

Building an Expansion (Real) Option for a Hospital Under Construction

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Constructors have "construction options" that they can and should present to Developers. The construction literature on real options focuses on infrastructure with research on toll roads, highways and parking structures thereby overlooking commercial and residential development.
Large buildings, especially technologically innovative facilities such as hospitals, are very expensive when built according to original plans. Concerns surrounding financial viability can exist with overextending a corporation to build the largest facility possible to take advantage of acquired land. Therefore having an option to construct a smaller building that can be expanded later on is a valuable option. This flexibility exists and is explored in this paper. After all, like a financial option, a real option also has a strike price. In this case, the strike price involves added HVAC connections, larger pipes (water, sewage, and vacuum tubes), enlarged electricity circuits, room for expansion of Ethernet cables and other technology, and space for an additional power generator for the hospital micro grid to ensure power reliability. Using this real option analysis we can produce value while minimizing investment today to ensure the financial viability of the hospital corporation.

Key Words: Real Options, Hospital Expansion, Construction, Binomial Models, Design Build

Introduction

A hospital is a major construction project consisting of a very large, dedicated building and unlike a commercial building shell, it requires pre-planning of dedicated rooms for reception, intensive/emergency care, operations, wardrooms, examinations, as well as significant specialized machinery and technology, among others for the specialized caring of unique patients. Once constructed, a hospital is a very unique building that is irreversible, as it cannot be easily converted to a hotel, apartment building, condo, or office structure. Further, do to technological innovation and changing demographics, the owners may find that there is demand for increased space and future expansion. Similar to a financial option, a real option has a strike price or investment cost that needs to be considered. As with a financial option, the investment gives owners the time to choose to make an investment. In the case of a financial option, the purchaser has the right to acquire the stocks or commodities. In the case of a building, a real option offers the right to expand or change the purpose of the building at some time in the future. In the case of a building, to allow the prospect of future expansion requires an initial upfront investment in the form of an enhanced foundation, structural, electrical and HVAC among other items as well as planning the future requirements of the facility incorporated in the design. This initial cost or upfront premium increases the flexibility to expand whenever needed. Traditional valuation methods using discounted cash flow analyses will not value flexibility (Trigeorgis 1996). The value of expansion both vertically and horizontally are not appreciated as a valuable real option in real estate development (Guma et al, 2009). Furthermore, books on flexible architecture appear to ignore this possibility (Kronenburg, 2007).

The remainder of this paper is divided into the following sections. Section 2 reviews the literature on real options and capacity expansion. Section 3 illustrates an expansion option for a recently constructed hospital in the greater Denver area. The final section presents the concluding remarks.

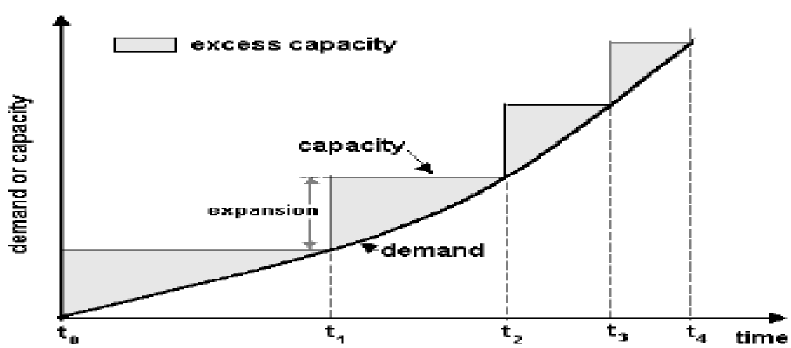
Literature Review

Expanding Capacity

The ability to expand capacity involves the capability to add facilities, space or size over time to meet increased demand (Manne, 1961; Freidenfelds, 1980, 1981), this process is simple when additional land exists. Increasing capacity is a capital investment decision, one not taken lightly in business, and requiring significant foresight to ensure that the individual expansions taken are made using the correct forecasts for demand. Since the era of the 1960s there has been a large amount of research undertaken to examine the problem of expanding capacity (Manne, 1961; Freidenfelds, 1980, 1981; Luss, 1982, Lieberman, 1989, Higle & Corrado, 1992; Bean *et al.*, 1992; Li & Tirupati, 1994; Souza, 1996). As expansions involve not only the physical space but more importantly, decisions are made based on time horizons, and timing can be everything for a product or service. Additional capacity provides added economies or efficiencies to scale, as a larger facility, in general, allows for more efficient operation than two smaller facilities even if they are side by side. With regards to a hospital, a large, modern, efficient hospital that can quickly treat a patient for any condition is much more efficient than multiple small buildings in a hospital complex, especially for urgent care and emergencies.

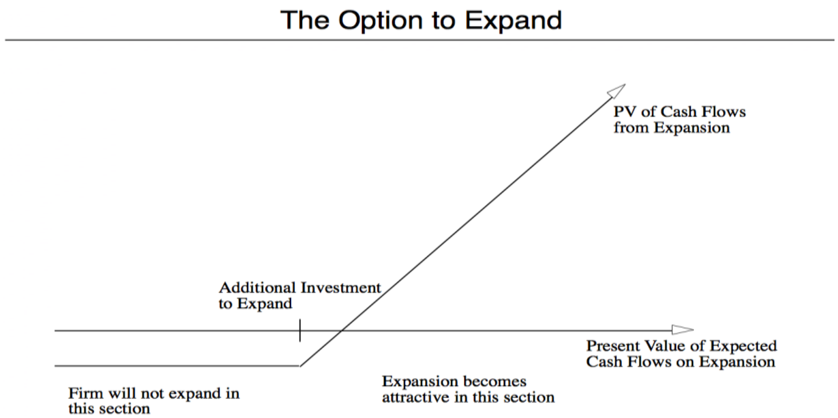
As demonstrated by Figure 1, continuously rising demand (from increased population, as an example), assuming demand backlog is not allowed, would require added capacity to be built ahead of time. The question becomes one of timing and finding an optimal tradeoff between capacity expansions and saving interest expense on capital costs.

Figure 1 – Excess Capacity in an Expanding World



The resulting tradeoff between the cost of excess capacity and the scaling for efficiencies by its nature needs to lead to a compromise (an ability to expand a building once at an optimal time in the future to be determined by demand). The literature has grown beyond size and timing of expansions to include alternative locations of the facilities and/or facility types (Luss, 1982; Fong & Srinivasan, 1986; Dixit & Pindyck, 1994; Souza, 1996). A future expansion should only be undertaken when it has a positive NPV, as shown in Figure 2.

Figure 2: Undertaking Expansions, Positive NPV Needed



This article examines Manne's (1961) expansion problem, which was extended by Srinivasan (1967), Freidenfelds (1980, 1981), Lieberman (1989), and Bean *et al*. (1992), with further examination in Guma *et al*. (2009), Throupe *et al.* (2012) and Sewalk and Dai (2014). Figure 1 allowed us to present the problem generally, if demand is growing and the cost of facilities is dependent on sizing, when does the optimal expansion exist? Using a linear demand function, Manne (1961), demonstrated that using Bachelier-Wiener diffusion process to represent demand, it was possible to tie this to a reduction in the discounting interest rate. Srinivasan (1967) showed it was possible to extend this for geometric growth rates. While Freidenfelds (1980) replaced forecasted demand with different demand levels. Allowing Bean *et al.* (1992) to generalize the processes under which the "equivalent interest rate" approach applies. Surprisingly, by 2001 few studies had been conducted to examine the application of the real option theory to actual construction projects in the realm of commercial real estate (Lucius, 2001). Guma *et al.* (2009) interestingly enough noted that the industry appears to use this process, but did not quantify or value the process. Throupe *et al.* (2012) proceeded to examine a mixed-use real estate development and valued the process of switching an apartment complex into a mixed apartment and hotel complex. Most research in real option expansion possibilities takes place in the manufacturing or extractive industries (oil, gas, minerals) and as such the assumption is that additional facilities can be added as needed.

In commercial real estate, the ability to expand is limited by the usage of the actual facility and the investment to make the expansion occur. Therefore, the ability to expand a project, typically a building, in a horizontal or vertical manner is limited to a one-time expansion. On the other hand, infrastructure projects, such as airports, bridges, highways, and others can be expanded multiple times.

Real Options and Expansion Possibilities

Real options allow corporations to proactively develop strategic flexibility to recognize and capture values hidden in dynamic project uncertainties (Ford *et al*. 2002). These dynamic investment strategies include the options to wait, exit, expand, switch, and improve, among others. Throupe *et al*. (2012) demonstrated how it is possible to increase flexibility in a built apartment complex by developing an output switch allowing a portion of the building to be converted into a hotel. In a hospital expansion, that ability to switch does not exist. Instead, real options offer a quantifiable path to address expansion scenario planning. In the case of a hospital expansion, it is the mechanical, electrical, and plumbing systems that function as the hard asset on which the investment, ie, expansion analysis, decision is based. In a hospital the expansion analysis will be bracketed by two additional parameters not as rigidly adhered to in other commercial construction, those parameters are patient safety and the continued push to reduce energy consumption. According to Ronald G. Holdaway, PE, author of the latest edition of the *Mechanical Systems Handbook*. "Forty-two percent of energy used in hospitals is spent on reheating air." As any hospital expansion is being considered, the percentage of energy spent reheating air must be carefully considered. Currently, the push to reduce energy use can trace its influence to the Energy Policy Act of 2005, and the Energy Independence and Security Act of 2007 (EISA), however; the true motivation boils down to the sensibility of saving dollars.

Hospitals are required to have fully ducted supply air and return air systems. There are areas such as OR suites and exam rooms that require their spaces be positively pressurized in relationship to adjacent areas and areas that are considered highly infective such as isolation rooms for tuberculosis patients that will be negatively pressurized. These fully ducted air systems are labor intensive to both fabricate and install. In addition, these ducted air systems must be installed by qualified craftsmen. An analysis may provide the data to fabricate, install, and cap off these air ducts for future growth. A cost savings may be realized as both labor and the energy used to produce this galvanized steel product increase. The pressurization conversation is fueling the examination between conventional recirculating air systems and 100% outside air systems. There exists only a relatively small amount of research and empirical evidence related to the transmission of airborne infectious disease through the Heating Ventilation and Air Conditioning (HVAC) system. There is however a growing number of health care mechanical designers that are leaning towards 100% outside air systems when appropriately coupled with forward thinking technology offering significant benefits for both safety and cost savings. Real option offers the stake holders an opportunity to potentially quantify those benefits. In examining the market conditions, the central Air Handling Unit (AHU) will be scrutinized. Undesirable organisms could potentially thrive where there is moisture build up such as in the AHU. A real option may be to replace the coils and potentially add UV lights to assist in the cleanliness and aid in heat transfer. Side stream separator systems such as copper-silver-ionization are definite upgrades and assist the ongoing fight with Legionellosis which can spread through the mist of air conditioning units in large buildings. Biomass boiler and cogeneration of electricity and steam have potential expansion possibilities. The Leadership in Energy and Environmental Design (LEED) and its pursuit for targeted points has offered additional avenues and strategies for mechanical designers to continue to strive for more efficient alternatives and potential cost savings for the once overlooked wistfulness of hospitals. The risk is that irreversible investments, such as hospital expansions, require a higher level of expected returns because once the assets are in place, the investment simply cannot be reversed without the loss of most of its value. Valuing a real option requires that all of the potential scenarios where exercising the option is favorable, are valued. The challenge is that this process becomes non-trivial once multiple options and multiple periods are involved. For valuing real options, two major approaches have been proposed - the lattice approach by Hull and White (1993) and the Monte Carlo simulation (Hull, 1999).

Construction Options

The future expansion capability gives the hospital a real option that may be exercised at any time or never. It allows a smaller hospital to be built and delivered more quickly to the marketplace and at a significant cost savings which thereby lowers the cost of financing for the hospital. For those hospitals that currently exist and are not new ground up projects a first step could be the expansion of the Central Utility Plant (CUP). That change could entail changing primary/secondary chilled water systems to primary pumping only in addition to upgrading the control and efficiency of the CUP. Other possibilities could include additional features such as optimized chilled water and condenser water temperature, sensible and latent chilled water plants, heat recovery chillers, and geothermal applications. Each hospital is unique and provides the mechanical designer an opportunity to present the stakeholders an à la cart approach to equipment matching for maximizing the efficiency impact and minimizing the cost impact. The boilers can be designed to produce distributed steam and optimized hot water temperatures. It is standard that any stored water be held at a minimum of 140°F. The boilers can be sized to integrate with heat recovery chillers. There are even geothermal application possibilities. Other considerations would include potential plumbing needs. If the hospital is “futured”, is the current oxygen farm and its delivery mechanisms adequate? A consideration that may be much less obvious is the electrical system required for expansion. During the real options analysis, an exploration of any potential new high technology equipment needs to be ensured for electrical fit and verified that the Uninterruptable Power Supply (UPS) is adequate. There will be redundancy so the generator sizing is critical. The National Electrical Code (NEC) is considered to be conservative with its requirements for the range that most systems perform. Because of this, hospitals rarely ever operate near their calculated demand loads. Using these calculations as a template, the generator can be oversized. A standard accepted supposition is that generators run better under loads of at least 50% of their provided electrical information. It has been recommended that paralleling (2) or more smaller generators could be a more sensible resolution. The real options process has resulted in the construction industry more readily developing and owners more readily accepting real options within the industry in order to construct an affordable building today, while leaving open the option to change, alter or expand the building in the future. This real option also has a place in the hospital expansion industry.

Static NPV

Traditionally Net Present Value (NPV) makes the assumption that an investment begins immediately and the cash flows are discounted to the present avoiding any flexibility that management may have to make a decision in time to expand, contract, abandon, stage or defer. The stream of cash flows takes into consideration the interest rate, the initial investment and the life of the project to arrive at a return to investment.

In this paper we use the example of St. Anthony's Hospital that was built in the city of Lakewood, Colorado. The data regarding the hospital's occupancy was acquired from the American Hospital Association. In 2011, occupancy was 60%, this increased to 65% by 2012, reached 69% in 2013 and was projected to hit 72% in 2014 and around 74% in 2015. The purpose of this paper is to explain the methodology used in construction to examine the key issues that need to be addressed during the process of building the hospital to incorporate the expansion option. However, to then explain this approach we do incorporate the model from Sewalk and Dai (2014) wherein we show that the growth in the occupancy rate at the hospital can be used to determine the optimal time to launch the expansion process. And in this case 3 different paths are followed, one considering slow growth, medium growth and fast growth. Even though as a non-profit St. Anthony has access to the capital market at an interest rate of 3.15% and was able to raise funding from foundations, private donations and the government, the capital investment in a hospital is significant and postponing the expenditure of several hundred million dollars provides significant savings to make an expansion option a realistic decision provided building design can accommodate the expansion.

Method

Our Model: Binomial lattice model and American style option

We use the multiplicative binomial approach by Cox et al. (1979) using discrete time and the standard tools of option pricing. The simplest of option pricing formulas according to Elton and Gruber (1995) is the binomial approach, of course we want an option that can be exercised at any time and therefore choose the American option, as the European option can only be exercised at the end of its life. However, we note that as this is construction, the ability to expand a building, particularly vertically may be constrained to perhaps 20 years and use this as an expiration timeframe. Expansion beyond this time frame may be logistically possible, but we assume that it would require greater analysis and possibly investment such as structural and foundation integrity which we did not want to examine for this article.

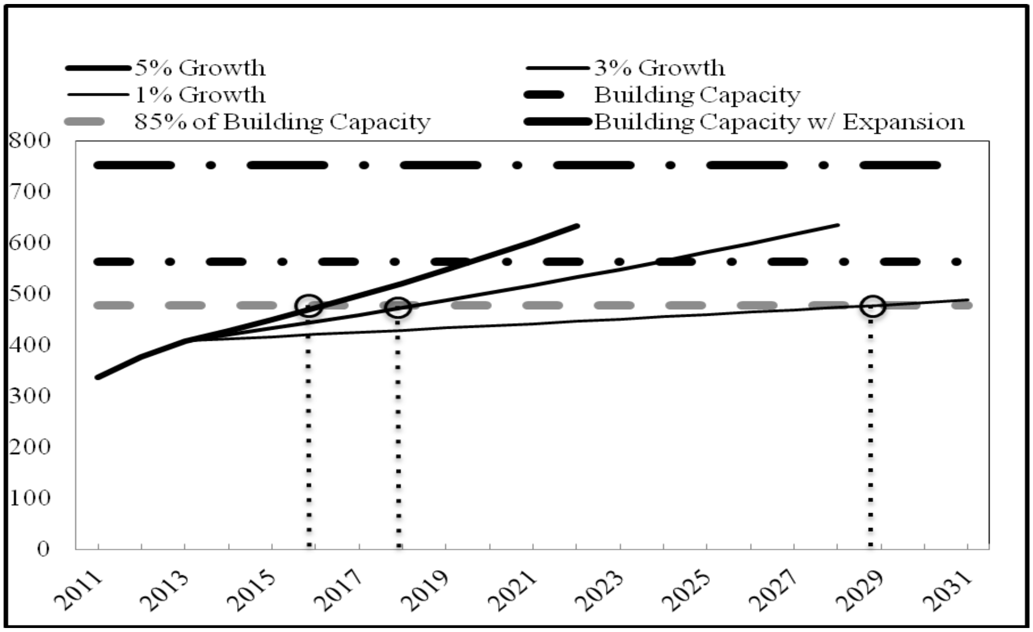
The model herein incorporated a cost of approximately \$6 million that needed to be invested to allow the building to expand in a seamless manner, meaning all building functions, such as HVAC, chilled water, multiple gas lines, structural integrity, electricity and lighting, walkways, among others would work together and be integrated. We assumed that at 85% occupancy, expansion would want to take place as hospitals tend to incur significantly more errors in processing patients as the occupancy rate rises above this level. The timing of 22 months was an estimate in terms of construction time for the expansion. Therefore, a future expansion would need to take place 22 months before the 85% level was reached. The value at 85% occupancy is P(o), post expansion the value is P(E), the expansion construction and facilities costs is C(E) or \$186.4 million. The American Call option formula is:

Equation 1: Expansion Option Valuation Formula - $V(RO) = \max(P(E) - P(o) - C(E), 0)$

Results

The American Call Option was calculated using a binomial tree based on industry knowledge as well as data from GE Johnson (the constructor) and Centura Health (the owner). Using occupancy as a basis and the projected rates of occupancy three growth models were calculated: slow or less than the growth in population (1% annually), medium (3% annually) and fast (5% annually) closely tracking the aging Colorado population. The result is Figure 3.

Figure 3: Decision Points to Expand



Source: AHA and Our Projections for Bed Occupancy and Projected Revenue Trends.

St, Anthony Hospital opened in July 2010 with 563 beds. As noted above the hospital industry uses 85% bed-occupancy rate as the point at which the ability for a hospital to function safely and effectively is called into question. Occupancy rates higher than this are associated with greater risks to patients of hospital-associated infections and have a negative impact on staff health (Keegan, 2010).

Applying 1% annual growth rate, St. Anthony Hospital reaches the 85% threshold in October 2028. Construction needs to begin December 2026, taking 22 months into consideration. At 3% growth rate, 85% occupancy is reached January 2018, construction needed to start March 2016 (this did not happen). Applying 5% annual growth implied the 85% threshold was reached December 2015 (this did not happen, assuming it had, construction would have begun February 2014). Centura projects growth will continue to slow after the rapid increase in usage from first opening, growth seems to be around 1.8-2.4% and this implies an expansion possibly occurring in the early 2020s.

Discussion

Binomial models provide constructors and owners with a method to consider and therefore value real options. The challenge for a binomial model is the estimate of the variance is biased downward and one restriction is required for stability (Lander and Pinches, 1998). A binomial model is more intuitive than continuous-time models and require less mathematical and modeling skills to develop and use. However, corporate managers and practitioners generally have had little experience with binomial models and how to apply them. This implies that construction management programs should consider teaching these skills as it seems that neither construction managers, corporate managers, nor developers intuitively understand valuing options as if investors are risk-neutral and using risk-neutral probabilities (Lander and Pinches, 1998). As construction research it is necessary to also discuss the issues pertinent to the construction process, as the capacity to expand a physical project requires not just financial models but construction insights and designing the expansion into the original facility. A facility without this planning would cost significantly more to expand than a facility where this planning occurs ahead of time. As minimum air changes, minimum outside air requirements, and the capability to maintain specific humidity levels are unique to hospital HVAC systems, there are considerations to be addressed in the overall mechanical system intent. Mechanical systems in health care facilities are regulated by standards established by a number of organizations, including the Facilities Guidelines Institute, American Society for Healthcare Engineering (ASHE), the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the American National Standards

Institute(ANSI), the National Fire Protection Association (NFPA) National Electrical Code(NEC); Health Care Facilities Code; Standard for Emergency and Standby Power Systems; Standard on Stored Electrical Energy Emergency and Standby Power Systems, and others. All of which have to be addressed in the mechanical design. Real options offers the owner an opportunity to maximize the current funding while capturing an actionable plan for future expansion at a potential discount. Overall, we believe this article adds significant value to the construction management field. Real options provide flexibility by creating future value and allowing owners to achieve significant upfront capital savings and interest expenses by building a smaller structure that can be expanded at a future time. Greater use of real options within construction would encourage investment and diversification within the development while allowing the field of construction to be financially savvy to the owners.

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