

System Dynamics: Selected Doctoral Theses

TITLE:

“Why Clinical Practice Guidelines Shift Over Time: A Dynamic Model with Application to Prostate Cancer Screening” - Özge Karanfil (2016)

COMMITTEE:

John Sterman (chair), Hazhir Rahmandad, Jack Homer, Richard C. Larson

ABSTRACT:

Essay 1: A Dynamic Model for Understanding Long-Term Trends in Prostate Cancer Screening Cancer remains the second leading cause of death in the U.S. after heart disease. After 35 years of routine cancer screening, we still have only a limited understanding of screening dynamics. There is evidence of over-screening and resulting overtreatment in certain cases, and significant provider variation and fluctuations over time in screening criteria. Here I present empirical data for fluctuations in official screening guidelines and in actual practice for the use of the prostate-specific antigen (PSA) test. I explore how these dynamics are affected by the main guideline-issuing organizations in the U.S. and by clinicians, patient groups, and the media.

Essay 2: Our Walk to the End of Cancer? Understanding Long-Term Trends in Medical Screening In this study we develop the first integrated, broad boundary feedback theory and formal model to explain the dynamics of medical screening. The theory includes a decision-theoretic core around harms and benefits including the fundamental tradeoff between sensitivity and specificity; and feedbacks that condition guidelines and actual practice. To provide context we use the case of PSA screening for prostate cancer as a motivating example, but our model is generic and applicable to other contexts. We present a behaviorally realistic, boundedly-rational model of detection and selection for health screening that creates oscillations in policy recommendation thresholds of formal guidelines. This core model, entailing only the evidence generation and translation processes, demonstrates how oscillations are natural to this category of problems due to inherent delays in evidence-based screening. These fluctuations lead to long periods during which screening guidelines are suboptimal.

Essay 3: A Dynamic Model for Understanding Long-Term Trends in Prostate Cancer Screening Whereas guidelines for routine screening should be based on medical evidence, evidence often has relatively little impact on practice. This situation has led to ongoing controversy and conflict over appropriate guidelines among scientists, clinicians, and patient advocacy groups. There are significant variations in clinical practice, including evidence of over-screening for some diseases, and under-screening for others. To explain the patterns of over-screening, fluctuations, low adherence to guidelines, and conflict, I develop the first explicit broad boundary feedback theory of the dynamics of medical screening, tested in a formal mathematical model. The model presents an extended case study specific to PSA screening for prostate cancer, including realistic presentations for the fundamental tradeoff between test sensitivity and specificity, the natural progression of the disease, and respective changes in population size and composition.

TITLE:

“Resistance from the Top to Bottom: The Dynamics of Risk Management in Complex Organizations” - John Landry Lyneis (2012)

COMMITTEE:

Nelson Repenning (chair), John Sterman, Susan Silbey, Ezra Zuckerman-Sivan

ABSTRACT:

Organizations today devote substantial resources towards the development of governance systems to increase transparency and accountability in areas such as quality, safety, financial accounting, and environmental performance. In this dissertation, I combine ethnographic and simulation methods to understand the implementation and performance of such systems.

In the first essay, I compare the implementation of a safety management system in two industrial plants following accidents. Despite a common process, workers at one plant resist portions of the new system, while at the other plant the system is a relative success. My argument has two parts. First, I argue that resistance to bureaucratic rules is rooted in the lack of involvement that front line actors are afforded in managing anomalies that occur in the application of rules. Second, lack of involvement is more likely to result in active resistance to rules when actors are familiar with one another and with work tasks. While much research emphasizes the benefits of familiarity for performance, I find that actors who are familiar have both the motivation and the ability to resist bureaucratic control, even when rules are designed to serve their own interests.

In the second essay, I extend the findings in the first essay to develop a dynamic theory of the success and failure of governance systems in organizations. Consistent with existing literature, I find that pressure to conform to externally imposed norms of bureaucratic rationality can cause dynamics of gradual decoupling between rules and practice. However, I find that the mechanism by which such pressures operate can be different than previously described. Rather than compelling organizations to adopt practices that are inefficient or opposed to the interests of managers or workers, external pressure creates a conflict that is temporal: necessary efforts to demonstrate compliance in the short run directly undermine efforts to make rules effective in the longer term. When organizational actors have the flexibility to build organizational capabilities absent imperatives to demonstrate strict compliance at all times, formal structure can evolve to become a highly effective means of organizing. Absent such flexibility, rules can become a source of conflict characterized by worker resistance, tighter control, and decoupling.

In the third essay, I develop and calibrate a detailed simulation model to illustrate why management efforts to develop capabilities that support governance systems so often fall short. For this essay, I study the case of energy efficiency and maintenance reliability in the built environment. Even where proactive investments would improve both regulated outcomes and the bottom line, I show that managers might easily abandon investments early, before crossing a tipping threshold that allows for the realization of full benefits. Thus, successful self-regulation depends not only on managers recognizing and acting on opportunities, but also on managers understanding tipping dynamics and sustaining investments beyond levels that might initially appear sufficient