ECONOMIC JUSTIFICATION

A Manufacturing Engineer's Point of View

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I. JUSTIFICATION METHODS

What's the best way to describe benefits and justify an automation project to upper management? Most companies today ***use a combination*** of the methods described below. Important concepts for economic justification are given here:

- The time value of money is important.
- A dollar today is worth more than a dollar tomorrow.
- The expected cash flows from each year of the project is discounted against the company's desired rate of return.

Consider the project information given here as a ***case study*** of each method.

ABC Company is considering an automation retrofit for a manual assembly process. It will cost $25,000 in planning and engineering costs for three years. In the fourth year, the project will require a capital investment of $200,000. The system will be up and running in year five. The system will increase productivity by $100,000 per year. It will have annual operating costs of $30,000. Assume no salvage value at the end of ten years. The company's required rate of return on projects like this is 15%.

C_0 to C_{10}	**=**	**expected cash flows for the project**
C_0	**=**	**initial investment = 0**
C_1 to C_3	**=**	**planning & engineering costs = $25,000**
C_4	**=**	**capital investment = $200,000**
C_5 to C_{10}	**=**	**cost savings – operating costs = $100,000 - $30,000 = $70,000**
r	**=**	**company's required rate of return = 15%**

a. NET PRESENT VALUE (NPV)

The net present value approach involves discounting the expected cash flows from each year of the project. These cash flows are then summed to produce the project's present value, hence the term *net present value.*

Acceptance Criteria: A project that produces a ***positive NPV*** is considered to be an attractive investment opportunity.

NPV = $-C_0 + \sum_{t=1}^{n} \frac{C_n}{(1+r)^n}$

$$= 0 + \frac{(-25)}{(1+15)} + \frac{(-25)}{(1+.15)^2} + \frac{(-25)}{(1+.15)^3} + \frac{(-200)}{(1+.15)^4} + \frac{70}{(1+.15)^5} + \frac{70}{(1+.15)^6} + \frac{70}{(1+.15)^7} + \frac{70}{(1+.15)^8} + \frac{70}{(1+.15)^9} + \frac{70}{(1+.15)^{10}}$$

NPV = $37.25 (thousands)

RESULT: This is a good investment.

Project Net Present Value	
YEAR	**PRESENT VALUE ($)**
0	0
1	-21,750
2	-40,300
3	-56,950
4	-114,350
5	-79,550
6	-49,250
7	-22,950
8	50
9	19,950
10	37,250

b. SIMPLE PAYBACK METHOD

The ***payback method*** is an ad hoc rule that looks at how quickly a project pays back the original investment. In other words, when the NPV of the project is zero. It is sometimes called the "break-even analysis" because of when you finally pay off your investment and start saving or making money.

The time period can be calculated quickly by constructing an NPV table like the one shown above. Notice that for this project, the payback period is 8 years ($C_8 = 50$).

$$-C_0 + \sum_{t=1}^{n} \frac{C_n}{(1+r)^n}$$

Acceptance criteria: In general, ***the shorter the payback period***, the more desirable the project, particularly when there is a great deal of uncertainty.

RESULT: Some companies have aggressive payback requirements, such as a maximum of two or three years to break even. With a payback of 8 years, this may be considered a marginal or poor investment.

c. PROFITABILITY INDEX (PI)

Closely related to NPV, PI compares the discounted cash inflows to the discounted cash outflows.

Acceptance criteria: Projects with an index greater than 1 are generally considered to be attractive investment opportunities.

PI = (discounted cash inflows) / (discounted cash outflows)

$$= \frac{\frac{70}{1+.15)^5} + \frac{70}{(1+.15)^6} + \frac{70}{(1+.15)^7} + \frac{70}{(1+.15)^8} + \frac{70}{(1+.15)^9} + \frac{70}{(1+.15)^{10}}}{\frac{(25)}{(1+15)} + \frac{(25)}{(1+.15)^2} + \frac{(25)}{(1+.15)^3} + \frac{(200)}{(1+.15)^4}}$$

PI = 1.33

RESULT: This is a favorable investment.

d. INTERNAL RATE OF RETURN (IRR)

Rather than specifying a discount rate, IRR calculates the rate of return that project is expected to yield over its lifetime. IRR is also know as the discount rate or breakeven point that makes the project NPV equal to zero. ***This method takes a little bit more effort to solve*** because it must be iterated for various values of IRR until the equation is solved. However, it is a much better indication of the value of the investment.

Acceptance Criteria: A project with an IRR greater than the company's rate of return is a good investment opportunity.

$$NPV = 0$$

$$= 0 + \frac{(-25)}{(1+IRR)} + \frac{(-25)}{(1+IRR)^2} + \frac{(-25)}{(1+IRR)^3} + \frac{(-200)}{(1+IRR)^4} + \frac{70}{1+IRR)^5} + \frac{70}{(1+IRR)^6} + \ldots + \frac{70}{(1+IRR)^{10}}$$

(iterate through various values of IRR to solve this equation = 0)

IRR = 11%

RESULT: While return on investment is made on this project, this may not be suitable to meet a company's internal requirements.

II. GENERATING THE DATA TO USE IN JUSTIFICATIONS

OK, so now you know the theory. But how exactly does one determine the savings of a project? Sometimes it is easy to calculate this. For example, if a robot is installed to retrofit a manual workstation, then an immediate labor savings can be added.

But what about productivity gains (throughputs and efficiency improvements)? How can quality improvements be ***quantified*** so that they can be added to the justification calculation. Many times these potential savings are challenging to quantify because of the "fuzzy" nature of the savings. For example, what is the potential increase in revenue because your customers now perceive your products to be of a superior quality?

This is a chance for your creativity to sing out, but be careful in this part. Failure to add these values can limit your ability to justify your projects. ***Failure to quantify your savings data can limit your career.***

Consider these savings when a cost justification is undertaken.

- Improve product quality and yield
- Lower manufacturing costs
- Reduce product rework effort
- Reduce direct labor and support labor (technicians, etc.)
- Cost avoidance for new equipment
- Eliminate existing equipment
- Reduce the design-to-market cycle time

- Increase manufacturing capacity
- Reduce inventory levels
- Reduce, control, and track Work In Process
- Improve control of process (simplify, lower, modify)
- Reduce paper handling
- Reduce product design and build time
- Reduction of scrap values and scrap rates
- Reduction of plant overhead charges
- Increase manufacturing producibility
- Lower product field support costs
- Eliminate redundant data entry & storage
- Improve data access
- Lower operational costs
- Integrate distributed systems and eliminate redundant information
- Lower cost of computer hardware installed
- Delivery of products on time
- Lower inspection costs
- Reduce space requirements
- Reduce material handling and storage costs
- Reduction in Accounts Receivables
- Opportunity costs of funds not being employed as capital
- Increased sales through higher customer satisfaction
- Increased sales through lower product costs

Be concerned about these potential ***cost gains*** also:

- Increased equipment and system support costs (adding robots will require adding programming skills)
- Qualified Repair & Maintenance requirements
- Higher training costs
- System modification costs
- Higher documentation costs
- Higher equipment tooling costs

III. REAL WORLD INSIGHTS INTO THE PSYCHOLOGY OF COMPANIES AND MANAGERS

We all have our bosses, so it's best we learn to fit their needs. That's why we were employed in the first place, right? Economic justification is a powerful tool that rarely is exploited to its fullest potential, and that includes selling to your boss. Here are some caveats gained over the years:

- Gather an array of alternatives…don't make it obvious you favor one solution over another.
- Make sure your have the support of all of the people involved. A reluctant manager can be swayed by the troops on the shop floor.
- Analyze the impacts of the multiple choices and be prepared to submit to a grueling review.
- Don't be afraid of making a recommendation, but be ready to justify your conclusion quantitatively.
- Go the extra mile and do your homework.
- Consider some sort of sensitivity analysis or a competitive benchmarking analysis, including assessing the action of "doing nothing."

- Be open to being overruled by the managers: their decision criteria usually include situations of which you aren't aware and of which they can't speak openly.
- Set the expectations of your target audience and pre-sell the ideas.
- Speak the language of the listener. Nothing turns people off more than listening to a nerdy engineer babble on about his pet project.
- Businesses are in business to make money. Dollar savings are king in economic justifications. Technical aspects are relegated to the lower rungs of the decision ladder.
- Relate the proposed investment to the well-being of the firm. Show how the investment relates to the firm's strategic plan and the stated corporate objectives.
- Failure to fund your proposal does not mean management is stupid. Management's decision to fund your proposal does not imply they are brilliant, either.
- A firm's ability to finance the proposal is as important as its economic merit.

IV. A METHOD FOR JUDGING MULTIPLE OPTIONS

Many times there are various solutions to the same problem. We do our best to make an apples-to-apples comparison by writing detailed specifications, talking with vendors, and trying to inform the world just what it is that we want. But when it comes down to it, the vendors supply slightly different variations of reality. Now what do you do? How do you determine ***quantitatively*** what is the best choice?

Here's a little trick developed over the years. Create a quantifiable comparative analysis. Here are the steps.

Step 1: Determine your required categories for important judgment criteria.

Here are some examples to think about. It is important to create criteria that is significant to your own situation. Don't overdo it, perhaps ten or so are sufficient.

- price
- worst case delivery (impacts production plans)
- location of vendor (for support issues)
- quality of proposal
- overall design of proposed system
- types of control systems
- health of company
- economic justification
- service and maintenance requirements

Step 2: Assign a weighting factor, an importance value, between 1 and 10 to each criteria.

In my own experience I have found that price is rarely the most important factor. I assign it a weight of 7 or 8. Being called at home in the middle of the night to fix a machine I procured is very important to me: I assign reliability a weight factor of 10.

Step 3: Create a method to judge each criteria.

This is an important Step, otherwise a value cannot be determined fairly and quantitatively. Consider the price factor. A machine specification may generate eight submissions from systems integrators. One method may be to set up a scoring system such as this:

5	(BEST)	20% or more below average price of group
4		10%-20% below average price of group
3	AVERAGE	plus or minus 10% of average price of group
2		10% - 20% above average price of group
1	(WORST)	20% or more above average price of group OR does not meet specification requirements

Step 4: Multiply each option's score by the weighting factor.

Step 5: Sum all of the scores of each factor for each option.

This last step will give a score value of all the options. This may or may not provide a decision, but certainly it will give insight into what criteria are important and how the different options stack up.

Some sample forms that you can easily create yourself and adapt to your particular needs are given here.

Competitive Analysis Summary (sample)

Insert weighted scores from worksheets here

Categories	Weight Factor	Vendor Option 1	Vendor Option 2	Vendor Option *n*
Price	7			
[illegible]	[illegible]			
[illegible]	[illegible]			
Control System	5			
- your criteria -	X			
SCORE				

Competitive Analysis Worksheet (sample)

Category: price **Weighting:** 8	Vendor 1	Vendor 2	Vendor 3	Vendor 4	Vendor 5
Value: $	462,406	618,415	470,615	386408	141,620
SCORING: 5 (best): 20% or more below average 4: 10%- 20% below average 3: Average, within +/- 10% 2: 10% - 20% above average 1 (worst): 20% or more above average OR does not meet specification	4	2	3	1	1
Weighted Score:	32	16	24	8	8
COMMENTS:	vendor has previously supplied excellent equipment	price doesn't include required peripheral		did not meet spec	did not meet spec

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