Strategically Integrating Environmental and Human Components into the Cost-Benefit Analysis Using the Triple Bottom Line Multiplier

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Identifying ethical situations and having an understanding of ethical decision making are key goals of the engineering education. There are two common traps prevalent in the teaching of ethics to engineering students. The first is the mis-identification of a situation as an ethical issue. The example of this is the use of the Tacoma Narrows Bridge Collapse [1]. In that case, there was not an unaddressed ethical issue in the construction of the bridge that lead to its failure, but rather the collapse of the bridge was due to a fault in its design based on a factor that was not known at the time.

The second most common trap in teaching ethics to engineering students involves the use of the utilitarian-based cost-benefit analysis [2]. Engineering students are predisposed to the use of mathematical equations and models; thus the cost-benefit analysis is attractive to engineering students as it translates something uncomfortable (making a decision about the effect of a situation or issue on people) into a mathematical model that produces a definitive answer. The Ford Pinto case [3] is the classical example used to teach the cost-benefit analysis and it produced a "wrong" answer because it failed to account for the most significant factor in ethical decision-making: a decision that has the potential to harm the environment, people or more specifically children, will have a more greater impact on the decision than the current model allows [4].

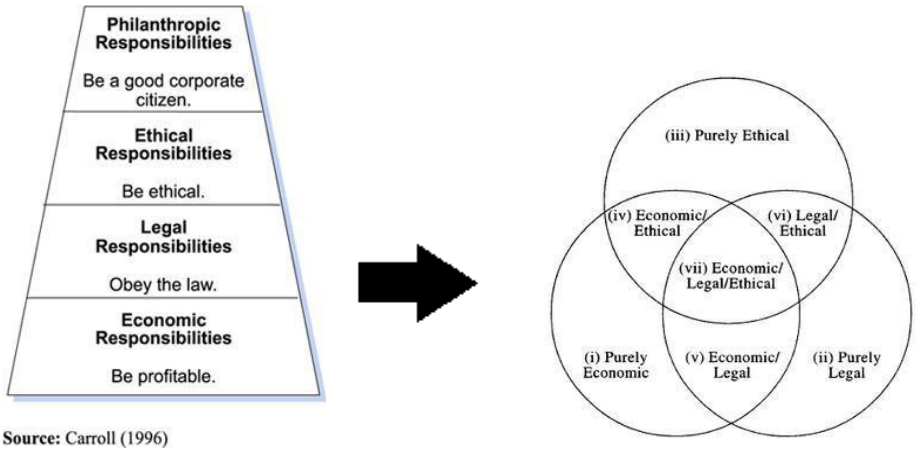
A traditional cost-benefit analysis (CBA) consists of listing alternative projects and programs, listing stakeholders, and selecting measurements. In the triple bottom line approach, quantifying such attributes becomes increasingly difficult as has been discussed since the introduction of the social and environmental components in the 1970's. The difficulty in creating a common measurement of quantity for comparing and creating a single CBA rests in the question of how human and environmental life, happiness, and value can be represented in dollars. The concept of triple bottom line, in fact, often turns out to be a "good old-fashioned single bottom line plus vague commitments to social and environmental concerns" [5].

To address the vague commitments, we will create and explain a conceptual model that uses a profitable/unprofitable output of the social and environmental concerns through utilization of a company designed index. Once the results are tabulated, they can then be applied to a traditional CBA by means of our "triple bottom line multiplier." The results allow companies to calculate a CBA in traditional terms with dollars as the unit, with more standardized and sustainable incorporation of humanistic and environmental measures. Each company should use cases in which to test their model against to ensure validity and consistency.

Three-Domain Model of Corporate Responsibility

In 2003, Mark Schwartz and Archie Carroll created a model of sustainability they called the three-domain model of corporate responsibility [6]. It was an extrapolation of an earlier model that Carroll had created termed "the four domains of corporate responsibility" depicted in the form of a pyramid. This model was a hierarchy with economic value forming the base, and legal, ethical and philanthropic filling out the top. A self-reported limitation of this model was the impression that the top of the model represented the most advanced corporations, and those residing primarily in the economic were considered "amoral." Carroll used a pyramid model that had been created by Reidenbach and Robin to substantiate this claim [7].

In an effort to address this limitation, Carroll and Buchholtz [8] created the three-domain model of Corporate responsibility pictured in Figure 1. This model improves on the mutual exclusivity of the previous pyramid model, and focuses on the three components of social responsibility. A difficulty that was acknowledged in their presentation was the ambiguity associated with their legal and ethical domains. They used legal as the area in which all legal expectations from society were included, and ethical enveloped all those expectations or prohibitions from society that aren't codified into law [6].



Source: Carroll (1996)

Figure1. Three Domain Model of Corporate Responsibility [8]

Our improvement upon this shortcoming of their model begins by replacing "legal" with "environmental sustainability", and "ethical" with the "human component." A similar Venn Diagram is therefore obtained that more closely aligns with the modern day triple bottom line, as well as integrates a more precise and applicable component to their model. We term this model the "Triple Bottom Line Multiplier."

Triple Bottom Line Multiplier

Our deviations to Carroll's model do not simply represent a semantic reformulation, but also attribute a scoring rubric into the diagram. Once a numerical score is identified, it can be used in a multiplicative manner to give more meaning to a traditional Cost Benefit Analysis calculated in dollars, as seen in Figure 2. The first step for any company utilizing this method is to create value through indexes to all three components: Humanistic, Environmental and Economic.

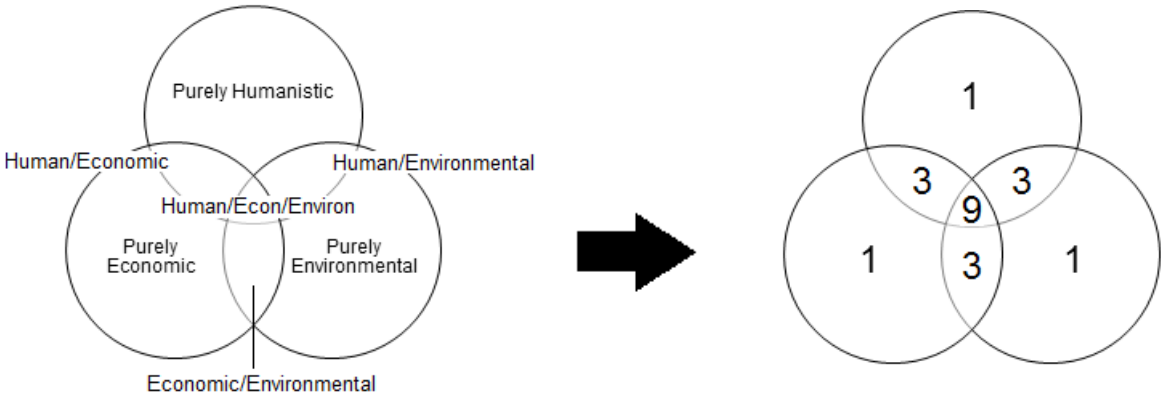


Figure 2. Triple Bottom Line Multiplier

Applying the three bottom line results to the diagram, leads to the identification of which multiplier to utilize. MacGillivray [9] states that the "economic, environmental and social balance sheets must all be in the black for a business to be sustainable". A category of each bottom line only advances to the second or third level if its CBA is positive. Therefore, a result that only benefits one bottom line does not change the traditional CBA in any way (multiplier of 1). However, a result that benefits all three bottom lines in a positive or sustainable way, will add a factor of nine to the monetary benefits; it can also be calculated as a divisor of nine to the costs.

It is critical that the business not try to quantify the human aspect in terms of dollars. The act of doing such is fundamentally misguided [10]. Rather, each component of the triple bottom line must be analyzed separately, with absolute results compared at a high level.

Step One: Calculating Each Component: Economic

This component, labeled "Economic" is performed here first via a traditional CBA to analyze the degree of economic gain or loss. The Ford Pinto case may be used to examine this economic component and will also be used later as the basis for applying the new multiplier.

To demonstrate the application of the triple bottom line multiplier we will look a historically controversial case in which failure to accurately identify the value of human life, left Ford Motor Company facing large lawsuits.
In 1973, Ford's Environmental and Safety Engineering division developed a cost-benefit analysis entitled *Fatalities Associated with Crash Induced Fuel Leakage and Fires* [11]. It was used to determine the financial implication of a repair that would fix a fuel system design flaw. The report estimated a fix would cost Ford $137 million compared to an alternative $49.5 million payout in injury and death lawsuits for the 360 individuals forecasted to be affected by the design flaw [11]. In the end, it cost Ford over $127 million in lawsuits along with criminal charges [12].

The Ford Pinto case is a heavily examined case since its exposure to the public nearly four decades ago. For an examination of our model, the Ford case was chosen with purpose. Only through time do the full financial, environmental and sociological impacts of poor corporate responsibility become fully realized. We believe this case showcases a good portrait of a corporate decision that contains well defined segments in which we are examining (humanistic, environmental, and economic). More importantly it has had enough time to fully flush out most of the detrimental ramifications to society, which allows us to fully examine the efficacy of our model. In addition, because of the publication of the internal cost memo and publication of the details related to the subsequent lawsuits, the mathematics behind this example are also known. More recent cases such as the Volkswagon "Cheat Device" or the Epipen case are missing publicized quantitative information to date.

Benefits

Savings: 180 burn deaths, 180 serious burn injuries, 2100 burned vehicles
Unit Cost: $200,000 per death, $67,000 per injury, $700 per vehicle
Total Benefit: 180 x ($200,000) + 180 x ($67,000) + 2100 x ($700) = **$49.5 Million**

Costs

Sales: 11 million cars, 1.5 million light trucks
Unit Cost: $11 per car, $11 per truck
Total Cost: 11,000,000 x ($11) + 1,500,000 x ($ 11) = **$137 Million**

Figure 3. Original CBA [13]

The mathematics in Figure 3 represent the economic circle in the Venn diagram. The math here is straight forward and since the costs outweigh the benefit by less than the potential multiplier of 3, there is no need for an additional overlap in the Venn diagram for economics. With this step of the analysis complete, we may then begin to incorporate the two new components derived from

the triple bottom line; the humanistic and environmental components. Note: the model as it is proposed here subsumes legal consequences within the economic component of the analysis. This current assumption works fine for the conceptual model as proposed though the authors intended to explore expanding this to its own independent component in later iterations of the model.

Step Two: Calculating Each Component: Humanistic

When defining humanistic, we will use a consequentialist standard which focuses on ends or consequences. This standard holds that the morally right thing to do is to promote the good of persons [14]. Carroll argues that this definition requires both egoism (good of the individual) and utilitarianism (good of society) [6]. Because we are focusing solely on the human factor, we are ignoring the utilitarian standard for this purpose. The stakeholders that are to be considered are only the end directly affected by the choice under consideration. Stakeholders such as shareholders, employees, competitors, suppliers, and the local community are addressed in the environmental, or more explicitly in the economic realm. There is a strong humanistic element present in the circumstances of this case so an overlap with the humanistic portion of the Venn diagram is appropriate. NOTE: since the potential loss of life is low when contrasted with the total population this will be one overlap (moving to a multiplier of 3) and not national or global in scale (which would warrant the movement to the triple-overlap section with a multiplier of 9).

Step Three: Calculating Each Component: Environmental

When looking at environmental, we take a further deviation from Carroll's legal category than we did in the preceding category of ethical and humanistic. Though legalities run deeply into environmental concerns, we want to keep economic sanctions or repercussions of such acts in the economic category.

For the purposes of quantification in our model, we advise businesses to utilize the standards set forth by the Organization for Economic co-operation and Development. Two pages of particulars are published in their manual, but generally ask that the business "Assess the foreseeable environmental, health, and safety-related impacts associated with the processes, goods, and services of the enterprise over their full life cycle [15]." For the purpose and scope of this paper, the case study below will only be broadly examined to determine the positive or negative impact to the environment. Since this component includes environmental, health and safety factors and there is clear risk to health and safety as well as potential environmental impacts as a result of explosions and burning of fuel, an additional overlap is warranted in the environmental component. NOTE: since the potential impact of this component is isolated to the locations of a potential explosion and not to a national or global level, this component only

warrants a move to a section with a 3 multiplier and not to the triple overlap section with a 9 multiplier.

Step Four: Applying the Multiplier

The above analysis determined that an additional factor was needed for both the humanistic and environmental components of the triple-bottom line, indicated the overlap section of the Venn diagram (Figure 4) in the right section of the diagram which represents an overlap with additional costs in humanistic and environmental. A simple index is used to calculate the cost to humanity and the environment, which is in the red for this example. The resulting multiplier is "3" or divisor "⅓".

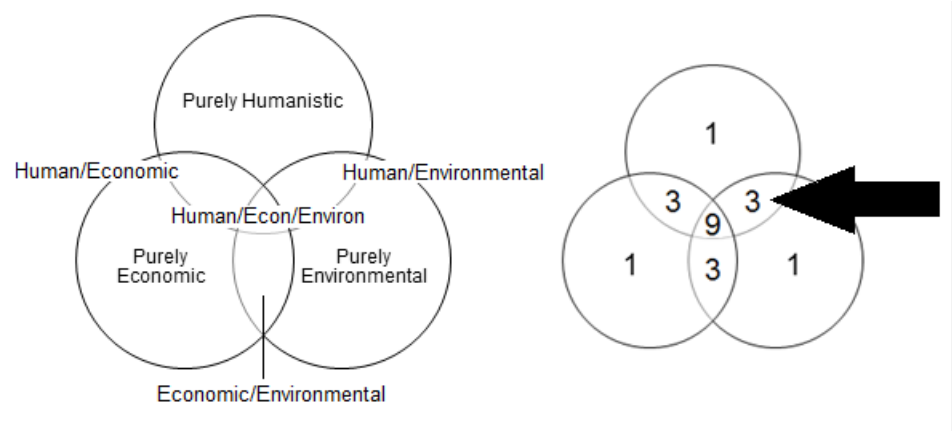


Figure 4. Multiplier for this Case

When the multiplier is included the mathematics of the analysis changes as seen in Figure 5. The true cost of the company of fixing the fuel system becomes $45.6 million after human life is factored into the equation. Applied to the benefits side of the equation, $148.5 Million becomes the true cost of failing to make the improvements rather than $49.5 Million. This more closely matches with the court's determination for $127.5 Million in compensatory and punitive damages charged to Ford after the fact, and lends itself to the efficacy and relative accuracy of the model.

Figure 5. CBA with Multiplier Applied

Benefits

Savings: 180 burn deaths, 180 serious burn injuries, 2100 burned vehicles
Unit Cost: $200,000 per death, $67,000 per injury, $700 per vehicle
Total Benefit: 180 x ($200,000) + 180 x ($67,000) + 2100 x ($700) = **$49.5 Million**

Costs

Sales: 11 million cars, 1.5 million light trucks
Unit Cost: $11 per car, $11 per truck
Total Cost: 11,000,000 x ($11) + 1,500,000 x ($ 11) = **$137 Million / 3 = $45.6 Million**

Conclusion

The model proposed in this paper, is meant to be quite simplistic. The purpose is to present the model with an accompanying case study showcasing the overall idea and founding background only. In a class room setting, the instructor could then use the model with other case studies to examine the overall utility of a utilitarian CBA with and without accounting for the additional human and environmental factors. It is the intent to further investigate the applicability of the Triple Bottom Line Multiplier applied to recent and ongoing cases relating to CSR in future papers. Additional testing can, and is proposed to be done on a variety of cases as the full economic and societal impacts are exposed. Further testing will address the limitations of this model, more specifically addressing and manipulating the numeric weights assigned to each of the three components and fleshing out additional factors related to the specific environs of each will be published in subsequent papers.

By combining the triple bottom line theory with the classic cost-benefit analysis model, the potential trap of underestimating the impact of damage or injury to the environment or people is corrected in a way that we believe will still resonate with the majority of engineering students as it is still a math-based approach. The introduction of the multiplier outlined above will allow engineering ethics educators to continue to use the utilitarian cost-based analysis theory and tool in a way that can easily be transitioned to a dialogue about the importance of humanity and the environment in making ethical decision.

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