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A Company Specific Analysis of the Capital Budgeting Process as it Pertains to a Zero Emissions Mandate on the American Automobile Industry

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The rapid growth of the U.S. auto industry in the 20th century has led to a fast-paced society that emphasizes the importance of convenience and time-efficiency. Consequently, the cost of this society has been high levels of emissions, causing pollution to the surrounding environment. General Motors' attempt at a solution to the problem is their introduction of the first electric vehicle known as the EV1. The EV1 has the potential to meet society's transportation demands and to create a more pollution-free environment. However, in a free market economy, the price tag for a solution such as GM's may currently be unaffordable. At present, only a portion of the extremely high costs of electric vehicles is borne by the consumer, while the remainder appears to be subsidized by the manufacturer in the form of production cost over-runs. By traditional capital budgeting analysis standards, the immense production cost over-runs incurred through introduction tend to necessitate the rejection of the EV project. General Motors' recognition of the flaws inherent in the capital budget, however, possibly allows for the acceptance, and claim of profitability of the project.

Oftentimes in a free market economy, government intervention in the "free market" is a necessity for the protection of society. The State of California came to this conclusion after reviewing the pollution predicament in the southern portion of the state. Emissions from automobiles were declared the culprits and thus blamed for the pollution problems. Hence in 1990[1], the California Air Resource Board (CARB) passed a mandate that called for the research and eventual production of zero-emission vehicles (ZEVs) by the seven major automobile manufacturers.

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[1] Automotive International (Oxted, Surrey, UK; A Leading Edge Publication, March 1996) 6.

The mandate passed by CARB in 1990 would gradually phase in a number of zero-emission vehicles on the road over a period of 6 years. It requires 2% of new automobiles sold by manufacturers to be zero-emission vehicles as of 1998. In addition, the zero-emission requirement would increase in the year 2001 and 2003 to a level of 5% and 10% respectively. However, due to the nature of the new product, manufacturers were able to convince CARB officials that the mandate was unrealistic. Manufacturers claimed current developments in technology were lagging, and the market demand for zero-emission vehicles was too low.

Because of the intense pressure the major automobile manufacturers and oil companies applied to CARB officials, the original mandate established in 1990 was revised in March of 1996. The revision would provide some relief for automakers while research on battery technology continued. Specifically, the new mandate drops any zero-emission requirements for 1998-2002, while the 2003 requirement (10% of all automobiles sold in California will be zero-emission) remains in effect.[2] To ensure that no emission reductions are lost by suspending the ZEV requirements, the CARB may enter into a memorandum of agreement (MOA) with each of the seven auto manufacturers.[3] These MOAs would formalize commitments by the auto manufacturers to achieve the air quality benefits of the percentage ZEV requirements through the production of cleaner-running combustion vehicles.[4] In exchange for the eased regulations, the seven automakers promised to sell a combined total of 3,750 electric vehicles by the year 2000. Furthermore, to promote the early production and sale of EVs, CARB has offered ZEV "credits" for ZEVs produced prior to the 2003 mandate. These credits may be applied to future obligations.

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[2] "California right to pull plug on electric mandate," USA Today 2 Apr. 1996: 12A.
[3] Title 13: California Air Resource Board, 2.
[4] Automotive International (Oxted, Surrey, UK; A Leading Edge Publication, March 1996) 6.

Although California and the California Air Resource Board have taken the lead and set the mandate standards for its own state, many other states have vowed to follow the California standards. New York and Massachusetts, for instance, are legally obligated to follow the lead established by CARB, and are not at liberty to set their own standards.[5] Vermont and Maine have also indicated an interest in demanding that the auto industry make significant moves toward the production of zero-pollution vehicles.[6] As states like California, New York, and Massachusetts make great strides in mandate legislation, more and more states could be expected to acquire similar mandates. Hence, the possibility of zero-emission mandates in most or all of the states in the future provides a serious degree of validity to the automakers' research efforts.

After conducting research on the viability of electric vehicles, General Motors had to make a decision regarding the acceptance or rejection of the project. The acceptance of a project is based primarily on its ability to add value to the firm. The easiest and most obvious means of measuring value is in monetary terms. Thus, to measure the value of a project, a capital budgeting analysis with an appropriate sensitivity analysis is performed. The following is a model of a possible capital budgeting analysis with an appropriate sensitivity analysis of General Motors' EV project.

Before constructing this capital budgeting model, a series of assumptions was made. First, the EV project is assumed to have a greater level of risk than that of an average-risk project and should produce a higher required rate of return. In capital budgeting, a company's average required rate of return is defined as its cost of capital. For General Motors, the cost of capital was determined to be approximately 9.34%.[7] If the EV project is assumed to be approximately

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[5] Ibid.
[6] "Norhteast's Push for Electric Cars Stalled," Boston Globe 10 Aug. 1996: 30.
[7] See Table G.

20% riskier than average, then its required rate of return is 20% greater (11.21%). In this particular analysis, adjustments to cost of capital have minimal effect on the final outcome. Second, the relative dollar amount of depreciable assets is minuscule compared to the cash flows. Therefore, the effects of depreciation are negligible and are ignored. Third, the presence or absence of taxes does not affect the ultimate outcome or decision of the model, so taxes were ignored for clarity. Fourth, since a traditional capital budgeting analysis requires the measure of cash flows, profits are assumed to be cash inflows per annum. Fifth, the anticipated net losses (production cost over-runs) for the first several years of the project, were discounted back to a single payment in year 0 and included in the calculation of the Net Investment Cash Outlay (NICO). The basis for this inclusion is to value the future losses in today's dollars and combine them with the other cash outflows (plant and equipment, labor, and materials). Sixth, although the EV1 is currently available for lease only with a base price of approximately $34,000, all vehicles are assumed to be purchased at this price. Seventh, it is assumed that levels of production match sales levels, so that every car produced is assumed to be sold in that year. Eighth, the growth of production is assumed to grow a rate consistent with the sum-of-the-years'-digits model.[8] This type of growth pattern reflects slower growth in the beginning years and increasingly greater growth in the latter years.

The analysis itself incorporates a sensitivity analysis composed of 6 different scenarios. The impending scenarios are derived from the different combinations of two variables that change to show the effects of various events. These two variables are profit margin and total level of EV production exclusive of the state of California. Throughout the 6 scenarios, profit margin will

[8] Table A-2, B-2, C-2, D-2, E-2, and F-2.

assume a value of 10%, 20%, or 30%, and EV production exclusive of California will either be zero or 35,000 (to represent production in New York and Massachusetts). The varying level of profit margin illustrates the effects of profitability on the potential success of the project, while EV production exclusive of California represents the effects of additional states adopting mandates similar to California's.

The first scenario of the sensitivity analysis places the profit margin at 10% and EV production exclusive of California at zero. This scenario assumes the lowest level of profitability for the EV1 project. Furthermore, it assumes that New York and Massachusetts, along with other states, have not adopted the ZEV mandates as promised. This illustrates a worst-case scenario for General Motors' EV endeavor.

After identifying all assumptions and appropriate values for variables, the first step of the traditional capital budgeting analysis is to calculate the project's Net Investment Cash Outlay (NICO). To calculate NICO, the present value of the project's production cost over-runs must be identified. The production cost over-run is simply the net losses initially expected to occur as a result of high fixed costs and low initial levels of production for the project. The high fixed costs are composed of labor and operational expenses. Labor is considered a fixed cost in this analysis, because employees are generally still compensated in the event of production slow-down or shut-down. In order to determine annual production cost over-runs, the projects break-even quantity must be established. In this first scenario, production is projected to break-even in year 7 at a quantity of 31,500 units.[9] However, in the preceding six years, unavoidable fixed costs amounting to $714,035,700 per year are incurred. Thus, the underutilized capacity produces a

[9] See Table A-1.

present value of production cost over-runs of $1,912,842,776.[10] Next, the increase in Net Working Capital (NWC) as a result of the project is added. The change in NWC is the difference between the projected increase in current assets and the projected increase in current liabilities.[11] In this case, an increase in NWC is the result of initial increases in labor (i.e., training costs) and material costs. The cost of labor was calculated as follows: an average cost of $80 per man-hour with 55 employees working a standard 40 hour week for a start-up period of 15 weeks produces a total labor cost of $2,640,000.[12] To arrive at a rough estimate, the cost of materials was approximated to be equal with the cost of labor. Hence, the cost of materials is approximately equal to $2,640,000, and the total amount for NWC is $5,280,000. Due to the relatively small size of these costs, variations in amount should not affect the conclusions of the analysis. The last element of the NICO calculation is depreciable assets. Depreciable assets are composed mainly of the plant and equipment costs. With the EV1 being built in the former Buick Reatta Craft Centre in Lansing, MI, plant and equipment costs are assumed to be $20 million (the estimated value of the plant). The summation of present value of production cost over-run, NWC, and depreciable assets, produces a Net Investment Cash Outflow of $1,938,122,776.[13] NICO, including the present value of production cost over-runs, is assumed to be the only cash outflow and occurs in year zero.

After determining the Net Investment Cash Outflow, the next step in a traditional capital budgeting analysis is to identify the benefits, or future annual cash inflows, created by the project. The cash inflows are found by adding the 10% profit margin for each unit sold with any additional

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[10] See Table A-2.
[11] Eugene F. Brigham and Louis C. Gapenski, Intermediate Financial Management (Fot Worth, TX; Dryden Press, 1996) 252.
[12] Tony Swan, "Electrifying," Detroit Free Press 11 Jul. 1996: F1.
[13] See Table A-3.

profit from units sold above and beyond the break-even quantity. In the first scenario of 10% profit margin and zero production (exclusive of California), the break-even quantity is calculated to be 31,500 units. For the first six years of the project, cash flows only reflect the 10% profit margin. Not until year 7 does production exceed the break-even quantity. From year 7 through year 10, all fixed costs are covered and units produced above break-even are returning greater profits. To calculate the dollar amount of profit earned above break-even, the quantity above break-even of 3,500 units is multiplied by the contribution margin (Revenue less variable cost) of $23,801.

The last step in the preparation of a traditional capital budgeting analysis involves the calculation of the last or terminal cash flow. This cash flow involves the last year's cash inflow, the recovery of Net Working Capital, the salvage value of remaining depreciable assets, and any resulting tax implications. Although, for analysis purposes, the project's life has been limited to ten years, the actual termination date is unknown or at least presumed to be far in the future. Moreover, the recovery of the change in NWC, the salvage value of depreciable assets, and any resulting tax implications are minuscule and do not have a significant effect on the outcome of the analysis. For this reason, these portions of the terminal cash flow are being disregarded in the current analysis. Therefore, in year 10, the cash flow does not show the effect of a terminal cash flow and is merely the amount of the year's cash inflow.[14]

Once all of the relevant cash flows have been identified, the traditional capital budgeting analysis uses these cash flows in the creation of various decision measures. Decision measures are analysis tools that indicate a recommendation for the acceptance or rejection of a project. Three

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[14] See Table A-4.

of the most common decision measures, and the ones used in this analysis, are Net Present Value, Internal Rate of Return, and Profitability Index. Net Present Value (NPV) is merely the present value of the cash inflows minus the present value of the cash outflows. The result is an indication of the amount of wealth (in dollar terms) added to or subtracted from the firm as a result of the acceptance of the project. Thus, a positive NPV would recommend acceptance, while a negative NPV suggests rejection of the project. In the first scenario of 10% profit margin and zero production exclusive of California, the resulting NPV was -$1,482,087,940.[15] Thus, according to the NPV decision measure the project should be rejected. Similarly, the Internal Rate of Return (IRR) evaluates the percentage return of a project relative to the project's cost of capital. By definition it is the discount rate that creates a NPV of $0. If the IRR is greater than the cost of capital, then the project is accepted; if not, the projected is rejected. With a cost of capital of 9.34%, and a rate of return of -8.17%[16], the IRR decision measure also indicates rejection of the project. The last decision measure, Profitability Index (PI), calculates the dollar amount return on a $1 investment in the project. Thus, a PI of 1.00 or greater implies the adding of value, and thus acceptance, while less than 1.00 indicates a rejection. Since the PI for the first scenario is 0.24[17], this measure also indicates a rejection. A rough interpretation of this outcome is that for every dollar spent the company only realizes eight cents of value. By nature of the traditional capital budgeting analysis, and readily apparent in this scenario, the conclusions of the three aforementioned decision measures will always be unanimous. Therefore, by traditional capital budgeting standards, the EV1 project would be rejected under this scenario.

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[15] See Table A-4.
[16] See Table A-4.
[17] See Table A-4.

It is not surprising that the effects of low volume and low profit margin lead to the rejection of the capital budgeting project. However, does a higher profit margin change the outcome of the analysis? For instance, examine the effects of a 20% profit margin, with the same production volume. By increasing profit margin to 20%, GM's break-even quantity falls from 31,500 to 28,000 units.[18] Consequently, production cost over-runs decline. The results of an increase in profit margin are obviously beneficial. However, the outcome of the traditional capital budgeting process is still contingent on the size and timing of the cash flows. Hence, the increase in profit may not be as beneficial as first thought. Because the present value of the production cost over-run is still very high relative to the present value of the cash inflows, the Net Present Value of the project remains negative at -$557,567,850.[19] Likewise, the Internal Rate of Return is 3.99% and the Profitability Index is 0.61.[20] Therefore, despite the 10% increase in profit margin, the traditional capital budgeting process still unanimously rejects the project.

Although a 10% increase in profit margin did not change the decision of the capital budget in the last scenario, its effects were still beneficial. Perhaps, the profit margin was merely not increased enough to change the resulting decision. For instance, maybe a 30% profit margin, with the prevailing production volume, will change the decision outcome. Raising profit margin from 20% to 30% further benefits the project. The break-even quantity is down to 24,500 units.[21] Consequently, the present value of the production cost over-runs further decline and the project breaks-even in year 6 as opposed to year 7 in the previous two scenarios.[22] The decision-measures for this scenario are promising. The Net Present Value has improved from the second

[18] See Table B-1.
[19] See Table B-4.
[20] See Table B-4.
[21] See Table C-1.
[22] See Table C-4.

scenario to a positive $269,007,242[23] and recommends acceptance. In like manner, the Internal Rate of Return is 14.94% (greater than the cost of capital of 9.34%), and the Profitability Index is 1.26[24]; both calling for acceptance. The aforementioned scenarios display the benefits of increased profit margins and the impairments of diseconomies of scale (the effects of production limited to California). Hence, at the present level of production, break-even is only possible with a 30% profit margin. However, the likelihood of attaining a 30% profit margin is not great.

The first three scenarios examined the effects of an increasing profit margin on a traditional capital budgeting analysis assuming that production and sale of the EV1 would be limited to California. Initially this was reasonable, considering that California was the first state to adopt such a mandate. However, as mentioned earlier, the states of New York and Massachusetts have since established written laws requiring adoption of the same mandates as California. Furthermore, Vermont and Maine have made indications of adopting similar laws. Therefore, there now exists reason to believe that GM's market is much larger than originally thought. The following will examine the possible effects of economies of scale, with various profit margins, on the outcome of a traditional capital budgeting analysis.

In examining the effects of increased production, volume will be doubled from 35,000 units to 70,000 units needed in 2003. This increase in production represents the 35,000 units in California and adds the additional 35,000 units to represent mandates in New York and Massachusetts. For evaluating the effects of increased production in this scenario, the level of profit margin will revert to the original 10% in the first scenario. Therefore, the traditional capital budgeting analysis will now analyze the effects of increased production. Doubling production

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[23] See Table C-4.
[24] See Table C-4.

levels needed in 2003, does not affect the production cost over-runs for the first 35,000 units produced. This is because the fixed costs of labor and operational expenses are only incurred for the single work shift. However, in the year that production is expected to surpass 35,000 units it is assumed that a second shift will be needed to accommodate for the increased production. This second shift will increase fixed labor costs by 100% (as the number of employees will essentially double). However, it is assumed that fixed operational expenses will only increase by 50% (machine operation expenses may double, but general building and some utility expenses will remain constant). Therefore, the fixed cost per unit amount is lower for cars produced beyond 35,000 units. In calculating the production cost over-runs for years 1 through 4, when only one shift is present, a per unit fixed cost of $20,401 is charged to each unit short of the 31,500 break-even quantity. When the second shift is added, units short of the new 63,000 break even quantity are charged a fixed cost per unit amount of $15,298. Thus, the resulting present value of the production cost over-runs is a -$1,644,566,625 while the NICO is -$1,669,846,625.[25] Examining the decision measures, we find the NPV to be -$757,776,953.[26] Compared to the -$1,482,087,940 NPV from the first scenario (10%, 35,000 units), there is a $724,310,987 improvement. This improvement is the results of economies of scale. Likewise, IRR and PI also showed improvement moving to 2.41% and 0.55 respectively. Although the decision measurements have shown improvement with economies of scale, they still indicate a rejection recommendation under this scenario.

Examination of another scenario with increased production of 70,000 units and an increased profit margin of 20% should reveal some improvement from the previous scenario.

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[25] See Table D-3.
[26] See Table D-4.

With an increase in profit margin to 20%, the break even quantity (after the second shift is added) falls from 63,000 units to 56,000.[27] In addition, the Net Investment Cash Outlay drops to -$1,166,398,194.[28] The resulting NPV measurement is $605,920,905.[29] Likewise, the IRR and PI are 18.08% and 1.52 respectively. The effects of economies of scale are evident. With production at the 70,000 unit level, and profit margin at 20%, the capital budgeting analysis recommends acceptance of the project.

The sixth and last scenario shows production at a level of 70,000 units with a 30% profit margin. Of all six scenarios, this portrays a best case scenario for General Motors. As in the previous scenarios, the increased profit margin results in a decreased break-even quantity of 49,000 units.[30] Furthermore, NICO drops to -$773,052,671[31] from the previous scenario. Examining the decision-measures reveal some very encouraging results for the project. The NPV is a positive $1,842,243,031.[32] Likewise, the IRR is 33.75%[33] which is much greater than the cost of capital (9.34%). Lastly, the PI is 3.38[34] and thus greater than 1.00. In this scenario, all three decision measures overwhelmingly indicate acceptance of the project.

Throughout the last three scenarios, economies of scale were at work with an increase in production of 100%. The laws of economies of scales claim that increased production will result in a per unit reduction of fixed costs. This implies that a 100% increase in production should have a substantial, beneficial effect on the decision measures of the project. When comparing the

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[27] See Table E-1.
[28] See Table E-3.
[29] See Table E-4.
[30] See Table F-1.
[31] See Table F-3.
[32] See Table F-4.
[33] See Table F-4.
[34] See Table F-4.

second scenario (20% profit margin, 35,000 units) with the fifth scenario (20% profit margin, 70,000 units), the effect of economies of scale transforms an otherwise unprofitable project into a conceivably profitable one. Unfortunately, there is no guarantee that the EV market will demand 70,000 units in the year 2003, but it does raise an interest for General Motors as more states consider mandates similar to California's.

After analyzing six possible outcomes of the EV capital budgeting analysis, some conclusions must be drawn. To arrive at an expected (or mean) outcome, the weighted average of the decision-measures if found. The probability of each scenario's occurrence is used as its weight. The probability of each scenario is as follows:

Scenario	**Probability**	**Scenario**	**Probability**
#1 (10%, 35,000)	0.15	#4 (10%, 70,000)	0.20
#2 (20%, 35,000)	0.20	#5 (20%, 70,000)	0.25
#3 (30%, 35,000)	0.12	#6 (30%, 70,000)	0.08

Assuming that the profit margin of the EV project lies somewhere between 10-20%, the probability was weighted accordingly. Furthermore, since New York and Massachusetts have written laws indicating the implementation of mandates, the probability for both 10% and 20% profit margins are weighted more heavily towards the 70,000 units of production (includes CA, NY, and MA). Recognizing that a company's best-case scenario is often its least likely alternative, scenario #6 (30%, 70,000) as been assigned the lowest probability of 0.08. Calculating the weighted average of NPV, using the probability weights, yields an expected value of -$715,834,863. Similarly, using the same weights, the expected IRR and PI are 1.92% and 0.61 respectively. Therefore, the conclusions of the aforementioned analysis indicate the project should be rejected. However, contrary to the conclusions of traditional capital budgeting analysis, General Motors accepted the project.

Why would a firm accept a project that appears to detract value from its net worth? For obvious reasons, no firm would accept a project with the intentions of detracting value. Therefore, one must assume that General Motors has accepted the EV1 Project with the intentions that it will ultimately add value to the firm. However, according to the aforementioned traditional capital budgeting analysis, it is unlikely the project will add value. If we maintain the assumption that the project will ultimately add value and the project does have a positive net present value, then the traditional capital budgeting analysis must be flawed. I propose that the traditional capital budgeting analysis contains several inherent flaws: inability to accurately predict and assess the value of long-term future cash flows, and inability to value research and development for future opportunities (Option Analysis).

In the analysis and valuation process there must exist a basis upon which to form a valuation. The traditional capital budgeting process follows the axiom that "cash is king".[35] "Cash is king" declares that the value of a capital project should be measured by the amount and timing of its cash flows. It argues that cash flows are ultimately what can be reinvested by the firm and therefore possess the value.

The traditional capital budgeting process suffers from its inability to predict and assess the value of the aforementioned long-term cash flows. Just as capital projects usually require large capital investments, they may also require a large project life. Many projects, as with General Motors' EV project, have indefinite life spans. This creates potential dilemmas because the

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[35] Keown, et al., Foundations of Finance (Englewood Cliffs, NJ: Prentice Hall, 1994) 304.

traditional capital budgeting analysis requires a firm to reasonably estimate both the amount and the timing of cash flows. Arguably, General Motors may be capable of reasonably predicting cash flows for several years in advance, but beyond this, the accuracy of cash flow projections is questionable. Hence, with longer project lives, capital budget analysis conclusions are less reliable. With the introduction of new projects, technological advancements are initially high in cost. However, these high costs may tend to subside as economies of scale take effect, as observed throughout the aforementioned analysis. Determining which costs will subside and when, is difficult, if not impossible. Therefore, the reliance of the traditional capital budgeting analysis on the amount and timing of future cash flows is a weakness that requires appropriate consideration.

Undeniably, cash inflows are valuable benefits from capital projects, but are they the only valuable benefits? By accepting the EV project, General Motors purchased the future cash inflows provided by the project, but they also purchased other potential benefits. The research and development required to implement a project such as the EV1 is immense. Experimentation with new materials and designs is essential. For example, to compensate for the 1,175 pound battery in the EV1[36], the remainder of the car needed to be as light as possible. Hence, after careful research, aluminum was designated as the most appropriate material for a light weight frame. Furthermore, the steering wheel and seats are made of light-weight, but strong, magnesium[37], while the body is entirely made of plastic.[38] Other technological advances as a result of the EV project consists of improved aerodynamics, inductive charging systems, high-

[36] Alan L. Adler, "Leading the Charge: GM's first electric cars head for showrooms," Detroit Free Press 14 Nov. 1996: E1.
[37] Tony Swan, "Electrifying," Detroit Free Press 11 Jul. 1996: F1.
[38] Tony Swan, "Electrifying," Detroit Free Press 11 Jul. 1996: F1.

pressure/low rolling resistance tires, advanced electric motors, and regenerative braking systems.[39] The end result is a total of 30 new patents.[40] These technological advances not only benefit the EV1, but benefit the whole corporation. As technological developments arise, they are immediately considered for implementation into future production vehicles. GM states, "the use of light materials will likely show up in many of its future cars; removing weight to increase gas mileage is a chief goal for many auto engineers."[41]

With the pending mandate in place, and the possibility of increased demand in zero-emission vehicles, the EV1 project is, if nothing else, a research opportunity in a potentially profitable market. The CARB mandate is indication that development in combustion engine alternatives is necessary. Further, as worsening environmental conditions continue, the demand for zero emission vehicles may increase. Assuming that General Motors recognizes a potentially profitable market with zero-emission vehicles in the long-run, research and development in such a market must exist. The sole purpose of research and development is to identify products and techniques that prove to be profitable in the future. The research and development process itself may be very costly and thus unprofitable. Although this process may lack positive cash flows, there still exists value in the form of knowledge. The knowledge gained from research and development adds dollar value to a firm in the success of future projects. Because the traditional capital budgeting analysis relies strictly on cash flows, the value of the research and development (and thus the value of potentially profitable opportunities) is disregarded. Therefore, a major limitation of the capital budgeting process is the failure to recognize value in the research and

[39] Joseph Szczesny, "GM Charged About EV1," The Oakland Press 18 Aug. 1996: D1.
[40] Rebecca Blumenstein, "Electric Car Drives Factory Innovations," The Wall Street Journal 27 Feb. 1997, B7.
[41] Ibid.

development of a project. Research and development is an essential component to the long-term capital structure.

The aforementioned analysis seriously challenges the ability of the traditional capital budgeting analysis to accurately measure the value of a capital project possessing a high degree of uncertainty of future cash flows and project developments. The traditional capital budgeting analysis is an applicable tool for valuing capital projects that possess a known span with readily determinable cash flows. However, General Motors' Electric Vehicle project does not fit the aforementioned criteria. Thus, the traditional capital budgeting analysis rejected what has apparently been determined on another basis to be an acceptable project.

The solution to this capital budgeting analysis dilemma lies in the implementation of the analysis and the interpretation of the results. For capital projects with a known life and reasonably certain cash flows, the traditional capital budgeting analysis will likely be useful. However, for projects with uncertainty of life span or cash flows, appropriate adjustments are needed. In addition to measuring the benefits of incremental cash inflows, a firm must recognize any appropriate "non-cash" or qualitative benefits that may ultimately increase the wealth of the firm. Appropriate qualitative benefits that have intellectual or intangible value may include such items as patents and increases in goodwill. To be more complete and accurate, the capital budgeting analysis may develop a method to quantify such assets in monetary terms and include them in the analysis. For example, by estimating the fair market value of the 30 patents created as a result of the EV project, General Motors may add this value to the capital budgeting analysis in an effort to account for all of the value incurred from the project. Matching these qualitative benefits, along with any cash inflows, against the Net Investment Cash Outlay will provide a more comprehensive analysis.

To compensate for the aforementioned inefficiencies in capital budgeting, General Motors may consider the selection of a more appropriate analysis tool. For instance, Merck Corporation, a highly R&D intensive pharmaceutical firm, developed "Option Analysis" to evaluate its capital projects.[42] Similar to the valuation of stock options, a firm can view capital investments as an "entry fee" for a right (but not an obligation) to continue research and development in a project."[43] Similarly, General Motors could possibly view the EV1 project as a "right" to continue research in the zero emission vehicle market and determine a value for this option. Adopting an "Option Analysis" approach would enable General Motors to avoid using the traditional capital budgeting analysis that is possibly distorting the true value of the EV project.

In conclusion, the best interests of General Motors, and all firms valuing capital projects, is to carefully match all quantitative (cash flows) and qualitative benefits against the appropriate Net Investment Cash Outlay. For some projects, the traditional capital budgeting analysis, with some qualitative adjustments, will be appropriate; other projects (such as the EV1) may require different approaches to capital budgeting such as "Option Analysis". Regardless of the capital budgeting approach used, it is crucial for a firm to recognize the flaws inherent in any analysis and adjust accordingly for the accurate valuation of capital projects.

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[42] Nancy A. Nichols, 'Scientific Management at Merck: An interview with CFO Judy Lewent," Harvard Business Review , January-February (1994): 90.
[43] Ibid.

Appendices

Table A-1
Analysis of Zero Additional Production and 10% Profit Margin

Break-even Calculation			
GM Car & Truck Sales in California			350,000
Electric Vehicles Mandated in Cal. (10%)			35,000
Addt'l EVs Mandated in NY, MA, VT, etc.			-
Total Production Level needed for 2003			35,000
Retail Selling Price	X	$	34,000
Total Revenue		$	1,190,000,000
Profit Margin	-	$	119,000,000
Revenue Needed to B/E Per Year		$	1,071,000,000
Break-even # of Units			31,500

Table A-2
Analysis of Zero Additional Production and 10% Profit Margin

Production Cost Over-run and Profit Calculation											
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Portion of 2003 Prod.	-	1/28	3/28	6/28	10/28	15/28	21/28	28/28	-	-	-
Prod. Level	-	1,250	3,750	7,500	12,500	18,750	26,250	35,000	35,000	35,000	35,000
Units short of B/E	-	30,250	27,750	24,000	19,000	12,750	5,250	-	-	-	-
Fixed Cost per Unit		20,401	20,401	20,401	20,401	20,401	20,401	20,401	20,401	20,401	20,401
Prod. Over-run	-	(617,130,855)	(566,128,305)	(489,624,480)	(387,619,380)	(260,113,005)	(107,105,355)	-	-	-	-
PV Prod. Over-run	(1,912,842,776)										
Units above B/E	-	-	-	-	-	-	-	3,500	3,500	3,500	3,500
Profit	-	4,250,000	12,750,000	25,500,000	42,500,000	63,750,000	89,250,000	190,403,570	190,403,570	190,403,570	190,403,570

Table A-3
Analysis of Zero Additional Production and 10% Profit Margin

Nico		
NPV Prod. Over-run		$ 1,912,842,776
NWC		
Cost of Payroll	$ 2,640,000	
Cost of Materials	2,640,000	
		5,280,000
Depreciable Assets		20,000,000
NICO		$ (1,938,122,776)

Table A-4
Analysis of Zero Additional Production and 10% Profit Margin

Incremental Cash Flow Analysis (in Dollars)											
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
CIF	-	4,250,000	12,750,000	25,500,000	42,500,000	63,750,000	89,250,000	190,403,570	190,403,570	190,403,570	190,403,570
NICO	(1,938,122,776)	-	-	-	-	-	-	-	-	-	-
Net Cash Flow	(1,938,122,776)	4,250,000	12,750,000	25,500,000	42,500,000	63,750,000	89,250,000	190,403,570	190,403,570	190,403,570	190,403,570

Decision-Measures	
NPV	$ (1,482,087,940)
IRR	-8.17%
PI	0.24

Table B-1
Analysis of Zero Additional Production and 20% Profit Marign

Break-even Calculation			
GM Car & Truck Sales in California			350,000
Electric Vehicles Mandated in Cal. (10%)			35,000
Addt'l EVs Mandated in NY, MA, VT, etc.			-
Total Production Level needed for 2003			35,000
Retail Selling Price	X	$	34,000
Total Revenue		$	1,190,000,000
Profit Margin	-	$	238,000,000
Revenue Needed to B/E Per Year		$	952,000,000
Break-even # of Units			28,000

Table B-2
Analysis of Zero Additional Production and 20% Profit Marign

Production Cost Over-run and Profit Calculation											
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Portion of 2003 Prod.	-	1/28	3/28	6/28	10/28	15/28	21/28	28/28	-	-	-
Prod. Level	-	1,250	3,750	7,500	12,500	18,750	26,250	35,000	35,000	35,000	35,000
Units short of B/E	-	26,750	24,250	20,500	15,500	9,250	1,750	-	-	-	-
Fixed Cost per Unit		18,134	18,134	18,134	18,134	18,134	18,134	18,134	18,134	18,134	18,134
Prod. Over-run	-	(485,090,920)	(439,755,320)	(371,751,920)	(281,080,720)	(167,741,720)	(31,734,920)	-	-	-	-
PV Prod. Over-run	(1,418,447,399)										
Units above B/E	-	-	-	-	-	-	-	7,000	7,000	7,000	7,000
Profit	-	8,500,000	25,500,000	51,000,000	85,000,000	127,500,000	178,500,000	364,939,680	364,939,680	364,939,680	364,939,680

Table B-3
Analysis of Zero Additional Production and 20% Profit Marign

Nico		
NPV Prod. Over-run		$ 1,418,447,399
NWC		
Cost of Payroll	$ 2,640,000	
Cost of Materials	2,640,000	
		5,280,000
Depreciable Assets		20,000,000
NICO		$ (1,443,727,399)

Table B-4
Analysis of Zero Additional Production and 20% Profit Marign

Incremental Cash Flow Analysis (in Dollars)											
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
CIF	-	8,500,000.00	25,500,000	51,000,000	85,000,000	127,500,000	178,500,000	364,939,680	364,939,680	364,939,680	364,939,680
NICO	(1,443,727,399)	-	-	-	-	-	-	-	-	-	-
Net Cash Flow	(1,443,727,399)	8,500,000	25,500,000	51,000,000	85,000,000	127,500,000	178,500,000	364,939,680	364,939,680	364,939,680	364,939,680

Decision-Measures	
NPV	$ (557,567,850)
IRR	3.99%
PI	0.61

Table C-1
Analysis of Zero Additional Production and 30% Profit Margin

Break-even Calculation			
GM Car & Truck Sales in California			350,000
Electric Vehicles Mandated in Cal. (10%)			35,000
Addt'l EVs Mandated in NY, MA, VT, etc.			-
Total Production Level needed for 2003			35,000
Retail Selling Price	X	$	34,000
Total Revenue		$	1,190,000,000
Profit Margin	-	$	357,000,000
Revenue Needed to B/E Per Year		$	833,000,000
Break-even # of Units			24,500

Table C-2
Analysis of Zero Additional Production and 30% Profit Marign

Production Cost Over-run and Profit Calculation											
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Portion of 2003 Prod.	-	1/28	3/28	6/28	10/28	15/28	21/28	28/28	-	-	-
Prod. Level	-	1,250	3,750	7,500	12,500	18,750	26,250	35,000	35,000	35,000	35,000
Units short of B/E	-	23,250	20,750	17,000	12,000	5,750	-	-	-	-	-
Fixed Cost per Unit		15,867	15,867	15,867	15,867	15,867	15,867	15,867	15,867	15,867	15,867
Prod. Over-run	-	(368,918,445)	(329,249,795)	(269,746,820)	(190,409,520)	(91,237,895)	-	-	-	-	-
PV Prod. Over-run	(1,010,767,007)										
Units above B/E	-	-	-	-	-	-	1,750	10,500	10,500	10,500	10,500
Profit	-	12,750,000	38,250,000	76,500,000	127,500,000	191,250,000	295,518,055	523,608,330	523,608,330	523,608,330	523,608,330

Table C-3
Analysis of Zero Additional Production and 30% Profit Marign

Nico		
NPV Prod. Over-run		$ 1,010,767,007
NWC		
Cost of Payroll	$ 2,640,000	
Cost of Materials	2,640,000	
		5,280,000
Depreciable Assets		20,000,000
NICO		$ (1,036,047,007)

Table C-4
Analysis of Zero Additional Production and 30% Profit Marign

Incremental Cash Flow Analysis (in Dollars)											
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
CIF	-	12,750,000.00	38,250,000	76,500,000	127,500,000	191,250,000	295,518,055	523,608,330	523,608,330	523,608,330	523,608,330
NICO	(1,036,047,007)	-	-	-	-	-	-	-	-	-	-
Net Cash Flow	(1,036,047,007)	12,750,000	38,250,000	76,500,000	127,500,000	191,250,000	295,518,055	523,608,330	523,608,330	523,608,330	523,608,330

Decision-Measures	
NPV	$ 269,007,242
IRR	14.94%
PI	1.26

Table D-1
Analysis of Additional 35,000 Units and 10% Profit Margin

Break-even Calculation			
GM Car & Truck Sales in California			350,000
Electric Vehicles Mandated in Cal. (10%)			35,000
Addt'l EVs Mandated in NY, MA, VT, etc.			35,000
Total Production Level needed for 2003			70,000
Retail Selling Price	X	$	34,000
Total Revenue		$	2,380,000,000
Profit Margin	-	$	238,000,000
Revenue Needed to B/E Per Year		$	2,142,000,000
Break-even # of Units			63,000

Table D-2
Analysis of Additional 35,000 Units and 10% Profit Margin

Production Cost Over-run and Profit Calculation											
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Portion of 2003 Prod.	-	1/28	3/28	6/28	10/28	15/28	21/28	28/28	-	-	-
Prod. Level	-	2,500	7,500	15,000	25,000	37,500	52,500	70,000	70,000	70,000	70,000
Units short of B/E	-	29,000	24,000	16,500	6,500	25,500	10,500	-	-	-	-
Fixed Cost per Unit (1st shift)		20,401	20,401	20,401	20,401	20,401	20,401	20,401	20,401	20,401	20,401
Fixed Cost per Unit (2nd shift)		-	-	-	-	15,298	15,298	15,298	15,298	15,298	15,298
Prod. Over-run	-	(591,629,580)	(489,624,480)	(336,616,830)	(132,606,630)	(390,110,985)	(160,633,935)	-	-	-	-
PV Prod. Over-run	(1,644,566,625)										
Units above B/E	-	-	-	-	-	-	-	7,000	7,000	7,000	7,000
Profit	-	8,500,000	25,500,000	51,000,000	85,000,000	127,500,000	178,500,000	380,807,140	380,807,140	380,807,140	380,807,140

Table D-3
Analysis of Additional 35,000 Units and 10% Profit Margin

Nico		
NPV Prod. Over-run		$ 1,644,566,625
NWC		
Cost of Payroll	$ 2,640,000	
Cost of Materials	2,640,000	
		5,280,000
Depreciable Assets		20,000,000
NICO		$ (1,669,846,625)

Table D-4
Analysis of Additional 35,000 Units and 10% Profit Margin

Incremental Cash Flow Analysis (in Dollars)											
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
CIF	-	8,500,000.00	25,500,000	51,000,000	85,000,000	127,500,000	178,500,000	380,807,140	380,807,140	380,807,140	380,807,140
NICO	(1,669,846,625)	-	-	-	-	-	-	-	-	-	-
Net Cash Flow	(1,669,846,625)	8,500,000	25,500,000	51,000,000	85,000,000	127,500,000	178,500,000	380,807,140	380,807,140	380,807,140	380,807,140

Decision-Measures	
NPV	$ (757,776,953)
IRR	2.41%
PI	0.55

Table E-1
Analysis of Additional 35,000 Units and 20% Profit Margin

Break-even Calculation			
GM Car & Truck Sales in California			350,000
Electric Vehicles Mandated in Cal. (10%)			35,000
Addt'l EVs Mandated in NY, MA, VT, etc.			35,000
Total Production Level needed for 2003			70,000
Retail Selling Price	X	$	34,000
Total Revenue		$	2,380,000,000
Profit Margin	-	$	476,000,000
Revenue Needed to B/E Per Year		$	1,904,000,000
Break-even # of Units			56,000

Table E-2
Analysis of Additional 35,000 Units and 20% Profit Margin

Production Cost Over-run and Profit Calculation											
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Portion of 2003 Prod.	-	1/28	3/28	6/28	10/28	15/28	21/28	28/28	-	-	-
Prod. Level	-	2,500	7,500	15,000	25,000	37,500	52,500	70,000	70,000	70,000	70,000
Units short of B/E	-	25,500	20,500	13,000	3,000	18,500	3,500	-	-	-	-
Fixed Cost per Unit (1st shift)		18,134	18,134	18,134	18,134	18,134	18,134	18,134	18,134	18,134	18,134
Fixed Cost per Unit (2nd shift)		-	-	-	-	13,599	13,599	13,599	13,599	13,599	13,599
Prod. Over-run	-	(462,423,120)	(371,751,920)	(235,745,120)	(54,402,720)	(251,574,840)	(47,595,240)	-	-	-	-
PV Prod. Over-run	(1,141,118,194)										
Units above B/E	-	-	-	-	-	-	-	14,000	14,000	14,000	14,000
Profit	-	17,000,000	51,000,000	102,000,000	170,000,000	255,000,000	357,000,000	729,879,360	729,879,360	729,879,360	729,879,360

Table E-3
Analysis of Additional 35,000 Units and 20% Profit Margin

Nico		
NPV Prod. Over-run		$ 1,141,118,194
NWC		
Cost of Payroll	$ 2,640,000	
Cost of Materials	2,640,000	
		5,280,000
Depreciable Assets		20,000,000
NICO		$ (1,166,398,194)

Table E-4
Analysis of Additional 35,000 Units and 20% Profit Margin

Incremental Cash Flow Analysis (in Dollars)											
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
CIF	-	17,000,000.00	51,000,000	102,000,000	170,000,000	255,000,000	357,000,000	729,879,360	729,879,360	729,879,360	729,879,360
NICO	(1,166,398,194)	-	-	-	-	-	-	-	-	-	-
Net Cash Flow	(1,166,398,194)	17,000,000	51,000,000	102,000,000	170,000,000	255,000,000	357,000,000	729,879,360	729,879,360	729,879,360	729,879,360

Decision-Measures	
NPV	$ 605,920,905
IRR	18.08%
PI	1.52

Table F-1
Analysis of Additional 35,000 Units and 30% Profit Margin

Break-even Calculation			
GM Car & Truck Sales in California			350,000
Electric Vehicles Mandated in Cal. (10%)			35,000
Addt'l EVs Mandated in NY, MA, VT, etc.			35,000
Total Production Level needed for 2003			70,000
Retail Selling Price	X	$	34,000
Total Revenue		$	2,380,000,000
Profit Margin	-	$	714,000,000
Revenue Needed to B/E Per Year		$	1,666,000,000
Break-even # of Units			49,000

Table F-2
Analysis of Additional 35,000 Units and 30% Profit Margin

Production Cost Over-run and Profit Calculation											
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Portion of 2003 Prod.	-	1/28	3/28	6/28	10/28	15/28	21/28	28/28	-	-	-
Prod. Level	-	2,500	7,500	15,000	25,000	37,500	52,500	70,000	70,000	70,000	70,000
Units short of B/E	-	22,000	17,000	9,500	-	11,500	-	-	-	-	-
Fixed Cost per Unit (1st shift)		15,867	15,867	15,867	15,867	15,867	15,867	15,867	15,867	15,867	15,867
Fixed Cost per Unit (2nd shift)		-	-	-	-	11,899	11,899	11,899	11,899	11,899	11,899
Prod. Over-run	-	(349,084,120)	(269,746,820)	(150,740,870)	-	(136,836,315)	-	-	-	-	-
PV Prod. Over-run	(747,772,671)										
Units above B/E	-	-	-	-	500	-	3,500	21,000	21,000	21,000	21,000
Profit	-	25,500,000	76,500,000	153,000,000	262,933,730	382,500,000	591,036,110	1,047,216,660	1,047,216,660	1,047,216,660	1,047,216,660

Table F-3
Analysis of Additional 35,000 Units and 30% Profit Margin

Nico			
NPV Prod. Over-run		$	747,772,671
NWC			
Cost of Payroll	$ 2,640,000		
Cost of Materials	2,640,000		
			5,280,000
Depreciable Assets			20,000,000
NICO		$	(773,052,671)

Table F-4
Analysis of Additional 35,000 Units and 30% Profit Margin

Incremental Cash Flow Analysis (in Dollars)											
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
CIF	-	25,500,000.00	76,500,000	153,000,000	262,933,730	382,500,000	591,036,110	1,047,216,660	1,047,216,660	1,047,216,660	1,047,216,660
NICO	$ (773,052,671)	-	-	-	-	-	-	-	-	-	-
Net Cash Flow	$ (773,052,671)	25,500,000	76,500,000	153,000,000	262,933,730	382,500,000	591,036,110	1,047,216,660	1,047,216,660	1,047,216,660	1,047,216,660

Decision-Measures	
NPV	$ 1,842,243,031
IRR	33.75%
PI	3.38

Table G
Cost of Capital Calculation

Calculation of Cost of Debt
Using a Sample of GM Outstanding Debt Issues

I-rate	$ Amount ('000)	Weight	Weighted Rate
8.125%	500,000	0.1303	0.010587
7.000%	206,040	0.0537	0.003759
5.000%	113,322	0.0295	0.001477
5.750%	118,000	0.0308	0.001768
9.750%	200,000	0.0521	0.005082
9.625%	700,000	0.1824	0.017558
8.800%	600,000	0.1564	0.013759
9.400%	300,000	0.0782	0.007349
9.125%	400,000	0.1042	0.009512
7.000%	300,000	0.0782	0.005473
7.625%	400,000	0.1042	0.007948
Weighted Average Cost of Debt			8.43%
Times (1- corporate tax rate of 34%)			0.66
After Tax Cost of Debt			5.56%

Total Amount of Debt in Billions = $77.9

Calculation of Required Rate of Return
Using the Capital Asset Pricing Model

$\%ROR = K_{RF} + Beta_{GM}(K_{Mkt} - K_{RF})$
$= .0519 + 1.15(.12 - .0519)$
$= .0519 + .0783$
$= .1302$

%ROR (Cost of Equity) = 13.02%

Total Amount of Equity (includes preferred) in Billions = $80.0

Weighted Average Cost of Capital

$WACC = W_D K_D(1 - T_C) + W_E K_E$
$= (77.9/157.9)(.0843)(1 - 0.34) + (80/157.9)(.1302)$
$= .0274 + .0660$
$= .0934$

WACC = 9.34%

Table H
Summary of Scenario Decision-Measures

Scenario #1 (10% PM, 35,000 Units) Decision-Measures	
NPV	$ (1,482,087,940)
IRR	-8.17%
PI	0.24
Probability	0.15

Scenario #4 (10% PM, 70,000 Units) Decision-Measures	
NPV	$ (757,776,953)
IRR	2.41%
PI	0.55
Probability	0.20

Scenario #2 (20% PM, 35,000 Units) Decision-Measures	
NPV	$ (557,567,850)
IRR	3.99%
PI	0.61
Probability	0.20

Scenario #5 (20% PM, 70,000 Units) Decision-Measures	
NPV	$ 605,920,905
IRR	18.08%
PI	1.52
Probability	0.25

Scenario #3 (30% PM, 35,000 Units) Decision-Measures	
NPV	$ 269,007,242
IRR	14.94%
PI	1.26
Probability	0.12

Scenario #6 (30% PM, 70,000 Units) Decision-Measures	
NPV	$ 1,842,243,031
IRR	33.75%
PI	3.38
Probability	0.08

Expected Returns	
NPV	$ (715,834,863)
IRR	1.92%
PI	0.61

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