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Ph.D. DISSERTATION DEFENSE

Candidate:	Hossein Basereh Taramsari
Degree:	Doctor of Philosophy
School/Department:	Charles V. Schaefer, Jr. School of Engineering and Science / Systems and Enterprises
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Title:	Product Sustainability Management: A Multi-Dimensional Framework for System Improvement
Chairperson:	Dr. Roshanak Nilchiani, Department of Systems and Enterprises, School of Engineering & Sciences
Committee Members:	Dr. Mo Mansouri, Department of Systems and Enterprises, School of Engineering & Sciences Dr. Philip Odonkor, Department of Systems and Enterprises, School of Engineering & Sciences Dr. Dibyendu Sarkar, Department of Civil, Environmental and Ocean Engineering, School of Engineering & Sciences Dr. Steven Hoffenson, Director of Data Science, Endevor LLC

ABSTRACT

Sustainable product design requires new perspectives and methods to achieve environmental, social, and economic success. The multi-agent, multi-variable, complex environment in which stakeholders of a product coexist creates a complex system, which is known as the wicked problem of sustainability. Sustainable product design is an approach to addressing sustainability challenges through product development processes and tools. The number of sustainable design methods has been increasing rapidly in recent years, but their adoption is limited, and many of these methods exclusively focus on the environmental impacts of products rather than taking a holistic perspective that includes social and economic sustainability. This dissertation is aimed toward providing a product sustainability management framework to consider social, economic and environmental sustainability simultaneously. In system definition phase of the methodology, a survey study has been conducted to investigate the views of engineers/managers and policymakers in the United States about definitions of sustainability, sustainability assessment, drivers, and barriers of sustainable design. The results provide a comprehensive understanding of this complex system's current state and future sustainable design tools requirements. The second phase of this approach is system overview, which generated a systems level understanding of the forces and dynamics underlying the wicked problem of sustainable design by applying systems thinking methods to the design of a reusable water bottle. The design variables and the various stages of the product's life cycle are systematically identified and mapped out and the dynamic relationships among these variables and the key stakeholders are formulated into a causal loop diagram (CLD), to form balancing and reinforcing loops. Interviews with domain experts were conducted to refine the CLD and ensure important parameters are represented in the model. A stock and flow model is created based on the CLD and simulations were performed by changing the variables associated with the policy making decisions to evaluate their outcomes overtime and identify the sustainable policies. The system analysis phase of the methodology proposes a novel holistic sustainable design (HSD) framework that utilizes life cycle assessment and change propagation to incorporate triple bottom line sustainability. The complex interdependencies between the design decisions and their sustainability outcomes have been identified and quantified in this framework to minimize the negative environmental impacts while maximizing the social and economic benefits.