The Capability Trap: Prevalence in Human Systems

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ABSTRACT: What do abused children, the fatal collapse of the I-35 bridge connecting Minneapolis and St. Paul, and the disproportionately high costs of the United States healthcare system all have in common? We suggest that these examples arise from systems caught in the capability trap, in which pressures to boost short-run system performance lead to greater work effort at the expense of investment in maintenance, process improvement, and learning. As the organization's capabilities erode, performance falls further, leading to even greater pressure to work harder and even lower investment in capabilities. However, the theory of the capability trap (Repenning & Sterman, 2001, 2002) was originally formulated in the context of maintenance and process improvement in manufacturing and petrochemicals, and empirical work to date has centered on such systems. We hypothesize here that the capability trap is more prevalent and maps equally well onto various social systems. We provide an initial assessment on its operation in several domains – critical infrastructure such as water supplies, electric grids, and transportation; social services, focusing on foster care; education, crime and prisons; and healthcare. We also further develop the capability trap theory to include nested traps and traps with caseload dynamics, as well as offer insight into the unique characteristics of human systems that need to be taken into consideration when attempting to escape the trap. Rather than providing definitive evidence for each case, we seek to encourage deeper research into these capability trap dynamics and how they can be overcome.

Keywords: *capability trap, infrastructure, foster care, healthcare, education, prison, nested traps, caseload*

1 INTRODUCTION

Two-year old Glenara Bates was returned from foster care to the custody of her birth parents despite their history of abuse. Glenara was sent back to her parents "despite doctors' documentation that the girl had a protruding abdomen and indications of malnutrition, anemia, muscular wasting and other problems several months before her death" (Franko and Cornwell, 2015). Just three months later, Glenara, starved and beaten, died when her father allegedly "swung her and slammed her against a door" (Phillips, 2016).

On August 1st, 2007, the I-35 bridge in Minnesota collapsed into the Mississippi, sending eight lanes of traffic into the river 60 feet below (Sander & Saulny, 2007). Thirteen people died and over 145 were injured.

The United States spends approximately $3.35 trillion/year on healthcare, just over $10 thousand per capita in 2016 (Keehan et al., 2016). With spending constituting 17.4% of GDP, the US spent almost 50 percent more in terms of GDP than the next highest country (Sweden) in 2014 (Keehan et al., 2016; The World Bank, 2017). Nonetheless, the US lags on key national health indicators, with lower life expectancy, higher infant mortality, higher prevalence of chronic conditions, and greater health inequities and uninsured fractions than other developed nations who spend far less per capita (Squires & Anderson, 2015).

The United States also currently has 2.3 million people incarcerated in prisons and jails (P. Wagner & Rabuy, 2017). With 698 per 100,000 people behind bars, the US boasted the world's second highest incarceration rate in 2015, lagging behind only Seychelles with 799 (Walmsley, 2016).

What do the stories of Glenara, the I-35 bridge collapse, the US healthcare system, and the US incarceration rate all have in common?

All are examples of systems caught in the capability trap (Repenning & Sterman, 2001, 2002). The theory of the capability trap recognizes that the performance of any process depends on both a set of organizational capabilities and on the intensity of work effort. Capabilities include the productivity and quality of plant, equipment, technology and other physical tools, and the knowledge and skills of the people who work in the system. The trap arises when pressure to boost short-run performance leads to greater work effort, including long hours, faster work pace, and cutting corners. Doing so boosts output and performance in the short run, but often at the expense of investments in safety, maintenance, process improvement and learning. The organization's capabilities then begin to erode. Performance falls further, leading to still more pressure to work harder and still lower investment in capabilities, resulting in a reinforcing feedback operating as a vicious cycle. Organizations often find it difficult to escape the trap because rebuilding capabilities requires greater investment in maintenance, improvement and learning, leading to higher costs, a reduction in output, or both; things get worse before they get better, exhibiting a classic dynamic in complex systems (Forrester, 1971).

However, the theory of the capability trap (Repenning & Sterman, 2001, 2002) was originally formulated in the context of maintenance and process improvement in manufacturing and petrochemicals, and empirical work to date has centered on such technical systems (Lyneis & Sterman, 2016), in which system performance depends heavily on the quality and state of repair of physical capital. Here, we hypothesize that the capability trap framework maps equally well onto various social systems where system performance is primarily determined by the knowledge, skill, attitudes, and motivations of employees and other people who work and live in the system. In this paper, we examine several important examples – infrastructure, foster care, prison and education, and healthcare – with the aim of encouraging deeper research into these capability trap dynamics and how they might be overcome. Specifically, we identify the particular feedback processes that arise in each case to determine whether and how they map onto the capability trap framework, consider additional feedbacks and alternative explanations for poor system performance, and how the particulars of each case condition the dynamics, including the length and depth of the worse-before-better (WBB) response that follows efforts to improve system performance.

1.1 The Capability Trap

Repenning and Sterman (2001, 2002) first developed the capability trap to understand why so many process improvement programs fail. The original capability trap theory was informed by fieldwork with several manufacturing and high-tech firms that had struggled with repeated unsuccessful efforts to improve the productivity and quality of their operations. The roots of the capability trap, however, lie in Jay Forrester's concept of "shifting the burden to the intervener", which first arose in *Urban Dynamics* (1969) and *Counterintuitive Behavior of Social Systems* (1971). Since the early 2000s, the capability trap framework has been applied to understand how organizations can cut energy use, greenhouse gas emissions and promote sustainability (J. Sterman, 2015), as well as take advantage of win-win opportunities with policies that improve environmental quality profitably using a detailed model-based case study of a major research university (Lyneis and Sterman 2016). Zuashkiani et al. (2011) examine the trap in the context of equipment maintenance, and Gonçalves (2011) applied the framework to humanitarian operations, showing how chronically resource-starved aid organizations could become stuck in the vicious cycle of providing emergency assistance at the expense of building the capabilities of refugees and the societies in which they live. Various authors have expanded the boundary of the capability trap theory and have explored feedbacks around the erosion of capabilities. These include the impact of competition among firms on the bias toward working harder at the expense of capability development (Rahmandad, 2012), and interaction between short-termism and capital markets (Rahmandad, Henderson, & Repenning, 2016).

The standard causal loop diagram for the capability trap is shown in Figure 1 (Repenning & Sterman, 2001, 2002).

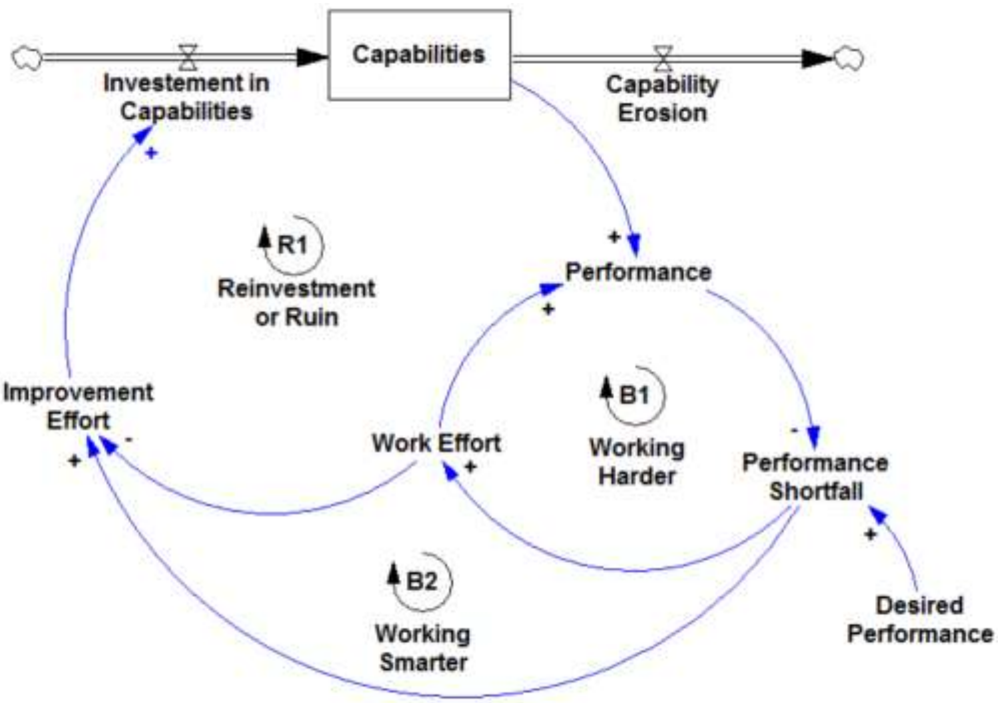

Figure 1. The Capability Trap: Generic Structure

Managers and workers in any process are constantly assessing performance against a target or desired level of performance, and face two fundamental options to close any performance shortfall: working harder or working smarter. Working harder generally consists of devoting more resources to production – working longer, working faster, cutting corners, skirting safety protocols, deferring maintenance – to boost performance quickly. These actions form the balancing *Working Harder* loop, B1. Alternatively, resources could be reallocated to activities that build the organization's capabilities, etc. – equipment quality, worker productivity, process quality, etc. Enhancing capabilities also increases performance and closes the performance gap, albeit usually with some delay, completing the balancing *Working Smarter* loop, B2. Capabilities are stocks that build up and erode over time as equipment wears and ages, personnel turn over, new requirements make existing skills obsolete, and so on. Because time and resources are limited, working harder comes at the expense of improvement effort that can build capabilities. Thus, while working harder boosts performance in the short run, the reduction in improvement effort can lead to erosion of organizational capabilities and a larger performance shortfall, leading to still more short-term effort. The result is the reinforcing *Reinvestment or Ruin* loop, R1. The name, Reinvestment or Ruin, signals that this reinforcing feedback can operate as either a virtuous cycle in which improvement effort builds capabilities, leading to higher performance, less firefighting and corner cutting and still greater investment in capabilities, or a vicious cycle in which poor performance leads to more firefighting, greater capability erosion, and still worse performance. There is, however, an important asymmetry. Increasing the time and effort devoted to work effort to boost performance in the short-run necessarily cuts the time and resources available for improvement efforts. On the other hand, higher performance and a reduction in work effort resulting from built capability is only sustainable if the organization chooses to reinvest those freed resources in further capability building instead of harvesting the improvement through cost cutting, downsizing, or increases in desired performance. Organizations are more likely to experience a vicious cycle leading to ruin than the virtuous cycle of reinvestment in capabilities, better performance and sustainable improvement.

1.2 NOT EVERY DEATH SPIRAL IS A CAPABILITY TRAP

In arguing that the capability trap contributes to the poor performance of infrastructure, social services, health care, and other systems, it is necessary to distinguish the capability trap from other reinforcing feedback processes that can lead to so-called "death spirals." The term "death spiral" is popular in the media and is increasingly used to describe any number vicious cycles, but not all death spirals arise from the capability trap. For example, in the "downward demand death spiral," a drop in demand increases fixed costs per unit sold. If a company raises prices in order to make up for the increased cost, demand may drop further, leading to still higher fixed costs per unit. Known as the "spiral of impossibility" in the context of power plants (Lovins, 1976) or the "utility death spiral" in the context of electric service providers, these dynamics do not arise from the capability trap. One of the challenges for future research we identify is determining whether an apparent "death spiral" in any setting arises from the capability trap, other reinforcing feedbacks operating as vicious cycles, or interactions among these different feedback structures. Carefully considering the appropriate boundary of analysis in these settings will condition the effectiveness of policies to limit the death spiral or convert it into a virtuous cycle of continuous improvement.

2 INFRASTRUCTURE

"What I found at [Metro], you would set up a [safety] training session and two-thirds of the people wouldn't show up… Their managers felt they were needed for something more important." - General Manager of Washington Metropolitan Area Transit Authority from 2007 to 2010

2.1 THE PROBLEM

On Monday, March 14th, 2016, Paul Wiedefeld, general manager of the Washington, DC, transit system announced, with no prior notice, that he was shutting down the entire metro system for 29 hours, starting the next day, leaving hundreds of thousands of people attempting to find other ways to work and school (Beech & Simpson, 2016). The decision came after a fire in the system was found to have started by jumper cables that had eroded and been left exposed. The similarity to a fire almost a year earlier that led to the death of a passenger and sickened 80 others from smoke inhalation, prompted Wiedefeld to take the unprecedented action (Beech & Simpson, 2016). "While the risk to the public is very low, I cannot rule out a potential life safety issue, and this is why we must take this action immediately," said Wiedefeld. "It's happened twice within a year… I can't wait for a third time" (L. Wagner, 2016).

When the DC Metro opened in 1976, it was the crown jewel of transit systems. Since then, the system has become the poster child for systematically poor performance. Plagued by "technical malfunctions, some involving automation, as well as faulty communications and poor training", such dysfunction has contributed to accidents that have killed over 15 people since 1982 (McCarney & Duggan, 2016). Lack of investment in maintenance of system capabilities led to more problems, and, sometimes literally, fighting fires.

Transit systems constitute one type of infrastructure system in the United States that appears to be stuck in the capability trap. The American Society for Civil Engineers releases a report card on US infrastructure every 4 years, with the grades A, B, C, D, and F, signifying "exceptional", "good", "mediocre", "poor", and "failing" respectively. In the six reports since 1998, US infrastructure has not achieved more than a D+, exemplifying consistently poor performance despite increasingly high levels of infrastructure spending. This aggregate score is composed of similarly poor scores for its component systems including roads, bridges, transit, drinking water, wastewater, dams, solid and hazardous waste disposal systems, energy and other built infrastructure.

With infrastructure hazards frequenting the headlines, including the I-35 bridge collapse (Sander & Saulny, 2007), Flint water crisis (Felton, 2016), DC Metro shutdown (L. Wagner, 2016), Oroville Dam evacuation (Nagourney & Fountain, 2017), and many others, the symptoms of our aging infrastructure are increasingly visible. Understanding the root causes, however, requires a systems perspective that explains why routine maintenance and investments in capabilities have not been done despite declining system performance, and an explanation for why some systems, both in the US and in other nations, have been able to avoid or escape the trap.

2.2 Infrastructure Dynamics

2.2.1 The Maintenance Game

At the heart of America's struggle with its poor infrastructure is a dynamic between reactive and proactive maintenance for infrastructure defect elimination. As illustrated in Figure 2, developed by Lyneis and Sterman (2016), the capability trap in the context of equipment and facilities maintenance manifests itself in the decision to either allocate effort toward proactive maintenance efforts or reactive repair efforts.

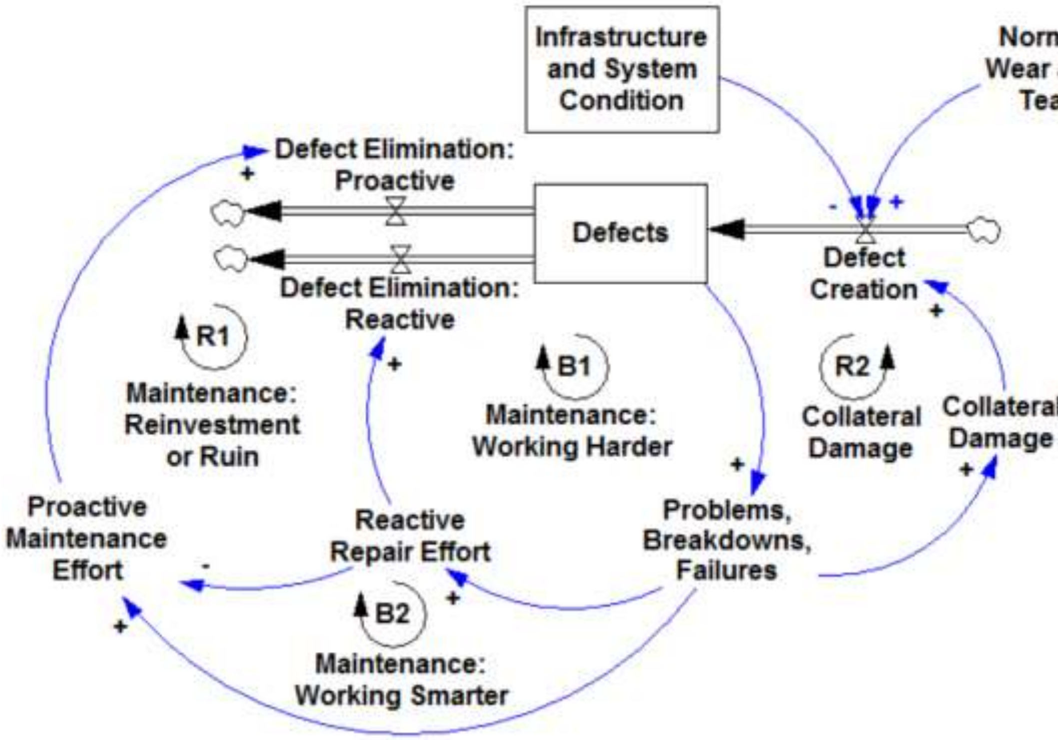

Figure 2. Maintenance Capability Trap

The tendency to react to problems and breakdowns with reactive repair efforts, driving the *Working Harder* loop, B1, arises from two sources. First, when equipment fails, it must typically be repaired, forcing resources to be allocated to reactive repair work at the expense of proactive work, which includes scheduled, preventive, and predictive maintenance. Second, not all defects cause breakdowns, but instead degrade the efficiency and safety of the system. Thus, defects can accumulate in equipment, facilities and infrastructure without generating feedback that would alert workers or managers to eliminate the defect prior to the problem or accident. For example, failure to maintain HVAC systems and controls can degrade energy efficiency in a building, but without equipment-specific instrumentation, routine inspections, or the resources to respond to what they may find, the problem might not be located, but will instead show up as a rise in overall energy costs. Similarly, a leak in the bearing seal on a pump, if uncorrected, will eventually lead to bearing failure. If the bearing seizes when the equipment is under load, the result can be an accident that causes leaks of possibly toxic material, fire, injury or death to workers, and damage to nearby equipment. This damage of other system components is denoted by the *Collateral Damage* loop, R2.

In 2016, there were a reported 15,498 dams in the US classified as deficient and "high-hazard", or likely to kill people downstream if they should fail. Furthermore, 4,862 of these did not have Emergency Action Plans in Place (U.S. Army Corps of Engineers, 2016). These numbers are up from the 10,213 high-hazard dams in 2005 and is expected to continue growing, increasing the risks to the public and environment (ASCE, 2017).

According to Federal Highway Administration estimates, “each dollar spent on road, highway and bridge improvements results in an average benefit of $5.20 in the form of reduced vehicle maintenance costs, reduced delays, reduced fuel consumption, improved safety, reduced road and bridge maintenance costs, and reduced emissions as a result of improved traffic flow” (TRIP, 2016). The ‘rule of thumb’ for the electric grid is that reactive maintenance costs about three to four times the cost of preventive maintenance (Alvis, 2016). Reactive maintenance is not only monetarily costly, but it is also costly in terms of safety. A report be ExxonMobil showed that employee injury was five times more likely for maintenance on failed equipment than on planned maintenance (Alvis, 2016). This is because (1) breakdowns can cause situations that are hazardous for maintenance workers, (2) preventive maintenance generally makes the size and scope of breakdowns smaller and less dangerous when they do occur, (3) preventive planning and design can mitigate and eliminate certain failures all together, and (4) planned jobs have less room for improvisation (Levitt, n.d.).

	Defects	**Problems/ Failures/ Complaints**	**Reactive/Repair Effort**	**Proactive Maintenance**
Electricity Infrastructure	-damage to equipment with sensitive electronic circuitry -faults in electrical grounding systems -defective installations of electrical accessories	-outages -electrocution -falls, other accidents and injuries	-repairing downed lines	-visual inspection -oil analysis -running current -vibration tests -insulation resistance (IR)
Roads and Surfaces	- potholes -cracking - unsealed shoulders - rutting - flushing - bleeding - structural deficiency - functional obsolescence	-congestion -delays -vehicle damage -accidents -collapse	-pothole filling -structural repairs -expansion	- resealing - rehabilitation - surface repair
Transit	-overruns -insufficient ventilation -defective ties -failure to wait three seconds before opening doors at stations	-delays -travel time variability -derailments -crashes -injuries and deaths	-expansion -single-tracking -rerouting -bus substitution	-track-walking -rail-car maintenance
Water and Wastewater	-cracks -leaks -clogged pumps -failed pumps	- shortage - flooding -water main breakage -sanitary sewer overflows -incidence of water borne illness	- costs of relocating - evacuation - health reparations	-inspect for worn or loose impellers -check impeller wear ring -check amperage draw on pump motor -change oil

Table 1.Non-exhaustive examples of maintenance capability trap variables for different types of infrastructure

Collateral damage is also a costly byproduct of breakdowns in the system. When a water main bursts, a dam overflows, a gas leak ignites, or some other latent hazard causes a failure, other infrastructure in the vicinity is often damaged. This is costly due to not only the required replacement or repair, but also because the previously undamaged infrastructure could have been brand new or recently renovated or maintained. Power outages, for example, cause collateral damage including spoilage of food and other items that are heated or refrigerated; wasted, unproductive time due to businesses downtime; added costs incurred by an increased reliance on backup generators, power quality monitoring and conditioning equipment; hazardous "effects on HVAC in buildings; effects on water systems; effects on health systems, including hospitals and public health efforts, and effects on road transportation systems" (McDaniels et al., 2007). Broken water mains can lead to flooded streets, causing congestion as well as increased street degradation (LaRiviere, Wichman, & Cunningham, 2016).

2.2.2 DC Metro: Working Harder, Yet Falling Farther Behind

In a comprehensive 2015 review of the DC Metro system, The Federal Transit Administration (FTA) identified many capability trap dynamics at work. Ultimately, whether it was due to "access limitations, staffing limitations, or coordination challenges in working with other departments or divisions… scheduled preventive maintenance activities or inspections had been missed or fallen behind" (Federal Transit Administration, 2015). The result was a build-up of deferred maintenance that led to the January 12, 2015 death of Carol Glover from smoke inhalation during a fire in which she and others in a train were trapped in a tunnel (L. Wagner, 2016). FTA's Safety Management Inspection team noted "an accumulation of dust and grime in ventilation shafts, as well as a level of accumulated dust and grime on third rail insulators that would seem to indicate that not all basic elements of inspection or maintenance activity were performed as required" (Federal Transit Administration, 2015). Should the ventilation shafts have been in good condition, Carol Glover might not have died that day.

The FTA also found high rates of rework. Reworking maintenance that was not performed properly the first time is a classic symptom of working harder, and arises from the time pressure on maintenance workers that force them to work rapidly and to cut corners. Workers in maintenance organizations stuck in the capability trap often also find inadequate planning for any scheduled work, missing or incorrect work orders, parts kits, tools and equipment drawings, hampering their ability to carry out maintenance work correctly. Instead of investing in process improvement or error avoidance earlier, rework signals inefficient use of resources to redo work that could have been done correctly the first time. FTA found, after "observing a few poorly planned or performed work elements involving… contractors," that the "contractors are sometimes required to partially re-conduct work that was already completed, including the need for escort and track access again" (Federal Transit Administration, 2015).

Similarly to the DC Metro, New York's MTA has come under ever increasing fire recently for its constant delays and came to a climax with the most recent derailment that led to the death of 34 passengers (Allen, 2017). Governor Cuomo's acknowledgment that "the [MTA's] current state of decline is wholly unacceptable" led to a billion dollar investment toward transit improvement (Allen, 2017). Smart implementation of these funds will determine its chance at escaping its own trap.

2.2.3 Infrastructure and System Condition

Capabilities are multidimensional. Lyneis and Sterman (2016) demonstrate how different organizational capabilities are nested and interact with one another. Figure 3 shows how such nesting operates in the maintenance of facilities and infrastructure. The reinforcing loops and structure in Figure 2 are now represented by the reinforcing feedback connecting Defects and Breakdowns (R1 in Figure 3). That structure is embedded in a larger system that controls the condition the infrastructure and systems as they deteriorate over time and are renewed through major overhauls (as opposed to maintenance to correct specific defects in a given piece of equipment of facility). Examples of Infrastructure and System Condition capabilities include energy efficiency measures and technology, better-planned roadways and public transportation systems, maintenance data collection and reporting systems, or any other capability that would increase the performance of the given system, but requires investment to construct, install, or implement.

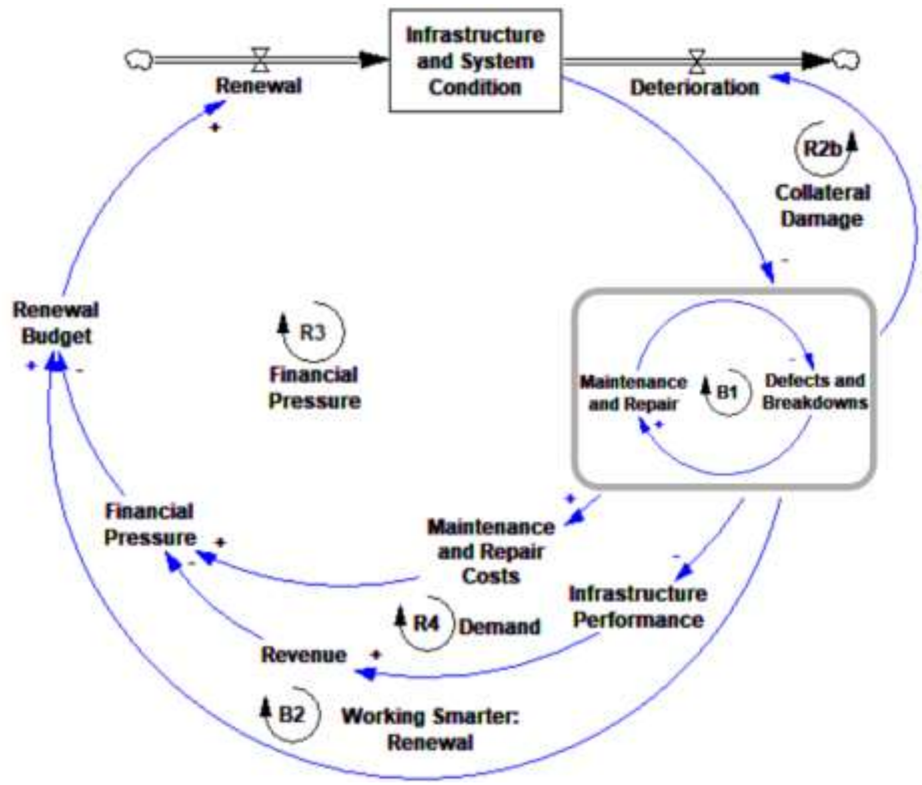

Figure 3. Infrastructure System with Figure 2's Maintenance Capability Trap simplified as inlay

Having to deal with more breakdowns, as discussed above, increases operating, maintenance, and repair costs, putting more financial pressure on those responsible for the system. That financial pressure often translates into reduced budget throughout the organization, including cuts in the maintenance and renewal budgets. Reduced maintenance in turn allows defects to go uncorrected until they cause breakdowns, completing the reinforcing *Financial Pressure* loop, R3. Additionally, the classic downward demand spiral reinforces the operation of the maintenance capability trap. In transit systems, breakdowns worsen performance – increasing variability in travel time, frequency of delays, etc. – that discourages ridership. Since fares generate revenue, decreased ridership puts increased financial pressure on the system, setting in motion the reinforcing *Demand* loop, R4.

Reactionary decision-making in the face of financial pressure is exemplified by the Flint water crisis. Lead levels in Flint's water rose dramatically after the city, in receivership, switched from water supplied by the Detroit Water and Sewage Department to water drawn from the Flint River. However, the river water was not treated adequately, leading to corrosion of old service pipes that leached lead into the homes and bodies of Flint's citizens. The switch was designed as a "cost-cutting maneuver aimed at saving $5 million over a two-year period" (Felton, 2016). However, the crisis has already cost upwards of $45 million (Felton, 2016) and the total costs may exceed $400 million (Sanburn, 2016).

2.2.4 Expansion vs. Maintenance and Repair

Although not included in the causal diagram, another feedback helping to tip infrastructure into the capability trap arises from a bias toward construction of new infrastructure at the expense of maintenance of existing systems. Politicians often find it politically expedient to attend ribbon-cutting ceremonies in the name of job creation and infrastructure "investment" than to invest in routine maintenance. Keith Parker, chief of the Atlanta transit system, acknowledges that expensive maintenance efforts for his system, "while necessary, will prevent the agency from doing… 'sexier' expansion projects" (Jaffe, 2015). Not all politicians are so forward looking. Not only does expansion put off needed investment in maintenance and repair of existing infrastructure, but it also adds to the stock of infrastructure that now must be maintained, lest it becomes neglected and crumble itself.

The bias toward new construction is perhaps most notable in the US highway system. Between 2009 and 2011, the US spent $20.4 billion on new roads that added 1% to total lane-miles of the road system. Meanwhile, $16.5 billion was spent on road maintenance and repair for the remaining 99% of roads, while the percentage of roads deemed to be in "good" condition fell to 37% from 41% in 2008 (Smart Growth America & Taxpayers for Common Sense, 2014). Mississippi spent 97% of its road expenditures on expansion at the expense of repairs (Smart Growth America & Taxpayers for Common Sense, 2014).

Another salient example is the recent $32.5 billion five-year capital plan for New York City's Metropolitan Transportation Authority that increased funding for expansion compared to the previous year's approved proposal (Fitzsimmons, 2017). This occurs despite the mounting frustration with constant breakdowns and delays.

2.2.5 Macroeconomic Feedbacks

Expanding the boundary of the analysis further to consider interactions between infrastructure and the economy, the health of infrastructure is central to economic vitality, creating another reinforcing macroeconomic feedback (Figure 4).

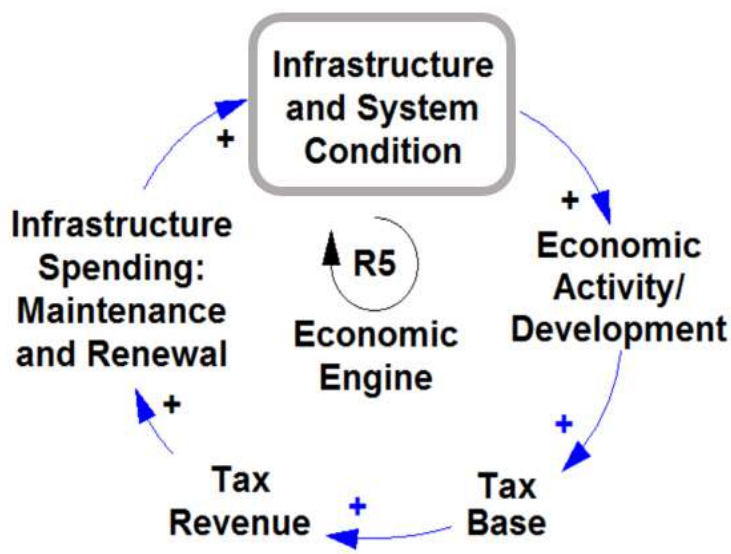

Figure 4. Reinforcing Economy Feedback with Figure 3's Infrastructure System in inlay

Poor infrastructure condition harms the economy and reinforces poor infrastructure. For example, some estimate the average cost of poor road conditions to the average American in "accelerating vehicle deterioration and depreciation, increasing the frequency of needed maintenance and requiring additional fuel consumption" to be around $523 annually, or $122 billion nationally (TRIP, 2016). In terms of infrastructure deficiencies in general, the cost to each American household averages $3,400 per year (Economic Development Research Group, 2016). Expanding beyond the American family to macroeconomic indicators, failure to address the shortfall in infrastructure sectors by 2025 is expected to cause a $4 trillion loss in GDP, and a loss of 2.5 million jobs (Economic Development Research Group, 2016). On the flip side, infrastructure investments are found to have one of the largest jobs multiplier impacts of all federal government stimulus elements, generating approximately $1.44 of economic activity for every $1 spent (Cooper, 2012). Essentially, much like the *Financial Pressure* loop at the system level, a better functioning economic engine allows more money to be budgeted toward infrastructure spending at the federal and state level.

2.3 ESCAPING THE TRAP

2.3.1 Staying the Course on Proactive Maintenance

Costa Mesa Sanitary District's General Manager, Scott Carroll, knows the value of proactive maintenance. "Our district doesn't believe in run-to-fail… That imposes too much risk and the potential for heavy fines here in California where the regional water quality control boards have policies even more stringent than the federal EPA" (London, 2014). Even in the face of the biggest spill in the utility's 70-year history, they chose to not only repair the system, but also invest even more into their annual proactive maintenance process. In so doing, they uncovered motors that were close to failure as well as wet wells without a backup pump. The lack of backup pumps means that a failure in the primary pump could have led to another spill, and thus, more costly repairs and the potential for collateral damage. (London, 2014)

2.3.2 DC Metro: A Story in the Making

After the sudden shutdown in March 2016, DC Metro general manager Paul Wiedefeld shocked DC commuters yet again with plans for additional shutdowns. Instead of "'lurching' from one crisis to another," Wiedefeld enacted a "comprehensive maintenance plan that will involve significant service disruptions to make room for work crews in tunnels" (McCarney & Duggan, 2016). SafeTrack, as the effort is called, is meant to accelerate three years' worth of maintenance into approximately one year (Washington Metropolitan Area Transit Authority, 2016). Requiring the shutdown of the system at midnight on weekdays, as well as 16 large "safety surges" that will close large portions of track for weeks at a time, SafeTrack is an acknowledgment that the previous maintenance efforts were inadequate and that the only solution is a dramatic increase in investment in system capabilities, with an attendant, and significant, period of reduced service (a classic Worse-Before-Better pattern). It remains to be seen whether the program, and Wiedefeld, will survive the service reductions and inconvenience to riders long enough for system performance to improve and Metro to escape the trap.

The DC Metro case also illustrates the limits on how fast one can attempt to escape the capability trap. In some systems, such as an oil refinery, it might be best to schedule a complete shutdown of several months and renew everything all at once. However, the complete shutdown of the DC transit system for a complete overhaul is politically and economically unacceptable. Furthermore, even if it could, Metro does not have enough maintenance workers to carry out such a huge volume of work. Rather, it must fix the airplane as it flies. Only time will tell if the maintenance efforts are deep enough not only to reverse the vicious cycles of defect and breakdown into virtuous cycles of greater proactive maintenance and better performance, but also to significantly shift the culture around maintenance so that it doesn't slide back into the trap afterwards.

2.4 Discussion

When Flint is in crisis, resources must be expended in order to relieve people of the emergency. So from where will the resources for capability investment come? As discussed above, a substantial portion can be reallocated from unnecessary expansion efforts. However, the capability trap is so deep that even total reallocation of those resources is insufficient. In accordance with the old adage, "it takes money to save money," extra funds will have to be injected into the system. The Economic Development Research Group estimated that an extra $3 per day from the average American family until 2025 should be able to close the infrastructure gap. While this seems like a lot, it would result in saving that same average family approximately $9 per day (Economic Development Research Group, 2016).

One argument against the urgency, or existence, of an infrastructure capability trap stems from the use of an incredibly rough metric, US public investment as a percentage of GDP. Citing a 2011 study, some claim that the US is "about where it should be" in terms of public investment, tracking OECD countries within about a percentage point or two since 1970 (Soltas, 2013). Indeed, public spending has been "fairly stable" at around 2.4 percent from 1956 to 2014 (Congressional Budget Office, 2015). However, infrastructure spending as a percentage of GDP does not reveal how much of the spending is for new construction, for renewal and proactive maintenance, or for reactive, emergency repairs. A system deep in the trap may spend as much as one in excellent condition, but in the former case, nearly all spending will be for reactive, emergency work while the latter will spend primarily on proactive work and upgrades. Proper management of infrastructure systems requires additional and finer-grained metrics, including measures of infrastructure condition, any backlogs of deferred maintenance, and capabilities including not only facility condition, but also organizational effectiveness, training, turnover, and skill. There must also be measures that distinguish between spending and activity on new construction, renewal, and maintenance, and between proactive improvement and maintenance versus reactive, emergency work. Such metrics and the information systems to collect, report and act on them are themselves capabilities that often appear to be lacking in systems with degraded infrastructure, as evidenced by the DC Metro.

In an interview with U.S. News, Robert Puentes, director of the Metropolitan Infrastructure Initiative at the Brookings Institution, said, "we need to stop talking about infrastructure as an engineering prospect and more as an economic one." (Soergel, 2016) To take this a step further, infrastructure needs to be treated as a systems one, one in which economic, social, and political processes are as important as engineering.

3 Foster Care

"When in doubt, take them out."
– Common saying about removing at-risk children from their families

3.1 The Problem

At every stage, children are dying. Unlike the case of Glenara Bates, who was killed by her biological parents after a short stay in foster care, three year-old Serenity Gandara and her 4-year old brother were removed from their biological family and entrusted to foster parents in Bakersfield California. Serenity died on July 7, 2010 after sustaining injuries including a lacerated spleen, pancreas, and stomach, as well as skull fracture. Her brother was found abandoned with "his body covered in bruises and scars" after the foster parents fled to Mexico with their three biological children (Kotowski, 2016).

Horrifying fatalities and abuse of children by their biological or foster parents are all too common. In 2015, more than 576 thousand children in the United States were known to be victims of maltreatment by their parents, 1,424 were known to be abused while in foster care, and 808 children died from maltreatment (Children's Bureau, 2015a). In many more cases families may not be able to provide for the healthy development of children despite their best efforts to do so. In these cases, temporary support in the form of medical services, welfare, or training can often be more effective, less traumatic for the children, and cost less than the process of placing the child into foster care. Nevertheless, the caseworker in charge of the decision to remove the child from the home might not be willing to take the risk of possible abuse. When it comes to removing children from their homes, case workers are, as the title of a 2012 documentary suggested, "damned if they do, damned if they don't" (Mohan, 2012).

According to the U.S. Department of Health and Human Services, in 2015 there were an estimated 428 thousand children in foster care, with the number entering and exiting each year hovering around 250 thousand for the past few years (Children's Bureau, 2015b). A child enters the foster care system upon removal from the child's home, a decision usually made by a social worker upon investigation of a referral or report of child abuse or neglect. Once in the system, the child is usually placed in either a foster home, residential or group home, an institution, or kinship care. Placements are meant to provide a safe and secure living arrangement for the child until the best permanent home for the child is identified. A child can exit the system by reunification with the child's parents, reunification with a relative or guardian, adoption, or sometimes aging-out of the system. There are also cases in which a child runs-away, as well as the tragic cases of child fatalities within the system.

The performance of the foster care system is evaluated through a wide variety of quantitative proxies for child well-being. The Children's Bureau of the U.S. Department of Health and Human Services produces a series of reports on Child Welfare Outcomes to Congress as mandated by section 203(a) of the Adoption and Safe Families Act of 1997. Seven performance outcome goals are described (Children's Bureau, 2013):

Outcome 1: Reduce recurrence of child abuse and/or neglect
Outcome 2: Reduce the incidence of child abuse and/or neglect in foster care
Outcome 3: Increase permanency for children in foster care
Outcome 4: Reduce time in foster care to reunification without increasing reentry
Outcome 5: Reduce time in foster care to adoption
Outcome 6: Increase placement stability
Outcome 7: Reduce placements of young children in group homes or institutions

Performance against these goals across US states varies widely, and within states, efforts to improve performance on one metric often comes at the expense of performance on others. Between 2000 and 2013, for example, Florida increased the percentages of reunification times within 12 months and adoption times within 24 months from 48.0 to 71.4 percent and from 21.7 to 56.2 percent, respectively. The percentage of children adopted rose from 10.3 to 22.0 percent. However, over the same period, the percentage of child maltreatment in foster care rose from by a factor of seven, from 0.14 to 0.98 percent. Re-entry to foster care rose from 11.8 to 23.1 percent of total removals (Children's Bureau, 2013). The percentage of children placed in group homes rose from 0.9 to 3.3 percent. Child fatalities grew from 65 to 121 children (Children's Bureau, 2015a). The data suggest speed of case "resolution" came at the cost of child welfare and lives. The capability trap framework can help explain these dangerous trends in Florida and other similarly struggling foster care systems.

3.2 FOSTER CARE DYNAMICS

3.2.1 Capability Stocks Modeled as Experience Chains

Employee knowledge, skill, quality of relationships, and other determinants of performance typically grow with experience. Rapid hiring or high turnover can skew the experience distribution of employees in an organization towards inexperienced people, harming performance and problem solving capability. Models often capture such dynamics through explicit disaggregation of the workforce into cohorts based on tenure since hiring, as shown in Figure 5, where employees are divided into inexperienced, lower skill "rookies" and experienced, higher skill workers. The higher the proportion of rookies, the lower average skill, productivity and work quality will be (Oliva & Sterman, 2010; J. D. Sterman, 2000).

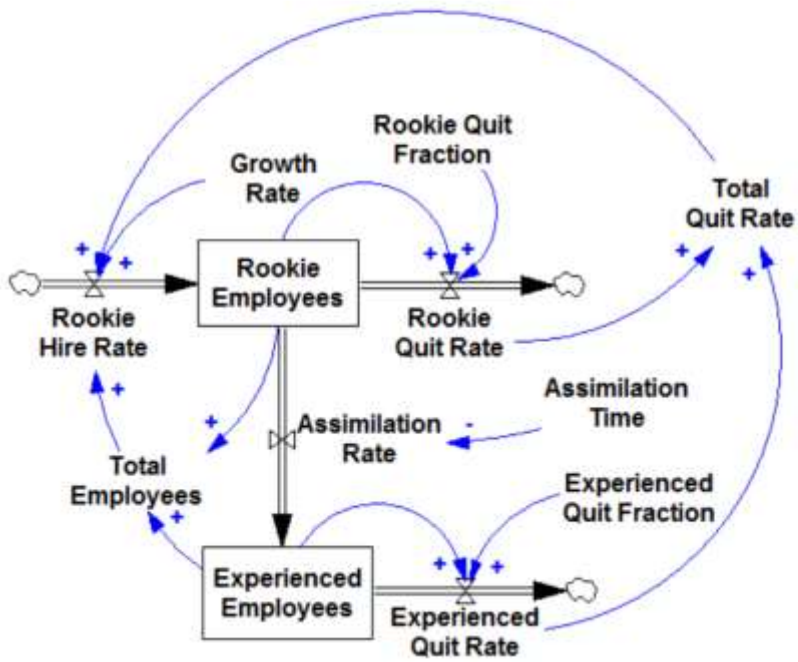

Figure 5. Experience Chain Structure (Oliva & Sterman, 2010)

Social service agencies including the foster care system often suffer from staff shortages and high employee turnover. Low salaries for social workers reduce hiring (and the quality of applicants) and increase turnover (U.S. Government Accountability Office, 2003). Likewise, quit rates may be reduced via well documented actions such as increased supervisory, organizational, and administrative support; greater training; and lower caseloads (Government Accountability Office, 2003; DePanfilis & Zlotnik, 2008; Webb & Carpenter, 2012). The resulting churn results in a high proportion of unfilled positions, low average experience, and hence low productivity and work quality, feeding back to keep caseloads high and leading to frustration and burnout that further increase quits; reinforcing feedbacks that can erode the organization's capabilities to adequately monitor and protect children.

The capabilities of foster parents—parenting skills and the ability to provide a healthy, stable home for their children—may also be framed with the experience chain structure. The number of people willing to be foster parents in many states is chronically insufficient, leading to placements exceeding guidelines for each foster family, placements in group homes or institutions, or delays in finding placements. Larger stipends for food, clothing and other expenses might incentivize the acquisition of foster parents, though it might also attract foster parents whose motivation is primarily income rather than those committed to the best interests of the children placed in their care. Support and respite care resources can help foster care parents to avoid burnout and can increase the retention of foster parents. Additionally, training can increase their skills in managing disruptive behavior and juggle the many issues that arise in foster children in particular (Chamberlain, Moreland, & Reid, 1992). Oppositional behavior in foster children is a predictor of the number of placements a child is likely to experience and vice-versa (Chamberlain et al., 1992). The impact that skilled foster parent intervention has on mitigating this vicious cycle of disruptive behavior becomes very powerful due to the self-reinforcing feedback between such behavior and placement stability (Price et al., 2008). Foster parent training also increases the chances that their foster children have a positive exit from the system, counteracting the damaging influence of number of placements on the chances of positive exit (Price et al., 2008).

Biological family capabilities are likewise affected by many additional feedbacks. For example, family capabilities can be eroded by factors such as poverty, drugs, unemployment, financial stress, etc., which can often be linked to poor economic and physical health (Ziliak, Figlio, Davis, & Connolly, 2000). Conversely, a family can build capabilities through family development, aided by multiple social and community services. Training, welfare, and intensive family preservation services all promote family development. Eroding biological family capabilities increases the hazard of maltreatment, which in turn increases the rate of child removal from the home, or, in the case of children who were previously reunited with their parents, the rate of re-removal. It comes as no surprise that children who rejoin their parents after being removed due to abuse are at a higher risk of being abused again. Once the child is removed, parents can improve their capabilities to provide a healthy environment for their children through education and training while their child is in foster care. With improvement in the health of the parents, parent mentorship, preservation of the health of the child, as well as preservation of the child/parent relationship, appropriate reunification may occur to build the capability of healthy families (Davis, Landsverk, Newton, & Ganger, 1996; Marsh, Ryan, Choi, & Testa, 2006).

Figure 6 shows how these three sets of capabilities—of social workers, foster parents, and biological parents—interact. Child welfare, as well as the capabilities of the social workers, foster parents and biological parents, is multidimensional. The nested relationships among these elements form the three basic feedback processes that define the capability trap: *Working Harder* through firefighting, *Working Smarter* to develop capabilities, and the reinforcing *Reinvestment or Ruin* feedback that can cause all three sets of capabilities to erode as the system is overwhelmed by children in need.

3.2.2 The Foster Care System Capability Trap

There are, however, additional feedbacks in the larger system. One dynamic of particular importance revolves around the caseload, the number of cases per social worker. Caseload powerfully affects the effectiveness of social workers and the social service system, and therefore child welfare. High caseloads reduce the number of social workers engaged in a case, and cut the number and duration of visits each child, foster family and biological family receives. Infrequent and short visits degrade or preclude the relationships between caseworkers and the families they serve, decrease child safety, delay placement decisions, and decrease the frequency of caseworker visits to the foster children (U.S. Government Accountability Office, 2003). Such deleterious effects can increase the number of placements a child experiences, harming child welfare.

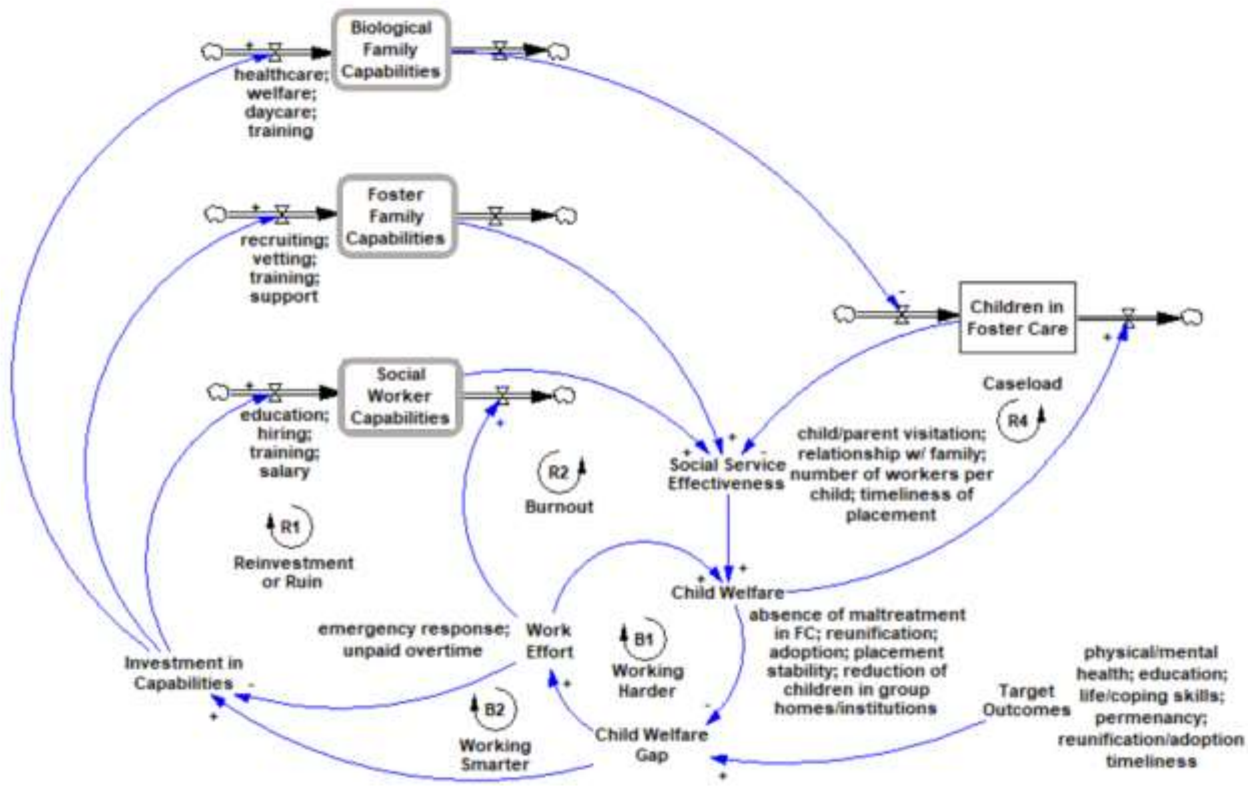

Figure 6. Foster Care Capability Trap

The caseload can cause chaos when there is a large influx of children into foster care, such as after a high profile death of a child at the hands of the biological parents. Often termed "foster care panic," case workers are far more likely to adhere to the saying, "When in doubt, take them out" (Sari Horwitz & Higham, 2000). Unfortunately, "foster care panic" can catalyze a destructive reinforcing feedback in which social workers leave due to high workload and emotional exhaustion (Anderson, 2009). The caseload then grows for those caseworkers left, increasing workload even more, setting in motion the reinforcing *Burnout* loop, R2. After the death of 23 month-old Brianna Blackmond two weeks after she was returned from foster care to her biological mother's home, "90 social workers left the agency--nearly one-third of the staff… because of the large caseloads and fears that they couldn't adequately protect children under their care" (S. Horwitz & Higham, 2000).

Overburdened caseworkers often have little choice but to spend the little time they have responding to those cases in crisis mode, following the *Working Harder* loop, B1. Consequently, the caseworkers have less time to spend on preventive work including training, planning, and building relationships with the children and their families, which enable the social worker to handle their cases more effectively, building their own capabilities while also building the capabilities of the children, foster parents and biological parents. Preventive work creates a balancing feedback to increase case performance through the *Working Smarter* loop, B2. As capability trap theory suggests, neglecting these preventive measures in favor of more 'urgent' matters leads to the erosion of the social worker capabilities, which in turn harms child welfare through inappropriate placements and, breakdown of family relations in the absence of visitation. Thus the *Reinvestment or Ruin* loop, R1, tips toward the "ruin" mode, in what is all too often a literal death spiral.

At the system level, management must decide how they allocate resources in the face of the performance gap. Child welfare is assessed by metrics such as timeliness of reunification, timeliness of adoption, incidence of maltreatment within the foster care system, and placement in group homes or institutions. Often times, the system does not have the resources (e.g. beds, foster parents, caseworkers, reporting systems) to handle increases in the number of children in the system (Wulczyn, 1991). The management emergency response aimed at balancing the child welfare metrics such as timeliness of placement or discharge via the *Working Harder* loop, B1, might consist of tactics such as implementing mandates that incentivize adoption for even those cases in which reunification could still be appropriate, hiring privatized foster care providers, or engaging in short-term contracts with expensive psychiatric hospitals to help with mental health cases (Miller, 2014; Weissert & Stengle, 2016). The use of the intervener – in this context the private foster care agency or hospital contractor – necessarily shifts allocation away from investment in the system's own capabilities: those of the biological families, social workers, and foster parents. The third party efforts to reduce adoption and reunification times without also building these capabilities can increase subsequent reentry, further strengthening the *Reinvestment or Ruin* loop, R1 (Myslewicz, 2010). In time, these three capability stocks atrophy, and the larger foster care system becomes dependent on the intervener, often at higher cost. This dynamic manifested itself in the upward trend in the ratio of reentry coincident with Florida's movement to completely privatize its foster care system (Myslewicz, 2010; Children's Bureau, 2013). Florida's current legislation to increase the use of child protection investigators involves removal incentivizing rhetoric that will no doubt put increased burden on the privatized foster care system (Miller, 2014). Meanwhile, when the "so-called community-based care providers [privatized foster care providers] … pleaded with lawmakers for more money", they were "largely rebuffed" (Miller, 2014).

On the other hand, investment in capabilities could lead social services and communities out of the trap. Investment in social worker capabilities may include hiring more social workers, salary increases, training, and scholarships for social work education. Investments in biological family capabilities may consist of job training, GED or other education, intensive family preservation services, daycare, and other forms of temporary assistance such as TANF and food stamps. Family development may also be facilitated by social worker preventive work such that non-abusive parents who might just need help will not have their children removed, further mitigating unnecessary caseload burden. Investment in the capabilities of foster families includes stipends, training, support groups, and access to respite care. Chamberlain et al. (1992) show that "the staffing and associated costs are offset by the benefit of holding more [foster] families in the care system while increasing their overall level of skill for dealing with more complex child problems."

3.3 Escaping the Trap

3.3.1 Reducing Re-entry

The structure outlined above emphasizes the role of caseload on foster child welfare and system capabilities. As the entry rate to foster care is one of the main determinants of caseload, the importance of the rate of re-entry becomes apparent. In many states, re-entry constitutes around 25% of all entries (Children's Bureau, 2013). After identifying high re-entry rates among children discharged to the care of relatives, Utah took steps to support kinship caregivers (Child Welfare Information Gateway, 2012b). With greater resources and transparency, the percentage of children placed with relative caregivers increased from 22 to 34% from 2005 to 2010 (Child Welfare Information Gateway, 2012b). This, coupled with the drop in reentry from relative care from 54 to 24 percent, constituted a significant reduction in reentry and directing Utah's foster system in the direction of virtuous cycle direction (Child Welfare Information Gateway, 2012b).

3.3.2 Concurrent Planning

Concurrent planning, the multi-entity cooperative and holistic case planning methodology consisting of support for case workers, integration of child welfare and adoption, support from court personnel, as well as other elements, represents an example of preventive work found in loop B2 (Child Welfare Information Gateway, 2012a). North Dakota implemented such an integrated program in 1999 and by 2003 saw significant improvement in its foster care performance. "Average time in care decreased from 17 months", "50 percent more children were placed with relatives", and "92 percent of children with a goal of reunification were returned to their families" (Child Welfare Information Gateway, 2012a).

3.3.3 Intensive Family Services

Perhaps one of the most convincing examples of capability building comes from Michigan's implementation of time-limited, intensive services to promote family reunification. The pilot program, created in 1992, boasted a 4 percent higher reunification rate than the control group, as well as an 81 percent successful reunification rate compared to the control group's 60 percent (Child Welfare Information Gateway, 2011). The program not only cut reentry, but also was also cost effective: "The average cost per child was $3,830 to return a child in the treatment group home, including 6 months of services and 12 months of follow-up. The cost for the same 18-month period was approximately $9,113 per child in the comparison group, due to more frequent contacts and more reentries into care after reunification" (Child Welfare Information Gateway, 2011).

3.4 Discussion

Depending on the source, Florida's foster care system is either praised or lambasted. Regardless, the trends can be rationalized using the capability trap framework. Indeed, Florida did make a shift toward family preservation in the early 2000's, and to its credit, reduced the number of children entering foster care by over 5,000 children per year from 2006 to 2009 (Eckholm, 2009). However, caution with regard to such a coarse metric as child entry rate was demonstrated by then-director of Children's Rights Marcia Lowry in reference to Florida's goal for 2012 (Eckholm, 2009). She said, "It worries me when people say the rate of children in care should be reduced by 50 percent… I don't think you can do it that way. You need to look at the quality of decision making and services" (Eckholm, 2009). Indeed, without stronger family preservation capabilities, simply reducing the number of children entering foster care would likely harm children who would be better served by removal. The number of child fatalities in Florida due to maltreatment increased over two-fold between 2004 and 2008 (Children's Bureau, 2015a). Alan F. Abramowitz, director of Florida's family safety office at the time, argued that the rise was due to expansion of the definition of neglect to include "more" cases of drowning. However, the rise in child deaths was underway already in 2004 and 2005. The eventual five-fold decline of fatalities of children of families who received family preservation services within the past five years of the incident between 2009 and 2015 seems to suggest that this capability is starting to increase. This mirrors the success reported Missouri, where the state began to provide services to at-risk families in St. Louis to reduce the need for removals. The private Family Resource Center in St. Louis received "a contract from the state to provide six weeks of intensive counseling to parents who are at risk of having their children placed in foster care. [Agency director Gregory] Echele said the success rate of the program has been more than 80 percent, potentially saving the state millions of dollars that would have gone to foster care. But so far, he said, Missouri hasn't repeated the approach statewide" (Franck, 2002).

Nevertheless, the rate of re-entry in Florida is still at almost an all-time high and maltreatment has been trending upwards. This suggests that although Florida might be doing better on the family preservation side, the children within the foster care system fair far worse. Florida's commitment to privatized foster care would suggest an atrophy of social worker and foster family capabilities. Strengthening its child protection services might very well increase entries into foster care, but without a similar investment in social worker and foster parent capabilities, the higher caseload could trigger the reinforcing feedbacks that prevent the system from escaping from the capability trap, with potentially catastrophic consequences for children who enter the system.

4 HEALTHCARE

"Our health care system squanders money because it is designed to react to emergencies. Homeless shelters, hospital emergency rooms, jails, prisons - these are expensive and ineffective ways to intervene and there are people who clearly profit from this cycle of continued suffering." – Pete Earley, Pulitzer Prize winning journalist

4.1 THE PROBLEM

In 2014, the United States spent over $3 trillion on healthcare (Keehan et al., 2016). This amounted to over 17.4% as a percentage of GDP, dwarfing that of Sweden with its second highest figure of 11.9%, and is projected to grow to 20.1% by 2025(Keehan et al., 2016; The World Bank, 2017). Yet, despite its enormous outspending on healthcare, the US still lags behind many of its Organization for Economic Co-operation and Development (OECD) counterparts in key health indicators including lower life expectancy, higher infant mortality, growing prevalence of chronic conditions, higher percentages of uninsured persona, and greater inequities in care (Squires & Anderson, 2015).

In fact, out of the thirty four countries of the OECD, US ranked twenty-fifth with a life expectancy of 78.8 years as compared to the OECD median of 81.4 years in 2015 (OECD, 2017a). Infant mortality, measured in deaths per 1000 live births, was 6.0 in 2014 against an the remaining OECD average of 3.5, the margin between which has been growing since the OECD surpassed the US in 1996 (OECD, 2017b). The Centers for Disease Control and Prevention record that the age-adjusted percentage of adults in the United States with diabetes has doubled in two decades from 4.4% in 1994 to 9.1% in 2014 ("U.S. Diabetes Surveillance System," 2017). Likewise, the age-adjusted hypertension-related death rate increased by 23.1% from 2000 through 2013 while the rate for all other causes of death combined decreased by 21.0% (Kung & Xu, 2000). Out of 11 compared OECD countries in a Commonwealth Fund report on international health profiles, the US avoidable death rate per 100,000 population, that is, mortality amenable to healthcare, was 115, compared to figures ranging from 64 to 89 for the other ten nations (Mossialos, Wenzl, Osborn, & Sarnak, 2016).

The anyway you slice it, US pays more for health care than any other nation and gets less for it; a classic symptom of a system stuck in the capability trap.

Some have claimed that the increases in medical spending since 1960 in certain areas of our healthcare system – research, tech, etc. – has provided "reasonable value" (Cutler, Rosen, & Vijan, 2006). This argument proves somewhat weak when compared to the overall outperformance of the US by many OECD countries, especially when spending is evaluated on a per capita basis, estimated at over $10,000 for the United States (Keehan et al., 2016). This raises the very important distinction between spending on healthcare and spending and healthcare value. The disparity between personal health expenditures of the highest and lowest spenders, with the top 1% of spenders accounting for over 20% of all spending and the top 5% accounting for almost half of all spending (Schoenman, 2012). What the graph does not show however, is that since 1989, the spending was even more concentrated in the upper percentiles (Stanton, 2006). This could be precisely because of the growing prevalence, and thus spending, to control chronic diseases such as hypertension, diabetes, and obesity in a greater swath of the population (Schoenman, 2012).

We are not the first to point out this systemic problem. In fact, it is at the heart of much research and recently tackled specifically in the book "The American Health Care Paradox: Why Spending More is Getting Us Less" (Bradley & Taylor, 2013). Additionally, the potential cost-savings from better primary care and prevention has been well-established (Friedberg, Hussey, & Schneider, 2010; Maciosek, Coffield, Flottemesch, Edwards, & Solberg, 2010; Ormond, Spillman, Waidmann, Caswell, & Tereshchenko, 2011a, 2011b; Parchman & Culler, 1999; Starfield, Shi, & Macinko, 2005).

Given the win-win nature of many of these preventative measures on not only a health basis, but also a cost basis, it begs the question of why prevention is not more emphasized in the U.S. healthcare system, let alone all healthcare systems. This phenomenon of leaving win-win opportunities on the table suggests that systemic dynamics have trapped the system in its current trajectory.

4.2 HEALTHCARE DYNAMICS

4.2.1 Nested Health Traps

Spending on health can be framed as a series of embedded capability traps. Ultimately, all of these dynamics could be combined into one, albeit complex, system dynamics model. However, the relatively directional nature of health degradation allows for the segmentation and nesting of trade-off dynamics.

At the most inner level, illustrated by Figure 7c, the capability trap framework manifests itself within the trade-off between *Working Harder* efforts of dealing with often very expensive emergency medical procedures, and *Working Smarter* tertiary prevention measures, which serve to preserve the health of symptomatic patients and reduce the likelihood of acute episodes. Tertiary prevention methods for coronary heart disease may include the use of antihypertensives or statin therapy. The emergency interventions are needed in situations such as strokes, heart attacks, or other coronary events, for which expensive surgeries such as coronary bypass surgeries could be required. The collateral health effects of acute episodes include complications that further erode the already ailing health of the symptomatic person.

At the intermediate level, shown by Figure 7b, the dynamics of the inner level are represented in its entirety by the inset, with tertiary prevention and emergency medical measures both serving to balance the occurrence of acute episodes. Here the *Working Smarter* tertiary prevention loop of the inner model is combined with the emergency intervention loop to become the *Working Harder* loop due to their collective competition for resources with secondary prevention efforts. Secondary prevention efforts serve to detect, diagnose, and prevent the afflictions of the afflicted population from becoming symptomatic. This could include controlling blood pressure, checking cholesterol levels, monitoring blood sugar levels, screening for breast cancer, and similar testing and monitoring methods to prevent afflictions like hypertension or diabetes from progressing.

Similarly, at the outer level, shown by Figure 7a, the dynamics of the intermediate level are represented in its entirety by the inset, with secondary prevention and tertiary measures both serving to balance the needs of the afflicted. Again, the *Working Smarter* secondary prevention loop of the intermediate model is combined with the inner loop dynamics become the *Working Harder* loop due to their collective competition for resources with primary prevention efforts. Primary prevention efforts serve to prevent the onset of afflictions from even occurring in the first place through general and targeted efforts promoting salubrious choices such as nutrition, exercise, maintaining a healthy diet and weight, and discouraging biologically unhealthy activities such as smoking and limiting alcohol consumption. Though not explicitly shown in the nested figures, these types of activities build health capabilities at all stages of health.

It is important to note that although B1 and B2 combine to form B3, the driving force within B3 is emergency intervention and the resulting *Reinvestment or Ruin* loop, R1. The reason for identifying the *Working Harder* loop in the Secondary Prevention Figure 7(b) as B3 instead of R1 is that B3 represents the represents the allocation choice rather than the resulting driving dynamic. It also matches the loop polarity of the standard capability trap framework. However, the reinforcing pathology of actors eventually falling into the innermost trap should not be overlooked; the presence of multiple balancing loops does not dominate the stronger *Reinvestment or Ruin* loops. The same applies to B5.

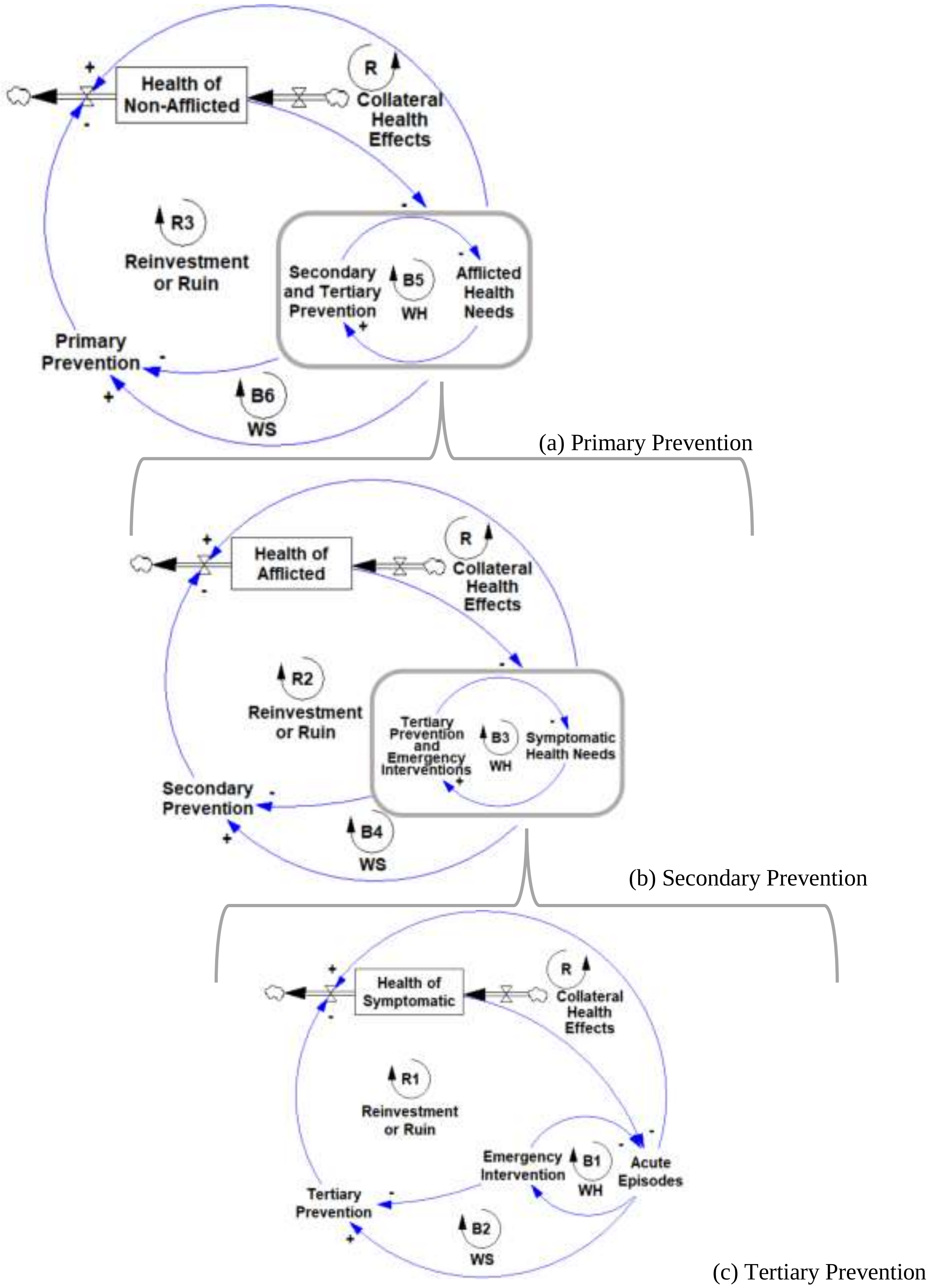

Figure 7. Nested Capability Health Traps (a) Primary trap (b) Secondary trap (c) Tertiary trap

Specifically, the system is oriented toward expensive treatment and underinvests in primary care and primary prevention. Americans have fewer hospital and physician visits – 4 annual visits compared to the OECD median of 6.5 visits; there are fewer practicing physicians per 1,000 population – 2.6 physicians compared to the OECD median of 3.2 physicians; and fewer acute care hospital beds per 1,000 population - 2.5 beds compared to the OECD median of 2.9 beds (Squires & Anderson, 2015). Meanwhile, the US is the top consumer in expensive medical technology such as diagnostic imaging and pharmaceuticals, and high procedure and pharmaceutical prices prop up high healthcare costs (Squires & Anderson, 2015). Resource allocation favors treatment, technology and medication for people once they are afflicted with acute and especially chronic conditions, rather than devoting resources to primary care and investments in public health, education, and a safe, healthy environment. Similar to the infrastructure dynamics described above, we are willing to spend huge sums to treat disease once we are afflicted, but very little to prevent the development of the afflictions in the first place.

4.2.2 The Cure for Cancer: A Wild Goose

The medical literature surrounding the prevalence of cancer generally supports the conclusion in the 2016 Nature paper that “cancer risk is heavily influenced by extrinsic factors” (Parkin, Boyd, & Walker, 2011; Song & Giovannucci, 2016; Wu, Powers, Zhu, & Hannun, 2016). Anand et al. even go so far as to conclude that “only 5–10% of all cancer cases can be attributed to genetic defects, whereas the remaining 90–95% have their roots in the environment and lifestyle” (2008). Even the authors of the highly contentious Science article, which reduced the cause of cancer to “bad luck,” produced another paper with the acknowledgment that “primary prevention is the best way to reduce cancer deaths” (Tomasetti, Li, & Vogelstein, 2017; Tomasetti & Vogelstein, 2015). Yet despite these compelling findings, the National Cancer Institute has been steadily decreasing its already small percentage of spending allocated toward cancer prevention and control.

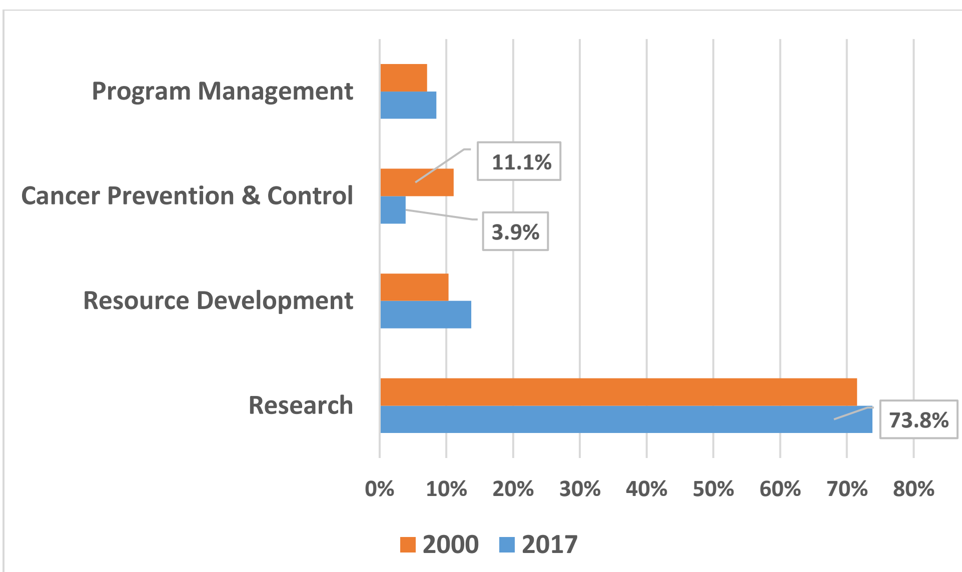

Figure 8. National Cancer Institute Spending Structure.
Research includes Cancer Causation, Treatment Research, Cancer Biology, Detection & Diagnosis Research.
Resource Development includes Cancer Centers, Research Manpower Development, Buildings & Facilities.

Given this trend in spending, the U.S. has become relatively good at increasing the lifetimes, and on occasion even “beating” the cancer, for those people that have already developed it. Thus, even if the age-standardized rate of cancer incidence in the United States is slowly declining, it does so from a rate that is consistently high relative to other OECD countries (Jemal et al., 2017; OECD, 2015).

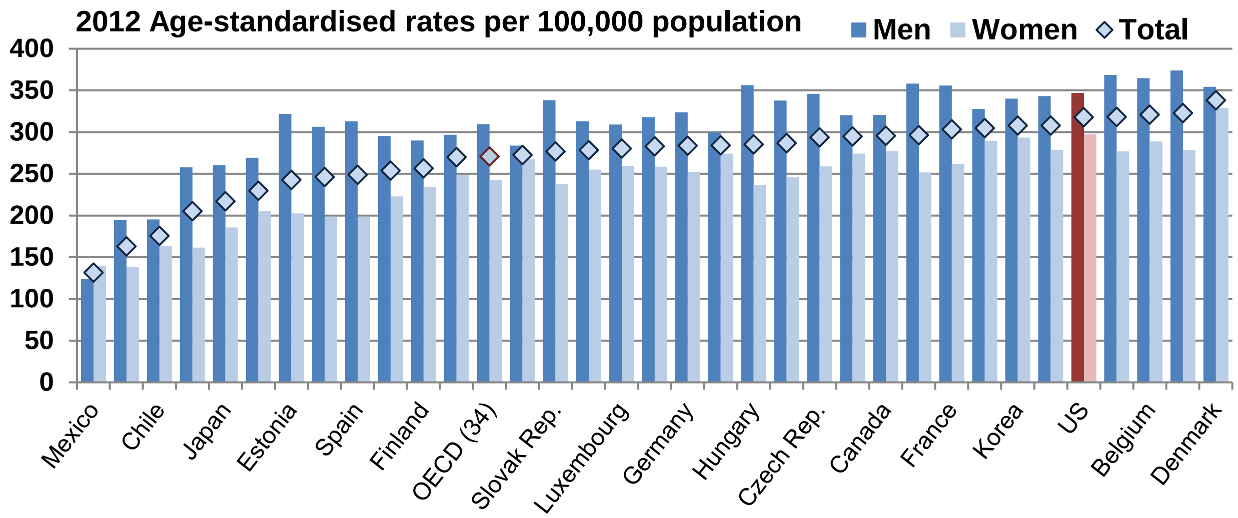

Figure 9. The United States has a high age-standardized rate of cancer relative to the OECD. Figure sourced from (OECD, 2015).

4.2.3 The Healthcare System Capability Trap

The capability trap of the population's health is directly related to the operation and efficacy of the healthcare system at large and can, in fact, be seen as yet another embedded dynamic in the healthcare system. As schematized in Figure 10, the healthcare system exhibits many similar dynamics to those of the foster care system. Just as in the foster care system, the capabilities in the healthcare system consists of not only capacity stocks – consisting of number of hospital beds, number of primary care physicians (PCPs), number of hospitals, etc. – but also higher order capabilities that directly affect the quality of care – consisting of care provider experience, relationships built with patients, efficacy of information systems, medical response coordination, continuity of healthcare service, medical surge, etc. (Dall, West, Chakrabarti, & Iacobucci, 2015; Office of the Assistant Secretary for Preparedness and Response, 2016). In Figure 10, these quantitative and qualitative capability types are delineated into separate stocks as opposed to consolidating them into experience chain structures as was done for the foster care example. Also of particular importance to the operation of the healthcare system are the reinforcing dynamics driven by caseload and, consequently, the quality of care provided.

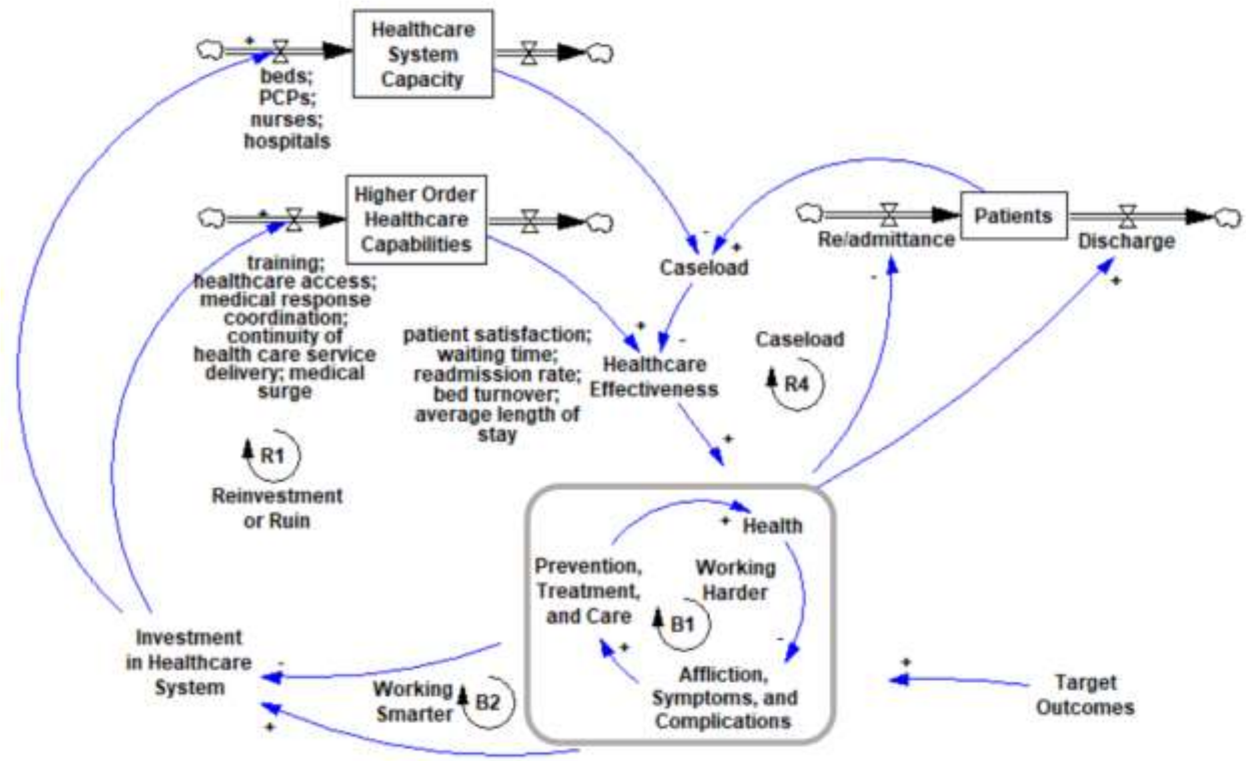

Figure 10. Healthcare System Capability Trap

Readmission of recently discharged patients has been shown to increase stress on the Emergency Department (ED) through overcrowding (Baer, Pasternack, & Zwemer, 2001). Overcrowding, captured by caseload, reduces healthcare effectiveness through longer wait times for the ED, and as such, degrades the quality of care and increases the likelihood of adverse events, possibly reinforcing readmission rates (L. I. Horwitz, Green, & Bradley, 2010). Conversely, better access to services has been shown to reduce readmission rates through chronic disease management (Kirby, Dennis, Jayasinghe, & Harris, 2009). When people are have built up trusting relationships with their care providers through regular and quality visitations, they are more likely to either prevent the onset of a chronic disease or at least catch it in its early stages of development (Thom, Hall, & Pawlson, 2004). Unfortunately, the trend in most health plans is toward fewer, shorter visits with primary care providers (Squires & Anderson, 2015). According to a 2015 study, “projected shortfalls in primary care will range between 12,500 and 31,100 physicians by 2025, while demand for non-primary care physicians will exceed supply by 28,200 to 63,700 physicians” (Dall et al., 2015). This directly exemplifies to the allocation of resources into deeper and deeper traps that, as in the foster care system, promote vicious cycles that undermine patient, erode the capabilities of providers and patients, and all the while increase costs.

4.2.4 Broadening the Scope of Healthcare

Figure 11 displays data that seems to support a different story. Out of a selection of other developed OECD countries, the US consistently spends more on preventative care as a percentage of GDP, second only to Canada.

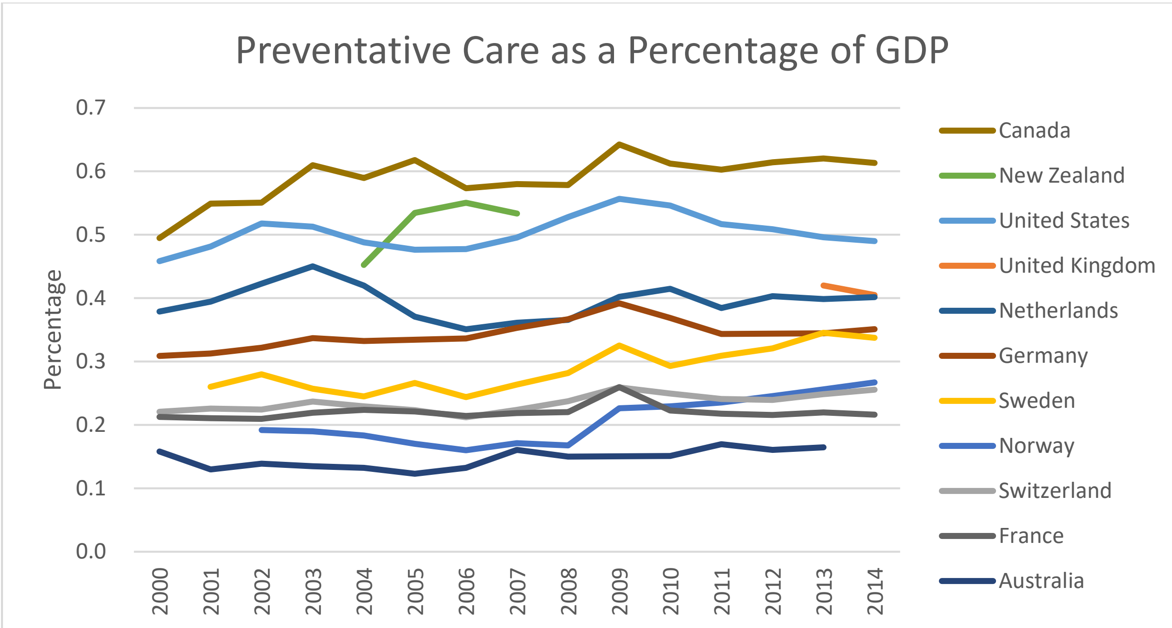

Figure 11. Preventative Care as a Percentage of GDP for selected OECD countries (OECD, 2017b)

Nonetheless, not only does this not contradict the capability trap model, but it actually strengthens it. It reveals the often forgotten fact that healthcare is not the only determinant of health. By expanding the scope of examination, we discover that the United States has consistently ranked among the lowest in public social service expenditure as a percentage of GDP, which is an important determinant of its long-term demographic health, compared to its OECD counterparts. In fact, the US has spent less as a percentage of GDP on social services than the OECD average since before 1960. In social care spending specifically, the US ranked last in 2013 at 9 percent as a percentage of GDP (Bradley & Taylor, 2013; Squires & Anderson, 2015).

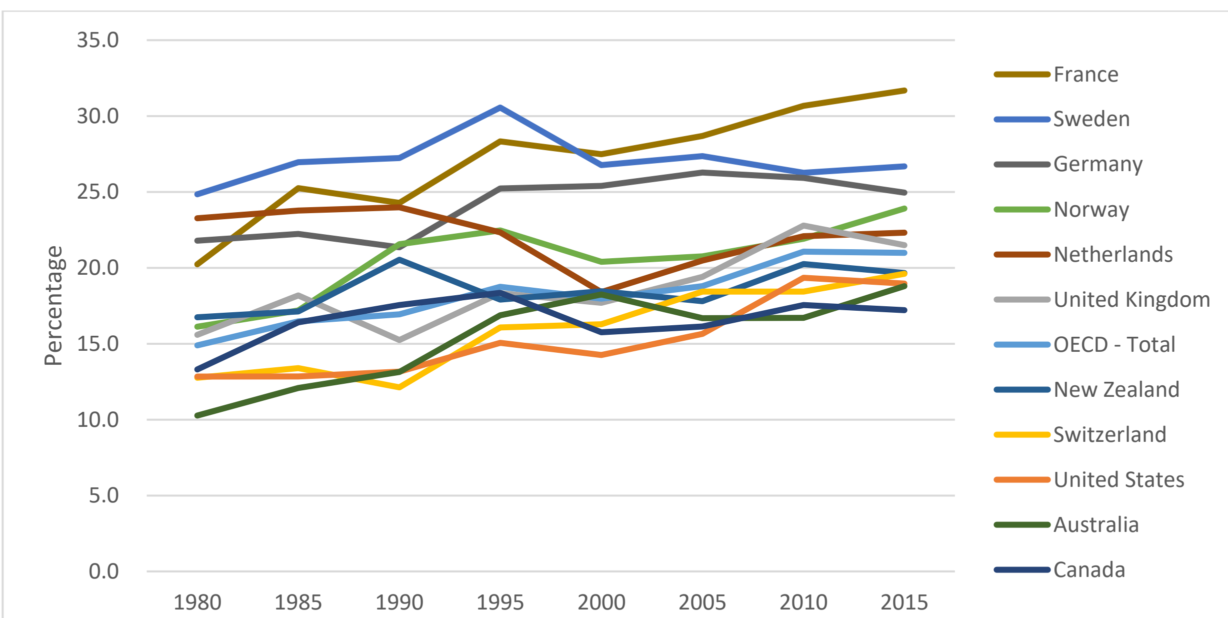

Figure 12. Public Social Expenditure as a Percentage of GDP (OECD, 2017b)

This gives rise to yet another, even larger capability trap, illustrated in Figure 13, in which 'downstream' systems like healthcare are heavily funded at the expense of investment in 'upstream' social capabilities.

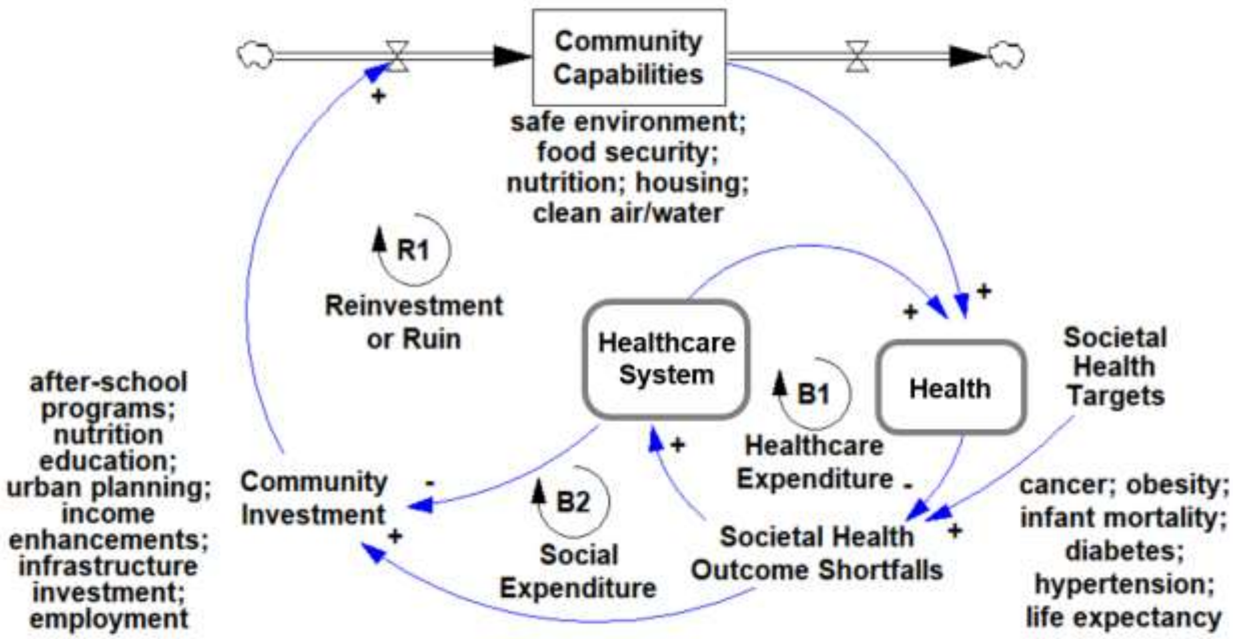

Figure 13. Expanded Health System

System dynamics models have been used to demonstrate how concerted investments into the capabilities of communities can promote significant and cost effective health outcomes (Homer, Milstein, Hirsch, & Fisher, 2016; Milstein, Homer, Briss, Burton, & Pechacek, 2011). The emphasis on reinvestment of savings is crucial to reversing the vicious cycle into a virtuous one.

While Ormond et al. demonstrated the health cost saving potential of investments in primary care and prevention, Thornton et al. demonstrate the health cost saving potential of investments in what has been generally acknowledged as Social Determinants of Health (Ormond et al., 2011a, 2011b; Thornton et al., 2016). They found that community investment in the form of "disparity-reducing policy intervention" built up community capabilities such as education, urban-planning and community development, housing, income enhancements and supplements, and employment (Thornton et al., 2016). In strong agreement with the Homer et al. and Milstein et al. system dynamics models, Thornton et al. concluded that "although the interventions we discuss primarily target a single social determinant, they likely have ripple effects across others" and that more research is needed to "connect the dots" (Thornton et al., 2016). Ultimately, there is an understanding that healthcare sector specific interventions are "insufficient to address population-level health disparities" due to its position within a larger system with more momentum (Thornton et al., 2016).

4.3 Escaping the Trap

In the United States, approximately 60 percent of the 4,862 community hospitals are not-for-profit, and are thus exempt from certain taxes on the basis that they qualify as charitable organizations (Health Forum LLC, 2017). As such, they are expected to allocate a portion of their operating expenses back toward the communities they serve. Facing scrutiny for the quality and quantity of those allocations, hospitals were made to conduct assessments of community needs and develop implementation strategies every three years under the Patient Protection and Affordable Care Act. A 2013 study found that for fiscal year 2009, these hospitals were shown to only spend an average of 7.5 percent of their operating expenditure on community benefit (Young, Chou, Alexander, Lee, & Raver, 2013). Of that, 85 percent went directly to patient care services such as charity care, unreimbursed costs for means-tested government programs, and subsidized health services, following the *Healthcare Expenditure* loop, B1, and 5.3 percent was allocated toward community health improvement, following the *Social Expenditure* loop, B2 (Young et al., 2013). However, a few outlier hospitals have made it a point to broaden the scope of their community benefits to focus on the social determinants of health.

4.3.1 Dignity Health

Dignity Health is a not-for-profit health care system and hospital provider based in San Francisco, California. Dignity Health has, along with initiatives such as Diabetes and Chronic Disease Self-Management workshops serving 1200 individuals, Social Innovation Partnership Grants, and Community Grants, has a Community Investment Program responding directly to the priorities identified in the Community Health Needs Assessment and/or community benefit plans of each Dignity Health hospital (Bailiff et al., 2016). In 2016, the program approved 19 below-market-rate loans of over $30.6 million to organizations working to improve communities in focus areas including housing, health-related, community financial intermediaries, small business and micro-lending, community services, arts and education, and even clean energy (Bailiff et al., 2016). As of March 31, 2016, the total portfolio of 68 projects boasted an average rate of return of 3 percent, surpassing the expected 1.1 percent benchmark set for the program (Bailiff et al., 2016). Heeding the *Reinvestment or Ruin* pathology, the principal and interest return on these strategic social investments are then re-lent to continue the promotion of community capabilities, provide short-term financial benefit, and also promote health benefits that will be captured by other parts of the greater societal health system.

4.4 DISCUSSION

4.4.1 Tax-Exempt Hospital Policy

In order to qualify for the tax-exemptions, not-for-profit hospitals must engage in those activities outlined in what is called Schedule H of the IRS tax code. Schedule H has to parts, which are treated differently. Part I refers to Community Benefit which consists of financial assistance and means-tested government programs such as Medicaid, as well as other benefits such as health professions education, subsidized health services, and research (IRS, 2016). Part II refers to Community Building which consists of activities including physical improvements and housing, economic development, community support, environmental improvements, coalition building, and workforce development, insofar as they have "promoted the health of the communities it serves" (IRS, 2016). Due to the ambiguity around how to account for Community Building and its effect on societal health outcomes, hospitals are more likely to opt towards Community Benefit, which, while good, generally only addresses those short-term individualized health shortfalls, following the balancing *Healthcare Expenditure* loop, B1 (Rosenbaum, Byrnes, Rothenberg, & Gunsalus, 2016). Many health organizations are calling for more clarity on the accounting of Part II, or its complete merging with Part I, such that not-for-profit hospitals may freely address those upstream social determinants of health via the balancing *Social* Expenditure loop, B2, which not only promotes longer-term health benefits, but also socio-economic and quality of life benefits as well (Rosenbaum et al., 2016).

4.4.2 Delays

Baicker et al.'s randomized natural experiment on health insurance found that "insurance led to increased access to and utilization of health care, substantial improvements in mental health, and reductions in financial strain," but that they did not "observe reductions in measured blood-pressure, cholesterol, or glycated hemoglobin levels" (2013). This result would suggest that the time to build physiological capital is longer than 2 years. This is not surprising. In order for an increase in physiological health to be observed due to increased access to healthcare insurance, not only does the biology of the body need to change, but also those enabled by the insurance accessibility would need to take advantage of it in the way that it was meant to be. As acknowledged by the authors, "the effects of Medicaid coverage may be limited by the multiple sources of slippage in the connection between insurance coverage and observable improvements in our health metrics; these potential sources of slippage include access to care, diagnosis of underlying conditions, prescription of appropriate medications, compliance with recommendations, and effectiveness of treatment in improving health." These "slippages," what Eisenberg and Power call "voltage drops," reduce the amplitude of the outcomes from the implemented inputs (2000).

Delays are also present in the development of symptoms due to the lack of underlying health capability, or what Fogel terms "physiological capital" (2003). He argues that "not all damage due to retarded development in utero or infancy caused by malnutrition shows up immediately" and that "enhanced physiological capital is tied to long-term reduction in environmental hazards and to the conquest of chronic malnutrition, since both nutritional status and the quality of the external and intrauterine environments appear to be linked to the quality of organ development and to the onset of chronic diseases later in life" (Fogel, 2003). These positions align very well to the framework of the expanded health capability trap.

4.4.3 A Discussion on National Health Priorities

Fogel's formulation of physiological capital as a stock of health capability that can be built up and eroded over time is a particularly useful one in the application of the capability trap framework. With this formulation, he developed a set of theses, some of which seem to corroborate the patterns hypothesized by the capability trap (Fogel, 2003):

1) Environmental Improvement Is More Important than Access to Health Care
2) Slowed Physiological Capital Depreciation Rates Are More Important than Improved Medical Technology
3) Neonatal Environment Is Crucial for Later Health The
4) Lifestyle Change Is Key to Improving Health
5) Health Care Outreach Programs Are More Important than Extension of Insurance

These theses hint at an underlying value based judgement on what is "more important". Geoffrey Rose's seminal work, *Sick Individuals and Sick Populations*, more explicitly tackles the issue of societal judgements on health equity (Rose, 1985). While these analyses tend to pit the mitigation of incidence among populations against the control of cases among individuals, it is important to remember that the capability trap suggests that both can be improved in an efficient and healthy system. Even the innermost loops will act efficiently because so much resource has been saved in the outermost loops.

5 PRISON AND EDUCATION

"Today, criminal justice functions and justifies itself only by this perpetual reference to something other than itself, by this unceasing reinscription in non-juridical systems."
Michel Foucault

5.1 THE PROBLEM

In 2015, the United States accounted for just over 4% of the world's population but over 20% of the world's prisoners (The World Bank, 2017; Walmsley, 2016). With the second highest prison population rate (the number of prisoners per 100,000 of the national population), behind only Seychelles (799), the United States (698) beat out other countries including Turkmenistan (583), Cuba (510), El Salvador (492), Thailand (461), the Russian Federation (445), and Rwanda (434) (Walmsley, 2016).

This rise in number of incarcerated individuals in the United States despite the falling crime rate, has led to increased expenditure on the corrections system. Since 1989, growth of state and local government spending on prisons has outpaced spending on elementary and secondary education three-fold (Stullich, Morgan, & Schak, 2016). The disparity at the postsecondary level is even more stark, with an 89 percent increase in corrections compared to no growth in appropriations for higher education (Stullich et al., 2016). The state of Texas boasted a 850 percent increase in corrections expenditure (Stullich et al., 2016). Such immense escalation has placed corrections spending at the third largest category of average state expenditures, trailing only education and healthcare. However, allocations of general state funds toward corrections surmounted those toward education in eleven states in 2013. (Mitchell & Leachman, 2014)

As with other systems caught in the trap, many of the individual dynamic links within the system are well understood. The lack of education significantly increases the likelihood of crime (Lochner & Moretti, 2004). Furthermore, research suggests that a 10 percent increase in high school graduation rates can lead to a 9 percent decrease in arrest rates (Furman, 2016). Furthermore, the increasing stock of incarcerated persons, and the allocation towards corrections facilities to handle it, not only distract from the allocation of resources towards building better community capabilities, but also actively degrade them. The vicious cycles at play are thus strongly reinforced and condemn certain communities to a trap that is nearly impossible to escape.

The trade-off is not limited to incarceration and education, though. Education is just one of many community capabilities that exhibit similar relationships and trends. The juxtaposition of education and prison spending simply serves as an easily comprehendible example of the alarming state of social prioritization reflected in spending trends.

5.2 PRISON AND EDUCATION DYNAMICS

5.2.1 Incarceration and Prison Capacity Dynamics

The stocks and flows in the prison system are somewhat unique, and for the past several decades have been dominated by what are arguably poorly aligned incentives. Figure 14 illustrates the main dynamics between the stocks of incarcerated population and prison capacity. It would seem as though having a balancing feedback acting upon the stock of incarcerated population would be a reasonable design. However, the interaction of these two balancing feedbacks disguises an extremely damaging growth-oriented dynamic.

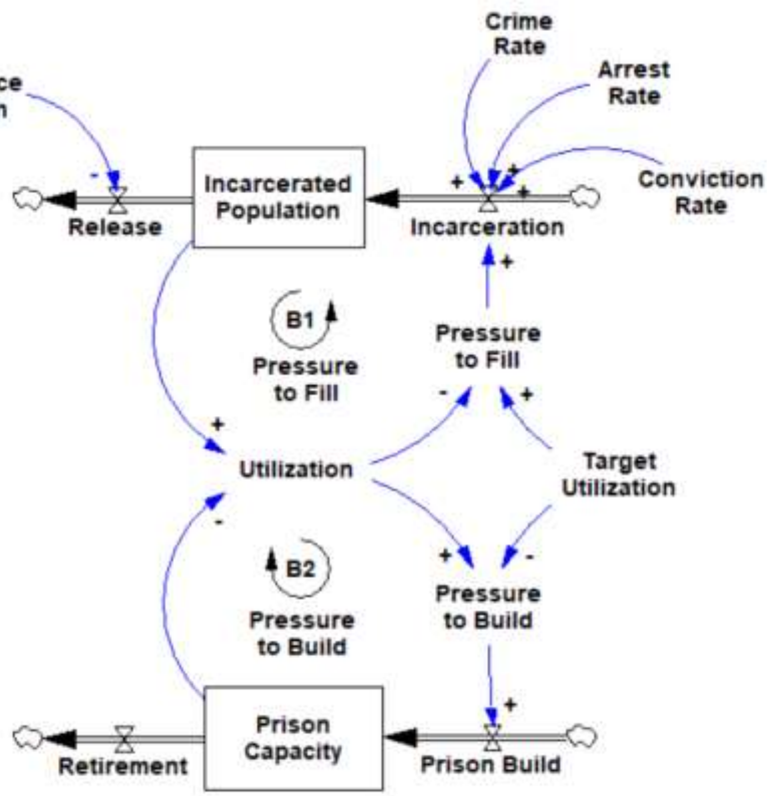

Figure 14. Incarcerated Population and Prison Capacity Dynamics

Utilization is the ratio of *Incarcerated Population* to *Prison Capacity*. If the *Utilization* increases, perhaps from a change in conviction policy that increases the incarcerated population, there is increased *Pressure to Build* extra *Prison Capacity*, especially when the *Utilization* surpasses the *Target Utilization* (Lutz, 2016). What lies hidden in the causal loop diagram, however, is the fact that the *Pressure to Fill* loop, B1, is inactive during times of increased *Utilization*. The *Conviction Rate* will not decrease, and it will certainly not induce a reduction in sentence length. Only the *Pressure to Build* loop, B2, is active. When extra capacity is achieved, *Utilization* normalizes and the system resumes equilibrium.

On the other hand, should *Utilization* fall, perhaps due to a reduction in *Crime Rate*, many private prisons, which were established widely throughout the United States concurrent the "War on Drugs" in the 1970's and 1980's, put pressure on courts to boost their *Conviction Rates*. A 2013 report found that 65 percent of the private prison contracts analyzed included quotas for prisoners (In the Public Interest, 2013). Should those quotas not be met, they are entitled to payments from the state; a so called "low-crime tax". This time, the *Pressure to Build* loop does not operate during under-utilization; the prisons do not decrease their capacity.

The problem arises due to the combination of the high target utilization and these two valve like balancing dynamics. Occupancy guarantee clauses in private prison contracts were found to lie in the range between 80% and 100% (In the Public Interest, 2013). If exogenous or endogenous factors introduce any volatility outside this narrowly defined range, one of the loops begins to work, always in the direction of greater incarcerated population or greater prison capacity. Thus, it is only *Utilization* that is balanced. The stocks, however, are always pushed in the direction of growth .

5.2.2 The Prison/Education Capability Trap

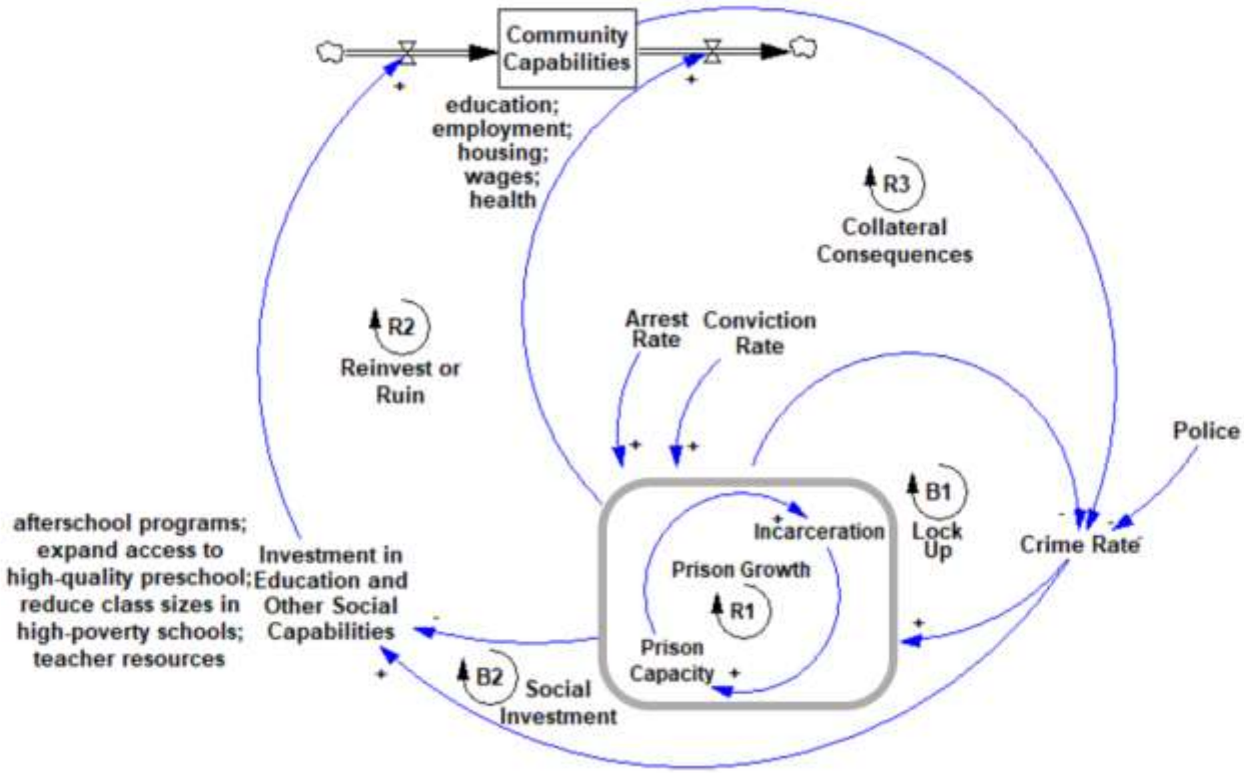

Figure 15. Prison System as a Driving Subsystem of a Greater Societal Capability Trap

As was mentioned before, one of the main causal links is that inverse relationship between education and crime rate (Furman, 2016; Lochner & Moretti, 2004). Meanwhile, incarceration impedes efforts toward poverty reduction, creating an incredibly strong reinforcing *Collateral Consequences* feedback, to borrow the terminology of the American Bar Association (American Bar Association, 2016; DeFina & Hannon, 2009). This loop includes a multitude of damaging effects – including the effect of parental incarceration on child education and cognitive development, the difficulty of finding work and housing upon release, the increased financial strain on the families of incarcerated person, etc. – eroding not only the social capabilities of the current society, but also that of the next generation (Mears & Siennick, 2016; Morsy & Rothstein, 2016; Murray, Farrington, & Sekol, 2012; Turney, 2014; Warren, 2010). Additionally, the incapacitative rationalizations behind the *Lock Up* loop, mentality turn out to be either less effective at balancing *Crime Rate* than commonly thought, and at times even incorrect. Increasing sentence length has little effect on arrest rates and is even suggested to increase average rates of recidivism (Durlauf & Nagin, 2011; Mueller-Smith, 2015). Similarly, juvenile detention has been shown, via a naturally randomized experiment, to increase the likelihood of re-offense by 22 to 26 percent and to reduce the likelihood of finishing high school by 13 percent (Aizer & Doyle, 2015). Given the already high levels of prison population, further prison construction has been shown to be cost ineffective due to decreasing marginal returns to incarceration (Spelman, 2005).

Nevertheless, in the face of all these well-researched interactions, states can still become stuck in the trap. States presumably do not want to cut education spending, but when faced with resource constraints such as budget cuts during the recession after 2008, short-termism tends to drive decisions. It is not coincidence that "six of the ten states with the highest incarceration rates – Arizona, Florida, Georgia, Missouri, Oklahoma, and Texas – cut preschool funding per child by more than 15 percent between 2008 and 2013" (Mitchell & Leachman, 2014).

It is important to mention that we are not advocating the release of all prisoners and the end of the corrections system. This might be analogous to stopping all tertiary prevention or emergency health interventions. We argue that the inefficiency due to the trap not only causes thousands of people and communities unnecessary harm, but also costs disproportionately more than it should.

5.3 ESCAPING THE TRAP

5.3.1 Reducing Prison Populations and Violent Crime Rates Simultaneously

The smart implementation of prison population reduction has been demonstrated by California, New Jersey, and New York (Mauer & Ghandnoosh, 2015). Between 1999 and 2014, the prison populations of New Jersey and New York were reduced by 31 and 28 percent, respectively, while the state prison population of the United States grew by 10 percent. Concurrently, the rate of violent-crime in New Jersey and New York decreased by 37 and 35 percent, respectively, outpacing the decrease of nationwide violent-crime of 28 percent. Likewise, between 2006 and 2014, the prison population of California was reduced by 22%, while the state prison population of the United States decreased by 2 percent (Bureau of Justice Statistics, 2016). Concurrently, the rate of violent crime in California decreased by 25 percent, outpacing the decrease of violent-crime in the nation of 22 percent (Federal Bureau of Investigation, 2017). While these trends cannot be said to definitively prove the working of the reinforcing *Reinvest or Ruin* dynamic yet, they do attest to the severely decreased marginal balancing effect of the *Lock Up* loop, B1, to the point where reductions in incarceration can produce immediate benefits including a decreased rate of violent-crime. Further research that connects these separately studied links in to a dynamical system could support the long-term savings potentials and fiscal notes that make policy makers more likely to accept certain corrections bills (Leachman, Chettiar, & Geare, 2012).

5.3.2 One Summer Chicago

In 2012, the One Summer Chicago program began accepting youths aged 14-24 to participate in summer jobs and internships provided by the government, community-based organizations and companies. A randomized control trial on a subset of the participating disadvantaged high school youth revealed that an assignment to a summer job decreased violent-crime by 43% over a 16 month period (Heller, 2014). This amounts to 3.95 fewer violent-crime arrests per 100 youth (Heller, 2014). Furthermore, the fact that the majority of the decline occurred after the end of the 8-week intervention combats the incapacitative notion that fewer violent-crimes happened only because there were fewer youths on the street to commit them (Heller, 2014). Instead, it points to the time delay in building behavioral capability in youths. That having been said, a change at that scale within 16 months is significant, the savings from which could be reinvested into similar programs. One Summer Chicago is now in its sixth year, and while disadvantaged youth behavior is certainly an important intervention point, many other changes will be needed to help pull these communities from their disadvantaged state in the first place.

5.3.3 Reinvestment Mechanisms

In order to reverse the vicious cycle of a trapped system to a virtuous one, more is almost always required than any single policy change. There must be a systemic shift in behaviors, one of which is the discipline to reinvest the savings from any reforms into the system capabilities. States typically have three alternative mechanisms to shift savings from criminal justice reforms into human capital investments. The first is the creation of a " 'reinvestment fund' that captures savings from the reforms and allocates those savings largely to human capital investments, including educational programming targeted to high-poverty communities and improved mental health and substance abuse treatment programs" (LaVigne et al., 2014). California passed a referendum in 2014 called Proposition 47 that follows this approach as one element of its statute. Alternatively, savings may be deliberately appropriated toward human capital programs through state budget processes (LaVigne et al., 2014). Similarly, savings may be reallocated within organizations at the department or agency level (LaVigne et al., 2014).

5.4 DISCUSSION

5.4.1 Mass Incarceration Myth

While the time correlation of skyrocketing incarceration rate against the falling crime rate might lead some to believe that the latter is a consequence of the former, the prevailing majority of economic research largely discredits this simplistic mental model. The *Incarcerated Population* can be modeled as a stock. This stock is function of primarily four factors that affect the rate of inflow and outflow from that stock: the *Crime Rate*, the *Arrest Rate*, and the *Conviction Rate* affecting the inflow, and the *Sentence Length* affecting the outflow.

First, incarceration rates and crime rates have largely acted independently of each other. Violent and property crime rates fluctuated throughout the 1980's, yet incarceration rates underwent its greatest period of growth (Mitchell & Leachman, 2014). Since then, crime rates have continued to fall, while incarcerations rates continued to grow to a peak in 2007 (Mitchell & Leachman, 2014).

Second, arrests per crime have remained relatively stable between 1980 and 2010 (Mitchell & Leachman, 2014). Indeed, the a report by the National Research Council concluded that "by the measure of the ratio of arrests to crimes, no increase in policing effectiveness occurred from 1980 to 2010 that might explain higher rates of incarceration" (Travis, Western, & Redburn, 2014).

This leaves us with the third factor of prison inflow: conviction rate. In the United States, the share of arrested persons sent to prison has gone up for all crimes, especially for drug-related crimes, for which the probability of being sent to prison rose by 350 percent between 1980 and 2010 (Mitchell & Leachman, 2014). The National Research Council report estimated that the increase in conviction rate accounted for approximately 49 percent of the growth in state incarceration rates during that same timeframe (Travis et al., 2014).

Likewise, the length of prison sentences has also had a significant impact on prison population growth. Between 1990 and 2009, the average time served for property crimes, and violent and drug crimes rose by 24 and 37 percent (Gelb, King, & Rose, 2012). The increase in sentence time was estimated to have accounted for the other 51 percent of state prison population between 1980 and 2010 (Travis et al., 2014).

Thus, the incredible rise of incarceration in the United States has been primarily driven by policy decisions as opposed to any kind of increase in crime or ability to catch offenders.

5.4.2 Policy Resistance

On May 10, 2017, Attorney General Jefferson Sessions released a memorandum in which he established charging and sentencing policy of the United States Department of Justice (Sessions, 2017). In the memorandum, he urges federal prosecutors to seek maximum charges and sentences available by the power of law, including mandatory minimum sentences. According to the configuration of inflows and outflows of *Incarcerated Population*, adherence to this policy would necessarily increase the stock of incarcerated persons, ceteris paribus. Such an increase perpetuates all three reinforcing feedbacks within the prison/education capability trap framework – *Prison Growth*, R1, *Reinvestment or Ruin*, R2, and

Collateral Consequences, R3 – ultimately eroding social capabilities of children, families, and communities, with little to no balancing effect on crime rate.

6 DISCUSSION

It is important to understand that the solution is not as simple as investing all available resources into capability building. Indeed, even the *Working Harder* loops rely on their own sets of capabilities, as evidenced by the existence of nested capability traps. Rather, the capability trap is a framework meant to organize, rationalize, and prioritize the relative efficacy of different investment allocation schemes with special attention paid to the reinforcing feedbacks within the respective systems. As such, there is an equilibrium allocation between investment and operation that serves to sustain capabilities while also handling inevitable performance shortfalls or other forces majeures. Problems, breakdowns, illnesses and injuries will always occur. The objective is not to deny people with chronic disease the treatment they need or to ignore a pipe that bursts. Rather, the purpose of capability building is to achieve a level of resilience such that these instances can be dealt with in an efficient and quality manner when they arise. Systems operating at this resilient equilibrium do so at a higher level of performance and lower cost than those with sub-optimal allocations, especially those that are caught in the capability trap.

6.1 WORSE-BEFORE-BETTER

Unfortunately for those wishing to escape the capability trap, the first outcome to interventions designed to boost capabilities is a drop in system performance or a rise in costs known as the Worse-Before-Better (WBB) dynamic (Repenning & Sterman, 2001, 2002). By allocating resources toward proactive maintenance, renewal efforts, and capability building in general, there will necessarily be either less allocation toward seemingly more urgent reactive efforts or a rise in cost. Even the Federal Transit Administration, in its report on the DC Metro, acknowledged that "because not all preventive maintenance can be done during off-peak and non-revenue hours, vehicles must be withdrawn from revenue service for some portions of the Preventive Maintenance Program" (Federal Transit Administration, 2015). If the dynamic is too severe, the system runs the risk of relapse into the trap. Upper management may perceive the severe drop in performance as confirming a belief that investment in capabilities and process improvement won't work and that working harder is the correct course of action (Repenning & Sterman, 2002). If they decide to revert to their original operation, capabilities will not have been built up enough to provide the sustainable increase in performance to allow for a reinvestment feedback. Alternatively, if the WBB dynamic is too long, it could drain the extra resources needed for capability investment. The WBB dynamic often causes promising improvement programs to be abandoned, or prevents them from being started in the first place. It is therefore critical to understand, in any particular case, how deep and how long the WBB period may be, and what can be done to mitigate it.

6.1.1 Delays

Different instances of the capability trap will exhibit different durations for the WBB period. The duration and depth of the WBB period will depend on the delays between increasing resources allocated to capabilities, the time required to lift the rate of increase in capabilities above the erosion rate, and the magnitude of any low hanging fruit that has accumulated. These vary widely. As shown by Lyneis and Sterman (2016), the energy efficiency of many buildings and facilities can be improved very quickly through routine maintenance such as cleaning HVAC systems, recalibrating controls so that buildings do not heat and cool themselves at the same time, and so on. These activities cost little and take but little time; in these cases WBB is often negligible. Similarly, cutting air pollution including NOx, SOx and particulates quickly reduces emergency room visits caused by asthma and lung disease, freeing resources that can be reinvested in further improvement. In contrast, investments in prevention through better diet, exercise and healthier behaviors can reduce the onset of chronic conditions such as obesity, diabetes, heart disease and hypertension, but the stock of those currently afflicted with these chronic conditions is so large that system improvement will take years or decades. Similarly, for reservoirs and dams with lifetimes of 50-80 years, it can take decades before proactive maintenance prevents a failure that might have occurred otherwise (Economic Development Research Group, 2011). "Major savings from reducing incarceration likely will accrue over a number of years, as reforms lead to prison closures and a reduction in the prison population, but states need to invest more in education more rapidly than that" (Mitchell & Leachman, 2014).

There is currently no strong research to assess the likely depth and duration of the WBB phenomenon in many important instances of the capability trap, including social services such as foster care. Such research is urgently needed.

6.1.2 Fixing and Improving a Plane Mid-Flight

In some industrial facilities, the optimal strategy is to shut the entire facility down for complete overhaul. However, this strategy is not always possible. As discussed in the case of the DC Metro, SafeTrack must not only tip the scales in favor of proactive maintenance, but must do so while continuing to serve its riders and the community. We cannot allocate resources away from Flint in order to renew water systems elsewhere. We cannot leave a person to die on the operating table to tend to the primary care of another patient. This obligation is especially pronounced in human systems where lives are at stake, bringing moral obligations into play. There is no such thing as a pause button for emergencies in the foster care system. Escaping the capability trap in such settings always requires injection of extra resources into the system so that investment in capabilities can rise while continuing to serve those in urgent need.

6.2 ESCAPE PLAN

While there are a variety of strategies to use in escaping a capability trap, none comes without confronting some hard realities. Thus, effective communication of not only the problem but also potential paths forward are essential to gaining the support of the actors involved in system operation and resource allocation. Costanza et al. propose one such methodology of communication to help societies escape what they term "societal addictions," another closely related type of trap (2017). Acknowledgment of potential reactive defensive denial or policy resistance is essential to the assembly of escape strategies into a holistic escape plan.

6.2.1 Quick Wins

Because organizations stuck in the capability trap have neglected basic maintenance and process improvement, they often build up a large backlog of low-hanging fruit—simple, quick, and inexpensive actions that could improve system performance. In such cases, the benefit-cost ratio for many actions will be above one (or, equivalently, these actions will have high ROI and NPVs, and short payback times). See Lyneis and Sterman (2016) for examples in the context of facilities maintenance.

Aim for the low hanging fruit first. Sometimes there are investments in capabilities that have a delay time that is short enough that they increase performance during the worse-before-better period, thus mitigating its severity, and freeing up relatively more resources for increased capability investment. The key is the short delay time before capability outcomes can be seen. However, the success of a quick-wins strategy requires that the resources freed up by quick wins must be reinvested in capabilities, not harvested by downsizing. The theory of "small wins" also applies here (Weick, 1984). Especially in the face of financial pressure, small wins can be used to market capability investment to gather more funding, which may then be funneled toward further capability investment.

6.2.2 How to Fix a Leaky Ship

Lyneis and Sterman (2016) offer a leaky ship as an analogy to illuminate the strategies needed to escape the capability trap. The captain and owners seek the fastest voyage, but must also attend to threats such as leaks that threaten to sink the ship. Five actions are needed to save the ship and keep it from sinking (literally) back into the capability trap (Lyneis & Sterman, 2016):

1. To survive we must reassign hands from sailing to bailing.

   Recognize and prepare for Worse-Before-Better.

2. Bailing is not enough. To survive, we must bail faster than water leaks in.

   Investment in capabilities must rise above capability erosion.

3. Bailing faster than water leaks in is not enough. We must also plug leaks faster than they spring, rebuild the hull faster than it ages and decays.

   Performance depends on multiple capabilities. To survive, investments must rise above erosion for all.

4. We must learn to bail, plug leaks and rebuild the hull faster than bailing erodes skill and saps morale.

   Improving the ensemble of capabilities is itself a critical capability.

5. As the need to bail eases, plug more leaks before sailing on.

   Reinvest initial savings in further improvement.

The first is an acknowledgement of the unavoidable worse-before-better dynamic. The second and third recognize the fact that simply responding reactively to performance gaps, even at an increased rate that reduces the backlog of problems, is by itself unsustainable. Ostensibly, that increased pace of working harder is not within the normal operational resources, or else it would already be operating in that manner. Thus, reducing the rate of defect generation is necessary to solve the problem without maintaining an unsustainable level of work effort. Points 3 and 4 recognize that system performance depends on multiple, nested sets of capabilities, and that these interact through multiple feedbacks. Sustainable improvement requires investment in all capabilities, including boosting the quality of metrics, IT systems, and especially the ability of people in the system to enhance their skills in process improvement and learning. For example, digital systems allowing for sharing of educational data between schools and child welfare agencies help schools more effectively manage foster care children as they transition from one system to another (Data Quality Campaign, 2017). This continuity is crucial to mitigating further problems in the already stressed educational development of the child. The fifth emphasizes the ease with which systems can slide back into a trap it is close to escaping. If initial gains are not built upon and used to invest further in the capabilities of a system, problem formation can slowly start to demand the allocation of the newly found operational resources, pulling it back into the trap. Reinvestment of initial gains requires managers, employees, and other stakeholders, including shareholders and taxpayers, to keep their eyes on the prize and resist the pressure to harvest initial gains, including downsizing to cut costs or cut taxes.

6.2.3 Reduce Caseloads by Increasing Capacity

In many of these dynamical systems, performance deteriorates strongly as the service provider caseload rises. In technical systems, this might be a backlog of deferred maintenance, in which more differed projects leads to a reduction in time or effort spent repairing each one. In human service settings such as foster care, hospitals, or prisons, higher caseloads mean fewer child visits, longer emergency room wait times, or fewer resources for rehabilitation. The volume of the stock in question is crucial to the performance and healthy operation of the system. Sometimes, the inflow of stock into a system is exogenous, perhaps due to an isolated policy change or unidirectional trend. In the social systems examined here, however, the performance of the system has a direct and measurable effect on the inflow of people into the system. It is consequently very important to reduce foster care re-entry, hospital re-admittance, and recidivism as much as possible. While zero re-entry rates for these systems is not likely to be achieved, careful attention must be paid to the trade-off between a reduction in performance in the present and the risk of an even greater reduction in performance later. Reducing caseloads by cutting the number of people served is self-defeating: denying foster care, health care, or rehabilitation services to people in need will trigger additional demand as child neglect or abuse, hospitalizations, and recidivism increase. Pushing people out of the system in to reduce caseloads and costs usually increases caseload, the acuity of those cases and costs, worsening the capability trap. Resources to boost staff and their capabilities are needed first. As these investments in capabilities begin to bear fruit, caseloads may decline as the underlying health of the population improves.

6.2.4 Challenge the Clouds

As per the convention in system dynamics notation, ‘clouds’ define exogenous stocks from and into which units from the system under examination flow (J. D. Sterman, 2000). For the stocks of a system, these clouds set the scope of the system to be studied. To ‘challenge’ them is to probe that next stock to see if the dynamics revealed play an important role in the current system.

High-leverage points for sustained improvement may lie outside organizational boundaries and stakeholder mental models of the problem. Hospitals that view patient arrivals as exogenous will focus on throughput and cost reduction, losing the opportunity to reduce treatment need and costs by improving the health of the people they serve. Challenging the boundaries of common mental models may reveal nested capability traps that can be overcome through collaboration across organizations and advocacy groups. ‘Solving’ the inner capability trap, then, may only lead to temporary performance gain unless the outer trap is also escaped. Thus, it becomes imperative that the clouds are challenged to the point where significantly endogenous influences are revealed and foundational capabilities may be targeted.

6.3 CONCLUSION

The capability trap helps explain why so many systems persist in a state of constant and expensive reactivity and poor performance. The appearance of ‘urgent’ matters often dominate resource allocation priorities, and in so doing, lead to the neglect of investments in the capabilities that underlie superior performance. The capability trap has previously been explored and documented primarily in business and technical systems. Here we hypothesize that the capability trap is not only found in mechanical systems, but in social systems and systems in which capabilities consist primarily of human skills, knowledge, relationships and trust. Capability trap dynamics can be found in infrastructure, social services, healthcare, and prison and educational systems. The traps for many of these systems are deep and are often times ingrained into institutional beliefs and work culture. Our goal in describing these examples is to encourage researchers and practitioners to carry out deeper studies that would test the hypotheses offered here. The synthesis of many well-studied links in to complete dynamical systems can help facilitate the exploration of policies that can help managers, policy-makers, workers, and other stakeholders escape from the trap and build high-performing systems that help build a healthy, sustainable, and safe society.

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