Overview of Social Impact Modeling Research

The purpose of this document is to help guide researchers and practitioners through the social impact modeling process.

This document maps social impact modeling research questions to answers and publications. These questions, answers, and publications have been the focus of the BYU Design Exploration Research Group since 2017. The work includes collaborations with Oregon State University, Iowa State University, the University of Buffalo, Loughborough University (UK), and with industry partners WHOlives and Sindicato Rural de Itacoatiara (Brazil). It also includes collaborations with BYU Social Science, BYU Marriot School of Management, and BYU Manufacturing Engineering. The work is funded by the National Science Foundation, the Crocker Innovation Holdings, and the McQuinn Family Foundation.

Premises (assumed truths we build upon)

1. Engineered products affect people, and therefore impact society.
2. Product impacts can be positive or negative.
3. Different groups of people may be impacted by engineered products in different ways.
4. Engineering design decisions can affect a product's impact on society.
5. Currently, outside of health and safety consideration, few tools exist to make an actionable connection between parameters of the product and the impact the product has on society.

Scope of Research

1. Our work is focused on sustainable design, seeking desirable economic, environmental, and social Impact.
2. Within sustainable design, we are presently concerned with the social impact of engineered products.
3. We treat social impacts as different than and (at present) separate from economic impacts and environmental impacts, both of which are important and already better understood in the engineering community.
4. We believe that social, economic, and environmental impacts can be interrelated, and we seek to understand the interrelatedness of them.
5. We are interested in the development of engineering design tools/theories that aid engineers in making socially conscious decisions while designing. Thus, we are focused on the estimation of future impacts (a priori), not the evaluation of existing products and their current impact (a posteriori).
6. We aspire to computationally assist decision making, which likely requires the quantifying the social impact of engineered products.
7. We also believe there is non-quantitative work to do to better understand the nature of social impact as it relates to engineered products.

Useful Analogy

Consider the mechanical stress and strain of a loaded structure. There are multiple boundary conditions for any such problem, and multiple resulting stresses and strains. Each should be considered and choices should be made about what to include and neglect in the evaluation of the structure. **This is different that choosing *any* boundary condition, *any* stress, and *any* strain to evaluate.** This is pertinent to social impact modeling because it can be common for design engineers to choose *any* social impact category, or *any* social impact indicator, without having thoughtfully considered the full possibility of impacts before choosing what to include and what to neglect in the social impact evaluation of the product.

Research Questions, Current Answers, and Publications

1. What is social impact, generally?
    - Social impact is "the influence [an engineered product has] on the day to day lives of persons" [1].

- More specifically, the Social Impact of Engineered Products is the way and extent to which an individual or group of individuals is affected by the presence of a particular engineered product or a particular set of products in their life or lives. The social impact of a product is a function of both the product and the individual(s) affected, therefore affecting different people differently. Social impacts may be immediate, or be dynamic only emerging over time. Social impact evaluation can be simplified to those experienced by a single stakeholder, or more realistically by many stakeholders some of which may be positively impacted by a product, while others are negatively impacted.

2. In what ways specifically can an engineered product affect society?

   - From Rainock et al [2], products can have impacts in at least the 11 areas listed below. These were extracted from 121 papers originating from 72 different sources, and are referred to as the 11 Social Impact Categories. Simple examples for each are provided in [3]:

     1. Impacts on Health and Safety
     2. Impacts on Paid Work
     3. Impacts on Stratification
     4. Impacts on Human Rights
     5. Impacts on Education
     6. Impacts on Family
     7. Impacts on Gender
     8. Impacts on Population Change
     9. Impacts on Conflict and Crime
     10. Impacts on Networks and Communication
     11. Impacts on Cultural Identity and Heritage

3. How can social impact be measured/evaluated?

   - There are various ways to evaluate social impact, from simple and quick to complex and time-intensive. The following list is provided in increasing method intensity and data requirements.

     1. Traditional Safety/Risk Analysis using existing FMEA methodology [4]. In Pack et al.'s industry survey surrounding social impact evaluation [5], it is clear that FMEA is one of only a few approaches used in industry to consider the social impacts of engineered products.
     2. 55 Social Impact Consideration Questions [3, 6]. These are simple non-quantitative thought questions that can be used to evaluate whether a social impact category is pertinent to a particular engineering problem. Ottosson et al. evaluated 150 products designed for social impact against the 11 social impact categories [26], linking existing products to these impact categories. What resulted where conditional and joint probabilities of the co-presence of multiple social impacts for a given product.
     3. Social Impacts and Effects Analysis (SIEA) [6]. This is an FMEA-inspired method to evaluate the effects of social impacts. This method allows designers to identify social impact categories that have the greatest potential for impact (similar to FMEA's Risk Priority Number).
     4. Product Impact Measure (PIM) [7]: This is a simple quantitative measure inspired by the UN's multidimensional poverty index, but has been made to apply to an individual or small group of individuals, not a country.
     5. Specific Product Impact Measure (SPIM) [8]: This method constructs relatively complex social impact models using various indicators and considers various stakeholders.

    6. Single stakeholder optimization [9, 10]: In Mattson et al. [9], the *sustainability space* (defined by economic impacts, environmental impacts, and social impacts) is identified and trade-space decision making techniques are used to optimize a design.
    7. Multi-stakeholder optimization [11]: In Stevenson et al. [11], 8 aggregate objective functions as derived from the literature are provided for handling different stakeholder needs as it relates to social impact optimization.
    8. Adoption-based societal behavioral modeling relative to products and their impacts [12, 13]. In Mabey et al. [12], society is modeled and agents are free to adopt or not adopt a product. This is based on many social factors and product impact factors. Simulations are run that track product impacts over time through society. In Mabey et al [13], a design framework is provided for constructing adoption based social impact models.
    9. Adoption-based simulations involving environmental objectives and Life Cycle Analysis (LCA) [14]. In Liechty et al [14], Life Cycle Analysis is coupled with adoption-based agent-based modeling, thus including the coupled affect between environmental impacts and social impacts.

4. How do products affect individuals differently within a population? And how do products affect individuals differently than they affect societies?
    - In Stevenson et al. [15] society is modeled using aggregated and micro data to produce synthetic populations. These synthetic populations allow a products impact to be measured across an entire population, sub populations, or across various individuals in the population. Not surprisingly, some products have positive impacts on people in the population while at the same time having negative impacts on others in the population. In Stevenson et al [11], multiple optimization problem formulations are provided to handle multiple stakeholders.
5. What kinds of data are needed to compute social impacts and where do we get that data?
    - Data for social impact modeling can come in many forms, including aggregated data from places such as the UN or World Bank, micro data from databases such as census reports, from sensor data, or from surveys and interviews. See [16-20].
6. What kind of sensors can be used for data collection?
    - Stringham et al [21, 25] developed a design framework for creating remote sensor systems for data collection. Stringham et al [22] then used this data with machine learning over a long period of time to predict social impacts of products.
7. How are companies considering social impacts today?
    - Pack et al [5], interviewed roughly 50 companies relative to social impact consideration. The results show nearly all respondents interested in considering social impacts more fully, but lacking tools to do so.
8. How are societal impacts influenced by product adoption, and how is product adoption affected by social impacts?
    - Mabey et al [12] and Liechty et al [14] explore this coupling.
9. How can these models be validated?
    - The framework provided by Agent Based Model pioneers North and Macal [23] is adopted for this.

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