Simulation-based excess return model for real estate development: A practical Monte Carlo simulation-based method for quantitative risk management and project valuation for real es...

Article *in* Journal of Property Investment and Finance · March 2011

DOI: 10.1108/14635781111112765

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Simulation-based excess return model for real estate development

A practical Monte Carlo simulation-based method for quantitative risk management and project valuation for real estate development projects illustrated with a high-rise office development case study

Received June 2010
Accepted October 2010

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Abstract

Purpose – An acute need exists for a practical quantitative risk management-based real estate investment underwriting methodology that clearly helps guide decision making and addresses the shortcomings of discounted cash flow (DCF) modeling by evaluating the full range of probable outcomes. This paper seeks to address this issue.

Design/methodology/approach – The simulation-based excess return model (SERM) is an original methodology developed based on an application of Monte Carlo simulation to project risk assessment combined with the widely practiced DCF modeling. A case study is provided where results of the modeling are compared with traditional DCF risk models and with prior projects with known outcomes.

Findings – This paper lays out a practical method for stochastic quantitative risk management modeling for real estate development projects and illustrates that for identical projects risk-adjusted returns derived with the use of SERM may differ significantly from returns provided by traditional discounted cash flow analysis. SERM corrects serious shortcomings in the DCF methodology by incorporating stochastic tools for the measurement of the universe of outcomes. It further serves to condense the results of Monte Carlo simulations into a simplified metric that can guide practitioners and which is easily communicational to decision makers for making project funding decisions.

Practical implications – SERM offers a simple, practical decision-making method for underwriting projects that addresses the limitations of the prevailing methodologies via: stochastic assessment of the range of outcomes; interdependence of input variables; and objective risk premium metrics.

Originality/value – This paper presents an original methodology for making project-funding decisions for real estate development projects that is based on Monte Carlo simulation combined with DCF analysis. The methodology presented here will have value for real estate developers, investors, project underwriters, and lenders looking for a practical and objective method for project valuation and risk management than is offered by traditional DCF analysis. A review of literature did not reveal analogous methodologies for risk management.

Keywords Monte Carlo simulation, Underwriting, Real estate, Risk management, Modelling, Return on investment

Paper type Technical paper

Journal of Property Investment & Finance
Vol. 29 No. 2, 2011
pp. 115-144

1463-578X
DOI 10.1108/14635781111112765

I. Introduction

Real estate development is a risky endeavor. Some projects generate outsized returns while others languish or else entirely erase investment capital. It is also an area of investment management that has historically seen slow adoption of financial risk modeling by practitioners. Too often, developers operating with their own funds proceed with projects with little more than back-of-the-envelope calculations based on intuition and developers' yield or return on cost metrics. Since institutional and private equity investors have become more active in funding development projects, many developers have adopted discounted cash flow (DCF) as their primary risk management methodology, often augmented by multi-point sensitivity analysis. A few practitioners, recognizing the limitations of DCF, have explored stochastic methods and real options in their search for more optimal quantitative risk management methods. However, these methodologies are sufficiently complex in their applications to restrict their usefulness for a majority of practitioners. Furthermore, they often fail to provide a clear go/no-go decision signal when employed.

While a number of papers address stochastic methods in real estate asset valuation and non-real estate related project evaluation, research did not reveal any analogous quantitative risk management models or methodologies specifically for use in real estate development, nor did research reveal a useful method for applying the results of Monte Carlo simulations to practical decision making.

In this paper we formulate a methodology for development of a stochastic model that represents a reasonable approximation of reality for development projects and combining it with DCF in such a way as to generate a clear decision signal for the practitioner. This paper will have value for real estate developers, investors, project underwriters, and lenders looking for a practical and objective method for project valuation and risk management than is offered by traditional DCF analysis. SERM is equally applicable to development of all product types; however, this paper only addresses SERM as it applies to ground-up development of office projects.

Limitations of DCF

The limitations of the DCF method have been extensively documented. Baroni *et al.* (2006), as well as Atherton *et al.* (n.d.) and Young (2007), for instance, discuss the challenges of proper identification of discount rates, future rent and expense levels and terminal value estimates. Selection of these values can be in fact sufficiently arbitrary as to make results of DCF analysis to be essentially meaningless. Many practitioners, for instance, will estimate rents, expenses, and the exit capitalization rate, with perhaps two or three sensitivity scenarios, and solve for the internal rate of return (IRR), looking for a set number as decision-making guideline, usually on the order of 20 percent, derived from a wide-sample average. However, the selected IRR hurdle often bears no relationship with the actual risks inherent in the particular project under consideration. Risk depends on the variability of income that the developed property can be expected to generate and variability of the market value at completion.

Too frequently the decision to proceed is based on nothing more than an intuition that the income necessary to clear the hurdle can be achieved at the time the project is completed, making it no more rigorous than a decision made on the basis of intuition alone. Finally, even when input variables are rigorously selected, DCF can only generate point estimates of returns, which, by ignoring the full range of probable outcomes necessarily tend to distort the picture used for decision-making.

Prior applications of stochastic methodologies to real estate investments

A number of papers have addressed application of Monte Carlo methods to real estate investments. Many have focused on the problem of asset valuation, including Baroni *et al.* (2006) and Young (2007). Atherton *et al.* (n.d.) examine, using a Monte Carlo simulation tool for development profitability analysis. In this paper we build on their work to formulate a decision-making methodology.

All of papers examined by the author use the mean valuation as the expected value of an asset or a project and use probability measures to represent the risk. Knowing the probability of achieving a certain outcome, however, is not sufficient to make a decision to proceed. What is needed is a way to weigh expected returns in the context of specific project risk.

II. The simulation-based excess return model

Existing tools for evaluation of simulated results concentrate on the probability of missing expected returns. As such they provide valuable information, but the question whether this probability is excessive or acceptable remains with the practitioner's judgment, rendering an objective determination of project feasibility impossible. What is needed is an objective way to determine what return is sufficient to compensate for the risk taken in undertaking a project. Risk is generally defined in terms of volatility of returns. Finance professionals have long used the Sharpe ratio in order to measure relative performance of portfolios with the returns of a market benchmark. The Sharpe ratio, however, suffers from two significant limitations, one of which is general and the other specific to the practice of real estate investment. The first limitation is the fact the Sharpe ratio defines volatility in terms of the standard deviation of returns, which includes both the undesirable, downside volatility as well as the desirable, upside volatility. As such, it produces a distorted metric. The second limitation is that the Sharpe ratio measures relative volatility with an index, or relative risk, whereas a real estate practitioner is generally concerned with absolute risk, both because direct real estate investments are essentially not diversifiable and because sponsor compensation metrics are based on absolute measures.

The first limitation of the Sharpe ratio has been addressed by Satchell and Pedersen (2002) in formulating the Sortino ratio, which expresses risk as only the downside tail of the distribution of returns. The Sortino ratio also incidentally eliminates the second limitation of the Sharpe method by substituting a target rate of returns for the actual market returns. As with the Sharpe ratio, the higher values of the Sortino ratio signify greater returns per unit of risk.

Having addressed the key limitations of the Sharpe ratio, however, the Sortino ratio still only allows comparison of projects to one another and does not offer an objective metric of sufficiency of returns for a given project. Here we submit the Simulation-Based Excess Return Model (SERM), a methodology to address this problem.

Since the Sortino and Sharpe ratios have been developed to measure risk-adjusted performance for investment managers in the equity markets, they take as their foundation volatility of actual portfolio and index returns. We apply an analogous methodology to the universe of simulated outcomes.

First we express the downside risk DR in terms of net present value NPV discounted the project's weighted average cost of capital WACC. We use NPV as a measure of returns because during simulation a large proportion of iterations produce undefined values for internal rate of return. In other words, downside risk is here defined as the semi-standard deviation of returns expressed as NPV divided by mean NPV:

$$DR = \frac{\sqrt{\int_{-\infty}^{0} NPV^2 f(NPV) dNPV}}{\overline{NPV}} \tag{1}$$

where *NPV* is the simulated net present value of returns as discounted by the weighted average cost of capital for the project.

Next, we determine the mean expected internal rate of return MEIRR. We can calculate the MEIRR from the mean investment and gains from the simulation and known effective project duration. Effective project duration is not equal to calendar duration because project cash flows are asymmetric, and is defined as the duration over which the known mean investment and gain amounts would produce a known IRR. A good value for the known IRR is generally the risk-free rate, and mean investments and gains discounted by the risk-free rate are simulated for the purpose. The MEIRR can be calculated based on this effective project duration.

We use IRR as a component of SERM because it offers an objective measure simulated returns given all cash flows and is the equivalent to the actual equity investment return measured by the Sharpe and Sortino ratios. In addition, it is widely understood and accepted by the practitioners. Naturally, in practice the size of the profit and loss projection needs to be taken into account even when the MEIRR appears attractive.

Given the MEIRR, we can calculate the mean return per unit of risk by dividing MEIRR by DR. we can then discount the MEIRR by the resulting metric to obtain the risk adjusted return for the project. Finally, we adjust the resulting value for the time value of money by subtracting from it the risk-free rate to arrive at excess risk-adjusted return ERR, resulting in the following formulation:

$$SERM = \frac{\overline{E[r]}}{\frac{\overline{E[r]}}{DR}} - r_f \tag{2}$$

where E[r] is the mean expected internal rate of return (IRR) for the project derived from simulation; DR is the simulated downside risk for the project; and is the risk-free rate.

Equation (2) reduced to its normal form is the definition of the excess risk-adjusted return under the SERM:

$$SERM = \frac{\overline{E[r]}}{\frac{\overline{E[r]}}{DR}} - r_f. \tag{3}$$

In other words, SERM adjusts the expected return by the ratio of the expected return and downside risk that is derived from simulation and measures the excess of this adjusted return over the risk-free rate.

Once the ERR is obtained, it becomes possible to derive the required rate of return MAR for the given project, by computing the rate of return at ERR = 0, as follows:

$$\text{MAR} = \sqrt{\text{r}_\text{f}|\text{DR}|}. \quad (4)$$

SERM MAR offers a useful metric to demonstrate the appropriate level of risk for the given project expressed in familiar terms. Care should be taken when applying the SERM MAR as a shortcut hurdle rate to other projects with potentially different characteristics because they may face vastly different probable outcomes.

Additional metrics

While the single-number ERR is a useful decision-making metric of the risk/return profile of a project, it does not address every aspect of the risk continuum for the practitioner. An informed decision to undertake a project requires additional information from the simulation, such as:

- Probability of loss, defined as the probably that the WACC-discounted NPV is less than zero.
- Median expected NPV, defined as the median NPV from simulation multiplied by the probability of loss.
- Probability of clearing an IRR hurdle is an additional metric that is useful for practitioners working with equity partners, enabling a practitioner to understand the probability to delivering promised return levels to investors.
- Mean expected loss in the event that the project is unsuccessful.

Risk-free rate

The most appropriate risk-free rate to use for SERM analysis is the interest rate paid by the Treasury obligation of a similar maturity to the development project, less an adjustment factor to back out the interest rate risk premium inherent in the Treasury security's interest rate:

$$r_f = r_{fT} - r_{rp} \quad (5)$$

where r_P is the risk-free rate for the project; r_{fT} is the US Treasury rate for an obligation of an equivalent term; and is the interest rate risk premium adjustment factor.

Discount rate: WACC

Because the purpose of the SERM analysis is to determine risk premium, it would distort results if a risk premium were also included in the discount rate. Therefore the discount rate for SERM is determined as follows:

$$r_P = (LTV)r_D + (1 - LTV)r_E \quad (6)$$

where r_P is the weighted average cost of capital WACC for the project; r_D is the effective construction period interest rate of the debt portion of the total cost; r_E is the break-even equity IRR applied to the equity portion of the total cost; and LTV is the loan to value ratio for the construction loan.

A normal profit for the developer needs to be included in the break-even IRR to ensure that the developer's overhead is at least covered. This is best implemented in the form of a developer's fee incorporated into the project cost model, or alternatively in the form of a predetermined markup to the project break-even IRR. Issues with the markup method include the fact that the normal profit fluctuates with the total return, thus putting overhead coverage at risk, as well as the potentially arbitrary nature of the predetermined markup that can undermine the objectivity of the SERM analysis.

It is imperative to use realistic component rates of return when constructing the WACC. Assuming the standard development capital structure prevailing in the Unites States where land acquisition is financed by developer's equity and construction is financed by a combination of investor equity and construction debt, for instance would produce a structure as follows. The rate of return on debt can be approximated by using the nominal interest rate on the construction loan. The rate of return on the investor's equity can be approximated by the preferred rate demanded by the investor plus a variable component that depends on the actual return based on the payout waterfall for the project, making the WACC an output variable of the simulation. For simplicity's sake it is possible to state the investor's equity rate of return equals the investor's stated required rate or return. Finally, the developer's minimal required rate of return should be incorporated in the WACC. This rate may represent the holding cost of the development parcel, opportunity cost of capital, or even zero in some cases.

Interdependence of input variables

The following variables are commonly assessed in simulation of outcomes in the case of office development. Variables for other product types may vary; however, analysis of other product types is outside the scope of this paper.

- *General inflation*. General inflation can be expressed as the average inflation from time T_0 to the time of project stabilization T_S.
- *Market vacancy*. The market vacancy of most interest is the vacancy at the time of project stabilization T_S. It may be possible to instead model vacancy as the endpoint of a Brownian-motion series from T_0 to T_S, but it is not clear that the added complexity of modeling is justified by the potential enhancement inherent in this methodology as only the terminal value is of interest and the range of terminal values is empirically derived.
- *Starting occupancy and stabilization period*. Starting occupancy at completion of a project and the duration of the stabilization period (T_D-T_S) are functions of market vacancy.
- *Market rent*. The market rent of interest is the rent at the of project stabilization T_S. While there is evidence that market rents follow a Brownian random walk over time, a simplification of modeling a range of static rents at the time of stabilization is possible because interim rent flows between time zero and stabilization are not required.
- *Rent escalation*. Rent escalation from the time of project stabilization T_S to the time of disposition T_D is best expressed as a spread above general inflation in order to capture the close interrelationship between these variables.
- *Hard (construction) cost inflation*. Hard cost inflation from time T_0 to the commencement of construction (T_C) is best expressed as a spread above general inflation in order to capture the close interrelationship between these variables.
- *Construction loan interest rate*. Construction loan interest rate is best expressed as a spread above general inflation in order to capture the close interrelationship between these variables.

- *Direct capitalization rate*. Direct capitalization rate of interest is the rate at T_D is a variable that is exogenous to the model as it primarily depends on macroeconomic factors and macro-level investment allocation decisions.
- *Construction period duration (T_S-T_C).*
- *Actual rate of return on invested equity (r_E)*. Because real estate development investment agreements frequently employ a waterfall payout schedule, the exact cost of equity depends on the profitability of the project, making the WACC a dependent variable in computing the developer's return. When analysis is performed from the developer's perspective rather than the investor's perspective, the variability of the cost of capital should be modeled as a dependent input variable, whereas in the converse case it may be treated as a fixed quantity.

For practitioners it is intuitively obvious that market rent levels, rent escalations, new project vacancy levels, and stabilization period durations, and possibly hard cost escalation, are all dependent on the supply and demand for new space, for which Market Vacancy can stand as a proxy. The statistical analysis of this relationship is presented in the case study in this paper.

There is a further relationship among general inflation, hard cost inflation, construction loan interest rates, and the direct capitalization rate.

To add complexity, hard cost inflation and the direct capitalization rate are also somewhat correlated with supply and demand for new space as proxied by market vacancy, but are also dependent on outside factors such as global demand for steel, relative demand for real estate as an asset class, and risk premiums demanded by real estate investors. For a simplified practical implementation, these variables can be treated as independent.

Construction period duration is an independent variable as it relates to project-specific considerations such as entitlement risk; however, it also exhibits a dependency on market conditions, insofar as few practitioners would contemplate or have the financing for launching new construction in the face of elevated vacancies[1].

The use of interdependent input variables in a simulation context is essentially an application of the familiar scenario-based sensitivity analysis extended to a continuum if a large number of intermediate scenarios that extends sensitivity analysis with statistical and probabilistic analysis tools.

1. Derivation. The relationship among the interdependent variables can be approximated by the following empirically-derived relationships by using curve fitting methodologies.

With the exception of new project vacancy, all variables can be derived from commercially available sources. Expert estimates of the spread need to be used in practice because there is little available hard data about vacancy for new projects vs general market vacancy. In selecting data observations for curve fitting the historical period needs to be sufficiently long to capture at least one and for preference multiple real estate cycles.

It is not expected that the relationships among the variables will hold universally true for all MSA, submarket and product type permutations, and in the absence of commercially available data sources practitioners will need to perform their own curve fitting exercises to obtain valid relationships.

2. Additional variables. The following independent variables can be additionally simulated in special circumstances:

- Project size, for cases where the size of the project developed depends on market or regulatory variables.
- Environmental and municipal fees.
- Construction commencement date, including modeling of potential delays resulting from subpar vacancy and rent for the particular simulation instance, as well as for project delays due to construction or regulatory issues.

These can be dependent on the outcome of entitlement processes such as zoning changes, density limits, height limits, etc. Modeling regulatory outcomes may require introducing a binary variable (1 for approval, 0 for disapproval) with a probability distribution based on prior experience for the market in question.

III. Comparison of SERM with common methodologies

SERM vs "pure" DCF

While DCF, which has in recent years gained wide acceptance among the more sophisticated developers, is a significant improvement on the older underwriting practices such as developer's yield and return on cost, it lacks the ability to accurately assess the risk/return profile of a project, forcing the practitioner to rely on rules of thumb for determination of risk premium.

The key difference between "pure" DCF and SERM is that SERM essentially adjusts the universe of outcomes from reliance of discount rates to serve as proxy for risk by adding stochastic methods.

SERM vs "naked" simulation

Monte Carlo simulation is widely acknowledged to overcome the static limitation of DCF; however, prevailing implementations of simulation practices suffer from a number of limitations:

- They treat all input variables as mutually independent despite the fact there are close interrelationships among them, and thereby producing skewed results.
- While they output a range of return outcomes, they offer no guidance as to whether sufficient risk premium is being generated by a project to justify (continued) investment.

SERM vs real options

Real options have been recently introduced into the real estate development underwriters' toolkit. While this approach hold considerable promise, it is not yet practical for use because:

- Problem setup for real options is highly complex and in the absence of standard "cookbooks" can be highly error-prone.
- No public data are available regarding periodic volatility of returns.
- Real options still produce point estimates of returns and offer no information on the statistical risk metrics of returns.

Limitations

The SERM methodology as described here is intended for modeling individual development projects indented for disposition on completion rather than portfolios of projects or investment performance of existing assets. With additional research it may be feasible to extend the methodology beyond the current application.

Quality of results produced necessarily depends on the quality and completeness of input assumptions. For instance, if the probability spread used for vacancy and rent is exceedingly optimistic, the model will fail to account for the probability of extreme movements and will produce skewed results. The financial crisis of 2008 has demonstrated that extreme ends of a probability spectrum must be included in any investment model of significant duration lest the impact of extreme outcomes overstate the return expectation.

IV. Practical implementation

Modeling environment

SERM relies on modeling using commercially available spreadsheet software with and a commercially available simulation engine. No purpose-designed commercial tools exist at present to automate the creation of the model suitable for SERM analysis.

Interpretation of simulation results for decision making

A zero-value SERM ERR return for a project indicates that the forecast returns are exactly equal to the risk inherent in the project, and effectively a zero NPV. A greater than zero-value ERR indicates a positive NPV for the project, while a negative ERR implies a negative NPV.

Further research and applications

The SERM methodology as described in this paper is limited to individual development project investment decisions. With additional theoretical work, the SERM concept may be possible to expend to portfolios of development project investments, individual and portfolio investments in stabilized real assets, and potentially outside of real estate in the areas of investment where stochastic methods may improve the quality of discounted cash flow modeling such as private equity-financed mergers and acquisitions. The author welcomes opportunities to collaborate with practitioners in extending the research into such fields.

V. Case study: high-rise office development

The following case study for a high-rise office development in the financial district of San Francisco, California is based on an amalgam of characteristics of several real projects and conditions, costs, and prices prevailing during the second quarter of 2010.

Project description

A development project sponsor owns a 0.41 acre parcel of land in the financial district of San Francisco with a fully-leased structure much smaller than permitted by current zoning regulations. The property is unencumbered by debt and generates $525,000 annually in free cash flow. Current zoning allows structures with floor area ratio up to 26:1 for a maximum net rentable area of 461,760 square feet. According to brokers' opinion, the parcel's market value is approximately $31.00 per square foot of FAR, or approximately $14,315,000. The sponsor has commissioned a preliminary design study for construction of an office building and obtained cost estimates with expected escalations. The design study suggests a concrete-framed 32-story tower with a gross area 572,831 square feet with retail space at street level. Construction costs are estimated to be $170.50 per gross foot in 2010 and are expected to escalate at 100 basis points above prevailing inflation which is currently running at 2 percent annually. The project is expected to take approximately 6.5 years to complete, at which point the average full-service gross rent for the office portion of this building is expected reach $51.95 which is an annual average escalation of 6 percent from the current potential average rent of $39.00. Annual step rent is expected to be 1.5 percent. Table I details the building and rental structure of the project. Lease terms and market-rate commissions are outlined in Table II. The sponsor believes that the project can be financed at the start of the construction phase with an interest-only mini-permanent loan of 65 percent of the terminal project value at a 6.5 percent interest rate. The mini-perm instrument can remain in place through construction and stabilization phases and be released upon final disposition of the project, which the sponsor intends to effect upon stabilization. The sponsor expects based on recent averages and trends that the project will fetch a disposition value based on price direct capitalization rate of 6.0 percent.

DCF analysis

A project budget and schedule constructed based above parameters, as presented in Tables III and IV and Figure 1. Table V summarizes forecast returns for the project. Because the sponsor uses an internal hurdle rate of 20.00 percent, this project is likely to be approved.

Static sensitivity analysis of varying key inputs by 10 percent in unfavorable directions reveals a generally acceptable level of risk, as illustrated in Table VI, with none of the scenarios indicating a direct financial loss.

Based on the DCF analysis, this project is likely to be approved to proceed.

Simulation parameters

Key drivers of financial performance of development projects of this type are understood to include the vacancy rate for the product type, construction cost, debt interest rate, exit capitalization rate, market rent and project duration. Other cost drivers such as entitlement, legal and architecture and engineering are generally predictable at the outset of projects and as such do not require simulation. Relative sensitivity of results to input variables within their respective ranges was analyzed with the use of a Tornado chart presented in Figure 2, confirming that rent, schedule, construction loan interest rate and exit capitalization rate offer the largest impact to profitability necessitating particularly careful attention to modeling their behavior for simulation[2].

Market rent is generally assumed to be a function of vacancy. Additionally, it assumed that construction cost is also related to vacancy insofar as it is a function of economic growth. These hypotheses were tested using publicly available sources wherever possible. Where public data were not available, information was gathered through private interviews with market practitioners. Sources not explicitly cited remain anonymous by request. A strong relationship between market vacancy and

Table I. Rent roll

				2010		2015	
	Floor	Usable area	Rentable area	Rent PSF	Total rent	Rent PSF	Total rent
Office rents, full-service gross	32	12,500	15,000	45.25	678,775	60.28	904,159
	31	12,500	15,000	45.25	678,775	60.28	904,159
	30	12,500	15,000	45.25	678,775	60.28	904,159
	29	12,500	15,000	45.25	678,775	60.28	904,159
	28	12,500	15,000	45.25	678,775	60.28	904,159
	27	12,500	15,000	45.25	678,775	60.28	904,159
	26	12,500	15,000	39.25	588,775	52.28	784,275
	25	12,500	15,000	39.25	588,775	52.28	784,275
	24	12,500	15,000	39.25	588,775	52.28	784,275
	23	12,500	15,000	39.25	588,775	52.28	784,275
	22	12,500	15,000	39.25	588,775	52.28	784,275
	21	12,500	15,000	39.25	588,775	52.28	784,275
	20	12,500	15,000	39.25	588,775	52.28	784,275
	19	12,500	15,000	39.25	588,775	52.28	784,275
	18	12,500	15,000	37.25	558,775	49.62	744,313
	17	12,500	15,000	37.25	558,775	49.62	744,313
	16	12,500	15,000	37.25	558,775	49.62	744,313
	15	12,500	15,000	37.25	558,775	49.62	744,313
	14	12,500	15,000	37.25	558,775	49.62	744,313
	13	12,500	15,000	37.25	558,775	49.62	744,313
	12	12,500	15,000	37.25	558,775	49.62	744,313
	11	12,500	15,000	37.25	558,775	49.62	744,313
	10	12,500	15,000	37.25	558,775	49.62	744,313
	9	12,500	15,000	37.25	558,775	49.62	744,313
	8	12,500	15,000	35.25	528,775	46.96	704,352
	7	12,500	15,000	35.25	528,775	46.96	704,352
	6	12,500	15,000	35.25	528,775	46.96	704,352
	5	12,000	14,400	35.25	507,624	46.96	676,178
	4	12,000	14,400	35.25	507,624	46.96	676,178
	3	12,000	14,400	35.25	507,624	46.96	676,178
Total office		73,500	448,200	39.00	17,479,800	51.95	23,283,871
Retail rents, net	2	9,500	12,000	22.00	264,000	29.30	351,660
	1	1,450	1,450	40.00	58,000	53.28	77,259
Total retail		10,950	13,450	23.94	322,000	31.89	428,918
Overall rents		384,450	461,650		17,801,800		23,712,789
Additional rent							
Antenna					120,000		159,845
Signage					100,000		133,204
Parking					312,000		415,598
Storage			8,000	20.00	160,000		213,127
Total					692,000		921,775
Building					18,493,800		24,634,564

rents was empirically demonstrated, as was an anecdotal relationship between vacancy and construction costs. Costs of funds, loan rates and capitalization rates were found to be related to spot inflation, but not to historic inflation patterns and not related to vacancy. Tenant Improvement costs, which may be reasonably assumed to be tied to construction costs, were found to have no clear relationship to either because once prevailing rates are established for a given market they tend to follow a predictable appreciation pattern tied to inflation. In practice, these costs bear some relationship to relative market power of landlords and tenants but fluctuations around the mean appear to be self-canceling.

Identifying statistical patterns in the independent drivers and their relationships with the dependent drivers comprised the bulk of the work in compiling this case study and, while the resulting patterns may possible to generalize across US real estate markets, the specific curve shapes and interrelationships will be specific to each market, and quite possibly submarket, so caution should be used in their applications.

Primary drivers

Market rent. Figure 3 details the history of market vacancy and average Class A office rent for the financial district of San Francisco from 1980 through 2009[3]. In order to test the hypothesis that rent is a function of vacancy, rent was expressed in terms of constant dollars according to three different metrics: the gross domestic product (GDP) deflator, consumer price index, and the producer price index for real estate. Rents were found to be relatively weakly tied with the CPI, with the correlation coefficient of -0.47, while correlations with the GDP deflator and PPI were nearly identical at -0.54 and -0.55 respectively. The sparseness of the PPI data set of only 23 samples suggested the use of the GDP deflator data for developing a regression. Linear regression analysis results in slope $m = -122.09$ with intercept $y = 55.95$. The data and regression charts are presented in Table VII and Figure 4.

The regression alone is not sufficient to present a complete picture of the relationship of vacancy and rents because sponsors and are reluctant to initiate – and lenders reluctant to fund – new construction projects at times when vacancies are elevated. In order to reflect this condition, commencement of construction is delayed if the simulated vacancy is above average according to the assumption that for every percentage point of difference between simulated vacancy and average vacancy construction will be delayed by 1.75 years. This assumption was based on the historical pattern of reversion to the mean observed in Figure 3. However, as vividly demonstrated by the financial crisis of 2008, vacancy rates can also plunge after construction has been substantially complete[4]. This eventuality is modeled with a second independent variable for vacancy at completion. The complete picture of the

Table II.
Lease structures and commissions

	Office	Retail
Term, years	5	5
Average escalation (%)	2.50	2.50
Commission basis	121,528,045	2,198,206
Commission rate (%)	7.0	6.0
Total commissions	8,506,963	131,892
Commissions PSF ($)	18.98	9.81

Table III. Budget and cash flow forecast

Project start	7/1/2010	Avg inflation		2.0%		Project end 12/1/2016			
Construction delay (months)	–								Starting occupancy
Revenues	2010$/unit	Units	2010$ total	Escalation	Escalated $	Start	Duration	End	(%)
In-place net rent			525,000	0.0%	525,000	7/1/2010	25	8/1/2012	100
Occupancy						6/1/2015	18	12/1/2016	
Office rent	39.00	448,200	17,479,800	6.0%	23,283,871	6/1/2015	18	12/1/2016	70
Retail rent	23.94	13,450	322,000	6.0%	428,918	6/1/2015	1	7/1/2015	50
Additional rent			692,000	6.0%	921,775	6/1/2015	6	12/1/2015	100
Step rent				1.5%	627,928	6/1/2015	18	12/1/2016	70
Less: office general vacancy		5.00%	(924,690)	6.0%	(1,231,728)	6/1/2015	18	12/1/2016	100
Less: property tax		1.20%			(1,548,606)	6/1/2015	18	12/1/2016	100
Less: insurance	2.00	461,650	(923,300)	2.0%	(1,017,795)	6/1/2015	18	12/1/2016	100
Less: operating expense	9.25	461,650	(4,270,263)	2.0%	(4,707,303)	6/1/2015	18	12/1/2016	100
Net operating income			12,375,548		16,757,060				
Task	2010$/unit	Units	2010$ total	Escalation	Escalated $	Start	Duration	End	
Acquisition phase						7/1/2010	1	8/1/2010	
Land	31.00	461,760	14,314,560	0.0%	14,314,560	7/1/2010	1	8/1/2010	
Title insurance			250,000	0.0%	250,000	7/1/2010	1	8/1/2010	
Legal expenses			350,000	0.0%	350,000	7/1/2010	1	8/1/2010	
Entitlement phase						8/1/2010	36	8/1/2013	
Transferable development rights			7,500,000	0.0%	7.500,000	8/1/2010	6	2/1/2011	
Architecture and engineering			4,500,000	2.0%	4,507,575	8/1/2010	24	8/1/2012	
Entitlement approval			250,000	2.0%	250,421	8/1/2010	36	8/1/2013	
Fees and permits			475,000	0.0%	475,000	8/13/2010	24	8/13/2012	

(continued)

Table III.

Construction phase						8/1/2012	34	6/1/2015
Impact fees			12,500,000	2.0%	13,027,598	8/1/2012	1	9/1/2012
Demolition			525,000	2.0%	558,102	8/1/2013	2	10/1/2013
Construction	155.00	572,831	88,788,728	3.0%	97,755,311	10/1/2013	18	4/1/2015
Commissioning			400,000	2.0%	439,481	4/1/2015	2	6/1/2015
Property taxes		1.20	1,291,239	2.0%	1,345,740	8/1/2012	34	6/1/2015
Artwork			887,887	2.0%	946,999	10/1/2013	18	4/1/2015
Insurance			425,000	2.0%	442,938	8/1/2012	34	6/1/2015
Security systems			200,000	2.0%	219,741	4/1/2015	2	6/1/2015
Stabilization phase						8/1/2013	26	10/1/2015
Tenant space planning			100,000	2.0%	109,870	4/1/2015	6	10/1/2015
Legal expenses			650,000	2.0%	714,157	4/1/2015	6	10/1/2015
Marketing and PR			1,500,000	2.0%	1,594,578	8/1/2013	24	8/1/2015
Tenant improvements – office	60.00	373,500	22,410,000	2.0%	24,621,932	4/1/2015	6	10/1/2015
Leasing commissions – office	17.10	373,500	6,386,396		8,506,963	12/3/2014	6	6/3/2015
Tenant improvements – retail	40.00	10,950	438,000	2.0%	481,232	4/1/2015	6	10/1/2015
Leasing commissions – retail	9.04	10,950	99,015		131,892	12/3/2014	3	3/3/2015
Miscellaneous leasing			350,000	2.0%	384,546	4/1/2015	6	10/1/2015
Administration						7/1/2010	63	10/1/2015
General and administrative			3,500,000	2.0%	3,500,000	7/1/2010	63	10/1/2015
Development fee		2.50	3,641,907		4,000,352	7/1/2010	63	10/1/2015
Project contingency		3.00	4,595,288		5,025,422	7/1/2010	63	10/1/2015
Interest-only debt service		6.50	22,258,767		22,258,767			
Total expenses			198,586,786		213,713,177			

(*continued*)

Construction financing								
Mini-perm loan		65.00	114,613,213		124,445,367	8/1/2012	1	9/1/2012
Less: lender fees		0.50	(573,066.06)		(622,227)	8/1/2012	1	9/1/2012
Net borrowing			114,040,147		123,823,140	8/1/2012	1	9/1/2012
Loan running balance								
Disposition						12/1/2016	1	1/1/2017
Reversion value	Cap rate	6.00			270,534,329	12/1/2016	1	1/1/2017
Less; disposition expenses		0.35			(946,870)	12/1/2016	1	1/1/2017
Net reversion					269,587,459	12/1/2016	1	1/1/2017
Debt retirement					(124,445,367)	12/1/2016	1	1/1/2017
		Yield	IRR	ROE	Profit			
Cash flow before leverage		8.48	16.55%	70.62%	120,792,536			
Cash flow before income taxes		7.60	22.51%	123.06%	97,911,543			

Table III.

Table IV. Budget and cash flow forecast

Period	0	1	2	3	4	5	6	7
Year ending		7/31/2011	7/31/2012	7/31/2013	7/31/2014	7/31/2015	7/31/2016	7/31/2017
Construction delay (months)								
Revenues								
In-place net rent		525,000	525,000	1,458	–	–	–	–
Occupancy								
Office rent		–	–	–	–	17,074,839	21,809,226	
Retail rent		–	–	–	–	428,918	428,918	
Additional rent		–	–	–	–	921,775	921,775	
Step rent		–	–	–	–	–	276,383	
Less: office general vacancy		–	–	–	–	(1,231,728)	(1,231,728)	(1,231,728)
Less: property tax		–	–	–	–	(1,548,606)	(1,548,606)	(1,548,606)
Less: insurance		–	–	–	–	(1,017,795)	(1,017,795)	(1,017,795)
Less: operating expense		–	–	–	–	(4,707,303)	(4,707,303)	(4,707,303)
Net operating income		525,000	525,000	1,458	–	9,920,100	14,930,870	16,757,060
Task								
Acquisition phase								
Land	14,314,560		–	–	–	–	–	–
Title insurance	250,000		–	–	–	–	–	–
Legal expenses	350,000		–	–	–	–	–	–
Entitlement phase		–	–	–	–	–	–	–
Transferable development rights		7,500,000	–	–	–	–	–	–
Architecture and engineering		2,263,113	2,238,244	6,217	–	–	–	–
Entitlement approval		84,012	83,089	83,089	231	–	–	–
Fees and permits		230,621	235,862	8,517	–	–	–	–
Construction phase		–	–	–	–	–	–	–
Impact fees		–	–	13,027,598	–	–	–	–
Demolition		–	–	–	558,102	–	–	–
Construction		–	–	–	54,149,651	43,605,660	–	–
Commissioning		–	–	–	–	439,481	–	–
Property taxes		–	–	490,831	485,437	369,472	–	–
Artwork		–	–	–	524,572	422,427	–	–
Insurance		–	–	161,553	159,777	121,608	–	–

(*continued*)

Table IV.

Period	0	1	2	3	4	5	6	7
Year ending		7/31/2011	7/31/2012	7/31/2013	7/31/2014	7/31/2015	7/31/2016	7/31/2017
Security systems		–	–	–	–	219,741	–	–
Stabilization phase		–	–	–	–	–	–	–
Tenant space planning		–	–	–	–	72,646	37,274	–
Legal expenses		–	–	–	–	472,202	241,955	–
Marketing and PR		–	–	–	800,588	791,790	2,199	–
Tennant improvements – office		–	–	–	–	16,280,075	8,341,857	–
Leasing commissions – office		–	–	–	–	8,506,963	–	–
Tenant improvements – retail		–	–	–	–	318,192	163,040	–
Leasing commissions – retail		–	–	–	–	131,892	–	–
Miscellaneous leasing		–	–	–	–	254,263	130,283	–
Administration		–	–	–	–	–	–	–
General and administrative		676,692	676,692	676,692	676,692	676,692	116,541	–
Development fee		81,361	80,847	361,362	1,433,876	1,817,078	225.827	–
Project contingency		971,618	971,618	971,618	971,618	971,618	167,334	–
Interest-only debt service		–	–	1,977,123	4,502,006	7,690,689	8,088,949	–
Total expenses	14,914,560	11,807,417	4,286,352	17,764,600	64,262,550	83,162,489	17,515,210	–
Construction financing								
Mini-perm loan								
Less: lender fees		–	–	(622,227)	–	–	–	–
Net borrowing		–	–	30,417.273	38,844,354	49,056,670	6,127,070	–
Loan running balance		–	–	30,417,273	69,261,627	118,318,297	124,445,367	–
Disposition								
Reversion value								
Less; disposition expenses								
Net reversion		–	–	–	–	–	–	269,587,459
Debt retirement		–	–	–	–	–	–	(124,445,367)
Cash flow before leverage	(14,914,560)	(11,282,417)	(3,761,352)	(15,786,018)	(59,760,544)	(65,551,700)	5,504,609	286,344,518
Cash flow before income taxes	(14,914,560)	(11,282,417)	(3,761,352)	12,031,905	(25,418.196)	(24,185,719)	3,542,730	161,899,152

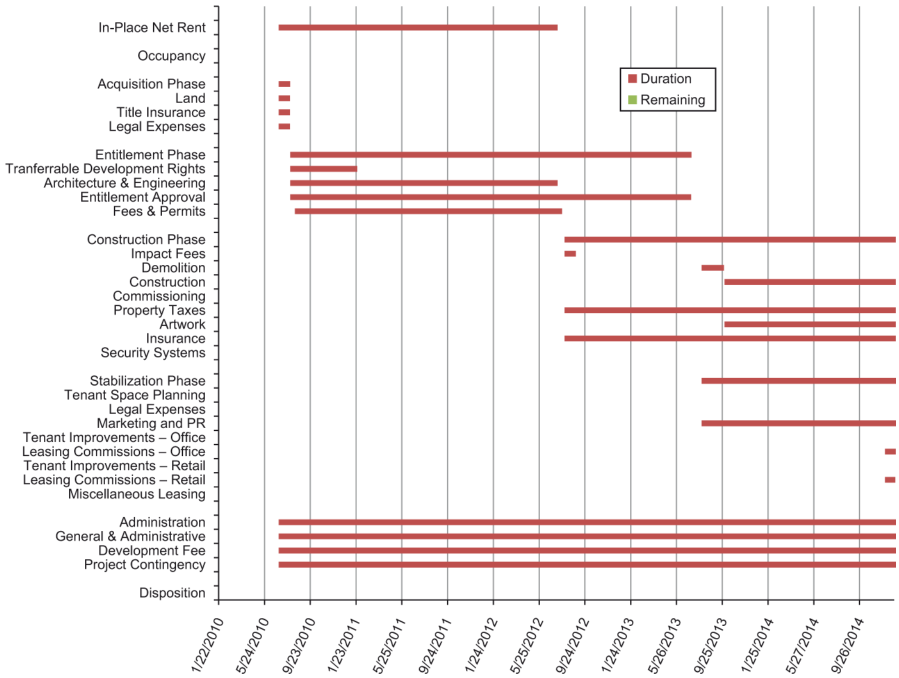


Figure 1.
Project schedule

Table V.
Summary of expected returns

	Yield (%)	IRR (%)	ROE (%)	Profit
Cash flow before leverage	8.48	16.55	70.62	120,792,536
Cash flow before income taxes	7.60	22.51	123.06	97,911,543

Table VI.
Sensitivity analysis

		Yield (%)	IRR (%)	ROE (%)	Profit	
Rent	Stat					
Construction cost	Stat	8.48	16.55	70.62	120,792,536	Before leverage
Cap rate	Stat	7.60	22.51	123.06	97,911,543	Before income taxes
Rent	−10%					
Construction cost	Stat	7.26	11.23	43.90	75,449,929	Before leverage
Cap rate	Stat	6.50	14.39	65.07	52,650,356	Before income taxes
Rent	Stat					
Construction cost	+10%	7.98	14.62	59.39	107,913,698	Before leverage
Cap rate	Stat	7.15	19.82	99.70	83,849,959	Before income taxes
Rent	Stat					
Construction cost	Stat	8.48	13.81	56.29	96,284,586	Before leverage
Cap rate	+10%	7.60	18.52	92.26	73,403,592	Before income taxes
Rent	−10%					
Construction cost	−10%	7.75	13.30	54.79	88,328,767	Before leverage
Cap rate	+10%	6.94	17.60	87.34	66,711,941	Before income taxes

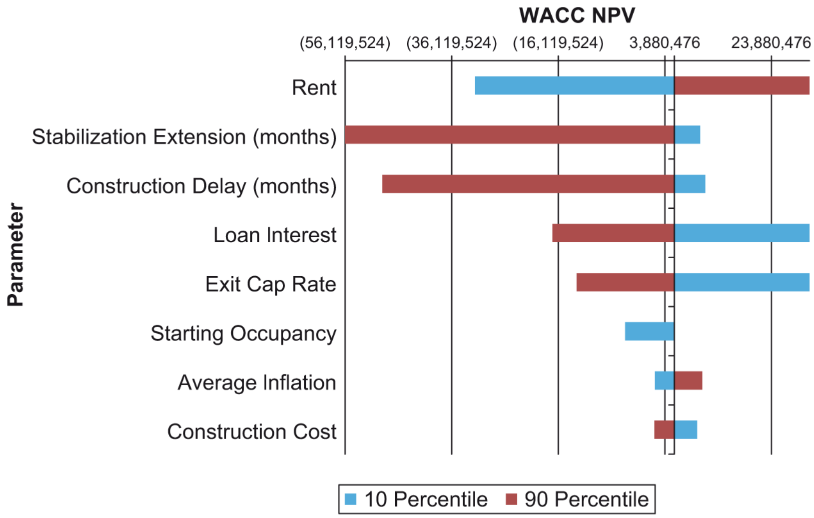


Figure 2.
Tornado analysis

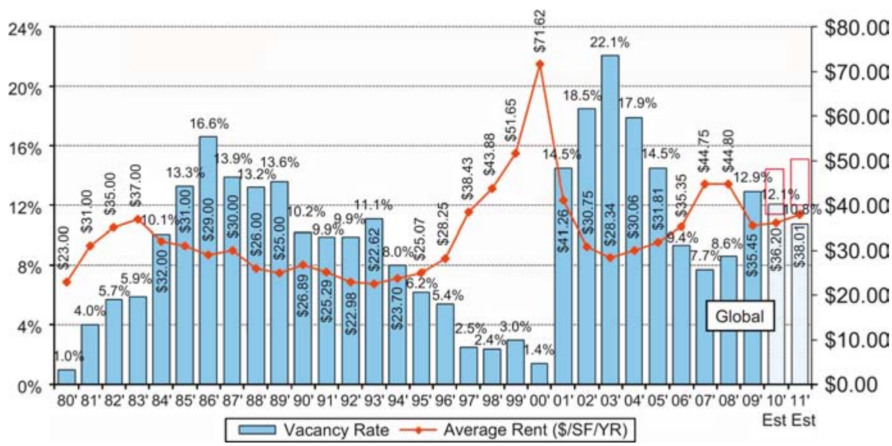


Figure 3.
San Francisco CBD class office rent and vacancy 1980-2011

effect of its elevated condition includes more than impact to rent because both the starting occupancy at project completion and the duration of the stabilization phase are also negatively affected. The extension of the stabilization phase may be assumed to follow the same pattern as the postponement of constriction. Modeling starting occupancy proved more challenging because hard data were scarce and the slope precipitous. A reasonable approximation of reality was achieved with a formulation where starting occupancy:

$$S_o = \mathrm{MIN}\left(Max\,S_o, 1 - \mathrm{MIN}\left(\mathrm{LN}\left(100\left(\mathrm{MIN}\left(Vacancy,\ Avg.\,Vacancy\right)\right)11/100{,}000,\ 100\%\right)\right)\right) \quad \text{(C1)}$$

where $Max\ S_o$ is a constant limiting the largest starting occupancy to that deemed possible by the sponsor. In this model, $Max\ S_o = 80$ percent.

Table VII.
Rent vs vacancy in constant dollars

Year	Vacancy rate (%)	Average rent, nominal	GDP deflator[a]	GDP deflator, 2009 dollars	Average rent, 2009 dollars	CPI[b]	CPI deflator in 1980 dollars	CPI deflator in 2009 dollars	Rent in 2009 CPI dollars	PPI[c]	PPI in 2009 dollars	Rent in 2009 PPI dollars
1980	1.00	23	54.043	181.792	41.81	13.5	100	126.1	29			
1981	4.00	31	59.119	173.206	53.69	10.3	101.103	125.009	38.75			
1982	5.70	35	62.726	167.455	58.61	6.2	102.165	123.969	43.39			
1983	5.90	37	65.207	163.65	60.55	3.2	103.197	122.969	45.5			
1984	10.10	32	67.655	160.032	51.21	4.3	104.24	121.969	39.03			
1985	13.30	31	69.713	157.08	48.69	3.6	105.276	120.985	37.51			
1986	16.60	29	71.25	154.923	44.93	1.9	106.295	120.026	34.81			
1987	13.90	30	73.196	152.264	45.68	3.6	107.331	119.061	35.72	101.4	156.357	46.907
1988	13.20	26	75.694	148.964	38.73	4.1	108.372	118.1	30.71	106.2	151.837	39.478
1989	13.60	25	78.557	145.32	36.33	4.8	109.42	117.142	29.29	110.8	147.685	36.921
1990	10.20	26.89	81.59	141.602	38.08	5.4	110.474	116.188	31.24	113.1	145.652	39.166
1991	9.90	25.29	84.443	138.224	34.96	4.2	111.516	115.254	29.15	114.2	144.688	36.592
1992	9.90	22.93	86.386	135.974	31.18	3	112.546	114.339	26.22	115	143.993	33.018
1993	11.10	22.62	88.381	133.717	30.25	3	113.576	113.432	25.66	117.8	141.616	32.033
1994	8.00	23.7	90.259	131.636	31.2	2.6	114.602	112.536	26.67	121.4	138.65	32.86
1995	6.20	25.07	92.106	129.631	32.5	2.8	115.63	111.647	27.99	126.1	134.923	33.825
1996	5.40	28.25	93.852	127.771	36.1	3	116.66	110.765	31.29	128.2	133.285	37.653
1997	2.50	38.43	95.414	126.134	48.47	2.3	117.683	109.895	42.23	130.5	131.523	50.544
1998	2.40	43.88	96.472	125.037	54.87	1.6	118.699	109.039	47.85	131.2	130.989	57.478
1999	3.00	51.65	97.868	123.611	63.84	2.2	119.721	108.186	55.88	133	129.636	66.957
2000	1.40	71.62	100	121.479	87	3.4	120.755	107.329	76.87	135.6	127.718	91.472
2001	14.50	41.25	102.399	119.136	49.14	2.8	121.783	106.485	43.93	136	127.424	52.562
2002	18.50	30.75	104.187	117.42	36.11	1.6	122.799	105.658	32.49	135.8	127.571	39.228
2003	22.10	28.34	106.404	115.336	32.69	2.3	123.822	104.832	29.71	137.6	126.263	35.783
2004	17.90	30.06	109.463	112.542	33.83	2.7	124.849	104.009	31.27	148.3	119.048	35.786
2005	14.50	31.81	113	109.411	34.8	3.4	125.883	103.188	32.82	159.6	111.968	35.614
2006	9.40	35.35	116.567	106.351	37.6	3.2	126.915	102.375	36.19	169.6	106.072	37.499
2007	7.70	44.75	119.682	103.749	46.42	2.8	127.943	101.571	45.45	175.2	102.875	46.033
2008	8.60	44.8	122.087	101.779	45.59	3.8	128.981	100.766	45.14	189.1	95.525	42.791
2009	12.90	35.45	124.298	100	35.45	-0.4	129.977	100	35.45	181	100	35.45

Sources: [a]International Monetary Fund, www.imf.org; [b]United States Bureau of Labor Statistics, www.bls.gov/cpi/cpid09av.pdf; [c]United States Bureau of Labor Statistics, ftp://ftp.bls.gov/pub/time.series/pc/pc.data.59.RealEstate

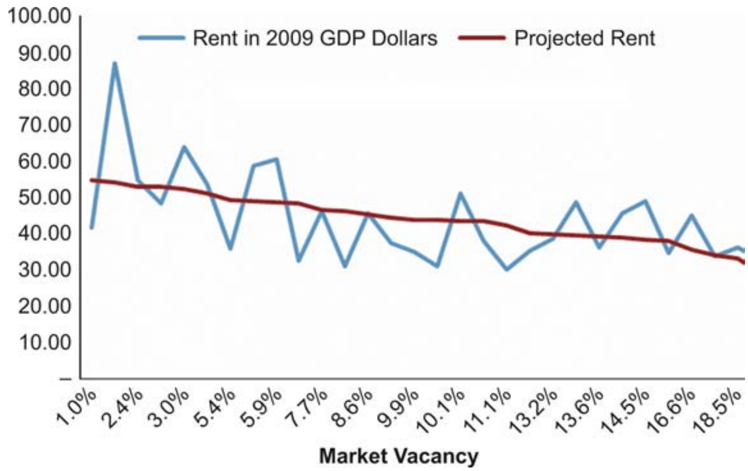


Figure 4. Rent vs vacancy regression

Interviews with experienced leasing agents established that asking and contact rents for new construction projects tend to be 5-15 percent greater than average. This case assumes a constant 10 percent premium for new construction beyond the average. Because of low materiality, retail and additional rents were assumed to maintain a constant ratio to with office rents and an unchanging starting occupancy and stabilization period.

Market vacancy. Statistical analysis of the population of vacancy values returns results and histogram are presented in Figure 5.

The observed population for this variable lends itself well for modeling with a simulated Beta distribution and reasonably well for a triangular set to produce meaningful results.

Average inflation. As further described above, rent and construction cost parameters were modeled in constant dollars, making it necessary to predict the inflation from initiation to the commencement of construction at which point costs may be locked in. Other costs and revenues are also affected by inflation. Because near-term expenses and revenues are affected in a relatively minor way and interim values of inflation are not material for this analysis we can model a single average inflation over

Market Vacancy Summary Statistics	
Mean	0.097806
Standard Error	0.009939
Median	0.099
Mode	0.099
Standard Deviation	0.054436
Sample Variance	0.002963
Kurtosis	–0.52736
Skewness	0.230924
Range	0.211
Minimum	0.01
Maximum	0.221
Sum	2.934187
Count	30
Confidence Level (95.0%)	0.020327

Figure 5. Market vacancy

the life of the project. As a reasonable proxy to the interim period of the project we selected a five-year moving average inflation expressed as a rate of change of the GDP deflator. Figure 6 demonstrates the data, statistical analysis and histogram for the five-year moving average inflation. Since no mode value was found, the mean of 2.63 percent was selected as the peak value for simulation using triangular distribution.

Construction cost. Unfortunately, no publicly available historical statistics for fluctuation in local construction costs were identified. Furthermore, national construction costs as measured by PPI Construction correlated very poorly with local metrics available, with the highest correlation coefficient obtained not exceeding 0.104. In the absence of statistical data, interviews were conducted with general contractors with a significant history of operating in the area. The interviews yielded information that construction costs depend broadly on cost of labor and materials, the latter being impacted by global construction demand. This is particularly true in the case of the cost of steel. Labor cost can be expected to be correlated with local building demand, which in turn is driven by market vacancy. Because this particular project is expected to be built on a concrete frame, the price of steel becomes less relevant and local variables assume primacy in determining a relationship with outside factors. Interviews with contractors yielded no information regarding absolute cost levels of construction but did suggest that relative change in costs is correlated with market vacancy in a relationship that can be represented a linear relationship with the slope $m = -0.57971$ and intercept $y = 0.088$ as presented in Figure 7.

Loan interest. Public information about construction loan terms has been as difficult to find as it was for construction costs. Lending agents interviewed indicated that

Year	GDP Deflator % Change
1981	9.39%
1982	6.10%
1983	3.96%
1984	3.75%
1985	3.04%
1986	2.20%
1987	2.73%
1988	3.41%
1989	3.78%
1990	3.86%
1991	3.50%
1992	2.30%
1993	2.31%
1994	2.12%
1995	2.05%
1996	1.90%
1997	1.66%
1998	1.11%
1999	1.45%
2000	2.18%
2001	2.40%
2002	1.75%
2003	2.13%
2004	2.87%
2005	3.23%
2006	3.16%
2007	2.67%
2008	2.01%
2009	1.81%

Inflation 5-Year Moving Average Summary Statistics	
Mean	0.026790349
Standard Error	0.00163851
Median	0.026273547
Mode	#N/A
Standard Deviation	0.008192549
Sample Variance	6.71179E-05
Kurtosis	2.641852819
Skewness	1.176905891
Range	0.036165944
Minimum	0.016324404
Maximum	0.052490348
Sum	0.669758729
Count	25

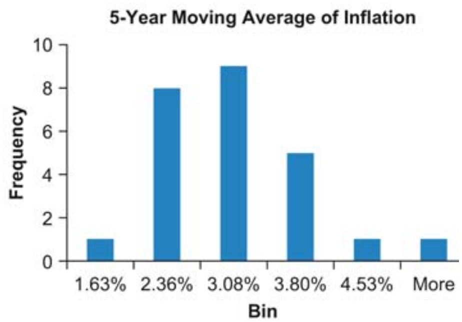


Figure 6.
Inflation

Vacancy rate	Cost % Change	Projected Cost
1.4%	8.0%	8.0%
2.4%	7.4%	7.4%
2.5%	7.4%	7.4%
3.0%	7.1%	7.1%
5.4%	5.7%	5.7%
6.2%	5.2%	5.2%
7.7%	4.3%	4.3%
8.0%	4.2%	4.2%
8.6%	3.8%	3.8%
9.4%	3.4%	3.4%
9.9%	3.1%	3.1%
9.9%	3.1%	3.1%
10.2%	2.9%	2.9%
11.1%	2.4%	2.4%
12.9%	1.3%	1.3%
13.2%	1.1%	1.1%
13.6%	0.9%	0.9%
14.5%	0.4%	0.4%
14.5%	0.4%	0.4%
17.9%	–1.6%	–1.6%
18.5%	–1.9%	–1.9%
22.1%	–4.0%	–4.0%

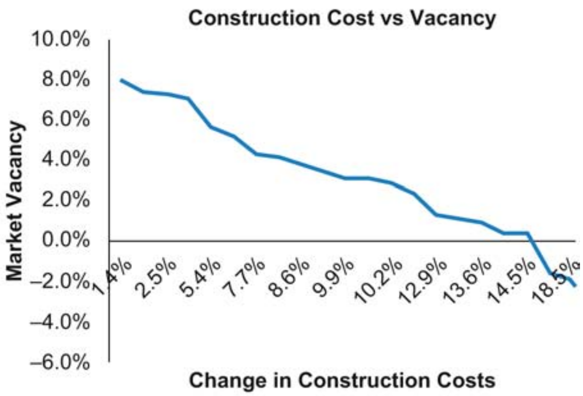


Figure 7.
Construction cost

construction loans are generally priced 300-400 basis points above prime. An average spread of 350 bps was selected as a benchmark for the model. Prime rates from 1947 to 2009 and statistical analysis of resulting interest rates are presented in Figure 8.

Capitalization rate. Direct capitalization rates for San Francisco office properties have only been recorded in a publicly available way since 1999, offering a limited dataset for ascertaining long-term patterns. However, the San Francisco cap rates appear to closely track the national office cap rate trends as derived in Chandrashekaran, 2000 for the period of 1985 to 1999, making it possible to extend the series by 15 data points for a more statistically significant picture. The resulting range of average cap rates is presented in Figure 9. One issue with the available sample is the fact that the largest and the smallest values in the dataset, 3.93 percent and 10.20 percent, represent single deals made during the top and bottom of the market respectively. These two points were therefore treated as outliers and eliminated them from the analysis.

Plotting cap rates against their spot market interest rate and spot GDP inflation rate resulted in poor correlation with the prime rate and, interestingly, a negative correlation with the spot inflation that becomes progressively smaller with the use of a longer moving average of rates. Since modeling spot inflation rates is outside the scope of the model here, cap rates can be treated as an independently simulated variable following a triangular distribution[5]. Figure 9 summarizes the statistics of the cap rate spread used.

Interviews with real estate agents in experienced in the San Francisco market yielded information that new construction project when sold command prices represented by cap rates in the lower ranges of the spread around the average value. The price premium was described as ranging between 100 and 150 basis points below the average value. A median value of 125 basis points below average was selected for

Year	Prime Rate[a]
1947	1.75
1948	2.00
1949	2.00
1950	2.25
1951	3.00
1952	3.00
1953	3.25
1954	3.00
1955	3.50
1956	4.00
1957	4.50
1958	4.00
1959	5.00
1960	4.50
1961	4.50
1962	4.50
1963	4.50
1964	4.50
1965	5.00
1966	6.00
1967	6.00
1968	6.75
1969	8.50
1970	6.75
1971	5.25
1972	6.00
1973	9.75
1974	10.25
1975	7.25
1976	6.25
1977	7.75
1978	11.75
1979	15.25
1980	21.50
1981	15.75
1982	11.50
1983	11.00
1984	10.75
1985	9.50
1986	7.50
1987	8.75
1988	10.50
1989	10.50
1990	10.00
1991	6.50
1992	6.00
1993	6.00
1994	8.50
1995	8.50
1996	8.25
1997	8.50
1998	7.75
1999	8.50
2000	9.50
2001	4.75
2002	4.25
2003	4.00
2004	5.25
2005	7.25
2006	8.25
2007	7.25
2008	3.25
2009	3.25

Construction Loan Rates 1947–2009	
Mean	6.9047619
Standard Error	0.45539761
Median	6.25
Mode	4.5
Standard Deviation	3.6146065
Sample Variance	13.0653802
Kurtosis	3.3896696
Skewness	1.38221751
Range	19.75
Minimum	1.75
Maximum	21.5
Sum	435
Count	63

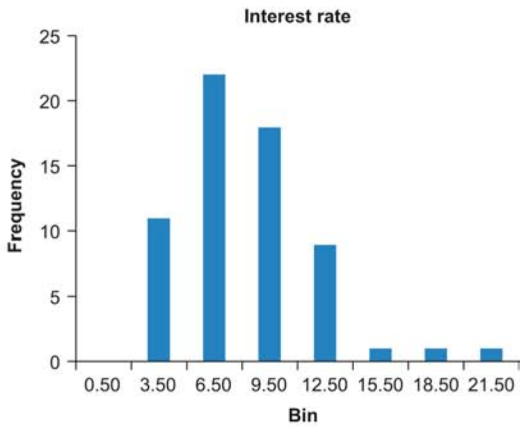
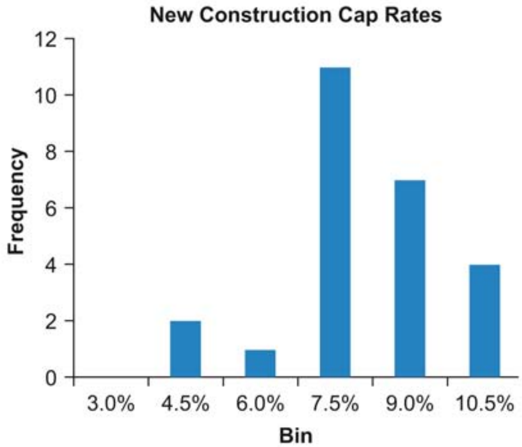


Figure 8.
Loan interest

Source: [a]erate.com, www.erate.com/mortgage_rates_history.htm

Year	Average Cap Rate[a]
1985	6.75%
1986	6.72%
1987	6.68%
1988	6.23%
1989	6.02%
1990	6.00%
1991	6.82%
1992	7.49%
1993	8.04%
1994	8.81%
1995	9.04%
1996	8.30%
1997	8.28%
1998	8.06%
1999	7.59%
2000	7.41%
2001	9.55%
2002	9.63%
2003	6.35%
2004	6.09%
2005	4.37%
2006	3.93%
2007	5.32%
2008	10.20%
2009	8.50%

New Construction Cap Rate	
Mean	6.06%
Standard Error	2.73%
Median	6.16%
Mode	#N/A
Standard Deviation	1.37%
Sample Variance	0.02%
Kurtosis	–47.75%
Skewness	–10.63%
Range	3.98%
Minimum	4.40%
Maximum	8.38%
Sum	139.28%
Count	23



Source: [a]1985-1999 Chandrashekaran (2000). 2000-2009 courtesy of the San Francisco office of Cornish & Carey Commercial

Figure 9.
Cap rates

Treasury rate	Term (years)	Rate (%)
Short term	5	2.08
Intermediate term	10	3.25
Long term	20	3.97

Table VIII.
Treasury rates

Independent drivers	Value (%)	Distribution	Min (%)	Mode (%)	Max (%)
Market vacancy	10.78	Triangular	1.00	9.90	22.10
Average inflation	3.06	Triangular	1.60	2.63	5.25
Prime rate	8.58	Triangular	1.75	4.50	21.50
Exit cap rate	6.30	Triangular	4.40	6.20	8.40

Table IX.
Independent simulation drivers

Table X.
Simulation results

	Risk-free NPV	WACC NPV	Hurdle NPV	Lev. gains	Lev. profit	Lev. ROE	Unlev. ROE	Risk-free rate	WACC
Min.	(206,849,820)	(92,345,744)	(79,542,871)	6,541,757	(264,177,899)	−97.48%	−100.00%	2.30%	6.94%
Max.	262,057,754	166,278,328	63,947,661	470,134,466	390,996,150	494.07%	266.07%	3.88%	19.66%
Mean	29,740,087	1,278,197	(10,863,064)	156,902,902	45,589,896	57.85%	45.80%	2.85%	11.82%
Median	40,191,619	1,085,024	(11,600,037)	167,534,747	62,322,968	59.49%	61.69%	2.84%	11.40%
Mode	N/A	N/A	N/A	N/A	N/A	N/A	−100.00%	2.30%	N/A
Avg dev.	65,411,473	33,747,537	17,382,149	70,566,409	84,142,204	80.49%	57.98%	0.38%	2.39%
SD	81,336,291	41,839,430	21,625,659	88,522,616	106,196,705	99.95%	75.29%	0.43%	2.86%
Coef. var.	2.734904246	32.73316525	−1.990751252	0.56418724	2.329391256	1.727706712	1.643752865	0.149831912	0.242043816
Skewness	−0.354244654	0.179935854	0.132647358	−0.208035519	−0.461382447	0.194647251	−0.673849811	0.089627981	0.497104935
Kurtosis	−0.439871078	−0.330771396	−0.210359406	−0.521282498	−0.278245878	−0.33961685	−0.296386351	−1.378681998	−0.63308832
Semi SD	46,340,607	28,269,415	21,944,920	–	59,431,972	39.65%	39.08%	0.00%	0.00%
Semi Coef. var.	1.558186638	22.11663531	−2.020140886	–	1.30362158	68.54%	85.33%	0.00%	0.00%
90 percent interval lower bound	(116,262,332)	(66,222,812)	(44,896,340)	9,441,200	(151,821,670)	(0.94)	−100.00%	2.30%	7.95%
90 percent interval upper bound	150,619,596	71,230,687	25,698,444	293,343,785	198,804,041	2.25	146.61%	3.49%	17.12%
Effective duration		3.179814832							
Probability of shortfall	35.73%	48.78%	69.23%	3.82%	33.39%				
Expected NPV/reversion	25,830,529	555,734	(8,030,472)	161,141,786	41,516,217				
Mean expected IRR		0.27%							
Risk-adjusted expected IRR		0.14%							
Risk-adjusted return on capital		1,085,025							
Sharpe ratio	0.365643514	0.030550055	−0.502322929	1.772461212	0.429296709	0.578801942	0.608363959		
Sortino ratio	0.641771644	0.045214834	−0.49501498	#DIV/0!	0.767093776	1.45896698	1.171941275		
Benchmark discount rate	2.85%	11.40%	20.00%						
Median profit	40,191,619	1,085,024	(11,600,037)	167,534,747					
Expected median profit	25,830,529	555,734	(8,030,472)	161,141,786					
Median Investment	(127,343,128)	(166,449,723)	(179,134,784)	127,343,128					
Total project volatility	166.31%	481.02%							
Annual project volatility	57.88%	167.39%							

use in the model. We have further elected to set a lower bound of 4.40 percent as the lowest observed cap rate excepting a single outlier.

Risk-free rate. Because the duration of the project is not fixed, and in fact was found in simulation to vary between six and 19 years, the normal practice of selecting a single Treasury rate as a proxy for the risk-free rate is inappropriate. The effective risk-free rate for the project is extrapolated from the available five-, ten- and 20-year Treasury rates and is calculated based on the duration of the project in each iteration of the simulation. The spot Treasury rates used in this case are presented in Table VIII.

Simulation analysis

The independent drivers thus selected for the simulation are market vacancy, average inflation, prime rate and capitalization rate. Distributions, distribution modeling parameters and median simulated results are summarized in Table IX.

The simulation was run with 10,000 iterations, with the statistical results presented in Table X[6]. As we can see, the median hurdle NPV result is negative, implying that the project as planned is unlikely to meet its profitability objectives. In fact, the probability of doing so is only 33.39 percent. The probable shortfall in covering the weighted average cost of capital is 48.78 percent, but since the median return for this metric is positive, the implication is that the project will at least not generate a cash loss for the sponsor. These may or may not be poor odds for the risk tolerance of a particular sponsor, but they do not offer any information as to whether the size of the expected profit justifies this level of risk. For the risk-adjusted return metric, we must turn to SERM analysis.

SERM analysis and recommendation

Applying SERM analysis to the results of the simulation, as presented in Table XI, we obtain the excess return metric ERR of -2.85 percent, which is a clear indication that the range of returns for this project does not justify the risk. In fact, once we solve for the required rate of return MAR, we obtain a discount rate of 79.44 percent, indicating that the project's viability is some distance from break-even.

Clearly, the returns from this project as presented do not justify the risks taken, barring significant mitigation of the primary risk factors such as the exit cap rate and rent and occupancy levels.

VI. Conclusions

The SERM corrects serious shortcomings in the DCF methodology for evaluating risk in real estate development projects by incorporating stochastic tools for the

	%
Downside risk (DR)	2,211.66
Return per unit of risk	0.012080
Risk-adjusted return	0.000032
Excess return above R-F rate (SERM ERR)	− 2.85365
SERM required rate of return (SERM MAR)	79.44

Table XI. SERM analysis summary

measurement of the universe of outcomes. It further serves to condense the output of Monte Carlo simulations into a simple metric that can generally understood and applied by practitioners for making decisions concerning funding projects. Additionally, key profitability drivers are identified to be market vacancy, capitalization rate and construction debt interest, with rent, construction cost and project schedule being functions of market vacancy.

Notes

1. Modeling variable durations of the phases of a project using spreadsheet software can be challenging. An acceptable approximation is the use of the Microsoft Excel XNPV function that computes NPVs for cash flows that do not follow a regular periodic pattern. However, such a model at best an approximation because it only captures the changes due to the time value of money and does nothing to account for additional debt service expenses that occur because of extended construction and stabilization periods. An alternative method, detailed in the case study to be published, utilizes a complex algorithm for adjusting calendar cash flows based on variable project duration.
2. Tornado analysis was performed with the use of the Dartmouth Sensitivity Toolkit, available at http://mba.tuck.dartmouth.edu/toolkit/index.html
3. Figure 3 data and chart courtesy of the San Francisco office of Cornish & Carey Commercial.
4. This is not the only extraordinary risk that may impact outcomes. For instance, the current tenant may terminate early, or adverse market conditions may manifest themselves during early stages of construction. Such eventualities would be analogous to the delay of construction commencement but without the attendant extension of cash flow. The materiality of the interim cash flows would dictate whether such a case would require inclusion in simulation. Additionally, the entitlement period here assumed to be fixed may in fact vary, requiring an additional delay factor.
5. See above for information on the use of triangular vs beta distribution.
6. Simulation for the case study was performed with the use of ExcelSim2003 (Mayes, 2003), a Microsoft Excel add-in simulation engine intended for academic use. The specific characteristic of this engine necessitated the use of triangular distributions in simulation of highly skewed sample populations. Analysis of the data suggests that in practical application a more accurate picture may be obtained with the use of Beta distributions in preference; nevertheless, triangular distributions offered sufficient accuracy for the purposes of this paper.

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