Real Options Application Portfolio

Analyzing the impact of developing a regional office for the sales strategy of Metal Forming Technologies.

ABSTRACT

MetalForming Technologies is a New Zealand based entrepreneurial company focusing on the design and production of Light Gauge Steel Framing (LGSF) systems. LGSF is a type of construction material that is gaining worldwide prominence, which explains the firm's global market focus and rapid expansion.

To compete in the international market they have decided to offer a complete vertical solution for framework layout design, which has been very successful in the Australasian region and the Middle East. Their current strategy involves developing a plan to penetrate the US market, where they will define distribution channels and potential business partners.

This application portfolio focuses on the design of a direct sales strategy under different uncertain scenarios. In consequence, the key parameters will be the size and location of the facilities required to service the region with respect to a fluctuating demand for construction products.

We present two alternative methods to evaluate the value of incorporatingbuilding flexibility into the design: (1) we use a decision analysis approach, which allows us to navigate through a range of scenarios. We compare a centralized sales office design (fixed), with the alternative of adding a regional subsidiary to take advantage of potential fluctuations in demand (flexible); (2) the second approach implements an option valuation. This method consists of reformulating the problem to create an option, which estimates the value of running a regional office.

Both analyses expose the value of flexibility in systems with variable input parameters. With flexibility the system can take advantage of excess demand and minimize losses. Flexibility makes projects facing high uncertainties more attractive as it can tackle risks by either containing the losses or converting opportunities into larger profits.

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I. Problem definition

I.1 Background

MetalForming Technologies (MFT) is a New Zealand based entrepreneurial company focusing on the design and production of Light Gauge Steel Framing (LGSF) systems. LGSF is a type of construction material that is gaining prominence worldwide, which explains the firm's global market focus and rapid expansion.

The overall turnover of the company comes from international sales. Their products are present in a broad range of countries: U.S.A., Canada, China, Korea, Caribbean, U.A.E., Australia, New Caledonia, French Polynesia (Tahiti), United Kingdom, Afghanistan, Ghana, Iraq and Europe.

To compete in these markets they have decided to offer a complete vertical solution from framework layout design through automated manufacturing and full product assembly. Their main products are:

- **FrameCAD**™ (LGSF Design Software) which offers a GUI based on standard CAD for ease of use, built in compliance of building standards and integration with more sophisticate CAD solutions to instantly transform architectural designs into framing layouts;[1]

- **SteelFrameMaster**™ (High Precision CadCam LGSF Rollformer) machine that receives the designs from FrameCadTM and offers high levels of manufacturing accuracy, provides broad design flexibility and offers different setups to attain desired manufacturing speed.[1]

Overall, the objective is to provide a comprehensive range of machinery to set up a modern efficient roll forming and sheet metal manufacturing factory and, more recently, a design-to-build service for end customers.

MFT has been extremely successful selling their total solution approach for LGSF, but has mainly focused on the Australasian region and Middle East. Their current strategy involves developing a plan to penetrate the US market, where they will define distribution channels and potential business partners.

This study focuses on a direct sales strategy and evaluates its design considering different scenarios that quantify uncertainty. Therefore, the key design parameters for this approach will be the size and location of the facilities required to service the region.

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[1] Metalforming Technologies website. Available at http://www.steelframemaster.com. Accessed on 12/07/06.

I.2 Cost/Benefit Model

The revenue model of the system is based on the sales of the total solution described before (namely a software and machine bundle).

It is observed that the main customers for this product are construction contractors that provide LGSF manufacturing and installation service to end clients. In order to evaluate alternate designs for the sales strategy, it is assumed that they are concentrated in two main areas separated by a known distance.

In consequence, the cost model for this business will consider a fixed cost (infrastructure lease and human resources' expenditure for the sales team) and a variable cost per sale (travel and fungibles) in order to service both markets.

II. Recognizing Uncertainty

II.1 Salient Uncertainties

As presented in the previous section, the main concern for the sales strategy is the fluctuating demand for construction products. The construction industry is coupled to the overall health of the economy. For this reason, the level of activity in the construction industry follows economic booms and busts.

The housing industry highly depends on inflation. Inflation risk puts increased pressure on the loan and mortgage rates and, therefore, in consumer's ability to pay for new housing. Housing demand also depends on need, which is determined by population growth, migration and net household formations.

Customer's preference for the product can be viewed as a secondary factor that will impact LGSF's demand. The relative value of steel, a substitute for timber in the framing industry, must be assessed to determine the market share. In the short term, product pricing is the main influence of this behavior. Additionally, the other natural factor to determine market share is the presence of competing firms that offer similar products. In the case of MFT, an example of such a company is Nucon Steel with its product NUFrame.

Other factors may impact the scenario in the long run, such as the enforcement of new building standards, building limiting regulations, environmental issues or education on the benefits of using the new technology.

II.2 Characterizing Uncertainty

For simplification, this project will only account for the first component of demand described. The estimate of product demand will be derived from the number of new housing units that will start[2] construction during the next two years.

The US Census Bureau and Steel Framing trade associations are amongst a number of resources that provide historical construction data. Construction information for *new residential housing* in the United States has been selected[3]. Specifically, the data has been gathered from the Midwest and Northeast regions since they are currently the most attractive market for LGSF.

This portfolio will present an estimation of housing starts in the Northeast for the purposes of discussion. Its historical trend by quarters for the last six years denotes a very clear cyclic pattern. This behavior will be used to estimate the forecast by adjusting a sine function to the historical trend and adding a factor for volatility. The

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[2] A start is defined as excavation (ground breaking) for the footings or foundation of a residential structure. For a multifamily structure, all units are counted as started when the structure is started.

[3] Includes Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey & Pennsylvania

next step is to correlate the forecast of total housing units being constructed with the product demand. Both these analysis are presented in the following section.

II.3 Uncertainty Metrics

Modeling Uncertainty

The estimation of product demand is based upon the historical trend of new privately owned housing units started in the Northeast of the US. The following table presents the number of units started by quarter since the year 2000.

Table 1. New privately owned housing units started in the Northeast (Estimations in yellow)

QUARTERLY DATA	Housing Units *(in thousands)*	Annual Average *(in thousands)*	Forecast
2000: 1st quarter	22.0	29.8	23.1
2nd quarter	34.0	29.8	29.8
3rd quarter	33.0	29.8	36.4
4th quarter	30.0	29.8	29.8
2001: 1st quarter	19.0	27.8	21.1
2nd quarter	31.0	27.8	27.8
3rd quarter	34.0	27.8	34.4
4th quarter	27.0	27.8	27.8
2002: 1st quarter	23.0	29.5	22.9
2nd quarter	35.0	29.5	29.5
3rd quarter	32.0	29.5	36.1
4th quarter	28.0	29.5	29.5
2003: 1st quarter	19.0	29.0	22.4
2nd quarter	34.0	29.0	29.0
3rd quarter	33.0	29.0	35.6
4th quarter	30.0	29.0	29.0
2004: 1st quarter	22.0	31.8	25.1
2nd quarter	39.0	31.8	31.8
3rd quarter	35.0	31.8	38.4
4th quarter	31.0	31.8	31.8
2005: 1st quarter	25.0	34.5	27.9
2nd quarter	40.0	34.5	34.5
3rd quarter	40.0	34.5	41.1
4th quarter	33.0	34.5	34.5
2006: 1st quarter	26.0	34.0	27.4
2nd quarter	35.0	34.0	34.0
3rd quarter	42.7	34.0	40.7
4th quarter	32.4	34.0	34.0
2007: 1st quarter	24.2	23.0	16.4
2nd quarter	28.7	23.0	23.0
3rd quarter	15.3	23.0	29.7
4th quarter	24.0	23.0	23.0
2008: 1st quarter	35.1	33.2	26.5
2nd quarter	33.8	33.2	33.2
3rd quarter	20.6	33.2	39.8
4th quarter	43.1	33.2	33.2

Source: "Quarterly Starts and Conclusions by Purpose and Design for New Residential Housing", US Census Bureau, Manufacturing, Mining and Construction Statistics. Available at http://www.census.gov/const/www/newresconstindex.html. Accessed on 10/18/2006.

Over the 2nd quarter of 2006, data was estimated using Data Tables and the *RAND()* function in MS Excel™, the historical mean and a volatility of 50%[4]. The following formula sums up the idea:

*Forecast of quarterly housing starts = H_MEAN * ((1-VOL)+2*VOL*RAND())*

The results were tested to see if housing starts can be modeled for future reference. A cyclic trend is clearly visible when plotting the historical information (Figure 1). This is expected for the housing industry, since construction tends to concentrate in the summer. One way to estimate the behavior of the data is to fit a sine function with the annual mean and historical standard deviation as parameters:

*Model of quarterly housing starts = ANNUAL_AVG + STD_DEV * SIN (QUARTER)*

This function was added as a column in Table 1 under "Forecast" and the result is plotted in Figure 1:

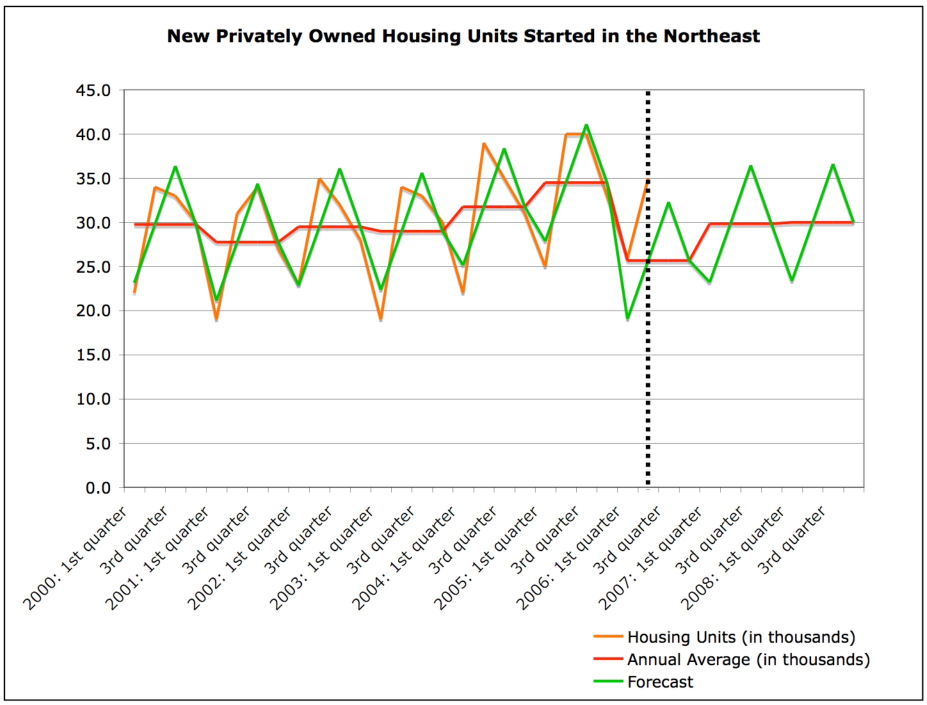

Figure 1. In red, the Annual Average of started Housing Units. In Orange, quarterly numbers up to the 2nd quarter of 2006. In Green, the fitted function and its forecast up to 2008.

[4] This volatility is estimated using 2.5 standard deviations of the historical sample, which according to Chebyshev's inequality includes 84% of the values. This equation states that $(1-1/k^2)$ of the values are within k standard deviations of the mean and it is used when the distribution of the data is unknown. Source: Wikipedia. Available at: http://en.wikipedia.org/wiki/Standard_deviation. Accessed on 12/07/06.

Estimating product demand

The last step is to find a correlation between housing starts and the product demand. New residential units in the region have an average floor of 2,500 sq-feet, as indicated by the US Census Bureau data previously cited. Then, in order to transform housing units into monetary terms, an average framing cost of 7.6 $\$/ft^2$ will be used (as suggested in a Report by the US Department of Housing and Urban Development[5]). This parameter includes all material cost but excludes the builder's labor cost, as the manufacturer may not necessarily be the building contractor.

The resulting potential demand for framing is represented by the equation below:

Framing Potential Demand $= (2{,}500\ ft^2 * 7{,}6\$/ft^2) *$ *Housing Units Started*

*Framing Potential Demand = ($19,000) * Housing Units Started*

According to the Steel Framing Alliance, an important trade association in the sector, only about 1.5 % of the US Housing market currently uses steel for framing. Therefore:

*Steel Framing Potential Demand = (1.5% * $19,000) * Housing Units Started*

*Steel Framing Potential Demand = ($950) * Housing Units Started*

To estimate the actual product demand based on the potential market for Steel Framing, the market share needs to be determined. It should take into account the productivity and cost for each new product bundle, equipment replacement rates and availability of substitute products. It is assumed that only 0.2% of this projection will be transformed into actual sales. This is expressed by the final equation for estimating product demand:

*LGSF Demand = (0.5% * $950) * Housing Units Started*

LGSF Demand = ($4.75) * Housing Units Started

[5] "Steel vs. Wood – Cost Comparison", US Department of Housing and Urban Development, Office of Policy Development and Research (January 2002).

III. Two-Stage Decision Analysis for Alternative Designs

III.1 System Designs

The firm's objective is to service customers in the northern United States and, for this purpose, they have segmented the market into two zones: Northeast and Midwest. Both areas are comparable by Gross Domestic Product (GDP) - around US $2,500 billion, although the Midwest States' have a larger percentage of that GDP coming from its Construction industry (4.4% against 3.9% in the Northeast – from Table 2). Moreover, housing starts in the Midwest where 356,917 for 2005, almost double than in the other region (189,417). This statistics are presented in Table 2.

Table 2. Statistics for the Northeast and Midwest regions.

Region	Total GDP 2005 (MMU$)	Construction in 2005 (MMU$)	Percent change in real gross state product 2004-2005	Percentage change in Construction 2004-2005	Housing Starts (thousands of units)
NORTHEAST	**2,564,523**	**99,775**	**2.5**	**-0.02**	**189.417**
MIDWEST	**2,627,823**	**115,921**	**1.6**	**-0.08**	**356.917**

Source: US Department of Commerce. Bureau of Economic Analysis. *News Release 10/26/06* (BEA 06-47)

Northeast includes: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey & Pennsylvania.

Midwest includes: Illinois, Indiana, Michigan, Ohio, Wisconsin, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota

As previously discussed, the basic design variable is the location of the sales headquarters that will service both regions under an uncertain demand forecast. The alternative designs are now introduced:

Fixed Design

In the base case, the design considers headquarters to be located in the Midwest region from which sales efforts for both regions will be conducted. This determines that the company will incur in a two-year lease contract for an office capable of hosting the entire sales force. The fixed cost for the implementation of this design takes advantage of the economies of scale of a larger office and its cost is calculated to be US $1,400,000.

The firm has also estimated an average cost per sale that considers the whole life cycle of the transaction, including all the necessary visits to each potential customer. In the base case, this cost is determined to be 20% of the total benefits for transaction in the Midwest region and 50% for sales in the Northeast. The latter is higher due to a greater distance to the customers and a lower presence in the market. This fact is also responsible for a 25% decrease in demand expectations for the Northeast region.

Flexible Design

The flexible design considers the implementation of smaller headquarters in the Midwest and a regional office to service the Northeast area. The lease for the headquarters remains under the same contractual terms as in the base case, but for the regional office a flexible one-year renewable contract is chosen. Under these circumstances, the fixed cost of this alternative is calculated to be US $1,000,000 for the Midwest region and US $700,000 for the Northeast area.

This alternative design affects the average cost per sale in both locations. The revised cost for the Midwest is now 25% of the total benefits, a 5% increase due to a larger administrative/sales people ratio in the now smaller headquarters. The revised cost for the Northeast is cut in half, due to market proximity and augmented brand presence (25%). The regional office also allows capturing total demand expectations for the market.

III.2 Two-Stage Decision Analysis

After describing the main characteristics of the alternative designs, it is time to review the optimal strategy that results from this problem definition.

The first thing we have to do is recall that the benefits of the firm are a factor of the number of housing starts in each region, as in:

*LGSF Demand = ($4.75) * Housing Units Started*

For this reason, the key factor to be determined is the number of housing starts (HS) for the different scenarios to be analyzed. First, the different settings need to be defined and their respective probabilities must be assigned.

First Stage

(H, H): High level of activity in the Midwest, high level in the Northeast (p=0.2)

(H, L): High level of activity in the Midwest, low level in the Northeast (p=0.3)

(L, H): Low level of activity in the Midwest, high level in the Northeast (p=0.3)

(L, L): Low level of activity in the Midwest, low level in the Northeast (p=0.2)

Second Stage

After the first stage's outcome, the flexible scenario encompasses a decision: to maintain the regional office running or to close it down. Closing it down would prevail any new business in the Northeast from occurring during that year.

The scenarios in the second stage are only dependent on the level of activity in the Northeast (even chance), since it is assumed that the Midwest will maintain the same level of activity shown in the previous stage. Therefore, the conditional probabilities for the second stage are:

(H,H/H,H):	High level of activity in the Northeast, given (H,H)	(p=0.5)
(H,L/H,H):	Low level of activity in the Northeast, given (H,H)	(p=0.5)
(H,H/H,L):	High level of activity in the Northeast, given (H,L)	(p=0.5)
(H,L/H,L):	Low level of activity in the Northeast, given (H,L)	(p=0.5)
(L,H/L,H):	High level of activity in the Northeast, given (L,H)	(p=0.5)
(L,L/L,H):	Low level of activity in the Northeast, given (L,H)	(p=0.5)
(L,H/L,L):	High level of activity in the Northeast, given (L,L)	(p=0.5)
(L,L/L,L):	Low level of activity in the Northeast, given (L,L)	(p=0.5)

Optimal strategy

The decision analysis approach will be used to study all the possible outcomes for the scenarios involved. Its methodology establishes the use of a decision tree to determine the best strategy (Figure 2). The following table presents the results from which the tree is derived:

Table 3. Cost/Benefit models for the alternative designs in all the scenarios.

FIXED DESIGN		Low MW Low NE	Low MW High NE	High MW Low NE	High MW High NE
Demand	MW	178.5	178.5	535.5	535.5
	NE	70.9	212.6	70.9	212.6
Benefits	MW	847.9	847.9	2543.6	2543.6
	NE	336.7	1010.0	336.7	1010.0
Fixed cost	MW	1400.0	1400.0	1400.0	1400.0
	NE	0.0	0.0	0.0	0.0
Variable cost	MW	169.6	169.6	508.7	508.7
	NE	168.3	505.0	168.3	505.0
Net Benefits	MW	-721.7	-721.7	634.9	634.9
	NE	168.3	505.0	168.3	505.0
Net Benefits	**Total**	**-553.4**	**-216.7**	**803.2**	**1139.9**

FLEXIBLE DESIGN		Low MW Low NE	Low MW High NE	High MW Low NE	High MW High NE
Demand	MW	178.5	178.5	535.5	535.5
	NE	94.5	283.5	94.5	283.5
Benefits	MW	847.9	847.9	2543.6	2543.6
	NE	448.9	1346.6	448.9	1346.6
Fixed cost	MW	1000.0	1000.0	1000.0	1000.0
	NE	700.0	700.0	700.0	700.0
Variable cost	MW	212.0	212.0	635.9	635.9
	NE	112.2	336.7	112.2	336.7
Net Benefits	MW	-364.1	-364.1	907.7	907.7
	NE	-363.3	310.0	-363.3	310.0
Net Benefits	**Total**	**-727.4**	**-54.1**	**544.4**	**1217.7**

Initial demands for both scenarios were calculated considering the number of housing starts in 2005 for both regions and assuming low (50%) and high (150%) situations (**Source**: U.S. Bureau of the Census, Construction Reports, Series C-20, Housing Starts. Prepared by Economics Department, NAHB. Available at www.HousingEconomics.com)

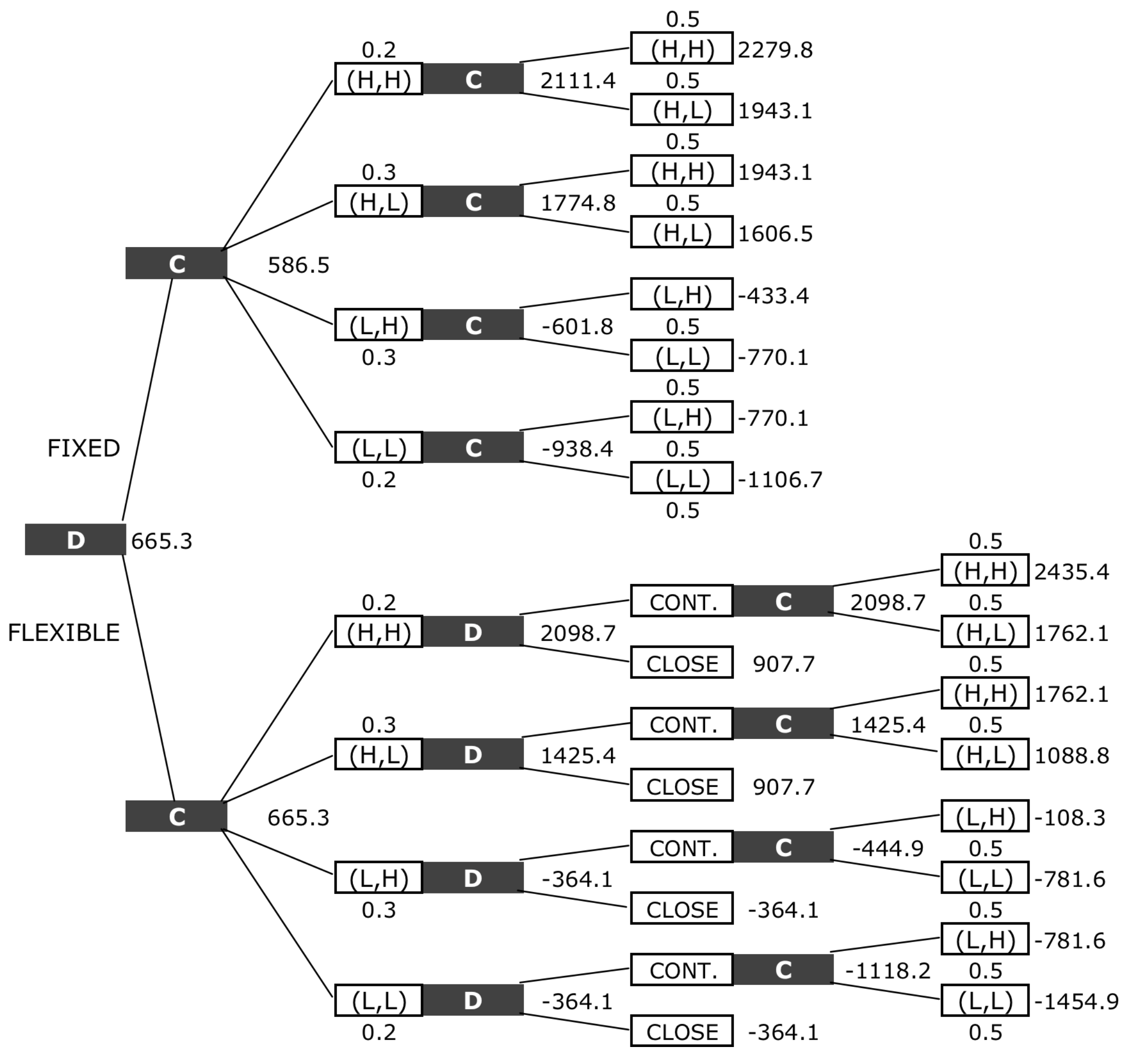

Figure 2. Decision tree for the design alternatives.

Each possible outcome is analyzed and after the first stage the decision is made to continue/close the regional office in the flexible design. The optimal strategy results from calculating the expected values for all the branches. For illustration purposes, values from the second stage are not discounted. The decision analysis determines that the optimal strategy is choosing the path of the flexible design for an EV=US $ 665,300.

The decision to continue/close the regional offices is heavily influenced by the level of activity in the Midwest during the first stage. For a high level of activity the choice is to keep the regional office running and for a low level of activity the choice is to close it.

III.3 Sensitivity Analysis

The two-stage decision analysis previously described is build upon a set of defined scenarios with corresponding probability of occurrence. Since these probabilities were not inferred from any historical data, it is beneficial for the current discussion to perform a sensitivity analysis on them.

The procedure is conducted using a two-dimensional data table in MS Excel, which defines two variables:

1) The probability of cases (H,L) (L,H) in stage 1, which are balanced scenarios compared to the extreme scenarios (H,H) (L,L) and is included as columns.
2) The probability that in the second stage the level of activity in the Northeast is high (H,H) (L,H), which is included as rows.

As expected, changing these variables affect the expected value of the decision analysis. This can be appreciated in Table 4:

Table 4. Sensitivity analysis on the scenario probabilities

DATA TABLE	STAGE 2 Probability (High)																				
STAGE 1 Probability (balanced)	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
0.00	699.0	715.8	732.7	749.5	766.3	783.1	800.0	816.8	833.6	850.5	867.3	884.1	901.0	917.8	934.6	951.5	968.3	985.1	1002.0	1018.8	1035.6
0.05	682.2	699.0	715.8	732.7	749.5	766.3	783.1	800.0	816.8	833.6	850.5	867.3	884.1	901.5	919.2	936.8	954.5	972.2	989.9	1007.5	1025.2
0.10	665.3	682.2	699.0	715.8	732.7	749.5	766.3	783.1	800.0	816.8	833.6	850.5	867.3	885.2	903.7	922.2	940.7	959.2	977.7	996.3	1014.8
0.15	648.5	665.3	682.2	699.0	715.8	732.7	749.5	766.3	783.1	800.0	816.8	833.6	850.5	868.8	888.2	907.5	926.9	946.3	965.6	985.0	1004.3
0.20	631.7	648.5	665.3	682.2	699.0	715.8	732.7	749.5	766.3	783.1	800.0	816.8	833.6	852.5	872.7	892.9	913.1	933.3	953.5	973.7	993.9
0.25	614.8	631.7	648.5	665.3	682.2	699.0	715.8	732.7	749.5	766.3	783.1	800.0	816.8	836.2	857.2	878.3	899.3	920.3	941.4	962.4	983.5
0.30	598.0	614.8	631.7	648.5	665.3	682.2	699.0	715.8	732.7	749.5	766.3	783.1	800.0	819.8	841.7	863.6	885.5	907.4	929.3	951.1	973.0
0.35	581.2	598.0	614.8	631.7	648.5	665.3	682.2	699.0	715.8	732.7	749.5	766.3	783.1	803.5	826.2	849.0	871.7	894.4	917.1	939.9	962.6
0.40	564.3	581.2	598.0	614.8	631.7	648.5	665.3	682.2	699.0	715.8	732.7	749.5	766.3	787.2	810.8	834.3	857.9	881.4	905.0	928.6	952.1
0.45	547.5	564.3	581.2	598.0	614.8	631.7	648.5	665.3	682.2	699.0	715.8	732.7	749.5	770.9	795.3	819.7	844.1	868.5	892.9	917.3	941.7
0.50	530.7	547.5	564.3	581.2	598.0	614.8	631.7	648.5	665.3	682.2	699.0	715.8	732.7	754.5	779.8	805.0	830.3	855.5	880.8	906.0	931.3
0.55	513.8	530.7	547.5	564.3	581.2	598.0	614.8	631.7	648.5	665.3	682.2	699.0	715.8	738.2	764.3	790.4	816.5	842.6	868.7	894.7	920.8
0.60	497.0	513.8	530.7	547.5	564.3	581.2	598.0	614.8	631.7	648.5	665.3	682.2	699.0	721.9	748.8	775.7	802.7	829.6	856.5	883.5	910.4
0.65	480.2	497.0	513.8	530.7	547.5	564.3	581.2	598.0	614.8	631.7	648.5	665.3	682.2	705.5	733.3	761.1	788.9	816.6	844.4	872.2	900.0
0.70	463.3	480.2	497.0	513.8	530.7	547.5	564.3	581.2	598.0	614.8	631.7	648.5	665.3	689.2	717.8	746.4	775.1	803.7	832.3	860.9	889.5
0.75	446.5	463.3	480.2	497.0	513.8	530.7	547.5	564.3	581.2	598.0	614.8	631.7	648.5	672.9	702.3	731.8	761.3	790.7	820.2	849.6	879.1
0.80	429.7	446.5	463.3	480.2	497.0	513.8	530.7	547.5	564.3	581.2	598.0	614.8	631.7	656.6	686.9	717.2	747.5	777.8	808.1	838.4	868.7
0.85	418.2	435.0	451.9	468.7	485.5	502.3	519.2	536.0	552.8	569.7	586.5	603.3	620.2	640.2	671.4	702.5	733.7	764.8	795.9	827.1	858.2
0.90	418.2	435.0	451.9	468.7	485.5	502.3	519.2	536.0	552.8	569.7	586.5	603.3	620.2	637.0	655.9	687.9	719.9	751.8	783.8	815.8	847.8
0.95	418.2	435.0	451.9	468.7	485.5	502.3	519.2	536.0	552.8	569.7	586.5	603.3	620.2	637.0	653.8	673.2	706.0	738.9	771.7	804.5	837.3
1.00	418.2	435.0	451.9	468.7	485.5	502.3	519.2	536.0	552.8	569.7	586.5	603.3	620.2	637.0	653.8	670.7	692.2	725.9	759.6	793.2	826.9

FLEXIBLE DESIGN FIXED DESIGN

There a few interesting conclusions that can be deduced by observing the data on Table 4, with respect to the result we presented in III.2.

1) First, the flexible design is the preferred choice in a vast range of the resulting scenarios. The expected value increases as the extreme outcomes are weighted more (Probability (balanced) decreases) and stronger activity level in the Northeast leads to a better outcome (Probability (High) increases). The maximum of US $1,035,600 is located in the top right corner of Table 4 and the minimum is US $418,200 located in the bottom left corner of the same table.

2) When the balanced scenarios have a probability of occurrence of over 83.4%, the choice of design changes to fixed. This can be explained due to the fact that flexibility takes advantage of the extreme results produced by volatility. When the probability of balanced scenarios is high the extremes have less weight in the overall result, favoring the fixed design. This means that flexibility is more valuable when there is more uncertainty (i.e. a larger volatility and a bigger difference in the outcome at the extremes)

3) Since this is a call option, the flexibility will kick in to reduce losses in the worst-case scenarios. When looking at the probability of high level of activity in the Northeast (stage 2) it is seen that for values over 62.0% the flexible design starts becoming even more attractive. Eventually, it becomes the only choice. This is actually not due to an additional effect of the flexibility, but because of the cost model in place. When the probability of high is over 62%, the losses in for scenarios (L,H) are so small that are even better than executing the option (i.e closing the office in this case).

IV. Lattice Decision Analysis

IV.1 Demand Estimation Using Lattice

As a conclusion of the Two-Stage Decision Analysis presented before, the strategy represented by the flexible design is more attractive than the fixed one. Given this plan, the impact of the strategy is derived from the demand in the Northeast region. Therefore, it is reasonable to extend the uncertainty analysis on this variable using a binomial lattice model. This methodology allows a broader scenario depiction, thus providing for a better uncertainty assessment.

Recalling previous sections, the demand for LGSF is commanded by housing starts in the region. The following table presents historical data for this index:

Table 5. Housing Starts in the Northeast and Midwest Regions

YEAR	U.S. TOTAL	NORTH EAST	MID WEST
1988	1,488	235	274
1989	1,376	179	266
1990	1,193	131	253
1991	1,014	113	233
1992	1,200	127	288
1993	1,288	126	298
1994	1,457	138	329
1995	1,354	118	290
1996	1,477	132	321
1997	1,474	137	304
1998	1,617	148	330
1999	1,641	156	347
2000	1,569	154	318
2001	1,603	149	330
2002	1,607	158	350
2003	1,848	163	374
2004	1,956	175	356
2005	2,068	190	357

Source: U.S. Bureau of the Census, Construction Reports, Series C-20, Housing Starts. Prepared by Economics Department, NAHB. Available at www.HousingEconomics.com

Given the historical information, we need to determine the demand growth trend as required for the lattice. The forecast demand is modeled by the following equation:

$$y(t) = y_0 \cdot a \cdot e^{rt}$$

where

y(t) : *Forecast*

y_0 : *Housing Starts in 1990*

a : *Scale factor*

r : *Annual Growth rate*

t : *Time interval (year)*

The parameters for this equation were determined by regression analysis, calculating an exponential curve that fits the available data (using the *LOGEST()* function of MS Excel™). The values for 1988 and 1989 were marked as outliers to improve the fit. The resulting formula is given by:

$$y(t) = (131) \cdot (2.8E - 24) \cdot e^{(0.027)t}$$

This represents Housing Starts forecast for the Northeast region and the following figure compares the projection with the real information:

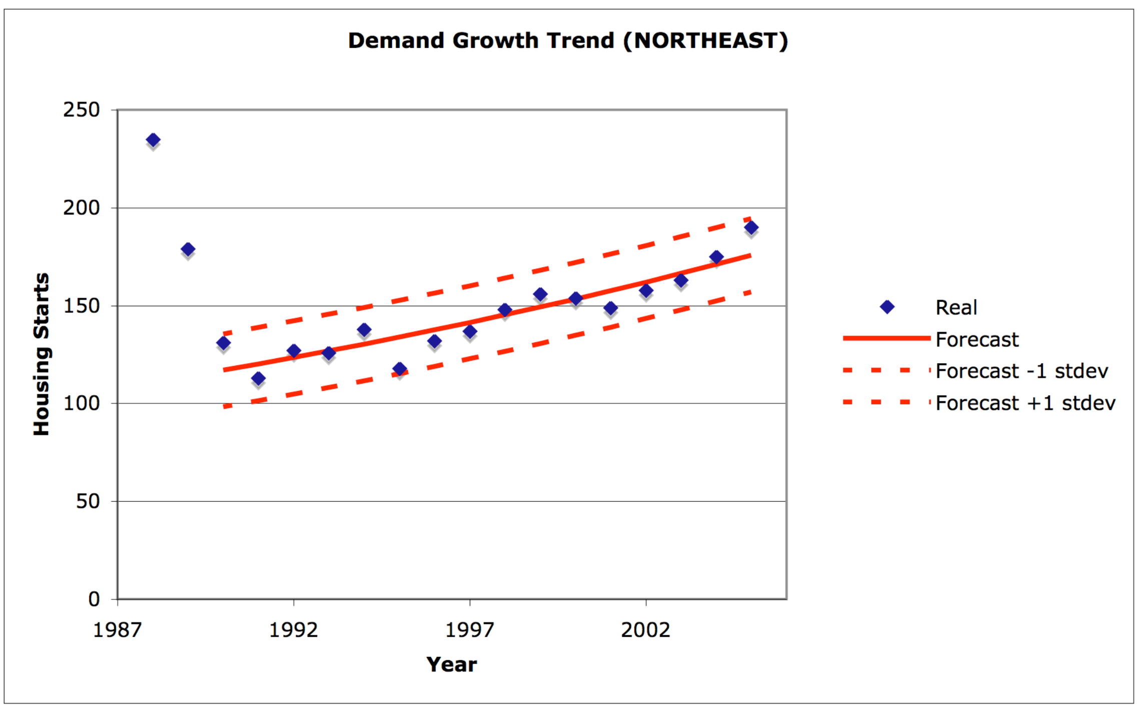

Figure 3. Demand growth trend as determined by the regression analysis

The forecast fits the historical data with an R^2 of 0.921, giving an average (S) of 144.44 Housing Starts per year and a standard deviation (σ) of 18.67 Housing Starts (12.93%). This statistical information is relevant for determining the parameters that will allow us to build the lattice.

The lattice model for this uncertainty is built for a 5-year period, starting at year 2005 and forecasting demand until the year 2010. The necessary parameters are given by the following equations:

$$u = e^{\sigma \sqrt{\Delta t}}$$

$$d = 1/u$$

$$p = 0.5 + 0.5 \cdot \left(\frac{v}{\sigma}\right) \cdot \sqrt{\Delta t}$$

where

u	*: Increment step*
σ	*: Volatility (equals the standard deviation)*
t	*: Time interval (year)*
d	*: Decrement step*
P	*: probability to move to the next state determined by u increment*
v	*: annual growth rate (equals the annual growth rate r)*

By using the values from the forecast and the preceding equations, we can obtain all the required results. We consider that there's a 100% chance to move from state 0 to state 1 in the lattice (*p Start = 1*) and input the starting value for the model as the number of Housing Starts recorded during 2005 in the Northeast (*Value Start = 190*).

Table 6. Input values and parameters for the lattice model

S	144.4
v	0.027
σ	0.129
Δt	1
u	1.138
d	0.879
p	0.605
p Start	1
Value Start	190

The previous results are used to construct the probability lattice, which in turn yields the outcome lattice (i.e. Housing Starts Scenarios).

PROBABILITY LATTICE

0	1	2	3	4	5	Step
1.000	0.605	0.366	0.222	0.134	0.081	5
	0.395	0.478	0.434	0.350	0.265	4
		0.156	0.283	0.343	0.346	3
			0.062	0.149	0.225	2
				0.024	0.074	1
					0.010	0

HOUSING STARTS LATTICE

2005	2006	2007	2008	2009	2010	
190	216	246	280	319	363	5
	167	190	216	246	280	4
		147	167	190	216	3
			129	147	167	2
				113	129	1
					100	0

Figure 4. Results of the Lattice Model. Probability and Outcomes for the Housing Starts forecast.

The Probability Distribution Function implicit in this model is presented in the following figure:

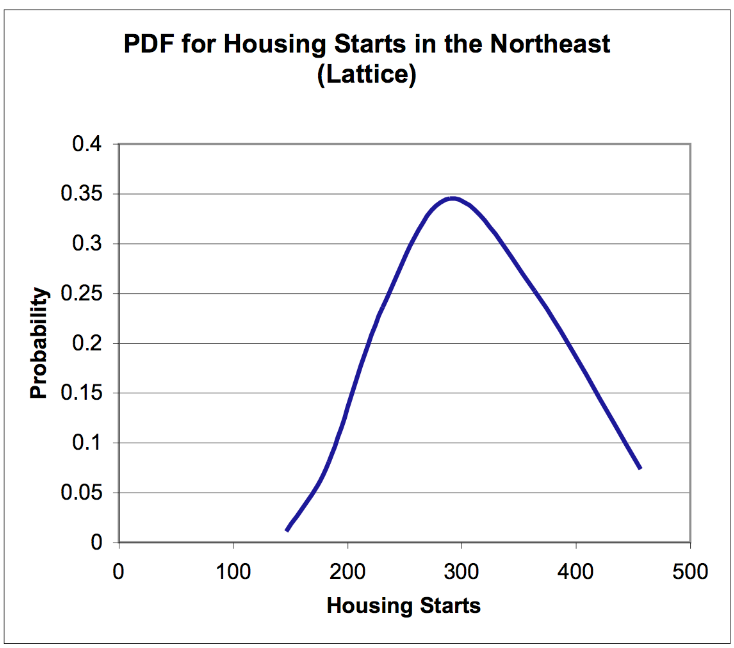

Figure 5. PDF for Housing Starts forecast as depicted by the lattice model.

IV.2 Decision Analysis Using Lattice

The lattice approach is used to value an option within the model. It will be used to determine the value of running a regional office in the Northeast region, given the cost structure presented in previous sections. This analysis is equivalent to a "call in" option, since the alternative evaluated would allow the firm to capture additional demand by augmenting their operational structure (i.e. changing their design).

Recalling the system designs, running a local office in the region would allow the company to increase their demand by 33% (since they would have more presence in the area) and to reduce its variable cost of service by 50% (mainly due to proximity to the clients). These two variables are new benefits for the company, leveraged by a larger fixed cost (US $300,000) and an extra variable cost at the central office (which we estimate from the scenarios in Table 3 as an average of US $ 85,000).

To value the option the lattice binomial model is recalled for the probability and distribution of possible housing starts scenarios in the Northeast (Figure 4). These results are used as the base for calculating the revenues for the company. The demand is determined by the following function:

*LGSF Demand = ($4.75) * Housing Units Started*

Although, we have to recall that the demand in the Northeast was penalized by 25% when serviced through the central office, thus:

*LGSF Demand Northeast = ($4.75) * Housing Units Started * 75%*

Incremental changes in operational levels were used to valuate the benefits of the option. For this reason, the base case costs are set to zero. This yields the lattice for demand and its expected values (when incorporating the probability distribution):

LGSF DEMAND LATTICE

2005	2006	2007	2008	2009	2010	Step
0	770	877	998	1135	1292	5
	595	677	770	877	998	4
		523	595	677	770	3
			459	523	595	2
				404	459	1
					355	0

EV (LGSF DEMAND) LATTICE

2005	2006	2007	2008	2009	2010	
0	466	321	221	152	105	5
	235	323	334	307	264	4
		81	168	232	266	3
			28	78	134	2
				10	34	1
					3	0

Figure 6. Results of the Lattice Model. LGSF Demand and its expected value.

The expected value for the LGSF demand gives us the possibility to calculate the net present value of our base case, which is US $2,692,200 as presented in Table 7:

Table 7. NPV calculation for the base case using the results from the lattice model (thousand $).

	2006	2007	2008	2009	2010
EV (Demand)	701.0	726.0	751.8	778.6	806.4
Discount Factor	1.12	1.25	1.40	1.57	1.76
Present Value	625.9	578.7	535.2	494.8	457.6
NPV (thousand $)	**2692.2**				
Discount Rate	12%				

In order to calculate the option value (having a regional office to service the Northeast region) the benefits of the alternative case need to be evaluated. This will help determine the option value:

VALUE OF REGIONAL OFFICE LATTICE

2005	2006	2007	2008	2009	2010	
0	129	199	280	372	476	5
	12	66	129	199	280	4
		-37	12	66	129	3
			-79	-37	12	2
				-116	-79	1
					-149	0

Figure 7. Results of the Lattice Model. Additional benefits of implementing a Regional Office.

The decision analysis is based on comparing the base case with its alternative situation when the option is in place in the following period, discounting the result one period and replicating this approach backwards from the last period to the first. The result net present value with options is highlighted and a map of when the option is being exercised is presented in Figure 8:

DECISION ANALYSIS LATTICE

NPV w/OPTIONS

					Step
3108.0	3840.1	3707.0	3305.7	2540.9	4
	2721.8	2654.5	2404.4	1883.7	3
		1900.0	1716.0	1376.3	2
			1276.7	1006.0	1
				776.8	0

VALUE OF REGIONAL OFFICE

25%	Increased demand
-385	Increased Fixed Cost
-25%	Decreased Variable Cost

EXERCISE OF OPTION

TRUE	TRUE	TRUE	TRUE	TRUE	4
	TRUE	TRUE	TRUE	TRUE	3
		FALSE	TRUE	TRUE	2
			FALSE	FALSE	1
				FALSE	0

Figure 8. Results of the Lattice Model. Decision analysis and exercise of option.

The valuation of the option is obtained by calculating the difference between the net present values of the case with options (US $3,108,000) and the base case (US $2,692,200), for a total value of US $415,800.

Table 8. Value of the option

VALUE OF OPTION

3108.0	NPV w/OPTIONS
-2692.2	NPV
415.8	OPTION (thousand $)

IV.3 Sensitivity Analysis

By inspecting the results, it can be determined that the option starts to get valuable when the fixed cost increase is less than US $783,000. Furthermore, for a fixed cost increase of less than US $279,000 the option is always exercised. This would give the company a range of costs to consider when evaluating the possibility of building a regional office (actual fixed cost increase is US $385,000)

A more interesting result comes from analyzing how different demand scenarios affect the option value. A data table is implemented using MS Excel™ to change the initial housing starts value for the lattice, and calculate the net present values for both cases. The results are presented in Table 9.

Table 9. Data table for option value analysis when varying the start value of the lattice.

DATA TABLE			
VALUE START	**OPTION**	**BASE**	**W/OPTION**
100	2.1	1416.9	1419.0
110	7.2	1558.6	1565.8
120	15.4	1700.3	1715.7
130	37.0	1842.0	1879.0
140	65.1	1983.7	2048.8
150	109.2	2125.4	2234.6
160	165.5	2267.1	2432.6
170	244.7	2408.8	2653.5
180	325.9	2550.5	2876.4
190	415.8	2692.2	3108.0
200	505.7	2833.9	3339.6
210	598.3	2975.6	3573.9
220	691.9	3117.3	3809.2
230	785.5	3259.0	4044.5
240	879.7	3400.7	4280.4
250	974.0	3542.4	4516.3
260	1068.2	3684.1	4752.3
270	1162.7	3825.7	4988.4
280	1257.1	3967.4	5224.6
290	1351.6	4109.1	5460.7
300	1446.0	4250.8	5696.9

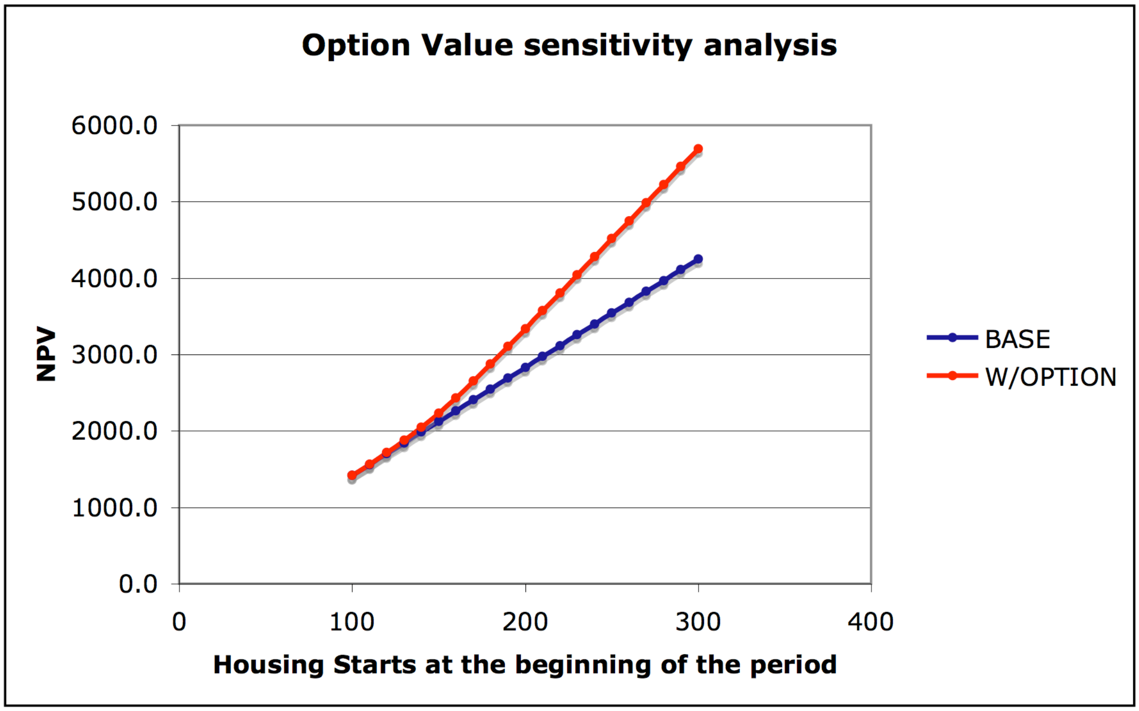

Figure 9. Plot of the resulting NPVs for the case with and without options given a range of starting values.

The plot lets us visualize the effect of the call option. It allows the company to increase their benefits, as the demand uncertainty gets favorable, thus creating an option with greater value.

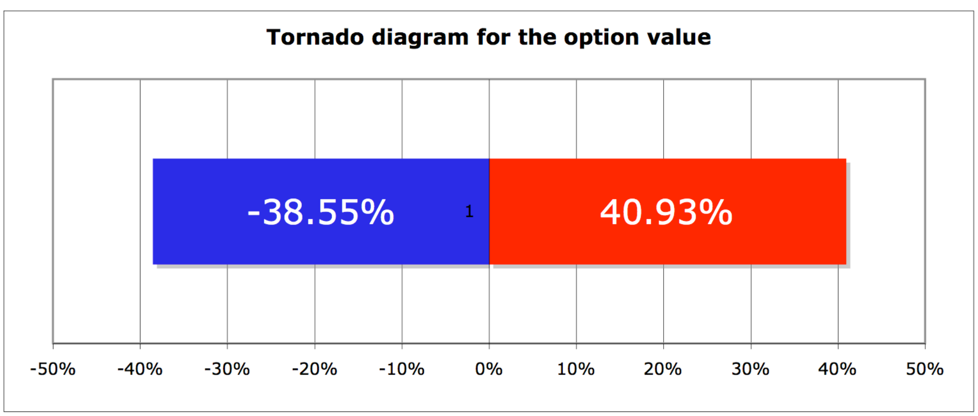

Figure 10. Tornado diagram (reduced to its minimum expression) for the revised uncertainty.

One interesting observation comes when looking at the graph from Figure 10. It plots the effect of varying the uncertainty in one standard deviation (recalled from Table 6). The key fact to observe is that the effect of varying the project with an option is not symmetric. It actually gives a greater outcome when the uncertainty shifts upward. When forecasting results, a common misconception is that the system will react symmetrically to this variance. Performing a thorough analysis and looking at the range of possible outcomes could avoid this problem.

V. Concluding Remarks

This report presented two alternative approaches to analyze a project that had uncertain variables affecting its outcome. In both cases flexibility proved valuable, thus making the decision of implementing a regional office attractive to the company.

First, the decision analysis approach was used, which allowed to navigate through a range of scenarios to compare two different designs. The first design presented the base case of running a centralized sales office, while the second one incorporated a degree of flexibility that allowed the firm to react under uncertain demand (regional office).

One of the benefits of this dynamic plan is that it makes decisions responsive to chance outcomes. It is also a very simple way to explain the chosen strategy to a potential audience. On the other hand, depending on the number alternative paths one decides to incorporate, the number of branches can grow very fast. For this reason, on section III.2 the number of scenarios were reduced on the second stage for clarity.

The second approach was implementing an option valuation. This method consisted in reformulating the problem to create an option that would estimate the value of building flexibility into our system. This process required some creativity in order to accommodate the initial definition of the problem to the restrictions of the approach.

This method used a lattice to expand a range of values for one of the uncertainties. This is a very interesting approach to work with a broader range of possible outcomes, allowing for several consecutive evaluation periods (which would be very complex to implement in a decision analysis tree). The major drawback of this method is that it makes it very difficult to use more than one uncertain variable at a time. We had to restate the problem to accommodate it for this limitation.

Another observation is that the lattice demands path independence between each step, which in our case was not a restriction, but it may limit the use of a dynamic design that could adapt to changing scenarios.

Both analyses depict the value that flexibility brings into the evaluation of problems governed by unpredictable variables. With flexibility the system can take advantage of excess demand and minimize losses. It makes projects with uncertainties more attractive as some of their risks can be either contained or converted into larger profits. This leads to the next advantage: by examining a range of results one can understand the real value of a project. The distribution of profitable results can be examined, eliminating the reliance on erroneous assumptions (i.e. flaw of averages) or ranking alternative decisions with limited scope (i.e. shut down project too early).

Working on this application portfolio has been of much value to the learning objectives of the class. First, it allows a gradual involvement into the key concepts of real options by building the report in incremental stages as the course advances. Second, it provides hands on experience in taking the methods and applying them to a real case. This is a great way for making sense of the advantages, limitations and implications of incorporating flexibility into the design of engineering problems.

Besides the commented results, I had to build and discuss demand estimations and sensitivity analyses using regression tools and data tables from MS Excel™, which also provided an opportunity for learning.

Overall, besides the fact that I had to redefine the project a couple of times, the experience was very enjoyable.