average winning bids of third-party participants. This pattern likely reflects quality factors that are not captured in our study.

We further analyze the results by examining the variances of each variable. While it is reasonable to expect a strong relationship between market prices (WD-recorded prices) and actual winning bids in TD auctions, the relationship between market prices and TD-adjusted prices is less straightforward. Recall that, according to Proposition 1, TD-adjusted prices—accounting for the inability to sell during the first four years following the sale—represent the rational bids that participants seeking immediate construction would be willing to submit.

We first report the relationship between market prices and winning bids in TD auctions in Tables 3 and 4, corresponding to the 2011–2012 and 2021–2025 periods, respectively.

[7] Four years as per proposition 1, which is not relevant for the period 2011-12.

[8] We eliminated sales of absurd properties such as unusable vacant common areas, unbuildable narrow strips of land, etc., in which cases the TDs were granted to the certificate holders.

2011-2012	% of all buyers	Averge winning bids	WD- value (market)	% winning bids to WD	TD- value Proposition 1	% wining bids to TD
All buyers	100%	3849.22	5815.50	66.2%	n/r	n/r
Individual buyers	20.0%	4001.21	5677.69	70.5%	n/r	n/r
Business entities	53.8%	3945.66	5893.67	66.9%	n/r	n/r
Certificate holders	26.2%	3535.35	5759.94	61.4%	n/r	n/r

Table 2 - Summary results for 2011-12
n/r - not relevant as WD-recorded deeds have the same value as TD

SUMMARY OUTPUT

The entire sample for 2012

Regression Statistics	
Multiple R	0.690284
R Square	0.476492
Adjusted R	0.467466
Standard E	2113.969

ANOVA

	SS	*MS*	*F*	*gnificance F*
Regression	2.36E+08	2.36E+08	52.79106	1.05E-09
Residual	2.59E+08	4468866		
Total	4.95E+08			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	2320.117	345.1937	6.721202	8.6E-09	1629.137	3011.097	1629.137	3011.097
X Variable	0.272537	0.03751	7.265746	1.05E-09	0.197453	0.347621	0.197453	0.347621

SUMMARY OUTPUT

Builders only

Regression Statistics	
Multiple R	0.347116
R Square	0.12049
Adjusted R	0.093005
Standard E	2095.868

ANOVA

	SS	*MS*	*F*	*gnificance F*
Regression	19256892	19256892	4.383876	0.04429
Residual	1.41E+08	4392663		
Total	1.6E+08			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	3239.173	491.5193	6.590122	1.99E-07	2237.98	4240.365	2237.98	4240.365
X Variable	0.123803	0.059129	2.093771	0.04429	0.003361	0.244246	0.003361	0.244246

SUMMARY OUTPUT

End-users only

Regression Statistics	
Multiple R	0.885544
R Square	0.784188
Adjusted R	0.775196
Standard E	1734.888

ANOVA

	SS	*MS*	*F*	*gnificance F*
Regression	2.62E+08	2.62E+08	87.2081	1.84E-09
Residual	72236080	3009837		
Total	3.35E+08			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	1677.552	405.8925	4.132995	0.000376	839.8306	2515.273	839.8306	2515.273
X Variable	0.369769	0.039596	9.338528	1.84E-09	0.288047	0.451491	0.288047	0.451491

Table 3
The relationship between the land market prices
and the winning bids in TD auction during 2012

SUMMARY OUTPUT

Entire sample

Regression Statistics	
Multiple R	0.688665
R Square	0.474259
Adjusted R	0.467431
Standard E	12794.91

ANOVA

	SS	*MS*	*F*	*gnificance F*
Regression	1.14E+10	1.14E+10	69.45991	2.31E-12
Residual	1.26E+10	1.64E+08		
Total	2.4E+10			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Ipper 95.0%*
Intercept	13204.35	1953.489	6.759367	2.36E-09	9314.454	17094.24	9314.454	17094.24
X Variable	0.372661	0.044714	8.334261	2.31E-12	0.283624	0.461699	0.283624	0.461699

SUMMARY OUTPUT

Business only

Regression Statistics	
Multiple R	0.655167
R Square	0.429244
Adjusted R	0.418866
Standard E	13256.53

ANOVA

	SS	*MS*	*F*	*gnificance F*
Regression	7.27E+09	7.27E+09	41.36335	3.21E-08
Residual	9.67E+09	1.76E+08		
Total	1.69E+10			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Ipper 95.0%*
Intercept	14898.07	2388.537	6.23732	6.64E-08	10111.33	19684.8	10111.33	19684.8
X Variable	0.344874	0.053623	6.431435	3.21E-08	0.237411	0.452338	0.237411	0.452338

SUMMARY OUTPUT

End users only

Regression Statistics	
Multiple R	0.783579
R Square	0.613995
Adjusted R	0.594695
Standard E	11450.84

ANOVA

	SS	*MS*	*F*	*gnificance F*
Regression	4.17E+09	4.17E+09	31.81286	1.61E-05
Residual	2.62E+09	1.31E+08		
Total	6.79E+09			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Ipper 95.0%*
Intercept	8861.824	3296.346	2.688378	0.014133	1985.766	15737.88	1985.766	15737.88
X Variable	0.449183	0.079638	5.640289	1.61E-05	0.28306	0.615306	0.28306	0.615306

Table 4
The relationship between the land market prices
and the winning bids in TD auction during 2022

SUMMARY OUTPUT

Entire sample for 2012

Regression Statistics	
Multiple R	0.220423
R Square	0.048586
Adjusted R	0.032183
Standard E	10388.47

ANOVA

	SS	*MS*	*F*	*gnificance F*
Regression	3.2E+08	3.2E+08	2.961911	0.090578
Residual	6.26E+09	1.08E+08		
Total	6.58E+09			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Ipper 95.0%*
Intercept	-15512.4	1696.351	-9.14458	7.66E-13	-18908	-12116.8	-18908	-12116.8
X Variable	0.317237	0.184331	1.72102	0.090578	-0.05174	0.686214	-0.05174	0.686214

SUMMARY OUTPUT

Builders only

Regression Statistics	
Multiple R	0.208988
R Square	0.043676
Adjusted R	0.013791
Standard E	9681.179

ANOVA

	SS	*MS*	*F*	*gnificance F*
Regression	1.37E+08	1.37E+08	1.461464	0.235554
Residual	3E+09	93725225		
Total	3.14E+09			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Ipper 95.0%*
Intercept	-15021	2270.413	-6.61598	1.85E-07	-19645.7	-10396.3	-19645.7	-10396.3
X Variable	0.330188	0.273129	1.20891	0.235554	-0.22616	0.886533	-0.22616	0.886533

SUMMARY OUTPUT

End-users only

Regression Statistics	
Multiple R	0.230834
R Square	0.053284
Adjusted R	0.013838
Standard E	11609.55

ANOVA

	SS	*MS*	*F*	*gnificance F*
Regression	1.82E+08	1.82E+08	1.350801	0.256566
Residual	3.23E+09	1.35E+08		
Total	3.42E+09			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Ipper 95.0%*
Intercept	-16199.2	2716.157	-5.96401	3.72E-06	-21805.1	-10593.3	-21805.1	-10593.3
X Variable	0.307958	0.264969	1.16224	0.256566	-0.23891	0.854828	-0.23891	0.854828

Table 5
The relationship between the land market prices
and the TD-adjusted prices during 2012

SUMMARY OUTPUT

Entire 2022 sample

Regression Statistics	
Multiple R	0.650024
R Square	0.422532
Adjusted R	0.415032
Standard E	2826.209

ANOVA

	SS	MS	F	gnificance F
Regression	4.5E+08	4.5E+08	56.34068	9.04E-11
Residual	6.15E+08	7987459		
Total	1.07E+09			

	Coefficients	tandard Err	t Stat	P-value	Lower 95%	Upper 95%	ower 95.0%	pper 95.0%
Intercept	5651.265	432.8594	13.05566	3.28E-21	4789.332	6513.199	4789.332	6513.199
X Variable	0.074339	0.009904	7.506043	9.04E-11	0.054618	0.09406	0.054618	0.09406

SUMMARY OUTPUT

Builders only

Regression Statistics	
Multiple R	0.764119
R Square	0.583878
Adjusted R	0.576312
Standard E	2074.337

ANOVA

	SS	MS	F	gnificance F
Regression	3.32E+08	3.32E+08	77.17288	4.68E-12
Residual	2.37E+08	4302876		
Total	5.69E+08			

	Coefficients	tandard Err	t Stat	P-value	Lower 95%	Upper 95%	ower 95.0%	pper 95.0%
Intercept	5820.098	373.7501	15.57216	8.16E-22	5071.086	6569.11	5071.086	6569.11
X Variable	0.073711	0.008391	8.78481	4.68E-12	0.056896	0.090527	0.056896	0.090527

SUMMARY OUTPUT

End-users only

Regression Statistics	
Multiple R	0.485399
R Square	0.235612
Adjusted R	0.197393
Standard E	4322.788

ANOVA

	SS	MS	F	gnificance F
Regression	1.15E+08	1.15E+08	6.164727	0.022023
Residual	3.74E+08	18686500		
Total	4.89E+08			

	Coefficients	tandard Err	t Stat	P-value	Lower 95%	Upper 95%	ower 95.0%	pper 95.0%
Intercept	5232.633	1259.22	4.155455	0.000489	2605.945	7859.32	2605.945	7859.32
X Variable	0.07541	0.030372	2.482887	0.022023	0.012055	0.138765	0.012055	0.138765

Table 6
The relationship between the land market prices
and the TD-adjusted prices during 2022

As expected, the results are statistically significant for both periods and across all participant categories. In the 2011–2012 period, immediate construction was largely infeasible, as construction costs exceeded the value of the completed structures. Consequently, buyers with a long-term horizon dominated the market, as shown in Table **2**. Furthermore, the significance level for short-term buyers, such as builders, was very low.

We hypothesize that, according to Proposition 1, if we divide the sample into builders-bidders and end-users-bidders, then:

H1. In the 2011–2012 period, we expect an insignificant relationship between market prices and TD-adjusted prices. During this period, construction costs exceeded the value of the completed structures, so long-term buyers—whose behavior is not captured by Proposition 1, dominated the market.

H2. In the 2021–2025 period, we expect a significant relationship between market prices and TD-adjusted prices. If confirmed, this finding would support the predictions of Proposition 1.

H3. For the 2021–2025 period, we expect that bidders with short-term horizons will exhibit a high level of significance, whereas long-term bidders will show a lower level of significance.

We report the relationship between market prices and the TD-adjusted prices in Tables **5** and **6** for the 2012 and 2025 periods, respectively.

Our hypotheses are confirmed, and the results have clear rational explanations. During the 2021–2025 period, immediate construction was feasible, so builders participating in TD auctions discounted the market price by the implicit costs associated with the delay in property sale (i.e., the TD-adjusted prices). However, builders seeking to outbid long-term bidders—who had an advantage due to their longer investment horizons—often had to compromise and bid slightly above their optimal prices. When the builder's premium, as described in Proposition 1, is added, bids in the 2021–2025 period exceeded market prices (see Table **1**).

The key finding from these results is that TD-adjusted prices provide a more accurate proxy for market prices in periods when the value of developed properties exceeds construction costs.

CONCLUSION

This paper establishes a theoretical financial framework to evaluate the difference between WD-recorded and TD-recorded sales. The primary distinction between these instruments arises from the fact that a buyer of TD property may not resell under a WD, as title insurance may be unavailable for up to four years, or resale may require initiating a costly prior QT action in court.

The raw data confirms the common observation that winning bids in TD auctions are generally lower than WD-recorded sale values. However, during periods when the option to develop vacant land should be exercised immediately—such as 2021–2025—the pattern is reversed. When the value of the structure substantially exceeds construction costs and carrying costs of vacant land are positive, TD-adjusted prices (as per Proposition 1) are significantly higher than both the winning TD bids and the market prices. In contrast, during periods such as 2011–2012, the difference is negligible, as the option to develop is effectively "out of the money."

If TD auction participants are rational and the market is perfectly efficient, the difference between TD-adjusted prices and corresponding market prices should be zero. Yet, during 2021–2025, TD-adjusted prices exceeded market values by 13%. This premium can be attributed to competition that forced short-term bidders, such as builders, to outbid end-users with longer investment horizons. Alternative explanations could include potential misspecifications of the parameters used to compute the theoretical values.

Overall, this paper demonstrates that the conventional belief that TD auction prices always reflect a discount is misleading if one accounts for the costs implied by TD constraints. More importantly, the results confirm that TD-adjusted prices, rather than the raw winning bids, provide a more accurate proxy for market values.

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