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CALCULATING THE EFFECT OF DELAY AND INFLATION ON PROJECT COSTS

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ABSTRACT

Environmental and safety regulations have been criticized for causing excessive delays in construction projects of various types, and for adding greatly to their cost. However, most studies of the costs of regulating housing development calculate the costs of delay incorrectly, usually because of careless treatment of the time dimension and improper treatment of inflation. This article examines the sources of confusion in treating inflation and delay, and presents a model for determining the effect of delay and inflation in terms of the discounted present value of construction costs. The model is applied to the case of housing construction, and the results show that the present value cost of a delayed project can be smaller than the costs of an undelayed project.

Most construction projects experience delays. Single-family houses are typically delayed from a few weeks to many months [1, 2], whereas large electricity generating plants, especially nuclear plants, are often delayed by several years. Housing developers, utility companies, and other firms subject to construction delays often criticize governmental regulations, usually based on environmental and safety concerns, for causing excessive delays and excessive cost increases.[1] Whether the costs of delay outweigh the benefits of regulation is a controversial question, whose answer depends on the specific situation. We do not attempt to address this question in this article. We do believe, however, that accurate

[1] Dowall notes that "In Novato [California], where approval periods range from several months to several years, builders charge that unreasonable and unnecessary delays add several thousand dollars to the cost of each new unit." He also comments, "In truth, part of the blame for approval and processing delays must be shared by project applicants" [1, p. 124].

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information should be available on the costs of delay so that decisionmakers can make an informed judgment as to whether the benefits justify the delay.

Most studies of the costs of regulating housing development calculate the costs of delay incorrectly. Researchers often fail to define their baseline or reference project, and they compare costs incurred at different points in time without adjusting for the time value of money. Much of the problem in calculating the cost of delay is due to careless treatment of the time dimension and in not treating inflation properly.

The present study examines the ways in which delay costs have been calculated, identifies the sources of confusion in treating inflation and delay, and presents a model for determining the effect of delay and inflation. We first illustrate the problems with a typical calculation of delay costs in housing studies and show why it is incorrect. Although our emphasis is on housing, much of the analysis is applicable to other types of construction projects.

PREVIOUS STUDIES

The Construction Industry Research Board examined the cost of project delays prior to the construction phase and concluded that a one-month delay on a $70,000 house would cost the developer $1,027 per unit (1.5% per month) [3]. Seidel quotes costs of delay on a $40,000 house at between $468 per month (1.2%) and $838 per month (2.1%) [4]. Muller, in a study of San Diego, California, estimated that a two-month delay during the environmental review process (also before construction) would cost the developer $89 per unit [5]. The Rice Center estimated the cost per month of delay prior to construction at between $76 and $112 on a $50,000 house (0.15% to 0.22%) [6], and Dowall estimated the delay cost at approximately $1,000 per month on a $115,000 house (0.87%) [1]. Clearly, the discrepancy among these estimates, which differ by more than a factor of 20 from the highest to the lowest, strongly suggests that there is an error in at least one of these studies. We examine several of these studies in greater detail.

The Rice Center broke down delay costs into four components [6]:

1. land interest cost, property tax and overhead,
2. development financing interest cost
3. inflation cost, and
4. cost of capital tie-up (opportunity cost).

The major items in most studies and the ones we are primarily interested in are the inflation cost and the development financing interest cost. The authors define the inflation cost as:

$$\text{Inflation Cost} = (\text{Remaining direct costs after delay}) \times (\text{yearly inflation rate}/12) \times (\text{months of delay}).$$

They define development financing interest cost as: the monthly interest cost on the amount borrowed for construction (i.e., the "loan draw") times the number of months of delay. (This is the extra cost of the construction loan due to delay during construction.) Inflation affects interest on the construction loan by raising construction costs.

The Rice Center model follows the logic of developers' accounting calculations, and is presented in considerable detail. However, there are important omissions that are only hinted at by footnotes to a key table. One footnote reads: "Direct costs are deflated in the various time periods at the three-year average rate of service price changes of 8.5%" [6, p. 30]; another footnote reads: "Inflation costs are presented in discounted cash flow terms" [6, p. 30]. Inasmuch as their detailed model does not indicate the need to deflate prices or discount inflation costs (but, curiously, not other costs), we are left puzzled by this omission. Furthermore, the authors' lack of justification for deflating some items and not others, and discounting inflation costs but not other costs, suggests a confusion over the treatment of the time dimension.

Dowall closely follows the Rice Center model but does not say anything about deflating current dollars or discounting [1]. We reproduce his calculation here because it is a useful starting point for our analysis. Dowall assumes that raw land costs $10,000 per housing unit, the entire amount is financed, and that the interest charge on the land cost is 12 percent per year (1% per month). Construction takes nine months without delay, and construction costs are $95,000 per unit, including both subdivision and construction activities. The inflation rate is assumed to be 10 percent per year; property taxes are 1.1 percent of full property value ($4.36 per $100 of assessed valuation, with assessed valuation at 25% of actual value). The minimum time for the review and approval process is assumed to be eight months, and for the delayed project, a delay of eight months occurs before the start of construction. These are reasonable assumptions, as in most projects the longest delays occur before construction. Dowall omits overhead costs, however, which can be as high during development review as during construction. Overhead during preconstruction delay should be treated in the same way as the interest on the land loan.

The eight-month delay before construction starts adds $100 per month (total of $800) to the interest on the land loan.[2] The added construction cost due to inflation is based on all construction costs inflating at a 10 percent annual rate, over the delay period of eight months; thus the construction cost is greater by 6.67 percent as a result of inflation acting over the delay period. Table 1 shows Dowall's per unit costs for the undelayed and delayed projects [1, p. 128].

[2] The calculation of the interest on the construction loan appears to assume that about 90 percent of the construction cost is borrowed at the start of construction and that interest is paid for the nine-month construction period. Dowall does not assume that the builder invests part of this loan in a money-market account, which would partially offset the interest cost. The Rice Center model, by calculating interest on the loan draw, is more realistic.

Table 1. Dowall's Comparison of the Cost of Construction of a House with Delay and Without Delay

Cost Item	Cost ($)	
	No Delay	Delay
Land	$ 10,000	$ 10,000
Interest on land loan	800	1,600
Construction costs	95,000	101,350
Interest on construction loan	7,950	8,475
Fees	2,300	2,300
Additional property tax		300
	$116,050	$124,025

Source: Dowall [1, p. 128].

Dowall thus calculates the additional cost percentage attributable to delay as 6.8 percent, or 0.85 percent per month of delay.

It is important to observe that Dowall is comparing two houses whose development review process *starts at the same time*. This is the usual assumption in the literature. Because of the delay, one house is completed eight months later than the other. Thus, Dowall's comparison of two houses completed at different times (see Figure 1, Project A (reference project) and Project B (delayed project)), means that the construction costs are in dollars of different value (purchasing power). The delayed house costs 6.8 percent more to build in *nominal (current) dollars*, but it is incorrect to attribute this difference to delay—it is due primarily to comparing costs in dollars of different value.

We illustrate by a simple example why it is incorrect to attribute the difference in cost, as measured in nominal dollars, to delay. To do so, we define the reference project differently. Suppose that instead of comparing the delayed house to one that is started at the same time, we compare it to one that is *completed at the same time*, without delay (see Figure 1, Project C). If the delay occurs before construction, as in Dowall's example, the construction cost will be the same for the two houses and, hence, the interest on the construction loan will be the same.

If the land is purchased eight months later for the house built without delay, it should cost 6.67 percent more as a result of inflation over the eight-month period (land cost = $10,667). This increase in price offsets most of the extra interest ($800) on the land loan, for the delayed house. Additional property taxes on the land are about $110 per year, which adds about $75 for an eight-month delay (not the $300 shown by Dowall).

By defining the undelayed reference house differently, the cost (cash expenditures) of the delayed house is now only about $200 greater than the cost of the undelayed house—a difference of about 0.2 percent, not the 6.8 percent shown by Dowall.

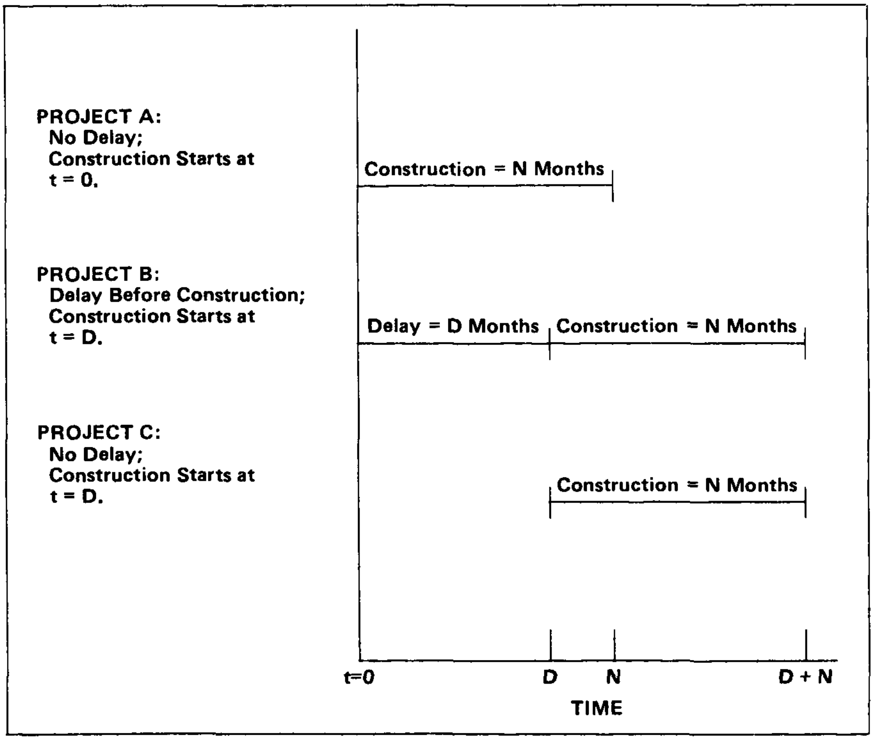

Figure 1. Timing of project construction and delays.

Explaining the Difference in Results

Why are the delay costs so different when the reference case is defined differently—houses completed at the same time rather than houses started at the same time? Dowall's comparison between houses completed at different times uses costs in nominal dollars of different periods, and hence of different value. Under an inflation rate of 10 percent per year, the dollars used to build the delayed house are worth less than the dollars used to build the undelayed house, by about 6.67 percent (if the inflation in construction costs is at the same rate as the inflation in the general price level). The comparison of two houses finished at the same time uses construction costs incurred at the same time, hence the costs are in nominal dollars of the same value. This is a better method of calculating the cost of delay, but it is still flawed. Another better method is to use constant (real) dollars and either reference case.

Although the two alternate methods discussed above are better than the comparison using nominal dollars and a reference house completed at different times, neither of these methods fully accounts for the time value of money. To do so, it is necessary to discount future amounts to present value (i.e., to calculate the discounted present value of the costs of the delayed and undelayed projects). It is not enough simply to convert nominal dollars to constant dollars and add up the constant dollar cash flows. Doing so ignores the opportunity cost of the investment. Even in a world of no inflation, there exists a non-zero opportunity cost—a real discount rate greater than zero.[3]

DEVELOPMENT OF THE MODEL

As shown in Figure 2, we assume that the two projects start at the same time, and that construction begins in the undelayed project at $t = 0$. In the delayed project, a delay of D months occurs before construction, and construction begins at $t = D$. The terms are defined as follows:

Let i = inflation rate (monthly)
D = delay period (months)
C_u = construction cost, undelayed project
C_d = construction cost, delayed project
L_u = construction loan interest (monthly), undelayed project
L_d = construction loan interest (monthly), delayed project
r_n = nominal discount rate (monthly)
r_r = real discount rate (net of inflation; monthly rate)

We make the simplifying assumption that the construction expenditures occur at the beginning of the construction period ($t = 0$ for the undelayed project and $t = D$ for the delayed project). We show later that, although the numerical result (the PV of cost) depends on when the construction cost occurs, the functional relationship between the delayed cost and the undelayed cost does not depend on when the cost is incurred.[4] For the purpose of this derivation, we consider only the construction expenditure and the interest on the construction loan—the major items affected by inflation. The other cost items are added later in the numerical illustration.

Two methods are presented for calculating the PV, one using nominal costs (Method 1) and one using constant dollar costs (Method 2). For either method, we calculate the discounted present value (PV) of the cost of the delayed project and subtract from it the PV of the cost of the undelayed project. The difference in the present values is the cost of delay.

[3] Hanke and Anwyll measured the real discount rate (net of inflation) in the range of 9 percent to 10 percent [7]. See Ray for a recent discussion of the proper measurement of the discount rate [8].

[4] This further assumes that there is no additional delay during construction, so that the pattern of expenditures during the construction period is the same in the delayed and undelayed projects.

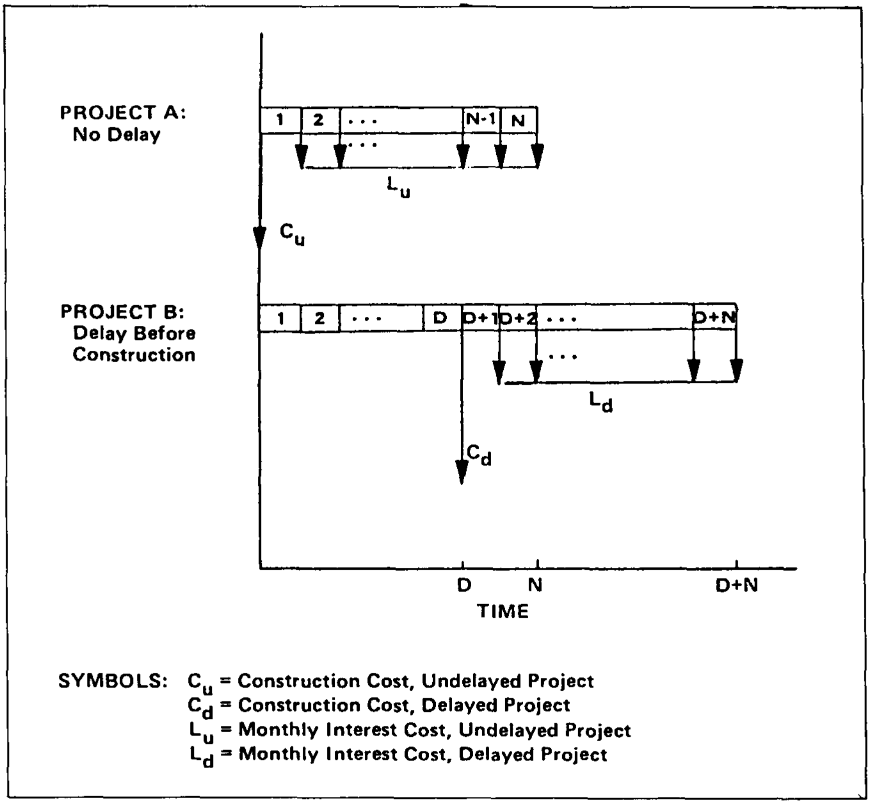

Figure 2. Cash flow diagram of construction cost and loan interest for construction loan, for present value calculation.

Due to the delay and inflation, the construction cost and loan interest cost of the delayed project are higher in nominal (current) dollars by the factor $(1 + i)^D$. That is,

$$C_d = (1 + i)^D C_u \tag{1a}$$

and

$$L_d = (1 + i)^D L_u. \tag{1b}$$

The real and nominal discount rates are related by:[5]

$$1 + r_n = (1 + i)(1 + r_r) \tag{2}$$

[5] See reference [9] for the derivation

or

$$r_n = 1 + r_r + ir_r$$

Method 1: PV Calculation Using Nominal Dollars and Nominal Discount Rate

Where the cash flows are in nominal dollars, the PV is calculated using the nominal rate of discount.

Undelayed project – The PV for the undelayed project is:

$$\mathrm{PV}_u = C_u + L_u(\mathrm{UPW}, r_n, N) \tag{3}$$

where (UPW, r_n, N) = uniform series present worth factor (present value of an annuity of \$1 per year), at discount rate r_n, for N periods.[6]

Delayed project – The PV for the delayed project is:

$$\mathrm{PV}_d = \frac{C_d}{(1 + r_n)^D} + \frac{L_d}{(1 + r_n)^D}(\mathrm{UPW}, r_n, N) \tag{4}$$

Substituting Equations (1a) and (1b) in Equation (4) and factoring:

$$\mathrm{PV}_d = \frac{(1 + i)^D}{(1 + r_n)^D}[C_u + L_u(\mathrm{UPW}, r_n, N)] \tag{5}$$

Substituting Equation (3) in Equation (5):

$$\mathrm{PV}_d = \frac{(1 + i)^D}{(1 + r_n)^D}\mathrm{PV}_u \tag{6}$$

This result says that the present value of the delayed project's cost will be *less* than the present value of the undelayed project's cost if the developer's *nominal* opportunity cost (discount rate) is greater than the inflation rate—i.e., the real discount rate is positive. For rational investors this condition is almost always true, although in periods of rapid inflation the real discount rate might be negative for short periods (if investors cannot invest at a rate that keeps them ahead of inflation). In different words, this result shows that the true present value cost of a project will be lower, accounting for changes in the value of the dollar, if a project is delayed, so long as the builder's opportunity cost (rate) is higher than the inflation rate. We have not seen a derivation or discussion of

[6] Different authors use different symbols for the uniform series present worth factor. This notation is from [10]. The algebraic form of this factor is:

$$\frac{(1 + r_n)^N - 1}{r_n(1 + r_n)^N}$$

where N = number of months.

the possibility that delay reduces the cost of construction. We consider later why developers do not prefer delay.

Method 2: PV Calculation Using Constant Dollars and Real Discount Rate

Undelayed project – First we convert expenditures (cash flows) to constant dollars at $t = 0$. The loan interest, L_u, is assumed to be paid each month in current dollars. To convert the payment due in period j to constant dollars, we divide by $(1 + i)^j$.[7]

$$\text{Loan interest paid in month } j, \text{ in constant \$} = \frac{L_u}{(1+i)^j}$$

To calculate the present value of the construction cost and loan interest in constant dollars, it is necessary to use the real discount rate, r_r, which is net of the inflation rate (see Equation (2)):

$$PV_u = C_u + \sum_{j=1}^{N} \frac{1}{(1+r_r)^j} \frac{L_u}{(1+i)^j} \tag{7}$$

Recall that $(1 + r_n) = (1 + i)(1 + r_r)$, and substitute in Equation (7)):

$$PV_u = C_u + L_u \sum_{j=1}^{N} \frac{1}{(1+r_n)^j}$$

and, since the sum of the geometric series $1/(1 + r)^j = (\text{UPW}, r, N)$:

$$PV_u = C_u + L_u(\text{UPW}, r_n, N) \tag{8}$$

This is the same result obtained by Method 1 (Equation (3)).

Delayed project – For the delayed project, the loan interest paid in month $j + D$, in constant dollars is:

$$\text{Loan interest paid in month } j + D, \text{ in constant \$} = \frac{L_d}{(1+i)^{j+D}}$$

Referring to Figure 2, for the timing of expenditures, we obtain for the present value of the construction and loan interest costs of the delayed project:

[7] It should be noted that the conversion of a nominal dollar amount in month j to constant dollars, in dollars of time $t = 0$, is mathematically the same as discounting, but converting to constant dollars does not remove the need to discount to present value.

$$\mathrm{PV}_d = \frac{C_d}{(1+i)^D} \quad \frac{1}{(1+r_r)^D} + \sum_{j=1}^{N} \frac{L_d}{(1+i)^{j+D}} \quad \frac{1}{(1+r_r)^{j+D}} \tag{9}$$

$$= \frac{C_d}{(1+r_r)^D(1+i)^D} + \sum_j \frac{L_d}{[(1+r_r)^D(1+i)^D]\,[(1+r_r)^j(1+i)^j]} \tag{10}$$

Substituting in Equation (10) for C_d and L_d from Equations (1a), (1b):

$$\mathrm{PV}_d = \frac{(1+i)^D C_u}{(1+r_r)^D(1+i)^D} + \sum_j \frac{(1+i)^D L_u}{[(1+r_r)^D(1+i)^D]\,[>(1+r_r)^j(1+i)^j]} \tag{11}$$

Cancelling like terms and factoring:

$$\mathrm{PV}_d = \frac{C_u}{(1+r_r)^D} + \frac{1}{(1+r_r)^D} \sum_j \frac{L_u}{(1+r_r)^j\,(1+i)^j} \tag{12}$$

Equation (12) differs from Equation (7) by the factor $1/(1+r_r)^D$. Therefore, substituting Equation (7) into Equation (12) yields:

$$\mathrm{PV}_d = \frac{1}{(1+r_r)^D} \mathrm{PV}_u \tag{13}$$

Substituting for $(1+r_r)$ from Equation (2):

$$\mathrm{PV}_d = \frac{(1+i)^D}{(1+r_n)^D} \mathrm{PV}_u \tag{14}$$

This is exactly the same result as that obtained from Method 1, which used nominal prices. Thus, the two methods are equivalent and we can specify the general rules for computing the present value of the costs of the delayed and undelayed projects, as a basis for calculating the cost of delay.

1. *Method 1:* Express costs in nominal dollars and discount to present value using the nominal rate of discount.
2. *Method 2:* Convert costs from nominal dollars to constant dollars (by deflating to their value at $t = 0$) and discount the constant dollar costs using the real rate of discount.[8]

The Effect of Different Timing of Construction Costs

We asserted earlier that if construction costs do not occur at the beginning of the construction period, as assumed above, the relationship derived in Equations (6) and (14) is unchanged. We assume now that construction costs occur at the end of the construction period, and derive the PV for the delayed and undelayed cases. The loan interest cost is assumed to be the same as before. We apply Method 1, using nominal prices and the nominal rate of discount.

[8] See [11] for a different presentation of these methods.

Undelayed project – To calculate the PV, the construction cost is now discounted over the N month period.

$$PV_u = \frac{C_u}{(1 + r_n)^N} + L_u(\text{UPW}, r_n, N) \tag{15}$$

Delayed project – The PV for the delayed project is:

$$PV_d = \frac{C_d}{(1 + r_n)^{N+D}} + \frac{L_d}{(1 + r_n)^D}(\text{UPW}, r_n, N) \tag{16}$$

Substituting Equations (1a) and (1b) in Equation (16) and factoring:

$$PV_d = \left[\frac{1}{(1 + r_n)^D}\right]\left[\frac{(1 + i)^D C_u}{(1 + r_n)^N} + (1 + i)^D L_u(\text{UPW}, r_n, N)\right] \tag{17}$$

Factoring $(1 + i)^D$ and substituting Equation (15) in Equation (17):

$$PV_d = \frac{(1 + i)^D}{(1 + r_n)^D} PV_u \tag{18}$$

This is the same result as Equations (6) and (14). The numerical value of PV_u is smaller, however, by the factor $(1 + r_n)^N$ because the cost is assumed to occur at the end of the construction period rather than at the beginning.

Numerical Calculation of the Delay Cost Using Method 1

We apply Method 1, using nominal dollars and the nominal rate of discount, to Dowall's numerical example (see Table 1). We assume a nominal rate of discount of 15 percent (per annum), which implies a real rate of discount of approximately 5 percent, as the inflation rate is assumed to be 10 percent. The value of r_n (monthly rate) is 1.25 percent. The construction cost (undelayed) is \$95,000, the interest on the construction loan is \$883 per month,[9] and interest on the land financing is \$100 per month. The PV of the two loan amounts is obtained by multiplying them by the factor (UPW, r_n, N), which has a numerical value of 8.4623, for $r_n = 1.25$ percent and $N = 9$ months.

For the delayed case, we discount the construction cost and additional property tax (using \$300, as Dowall did) over the eight-month delay period. Interest on the land loan (\$100 per month) is assumed to be paid for seventeen

[9] Dowall's assumption that interest is paid on the full amount of the construction loan overstates the interest cost. The developer will either draw from his line of credit as he needs the funds, and pay interest only on the actual amount borrowed, or, if he borrows the entire construction cost at the start of construction, he will invest those funds in a short-term (money-market) account and withdraw them as needed. In either case, the developer's net cost is less than Dowall estimates. We use Dowall's estimate, however, for consistency in comparing to his results.

Table 2. Present Value of Costs for
Delayed and Undelayed Houses

Cost Item	*Present Value of Cost ($)*	
	No Delay	*Delay*
Land	$ 10,000	$ 10,000
Interest on land loan	846	1,523
Construction costs	95,000	91,893
Interest on construction loan	7,472	7,231
Fees	2,300	2,300
Additional property tax		272
Total Without Overhead	$115,618	$113,219
Overhead	1,692	3,046
Total With Overhead	$117,310	$116,265

months, and has a present value of $1523.[10] The construction loan interest ($883 per month) is discounted over the ninth through seventeenth months, and has a PV of $7,231. The fees of $2300 are assumed to be paid at $t = 0$ in both cases.

The present value of costs for the delayed and undelayed houses, using the above assumptions, are tabulated in Table 2. Since Dowall does not include the builder's overhead cost, we also show the result of adding this cost, which we assume to be $200 per month per house. The PV of the overhead cost is calculated in the same way as the interest cost on the land.

The present value of the cost of the delayed house is *smaller* by $2,399 than the present value of the cost of the undelayed house, when overhead is not considered. With overhead included, the present value of the cost of the delayed house is smaller by $1,045. The smaller cost for the delayed house is consistent with Equation (6) for the assumed parameter values of this calculation—a nominal discount rate greater than the rate of inflation. The major difference between this calculation and Dowall's is in the effect of inflation on construction costs. The undelayed costs are the same, but the delayed costs differ by nearly $10,000 (compare Table 1 and Table 2). Thus, Dowall's treatment of inflation due to delay greatly overstates the effect of delay in the development review process.

DISCUSSION

We have shown that using a correct present value calculation for determining the cost of delay yields much different results than have been reported in the literature. These results raise an important practical question: If delay can *reduce*

[10] (UPW, r_n, N) = 15.2299 for $N = 17$.

costs (calculated in present value terms), why do builders not prefer delays rather than objecting to their occurrence?

There are two principal reasons why builders oppose delays. First, builders often have cash flow problems–they must raise large amounts of cash to pay their overhead and the interest on their loans. Their main source of cash is from sale of the houses that they build. Delays mean that they have to pay overhead and make loan payments over a longer period, when there is little or no revenue from sales. Such costs over a longer period than expected could deplete their cash reserves and could threaten their financial stability. Thus, delays increase a builder's risk of failure, and as Dowall points out, the normal response to increased risk is to require a higher profit on the project. The increased profit is not included in the cost calculation, but it is important to the consumer who has to pay more for the house and to the policymaker concerned about housing affordability. Second, delay not only reduces the present value of the cost of construction but it also reduces the present value of the revenue from sale of the house. Thus, the builder's internal rate-of-return on the project could decline because of the delay. [11] Builders tend to view the situation in a less abstract way: the longer the delay, the slower their money is working for them; the faster they build and sell houses, the more they can build, and the greater their total profits and total assets.

Even though delay could *reduce a builder's costs* (calculated in present value terms and accounting for inflation), delays are hardly desirable – they could also reduce long-term profitability. One lesson of this analysis is that calculating only the effect of inflation and delay on direct costs of a project will not support the building industry's argument against regulation, if the calculation is done correctly. It will also be necessary to look at the effect of delays on builders' revenues, their financial risk, and their rate-of-return in order to make a more persuasive case.

ACKNOWLEDGMENTS

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