APPLICATION OF SOCIAL IMPACT BONDS IN BUILT INFRASTRUCTURE SUSTAINABILITY PROJECTS

A Dissertation

by

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ABSTRACT

This study examines a first look at the implementation of Social Impact Bonds (SIB) for sustainability projects by comparing two cases. The cases are described using System Dynamic (SD) modeling to portray the feedback structures and characteristics of the cases. The comparison consists of two milestones looking at four case descriptors and how the cases align with the criteria outlined by previous research. This provides practitioners with a first look at how a SIB could integrate into built infrastructure sustainability projects.

The study results in six major contributions to practice and research. First, the SIB model is useful for determining the impact different policies have on the system outcomes for a SIB in the Peterborough case. This provides practitioners with a useful means of testing different scenarios for SIB success/ failure. Second, the TAMU case and other sustainability improvement projects for universities make ideal candidates for the use of a SIB structure. Third, the structures required for a SIB (pay for performance, pay from savings, investors, third party assessors, special purpose vehicles, etc.) are already used through ESCOs for sustainability projects. Fourth, the study shows how BIS cases present a preventative intervention, with measureable outcomes that benefit a broad range in society. This shows how BIS cases can extend the definition of "socio-economic" and alter the requirements for government sponsorship. Fifth, the BIS case is able to return practical savings faster, and the social SIB is able to return a greater savings in the long run. Both projects present a preventative intervention through energy saving improvements or social programs. While both projects are able to align the

incentives of program effectiveness, the SIB is also able to align the unit program cost. Finally, a SIB presents a viable opportunity for TAMU project if the funds from the State were not available. This shows researchers how a BIS cases compare with SIB programs and it shows practitioners the similarities of SIB structures to existing BIS cases.

DEDICATION

I dedicate this to my wife, our parents, grandparents and siblings:

Wife: Bernadette Rose-Garcia White

Father: Robert J. White Jr.

Mother: Jane H. White

Father-in-law: Benjamin Garcia

Mother-in-law: Barbra Garcia

Grandparents: Robert J. White Sr.; Marlyn White; James Hanrahan III; Elizabeth Hanrahan; Jose Vallejo Jr.; Antonia Vallejo; Mercedes Garcia; Rosa Garcia

Sisters: Jessica White; Sharon Schoolcraft

Brothers: Jeremiah White; Joshua White; David White

Brother-in-laws: Bradford Garcia; Evan (David) Schoolcraft

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NOMENCLATURE

AMC	Advance Market Commitments
ALDOC	Alabama Department of Corrections
BCR	Benefit Cost Ratio
BIS	Built Infrastructure Sustainability
BM	Behavior Modification
BTL	Bridges to Life
CBA	Cost-Benefit-Analysis
CDM	Clean Development Mechanisms
CGC	Compagnie Générale de Chauffe
CLD	Causal Loop Diagram
CLG	City Leader's Group
DOC	Department of Corrections
DOE	Department of Energy
EPA	Environmental Protection Agency
ESCO	Energy Service Company
FBP	Federal Bureau of Prisons
GhG	Greenhouse Gas
GOP	Grand Old Party
HMP	Her (or His) Majesty's Prison
IE	Investor Earned

IRR	Internal Rate of Return
LTG	Limits to Growth
MBC	Modell Boundary Chart
MOJ	Ministry of Justice
NPV	Net Present Value
NOLFA	Notice of Loan Fund Availability
P3/ PPP	Public Private Partnership
PBB	Performance Based Budgeting
PBR	Payment by Results
PDV	Present Discount Value
PFP	Pay-for-Performance
PMS	Performance Measurement System
PSE	Plan, Specification, Estimate
PSM	Propensity Score Matching
R&D	Research and Development
RFA	Request for Application
SD	System Dynamics
SDM	System Dynamic Modeling
SECO	State Energy Conservation Office
SF	Social Financing
SGT	St. Giles Trust
SIB	Social Impact Bond

SIP	Social Impact Partnership
SPV	Special Purpose Vehicle
TAMU	Texas A&M University
TIF	Tax Incremental Financing
US EPA	(See EPA)
USGBC	U.S. Green Building Council
YF	Young Foundation

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CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

Context: Sustainable Improvement in the Built Infrastructure

The intent of this study is to compare the characteristics, structure and results of a sustainability project and a project using a Social Impact Bond (SIB), so that researchers and practitioners may have better insight into the application of a SIB in sustainability projects. Facility owners and managers need innovative financial tools and strategies to provide more funding option to improve the sustainability of built infrastructure. Sustainable improvement has attracted a lot of attention because of the beneficial externalities that are provided such as, improved air quality (Kats 2010). Some sustainable improvements are underfunded because of these externalities, such as solar panels, while others are underfunded because of decision maker influences. Therefore, finding creative investment tools will aid facility owners and managers in pursuing sustainable improvements.

Sustainability improvement has become a key issue for the built infrastructure over the last decade. The built infrastructure is one way people influence the environment, such as roads, bridges, hospitals, churches and grocery stores (Kats 2010). The US Environmental Protection Agency (EPA) defines sustainability as the conditions which allow humans and nature to exist in productive harmony for social, economic and other requirements of present and future generations (US EPA n.d.). In 2009 President Barak Obama issued executive order 13514 requiring federal agencies to reduce building energy consumption (Obama 2009). Sustainable improvement or "green construction" in the built infrastructure is the improvement of systems and structures in the built environment to reduce consumption, improve environmental quality, and account for operational costs (Kibert 2008, Kats 2010). The benefits of sustainability continue to attract the attention of both public and private organizations. This illustrates the importance of sustainability for the built infrastructure.

Sustainable improvement in the built infrastructure is a public good and service. Public goods and services are nonexclusive and non-rival. A common example of a public good or service is a streetlight, because the light cannot be excluded from some people seeing the area it illuminates and is not hindered by multiple users. Similarly for built infrastructure sustainability, energy costs have increased in conjunction with population demand (Kats 2010). Sustainable improvements that reduce energy consumption and greenhouse gas (GhG) emissions improve energy markets and the air quality for the region (Kibert 2008, Gruber 2011, Daly and Farley 2011). This supports the idea that sustainable improvements in built infrastructure have similar issues as public goods and services because sustainability projects have benefits that are non-rival and nonexclusive.

Public goods and services tend to be underfunded. Since public goods and services are non-rival and nonexclusive they have issues, like free-riders, that stem from externalities (Gruber 2011). The free rider issue occurs when the provisions of some contributors meet the requirements of non-contributors, and the non-contributors exact the benefits of the service without the costs (Gruber 2011, Daly and Farley 2011). This supports the idea that sustainable improvement in built infrastructure suffers from funding issues in that the benefits are shared beyond the investors.

Public goods and services use well defined property rights to create market opportunities for proper funding. The Coase theorem states that well defined property rights can resolve externality issues (Gruber 2011, Daly and Farley 2011). For example, one of the by-products of industrial production is waste that may be diluted into rivers and lakes. If the waste reduces the amount of fish that can be pulled from the river, then the manufactured price of the waste should include the cost of the fish population reduction. Coase theorem defines the fish population as a property that if damaged or destroyed would require compensation. Pigouvian taxes or subsidies are a solution that uses the Coase theorem to account for private externalities that organizations create when private goods or services are joined with public sector affairs (Gruber 2011, Daly and Farley 2011). Therefore, quantifying the goods and services that result in externalities is an important issue that sustainable built infrastructure programs must address in order to identify beneficiaries.

In built infrastructure, utility consumption can be defined as a property right. Organizations that can reduce their utility consumption are able to spend their savings on paying off the investment in projects or by reinvesting in more sustainability projects (Van Der Like & Meehan, 2009; Kim, Hessami, Faghihi, & Ford, 2012). If an organization does not want to invest in sustainability options, then that organization could instead set up a performance based contract, or a pay from savings contract (Steinberger, van Niel, & Bourg, 2009). So like property rights, the consumption of utilities can be bought or sold among competing interests. This illustrates how organizations use well defined performance measures for energy consumption and costs that allow for sustainable projects to be considered based on financial qualities over the altruism of the projects' natures.

However, even with well-defined performance measures, a sustainability project can still be underfunded due to risk and competition for funds. Risk adversely affects a project's cause when competing for funding with other projects (Bowman, 1980). As the risks increase for a project—assuming that rewards are held constant for project success—companies are more likely to avoid funding the riskier project and pass off on the potential benefits (Bowman, 1980). Therefore, organizations are more likely to enact the projects that return the greatest perceived benefits.

Some organizations lack the ability to hedge sustainable infrastructure projects. Large organizations, such as universities and the retail industry, have significant investments that benefit from sustainable construction and innovation (Kibert, 2008; Kats, 2010). Some of the impact of the risk in sustainable investment for these organizations is lost in economies of scale (Business Case Studies LLP, 2013); however, smaller organizations may see the risk of failure as greater than the benefits of success. If organizations see risk in sustainable built infrastructure programs, then they would alter the values of benefits and costs based on the perceived risk (Trigeorgis, 1996). These would explain the overestimation found in Greg Kats book "Greening our Built World," where a survey of professionals estimated 17% cost increase and a survey of projects found 2% (2010). Therefore, sustainable projects have issues with funding from the beneficiary when the beneficiary lacks the knowledge and data to properly assess their benefits and costs.

There are four types of risk that an organization must consider for a new project: execution risk, measurement risk, performance risk, and the risk of unintended consequences. Execution risk is the risk of a project not performing similar to the tests. Measurement risk is the risk that measurements are fair and equal to all stakeholders. Performance risk is the risk of the project showing actual performance. Unintended consequences are the risk of an externality resulting from the project. These four types of risk illustrate the risk considerations for project decision making.

A guarantee eliminates execution risk and performance risk from the owner agency in exchange for a share of the savings. Energy service companies (ESCOs) were brought to the U.S. in the late 1970s by Scallop Thermal, a division of Royal Dutch Shell as a formal structure, but the original idea came from a guarantee that Compagnie Générale de Chauffe (CGC) had been offering for almost 100 years prior (Hansen, Langlois, & Bertoldi, 2009). ESCOs offer a plan for sustainable improvement in built infrastructure and then either guarantee or fund the improvements for a portion of the savings (Vine, 2005; Hansen, Langlois, & Bertoldi, 2009). Therefore ESCOs provides a risk solution to the underfunding of sustainability projects.

How can ESCOs fund all the needed sustainability projects for the built infrastructure? When the price of energy is high, ESCO's are extremely profitable; however low energy prices marginalize the profitability of sustainable improvements and extend the payback period for borrowed capital (Vine, 2005; Hansen, Langlois, &

Bertoldi, 2009). As a result the number of ESCOs that use pay from savings has declined (Hansen, Langlois, & Bertoldi, 2009). ESCOs still struggle with adverse cultures to project finance and substantial market opportunities (Vine, 2005). Therefore, organizations, including ESCOs need additional financial strategies to fund sustainability projects.

What creative financial solutions could provide funding for sustainability projects in the built infrastructure when the owner does not want to pay for the improvements? Who else besides ESCOs can initiate funds for a sustainability project? What drives the success and failure of sustainability projects? How can these strategies be studied before one is implemented? These are the questions that practitioners need answered when considering the use of an ESCO for new sustainability projects. Therefore, some practitioners lack the necessary knowledge and/or data to properly assess the value of sustainable improvement for their organization.

Motivation for Research: Issues with Funding

Facility owners and managers use inappropriate knowledge and data to assess the profitability of a sustainability project. Decision makers consider two dominate strategies for investment selection, the net present value (NPV) and the benefit cost ratio (BCR) (Trigeorgis, 1996; Kim, Hessami, Faghihi, & Ford, 2012). These strategies are used to target specific issues and concerns of the owner. An NPV, also referred to as a present discount value (PDV), assessment will determine the worth of a project to the owner (Trigeorgis, 1996). For sustainable improvements in built infrastructure, this assessment depends on energy costs and its fluctuations (Vine, 2005; Hansen, Langlois,

& Bertoldi, 2009). However, improper methods of substitution and comparison may inflate costs and reduce the NPV (Kibert, 2008). Sustainability projects are likely to have long payback periods and require a substantial initial investment (Hansen, Langlois, & Bertoldi, 2009). Therefore, facility owners and managers need to understand the fluctuation of utility costs and the methods for conducting an accurate NPV assessment. When owners use a BCR assessment, also referred to as a cost benefit analysis (CBA), the options with the greatest return for the initial investment amount are chosen (Trigeorgis, 1996). Increasing the initial investment or reducing the returns of a project reduces its BCR. If owners are over estimating the cost of sustainability projects as Kats suggests, then sustainability projects are less likely to receive funding (2010). This illustrates the issue facility owners and managers have with funding sustainability projects. Therefore, facility owners and managers need the appropriate knowledge and data to properly assess the value of sustainable built infrastructure projects.

Problem Statement: Beneficial Financial Structures

Organizations will overestimate the cost of sustainability programs, under estimate the benefits of sustainability programs or apply some combination of both in their decision making process. When organizations alter the projections of benefits or costs, such as deflation rates, they are adding a factor of safety to the system. Factors of safety are used by engineers to safe guard against failure in system unknowns (Ullman, 1992). Companies will use the interest charged on a loan as the value of borrowing money including the cost of default (Pearce & Warford, 1993); however, the cost of energy saved from these improvements may go unclaimed. Organizations without sustainable expertise need the knowledge and data to properly spend funds to improve the sustainability of their built infrastructure (Kaplan & Norton, 1996). This illustrates the relationship between knowledge and overestimation of costs for sustainability projects that result in sustainability projects being terminated by organizations during the preliminary phase.

ESCOs provide expertise in developing, installing, and financing comprehensive performance based energy efficient or load reducing projects to their clientele. The Siemens Corporation is an example of an ESCO and the Texas A&M University (TAMU), is an example of a client. TAMU and Siemens have entered into an agreement for Siemens to guarantee savings from sustainable improvement up to the value of a loan with interest (Kim, Hessami, Faghihi, & Ford, 2012). In this relationship, the ESCO prescribes and enacts various sustainable built infrastructure projects with the owner's funds (Kim, Hessami, Faghihi, & Ford, 2012). TAMU and other public schools are able to borrow the needed funds from the state of Texas at a 2% interest rate (Kim, Hessami, Faghihi, & Ford, 2012; Combs, 2013). This supports the idea that the involvement of an ESCO can shift risk from sustainable projects that the owner is willing to invest.

The problem that practitioners run into is thinking that the utility savings cannot be reinvested and the savings need to cover the repayment. What if the benefits from the investment are not steady or consistent? What funding structure for built infrastructure sustainability improvement can allocate risk and reward to protect owners and attract capital investors?

The dynamic nature of the problem appears at first to be an issue of limit to growth as shown below. "Limits-to-growth" (LTG) is a system archetype (Senge, 1990; Braun, 2002). System archetypes are repeated system behaviors found across different industries. Sustainable improvements are an example of an LTG because the improvements are reducing the utility costs under the assumption that the organization does not want to become a major producer. As shown in Figure 1 below, the savings are limited by the availability and effectiveness of the programs. The savings creates a fund for sustainability programs that have not been implemented. As funds are invested, an organization's program options and ability to change is reduced leaving fewer options to invest, similar to the investment and option constraint seen in construction. This is an example of an organization allowing their utility savings to compound, only hindered by the performance of the sustainable options as shown in Figure 1.

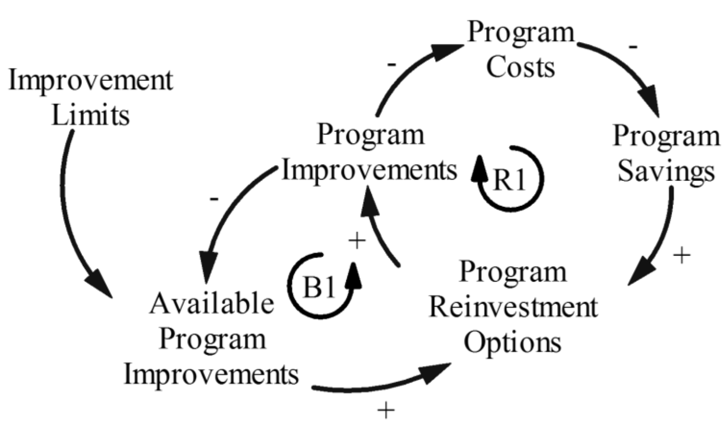

Figure 1: Basic Sustainability LTG Structure

<u>Legend of Loops: Figure 1</u>

R1: Sustainable Program Reinvestment- Program improvements reduce costs which increase the savings of the program and increase the amount that can be reinvested into additional programs.

B1: Limits to Available Program Improvements- The more programs invested in the fewer programs left for investment.

However, the problem that practitioners face is not a traditional LTG issue. Even though LTG is a common issue, practitioners cannot just focus on the limits of the sustainable improvement (Senge, 1990; Braun, 2002) because of the loan. The traditional LTG does not account for multiple impacts constraining the reinforcing structure (Braun, 2002). Under the presumption of the traditional LTG for built infrastructure, the savings exist for the sole purpose of funding more options, the problem that practitioners face should include a tradeoff or constraint for LTG systems dealing with savings. This explains why the traditional LTG archetype ignores an important factor in managing the financing of the reinforcing structure.

This study will take a new look at the LTG system archetype, from the perspective of sustainable finance, to better understand how built infrastructure managers and owners can subvert the risk of financing. The issue that practitioners face in funding sustainability programs is an inflated perception of costs (Kats, 2010). The problem that practitioners face is that the inflated perception of costs may prevent projects from being pursued. This can be represented by the alternative CLD found in Figure 2 below. Therefore, this study will internalize a feedback structure viewed as an externality to test a potential solution for facility managers and owners that alters their value of risk and reward.

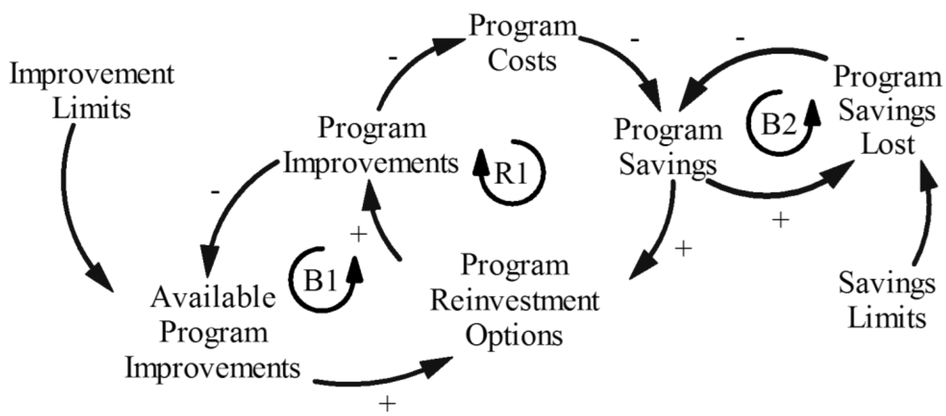

Figure 2: Additionally Constrained Sustainability LTG Structure

<u>Legend of Loops:</u> Figure 2

R1: Sustainable Program Reinvestment- Program improvements reduce costs which increase the savings of the program and increase the amount that can be reinvested into additional programs.

B1: Limits to Available Program Improvements- The more programs invested in the fewer programs left for investment.

B2: Recapturing of Savings-Increasing program savings causes an increase in the recaptured savings

CHAPTER II

HYPOTHESIS: SOCIAL IMPACT BONDS FOR BUILT INFRASTRUCTURE

The Social Impact Bond (SIB) financial structure can balance risk and reward for sustainable improvement projects in built infrastructure**.** SIBs are different from traditional bonds (Fox & Albertson, 2011). SIBs are a new financial tool that combines multiple social funding ideas to encourage private funding for social equality (Loder, Mulgan, Reeder, & Shelupanov, 2010). SIBs divert risk from the owner to the investors by using performance based contracts when public funds would only be available if budget cuts could be achieved elsewhere (Strickland, 2010; Loder, Mulgan, Reeder, & Shelupanov, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011). SIBs are a financial structure that protects the owner from some of the risk and provides substantial returns to attract long term investors.

Background: Ideas Surrounding SIBs

SIBs are a new form of financing for public agencies. The term SIB was first coined in 2008 by the Young Foundation (YF) with Social Finance (SF) and City Leader's Group (CLG) (Loder, Mulgan, Reeder, & Shelupanov, 2010). The conglomerate developed SIBs in response to the increasing demand for research and development (R&D) of social issues (Loder, Mulgan, Reeder, & Shelupanov, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011). SIBs differ from traditional low risk, low reward bonds in that with a SIB the owner entity—typically a government or public agency—attempts to remove their financial risk of paying for a program before the performance measures are realized (Loder, Mulgan, Reeder, & Shelupanov, 2010). Governments offer a share of the reward to the private sector markets in exchange for the risk of what potentially may be a capital intensive, government improvement program (Hutton, 2011; Mulgan, Reeder, Aylott, & Bo'sher, 2011). In the fall of 2010, the first SIB was enacted by the Ministry of Justice (MOJ) at Her Majesty's Prison (HMP) Peterborough (Strickland, 2010). In the summer of 2011, lessons learned about the establishment of the Peterborough SIB were released (Disley, Rubin, Scraggs, Burrowes, & Culley, 2011). By the spring of 2012, the methodology for the comparison of the Peterborough SIB was developed and published with an anticipation of the first cohort's results to be reported around 2014 (Cave, Williams, Jolliffe, & Hedderman, 2012). This illustrates the need for testing to develop knowledge of application and expectancy for SIBs.

SIBs combine different social investment methods to create a more holistic approach to social issues. The SIB financing combines ideas from four different investment methods for social benefits: direct commissioning for outcomes, Advance Market Commitments (AMCs), Tax Increment Financing (TIF), and Clean Development Mechanisms (CDM) (Loder, Mulgan, Reeder, & Shelupanov, 2010). Direct commissioning for outcomes is a pay for performance contract (Fox & Albertson, 2011). SIBs use direct commissioning to reduce risk from the owner (Mulgan, Reeder, Aylott, & Bo'sher, 2011). AMCs are payment guarantees to encourage R&D (Tetteh, 2012). SIBs use AMCs to encourage R&D for social issues (Mulgan, Reeder, Aylott, & Bo'sher, 2011). TIFs use extra tax revenues generated from projects as repayments

(Davis, 1989). SIBs may use TIF strategies to capture added benefits of a project through increased government revenue (Mulgan, Reeder, Aylott, & Bo'sher, 2011). CDMs are tradable commodities for carbon emissions and GhG markets that allow companies to capture and trade the savings from air quality permits (Lee, Park, Kim, Kim, & Kim, 2013). SIBs use the same concept to target organizations' budgets, so that a public agency that reduces their costs can capture the budget savings (Mulgan, Reeder, Aylott, & Bo'sher, 2011). These four forms have been used for community development, improving health care systems, sustainable improvement, and controlling infectious diseases (Davis, 1989; Tetteh, 2012; Conceicao & McCarthy, 2011; Lee, Park, Kim, Kim, & Kim, 2013). This illustrates the broad use of applications leading to the development of SIBs.

SIBs are higher risk bonds with long pay off periods. If the program is unsuccessful in providing savings to the owner, then the owner is not obligated to pay for the bond (Loder, Mulgan, Reeder, & Shelupanov, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011). Performance is measured by outcomes instead of inputs (Fox & Albertson, 2011). In the case of a prison SIB, the reduction of recidivism, or the reconviction rate, determines whether the investors receive repayment (Fox & Albertson, 2011; Glahn & Whistler, 2011). Since the outcomes take time to measure payments are unlikely to form a steady, predictable pattern in the short run (Hatry, 2006; Loder, Mulgan, Reeder, & Shelupanov, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011; Glahn & Whistler, 2011). For example, in the prison SIB case (described later) investors must wait till a significant number of offenders have been released from the system with ample opportunity for reconviction (Fox & Albertson, 2011; Disley, Rubin, Scraggs, Burrowes, & Culley, 2011; Cave, Williams, Jolliffe, & Hedderman, 2012). In one prison case, significant offenders is 1000 offenders and ample opportunity is a year after the final offender's release with a minimum of six months for systems to update the status of offenders (Cave, Williams, Jolliffe, & Hedderman, 2012). Therefore, SIBs are a high risk, long term bond that does not receive predictable returns.

SIBs provide an innovative form of financing social improvements for public goods and services where the owner is not required to fund the projects. SIBs address two major issues of funding for public goods and services: underfunding and ineffective funding (Strickland, 2010). Public goods and services tend to be underfunded because they are non-rival and non-exclusive (Gruber, 2011; Daly & Farley, 2011). Furthermore, when funds are spent on public goods and services they are expected to deliver outcomes as a result of those services (Moynihan, 2008). The built in performance contract in a SIB provides a guarantee to the owner that either the project will succeed or the owner will not be held liable for payment (Loder, Mulgan, Reeder, & Shelupanov, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011). The payment by results (PBR) contract enables the use of SIBs in performance based budgeting (PBB), a tool used by governments to determine how to spend money (Wholey, 1999; Moynihan, 2008). These contracts transfer the risk associated with implementing or rolling out an intervention targeting a system's efficiency from the owner agency to the investors (Loder, Mulgan, Reeder, & Shelupanov, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011). The risk of intervention or innovation may require substantial resources as the previous system becomes obsolete (Henderson & Clark, 1990). PBR contracts differ from traditional Plan, Specify and Estimate (PSE) contracts, because the private entity is no longer following the prescription of the problem but instead is given a schedule of desired outcomes and related compensation (Evelhoch, Michelsen, Mitchell, Pomponio, & Webb, 2000). SIBs require no commitment of capital by the owner agency until the program outcomes have been analyzed and result in cost savings (Loder, Mulgan, Reeder, & Shelupanov, 2010; Strickland, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011). Normally, pay-for-performance contracts carry a taboo of controversy for public and nonprofit industry because of flawed performance criteria (Hatry, 2006). However, governments can reduce waste on failed models and studies by connecting the monetary savings of a comprehensive performance measurement system (PMS)—as defined (Hatry, 2006)—with a pay-for-performance (PFP) contract that sells the capital exposure, associated with research and development or implementation for public policy and practice, to private investors (Fox & Albertson, 2011). With the right performance measures, that include monetary savings to implement a pay-from-savings SIB, the cost of government can decrease by improving their performance (Mulgan, Reeder, Aylott, & Bo'sher, 2011; Loder, Mulgan, Reeder, & Shelupanov, 2010). This supports the idea that SIBs could establish a market for R&D opportunities on social issues.

The Young Foundation specifies seven criteria a project must have to be considered eligible for a SIB regarding the: prevention, improvement, evidence, measurable, incentives, savings, and preferences. Table 1 below lists the criteria with their descriptions.

Table 1: Seven Criteria for a SIB (after Mulgan et al. 2011)

	Criteria	Description
1	Preventative intervention	The intervention is preventive in nature and sufficient funding for the intervention is currently unavailable
2	Improves wellbeing in an area of high social need	The intervention improves social wellbeing and prevents or ameliorates a poor outcome
3	Evidence of efficacy	The intervention is supported by evidence of its efficacy and impact, giving funders confidence in the scheme's likely success
4	Measureable impact	Whether it is possible to measure the impact of the intervention accurately enough to give all parties confidence of the intervention's effect, including a sufficiently large sample size, appropriate timescales and impacts that closely related to the savings and relatively easy to measure
5	Aligns incentives	A specific government stakeholder achieves savings or lower costs as a result of actions undertaken by others. These savings need to be cash releasing and provide an actual saving to government stakeholders
6	Savings greater than costs	The savings for the specific government stakeholder are relatively immediate and much greater than the cost of the intervention and transaction costs. This provides investors with enough return to absorb the risks inherent in the scheme, and can provide significant funds for social investment
7	Government preference for a SIB	Government policy for the specific agenda is keen on or at least open to the use of a SIB

Joining Public and Private

Public Private Partnerships (P3) are a form of cooperative agreement between public agencies and private organizations. P3s are meant to establish a shared role in power between the public government and private firm(s), such as tax exemptions for services to improve housing (Miraftab, 2004; Brinkerhoff & Brinkerhoff, 2011). Toll roads are often portrayed as the exemplar of P3s (Brinkerhoff & Brinkerhoff, 2011). P3s have been largely successful as toll roads in alleviating issues of public funding for roadway systems around the world (Damnjanovic, Duthie, & Waller, 2008). Increases in roadway demand causes traffic. Increased traffic causes people to spend more time commuting. Increased commute time may causes people to increase the value of their time which would create a market opportunity for someone to provide a non-congested means of travel. State roadway agencies have rented out tolling rights to private organizations who are willing to finance and operate these non-congested roadways (Poole & Samuel, 2006). However, not all social funding issues present an opportunity for a market between levels of service. In instances where government agencies are moving public services off book, the use of P3s for social services either reduces the demand, or increases the revenues through a fee, but the quality of services rarely improve (Motenko, et al., 1995; Osborne & Hutchinson, 2004). The issues with P3s arise when services are only delivered to those willing and able to pay the additional fees on top of normal levels of taxation (Motenko, et al., 1995; Osborne & Hutchinson, 2004). This explains the lack of private funding in social issues where markets could exist.

SIBs are like P3s with two distinctions from a traditional P3 focusing on social issues: the performance contract and new scope for the public agency. Since SIBs are used in R&D for social issues, they fit what Derick Brinkerhoff and Jennifer Brinker term as a "Capacity Building" P3 (2011). SIBs widen the scope of public agencies by targeting funds in areas where public funding is non-existent or underfunded (Loder, Mulgan, Reeder, & Shelupanov, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011). For example, the government does not provide loan assistance for released offenders, but a prison SIB may (Disley, Rubin, Scraggs, Burrowes, & Culley, 2011). SIBs are an improvement for traditional social P3s. Governments exist to ensure equality and fairness instead of efficiency and effectiveness; this differs from a traditional P3 structure in that a SIB is not replacing a government organization (Miraftab, 2004; Gruber, Public Finance and Public Policy, 2011; Strickland, 2010). SIBs use private funding to deliver public goods; however, the cost of the programs are funded by the savings they provide (Loder, Mulgan, Reeder, & Shelupanov, 2010; Strickland, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011). With a SIB, the private entities are only paid from public funds when success has been measured and public costs have been reduced (Cave, Williams, Jolliffe, & Hedderman, 2012). This explains why SIBs would function as an emerging P3 where traditional social P3s would fail.

Roles of Participants in an SIB

SIBs require five key stakeholder groups: owners, investors, consultants/ contractors, third party assessors, and the target population. The owner(s) represents the benefiting organization(s) that would receive a portion of the savings if the program is successful (Loder, Mulgan, Reeder, & Shelupanov, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011; Glahn & Whistler, 2011). The investors are the group funding the project under the guarantee of payment when the program is successful (Fox & Albertson, 2011; Cave, Williams, Jolliffe, & Hedderman, 2012). The consultants/ contractors are the service providers implementing the programs for the investors (Loder, Mulgan, Reeder, & Shelupanov, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011; Glahn & Whistler, 2011). The third party assessors analyze the data to determine the success or failure of the project along with the payment value (Glahn & Whistler, 2011; Cave, Williams, Jolliffe, & Hedderman, 2012). The target population is the socio-economic disadvantaged group whose behavior is modified by the program (Loder, Mulgan, Reeder, & Shelupanov, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011). This illustrates the functions of different SIB stakeholders.

The owner and investor stakeholders are the most critical stakeholders. If the owner goes unidentified, then there are no returns for the investors. If there are no returns for the investors, then there are no funds for the program. Without any of the stakeholders the program cannot exist, but without these two stakeholders the SIB cannot exist.

Owner Application of SIB for Sustainability Programs

Owners may benefit from a sustainability SIB by reducing their operating costs and improving their work environment by gaining access to capital for sustainability improvement projects. Owners may be adverse to the risks of trying certain sustainability projects and as a result will not implement them. A SIB would allow experts, who have a better grasp of the risks, to have oversight of the implementation process (Loder, Mulgan, Reeder, & Shelupanov, 2010; Brinkerhoff & Brinkerhoff, 2011). Meanwhile, the owner has no additional out-of-pocket expenses, similar to some ESCOs (Strickland, 2010; Vine, 2005; Hansen, Langlois, & Bertoldi, 2009). As the benefits of the implemented program increase, the owner's operating costs should decrease (Loder, Mulgan, Reeder, & Shelupanov, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011). These savings would collect into an account that would share the savings with the investors (Loder, Mulgan, Reeder, & Shelupanov, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011). This illustrates how the owner can receive a return from the sustainability projects without being exposed to the risks.

Investor Application of SIB for Sustainability Programs

Investors may benefit from a sustainability SIB by capitalizing on a share of the long term cost savings from the programs implemented. A SIB is long term investment (Disley, Rubin, Scraggs, Burrowes, & Culley, 2011). Even though energy has a sporadic history of increasing and decreasing costs (Ghosal, 2000), the price of energy has generally increased since the 1970s. Since the savings from sustainability programs are tied with the utility costs, the value of a sustainability SIB will increase with the utility markets over time. As the benefits of the implemented program increase, the investors' returns may also increase (Loder, Mulgan, Reeder, & Shelupanov, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011). Therefore, investors can find monetary compensation for both risk and reward of sustainability projects.

Application of an SIB

A Prison System Proof of Concept

One of the founding cases that inspired SIBs comes from the relationship between prison system programs and their funds. The recidivism of a prison system starts with the design of the prisons and extends into the programs implemented in their system (Hood, 2013). In recent years, the “Tough on Crime” stance has begun to wane from politics as evidence of practice reveals increases in prison populations (King Jr., 2013). Prisons are more likely to see increases in recidivism when under financial constraint (King Jr., 2013; Hood, 2013). This reinforcing structure is checked by the funding of the prison system and a limits-to-growth (Senge, 1990; Moynihan, 2008). Figure 3 below illustrates the reinforcing structure of a prison system that can lead to either an increase or a decrease in the prison population.

The issues in funding rehabilitation programs in a prison system fit the seven criteria for a SIB—listed later in the table found on page 90. Funding rehabilitation programs could resolve the overcrowding issues in prisons (Glahn & Whistler, 2011). Short term offenders incarcerated for theft or other non-violent offences are unlikely able to self-fund these interventions (Loder, Mulgan, Reeder, & Shelupanov, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011). Groups like St. Giles Trust (SGT), Bridges to Life (BTL) and others have had substantial success when properly funded (Loder, Mulgan, Reeder, & Shelupanov, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011; Bridges-to-Life(BTL), 2011; Mayfield-Greiger & Rudnicki, 2007). The savings can be measured as the reduction of recidivism or reconvictions (Mulgan, Reeder, Aylott, & Bo'sher, 2011; Cave, Williams, Jolliffe, & Hedderman, 2012). The performance contract then establishes the reduction of recidivism to be equal or greater to the value paid for success (Cave, Williams, Jolliffe, & Hedderman, 2012). This incentivizes the investors to improve the quality of service in order to guarantee their returns (Loder, Mulgan, Reeder, & Shelupanov, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011). This illustrates the requirements for a prison system to establish a SIB.

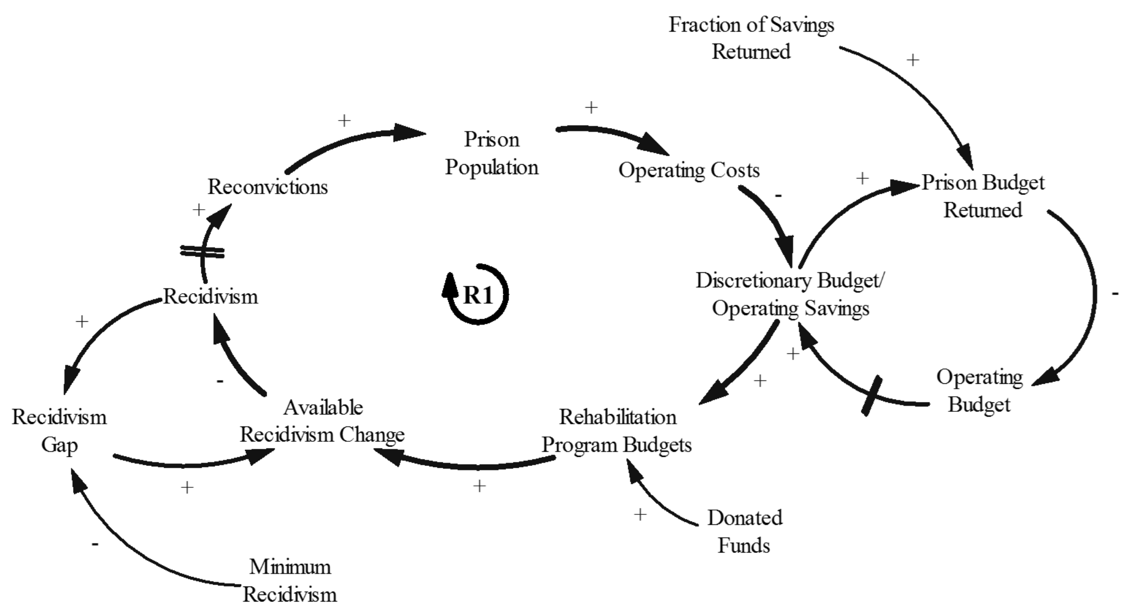

Figure 3: Basic Prison Casual Loop Diagram

__Legend of Loops: Figure 3__

R1- Paid-from-Success Rehabilitation loop: Prison budget funds program which reduces population and generates savings which are used to pay for the program.

B1- Limits to Improvement loop: Decreased recidivism reduces improvement available, which limits the amount of future recidivism reduction.

B2- External Constraint loop: Increases in budget surplus trigger increases in the returned budget from the prison, which limits the amount of future Operating Budgets.

Her Majesty's Prison (HMP) Peterborough

The first SIB implemented, Her Majesty's Prison (HMP) Peterborough prison SIB, was implemented as a proof of concept that a SIB could provide positive returns for the investors and owners. The six-year SIB funds are designed to reduce the recidivism of released short term offenders from the HMP Peterborough by funding intervention programs—criteria 1 from Table 1 (Strickland, 2010; Disley, Rubin, Scraggs, Burrowes, & Culley, 2011; Cave, Williams, Jolliffe, & Hedderman, 2012). Short term offenders are young and commit non-violent offences; however, after their first conviction they are unemployed and homeless—criteria 2 of Table 1 (Mulgan, Reeder, Aylott, & Bo'sher, 2011; Cave, Williams, Jolliffe, & Hedderman, 2012). The program is operated by NGOs that consist of organizations with proven track records but insufficient funds to operate on a scale as large as the Peterborough system—criteria 3 of Table 1 (Loder, Mulgan, Reeder, & Shelupanov, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011). The Ministry of Justice (MOJ), the governing agency for prisons in the U.K., expects savings from the reductions in the number of arrests, convictions, and prison terms.

The Peterborough SIB investors provided £5 million across a maximum period of six years through a special purpose vehicle (SPV) to fund the non-government organizations (NGO) (Strickland, 2010)**.** To measure performance the Peterborough SIB has two groups with four cohorts of first-time released offenders (Cave, Williams, Jolliffe, & Hedderman, 2012). In the Peterborough group, the first three cohorts consist of up to 1000 first time offenders each (Cave, Williams, Jolliffe, & Hedderman, 2012). The fourth cohort is the articulation of the first three cohorts (Cave, Williams, Jolliffe, & Hedderman, 2012). The second group is a comparison group made up of statistically similar offenders—as determined by the third party assessor—of a value equaling about 10 times that of the Peterborough group—criteria 4 of Table 1 (Cave, Williams, Jolliffe, & Hedderman, 2012). The investors may receive a greater return on their investment by further reducing recidivism—criteria 5 of Table 1 (Cave, Williams, Jolliffe, & Hedderman, 2012). If the program reduces recidivism between the Peterborough and comparison group by 10% for any of the first three cohorts or 7.5% for the fourth cohort, then the MOJ will pay a portion of the savings to the investors—criteria 6 of Table 1 (Strickland, 2010). This illustrates the first active SIB used by the MOJ to fund a program that may reduce their budget—criteria 7 of Table 1.

The Peterborough SIB potentially addresses at least two major challenges for rehabilitation programs: adequacy of resources and aggressiveness of the implementation schedule (Loder, Mulgan, Reeder, & Shelupanov, 2010). Government agencies, like Alabama Department of Corrections (ALDOC), are looking for ways to reduce prison expenses (Moynihan, 2008). The BTL rehabilitation program in Texas is an example of how successful a program can be if these two challenges are addressed (Mayfield-Greiger & Rudnicki, 2007; Bridges-to-Life(BTL), 2011). A SIB addresses resource allocation by incentivizing investors to provide adequate funds for success. A

SIB addresses challenges with the implementation schedule by structuring oversight from the investors, who will seek to roll out the program for the maximum profitability.

Relationship between Social and Sustainable Issues

Sustainability issues struggle with funds because, like social issues, there are a lot of public benefits associated in sustainable programs and a lack of trust in estimates. As individual projects, sustainability projects have very little effect on the rest of the developed world; however, as the number of projects grow those effects are amplified (Kibert, 2008). Just as a prison system may rely on the altruistic donations by a few, built infrastructure hopes for enough of an investment in sustainability to keep demand down. Furthermore, estimates for costs have not improved in roadway construction over the last half century (Flyvberg, Holm, & Buhl, 2002). This explains why sustainability and social issues may struggle financially.

This study seeks to identify how, and how well, a SIB could work for sustainability projects in the built infrastructure. Sustainability is a social issue (Kibert, 2008; Kats, 2010). The founding of SIBs uses an idea from sustainable development (Lee, Park, Kim, Kim, & Kim, 2013). Sustainable improvements are a preventative intervention, but some owners may not have the capital or may be unwilling to risk the capital they have access to on sustainable improvements (criteria 1). Improvements are going to be more beneficial for projects with the greatest need for sustainability (criteria 2). The projects would only use tools and methods with proven success (criteria 3). The impact of the project can be measured by the reduction of energy (criteria 4). The investor and owner are incentivized to reduce energy consumption (criteria 5). The only projects that would make it to fruition are the projects where the savings are greater than the costs and the owner agency is open to a sustainable SIB (criteria 6 and 7).

Therefore:

> H1: The structure of a SIB can be applied to the financing of a sustainability improvement project for built infrastructure.
>
> Hypothesis: A SIB financial structure could be used just as effectively as a guarantee to fund sustainability projects when funds do not exist or are unavailable by the owner agency.

CHAPTER III

RESEARCH METHODOLOGY

Three components are needed to test how a SIB can impact the risk/reward in a built infrastructure sustainability improvement project. First, a case study of both a SIB and a sustainable improvement project must exist, because the case studies provide a means of examining the structures and effects of the financial structure. Second, the cases must be structurally comparable, because comparability of structure provides a form of face validation that explains the differences in results. Third, there must be results from the cases that can be measured and compared, because the results indicate the outcomes of the financial tools. If the examples are comparable and the results available, then the differences in results may support the hypothesis. This illustrates the required scope for the study.

Modeling a case study provides a greater opportunity to study the system components than just an analysis of the case results. Formal models provide detailed descriptions of system structures (Martinez-Moyano, 2012). These detailed models may be generalized for comparison with other models. When different systems have common behavior, they are sometimes classified into a system archetype. These archetypes outline the controlling structure that organizations and decision makers use in altering program performance. System archetypes are identified by both their feedback loops and their delays (Senge, 1990). Feedback loops are classified as either balancing or reinforcing (Sterman, 2000; Senge, 1990). A balancing loop keeps a system focused on a target value, similar to a pendulum trying to swing toward the center of an arc. A reinforcing loop causes continuous escalation and can be classified as either virtuous or vicious (Senge, 1990). A virtuous reinforcing loop grows continuously out of control toward a positive resultant. For example, an investment account, left alone with a high interest rate, will continue to amass fortune—seen in Figure 4. Conversely, a vicious reinforcing loop grows out of control toward a negative resultant—seen in Figure 4. For example, a loan, left unpaid with a high interest rate, will continue to amass debt. Varying delays and combinations of these structures comprise the various known system archetypes. This explains how systems can be compared across different industries by using common structures.

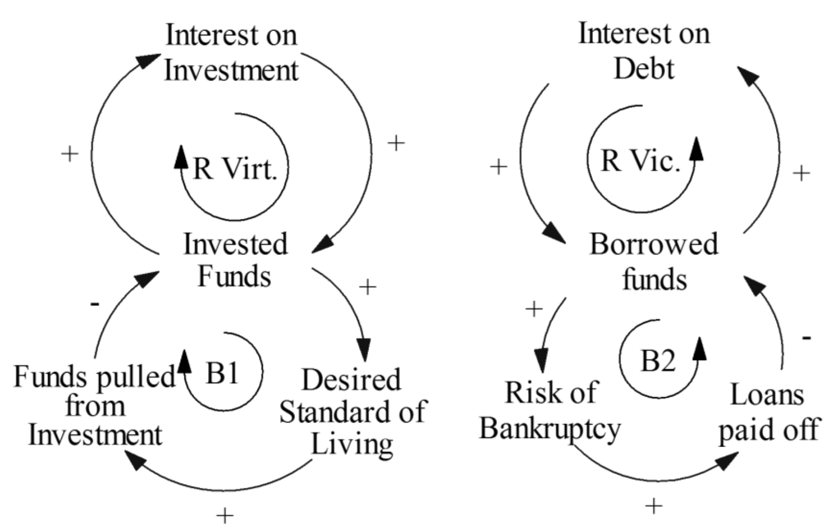

Figure 4: Virtuous and Vicious Reinforcing Loops in a "Limits to Growth" System Archetype

A SIB and a sustainable built infrastructure project with similar structures can be compared for similarities and differences in key stakeholders and policy actions using generalized performance measures. The common traits between models of the two systems can be used as performance criteria and the differences can be used as descriptors for changes in the results. For example, both models will use a means of measuring program performance. If both models use reductive measures, then both program structures will represent a LTG. Conversely, prisoner reconvictions cannot go below zero, but if energy use goes below zero, then the user is classified as a producer. The difference between an absolute zero (recidivism value) and a softer zero (energy use) is the strength of the balancing limit to growth. In both cases profits may appear similar, but revenues and costs may appear different. This illustrates the use of face validation between the model structures for an accurate and informed comparison.

System Dynamics modeling (SDM) (Sterman, 2000; Forrester, 1961) provides the ideal medium to formally study the dynamic feedback relationship between the key stakeholders, the system, and the environment of the system. SDM is a methodology that focuses on the system feedback loops using computer aided modeling software to calculate complex non-linear equations (System Dynamics Society, 2013). The purpose of building a model is to gain insight and understanding about the real system without the drawbacks to cost, time, and other complications of ethics (Sterman, 2000). The models will be screened using the standard methods for analyzing system dynamic models (Sterman, 2000). These methods include statistical screening, SDM Docs, Extreme Conditions, univariate sensitivity analysis, and more (Sterman, 2000; Taylor, Ford, & Ford, Improving model understanding using statistical screening, 2010; Martinez-Moyano, 2012). Therefore, SDM has the tools and methods for analyzing and comparing the two project types.

Therefore, the hypotheses—a SIB provides a funding option that reduces the owner's exposure to risk—will be tested using four milestones for the applicability of a SIB financial structure in a built infrastructure sustainability improvement program:

1. Modeling and understanding how a SIB works
2. Identifying a comparable built infrastructure sustainability model
3. Comparing the structures of a SIB to existing sustainable financial options
4. Comparing the results of a SIB with those of a sustainability project.

Modeling a SIB using SDM is an important start because it has not been done before. Furthermore, HMP Peterborough is the first SIB enacted and is not expected to be completed until 2019 (Cave, Williams, Jolliffe, & Hedderman, 2012). Therefore, the creation of a SIB model provides a base to compare a sustainable finance option with a SIB. A comparable model of a sustainable project built infrastructure case will reduce differences between itself and the SIB model. The comparison of the two model structures would provide a list of differences and similarities. This list would show causes for the different results of the model analysis. This illustrates the process of comparing the two financial structures and their project characteristics.

Milestone 1: Model an Existing SIB

There are five accepted steps to the SDM methodology (Sterman, 2000). The first is problem articulation which focuses on identifying and defining themes, key variables, time horizons, and the dynamic nature of the problem (Sterman, 2000). The second is the formulation of the dynamic hypothesis using variable mapping and looking for endogenous factors (Sterman, 2000). The third is the formulation of the simulation model or the specification, estimation and testing of values, relationships and behaviors from literature (Sterman, 2000). The fourth is testing the model by comparing reference modes, and the fifth step is to design and evaluate relevant policies (Sterman, 2000).

Step 1: Problem Articulation

The first step in SDM is the articulation of the problem (Sterman, 2000). Models are built like targets; there is point to be made even when missing the initial target. The theme specifies the problem the model should address so the work can be taken in context. The problem is described to draw attention to an issue and focus the model on particular policy actions. This study will focus on the successful completion of projects and how the key stakeholders are affected by the results.

Step 2: Formulation of the Dynamic Hypothesis

The second step separates SDM from other modeling methods because it looks at policy changes over time by formulating a dynamic hypothesis. John Sterman defines a dynamic hypothesis as a working theory of how the problem arose with endogenous characteristics (2000). There are several tools in SDM for defining the dynamic hypothesis. The first sub-step is to map the system structures. A model boundary chart (MBC) and subsystem diagram is a great way to show the boundaries and architecture of the model. Causal loop diagrams (CLD) are another way to express a dynamic hypothesis by showing the relationship between different variables while stock and flow maps describe the accumulation and flow of goods and services (Sterman, 2000). This study uses the CLD to explain the dynamic hypothesis and how a SIB alters the constrained LTG.

Step 3: Formulation of a Simulation Model

The formulation of a simulation model as the third step allows for real world scenarios to be enacted without real world costs. Formalizing the modeling structure allows the hypothesis to be tested (Sterman, 2000). Implementing policy change in real world systems can be costly if the hypothesis is wrong. Building a model allows practitioners and researchers to test the hypothesis without impacting the real systems (Sterman, 2000). This explains how the SDM simulation model is used in the study.

Step 4: Testing

The fourth step of testing the model validates the usefulness of the model. There are two model tests used to validate the models in this study: reference mode comparison and extreme conditions testing. Reference mode comparison is a comparison between different real world scenarios and the results from the model to build confidence in the model properly representing the issues at hand (Sterman, 2000). Reference mode comparison will be used to compare between models, but not to validate models because the outcomes of the Peterborough SIB will not be available till sometime after 2019. While the SIB literature lacks quantitative data on the results of the Peterborough case the qualitative expectations for the system are well documented (Strickland, 2010; Loder, Mulgan, Reeder, & Shelupanov, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011). Therefore, the extreme conditions testing, a test of exogenous values and their expected behavior in extenuating circumstances, will be used to build confidence in the model (Sterman, 2000). These are the testing methods for the model development in this study.

Step 5: Policy Design and Evaluation

The fifth step is policy design and evaluation. Through tools, such as statistical screening, univariate sensitivity analysis, and policy interactions, SDM modelers are able to simulate real world scenarios, and infer valuable contributions to system behavior (Sterman, 2000; Taylor, Ford, & Ford, Improving model understanding using statistical screening, 2010). Statistical screening is used to show the correlation over time of different exogenous variables to specified performance variables (Taylor, Ford, & Ford, Improving model understanding using statistical screening, 2010). If performance variables are specified to represent key stakeholder interests, then the correlation over time shows the importance of these variables to the key stakeholder. The addition of a univariate sensitivity analysis provides a magnitude for the significantly correlated variables. Whereas the statistical screening shows the significance of different exogenous variables, then the univariate sensitivity analysis shows the importance of those variables. By identifying the significant and important variables, this study can identify common problems and possible solutions. The results of policy analysis provide a comparison of final benefit/cost levels within different SIB scenarios. This illustrates how the policy design and evaluation phase of the SDM process is used in the current work.

Milestone 2: Identify a Model of a Sustainable Built Infrastructure Case

The second milestone is like validating a SIB financial structure to a non-SIB financial structure. The costs and benefits between the two financial structures should be exemplified by identifying and comparing a SD model of a built infrastructure sustainability review for a possible application of a SIB structure to a case where a SIB is used. The project selected will share similar model development traits to the SIB case. From the problem articulation to the possible policy designs, there should be some resemblance between the two models. These common traits allow the models to be compared.

Milestone 3: Comparing and Contrasting Model Characteristics

The third milestone is a comparison between the two model structures which develops a list of similarities and differences. This emulates a face validity test between the two models' structures and mapping. The comparison identifies their similarities and differences using a seven step process.

Step 1: Identify the causal structures in both models' causal loop diagrams (CLD) as well as their function.

Step 2: Identify the comparable structures between the two models' CLDs and pair structures when possible.

Step 3: Identify what makes the similar causal feedback structures different.

Step 4: Identify key structures in formal models and characterize their roles and separate larger structures into smaller structures as needed.

Step 5: Identify and pair the comparable structures between the two models' formal structures.

Step 6: Identify what makes the similar formal simulation model structures different.

These steps explain the delineation used to define a list of causes for performance variance between the two models.

Milestone 4: Defining Model Performance

The fourth milestone is defining owner and investor performance measures as a basis for comparing a SIB to a non-SIB financial structure. These measures may be different from the contractual performance measures in the project. The programs' performance measures determine the success and failure of the program in achieving the desired goal (Hatry, 2006; Mulgan, Reeder, Aylott, & Bo'sher, 2011; Cave, Williams, Jolliffe, & Hedderman, 2012). How the programs' measures of success are established drives the risk assumed by different stakeholders (Loder, Mulgan, Reeder, & Shelupanov, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011). The key stakeholders' performance measures represent their interests in the project. The owners and investors are two major roles of the key stakeholders in a SIB (Disley, Rubin, Scraggs, Burrowes, & Culley, 2011; Cave, Williams, Jolliffe, & Hedderman, 2012). Therefore, each key stakeholder should have a performance measure for their success and the success of the project.

Defining the Owner Benefits

The owner's benefits will be measured as a percentage change in program outcomes and the cost savings. The owner's interests are represented in the contractual performance measures that result in savings. The balanced scorecard literature supports the assumption that the categories of consumer satisfaction, internal processes, knowledge and data, or financial management are reflected to and from the goal or mission of an organization. Measuring both the program performance and savings of the program will bracket the operations and goals of the owner. This explains the use of two performance measures to represent the owner's interests in both project cases.

Defining the Investor Benefits

The final internal rate of return (IRR) provides a generalized measure of attractiveness for the investors' benefit. The IRR represents the average interest rate of the investment for a net present value (NPV) equal to zero. Though NPV and IRR are often used for considering the most financially viable option (Trigeorgis, 1996), using an IRR instead of an NPV provides a generalized measure that will not be skewed by the investment amount. This explains the use of the IRR to moderate the investors' view of a successful program in both cases.

Comparing Across Models

The results of the SIB will be compared with the built infrastructure sustainability case model as though it were a reference mode. The four aforementioned steps set the background for four resultants to understand how a SIB could work in a built infrastructure sustainability program:

1. A comparison of the statistical screening results to answer the change in the stakeholder preferences between the cases. One hypothesis of a SIB is that the owner and investors will align their incentives. This is tested by looking at the common variables between owner and investor in both cases statistical screening results. This shows how preferences change in using a SIB financial structure.
2. A comparison of generalized outcomes (i.e. performance outcome percent change, owner savings, and Investor IRR) provides an answer to changes in magnitude for key stakeholder benefits. Combing these variables (e.g. investor IRR/ owner savings) and comparing between cases will tell how the costs and benefits change between cases for the different stakeholders. This information may be used to addresses questions about the benefits, costs and risks incurred by the owner. This shows the change in costs and benefits of different stakeholders when using a SIB financial structure.
3. A comparison of similar policy experimentation would answer the rigor of the financial tool under different circumstances. This technique is used in conjuncture with the generalized outcomes to answer "what if" questions. Some of the policy questions that are asked include:
    a. What if the program is a complete failure?
    b. What if the program is an astounding success?
    c. What if the savings are siphoned from their existing fund?

    This shows case specific differences in how a SIB functions.

4. Last, a comparison univariate sensitivity analysis from common variables determined as significant from the statistical screening analysis. This is used to determine the sensitivity of performance measures with drivers. This shows whether there is any variance in the sensitivity of the change when using a SIB.

With these four results, the SIB case may be compared with the sustainability case in built infrastructure using Mulgan's et al. (2011) seven criteria. The first step provides a means of attaining results. The second step identifies a comparable sustainability project. The third step defines the differences between the two using a facial validity test. The fourth step identifies the resulting differences of the models and their outcomes. With that comparison the study may yield an analysis on the changes in preferred variables and how the key stakeholders fair in a variety of scenarios. With this information, practitioners and researchers can gain insight into the application and environment for a successful SIB. This explains the methodological steps of this study for the comparison between a SIB and a built infrastructure sustainability project.

CHAPTER IV

SIB MODEL DEVELOPMENT: THE HMP PETERBOROUGH CASE STUDY[1]

Problem Articulation

The impact of a SIB on a system is not fully understood. SIBs were developed to aid underfunded and disputed social issues (Loder, Mulgan, Reeder, & Shelupanov, 2010; Mulgan, Reeder, Aylott, & Bo'sher, 2011). In 2011 the first case study began and since then several others have gone into development (Mulgan, Reeder, Aylott, & Bo'sher, 2011; Loder, Mulgan, Reeder, & Shelupanov, 2010; Strickland, 2010; Rockefeller Foundation, 2012). The goal of these case studies is to provide evidence of effectiveness (Strickland, 2010). Practitioners looking to use SIBs would be interested in understanding the factors that affect SIB outcomes. Therefore, the problem this portion of the study focuses on is the ability of SIBs to work successfully.

Prisons measure performance in multiple dimensions**.** One measure is the population of offenders held in prisons. The Federal Bureau of Prisons (FBP) mission is to imprison offenders and provide rehabilitation. Assuming a steady or rising general population and a declining prison population with this goal provides a better outcome than a growing or steady prison population. This objective is partially reflected in the

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[1] This chapter is an adaptation of White III, R. J., & Ford, D. N. (2013) "Dynamic Drivers of Successful Social Impact Bonds," in the proceedings of the 2013 International System Dynamics Conference, Cambridge, MA, System Dynamics Society. (http://www.systemdynamics.org/conferences/2013/proceed/papers/P1294.pdf)

prison's recidivism, the fraction of released offenders that are reconvicted (Castillo, et al., 2004; Disley, Rubin, Scraggs, Burrowes, & Culley, 2011). Prisons also measure performance using unit cost per offender year (e.g. dollars per offender-year) (Moynihan, 2008). Like in many systems, these performance measures create tradeoffs. Rehabilitation programs can lower the recidivism rate for a prison system by influencing released offenders away from a life of crime, but these programs cost money and thereby also increase the cost per offender (Loder, et al. 2010, Mulgan, et al. 2011). Therefore efforts to limit cost can prevent the initiation and use of rehabilitation programs. Thus rehabilitation programs are likely to be underfunded when cost per offender is the primary performance metric. Therefore, a major challenge for prisons systems is how to fund rehabilitation programs with little public funding (Moynihan D. P., 2008; Loder et al., 2010; Mulgan et al., 2011). Donald Moynihan (2008) describes the Alabama Department of Corrections (ALDOC) as an example of this dilemma. ALDOC was underfunded, requiring it to operate at almost 200% capacity (Britt 2012). Single guards were responsible for 200 offenders, forcing them to stand back and try to prevent full scale riots (Britt 2012). Under such circumstances funds for rehabilitation programs could not even be considered.

Figure 5 shows a portion of the feedback structure of an offender rehabilitation program. When operating as a vicious cycle of decay reinforcing loop 1 (R1) degrades prison system performance by reducing rehabilitation programs and thereby increasing recidivism as budgets are reduced, which increases reconvictions, prison populations and costs, thereby reducing funds for rehabilitation programs farther. Figure 5 also illustrates the challenge of initiating changes if the total prison budget (Figure 5, right) is constrained without an allowance for surplus or deficit. A reduction in the total budget of a prison system operating in a steady state can reduce the discretionary budget enough to initiate the vicious cycle of decay.

However, reinforcing loop 1 (R1) in Figure 5 also describes a potential solution if the reinforcing loop operates as a virtuous cycle of improvement instead of a vicious cycle of decay. In this behavior mode loop R1 depicts the use of a paid-from-savings approach in which a rehabilitation program reduces recidivism and then reconvictions, thereby reducing a prison's population and operating costs. This increases operating savings, which can be used to continue to fund the rehabilitation program. These improvements are limited by the minimum recidivism that the rehabilitation programs can create (Figure 5, loop B1). Changing the behavior mode of this reinforcing loop into a virtuous cycle of improvement is the primary objective of a Social Impact Bond applied to offender rehabilitation. A SIB can solve this financing problem by having its investor provide the required funds to start and initially operate a rehabilitation program and be repaid (with profit) from the operating savings (Figure 5, loop R2). Thus a SIB can change the prison budget dynamics from tradeoffs (Figure 5, loop B2) among alternative uses or a vicious cycle of decay to the use of savings from reduced recidivism to continuously improve the prison system. After the SIB ends, the prison system can operate the rehabilitation program in perpetuity with its share of the savings generated by the SIB-funded program and future savings. In addition, after the SIB has ended the investors can continue this dynamic by reinvesting in a larger or different rehabilitation programs (Disley, Rubin, Scraggs, Burrowes, & Culley, 2011). See Strickland (2010), Loder et al. (2010), Mulgan et al. (2011), and von Glahn and Whistler (2011) for detailed descriptions of a SIB for offender rehabilitation.

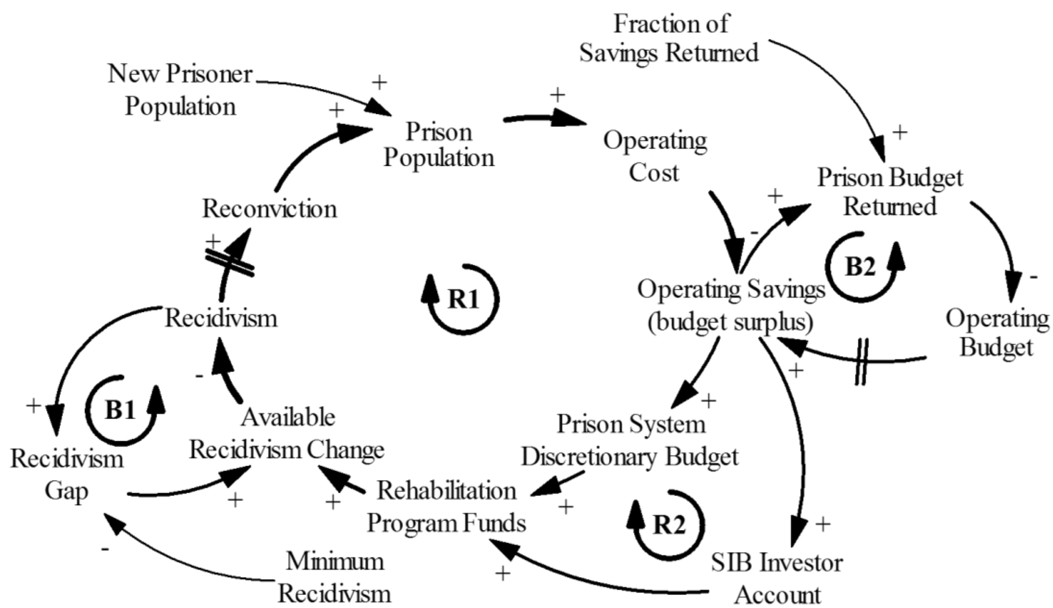

Figure 5: Prison System Rehabilitation Program CLD

<u>**Legend of Loops: Figure 5**</u>

R1- Paid-from-Success Rehabilitation loop: Prison budget funds program which reduces population and generates savings which are used to pay for the program

R2- Social Impact Bond loop: SIB invests in rehabilitation program, reducing population and creating savings, part of which are paid to investors as returns

B1- Limits to Improvement loop: Decreased recidivism reduces improvement available, which limits the amount of future recidivism reduction

B2- External Constraint loop: Increases in budget surplus trigger increases in the returned budget from the prison, which limits the amount of future Operating Budgets

Model Structures

The Peterborough SIB model has three sectors, depicting the prison system, the performance measurement, and SIB finances. In general, the prison system structure models the flow of offenders through the system and the effects of the SIB on prison population dynamics (Strickland 2010). The performance measurement sector compares the offenders in the Peterborough cohorts and a comparison group of offenders to assess the performance of the SIB (Cave et al., 2012). The SIB finances sector use the performance assessment to simulate the financial returns to investors according to the SIB (Strickland, 2010; Disley et al., 2011; Cave et al., 2012).

Prison System Model Sector Structure

The prison system sector provides a simplified view of how people move in, out, and around the prison system. New offenders are incarcerated from the general population (Figure 6, upper left). In the model released offenders unknowingly come from one of two stocks: those who function within the norms of society (rehabilitated offenders) or those who will recommit (undiscovered reoffenders). At the time of release the actual prison system does not know what fraction of released offenders will recommit, be arrested and convicted again, and reenter the prison. But the model distinguishes these stocks and their related flows using Stickland's (2010) historical value of 75% re-offending fraction to initialize the model. After their release, offenders are reintroduced to society where they either stay clear of trouble as rehabilitated offenders (i.e. are rehabilitated, Figure 6, top center) or recommit crimes (i.e. are unrehabilitated, Figure 6, left) and will eventually re-offend, be arrested and convicted, and returned to prison (Figure 6, bottom) (Disley, Rubin, Scraggs, Burrowes, & Culley, 2011). The model simulates these two types of released offenders separately.

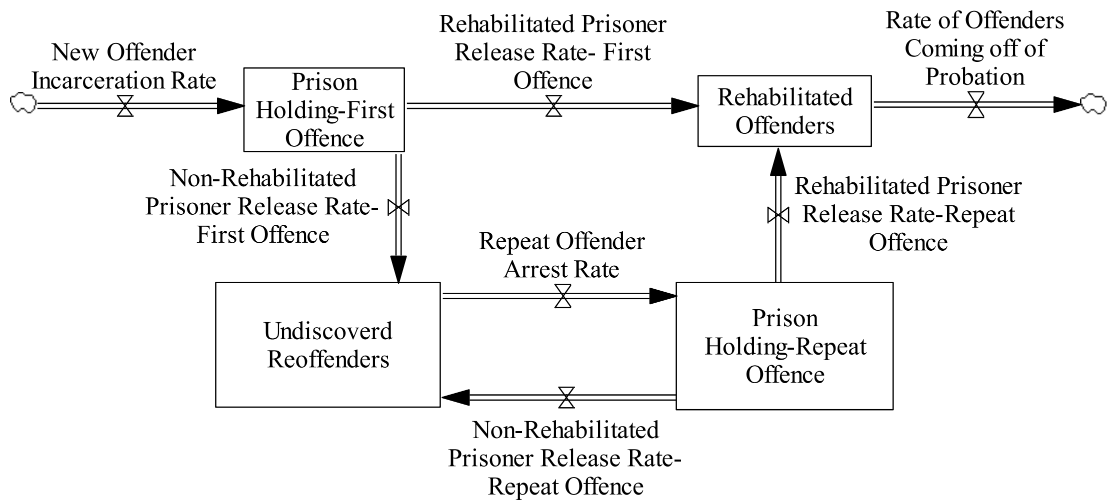

Figure 6: Rework Cycle of a Prison System

Rehabilitated offenders leave the system after the one-year probation period (Figure 6, upper right). Those that will recommit and be reconvicted remain under the same probation period until they are reconvicted. Once reconvicted, an offender returns to the prison for the duration of their holding, where they are again released into the same system (some being rehabilitated and the rest unrehabilitated). The prison system has a structure of stocks and flows similar to the rework cycle in most system dynamic project management models (see Lyneis and Ford, 2007) with work being replaced by offenders, the fraction requiring rework being replaced by the recidivism fraction, and the quality assurance function replaced by the probation period. Similar to how improved work quality reduces rework in project models, reducing the recidivism of first time offenders can greatly reduce the magnitude of repeat offenders (Langan & Levin, 2002).

Performance Measures Model Sector Structure

The performance management sector compares the offenders in the Peterborough system with a control group. To assess the effects of SIBs, the performance measurement sector compares the offenders in the four Peterborough cohorts to four parallel cohorts in a comparison group of offenders at other UK prisons. The effects of large scale factors such as a national decline in crime do not influence program performance because prison reconviction is compared to concurrent offender cohorts. Reconviction rate is used as the performance measure for recidivism (Cave et al., 2012). The third party assessor, QinetiQ, accumulates the entrants of first time offenders into the Peterborough prison system (Figure 7, top right). After the cohort closes, every first-time offender's reconvictions are accumulated from national databases (Figure 7, bottom left). The reconviction rate, listed in the model as the Reconviction Fraction (Figure 7, center), is the number of reconvictions divided by the number of offenders in the cohort. Success is defined as a reduction in recidivism or reconviction rate of 10% or more than the reconviction rate in the comparison cohort for each of the three 1000 offender (maximum) cohorts at Peterborough or a reduction in recidivism of 7.5% or more than the recidivism change in the comparison cohort for the fourth (combined) Peterborough cohort (Figure 7, left). If the performance meets either of these targets the MOJ pays the SIB investors a specified fraction of the savings captured by the MOJ based on the reconvictions prevented (Figure 7, bottom).

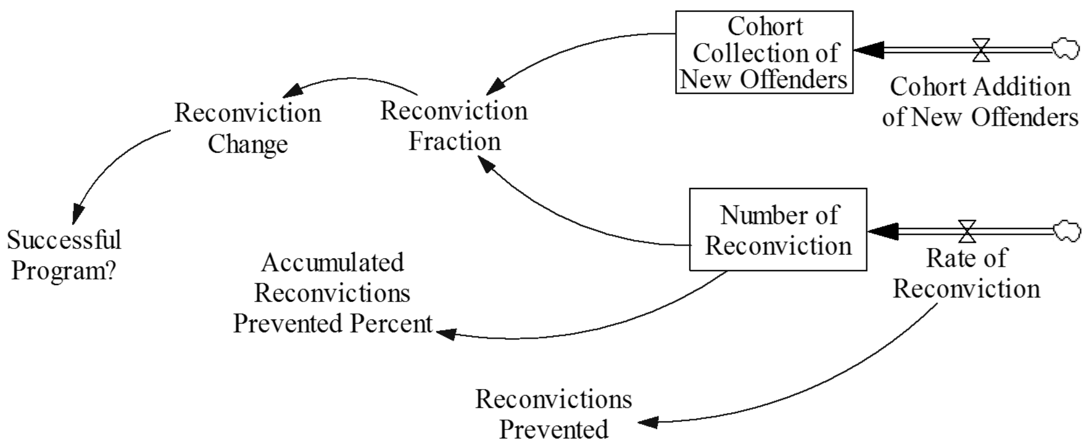

Figure 7: Performance Measurement System

Financial Model Sector Structure

The SIB financial sector uses the assessments of success from the performance measurement sector to simulate payments to investors and calculate returns. Investors providing funds for program operations and expenses create outflows of investor cash to the SIP (Figure 8, bottom left). The SIP uses the investors' funds to pay the One Service providers for program costs (Figure 8, bottom right). Loder et al. (2010) and Mulgan et al. (2011) describe the costs of the program, including the overhead for the special purpose vehicle used to structure and operate the SIB. If the program is successful the MOJ makes payments based on savings captured to the SIB investors, creating cash inflows to the investors. The benefits of the program used to determine payments are the savings in reconvictions and re-incarceration (Strickland, 2010; Mulgan et al., 2011; Cave et al., 2012). The modelers assumed (consistent with the SIB intent) that if the program is successful the MOJ will use its savings (including those that were used to pay SIB investors) to continue to operate the rehabilitation program (Figure 8, top). This closes the "big" feedback loop from funding from the SIB through the prison system, performance measurement and finances, and back to funding the program (by the MOJ after the SIB), and the shifting of dominance from loop R2 in Figure 5 (SIB-based success) to loop R2 (internally supported success). If, in contrast, the program is unsuccessful the MOJ makes no payments to the SIB investors and the program closes out after the investment period. Standard formulas with an assumed discount rate are used to estimate benefit cost ratios (BCR) and the net present value (NPV) of the SIB for the investor.

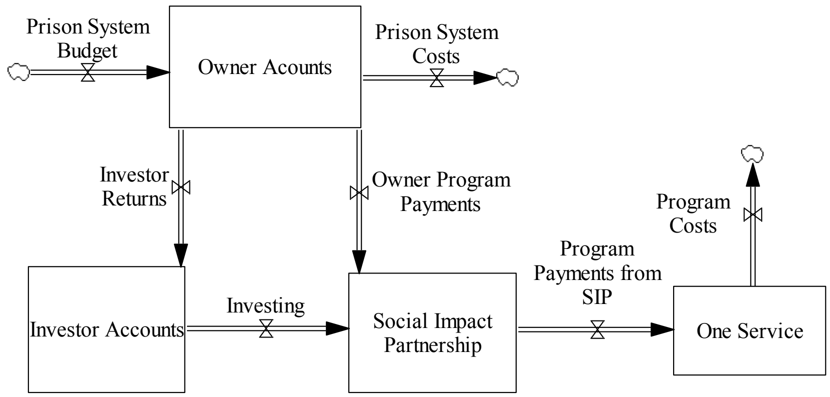

Figure 8: Stocks and Flows with Financial Structure of a SIB

Model Documentation

See Appendix I for a complete equation listing, variable names, descriptions, and citations for the HMP Peterborough SIB Model.

Model Calibrations

The model was calibrated to the Peterborough SIB case using publicly available literature as referenced in Table 2, below. Langan & Levin (2002), Loder et al. (2010), Strickland (2010), Mulgan et al. (2011), Disley et al. (2011), and Cave et al., (2012) describe the program impact, costs, assessment process and timing, and magnitude. Mulgan et al. (2011) and Loder et al. (2010) describe the expected impact of the rehabilitation program as well as various costs added to the assessment. Strickland (2010) identifies the value of investment and limits of the investment. Disely et al. (2011) also provide results of a preliminary assessment of the SIB in terms of magnitude and affect. Model values coincide with the information on the SIB and program found in this literature. Values that were not described in the literature were estimated and the model initially set to steady state conditions. For example, Disely et al. (2011) noted that about 315 new offenders entered HMP Peterborough in just over six months and the steady state model uses about 317 in a similar time frame. Cave et al. (2012) noted that the normal reconviction rate for HMP Peterborough was 1.64 persons per month for data collected up to one year after the close of the cohort. The calibrated model calculates about 1.53 persons per month in a similar time frame.

Table 2, below, lists the variables used to calibrate the model including author defined variables, and initial conditions:

Table 2: Calibrated Values

	Exogenous Variable	Description	Calibration	Units	Source
Peterborough Specific	Average Prisoner incarceration Rate for Peterborough	This represents the maximum number of new people that can be placed in the prison system, all other prisoners must go to a different prison system.	57.83 or 694/12	Offenders/ Month	Cave et al. (2012)
	Minimum Change in Reconvictions	This represents the minimum change in reconvictions for the program to be considered a success.	10% (7.5%)	DMNL	(Strickland 2010, Mulgan et al. 2011, Cave et al. 2012)
	Normal Recidivism Fraction	The normal quality of the system without having the project in play.	75%	DMNL	(Strickland 2010, Loder et al. 2010, Mulgan et. al. 2011)
	Offender Multiplier between Prison Systems	This represents the ratio of people needed in each grouping to have an appropriate power level.	10	DMNL	Cave et al. (2012)
	Probationary Period Length	This represents how long the rehabilitation program lasts and how long prisoners are tracked for reconvictions.	12	Months	(Mulgan et al. 2011, Cave et al. 2012)
	Program Cost per Member	This is the average cost per member for the program.	1.5	k£/ Offender	Mulgan et al. (2011)
	Standard Cohort Length	This is the standard time length of a cohort.	24	Months	Cave et al. (2012)
	Standard People in Cohort	It represents how many new incarceration releases are needed to finish a standard cohort.	1000	First-time Offenders	Cave et al. (2012)
	Time for System Update	This represents the time taken for systems to update any information change in the sysem. This includes both the recording of reconvictions and Budget surpluses.	6	Months	Cave et al. (2012)
	Time after Cohort for Reconviction Collection	This represents the time from when cohort collection ends and the reconviction collection ends.	12	Months	Cave et al. (2012)
	Time Spent in Prison for a Conviction	The average time a short-term offender remains in prison per visit.	1.5	Months	Cave et al. (2012)
	Yearly Cost of Incarceration	This represents the annum cost for each incarceration by the British government per person that is in prison.	39	k£/ Offender	Loder et al. (2010)
	Conviction Cost	This represents the legal costs per conviction. There is a discrepancy of conviction costs.	2.853	k£/ Offender	SEU (2002) & Mulgan et al. (2011)
	Expected Program Investment amount	This represents the minimum required investment from the investors.	5000	k£	Strickland (2010)
	Offenders' Willing to enter program Fraction	This represents the percentage of prisoners that elect to go through the program.	70%	DMNL	Disely et al. (2011)
	Annual Interest Rate for Investment [Maximum]	This represents the maximum interest rate rate that investors can accrue from their investment for a successful case.	13%	DMNL	Cave et al. (2012)
	Annual Interest Rate for Investment [Minimum]	This represents the minimum interest rate that investors can accrue from their invesment for a successful case.	7.5%	DMNL	Cave et al. (2012)
	Recidivism Reduction Fraction	This represents the change in recidivism that occurs from the program.	0.3	DMNL	(Mulgan et al. 2011, Loder et al. 2010)
	Fraction for Investor shares	This represents the percentage share of savings that the investors receive in a successful project. The actual value is confidential and the value listed is estimated.	50%	DMNL	Disely et al. (2011) and Author Defined
	MOJ Starts Paying	This represents the time that the MOJ starts paying and is tuned to the end of offenders collecting in the SIB.	73	Months	Model/ Author Defined
	Normal Recidivism Discovery Time	The average amount of time it takes to convict a recently released offender of a new crime.	6	Months	Cox (2006)
	Initial Undiscovered	This represents the number of released offenders awaiting their discovery for reconviction that starts the model in	1041	Offenders	Cave et al. (2012)

Table 2: Continued

	Exogenous Variable	Description	Calibration	Units	Source
Initial Conditions	Average Prisoner incarceration Rate for Peterborough	This represents the maximum number of new people that can be placed in the prison system, all other prisoners must go to a different prison system.	57.83 or 694/12	Offenders/ Month	Cave et al. (2012)
Initial Conditions	Minimum Change in Reconvictions	This represents the minimum change in reconvictions for the program to be considered a success.	10% (7.5%)	DMNL	(Strickland 2010, Mulgan et al. 2011, Cave et al. 2012)
Initial Conditions	Normal Recidivism Fraction	The normal quality of the system without having the project in play.	75%	DMNL	(Strickland 2010, Loder et al. 2010, Mulgan et al. 2011)
Author Defined	Offender Multiplier between Prison Systems	This represents the ratio of people needed in each grouping to have an appropriate power level.	10	DMNL	Cave et al. (2012)
Author Defined	Investor Discount Rate	This represents the discount rate for investors as an alternate investment rate of return.	5%	DMNL	(Mulgan et al. 2011, Cave et al. 2012)
Author Defined	MOJ Discount Rate	This represents the discount rate for the MOJ as an alternate investment rate of return.	3%	DMNL	Author Defined
Author Defined	Fraction of Surplus Returned	This represents the fraction of budget surplus between the expected and actual expenses that is returned to the MOJ.	50%	DMNL	Author Defined
Author Defined	Time Program has to Pay	The time interval across which payments are made to the investors of Social Impact Partnership	3	Months	Author Defined
Author Defined	Time MOJ Backlog Payments	This represents the time delay used by the MOJ to pay the savings of the program for program operations.	12	Months	Author Defined

Normal Recidivism Discovery Time	The average amount of time it takes to convict a recently released offender of a new crime.	6	Months	Cox (2006)
Initial Undiscovered Reoffenders	This represents the number of released offenders awaiting their discovery for reconviction that starts the model in steady state.	1041	Offenders	Cave et al. (2012)
Initial First time Offender Prisoner Holding	This is the tunded value for the initial prisoners that starts the model in steady state.	86.75	Offenders	Cave et al. (2012)
Initial Reconvicted Prisoner Holding	This represents the initial amount of offenders that have been reconvicted in the prison to start the model in steady state.	260.25	Offenders	Cave et al. (2012)
Time to Adjus Maximum Program Cost	Time delay to change the maximum program costs.	1	Months	Author Defined
Probationary Period Length	This represents how long the rehabilitation program lasts and how long prisoners are tracked for reconvictions.	12	Months	Author Defined
Program Cost per Member	This is the average cost per member for the program.	1.5	K£/ Offender	Mulgan et al. (2011)
Standard Cohort Length	This is the standard time length of a cohort.	24	Months	Cave et al. (2012)
Standard People in Cohort	It represents how many new incarceration releases are needed to finish a standard cohort.	1000	First-time Offenders	Cave et al. (2012)
Time for System	This represents the time taken for systems to update any			

Typical Model Behavior

Typical model behavior is illustrated by two performance variables one representing the SIB investors and the other representing the MOJ. Although recidivism is the metric used in the SIB, a (perhaps ***the***) primary performance measure of the MOJ is the reduction in the Peterborough population. Figure 9: Typical Model Behavior-HMP Peterborough Prison Population Reduction shows the simulated behavior over time of this variable for the calibrated model.

After a period of steady state operations (months 0-20) the program begins and more offenders are rehabilitated in the Peterborough system, reducing the prison population (months 20-60). However, as available funds decrease, so does the number of offenders allowed to enter the program, slowing the rate of improvement (months 30-60) and eventually reversing the progress and causing an increase in prison population when SIB funds have been depleted (months 60-75). After the completion of the program funded by the SIB the rehabilitation program is continued by the MOJ (consistent with van Glahn and Whistler, 2011), initially using the savings generated by the SIB funded program. This causes the prison population to reduce again, approaching a steady state at its maximum which is controlled by a minimum recidivism (months 75-200). The potential dangers of the temporary increase in prison population and use the model to investigate the causes and a possible solution are described later.

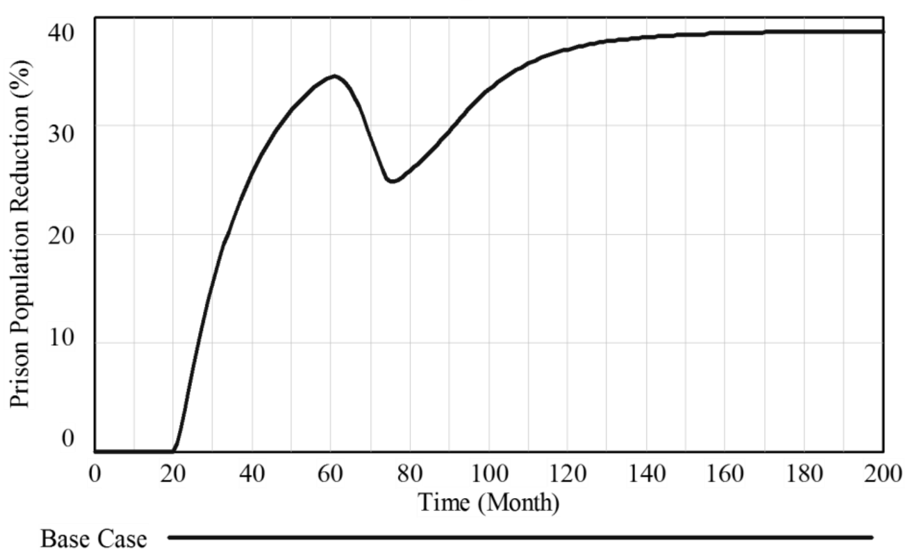

Figure 9: Typical Model Behavior-HMP Peterborough Prison Population Reduction

The primary performance measure of the SIB investors is their return, reflected in the internal rate of return. Figure 10 shows the internal rate of return (IRR) for the SIB investors for the calibrated model case.

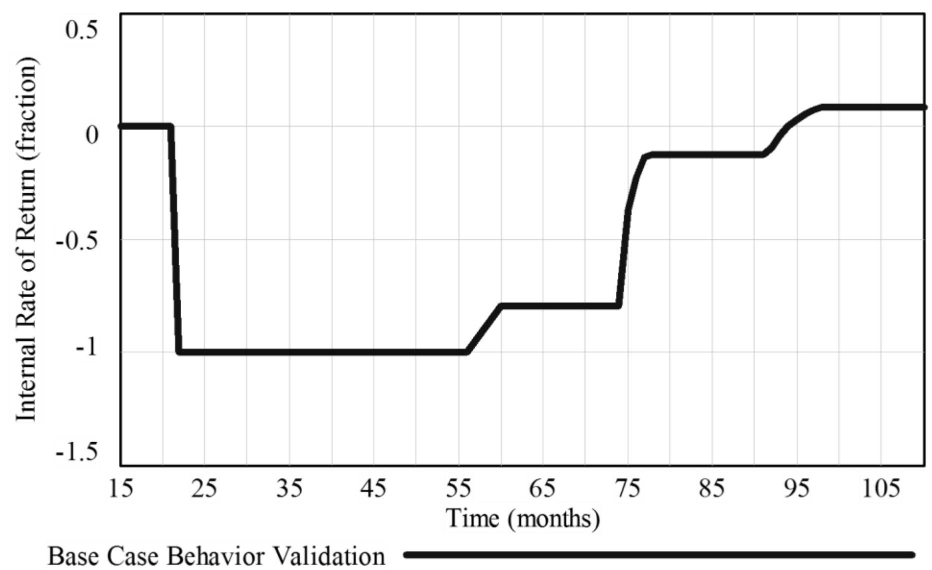

Figure 10: Typical Model Behavior-HMP Peterborough SIB Internal Rate of Return

The SIB-funded program starts in month 20, paying startup and operating costs. Until returns are paid to the investors the IRR is -100%. The success or failure of the first cohort occurs after the first assessment period, when (for the calibrated case) success reduces recidivism and creates savings. This initiates the first payment by the MOJ to the SIB investors (month 57), consistent with Cave et al. (2012) and Mulgan et al. (2011). Similarly, the second and third successful cohorts are paid starting in months 75 and 92, each increasing the IRR. In the actual Peterborough case and the calibrated model used for the calibrated case the IRR is limited to 8.25% (months 100-200). Model analysis results are used later to investigate performance without this limit.

Model Validation

The model contains a total of 141 variables consisting of 23 basic stocks, 24 flows (with five arrays), and 29 exogenous variables. The model generated reasonable behavior when each of the 29 exogenous variables were set to extreme values. More specifically, each exogenous variable was tested for its impact on several outcome variables, including SIB investor IRR, offender release rate, and the reconviction fraction. For example, when the Normal Recidivism Discovery Time (average time to discover that a released offender has re-offended) was set to a relatively high value (twelve months) the SIB investor IRR decreases because there are fewer reconvictions for every unrehabilitated offender and therefore less savings and reduction in recidivism. See the supporting documents in Appendix I for details on the extreme conditions testing and results.

The Peterborough SIB has not progressed adequately to provide actual behavior data for use in model validation. However, the literature describes the expected behavior for the case, including Disely et al. (2011) reviewing the expectations for both how investors earn money as well as how the SIB financially functions, Cave et al. (2012) describes how the third party assessor of performance defines the limits among the different cohorts and determines cohort success, Langan and Levin (2002) describes how the prison system creates a perpetual cycle of offences, and Mulgan et al. (2011) describes the transfer of risk, cost savings to the MOJ, and flows of capital between key stakeholders. The model's behavior is consistent with the expected behavior for financial and other performance measures. For example, Disely et al. (2012) describes the increase in investor returns due to either a decrease in reconvictions, or an increase in the investors' share of the total savings. By varying these two parameters the model also simulates this increase in returns (Figure 11), building confidence in the ability to generate "the right behavior for the right reasons".

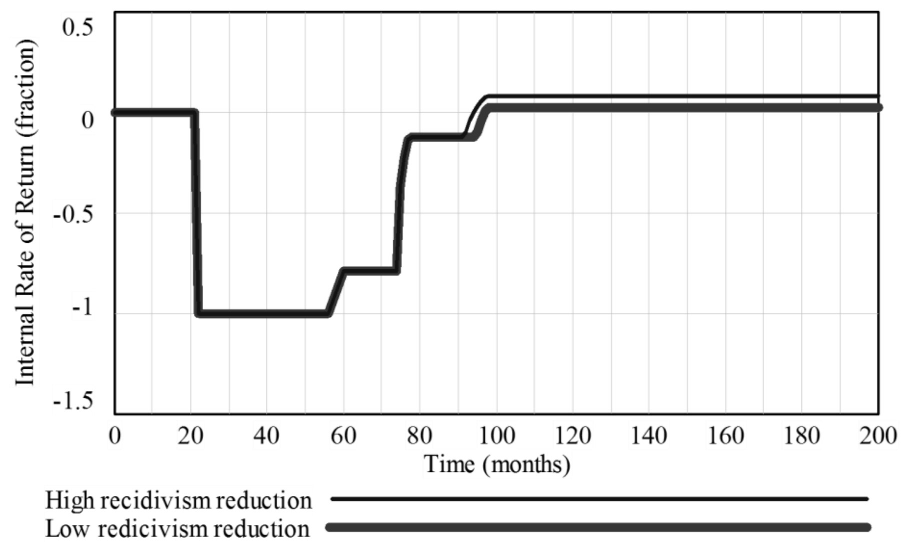

Figure 11: Behavior Validation Test of SIB Return Based on Recidivism Reduction

As another example of model behavior validation the model successfully reflects the expectation that the government would continue a successful program, as described by Glahn and Whistler (2011). The model's behavior is consistent with what would be expected in the operation of the actual SIB at HMP Peterborough.

Based on these model validation tests the Peterborough SIB model is considered valid for investigating the impacts of SIB design parameters on system behavior and performance.

Model Analysis

The model analysis was conducted in two steps to identify and describe the high leverage parameters for the key stakeholders. First statistical screening (Taylor, Ford, and Ford, 2010; Ford and Flynn, 2005) was used to identify high leverage parameters for one performance measure for the MOJ (prison population reduction) and for one performance measure for SIB investors (IRR). Statistical screening is a simple, structured, and user-friendly means of identifying high leverage model parameters based on model behavior. Statistical screening quantifies parameter influence throughout simulation, thereby describing the evolution of exogenous impacts on behavior. In addition, statistical screening provides modelers with the objective model analysis results required to generate clear behavior distinctions. Consistent with the application of statistical screening (Taylor et al., 2010), the time frame after the SIB is completed (months 100-165) was chosen as the focus of the analysis. The results of the statistical screening analysis were used to identify two of the highest leverage parameters that could be influenced by SIB designers. These were then described with univariate sensitivity analysis. See the model analysis supporting documentation for details on these analyses.

The four most influential exogenous variables that impact the prison population reduction are shown in the results of the statistical screening analysis (Figure 12). The analysis results show the relative influence of the four exogenous parameters with the most impact on the prison population reduction. Correlation coefficient values farther from zero indicate more influence. Positive values indicate movement in the same direction and vice versa. The results indicate that, after the SIB is over, the reduction in recidivism, maximum cohort size, reference (pre-program) recidivism fraction, and unit program cost (per participant) are most influential on the prison population reduction (in decreasing order of influence). The reduction in recidivism after the SIB is particularly important because it is a metric of program effectiveness, something that SIB designers can influence through their choice, design, and management of the rehabilitation program. Similarly, the unit program cost can also be influenced by SIB designers and managers.

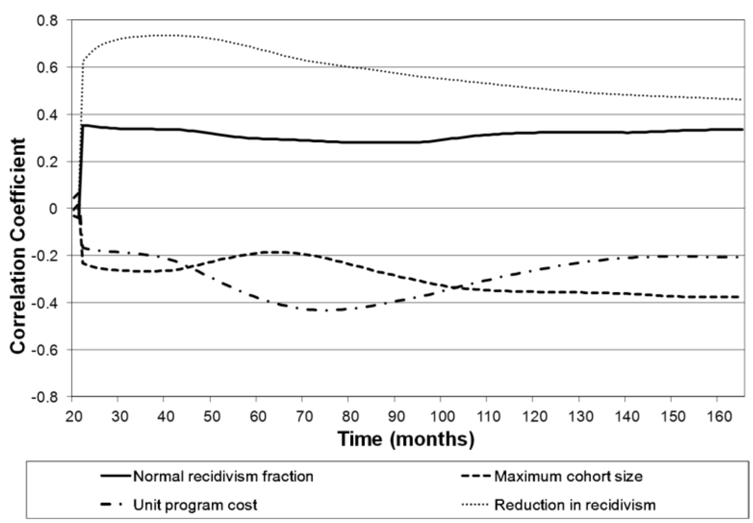

Figure 12: Statistical Screening Model Analysis Results—Prison Population Reduction

Figure 13 shows the results of the statistical screening analysis for the four most influential exogenous variables that impact the SIB investor IRR. The analysis results show that, in decreasing order of influence, the relative influence of the four exogenous parameters with the most impact on the SIB investor internal rate of return. The results indicate that, after the SIB is over, the reduction in recidivism, unit program cost, unit cost of conviction, and investor discount rate are most influential on SIB investor IRR.

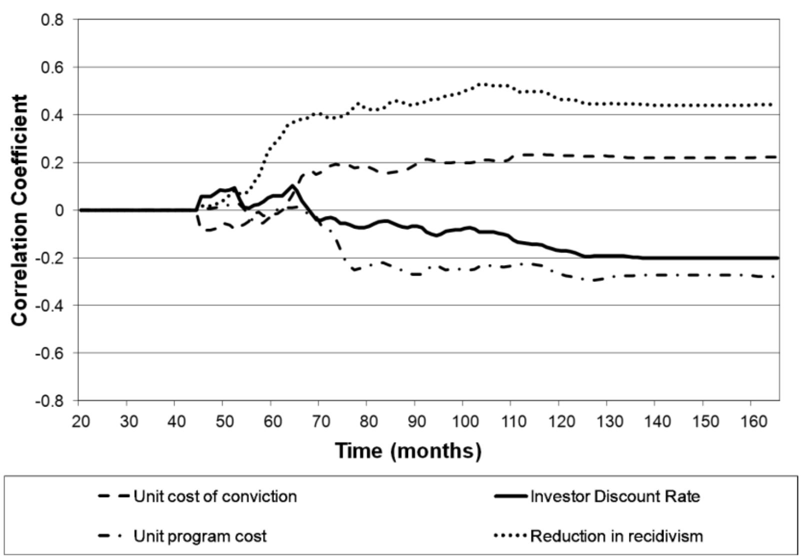

Figure 13: Statistical Screening Model Analysis Results—SIB Investor Internal Rate of Return

The results of the two statistical screening analyses indicate that reduction in recidivism and unit program cost are two of the highest leverage parameters for both the MOJ and SIB investors that SIB designers can influence**.** Consistent with model analysis using statistical screening (Taylor et al., 2010), the model structure is used to link these parameters to potential drivers of system behavior and performance (e.g.

feedback loops, delays, accumulations). Both variables have a direct impact on the strength of core feedback loops in the Peterborough SIB. Increasing the program effectiveness and thereby the reduction in recidivism (Figure 5, left side) reduces reconvictions, prison population (a MOJ performance metric), operating costs, and thereby savings that generate return for SIB investors (Figure 5, Paid-from-Success rehabilitation loop R2). As described above, strengthening this loop drives the Social Impact Bond loop (Figure 5, loop R1) that allows the MOJ to operate the rehabilitation program on a self-sustaining basis. This demonstrates the critical role of understanding and managing these two feedback loops.

However, knowing what system parameters and feedback loops have the most influence does not provide operational recommendations to system designers and managers because the amount of benefits derived from changes, limits of change, difficulty of change, cost of change, and other factors impact the attractiveness of change alternatives. Knowing the relative amounts of leverage that each of these parameters have on performance can facilitate SIB design. Therefore, univariate sensitivity analysis, initially using the calibrated model as a case, was performed to better describe their impacts. Figure 14 shows the relative impacts of these two variables on prison population reduction. These results indicate that the reduction in recidivism has an equal or larger impact on prison population than the unit program cost and that reducing the unit cost below a specific value (40% above the calibrated case cost in these simulations) does not reduce the prison population. This latter lack of impact is due to the program having achieved the maximum possible reduction in recidivism (Figure 5, Balancing loop 1).

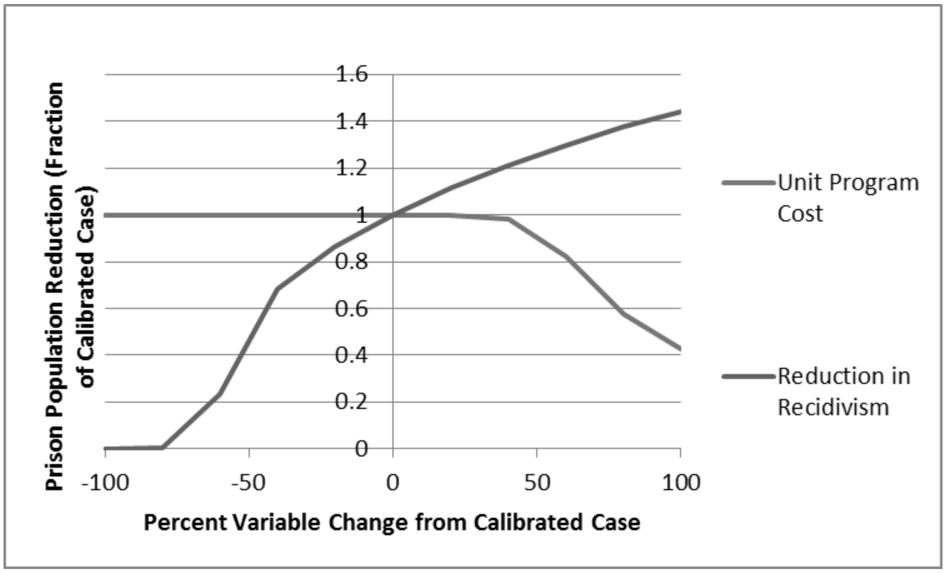

Figure 14: Results of Univariate Sensitivity Analysis with Calibrated Case - Prison Population Reduction

Figure 15 shows the results of the univariate sensitivity analysis for the impacts of the reduction in recidivism and unit program cost on the SIB investor internal rate of return.

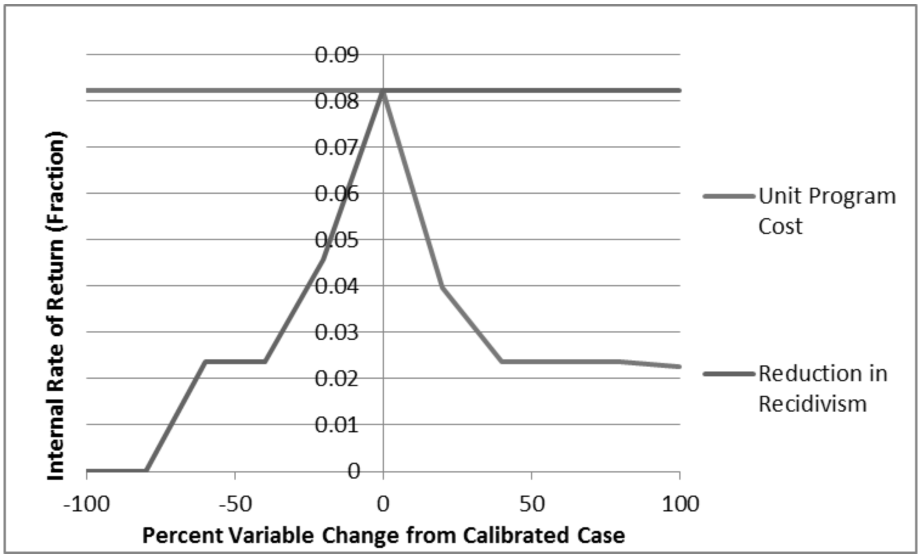

Figure 15: Univariate Sensitivity Analysis Results with Calibrated Case - SIB Investor Internal Rate of Return

SIB investor IRR increases as the final recidivism reduction increases from a loss of all invested funds if recidivism reductions are not adequate and no cohorts are successful to the calibrated reduction values, after which they remain constant at 8.25% (Figure 15, top). This limit is because the Peterborough SIB and the model include a maximum return regardless of performance. Similarly, SIB investor IRR increases as the program cost per participant decreases from 2.27% when costs are double the Peterborough costs (Figure 15, lower right) to a return of 8.25% at the calibrated costs (Figure 15, upper left). Returns fall to -100% because there are no successful cohorts if there is inadequate reduction in recidivism (Figure 15, lower left) or 2.37%, the minimum return for successful cohorts in the SIB, if unit costs are very high (Figure 15, lower right). As shown by similar slopes in Figure 15 near the calibrated case conditions, reductions in recidivism and unit program cost have similar amounts of leverage near the calibrated case conditions and less influence with increased variance from calibrated case conditions. To better understand performance for other possible SIB designs the model was altered to remove the 8.25% maximum allowed return and 2.37% minimum return on successful cohorts. The univariate sensitivity analysis was repeated and the results are shown in Figure 16.

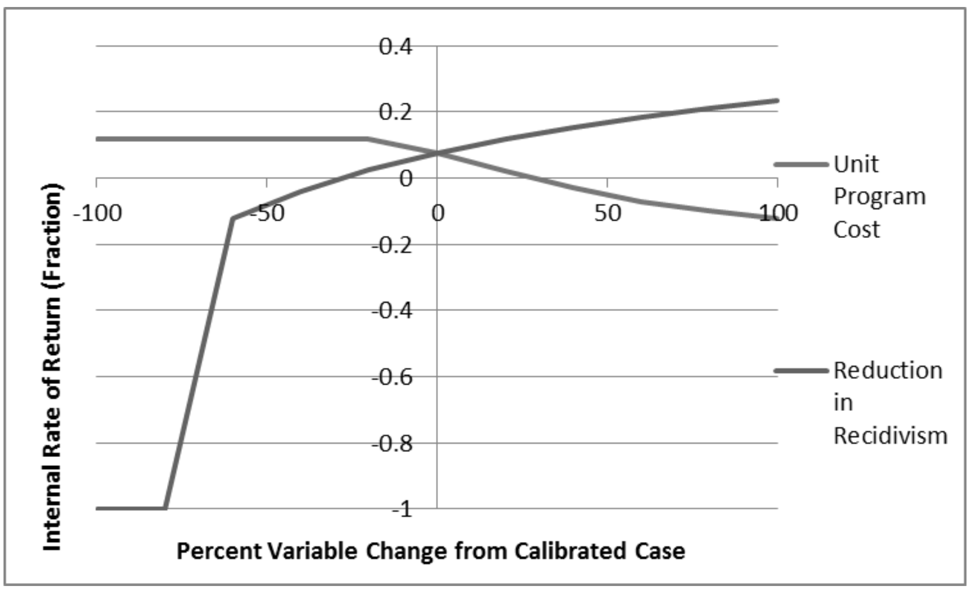

Figure 16: Univariate Sensitivity Analysis Results with Unlimited Return - SIB Investor Internal Rate of Return

Note, there are different vertical scales between Figure 16 and Figure 15**.** Results indicate that a reduction in recidivism that is twice as large as the base case (i.e. if the program is very effective) can generate much larger returns when returns are unrestricted (23.49% vs. 8.25%). Similarly, returns can increase from 8.25% to 11.61% if program costs are cut to at least 80% of the calibrated costs if returns are not limited. However, unconstrained returns can fall to (-12.1%), well below the minimum return of 2.37% (Figure 16) with high costs. This illustrates how the SIB investor traded away the opportunity for a higher reward if the program was very successful to gain some protection with a minimum return if case costs were high.

Base Case Changes

The base case is changed from the calibrated case to observe the effects of a SIB without the constraints imposed for investor security. The following changes were implemented to alter the model from a calibrated case:

1. Removal of minimum and maximum returns for success allowing the model to show real values for the investors' and owner's benefits and costs. These constraints were imposed as a means of reducing the investors' risk while this study is not concerned about addressing the investors' risks, but the owners. Leaving these constraints in would affect the value of the return for the investors. The investors trade the possibility of overly successful funds for the risk of a less than successful circumstance. This explains how excluding these constraints, the model, looks at the impact of a SIB structure instead of the securities provided in an insured SIB.
2. Removal of Deflation Rates allowing consistent value for actions in the present and future. The value of borrowing capital is still accounted through interest rates, but the inclusion of a deflation rate would assume a greater cost for current generation goods and services than for future generations. Therefore, the deflation rate is assumed zero to negligible because the cost of present and future

generations for goods and services is assumed equal (Pearce & Warford, 1993). This explains why the capital and goods that are not borrowed do not use an inflation or deflation rate.

Conclusion

A system dynamics model of the only known operating Social Impact Bond (SIB to fund a prisoner rehabilitation program at the Peterborough prison in the United Kingdom was developed and validated. The model was analyzed using statistical screening to identify high leverage parameters for one important performance metric for both the owner and investors. Univariate sensitivity analysis was then used to describe the impacts of the two highest leverage parameters that can be used in SIB design. The analysis results were used to investigate two SIB design issues.

The highest leverage parameters for the final reduction in the prison population (MOJ performance metric), in decreasing order of influence, were found to be the fractional reduction in recidivism, maximum cohort size, reference (pre-program) recidivism fraction, and unit program cost (per participant). The highest leverage parameters for final SIB investor returns were found to be the fractional reduction in recidivism, unit program cost, unit cost of conviction, and investor discount rate. These high leverage parameters influence the strength of the feedback loops that control the prison population and savings captured by the MOJ and partially paid to investors. To maximize SIB performance designers and managers must understand and influence the strength of this feedback loop.

The two parameters shared by the performance measures identified with statistical screening analysis are also two parts of the system that SIB designers can influence: program effectiveness (reduction in recidivism) and unit program cost. The univariate analysis revealed that the constraints built into the SIB agreement controlled the relative effectiveness of these parameters on performance, particularly return limits on investor performance. Univariate analysis without those constraints indicate that program effectiveness has equal or more influence on MOJ performance (prison population) and investor performance (IRR) than unit program cost. This suggests that SIB designers should focus on developing and selecting highly effective interventions, with less regard for costs (which also might decline over time due to learning curve effects).

The work also identified two potentially fatal characteristics of the Peterborough SIB design. First, the delay between the end of investments in the program and information feedback to investors (through the first returns) about performance could prevent the program from becoming self-sustaining by creating a temporary increase in the prison population. Reducing the delay by having the MOJ start funding the program before the testing of the SIB is a counterintuitive policy that can address this challenge. Second, ending investor funding before they receive feedback on SIB financial performance may prevent the SIB investors from being active participants by effectively influencing the system intervention for improved performance and higher returns. This challenge can be addressed in future SIB-funded programs with longer SIB-investor funding and should improve as a track record of performance is established.

The current work can be extended with additional analysis of SIB design principles using the model. It can also be used as the basis for modeling other planned and operational application of the SIB approach. Finally, the model can be used to model the application of SIBs to other systems that generate savings from improvements, such as sustainability improvements to built infrastructure projects. This illustrates the case and model for the existing SIB at HMP Peterborough prison.

More information on the analysis and usefulness of the SIB model and the “Dip” may be found in Appendix II.

CHAPTER V

BUILT INFRASTRUCTURE SUSTAINABILITY CASE AND MODEL[1]

This chapter describes and defines the TAMU project study, a Built Infrastructure Sustainability (BIS) case, and how it qualifies for comparison with the Peterborough SIB case for three reasons:

1. Validity of Study- The case has already been studied and the model already developed. This provides documented and citable analysis that can be used to support any similarities or differences.
2. Common Financing Strategy- At first glance, the TAMU project, like the Peterborough project reduces an expense to the owner organization and uses the savings as repayment for an investment. These common traits provide a basis to compare the two projects.
3. Transitivity between Industry- Universities exist in both a public and private industry. As a public institution, TAMU has access to funds that private universities would not (Combs, 2013). Even though TAMU uses a loan, a similar university in the private sector might not have access to the interest rate. The higher interest rates would increase the cost for improvement and deter project consideration (the same argument made in chapter 1).

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[1] This chapter references Kim, A., Hessami, A., Faghihi, V., & Ford, D. 2012. "Design Perpetual Sustainability Improvement Programs for Built Infrastructure," in proceedings of the 2012 International System Dynamics Conference, St. Gallen, Switzerland, System Dynamics Society unless otherwise noted.

Therefore, a private university may consider a SIB for the same improvements.

The validity of the BIS study provides a means of comparison and the common financing strategy aligns the case of the study while the transitivity between industries provides justification for a possible real world application. This explains why the TAMU project is the ideal candidate for comparison. Therefore, the TAMU SIB case is a well-defined model that shares similar model development traits to the Peterborough case and provides an ideal case for comparison.

Problem Articulation

Built infrastructure sustainability (BIS) is the alteration of existing structures to improve the quality of living and reduce the consumption of goods and services for built infrastructure projects (Kats, 2010). These improvements are often referred to as "green" or "sustainable" construction. In a BIS project, an owner undertakes to improve an existing facility or group of facilities.

Sustainable construction has textbook examples of externalities from goods and services and their negative impacts on society (Daly & Farley, 2011; Gruber, Public Finance and Public Policy, 2011). Pollutants and wastes create an unnecessary hardship on economic circumstances that produce a deadweight loss and cause either over or under consumption of goods or services (Daly & Farley, 2011; Gruber, Public Finance and Public Policy, 2011). The over and/ under consumption of goods and services from these externalities create a gap between society and the Pareto optimal equilibrium, a case where everyone is better off without making anyone worse off (Daly & Farley, 2011; Gruber, Public Finance and Public Policy, 2011). Greg Kats (2010) and Charles Kibert (2008) have both published books pertaining to improving built infrastructure and how different organizations could approach the benefits of green construction, while the U.S. Green Building Council (USGBC) works to study paid from savings reinvestment strategies (Van Der Like & Meehan, 2009). There are still conflicting thoughts toward sustainable design as the average overhead expected represents a value nine times larger than what research has found (Kats, 2010). This explains the development of research to improve financial options for owners and investors in BIS projects.

New construction projects are beginning to incorporate more efficient systems as they are developed. The U.S. Green Building Council (USGBC) established the Leadership in Energy and Environmental Design (LEED) certification in the United States as a standard for sustainable construction (USGBC, 2013). LEED certifications were first launched in 1998 and have continued to alter and improve their rating systems (Richards, 2012). Designing a building from a sustainable platform allows the owner to maximize the benefits of new systems and technologies that reduce consumption and improve working environments (Kats, 2010). This explains the growing trend among designers for sustainable construction.

However, existing infrastructure has met more resistance than new construction. The LEED certifications took 7 years to develop and incorporating existing building structures in the certification process (Richards, 2012). Furthermore, building space with owner-tenant relations do not share common goals or interests. Funding sustainable improvement for existing structures often requires funds that an owner does not have readily available. Therefore, building owners and managers have an interest in financial options that would change the effectiveness of programs' profitably.

Figure 17 shows a portion of the feedback structure of a BIS system program. When operating as a vicious cycle of decay reinforcing loop 1 (R1) degrades BIS system performance by reducing sustainable improvements and thereby increasing energy consumption as budgets are reduced, relative to what they would have been otherwise, which increases energy costs, thereby reducing funds for BIS programs farther. These effects can be seen as nickel and diming employees or as delaying maintenance and replacement of assets (Osborne & Hutchinson, 2004). Figure 17 also illustrates how the challenge of initiating changes if the total prison budget (Figure 17, right) can be constrained by borrowing capital for improvements. A reduction in the total budget of a building energy use system operating in a steady state can reduce the discretionary budget enough to initiate the vicious cycle of decay.

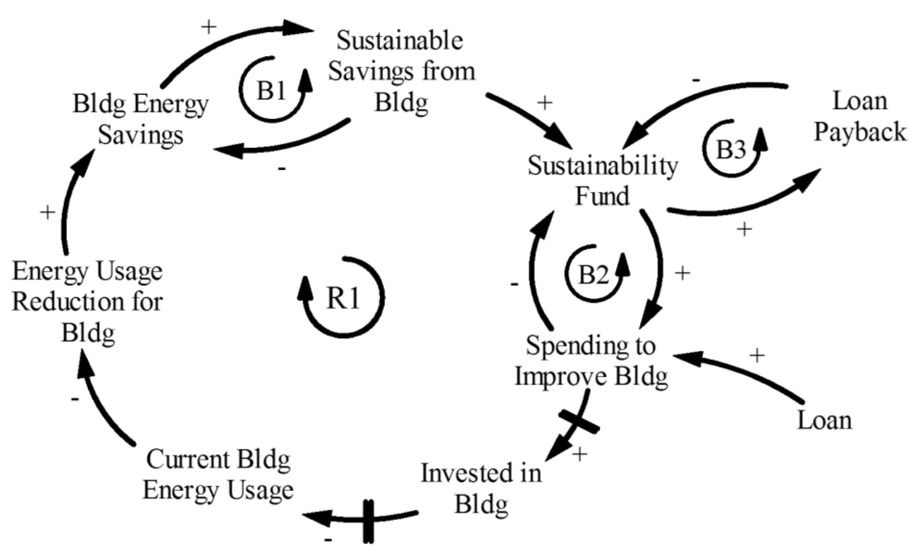

Figure 17: Designing Perpetual Sustainability Improvement Programs for Built Infrastructure" CLD after Kim et al. (2012)

<u>Legend of Loops: Figure 17</u>

R1: Savings Growth- As savings from improvements increase, investments in energy reductions increase savings by reducing consumption.

B1: Building Savings Limit- As energy reduction cost savings increases, the captured savings from the building increases which reduces the unclaimed savings.

B2: Sustainable Development Limit- As the sustainability fund increases; more funds can be spent on improvements which reduces the sustainability fund.

B3: Loan Repayment Limit- As the sustainability fund increases, more of the loan can be repaid which decreases the sustainability fund.

However, reinforcing loop 1 (R1) in Figure 17 also describes a potential solution if the reinforcing loop operates as a virtuous cycle of improvement instead of a vicious cycle of decay. In this behavior mode loop R1 depicts the use of a paid-from-savings approach in which a sustainability improvement program reduces energy consumption thereby reducing operating costs. This increases operating savings, which can be used to continue to fund the sustainability improvement program. These improvements are limited by the available energy savings that the sustainability improvement programs can create (Figure 17, loop B1). In the TAMU case, the primary object of the loan is to change the behavior mode of this reinforcing loop into a virtuous cycle of improvement for energy reduction. The state of Texas has an allotment of capital for public schools to borrow in order to initiate these changes (Figure 17, Loan) (Combs, 2013). Thus a investment in sustainability can change the energy budget dynamics from tradeoffs

(Figure 17, loop B2) among alternative uses or a vicious cycle of decay to the use of savings from reduced energy consumption to a more efficient system of built infrastructure components. After the loan is paid off, the owner continues to collect savings from the program in perpetuity. With this share of the savings generated by the loan-funded portion of the program, the owner has a self-funding option for further improvement and added future savings. See the Kim et al. (2011) for more information on the Texas State program, Combs (2013) for application and requirements, and Kats (2006) for the benefits of greening public schools.

Model Structure

The TAMU model has two sectors depicting the performance measurement and energy savings/ finance. The performance measurement sector estimates the energy savings of various sustainable improvements. The energy savings/ finance sector use the performance assessment to simulate the costs and savings for the sustainable improvements.

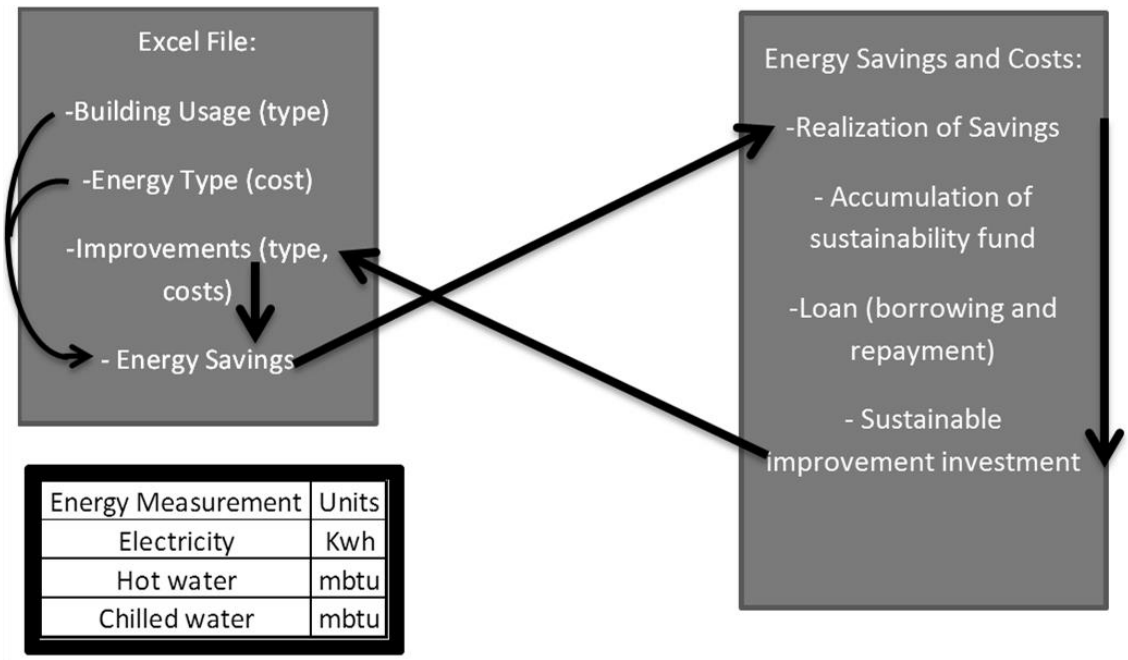

Figure 18: Built Infrastructure Sustainability Model Sector Diagram

The performance management sector estimates the amount of energy saved with the cost of energy. These estimates are based off laboratory tests for different building improvements. These values can be tested and compared during system operations using modeling software such as DOE2 (Norford, Socolow, Hsieh, & Spadaro, 1994; Carriere, Schoenau, & Besant, 1999), but for purpose of the TAMU model do not need to be verified. The energy savings is measured using two sets of units for three forms of measurement seen in Figure 18 below. The Excel file alters the energy use based on the sustainability funds spent for improvement and the improvement types. This explains how the excel file operates as the performance measurement sector.

The energy savings/ finance sector uses the assessments of success from the performance measurement sector to simulate the accumulation of savings in the sustainability fund. The sustainability fund, originally initiated by borrowing from the state, is used to invest in sustainable improvements. As the fund accumulates savings, the loan is repaid from the same account. This explains how the energy savings/ finance sector effect the performance measurement sector.

Model Documentation

The model documentation may be found in Appendix III and provides the following information: variable names, descriptions, citations, applicable equations, and the excel file used in conjecture with the model.

Model Calibrations

The model calibrated case uses data from the TAMU case via the school's utility records, contracts and meetings with the representatives of TAMU project. The base case alters the model values as listed in Chapter III of the Research Methods. The differences can be seen in Table 3.

Table 3: Calibrated and Base Case Values

	Base Case	Calibrated
Funding Portion	50%	100%
Behavior Modification (BM) Strategy	12%	12%
Install BM cost per building	4833	4833
BM Monthly Maintenance Cost	41.67	41.67
Buildings used (excludes Garages)	12	12
Interest rate for negative funds	2%	2%
Fraction of Savings to Sustainability Fund	50%	100%

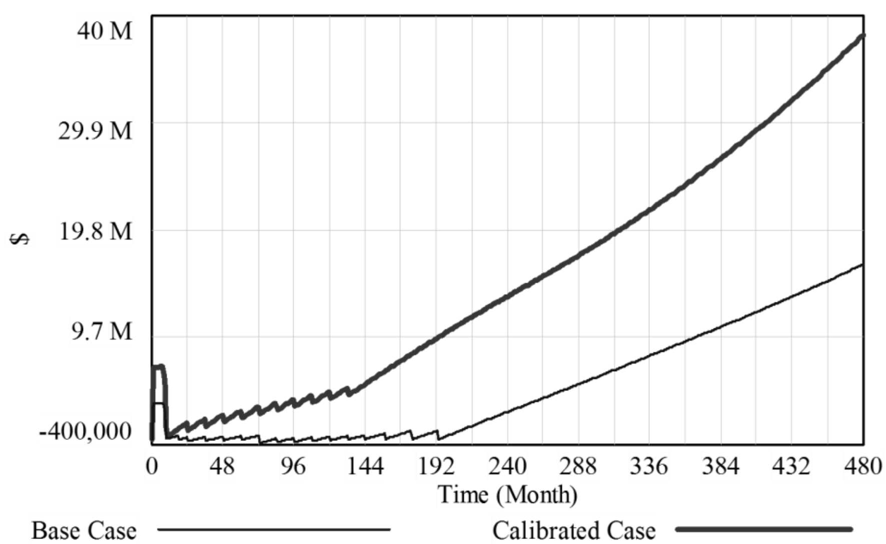

Figure 19: TAMU Base Case verses Study Calibrated Case

The Behavior Modification (BM) values listed in Table 3 are the values selected for both the base case and calibrated case. A comparison between the sustainability fund, the performance measure used in the TAMU models case study, is shown below in Figure 19.

Typical Model Behavior

Typical model behavior is illustrated using the sustainability fund for the TAMU project. This stock measures the available capital for reinvestment in sustainability projects, other projects at the owner's discretion, and the repayment of the loan. Although cost savings are used as the performance measure for the Siemen's contract, the primary performance measure for TAMU is the energy reduction. Figure 20 shows the simulated behavior over time of this variable for the calibrated model.

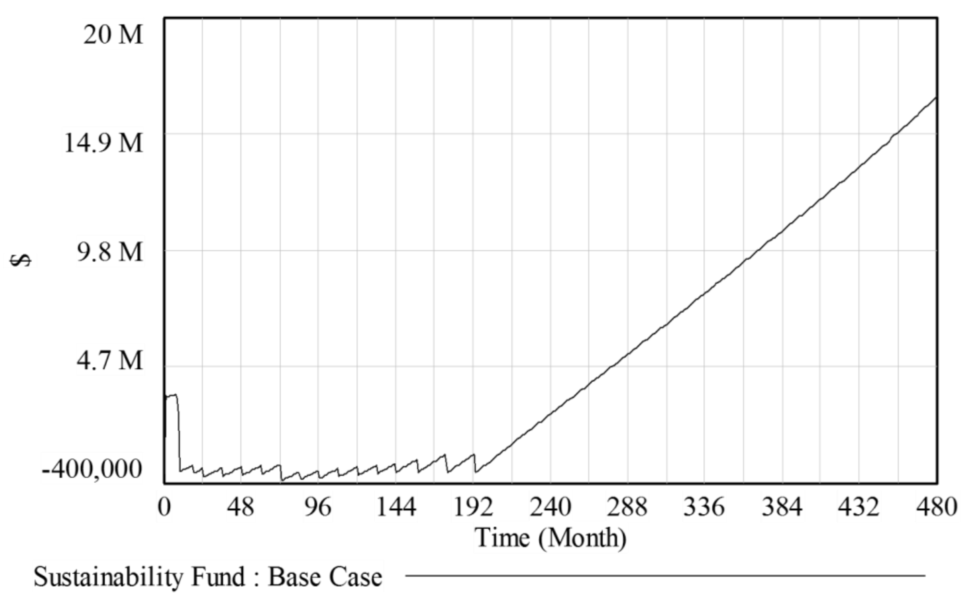

Figure 20: Typical Model Behavior—TAMU Sustainability Fund

The model starts when the loan is taken and the program begins and as improvements are made, the energy reduction is increased for the TAMU system until all beneficial options have been funded (a LTG constraint) (months 10-130). After the completion of the program funded by the loan the sustainability improvement program is continued by TAMU through the accrued savings (consistent with van Van Der Like, 2009), initiated by the loan (months 130-480). This causes the energy reduction to remain at the reduced values, a steady state at its maximum, which is controlled by a minimum energy use (months 10-480). Reducing or eliminating the funds would cause either a penalty for default.

Model Validation

The model contains a total of 76 variables consisting of 7 basic stocks, 10 flows (with two arrays), 7 exogenous variables, and 9 switches for simulation control. The model closely resembles the structural design of the Harvard Green Campus Initiative Environmental Loan, because of the models ability to repay, reinvest and share savings with the university. Unlike Harvard, the TAMU case focuses on built infrastructure improvement excluding transportation and purchasing costs/ savings. For example, as the sustainability fund increases, more projects are enacted thereby reducing the energy consumption and increasing the energy savings. See the supporting documents in Appendix III for details structural assessment of the TAMU model.

The TAMU case has not progressed adequately to provide the actual behavior data for use in model validation. However, the contract documents and other literature sources on sustainable improvements describe the financial behavior and other performance measures that were used to validate the model. Figure 20 above, shows the base case used in the model study. The entirety of the budget ($3.4 million) is spent on the improvements; however, the account never drops below zero because the improvements generate immediate savings. This illustrates the models ability to respond.

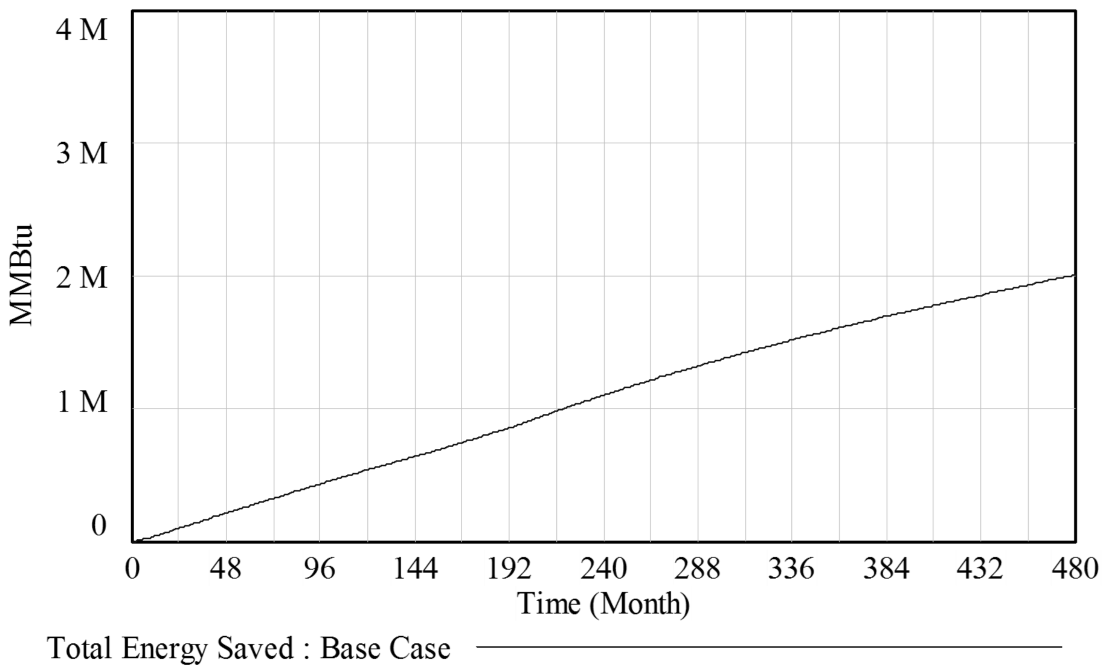

Figure 21: Behavior Validation Test of TAMU Total Energy Reduction

Model Analysis

As another example of model behavior validation the model successfully reflects the expectation that the funds invested in sustainable improvements would upfront increase the Energy Savings and then level off as shown in Figure 21 (Invested funds occur in the beginning and results level off during the simulation) while the benefits to the owner are received throughout the life of the project (Owner funds steadily increase through the simulation shown in Figure 22). This illustrates the model's ability to produce expected behavior. The "Owner's Fund" is used in the validation test showing the satisfaction of the owner (this is not adequately displayed in the sustainability fund).

Based on these model validation tests the TAMU BIS model is considered valid for investigating the impacts of BIS case design parameters on system behavior and performance.

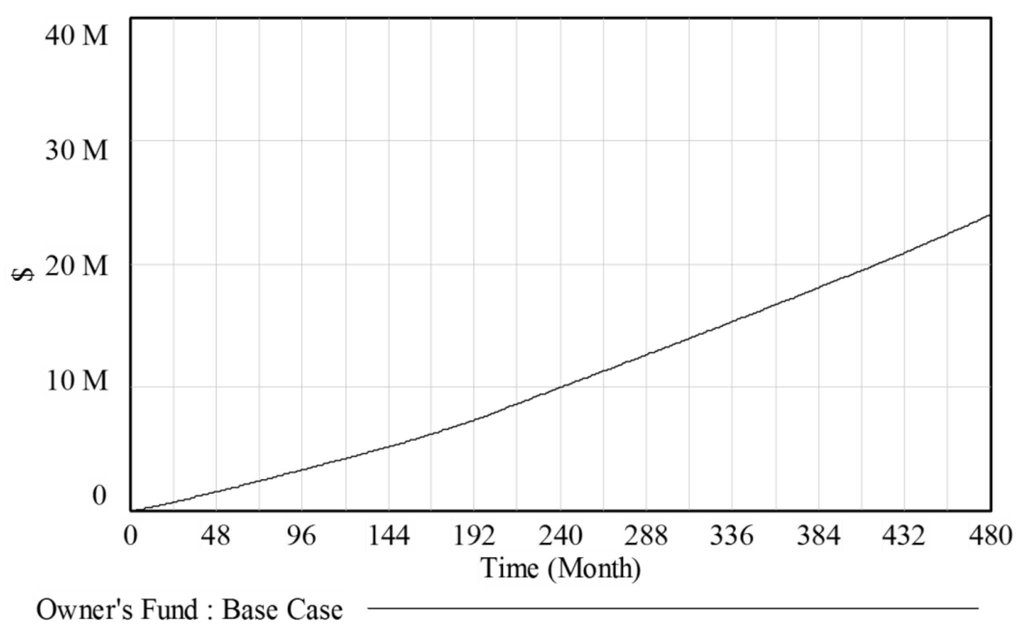

Figure 22: Behavior Validation Test of TAMU Owner Fund

The model analysis was conducted in two steps to identify and describe the high leverage parameters for the key stakeholders. First statistical screening (Taylor, Ford, and Ford, 2010; Ford and Flynn, 2005) was used to identify high leverage parameters one performance measure for the owner (TAMU) and another representing an investor (the SECO). The original model analysis was conducted to test the benefit of different prioritization for building improvement options; however, the model can also be used to determine the impact of different exogenous variables on the performance measures. The sustainability funds balance after the loan was repaid, at month 200 was used to compare the different prioritization methods. The sustainability fund represents the available capital for reinvestment and for ulterior uses by the owner. To separate the owner's actions from their goals, the owner's (TAMU's) satisfaction will be measured by the magnitude of a separate account (Owner's Fund). The 'Total Energy Saved' was chosen as the investor performance measure as it reflects the goals and mission of the SECO. Statistical screening is a simple, structured, and user-friendly means of identifying high leverage model parameters based on model behavior. Statistical screening quantifies parameter influence throughout simulation, thereby describing the evolution of exogenous impacts on behavior. In addition, statistical screening provides modelers with the objective model analysis results required to generate clear behavior distinctions. Consistent with the application of statistical screening (Taylor et al., 2010), the time frame after the loan is repaid (beyond month 200) was chosen as the focus of the analysis. The results of the statistical screening analysis were used to identify two of the highest leverage parameters that could influence key stakeholders in policy designs.

These were then described with univariate sensitivity analysis. See the model analysis supporting documentation for details on these analyses.

Figure 23 shows the results of the statistical screening analysis for the most influential exogenous variables that impact the owner's fund. The analysis results show the relative influence of the four exogenous parameters with the most impact on the owner's fund. Correlation coefficient values farther from zero indicate more influence. Positive values indicate movement in the same direction and vice versa. The results indicate that, after the repayment, the fraction of savings sent to the sustainability fund (verses the owners pockets), Cost of Energy (regardless of type), and the percent reduction of electricity and hot water heating (or program effectiveness) are most influential on the owner's fund (in decreasing order of influence). The fraction of savings replenishing the sustainability fund is particularly important because its inverse replenishes the owner's funds. Similarly, the unit energy cost is very influential to the program because it directly impacts the amount of savings.

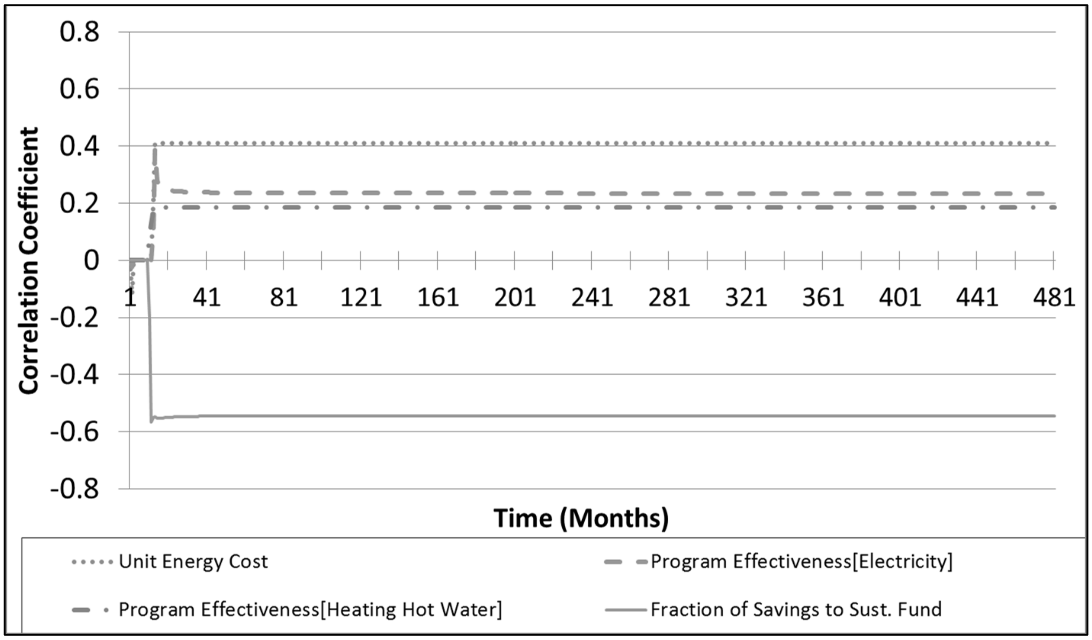

Figure 23: Statistical Screening Model Analysis Results: Owner's Fund

Figure 24 shows the results of the statistical screening analysis for the three most influential exogenous variables that impact the SECO total energy reduction. The analysis results show that energy reduction, in decreasing order, after the loan is paid off is influenced by chilled water cooling, hot water heating, and electricity (program effectiveness variables). The results indicate that, for the SECO, the system should work to be more effective.

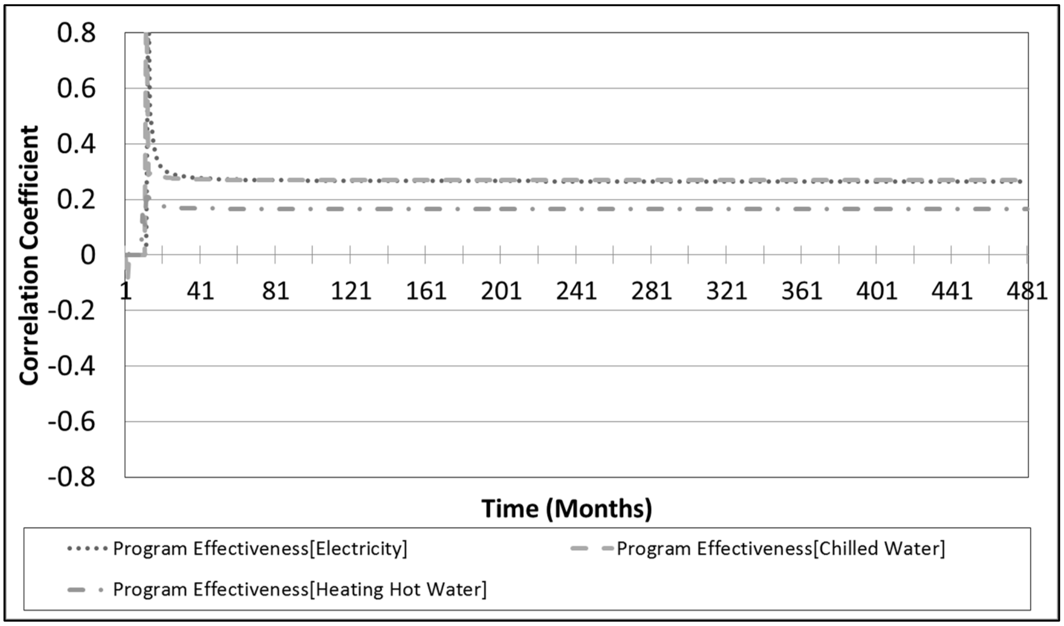

Figure 24: Statistical Screening Model Analysis Results: Total Energy Reduction

The results of the two statistical screening analyses indicate that energy reduction (program effectiveness) contributes two of the highest leverage parameters for both TAMU and the SECO. Consistent with model analysis using statistical screening (Taylor et al., 2010), the model structure is used to link these parameters to potential drivers of system behavior and performance (e.g. feedback loops, delays, accumulations). Program effectiveness variables have a direct impact on the strength of core feedback loops in the TAMU case. Increasing the program effectiveness and thereby the reduction in energy use (Figure 25, left side B1) reduces demand for energy and the operating costs, and thereby creating a savings that generates a return the owner repay the investor with (Figure 25, Paid-from-Success rehabilitation loop R2). As described above, strengthening this loop drives the savings (Figure 25, loop R1) that allows TAMU to operate the energy reduction program on a self-sustaining basis. This demonstrates the critical role of understanding and managing these two feedback loops.

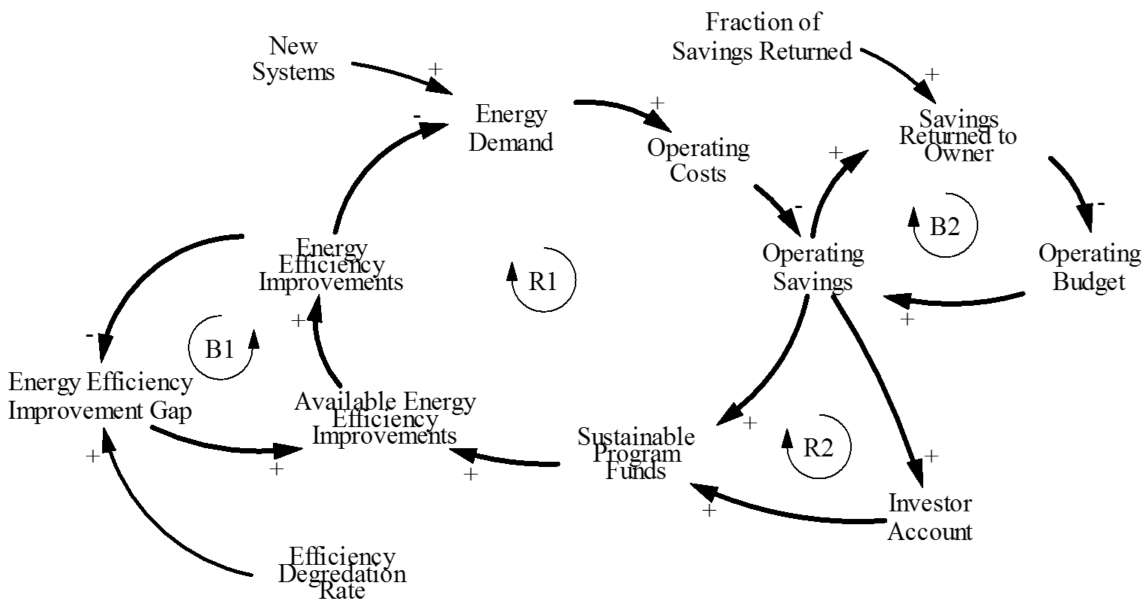

Figure 25: TAMU-Siemens Project Demand Side

Legend of Loops: Figure 25

R1- Savings Growth Loop- As savings from improvements increase, investments in energy reductions increase savings by reducing consumption.

R2- Investor Incentive Loop- As investors increase their investment, the program outcomes increase and increase the investor group's return.

B1- Energy Savings Limit- As energy reduction cost savings increases, the captured savings from the building increases which reduces the unclaimed savings.

B2- Savings Return Limit- As the sustainability fund increases, more of the loan can be repaid which decreases the sustainability fund.

However, knowing what system parameters and feedback loops have the most influence does not provide operational recommendations to system designers and managers because the amount of benefits derived from changes, limits of change, difficulty of change, cost of change, and other factors impact the attractiveness of change alternatives. Knowing the relative amounts of leverage that each of these parameters have on performance can facilitate project design variables. Therefore, univariate sensitivity analysis, initially using the calibrated model as a case, was performed to better describe their impacts. Figure 10 shows the relative impact the fraction of savings that is used to restore the sustainability fund (closing R1 in Figure 25) has on the performance variables (owner's fund and total energy saved) after the completion of the loan (month 200). These results indicate that increasing the fraction to the sustainability fund reduces the owner's ability to capture savings, but increases the total energy reduction. This increase in owner's fund by reducing the fraction illustrates B1 in Figure 26.

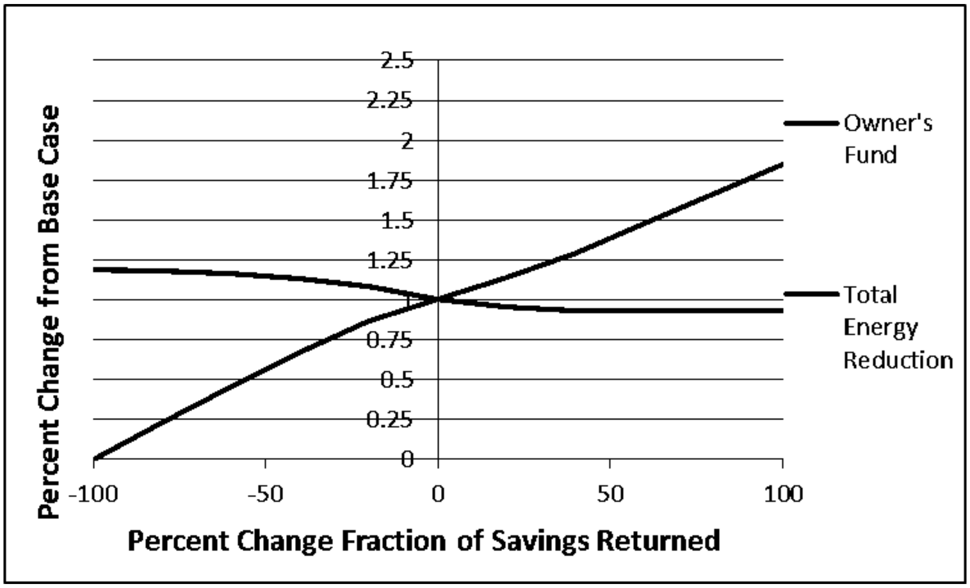

Figure 26: Univaiate Sensitivity Analysis for Fraction of Savings used to restore Sustainability Fund

Figure 27 shows the results of the univariate sensitivity analysis for the impacts of changing the reduction in electricity (one of the program effectiveness variables). The other program effectiveness variables may be seen in Appendix III.

Satisfaction for the TAMU and SECO increase as the total energy reduction increases; however, the scales of benefits are marginal in comparison with TAMU's benefits of altering the sustainability fund's replenishment fraction (Figure 26). This presents an issue of incentives between TAMU and SECO. The SECO would be benefited by maintaining oversight or requiring TAMU to set aside the savings.

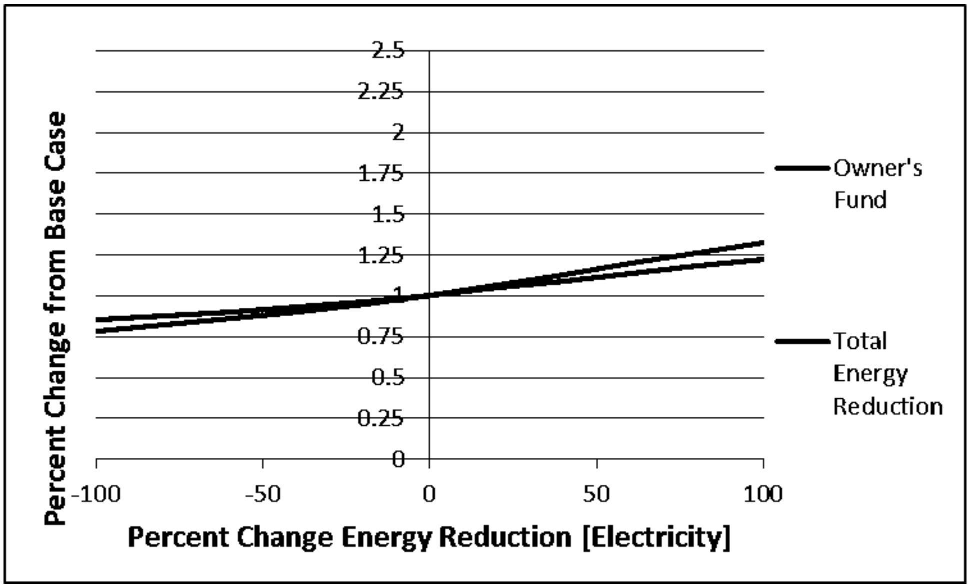

Figure 27: Univariate Sensitivity Analysis for Program Effectiveness (Electricity)

Conclusion

A system dynamics model of the TAMU built infrastructure sustainability improvement case was developed and validated by Kim et al. (2012). The model was analyzed using statistical screening to identify high leverage parameters for one important performance metric for both the owner (TAMU) and investor (SECO). Univariate sensitivity analysis was then used to describe the impacts of the high leverage parameters that can be used in project design. The analysis results were used to identify a difference of incentives between TAMU and the SECO.

The highest leverage parameters for the TAMU and SECO shared program effectiveness variables (reduction in electricity, heating hot water, and chilled water). These parameters showed incentives for increasing their effectiveness, but were less potent for TAMU than the available change offered from recapturing savings for ulterior purposes. The fraction of savings returned to the sustainability fund is a high leverage parameter that influences the strength of the feedback loops that control the savings captured by TAMU and the continuance of sustainable development in built infrastructure. To maximize sustainable development built infrastructure owners and managers must understand and influence the strength of this feedback loop.

The current work has been extended from the initial analysis of the TAMU case using the model developed by Kim et al. (2012). It is used to understand the TAMU built infrastructure sustainability case. Finally, the model can be compared with the application of a SIB model to test the applicability of a SIB for a sustainability improvement project inbuilt infrastructure.

CHAPTER VI

ASSESSMENT OF THE SIB APPLICABILITY TO A BIS CASE

This chapter compares the TAMU and Peterborough cases by assessing how they meet the seven criteria outlined by the Young Foundation. First, the two models were compared between their characteristics, structures and results. Then the comparison was used to define how the projects either satisfy, void, or fail the seven criteria associated with the determination of a SIB financial tool's application from Mulgan et al. (2011) (See Table 4). This provides the basis for an assessment of the applicability of a SIB to the TAMU case.

Table 4: SIB Criteria (after Mulgan et al. 2011)

	Criteria	Description
1	**Preventative intervention**	The intervention is preventive in nature and sufficient funding for the intervention is currently unavailable
2	**Improves wellbeing in an area of high social need**	The intervention improves social wellbeing and prevents or ameliorates a poor outcome
3	**Evidence of efficacy**	The intervention is supported by evidence of its efficacy and impact, giving funders confidence in the scheme's likely success
4	**Measureable impact**	Whether it is possible to measure the impact of the intervention accurately enough to give all parties confidence of the intervention's effect, including a sufficiently large
5	**Aligns incentives**	A specific government stakeholder achieves savings or lower costs as a result of actions undertaken by others. These savings need to be cash releasing and provide an
6	**Savings greater than costs**	The savings for the specific government stakeholder are relatively immediate and much greater than the cost of the intervention and transaction costs. This provides
7	**Government preference for a SIB**	Government policy for the specific agenda is keen on or at least open to the use of a SIB

Assessment Methods

The study first used four case descriptors to compare the TAMU and Peterborough cases for similarities and differences: Key stakeholders, project characteristics, model structures and model results. The key stakeholders and their roles and responsibilities help gain insight to the scoping for the alignment of incentives and the characteristics of the intervention. Shifting to the project characteristics helps understand the values between the projects that determine the success and failure as well as the relationship between efficacy and savings. Finally, the model structure and results provide more definitive conclusions about case results and policy actions. Therefore, these four descriptors were used to provide context to how each case satisfies, voids, or fails the criteria.

Model Assessment

Key Stakeholders

The comparison of the cases started with identifying and categorizing the similarities and differences between the Key stakeholder roles and responsibilities. Table 5 below summarizes the primary roles and responsibilities of the key stakeholders between the Peterborough and TAMU cases.

Table 5: Key Stakeholder Roles and Responsibilities

Key Stakeholders	Case in Peterborough	Case in TAMU	Assessment (TAMU)
Owner	Commits to repay investors and reinvest in successful programs	Commits funds to the programs and continues to fund programs if successful.	Owner pays upfront for intervention.
Investor	Provides funding and carries the risk of program success thus providing oversight in the project implementation	Provides funding based on the projects projected success, receives repayment regardless of results.	Loss of oversight through the program by the Investor. Owner is responsible to the investor for repayment.
Contractor/ Service Provider	Influence the target population and promote confidence in the investors.	Influence the target system and promote confidence in the owner through guarantee.	Promotes confidence in owner, instead of investor, via guarantee.
Third Party Assessor	Determine success and failure of program. If successful, then determines value of return from success.	Determine whether or not guarantee pays (Value only assessed in failure)	Specific measurement only occurs in failure instead of success.
Target Population/ systems	Receives the intervention that has measurable impact on their life.	Receives the intervention that has measurable impact on their life cycle costs.	People to systems.

There are three major differences to the key stakeholders roles and responsibilities for the owner, investors, and the third party assessors. In the Peterborough case the owner (the MOJ) is not liable for payment until the programs have proven success. In the TAMU project, TAMU (the owner) borrows the money and contracts Siemens with a guarantee to reduce their liability. One difference between the pay for performance contract and a guarantee is that Siemens is not an investor, but a contractor. Another is that a SIB should void the owner of risk from the project[1]; however, ESCOs (similar to Siemens) may provide the funding in lieu of a guarantee. Under these circumstances, the SIB investors (or the investing ESCO) assume the risk

[1] This assumes that the contract is properly written as described by Mulgan et al. (2011).

for the owner providing an incentive for the investors to get involved with the service providers and increase their returns. This explains how the key stakeholders' roles and responsibilities vary between the TAMU and Peterborough cases as a result of the guarantee. Therefore, TAMU would not benefit from the reduced risk because the ESCO has already reduced the owners risk by using a guarantee; however, a SIB could benefit the ESCO by creating a market opportunity for investors to share in the risk and rewards of the project.

Model Structures

After comparing the key stakeholders, the study compares the key structures between the Peterborough and TAMU cases. The two models are compared similar to a face validation with the major difference being the models are compared to each other instead of the real system. The six steps used to define the differences and similarities between the TAMU and Peterborough models are defined in the research methodology. These steps identify similarities and differences in both the causal feedback structure and the formal model structures, which can then be used to define the differences in model behavior.

Table 6 below the relevant differences in the case characteristics:

Table 6: Characteristics between TAMU and HMP Peterborough

Item	Peterborough	TAMU
Investment amount	5m£	$3.4m
Total Intervention Cost	7.7m£	$6.7m
Percent of Intervention Funded	~65%	~50%
Targetted flow rate (Units)	New Offenders/ month	GWh/month and Gbtu/month
Targetted flow rate (Quantities)	57.8	2.55 and 18.0 (respectively)
Expected Percent Reduction	30%	21% and 23% (respectively)
Real Annual Cost (without intervention)	19.5M£/year	6.7M$/year
Expected Real Annual Savings	4.4M£/year	686k$/year
Real Annual Percent of Costs Savings	~22.6%	~10.2%
Delay to Maximum Savings	8 years	<1 year
Expected Duration of Investment	8 years	10 years

Although the cases have similar characteristics, their differences are crucial in defining the use and scale for the success of SIBs in sustainability projects. There are three primary characteristic differences between the two cases. First, the TAMU case used three energy reduction methods, which use two different units to measure energy, while the Peterborough case specifies a reconviction rate. Reconvictions and Energy consumption create an interesting difference in that energy consumption may go below zero (energy production), but the reconviction rate cannot. Second, the ratio between the annual system costs and intervention costs for the Peterborough case are nearly three times the values for the TAMU case. This change in budget to intervention ratio presents an issue of scale that directly relates to the fastest timing for the project to pay back barrowed money. Third, the expected savings between the two cases is greatly despaired while the investments are similar, including a delay in savings for the Peterborough case (~8 years). Therefore, the difference in intervention costs and available savings would increase the expected duration for investment in the TAMU case, while the increased delay in results would increase the expected duration for investment in the Peterborough case (ceteris paribus).

In Table 6, the BIS case has a longer expected duration for investment than the prison case due to a longer delay to a steady state. In the prison case offenders are released and enter a rehabilitation program, and in the BIS case the building systems are upgraded. The length in delay for the prison case comes because unlike the BIS system, installing the programs does not immediately reduce the recidivism. It takes 8-10 years for the prison program to reach a new steady state when the program is implemented. The BIS improvements have a more efficient means of enacting savings, and a smaller portion, 20% to 10% of the annual cost. This illustrates the difference in delays between a prison improvement program and a BIS program.

Defining the System Archetype

Various sources were consulted when looking for the proper archetype defining this structure. The Limits to Growth (LTG) system archetype (shown below in Figure 28) is a basic archetype that was first introduced in the 1970s (Braun, 2002). In LTG systems growth can be just as dangerous as decay (Braun, 2002). Both the Peterborough and TAMU cases display a growing and slowing action in the system improvement. As a result both systems are constrained by the limits of their respective improvements. Therefore, the LTG archetype was selected as the most similar, for more on system archetypes please refer to Senge (1990), Braun (2002), and Wolstenholme (2003).

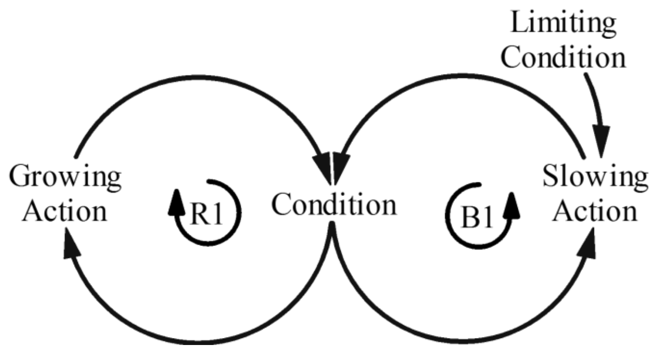

Figure 28: Limits to Growth System Archetype (after Senge 1990)

The comparison uses a new archetype that extends beyond the traditional limits to growth (LTG) (seen in Figure 28). In the new archetype, the reinforcing loop is constrained by more than just the limits of the programs improvement, but also by the ability of the program to maintain the savings in an account for future funds. The reinvestment of funds starts the reinforcing loop by improving the program and reducing costs. As costs decrease the program accumulates savings which increases the amount a reinvestment option could fund. The two balancing loops then constrain the reinforcing loop, one on program performance and the other on program savings. The constraint on program performance completes the traditional LTG. As the program improves the available improvements diminish which reduces the options for investment. This covers the cost/ quality trade off by promoting the most beneficial programs. The second balancing loop is caused by a repurposing of funds, a captured savings that is filtered to another program or other investments. This explains the use of the new system archetype shown below.

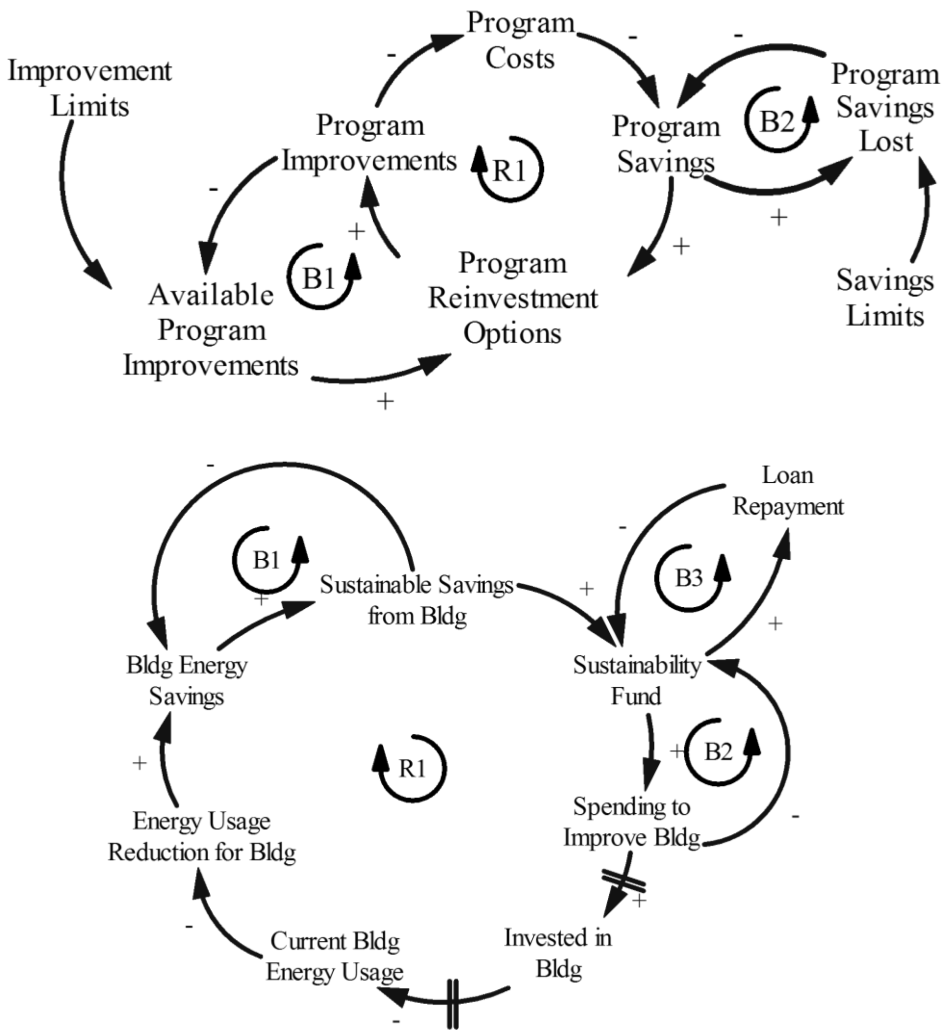

Figure 29: Constrained Limits to Growth (General SIB [Top], BIS [Bottom])

<u>Legend of Loops: Figure 29</u>

R1- Preventative Intervention- As savings from improvements increase, investments in improvements increase savings by reducing costs.

B1- Program Efficiency- As improvements are funded, the remaining improvement available diminishes.

B2&3- Program Cost Constraint- As savings increase, sources remove funds from the system decreasing the available spending.

Casual Loop Diagram Comparison

The causal loop diagram (CLD) maps the relationship between the variables to explain how the system operates. CLDs are defined into different system archetypes to generalize common system attributes. Both the Peterborough and TAMU cases fit the overall system operations for a constrained LTG archetype. Table 7 below identifies the similarities and differences between the two projects' CLD:

Table 7: CLD Comparison between TAMU and HMP Peterborough

Item	Peterborough Specific	TAMU Specific	Similarities
Overall Structure	Single solution program and activities	Two solution program and activities	Limits to growth structures
Reinforcing Program Loop	Focuses on Prison population	Focuses on the energy consumption and demand	Both loops are driving reduction of system in virtuous and driving growth in vicious.
Program Limit Balancing	Performance variable measured as Reconvictions	Performance variable measured as energy reduction	Increasing effectiveness decreases the gap between actual and ideal thus reducing the growth of the primary reinforcing loop
Investor Reinforcing loop	Peterborough SIB project set to operate through one (1) iteration and then owner takes over	TAMU theorizes a revolving loan that could be paid off and reinvested in. Assumed that investments paid off are not borrowed from again.	Both programs involve investors that could have long term interests in the programs.
Owner Balancing loop	Purpose of the SIB is to save money making this loop inevitible	The TAMU case could have an unintended consequence of owner captured savings used for alternative purposes.	Both loops are driven by the amount of savings that the owner wants to capture from the system

Table 7 was used to assess two characteristic differences between the Peterborough and TAMU cases.

First, the characteristics of the performance measures, prison population and energy consumption, operate differently. Prison population cannot go negative, but energy consumption can go negative. As previously mentioned, when energy consumption goes negative it is referred to as energy production. This issue of transitivity presents the option for energy reduction cases to provide both supply and demand side solutions opposed to the supply side solutions of the Peterborough case. Therefore, the application of a SIB in the TAMU case could include revenue production with the cost savings.

Second, the SIB is purposed for establishing savings that the owner can capture while the TAMU case was part of a program, run by the SECO, intent on reducing public schools' energy consumption. The SECO funds the programs for public schools, like TAMU, that create perpetual savings captured for ulterior projects and purposes; however, the common variables in both models used the same settings to reduce the associated impacts in the results. Therefore, the use of a SIB would expand the investor options of sustainability programs beyond agencies with specific goals in energy reduction.

Model Structure Comparison

The next step for comparison is to identify the similarities and differences of the formal model structure. This comparison categorizes the structure and components that distinguish between the Peterborough model and the TAMU model. Table 8 below lists the similarities and differences of the formal modeling structure. Repeat line items were omitted.

Table 8, above, is used to identify additional characteristics between the TAMU and Peterborough case. The TAMU model uses an excel file because sustainable upgrades are look at as projects with defined beginnings and endings while the Peterborough case uses a program that does not necessarily have a defined start and end date. However, each released offender could also be viewed as a project with a defined beginning (release from prison) and ending (graduation from the program). Therefore, the TAMU case's program success is hinged on a smaller population of projects with a larger impact. Sustainability SIB programs could then incorporate projects across different owners to increase the total value of the SIB.

Table 8: Formal Model structure Comparison between TAMU and HMP Peterborough

Item	Peterborough Specific	TAMU Specific	Similarities
Existing Program Structure	Project Management Rework structure limits the programs effectiveness by the flow of offenders	Reference Table exogenously impacts the reduction and forces a limited impact.	Reductions in performance are measured based on the cost of funding the intervention
Degradation of program effectiveness	Assumes that new offenders are a constant value and thereby need constant intervention.	The efficiency loop operates under an assumption of limited improvement where an intervention is a one time investment.	The conservation portion of TAMU is similar to Peterborough with an inflow of new material (offenders/users)
Performance Measurement Structure	Stock flows representing occurences in separate systems.	Exogenous inputs referenced by an excel file	Both systems measure the savings or a reduction in use by the intervention.
Repayment of Investment	Accumulation as a portion of the savings from the performance measurement structure	exogenous value driven by contractual terms.	Both systems draw repayment from an accumulated savings account.
Financial Structure	Program payments occur after measurements can be confirmed from the program performance	Program payments are guaranteed and exogenously applied	Payments are based on either actual or projected savings
Debt accumulation	Debt is accounted to the owner when success is measured	Debt is accounted to the owner before the program proceeds.	Both models account for program degredation due to insuficient funds.

Model Results Comparison

Last, the study compares the similarities and differences of the model results from the statistical screening analysis. This comparison shows the rank order of the four most influential variables for the investors and owners in both projects.

Table 9, above, identifies three similarities/ differences from the model analysis resultants: program effectiveness, Unit Use Cost, and unit program cost. In both projects the owner and investors have highly correlated coefficients for program effectiveness. The TAMU owner and the Peterborough Investor have highly correlated values for the Unit Use Cost (Unit Conviction Cost and Cost of Energy—they are the unit cost that the owner expends in their use of the system). Both the owner and investor have significantly correlated values for the unit program cost. The common variable(s), program effectiveness, exists in the TAMU case because investor directly seeks to improve/ reduce the energy consumption for state agencies; however, the Peterborough case uses generic investors and is able to align their goals for both program effectiveness and cost. Therefore, a SIB could have provided the investment for the TAMU case in lieu of the SECO without altering the design to reduce energy costs.

Table 9: Model Results Comparison between TAMU and HMP Peterborough

	TAMU		Peterborough		KEY
Rank Order	Owner	Investor	Owner	Investor	
First	Fraction of Savings	Program Effectiveness [Electricity]	Program Effectiveness	Program Effectiveness	Program Effectiveness
Second	Cost of Energy	Program Effectiveness [Cold Water]	Maximum Cohort Size	Unit Program Cost	Unit Use Cost
Third	Program Effectiveness [Electricity]	Program Effectiveness [Hot Water]	Normal Recidivism Fraction	Unit Conviction Cost	Unit Program Cost
Fourth	Program Effectiveness [Hot Water]	None Significant	Unit Program Cost	Investor Discount Rate	

Fitting the SIB Criteria

In this portion both the TAMU and Peterborough cases are aligned with the seven SIB criteria outlined by the Young Foundation.

Preventative Interventions

Preventative intervention means the system has excess waste that could be avoided if funding were available. Mulgan et al. (2011) site an example of an adult reoffending case—similar to Peterborough—where the charitable sector is capable of providing services to released offenders; however, the charitable sector is dependent on the generosity of donors.   This explains why a LTG structure can be identified in the CLD without a SIB.

Row 1: Peterborough and TAMU Criteria 1 for a SIB

	Criteria	Description	Peterborough	TAMU	Adult Reoffending (Example)
1	Preventative intervention	The intervention is preventive in nature and sufficient funding for the intervention is currently unavailable	The charitable sector has programs that reduce the reoffending, but have no incentive to invest beyond donations.	New technology provides a means of reducing consumption, but the benefits of new technology are often balanced with their costs.	The charitable sector is well equipped to provide support services to reduce reoffending.

Both the Peterborough and TAMU case target actions or system uses that can be prevented or holistically reduced. In Peterborough case, One Service (the conglomerate of NGOs) works with offenders after their release to prevent or reduce their likelihood of recidivating. In the TAMU case, contractors install energy efficient equipment to reduce energy consumption. The constrained LTG CLD for both the Peterborough and TAMU cases explains the preventative nature and insufficient funds for both of the improvements (See Figure 29 and summary of CLD in Table 7).

Discussion: Pass

Both the TAMU and Peterborough cases are trying to reduce consumption due to waste. In the Peterborough case, the NGOs are funded to work with released offenders to reduce their recidivism. In the TAMU case, the systems are upgraded to reduce the consumption of energy. Therefore, both cases provide a means of generating savings that could reduce expenses to the owner.

Improves Wellbeing in an Area of High Social Need

Improving wellbeing in an area of high social need means the target population exists below the national median and mean and is economically better off after the intervention. The example offered in Mulgan et al. (2011) provides similar statutory support as the Peterborough case by targeting young adult offenders with high recidivism due to their environment. This illustrates a characteristic need in both cases to provide social benefit.

Row 2: Peterborough and TAMU Criteria 2 for a SIB

	Criteria	Description	Peterborough	TAMU	Adult Reoffending (Example)
2	Improves wellbeing in an area of high social need	The intervention improves social wellbeing and prevents or ameliorates a poor outcome	The programs provide accountability, loans, and assistance in finding housing for released offenders.	The TAMU interventions have a broad social impact that is not confined to specific social groups.	The prison population stands at 85,276 (15th October 2010). Short term offenders who serve a sentence of 12 months or less are not provided statutory support, and frequently return to a life of crime

Both TAMU and Peterborough provide social benefits to society; however, the benefits of TAMU's sustainable improvement are non-discriminatory of socio-economic status. The Peterborough case targets short term offenders who benefit from offending and create a social cost; conversely, TAMU provides the benefits of lower energy use leading to better air quality and lower energy cost. As energy consumption is lowered, the TAMU utility cost is lowered by the consumption, and the cost of alternative supply side solutions is also decreased; however the TAMU sustainability case has a significant quality that other sustainability cases may not contain. The greatest fiscal beneficiaries in the TAMU project are the students whose fees do not need to cover a growing demand for energy. In other cases these primary benefits may target private sector holdings. This explains how both cases improve the wellbeing of low socio economic groups; however, it also explains how sustainability projects like TAMU affect the financial wellness of students and the environmental quality surrounding the projects.

Discussion: Pass

The TAMU case was selected for its application in the education industry for both public and private sectors. As a university, the primary consumers are students. In

July of 2013 the Huffington post reported that the average student loan debt would eclipse the median annual income within the next 10 years (Fairchild, 2013). Not all sustainability project target universities or organizations directly impacting a low socio-economic group. While general sustainability projects do not target specific social hierarchies, they still provide a social good—improved air quality, aesthetically appeasing, reduced energy demand (Kibert, 2008; Kats, 2010). Therefore, a SIB may generalize its impact on low socio-economic groups for sustainability projects because sustainability projects do not discriminate by socio-economic status.

Evidence of Efficacy

Evidence of Efficacy means the intervention has shown success in similar or comparable cases. The Peterborough case sites 30 years of work showing the benefit a proactive approach. The benefits of the case are well documented, See Mulgan et al. (2011). This explains the need for formal documentation on the workings of the preventative interventions. The TAMU used established tests from the US Green Building Council (USGBC) (Van Der Like & Meehan, 2009).

Row 3: Peterborough and TAMU Criteria 3 for a SIB

Criteria	Description	Peterborough	TAMU	Adult Reoffending (Example)
Evidence of efficacy	The intervention is supported by evidence of its efficacy and impact, giving funders confidence in the scheme's likely success	Studies show an average change in recidivism of (-20%) when charitable organizations are involved.	Studies have shown how green (sustainable) improvements reduce energy consumption.	Review of the last 30 years shows consistency and strong results for the success of intervention programs (Lipsey & Cullen, 2007)

Both the TAMU and Peterborough cases use successful intervention/alterations that led to a cost savings. The Peterborough case estimates an average of 20% reduction in recidivism for short-term offenders (Mulgan, Reeder, Aylott, & Bo'sher, 2011). The

TAMU case, backed by Siemens, uses different sustainable improvement projects to reduce energy consumption, see Kats (2008) and Van der Like and Meehan (2009) for more on the cost savings for sustainable projects. This explains how both TAMU and Peterborough meet the third SIB criteria for evidence of efficacy (see Table 10 for sources and values).

Table 10: Example Program Types and Effectiveness

Program Name	Program Type	Reduction Value	Source
St. Giles Trust	Prison Rehabilitation	20%	Mulgan et al. (2011)
Bridges to Life	Prison Rehabilitation	>50%	BTL (2011)
Solar Hot Water Heater	Hot Water Energy Reduction	70-90%	EnergyStar(2006)
Conservation Promotion Program	Reduce Demand on Energy needs	12%	Kim et al. (2012)
TAMU Case	Electricity Reduction	12%	Kim et al. (2012)
TAMU Case	Water Heating and Cooling Reduction	19%	Kim et al. (2012)

Discussion: Pass

While both studies use historical data to display evidence of effectiveness, the sustainable improvements in the TAMU case have received a lot more attention than prison rehabilitation due to decrease in delay between outcomes. In the Peterborough case the SIB is used to establish a new steady state for the prison system operations while the TAMU case realizes most of the risk early on in the program. The TAMU project is still subject to the volatility of the energy markets and additional maintenance costs (Vine, 2005); however, the benefits of many sustainable projects are almost instantaneous. Therefore, if TAMU were to use a SIB, then the payments could be more periodic when successful.

Measureable Impact

Measurable Impact means the outcomes of the system can be measured. The example descriptor by Mulgan et al. (2011) uses the national computer base to look at the reconviction of released offenders. The system provides the information for both the target group and its comparison. This explains how SIB impact is expected to be measured.

Row 4: Peterborough and TAMU Criteria 4 for a SIB

	Criteria	Description	Peterborough	TAMU	Adult Reoffending (Example)
4	Measureable impact	Whether it is possible to measure the impact of the intervention accurately enough to give all parties confidence of the intervention's effect, including a sufficiently large sample size, appropriate timescales and impacts that closely related to the savings and relatively easy to measure	National data bases provide information on sentencing and release. Recidivism is measured for three years.	Historical data records prior to the improvements are compared to the current values after the improvements.	Data on reoffending and sentencing outcomes are held by the Police National Computer. Most reoffending occurs in the first two years after release, and is typically measured at one and two years.

The Peterborough and TAMU cases both provide means of measuring the success of the programs. The Peterborough case uses the reduction of recidivism that can be obtained by acquisitioning data from the police national data bases. TAMU uses the savings of energy confirmed by the use of calibrated models such as DOE2. This explains how both the TAMU and Peterborough cases satisfy the fourth criteria for a SIB.

Discussion: Pass

The Peterborough case is able to use a two model method for comparing prisoner recidivism, but the TAMU case must rely on historical data models to verify savings in energy costs. A SIB does not resolve problems or issues in measuring the success of sustainability projects. However, the USGBC has shown that owners and investors can successfully agree on realized benefit measurements (Van Der Like & Meehan, 2009). Therefore, the paid from savings structure that exists in a SIB already has precedents in sustainability projects.

Aligns Incentives

Aligning incentives means the use of a SIB creates a symbiotic relationship between the key stakeholders. The example from Mulgan et al. (2011) describes this as the alignment of funds allowing the charitable sector to continue their interventions. In a traditional use-it-or-lose-it budget setting, the MOJ would return all savings from their prison systems. Donors with altruistic tendencies would donate to the program, but only what they felt it was worth the donation. The public nature of recidivism reduction leaves the programs underfunded; however, with a SIB, altruistic donors become incentivized to increase their donations because successful programs receive returns. A successful program yields returns that can then be reinvested and eliminate the siphoning of savings that would otherwise be removed from the prison budget (see Figure 5 R2). This explains how alignment of incentives can be defined in a SIB.

Row 5: Peterborough and TAMU Criteria 5 for a SIB

	Criteria	Description	Peterborough	TAMU	Adult Reoffending (Example)
5	Aligns incentives	A specific government stakeholder achieves savings or lower costs as a result of actions undertaken by others. These savings need to be cash releasing and provide an actual saving to government stakeholders	The MOJ and the Investors take interest in program effectiveness and costs.	In the calibrated case, TAMU is concerned about savings leaving their investment options for sustainable finance to investors with a stake in the energy reduction.	A SIB realigns the incentives for private sector intervention to encourage greater preventative action. The money saved, as a result of reduced offending, by the central government can be used to repay investments.

The TAMU and Peterborough cases have similar variables in their statistical screening rankings (see Table 9). Program Effectiveness is a significant variable for the owners and investors in both cases. The measurement reduction's cost is also a significant variable in both cases; however, the variable is significant to the owner of the TAMU case and the investor of the Peterborough case. In the Peterborough case, where the SIB is used, the unit program cost is also a significant variable. This explains how the Peterborough and TAMU case match with the fifth criteria for a SIB.

Discussion: Pass

The TAMU case uses an investor whose interest is rooted in the reduction of energy for state agencies (Combs, 2013); however, the Peterborough case does not discriminate against risk neutral investors. Despite TAMU's beneficial investors, the Peterborough case was able to align investor and owner concerns about the program costs and effectiveness. Therefore, the use of a SIB for a sustainability project, such as TAMU, could be used to aligning the incentives of the investor and the owner by targeting specific investors with knowledge and experience in sustainability.

Savings Greater than Costs

A savings greater than the costs of intervention means the system and the evidence of efficacy must be profitable. Mulgan's et al. (2011) example calculates the average cost and benefit for someone entering the program at a success rate of 10%. Mulgan et al. (2011) cite an immediate savings, within 3 to 4 years of investment, greater than 1.5 times the value of the investment; however, the modeled savings show that the perpetual savings, once a new steady state has been achieved, to be equal to 4-6 years of the program operating costs, at a 20% success rate. This illustrates the finite means for a successful SIB to calculate the costs and savings opposed to the savings that would be captured into perpetuity.

Row 6: Peterborough and TAMU Criteria 6 for a SIB

	Criteria	Description	Peterborough	TAMU	Adult Reoffending (Example)
6	Savings greater than costs	The savings for the specific government stakeholder are relatively immediate and much greater than the cost of the intervention and transaction costs. This provides investors with enough return to absorb the risks inherent in the scheme, and can provide significant funds for social investment	The calibrated case shows that the investors and owner are better off at the minimum program effectiveness value.	The yearly savings from the model results in a value above 10% of the intervention cost. The delay for sustainable options is less than a year (1 month).	The model shows that once the program has entered a steady state the savings is equal to 4-6 years of intervention costs. The delay to reach those values is about 8 years. The immediate estimated cost per person is £1,500 and result in an estimated benefit of £2,300 per person.

Figure 30 shows both the TAMU and Peterborough cases result in savings that are greater than their costs. While the savings from the Peterborough case eventually reach over 80% of the payback in a single year, the accumulated savings from the program, as it progresses, reduce the reconviction rate and cover the cost of prison holdings when investor returns are due. The TAMU case has less delay and provides less of a return (just over 10% per year). The savings captured in real time are more sensitive to the fraction of savings reclaimed by the owner agency. This explains how both the TAMU and Peterborough cases meet the finite requirements for the sixth SIB criteria that savings exceed costs.

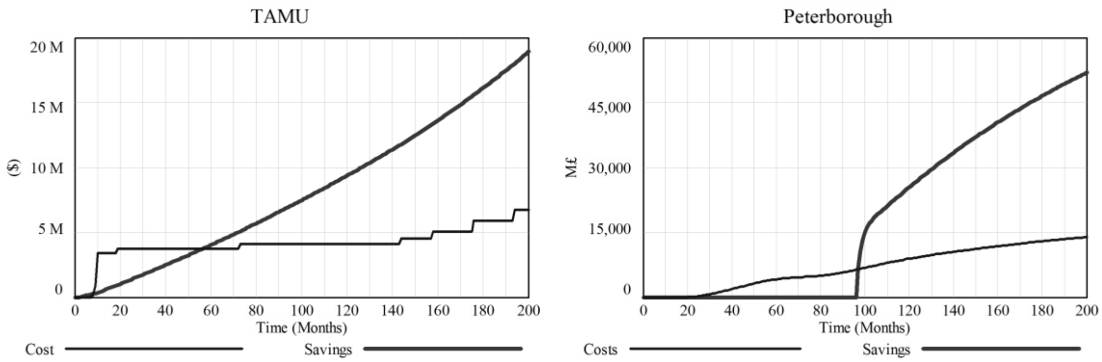

Figure 30: Peterborough and TAMU Cases Costs and Benefits over Time

Discussion: Pass

The Peterborough case has a significantly longer delay to their steady-state savings, and also has a larger portion of savings to intervention cost ratio compared to the TAMU case. Once at a steady-state, savings from the Peterborough case snowball in a virtuous cycle. The calibrated case for Peterborough used upper and lower limits to hedge the delayed savings effect for investors (Cave, Williams, Jolliffe, & Hedderman, 2012). Conversely, the TAMU case reaches a steady-state more quickly, but has a smaller savings to intervention ratio. Therefore, sustainability SIBs may have a longer life than short-term offender intervention program SIBs.

Government Preference for a SIB

The final criteria listed in Mulgan et al. (2011) establishes the prerequisite laws and regulations for a SIB to operate by setting the governing preferences for a SIB. In Mulgan's et al. (2011) example the government is committed to reducing offending rates through proactive programs; however, in conjunction with the first criteria, funds within the budget of the MOJ do not exist for the interventions. Therefore, the government must allow for the influenced agencies to capture the savings from the programs.

Row 7: Peterborough and TAMU Criteria 7 for a SIB

	Criteria	Description	Peterborough	TAMU	Adult Reoffending (Example)
7	Government preference for a SIB	Government policy for the specific agenda is keen on or at least open to the use of a SIB	MOJ commits to pay savings from the programs' ability to reduce recidivism.	Guarantee is used, but in some cases the ESCO funds the programs under promise of payment from savings.	The Government is committed to a 'Rehabilitation Revolution', that would fund up-front activities designed to reduce later offending rates.

Both the Peterborough and TAMU cases make allowances for repayment; however, the ESCO uses a guarantee instead of funding the improvements. The MOJ commits to repaying the investors for a successful program in the Peterborough case by allowing the prison system to accumulate savings from their normal budget, without the intervention. The TAMU case makes similar provisions to repay the SECO; however, if the program is unsuccessful, then Siemens, the ESCO, repays the loan. Therefore, in both cases the owner agency establishes two critical policies: first an agreed upon measure between stakeholders that relates the success of the programs to financial savings, and second an allowance for an accumulation of those savings that results in a return to the investor/ lender. This explains how both cases satisfy the seventh criteria from Mulgan et al. (2011).

Discussion: Void

Both the TAMU and Peterborough case use a "sole proprietor" assumption that SIBs can only be operated by governing agencies or public organizations. While SIBs target social benefit that are underfunded and result in inflated government budgets addressing symptoms instead of causes, the nature of a SIB resemble the outsourcing of R&D. Government organizations are paying private investors to find successfully innovative social practices. Sustainability not only transcends social hierarchy, but public and private domain as well. Therefore, "Government" may be substituted with "The influenced organization" as the beneficiary/owner(s) may not be under government provisioning.

Summary of Assessment

In summary the seven criteria outlined by Mulgan et al. (2011) was used to compare the TAMU and Peterborough case in the determination of sustainable project satisfying, failing or nullifying the criteria. The assessment was broken into two categories where the first established the characteristics of the model and case for both Peterborough and TAMU and the second aligned those characteristics with the criteria from Mulgan et al. (2011). Table 11 below, lists the summary assessment for the TAMU case, Peterborough case and one of Mulgan's examples compared with the seven criteria.

Table 11: SIB Criteria for Peterborough and TAMU

	Criteria	Description	Peterborough	TAMU	Adult Reoffending (Example)
1	Preventative intervention	The intervention is preventive in nature and sufficient funding for the intervention is currently unavailable	The charitable sector has programs that reduce the reoffending, but have no incentive to invest beyond donations.	New technology provides a means of reducing consumption, but the benefits of new technology are often balanced with their costs.	The charitable sector is well equipped to provide support services to reduce reoffending.
2	Improves wellbeing in an area of high social need	The intervention improves social wellbeing and prevents or ameliorates a poor outcome	The programs provide accountability, loans, and assistance in finding housing for released offenders.	The TAMU interventions have a broad social impact that is not confined to specific social groups.	The prison population stands at 85,276 (15th October 2010). Short term offenders who serve a sentence of 12 months or less are not provided statutory support, and frequently return to a life of crime
3	Evidence of efficacy	The intervention is supported by evidence of its efficacy and impact, giving funders confidence in the scheme's likely success	Studies show an average change in recidivism of (-20%) when charitable organizations are involved.	Studies have shown how green (sustainable) improvements reduce energy consumption.	Review of the last 30 years shows consistency and strong results for the success of intervention programs (Lipsey & Cullen, 2007)
4	Measureable impact	Whether it is possible to measure the impact of the intervention accurately enough to give all parties confidence of the intervention's effect, including a sufficiently large sample size, appropriate timescales and impacts that closely related to the savings and relatively easy to measure	National data bases provide information on sentencing and release. Recidivism is measured for three years.	Historical data records prior to the improvements are compared to the current values after the improvements.	Data on reoffending and sentencing outcomes are held by the Police National Computer. Most reoffending occurs in the first two years after release, and is typically measured at one and two years.
5	Aligns incentives	A specific government stakeholder achieves savings or lower costs as a result of actions undertaken by others. These savings need to be cash releasing and provide an actual saving to government stakeholders	The MOJ and the Investors take interest in program effectiveness and costs.	In the calibrated case, TAMU is concerned about savings leaving their investment options for sustainable finance to investors with a stake in the energy reduction.	A SIB realigns the incentives for private sector intervention to encourage greater preventative action. The money saved, as a result of reduced offending, by the central government can be used to repay investments.
6	Savings greater than costs	The savings for the specific government stakeholder are relatively immediate and much greater than the cost of the intervention and transaction costs. This provides investors with enough return to absorb the risks inherent in the scheme, and can provide significant funds for social investment	The calibrated case shows that the investors and owner are better off at the minimum program effectiveness value.	The yearly savings from the model results in a value above 10% of the intervention cost. The delay for sustainable options is less than a year (1 month).	The model shows that once the program has entered a steady state the savings is equal to 4-6 years of intervention costs. The delay to reach those values is about 8 years. The immediate estimated cost per person is £1,500 and result in an estimated benefit of £2,300 per person.
7	Government preference for a SIB	Government policy for the specific agenda is keen on or at least open to the use of a SIB	MOJ commits to pay savings from the programs' ability to reduce recidivism.	Guarantee is used, but in some cases the ESCO funds the programs under promise of payment from savings.	The Government is committed to a 'Rehabilitation Revolution', that would fund up-front activities designed to reduce later offending rates.

From the seven criteria the TAMU project shows that sustainability projects have the potential to meet all seven criteria; however, the final criteria may be voided. In the

TAMU case the owner is a public school; however, "Government" may be substituted with "The influenced organization" as the beneficiary/owner(s) may not be under government provisioning for sustainability projects. Both the TAMU and Peterborough cases provide a means of generating savings that could reduce expenses to the owner. Conditionally, in a sustainability project, a SIB may generalize its impact on low socio-economic groups; however sustainability projects do not discriminate by socio-economic status. Furthermore, the more instantaneous success of sustainability projects like the TAMU case would provide more periodic payments when successful. Even though the resultants may be measured faster, these sustainability projects may have a longer life than short-term offender intervention programs due to smaller savings capacity. The paid from savings structure that exists in a SIB already has precedents in sustainability projects and the use of a SIB for a sustainability project, such as TAMU, could align the incentives for the investor with owners desires by specifying the pay for success structure to investor returns. Therefore, a SIB could be used for a sustainable improvement project like TAMU.

Conditionally, a SIB-like financial structure could be used for sustainability projects; furthermore, under the right conditions ESCOs may already implement a SIB-like structure. The LTG archetype was selected as the most similar. A SIB could have provided the investment for the TAMU case in lieu of the SECO without altering the design to reduce energy costs. TAMU would not benefit from the shifting of risk because the ESCO has already assumed the owner's risk by using a guarantee; however, a SIB could benefit the ESCO by creating a market opportunity for investors to share in the risk and rewards of the project. The TAMU case's program success is hinged on a smaller population of projects with a larger impact. Sustainability SIB programs could then incorporate projects across different owners to increase the total value of the SIB. Both the TAMU and Peterborough cases require multi-year investment commitments. The difference in intervention costs and available savings increases the expected duration for investment in the TAMU case, while the increased delay in results increases the expected duration for investment in the Peterborough case (ceteris paribus). The application of a SIB in the TAMU case could include revenue production with the cost savings because some sustainable improvements incorporate energy production and energy reduction options. The use of a SIB could expand the investor options of sustainability programs beyond agencies with specific goals in energy reduction. Therefore, if an ESCO were to establish a pay from savings contract with investors for sustainability improvement and provide funding for the improvement to an owner in an area that would enforce the proper contractual obligations, then an ESCO would be using a SIB-like structure for a sustainability project.

CHAPTER VII

CONCLUSION

Summary

SIBs are a new financial tool to improve social issues including environmental and health issues. The Peterborough case examines the application of SIBs for social issues

The seven criteria outlined by Mulgan et al. (2011) were used to compare the TAMU and Peterborough cases to determine if the sustainable project satisfies, fails or nullifies the criteria. The assessment was broken into two categories where the first established the characteristics of the model and case for both Peterborough and TAMU and the second aligned those characteristics with the criteria from Mulgan et al. (2011). Table 11 listed the summary assessment for the TAMU case, Peterborough case, and one of Mulgan's examples used to define the seven criteria.

The TAMU case shows that sustainability projects have the potential to meet all seven criteria; however, the final criteria may be voided. In the TAMU case the owner is a public school. If TAMU was not a public school, and a SIB were used, then the owner would be a private entity. Therefore, "Government" may be substituted with "The influenced organization" as the beneficiary/owner(s) may not be a government organization for sustainability projects.

Conditionally, a SIB generalizes its impact on low socio-economic groups when the projects are associated with an organization whose clientele is primarily or significantly made of that grouping. In the Peterborough prison system, a significant portion of the short term offenders fit the criteria as low socio economic. Similarly in the TAMU system, a majority of students may be classified as low socio economic. Therefore sustainability projects' benefits do not discriminate by socio-economic status because the benefits (aside from the reduced energy bill) are shared across all of society.

The comparison identified two impacts on the payback period for a SIB, the delay to savings and the impact of the intervention. The budget for the Peterborough Prison system is 3 times the energy cost in the TAMU system which reduces the available returns for a sustainability program. Conversely, the TAMU case, a sustainability program, has more instantaneous success while the Peterborough case, a short term offender rehabilitation program, has a longer delay to savings. The delay in savings reduces the immediate returns of the Peterborough case. This illustrates why the TAMU and the Peterborough cases have a relatively similar payback period (8-10 years).

Both the TAMU and Peterborough cases provide a means of generating savings that could reduce expenses to the owner. The paid from savings structure that exists in a SIB already has precedents in sustainability projects and the use of a SIB for a sustainability project, such as TAMU, could align the incentives for the investor with the owner's desires by specifying the pay for success structure to the investor returns. Therefore, the comparison supports a hypothesis that a SIB could be used for a sustainable improvement project like TAMU.

Conclusions

Conditionally, a SIB-like financial structure could be used for sustainability projects if an ESCO seeks external funds from private investors using a high risk performance bond. The possibility exists that ESCOs may have already implemented a SIB-like structure. Sustainability projects use the same LTG archetype constrained by program improvements and the available savings as a SIB program. A SIB could have provided the investment for the TAMU case in lieu of the SECO without altering the design of reduce energy costs. In a sustainability project, a SIB would shift the risk of new technology from the owner to the investors. Even though TAMU would not benefit from the shifting of risk because the ESCO has already assumed the owner's risk by using a guarantee, a SIB could benefit the ESCO by creating a market opportunity for investors to share in the risk and rewards of the project. Therefore, SIBs shift the risk from the owner, like a guarantee, and also provide an additional source for funding via outside investors that can be used by sustainability improvement programs; however, unlike a guarantee, a SIB would shift the risk to the investors instead of the ESCO.

The pay from savings structure separates the guarantee in the TAMU case from the SIB structure in the Peterborough Case. Both the TAMU and Peterborough cases require multi-year investment commitments. The TAMU case's program success is hinged on a smaller population of projects each with a larger impact. Sustainability SIB programs could then incorporate projects across different owners to increase the total value of the SIB. The difference in intervention costs and available savings increases the expected duration for investment in the TAMU case, while the increased delay in results increases the expected duration for investment in the Peterborough case (ceteris paribus). The application of a SIB in the TAMU case could include revenue production with the cost savings because some sustainable improvements incorporate energy production and energy reduction options. The use of a SIB could expand the investor options of sustainability programs beyond agencies with specific goals in energy reduction. Therefore, in an area that would enforce the proper contractual obligations, an ESCO could consider the use of a SIB-like structure for sustainability projects.

SIBs present a familiar strategy to ESCOs as a possible strategy for funding sustainable improvement projects where the owner struggles with uncertainty of the sustainable improvements and is unable to acquire the capital for such projects. Both the TAMU and Peterborough cases show the similarity between the program characteristics in sustainability projects and social improvement programs. The TAMU case is capable of passing the seven criteria outlined by Mulgan et al. (2011) for determining whether a SIB is applicable. Therefore, the results of the study find that SIBs are a plausible financial structure for sustainable improvements.

Contributions

This paper has six major contributions to practice and research:

1. Usefully models the Peterborough SIB case:

    The SIB model is useful for determining the impact different policies have on system outcomes for a SIB in the Peterborough case. This provides practitioners with a useful means of testing different scenarios for SIB success/ failure.

2. Identifies a possible BIS case for SIB application:

   The TAMU case and other sustainability improvement projects for universities make ideal candidates for the use of a SIB structure.

3. Identifies existing structures in BIS case for SIB functions:

   The structures required for a SIB (pay for performance, pay from savings, investors, third party assessors, special purpose vehicles, etc.) are already used through ESCOs for sustainability projects.

4. Compares the structures and outcomes of the SIB and BIS cases.

   The BIS case is able to return practical savings faster, and the social SIB is able to return a greater savings in the long run. Both projects present a preventative intervention through energy saving improvements or social programs. While both projects are able to align the incentives of program effectiveness, the SIB is also able to align the unit program cost.

5. Establishes an example of how a BIS case fulfills the SIB criteria.

   BIS is a preventative intervention, with measureable outcomes that benefit a broad range in society. This shows how BIS cases can extend the definition of "socio-economic" and alter the requirements for government sponsorship.

6. Establishes the foundations for SIB application in a BIS project.

   Furthermore, a SIB presents a viable opportunity for TAMU project if the funds from the State were not available.

Implications for Practice

The contributions of this study can be separated into two categories based on their implications for practice. These define the application and structure of a SIB in sustainability:

1. The study assesses how sustainability projects align with the seven criteria outlined by Mulgan et al. (2011) and
2. Identifies the precedents in industry for the proper establishment of a sustainability SIB.

Therefore, this study has direct value to practitioners interested in implementing SIBs in their own field of practice.

SIBs are a new financial tool without a lot of information describing their application in different fields. From this study practitioners and researchers find the practical application of a SIB-like structure for sustainability projects. The TAMU project is an example case where SIBs could be used to fund sustainability projects. Sustainability projects fit with the constrained LTG archetype. Facility managers and owners may not wish to assume risk of new technology for sustainable development, yet there are substantial savings in support of sustainability projects with measurable results. This illustrates the applicability SIBs could have on sustainability projects by aligning with the seven criteria outlined by Mulgan et al. (2011).

Additionally, the study found similar processes required in a SIB that are used by ESCOs. For a SIB to work it requires measurable performance outcomes like the contractual measures used by ESCOs for their guarantees. One alternative to a guarantee is for the ESCO to fund the improvements and then share in the savings as a return. A significant added benefit that a SIB provides over the current ESCO structures is that a SIB is a tradable commodity. This illustrates the existing structures established by ESCOs that align with the operation of SIBs.

Therefore, the study expands on the current body of knowledge for SIBs and ESCOs by defining key synergy between the two tools. Sustainability projects have similar project structures as SIB programs and meet the requirements for SIB application. ESCOs have established business process required for SIB implantation and SIBs provide an additional source of funding for more sustainability projects. This summarizes the contribution that the project makes by identifying the use of SIBs for ESCOs in funding sustainability projects.

Implications for Research

This study identifies the challenges with SIB-like structures being implemented in the TAMU case. As the first assessment of SIB application in a sustainability program research must look at the strengths and weaknesses of both the assessment—using Mulgan's et al. (2011) criteria—and conclusions drawn for further validation of the environment a SIB induces—the changes in behavior through the alteration of incentives and more. The next step would be to include a SIB-like structure into a sustainability project using the information found in the modeling and comparison sections of this study. Then research on this topic should move toward answers to the question of what makes a SIB successful for sustainability projects.

According to this study, a SIB-like structure could be an effective means of funding sustainable improvements when funds are otherwise not available for profitable projects. There are significant characteristic similarities between the TAMU and Peterborough cases that provide evidence to support the TAMU case's ability to meet all of the SIB criteria outlined by Mulgan et al. (2011). The primary concern for practitioners wanting to enact a SIB like structure for sustainability projects is the legal obligations and structures allowing for a pay from savings bond. In areas where these structures exist, ESCOs could establish funds for improving the sustainability of an area. The development of sustainability SIBs for large urban or metropolitan areas could then improve the quality of life and environment around them. Therefore, researchers should look to state and local governments to establish the laws and regulations that would allow SIBs to measure, capture, and return savings from sustainability programs.

Additionally, SIB-like structures for sustainability projects may already be in use by ESCOs. Some ESCOs already provide the project financing for a portion of their projects with returns in the form of pay-from-success payments. The last step would be for the ESCO to establish a performance bond for the project and allow investors to carry equal rates of risk and reward from the project. ESCOs already work with state and local governments to capitalize on sustainability improvement, by selling these bonds to citizens that want to improve the quality of their communities the funds would be directed toward the areas with the greatest returns.

Therefore, the study expands the current knowledge of SIBs by modeling their structures and expanding their uses to a new area of social improvement. This study is the first to assess the application of a SIB for sustainability projects and establishes a basis for other studies to move forward. This summarizes the contribution of this study to expand research in the development of SIB by providing a first look at SIB application in sustainable development financing.

Assessment of the Research

This research project closest resembles the pre-experimental design of static-group comparison (Campbell & Stanley, 1963). It is the first assessment for applicability of a SIB toward sustainability projects and is the first to compare between two cases, one representing a known SIB program and the other representing a known sustainability improvement program. The SIB program is known to meet all SIB requirements and the BIS case is tested in comparison with the SIB requirements.

Campbell and Stanley (1963) note the strengths of this study in four areas of internal validity: history, testing, instrumentation, and regression. They also define four weaknesses (3 for internal validity and 1 for external validity) in: selection bias, experimental mortality, selection-maturation interaction, and the interaction effects of selection bias. These weaknesses are seen in the two points of the study:

1. The SIB is able to align investor incentives while TAMU uses investors whose mission is to reduce energy consumption. The investor in the TAMU case, the SECO, was established to reduce energy consumption by the state. The endogeneity of an investor whose goals align with sustainability projects impact the investors' satisfaction when generalized. An obvious selection bias for the

TAMU case where the effects of a SIB will be influenced by investors with an external effect.

2. SIBs shift the technology risk (or the basis risk) on the investors while the TAMU case shifts the risk onto the ESCO by using a guarantee. The guarantee presents another bias in the TAMU case where the owner's use of a SIB to diminish the impact of their losses may be influenced by the presence of a guarantee in the TAMU case.

This explains both the strengths and weaknesses of the study as a static group comparison.

Future Research

There are five major points of research that could be expanded from this project. The first two address weaknesses of the study by expands on the decision making process for ESCOs as well as owners deciding whether or not to contract an ESCO and the development of the model for both Peterborough and TAMU to provide further application and even the integration of the different financial structures. The third addresses the issues that could be identified under the continuous testing of the model structures. The fourth addresses a survey of general legal allowances and how the requirements for a SIB compare to their current standings. The fifth addresses the performance evaluation and integration of sustainability measures in a balanced score card. These five topics would expand on this research topic by providing more answers to questions about endogeneity, limitations of externalities, historical application from the ESCO's perspective, as well as the practical application of sustainable pay from success measures.

On a similar note, SIBs in sustainability provide an opportunity to study the effectiveness of different program options in a variety of locations. The enactment of SIBs for sustainability projects would provide researchers with an abundance of data for analysis by creating measurable standards that are tracked with lists of what and when improvements were made. The use of SIBs for sustainability would allow researchers to more effectively study the impact of various sustainable interventions and identify the weakness of current sustainable improvement programs. These weaknesses could provide key insight into where researchers could find future developments that further reduce the consumption or waste from the built infrastructure industry.

The TAMU-Peterborough case is used in the comparison as a sustainability case to assess the similarities and differences with a known SIB program. The study finds that the program of the Peterborough case and the projects in the TAMU case share common ground in criteria for the SIB. Since the ESCO industry is not surveyed and the results of Vine (2005), Hansen, Langlois, and Bertoldi (2009) does not carry the decision tree for ESCO funding options, the study can only piece together possible scenarios where an ESCO would establish a SIB-like structure for a sustainability project. Therefore, the study lacks support from the practical use or application by ESCOs because there is no predecessor requesting or pointing to the lack of knowledge.

Closing

The research has assessed the usefulness of SIBs for sustainability programs and has found that the structures needed for SIBs to work in sustainability projects already exist. The results and conclusion support the continued research and development of SIBs as an innovative financing method and tool for social issues.

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APPENDIX I

PETERBOROUGH MODEL SUPPORTING DOCUMENTS

This appendix details the supporting documents for the Peterborough Model including the Equations, Stock Flow Diagrams, Exogenous Variable Values, Extreme Conditions Testing, values used for Statistical Screening Analysis, and additional testing results.

Equation List

Legend

Variable Name

Equation or Value

Units

Description

Equations

Accumulated Reconvictions Prevented Percent [Cohorts] =

*ZIDZ ((Number of Reconviction [Cohorts, Comparison]/Offender Multiplier between Prison Systems [Comparison]-Number of Reconviction [Cohorts, Peterborough]/Offender Multiplier between Prison Systems [Peterborough]), (Number of Reconviction [Cohorts, Comparison]/Offender Multiplier between Prison Systems [Comparison]))*100*

Units: Dmnl

This represents the accumulated percent of prisoners kept out of prison.

Actual Cohort Closing Times [Cohorts] =

INTEG (Cohort Time [Cohorts], 0)

Units: Month

This represents the ending time of the cohorts based on the rules of Cave et al. (2012).

Actual Cohort Start Times [Cohorts] =

INTEG (Cohort Time Delay Rate [Cohorts], 0)

Units: Month

This is the actual start time of the project. The time is accumulated to account for the rules set forth by Cave et al. (2012).

Amount Investors are willing to Invest=

INTEG (-Investing, Expected Program Investment amount)

Units: k£

This represents the amount of capital that the Investors are have set aside to invest in the program. This stock is located in both Social Finance (2011) and Glahn & Whistler (2011).

Available Capacity=

XIDZ (Funds Available for the Program, Program Cost per Member, 99999)

Units: People

This represents the estimated number of people that can be admitted into the program and is an author defined variable based on the fund available for all the cohorts.

Average Prisoner Incarceration Rate for Peterborough=

57.8333

Units: People/Month

This represents the maximum number of new people that can be placed in the prison system; all other prisoners must go to a different prison system. 57.83333 is the average for 2008 according to Cave et al (2012).

Average Time between Release and Reconviction [Prison Systems] =

Normal Recidivism Discovery Time

Units: Month

The average amount of time it takes to convict a resent release from the Peterborough group of a new crime. This takes Disely et al. (2012) value from the analysis and introduces a change from the programs operations.

Budget Excess=

INTEG (Budget Surplus-Budget Excess Recovered-MOJ SIB Savings Rate-"Post-SIB Program Payments", 0)

Units: k£

This represents the accumulated budget surplus for Peterborough Prison. This is an Author Defined Variable.

Budget Excess Recovered=

"Surplus Returned?" (Budget Excess/MOJ Surplus return check*Fraction of Surplus Returned-MOJ SIB Savings Rate)*

Units: k£/Month

This is an author defined variable used to measure the amount of budget excess returned to the upper echelons of government each month.

Budget Peterborough=

*(Total Prison Population [Comparison]*monthly cost+ Conviction Cost*SUM (Repeat Offender Arrest Rate [Overall, Comparison, Release Program!]))/Offender Multiplier between Prison Systems [Comparison]*

<u>Units: k£/Month</u>

This is the expected payment rate that is allocated to MOJ for the Peterborough Prison System. This is an author derived equation set so that the MOJ receives funds under the expectation that business is operating as usual. The values are discounted from the start of the program to consider with deflation from projection.

Budget Surplus=

Budget Peterborough-Peterborough Operations Costs

<u>Units: k£/Month</u>

This represents the budget surplus of the Peterborough case. This is an author defined equation.

Cash Flow=

Investor Return Rate-Investment Rate

<u>Units: k£/Month</u>

This represents the net cash flow for the investor in PV dollars to the start of the program.

Change in Max Program Costs=

Max (0, Program Costs-Max Program Costs)/Time to Adjust Maximum Program Cost

<u>Units: k£/Month/Month</u>

This represents the rate of change in the Maximum Program Costs. This is an Author defined variable.

"Cohort Active?"[Overall]=

1

"Cohort Active?"[Cohort 1]=

IF THEN ELSE (Actual Cohort Start Times [Cohort 1] <Time, IF THEN ELSE (Actual Cohort Closing Times [Cohort 1]>=Time, 1, 0), 0)

"Cohort Active?"[Cohort 2]=

IF THEN ELSE(MIN(Actual Cohort Closing Times[Cohort 1],Actual Cohort Start Times[Cohort 2])<Time, IF THEN ELSE(Actual Cohort Closing Times[Cohort 2]>=Time,1,0),0)

"Cohort Active?"[Cohort 3]=

IF THEN ELSE(MIN(Actual Cohort Closing Times[Cohort 2],Actual Cohort Start Times[Cohort 3])<Time, IF THEN ELSE(Actual Cohort Closing Times[Cohort 3]>=Time,1,0),0)

"Cohort Active?"[Cohort 4]=

IF THEN ELSE (Actual Cohort Start Times [Cohort 4] <Time, IF THEN ELSE (Actual Cohort Closing Times [Cohort 4]>=Time, 1, 0), 0)

<u>Units: Dmnl</u>

This turns on the flow of new incarcerations between each cohort group. The definitions are laid out in Cave's et al. (2012) description of cohort groupings.

Cohort Addition of New Offenders [Cohorts, Prison Systems] =

SUM (("Rehabilitated Prisoner Release Rate- First Offence"[Cohorts, Prison Systems, Release Program!]+"Non-Rehabilitated Prisoner Release Rate- First Offence"[Cohorts, Prison Systems, Release Program!])) "Cohort Active?"[Cohorts]*

<u>Units: People/Month</u>

This represents the rate people enter the Peterborough Cohorts as per Cave et al. (2012) study.

Cohort Collection of New Offenders [Cohorts, Prison Systems] =

INTEG (Cohort Addition of New Offenders [Cohorts, Prison Systems], 0)

<u>Units: People</u>

This represents the accumulation of people in collected in the different cohorts for the Peterborough group based on Cave et al. (2012).

Cohort Expense Rate=

Program Costs

Units: k£/Month

This represents how the funds are allocated. This is an author defined variable.

Cohort initiate switch [Overall] =

1

Cohort initiate switch [Cohort 1] =

IF THEN ELSE(Cohort Collection of New Offenders[Cohort 1,Peterborough]<= Max People in Cohort[Cohort 1] , IF THEN ELSE((Actual Cohort Start Times[Cohort 1]+Max Cohort Length[Cohort 1]) >Time,1,0),0)

Cohort initiate switch [Cohort 2] =

IF THEN ELSE(Cohort Collection of New Offenders[Cohort 2,Peterborough]<= Max People in Cohort[Cohort 2] , IF THEN ELSE((Actual Cohort Start Times[Cohort 2]+Max Cohort Length[Cohort 2]) >Time,1,0),0)

Cohort initiate switch [Cohort 3] =

IF THEN ELSE(Cohort Collection of New Offenders[Cohort 3,Peterborough]<= Max People in Cohort[Cohort 3] , IF THEN ELSE((Actual Cohort Start Times[Cohort 3]+Max Cohort Length[Cohort 3]) >Time,1,0),0)

Cohort initiate switch [Cohort 4] =

*IF THEN ELSE(Cohort Collection of New Offenders[Cohort 3,Peterborough]<=Max People in Cohort [Cohort 3], IF THEN ELSE(Actual Cohort Start Times[Cohort 4]+3*Max Cohort Length[Cohort 4]>Time,1,0),0)*

Units: Dmnl

This determines whether the cohorts have started in accordance with the rules set forth from Cave et al. (2012) primarily that the maximum time cannot be exceeded and the cohorts must switch before if the maximum number is met or exceeded.

Cohort Investment switch [Cohorts] =

IF THEN ELSE (Actual Cohort Start Times [Cohorts] <Time, IF THEN ELSE (Investment Finalization Time [Cohorts]>=Time, 1, 0), 0)

Units: Dmnl

This represents when investors are investing in different cohorts. This is an author derived variable from Cave et al. (2012).

Cohort Payment Time [Overall] =

0

Cohort Payment Time [Cohort 1] =

Actual Cohort Closing Times [Cohort 1] +Time after Cohort for Reconviction Collection+ Time for System Update

Cohort Payment Time [Cohort 2] =

Actual Cohort Closing Times [Cohort 2] +Time after Cohort for Reconviction Collection+ Time for System Update

Cohort Payment Time [Cohort 3] =

Actual Cohort Closing Times [Cohort 3] +Time after Cohort for Reconviction Collection+ Time for System Update

Cohort Payment Time [Cohort 4] =

Actual Cohort Closing Times [Cohort 4] +Time after Cohort for Reconviction Collection+ Time for System Update+ Time Program has to Pay

<u>Units: Month</u>

This represents the time at which the program is measured as a success or as a failure. RT Time and System Update Time (18 months) are added on to the accumulation time as per Cave et al. (2012) to show the time between cohort collection finishing and the data results being collected.

Cohort Time [Cohorts] =

Cohort initiate switch [Cohorts]

<u>Units: Month/Month</u>

This represents the time that the cohorts are collecting people for comparison. This is determined by Cave et al. (2012) using the Cohort initiate switch.

Cohort Time Delay Rate [Overall] =

0

Cohort Time Delay Rate [Cohort 1] =

*IF THEN ELSE (Max People in Cohort [Cohort 1]>Cohort Collection of New Offenders [Cohort 1, Peterborough], IF THEN ELSE (Latest Cohort Start Times [Cohort 1]>Time, 1, 0), 0)*Cohort initiate switch [Cohort 1]*

Cohort Time Delay Rate [Cohort 2] =

*IF THEN ELSE(Max People in Cohort[Cohort 2]>Cohort Collection of New Offenders[Cohort 2, Peterborough],IF THEN ELSE(Latest Cohort Start Times[Cohort 2]>Time,1,0),0)*Cohort initiate switch[Cohort 1]*

Cohort Time Delay Rate [Cohort 3] =

*IF THEN ELSE (Max People in Cohort [Cohort 3]>Cohort Collection of New Offenders [Cohort 3, Peterborough], IF THEN ELSE (Latest Cohort Start Times [Cohort 3]>Time, 1, 0), 0)*Cohort initiate switch [Cohort 2]*

Cohort Time Delay Rate [Cohort 4] =

IF THEN ELSE (Max People in Cohort [Cohort 4]>Cohort Collection of New Offenders [Cohort 4, Peterborough], IF THEN ELSE (Latest Cohort Start Times [Cohort 4]>Time, 1, 0), 0)

Units: Month/Month

This is an Author derived control to increase time according to the rules set in Cave et al. (2012).

Conviction Cost=

2.853

Units: k£/People

This represents the legal costs per conviction based on the data from SEU (2002) [May also be found in Mulgan 2011]. There is some discrepancy among the literature about how much a conviction costs. Strickland notes a value closer to 40k£.

Cost per Participant per month=

Program Cost per Member/Defined Year

Units: k£/ (Month*People)

This represents the cost for one person to be in the program for one month as per Mulgan et al. (2011) page 30.

Cumulative Investor Returns=

INTEG (Owner Success Payment, No Initial Worth)

Units: k£

This represents the amount of money the investors have during the program cycle. This stock is pulled from Social Finance Limited (2011).

Cumulative Program Cost=

INTEG (Program Costs, No Initial Worth)

Units: k£

This represents how much money has been paid into the program. This is an Author defined variable operating as a performance measure for total cost.

Defined Year=

12

Units: Month

Within this model a year is estimated at 12 months. Author defined.

Desired Payment Value [Cohorts] =

Unpaid Investor Earned Returns [Cohorts]"Payment Consideration?"[Cohorts]* "Successful Program?"[Cohorts]*

Units: k£

This represents the value of the payments to investors based on the information provided by Cave et al. (2012). The value for a successful payment is the "Investor Earned" if it is between the maximum and minimum return values, or the values of the maximum (if the IE is greater) or minimum (if smaller) return. Cohort 4 is only viable if an investment opportunity was missed by any of the Cohorts not meeting their hurdle value.

Earned Investor Return payments [Cohorts] =

"Investors Cohorts Paid? Amount"[Cohorts]

<u>Units: k£/Month</u>

This represents the amount of payment to the investors from the program reducing the amount of payment to the investors in future. This is an Author defined equation.

Expected Program Investment amount=

5000

<u>Units: k£</u>

This represents the minimum required investment from the investors (Strickland 2010).

Fraction for Investor share=

0.5

<u>Units: Dmnl</u>

This represents the percentage share that the investors receive of the savings (assuming a successful project). This value is not presented in the literature for confidentiality (Disely 2011). Modeler estimate.

Fraction of Surplus Returned=

0.5

Units: Dmnl

This is an author defined variable that represents the fraction of budget surplus between the expected budget and the actual expenses that is deducted from the actual budget. The value 0.5 was selected for the base case because the program pays the investors 50% of the savings. If the investors return is met by 50% of the savings, then the MOJ should be able to run the program with 50% of the savings.

Funds Available for the Program=

INTEG (MOJ Payments-Cohort Expense Rate, Expected Program Investment amount)

Units: k£

This represents the amount of funds remaining for the program activities. This is an Author defined stock.

Funds Earned by SIB=

INTEG (MOJ SIB Savings Rate-MOJ SIB Payment Rate, 0)

Units: k£

This represents the amount Funds set aside by the MOJ to pay for the SIB.

Initial First time Offender Prisoner Holding=

86.75

Units: People

This is the tuned value for the initial prisoners to meet Cave et al. (2012) values. It starts the model off in steady state.

Initial Reconvicted Prisoner Holding=

260.25

Units: People

This represents the initial amount of people that have been reconvicted under the program and is tuned to Cave et al. (2012). This starts the model off in a steady state.

Initial Undiscovered Reoffenders=

1041

Units: People

This represents the number of people awaiting reconviction discovery and is tuned to 555 people as per Cave et al. (2012). This starts the model off in steady state.

Interval time between Cohort completion and Payment Time [Overall] =

0

Interval time between Cohort completion and Payment Time [Cohort 1] =

Time after Cohort for Reconviction Collection+ Time for System Update+ Time Program has to Pay

Interval time between Cohort completion and Payment Time [Cohort 2] =

Time after Cohort for Reconviction Collection+ Time for System Update+ Time Program has to Pay

Interval time between Cohort completion and Payment Time [Cohort 3] =

Time after Cohort for Reconviction Collection+ Time for System Update+ Time Program has to Pay

Interval time between Cohort completion and Payment Time [Cohort 4] =

Time Program has to Pay

<u>Units: Month</u>

This represents the time at which payment will be made if the program is successful. 18 months is added on to the accumulation time as per Cave et al. (2012) shows for time between cohort collection finishing and the results being tabulated. Cohort 4 is tabulated after the Cohort 3 has been given a chance to process.

INV IRR=

IF THEN ELSE (Investment Starts=0, 0, IF THEN ELSE (Investment Return starts=0,-1, IRR))

<u>Units: Dmnl</u>

This represents the IRR of the investors throughout the program life. The value starts at 0. IRR moves to (-1) after an investment occurs and before a return is made. Then the automated function is used to calculate the value.

Invested Amount=

INTEG (Investment Rate, 0)

Units: k£

This represents the accumulation of investment by the investors into the program as valued at the start of the program.

Investing=

*PULSE(Actual Cohort Start Times[Cohort 1]+1,1)*Investment Payment per Cohort+*

*PULSE(Actual Cohort Start Times[Cohort 2]+1,1)*Investment Payment per Cohort+*

*PULSE(Actual Cohort Start Times[Cohort 3]+1,1)*Investment Payment per Cohort*

Units: k£/Month

This represents the steady flow of investor funds into the system. It is an Author derived variable equivalent to the amount of the investment divided by the total duration of the project and comes from Social Finance Limited (2011).

Investment Finalization Time [Overall] =

Actual Cohort Closing Times [Overall]

Investment Finalization Time [Cohort 1] =

Actual Cohort Closing Times [Cohort 1]

Investment Finalization Time [Cohort 2] =

Actual Cohort Closing Times [Cohort 2]

Investment Finalization Time [Cohort 3] =

Actual Cohort Closing Times [Cohort 3]

Investment Finalization Time [Cohort 4] =

Cohort Payment Time [Cohort 4] +Interval time between Cohort completion and Payment Time [Cohort 4]

<u>Units: Month</u>

This represents when the investment is finalized and ready for repayment as per the timeline in Cave et al. (2012).

Investment Payment per Cohort=

Expected Program Investment amount/number of payments

<u>Units: k£/Month</u>

This represents the payment amount from the investors while the cohorts are collecting as per Strickland (2010) and Mulgan et al. (2011).

Investment Rate=

(Investing)

Units: k£/Month

This represents the Present value of investments at the start of the project for investors by using the discount factor. This is an Author defined flow.

Investment Return starts=

IF THEN ELSE (Cumulative Investor Returns>0, 1, 0)

Units: Dmnl

This switch turns on the investors returns.

Investment Starts=

IF THEN ELSE (Invested Amount>0, 1, 0)

Units: Dmnl

This value is used for the INV IRR variable to mark when the investors start investing.

Investor Account=

INTEG (Investor Return Rate-Investment Rate, 0)

Units: k£

This represents the value of the investor account at the time of program initiation, but does not include initial funds because the discount rate represents an alternate investment option. This allows the final value of the investors account to be compared with the stock for the investment amount. This is an Author Defined stock.

Investor Balance=

Cumulative Investor Returns+ Amount Investors are willing to Invest

Units: k£

This represents the current balance of the investors' accounts with both what they have set for investing along with the returns for a successful program. This is an Author defined performance variable that may be considered in the tests.

Investor Earned [Cohorts] =

*(Savings from Reduced Reconvictions [Cohorts])*Fraction for Investor share*

Units: k£/Month

This represents the value of savings determined in the contracts without the limits. The Investor share value is kept anonymous to the public. According to Cave et al. (2012) and Disely et al. (2011). The value is determined by multiplying the number of reconvictions that should have been based on the comparison group results (Cave et. al. 2012).

Investor Earned Return Accumulation [Cohorts] =

*Investor Earned [Cohorts]*Cohort Investment switch [Cohorts]*

Units: k£/Month

This represents the accumulation of investor earnings based on Cave et al. (2012).

Investor Return Rate=

Owner Success Payment

Units: k£/Month

This represents the present value at the time of the initial project for payments from the owner to the investor by using the discount factor. It is author defined using the value of the payment times a discount factor from the initiation of the program.

IRR=

INTERNAL RATE OF RETURN (Cash Flow, Defined Year, 0, 0)

Units: Dmnl

This is the average annual Rate of Return for the investors.

"Investors Cohorts Paid? Amount"[Cohorts] =

Owner Success Payment"Payment Consideration?"[Cohorts]*

Units: k£/Month

This represents the payment rate to the investors when they are paid within their investment. This is an Author derived equation.

Latest Cohort Start Times [Cohorts] =

-0.5, 20,44,68,20

Units: Month

This represents the latest time for a cohort to start (Cave et al. 2012).

Max Cohort Length [Overall] =

0

Max Cohort Length [Cohort 1] =

Standard Cohort Length

Max Cohort Length [Cohort 2] =

Standard Cohort Length

Max Cohort Length [Cohort 3] =

Standard Cohort Length

Max Cohort Length [Cohort 4] =

Max Cohort Length [Cohort 1] +Max Cohort Length [Cohort 2] +Max Cohort Length [Cohort 3]

Units: Month

This represents the maximum length of an individual Cohort (1-3) or 1/3 of the maximum time for the final cumulative cohort as outlined by Cave et al. (2012).

Max People in Cohort [Overall] =

1e+015

Max People in Cohort [Cohort 1] =

Standard People in Cohort

Max People in Cohort [Cohort 2] =

Standard People in Cohort

Max People in Cohort [Cohort 3] =

Standard People in Cohort

Max People in Cohort [Cohort 4] =

Max People in Cohort [Cohort 1] +Max People in Cohort [Cohort 2] +Max People in Cohort [Cohort 3]

<u>Units: People</u>

This is the maximum number of people allowed in the cohort (Cave et. al. 2012).

Max Program Costs=

INTEG (Change in Max Program Costs, 0)

<u>Units: k£/Month</u>

This represents the maximum program costs or the expected payment value, for the program, by the MOJ, after the SIB is complete. This is an Author defined variable.

Maximum Payment Accumulation [Cohorts] =

IF THEN ELSE(Cohort Payment Time[Cohorts]<Time, IF THEN ELSE(Desired Payment Value[Cohorts]> Maximum Successful Program Payment Value[Cohorts],Desired Payment Value[Cohorts]-Maximum Successful Program Payment Value[Cohorts],0)/TIME STEP,0)

Units: k£/Month

This represents the accumulation for the maximum payment value. This is an Author defined equation to ensure investors are paid the amount they are due.

Maximum Successful Program Payment Value [Cohorts] =

INTEG (Maximum Payment Accumulation [Cohorts], 0)

Units: k£

This represents the maximum value for payment. This is Author defined to ensure a complete payment to investors.

Minimum Change in Reconvictions [Cohorts] =

1, 0.1, 0.1, 0.1, 0.075

Units: Dmnl

This represents the minimum change in reconvictions for the program to be considered a success (Strickland 2010, Mulgan et al. 2011, and Cave et al. 2012).

MOJ Account=

INTEG (Budget Peterborough-Budget Surplus-Peterborough Operations Costs, 0)

Units: k£

This represents the amount of money in the MOJ and BLF account. The structure of this account to investors is pulled from Social Finance Limited (2011).

MOJ Payments=

Owner Program Payments

Units: k£/Month

This represents the rate of MOJ replenishment before the program ends. This is an Author defined variable.

MOJ SIB Payment Rate=

Owner Success Payment

Units: k£/Month

This represents the rate at which MOJ pays the investors back from their investment. Also see "Investor Return Rate" and "Owner Success Payment".

MOJ SIB Savings Rate=

Investor Earned Return Accumulation [Cohort 4]

Units: k£/Month

This represents the MOJ's accumulation of savings for the SIB. This is an Author Defined variable (See "Investor Earned Return Accumulation").

MOJ Starts Paying=

73

Units: Month

This represents the Time that the ministry of Justice starts paying. This is an Author Defined Variable.

MOJ Surplus return check=

1

Units: Month

This is the amount of time that the MOJ waits to check for a budget surplus. This is an Author defined variable.

Monthly Cost=

Yearly Cost of Incarceration/Defined Year

Units: k£/Month/People

This represents the monthly cost of incarcerating a prisoner. Derived from Loder et al. (2010).

New Offender Incarceration Rate [Peterborough] =

*Average Prisoner Incarceration Rate for Peterborough*Offender Multiplier between Prison Systems [Peterborough]*

New Offender Incarceration Rate [Comparison] =

*Offender Multiplier between Prison Systems [Comparison]*New Offender Incarceration Rate [Peterborough]*

Units: People/Month

This represents the flow of first time offenders into the prison system that fit the criteria for the program as outlined in Strickland (2010). The inflow of new prisoners is the difference between the number of prisoners that can be accepted on a monthly basis and the recidivism rate of prisoners from the overall cohort. This is one of the variations from the Lyneis and Ford (2007) model.

No Initial Worth=

0

Units: k£

This represents a zero (0) initial value for any stock that has no starting value. Use the uses tree to see what values do not have an initial value. Author defined.

"Non-Rehabilitated Prisoner Release Rate- First Offence"[Cohorts, Prison Systems, Release Program] =

*Program Entry Rate [Cohorts, Prison Systems, Release Program]*Program Recidivism Fraction [Release Program]*

Units: People/Month

This represents the rate of people released from their first conviction that will recommit a crime. This is an Author derived variable.

Normal Recidivism Fraction=

0.75

Units: Dmnl

This represents the normal quality of the system without having the project in play. Value pulled from Strickland (2010), Loder et al. (2010), and Mulgan et al. (2011).

Number of payments=

3

Units: Month

This represents the number of payments that are made by the investors. The number is derived based on the number of primary cohorts identified in both Disely et al. (2012) and Cave et al. (2012). There are three primary cohorts (the fourth is an overall grouping).

Number of Reconviction [Cohorts, Prison Systems] =

INTEG (Rate of Reconviction [Cohorts, Prison Systems], 0)

Units: People

This represents the accumulation of reconvicted people in the cohort for the comparison group as per Cave et al. (2012)

Offenders entering Program [Cohorts] =

"Non-Rehabilitated Prisoner Release Rate- First Offence"[Cohorts, Peterborough, SIB] +"Non-Rehabilitated Prisoner Release Rate- Repeat Offence"[Cohorts, Peterborough, SIB] +"Rehabilitated Prisoner Release Rate- First Offence"[Cohorts, Peterborough, SIB] +"Rehabilitated Prisoner Release Rate-Repeat Offence"[Cohorts, Peterborough, SIB]

Units: People/Month

This represents the flow of released offenders into the program. This is an author defined variable that may be used to measure the outcome of the program size.

Offender Multiplier between Prison Systems [Prison Systems] =

1, 10

Units: Dmnl

This represents the ratio of people needed in each grouping to have an appropriate power level in accordance with Cave et al. (2012)

Offender Release Rate [Cohorts, Prison Systems, Release Program] =

"Non-Rehabilitated Prisoner Release Rate- First Offence"[Cohorts, Prison Systems, Release Program] +"Non-Rehabilitated Prisoner Release Rate- Repeat Offence"[Cohorts, Prison Systems, Release Program] +"Rehabilitated Prisoner Release Rate- First Offence"[Cohorts, Prison Systems, Release Program] +"Rehabilitated Prisoner Release Rate-Repeat Offence"[Cohorts, Prison Systems, Release Program]

<u>Units: People/Month</u>

This represents the total number of prisoners released by prison system and cohort. This is an author defined variable.

Offenders' willing to enter program Fraction=

0.7

<u>Units: Dmnl</u>

This represents the percentage of prisoners that elect to go through the program and can be changed to tune for different levels of participation between 0 and 1. Disely et al. (2012) note a 70% acceptance.

One Service=

INTEG (Program Payments from SIP-Program Costs, No Initial Worth)

<u>Units: k£</u>

The amount of built up capital that the conglomerate of NGOs have in their system. This is representative of the Social Finance Limited (2011).

Owner Program Payments=

Max (IF THEN ELSE (MOJ Starts Paying<Time, (Program Payment Rate+0*Program Payments from SIP) * ("Successful Program?"[Cohort 4]), 0), 0)

<u>Units: k£/Month</u>

In the event of a successful program the owner would want to assume the payments for the program. This is represented by using a switch ("Program Off?") and the value of the payments. This is an Author derived flow based on Glahn and Whistler (2011).

Owner Success Payment=

(Payment for Cohort 1+Payment for Cohort 2+Payment for Cohort 3+Payment for Cohort 4)/Time Program has to Pay

<u>Units: k£/Month</u>

This represents when and how much the investors are paid. This relationship is made from the Social Finance Limited (2011).

Paying Early=

IF THEN ELSE (Actual Cohort Closing Times [Cohort 4] <Time, 0, MOJ Payments)

<u>Units: k£/Month</u>

This represents the rate of early payments by the MOJ. This is an author defined policy solution for the MOJ to improve the effect of the program.

Payment for Cohort 1=

Maximum Successful Program Payment Value [Cohort 1]"Payment Consideration?"[Cohort 1]*

Units: k£

This represents the value of the payment for Cohort 1. Author defined from Mulgan et al. (2011) and Cave et al. (2012).

Payment for Cohort 2=

Maximum Successful Program Payment Value [Cohort 2]"Payment Consideration?"[Cohort 2]*

Units: k£

This represents the payment value for Cohort 2. Author defined from Mulgan et al. (2011) and Cave et al. (2012).

Payment for Cohort 3=

Maximum Successful Program Payment Value [Cohort 3]"Payment Consideration?"[Cohort 3]*

Units: k£

This represents the payment for Cohort 3. Author defined from Mulgan et al. (2011) and Cave et al. (2012).

Payment for Cohort 4=

Maximum Successful Program Payment Value [Cohort 4]"Payment Consideration?"[Cohort 4]*

<u>Units: k£</u>

This represents the payment value for the entire project. Author defined from Mulgan et al. (2011) and Cave et al. (2012).

"Payment Consideration?"[Overall]=

1

"Payment Consideration?"[Cohort 1]=

IF THEN ELSE (Cohort Payment Time [Cohort 1] <=Time, IF THEN ELSE (Cohort Payment Time [Cohort 1] +Time Program has to Pay>=Time, 1, 0), 0)

"Payment Consideration?"[Cohort 2]=

IF THEN ELSE (Cohort Payment Time [Cohort 2] <=Time, IF THEN ELSE (Cohort Payment Time [Cohort 2] +Time Program has to Pay>=Time, 1, 0), 0)

"Payment Consideration?"[Cohort 3]=

IF THEN ELSE (Cohort Payment Time [Cohort 3] <=Time, IF THEN ELSE (Cohort Payment Time [Cohort 3] +Time Program has to Pay>=Time, 1, 0), 0)

"Payment Consideration?"[Cohort 4]=

IF THEN ELSE (Cohort Payment Time [Cohort 1] <=Time, IF THEN ELSE (Cohort Payment Time [Cohort 4] +Time Program has to Pay>=Time, 1, 0), 0)

Units: Dmnl

This marks the time that a payment is considered in the project (Cave et. al. 2012). Payment cannot be considered before the completion of cohort collection plus the time interval for data occurrence, collection and analysis.

Peterborough Operations Costs=

*Total Prison Population [Peterborough]*monthly cost+ SUM (Repeat Offender Arrest Rate [Overall, Peterborough, Release Program!])*Conviction Cost*

Units: k£/Month

This represents the actual expenses for the Peterborough prison system using the costs of reconvictions found in Strickland (2010). (Reconviction cost times the number of reconvictions from Peterborough Released prisoners. This is an Author derived equation of the actual expenses and is deflated to maintain consistent projection value.

Population in Program [Cohorts] =

Rehabilitated Offenders [Cohorts, Peterborough, SIB] +Undiscovered Reoffenders [Cohorts, Peterborough, SIB]

Units: People

This represents the number of people that are in the program at any point in time. This is an Author defined variable used to calculate the monthly program costs.

"Post-SIB Program Payments"=

Owner Program Payments

Units: k£/Month

This is an Author defined variable representing the payments from the MOJ to the SIB after the program (see "Owner Program Payments").

"Prison Holding-First Offence"[Prison Systems] =

*INTEG (New Offender Incarceration Rate [Prison Systems]-SUM ("Rehabilitated Prisoner Release Rate- First Offence"[Overall, Prison Systems, Release Program!])-SUM ("Non-Rehabilitated Prisoner Release Rate- First Offence"[Overall, Prison Systems, Release Program!]), Initial First time Offender Prisoner Holding*Offender Multiplier between Prison Systems [Prison Systems])*

Units: People

This represents the amount of first time offenders in prison holding after their first conviction. {70 people tunes the model to Cave et al (2012).} Similar to Ford and Lyneis (2008).

"Prison Holding-Repeat Offence"[Overall, Prison Systems] =

INTEG (SUM (Repeat Offender Arrest Rate [Overall, Prison Systems, Release Program!]-"Non-Rehabilitated Prisoner Release Rate- Repeat Offence"[Overall, Prison Systems, Release Program!]-"Rehabilitated Prisoner Release Rate-Repeat

*Offence"[Overall, Prison Systems, Release Program!]), Initial Reconvicted Prisoner Holding*Offender Multiplier between Prison Systems [Prison Systems])*

"Prison Holding-Repeat Offence"[Cohort 1, Prison Systems] =

INTEG (SUM (Repeat Offender Arrest Rate [Cohort 1, Prison Systems, Release Program!]-"Non-Rehabilitated Prisoner Release Rate- Repeat Offence"[Cohort 1, Prison Systems, Release Program!]-"Rehabilitated Prisoner Release Rate-Repeat Offence"[Cohort 1, Prison Systems, Release Program!]), 0)

"Prison Holding-Repeat Offence"[Cohort 2, Prison Systems] =

INTEG (SUM (Repeat Offender Arrest Rate [Cohort 2, Prison Systems, Release Program!]-"Non-Rehabilitated Prisoner Release Rate- Repeat Offence"[Cohort 2, Prison Systems, Release Program!]-"Rehabilitated Prisoner Release Rate-Repeat Offence"[Cohort 2, Prison Systems, Release Program!]), 0)

"Prison Holding-Repeat Offence"[Cohort 3, Prison Systems] =

INTEG (SUM (Repeat Offender Arrest Rate [Cohort 3, Prison Systems, Release Program!]-"Non-Rehabilitated Prisoner Release Rate- Repeat Offence"[Cohort 3, Prison Systems, Release Program!]-"Rehabilitated Prisoner Release Rate-Repeat Offence"[Cohort 3, Prison Systems, Release Program!]), 0)

"Prison Holding-Repeat Offence"[Cohort 4, Prison Systems] =

INTEG (SUM (Repeat Offender Arrest Rate [Cohort 4, Prison Systems, Release Program!]-"Rehabilitated Prisoner Release Rate-Repeat Offence"[Cohort 4, Prison Systems, Release Program!]-"Non-Rehabilitated Prisoner Release Rate- Repeat Offence"[Cohort 4, Prison Systems, Release Program!]), 0)

<u>Units: People</u>

This represents the stock of reconvicted persons in prison at any point in time during the life of the measures. {168.75 people tunes the model to Cave et al (2012).} Similar in structure to Ford and Lyneis (2008).

Prison Population Percent Reduction=

(1-(Total Prison Population [Peterborough]/Offender Multiplier between Prison Systems [Peterborough])/ (Total Prison Population [Comparison]/Offender Multiplier between Prison Systems[Comparison]))*100

<u>Units: Dmnl</u>

This represents the fraction of prisoners from the Peterborough population that has been reduced as a result of the program.

Probationary Period Length=

12

<u>Units: Month</u>

This represents how long the rehabilitation program lasts (Mulgan et al. 2011, Cave et al. 2012).

"Program Continues?"=

Max ("Cohort Active?"[Cohort 4], "Successful Program?"[Cohort 4])

Units: Dmnl

This represents whether or not the program continues after investment based on the success of the program and the investment time being met. This is an Author Defined variable in accordance with Glahn and Whistler (2011).

Program Cost per Member=

1.5

Units: k£/People

This is the average cost per member for the program. This value is pulled from Mulgan et al. (2011).

Program Costs=

*Population in Program [Overall]*Cost per Participant per month*

Units: k£/Month

This represents the rate of expense by the conglomerate when adding people to the program. This is an Author derived flow from the Social Finance Limited (2011).

Program Entry Rate [Cohorts, Prison Systems, SIB] =

*MIN ("Prison Holding-First Offence"[Prison Systems]*Offenders' Willing to enter program Fraction, max (Space Available in Program, 0))/Time spent in prison for a Conviction*"Cohort Active?"[Cohorts]*Program Switch [Prison Systems]*

Program Entry Rate [Cohorts, Prison Systems, Normal] =

"Prison Holding-First Offence"[Prison Systems]/Time spent in prison for a Conviction"Cohort Active?"[Cohorts]-Program Entry Rate [Cohorts, Prison Systems, SIB]*

<u>Units: People/Month</u>

This represents the rate of people that enter either the SIB program or the Normal program.

Program Recidivism Fraction [SIB] =

*Normal Recidivism Fraction-Recidivism Reduction Fraction*Normal Recidivism Fraction*"Program Continues?"*

Program Recidivism Fraction [Normal] =

Normal Recidivism Fraction

<u>Units: Dmnl</u>

This represents the estimated quality of the program in terms of the number of satisfactory outcomes divided by unsatisfactory outcomes. The change in recidivism is subtracted because of its representation in Loder et al. (2010) and Mulgan et al. (2011).

This relates to the Mission portion of the Balanced Scorecard for the conglomerate of NGOs.

Program Payment Rate=

MIN (Budget Excess/Time MOJ Backlog Payments, Max Program Costs)

Units: k£/Month

This is an author defined variable that represents the amount of payment made for the new program initiated by the SIB.

Program Payments from SIP=

Program Costs

Units: k£/Month

The amount that SIP pays the conglomerate per month. This is based on the expected budgeted expenses and the lacking funds of the NGOs. This flow represents the flow from One* Service to the conglomerate of NGOs in Social Finance Limited (2011).

Program Switch [Peterborough] =

IF THEN ELSE (Time>=20, 1, 0)

Program Switch [Comparison] =

0

Units: Dmnl

This is an on/off switch to control whether or not the project is in operation. Author defined.

Program Savings Collected by Government=

INTEG (Budget Excess Recovered, 0)

Units: k£

This is an Author defined performance variable showing the accumulated savings by the government.

Rate of Offenders Coming off of Probation [Cohorts, Prison Systems, Release Program] =

Rehabilitated Offenders [Cohorts, Prison Systems, Release Program]/Probationary Period Length

Units: People/Month

This represents the rate at which people that will not be convicted leave the program.

Rate of Reconviction [Cohorts, Prison Systems] =

*SUM (Repeat Offender Arrest Rate [Cohorts, Prison Systems, Release Program!])*Reconviction Termination [Cohorts]*

Units: People/Month

This represents the rate of reconvicted people for the comparison group by summing the Recidivism Exclusion Rate and Recidivism Rate as per Cave et al. (2012).

Recidivism Reduction Fraction=

0.25

Units: Dmnl

This represents the change in recidivism that occurs from the program. Based on Mulgan et al. (2011) and Loder et al. (2010) average difference recidivism is 20% (75%*0.3 =20%).

Reconviction Change [Cohorts] =

1-XIDZ (Reconviction Fraction [Cohorts, Peterborough], Reconviction Fraction [Cohorts, Comparison], 1)

Units: Dmnl

Percent of change between the comparison group and the Peterborough group. The equation is derived from Cave et al. (2012) explanation of the program measures.

Reconviction Fraction [Cohorts, Prison Systems] =

ZIDZ (Number of Reconviction [Cohorts, Prison Systems], Cohort Collection of New Offenders [Cohorts, Prison Systems])

Units: Dmnl

This represents the rate of reconviction for people in the Peterborough group as prescribed by Cave et al. (2012).

Reconviction Termination [Cohorts] =

IF THEN ELSE (Actual Cohort Closing Times [Cohorts] +Time after Cohort for Reconviction Collection< Time, 0, 1)

Units: Dmnl

This represents when the reconviction counts for the project stop being collected as per Cave et al. (2012). RT Time is (12 months) added as the time when reconvictions will be measured.

Reconvictions Prevented [Cohorts] =

Rate of Reconviction [Cohorts, Comparison]/Offender Multiplier between Prison Systems [Comparison]-Rate of Reconviction [Cohorts, Peterborough]/Offender Multiplier between Prison Systems [Peterborough]

Units: People/Month

This represents the number of reconvictions that the program saved the government from having to go through. This is an Author derived equation.

Rehabilitated Offenders [Cohorts, Prison Systems, Release Program] =

INTEG ("Rehabilitated Prisoner Release Rate- First Offence"[Cohorts, Prison Systems, Release Program] +"Rehabilitated Prisoner Release Rate-Repeat Offence"[Cohorts, Prison Systems, Release Program]-Rate of Offenders Coming off of Probation [Cohorts, Prison Systems, Release Program], 0)

Units: People

This represents the people in the program that are in the program.

"Rehabilitated Prisoner Release Rate- First Offence"[Cohorts, Prison Systems, Release Program] =

Program Entry Rate [Cohorts, Prison Systems, Release Program](1-Program Recidivism Fraction [Release Program])*

Units: People/Month

This represents the number of people released from prison every month to provide.

"Rehabilitated Prisoner Release Rate-Repeat Offence"[Cohorts, Prison Systems, Release Program] =

*Repeat Offender Program Entry Rate [Cohorts, Prison Systems, Release Program] *(1-Program Recidivism Fraction [Release Program])*

Units: People/Month

This represents the rate people are released from repeat offences, but will not recommit. This is an Author Derived Equation.

Repeat Offender Arrest Rate [Cohorts, Prison Systems, Release Program] =

(Undiscovered Reoffenders [Cohorts, Prison Systems, Release Program])/Average Time between Release and Reconviction [Prison Systems]

Units: People/Month

This is the rate of discovery for people who recommit crimes. The flow is averaged from the backlog and the time found in Cox (2006).

Repeat Offender Program Entry Rate [Overall, Prison Systems, SIB] =

*MIN("Prison Holding-Repeat Offence"[Overall, Prison Systems]*Offenders' Willing to enter program Fraction/Time spent in prison for a Conviction, max(Space Available in Program,0)/Time spent in prison for a Conviction-Program Entry Rate[Overall, Prison Systems, SIB] -Repeat Offender Program Entry Rate[Cohort 4,Prison Systems, SIB])*Program Switch[Prison Systems]*

Repeat Offender Program Entry Rate [Cohort 1, Prison Systems, SIB] =

*MIN("Prison Holding-Repeat Offence"[Cohort 1,Prison Systems]*Offenders' Willing to enter program Fraction/Time spent in prison for a Conviction, max(Space Available in Program,0)/Time spent in prison for a Conviction-Program Entry Rate[Cohort 1,Prison Systems, SIB])*Program Switch[Prison Systems]*

Repeat Offender Program Entry Rate [Cohort 2, Prison Systems, SIB] =

*MIN("Prison Holding-Repeat Offence"[Cohort 2,Prison Systems]*Offenders' Willing to enter program Fraction/Time spent in prison for a Conviction, max(Space Available in Program,0)/Time spent in prison for a Conviction -Program Entry Rate[Cohort 2,Prison Systems, SIB]-Repeat Offender Program Entry Rate [Cohort 1,Prison Systems, SIB])*Program Switch[Prison Systems]*

Repeat Offender Program Entry Rate [Cohort 3, Prison Systems, SIB] =

*MIN("Prison Holding-Repeat Offence"[Cohort 3,Prison Systems]*Offenders' Willing to enter program Fraction/Time spent in prison for a Conviction, max(Space Available in Program,0)/Time spent in prison for a Conviction -Program Entry Rate[Cohort 3,Prison Systems, SIB]-Repeat Offender Program Entry Rate[Cohort 1,Prison Systems, SIB]-Repeat Offender Program Entry Rate[Cohort 2,Prison Systems, SIB])*Program Switch[Prison Systems]*

Repeat Offender Program Entry Rate [Cohort 4, Prison Systems, SIB] =

*(Repeat Offender Program Entry Rate[Cohort 1,Prison Systems, SIB]+Repeat Offender Program Entry Rate[Cohort 2,Prison Systems, SIB]+Repeat Offender Program Entry Rate[Cohort 3,Prison Systems, SIB])*Program Switch [Prison Systems]*

Repeat Offender Program Entry Rate [Cohorts, Prison Systems, Normal] =

"Prison Holding-Repeat Offence"[Cohorts, Prison Systems]/Time spent in prison for a Conviction-Repeat Offender Program Entry Rate [Cohorts, Prison Systems, SIB]

Units: People/Month

This represents the rate at which repeat offenders enter either the SIB program or the Normal program.

Savings from Reduced Reconvictions [Cohorts] =

*Total Cost of Incarceration *(Reconvictions Prevented [Cohorts])*

Units: k£/Month

This represents the total savings from the reconvictions that remain short term convictions. This is an Author Derived equation.

Social Impact Partnership=

INTEG (Investing+ Owner Program Payments-Program Payments from SIP, No Initial Worth)

Units: k£

This represents the funds available for the One* Service (i.e. SGT and Other NGOs) to operate in the Peterborough Prison. This comes from Social Finance Limited (2011).

Space Available in Program=

Available Capacity-Population in Program [Overall]

Units: People

This represents the number of people that could enter the program based on the available space.

Standard Cohort Length=

24

Units: Month

This is the standard time length of a cohort based on Cave et al. (2012).

Standard People in Cohort=

1000

Units: People

This is an Author defined variable based on information provided in Cave et al. (2012). It represents how many new incarceration releases are needed to finish a standard cohort.

"Successful Program?"[Overall]=

IF THEN ELSE (Reconviction Change [Overall]>=Minimum Change in Reconvictions [Overall], 1, 0)

"Successful Program?"[Cohort 1]=

IF THEN ELSE (Reconviction Change [Cohort 1]>=Minimum Change in Reconvictions [Cohort 1], 1, 0)

"Successful Program?"[Cohort 2]=

IF THEN ELSE (Reconviction Change [Cohort 2]>=Minimum Change in Reconvictions [Cohort 2], 1, 0)

"Successful Program?"[Cohort 3]=

IF THEN ELSE (Reconviction Change [Cohort 3]>=Minimum Change in Reconvictions [Cohort 3], 1, 0)

"Successful Program?"[Cohort 4]=

IF THEN ELSE (Reconviction Change [Cohort 4]>=Minimum Change in Reconvictions [Cohort 4], 1, 0)

Units: Dmnl

This variable measures whether or not the program successfully pays out as described by Cave et al. (2012).

"Surplus Returned?"=

IF THEN ELSE (Investment Finalization Time [Cohort 4] <Time, 1, 0)

Units: Dmnl

This is an author defined variable used to switch when the upper echelon of the MOJ starts to retrieve surplus payments beyond the legal obligation to repay investors.

Time after Cohort for Reconviction Collection=

12

Units: Month

This represents the time from when cohort collection ends and the reconviction collection ends. It is set at 12 months as per Cave et al. (2012)

Time for System Update=

6

Units: Month

This represents the time taken for systems to update any information change in the system. This includes both the recording of reconvictions and Budget surpluses. This value is pulled from Cave et.al. (2012)

Time MOJ Backlog Payments=

12

Units: Month

This is an author defined variable that represents the amount of time spent paying out the savings of the program.

Time Program has to Pay=

3

Units: Month

The time interval across which that payments are made to the investors of Social Impact Partnership (SIP). This is an Author defined variable since the payment timing and methods are confidential.

Time spent in prison for a Conviction=

1.5

Units: Month

The average time a short-term offender remains in prison per visit according to Cave et al. (2012). {1.5= 43/30}.

Time to Adjust Maximum Program Cost=

1

Units: Month

This is an Author defined Variable representing the time delay to change the maximum program costs.

Total Cost of Incarceration=

*Monthly cost*Time spent in prison for a Conviction+ Conviction Cost*

Units: k£/People

This represents the cost for each reconviction by the British government per person. It is a combination of both the legal action and the time spent in prison. This is an Author derived equation from Mulgan et al. 2012).

Total Prison Population [Prison Systems] =

"Prison Holding-First Offence"[Prison Systems] +"Prison Holding-Repeat Offence"[Overall, Prison Systems]

Units: People

The percentage of system use.

Total Program Participants [Cohorts] =

INTEG (Offenders entering Program [Cohorts], 0)

Units: People

This represents the accumulated number of people to enter the program.

Undiscovered Reoffenders [Overall, Prison Systems, Normal] =

*INTEG ("Non-Rehabilitated Prisoner Release Rate- First Offence"[Overall, Prison Systems, Normal] +"Non-Rehabilitated Prisoner Release Rate- Repeat Offence"[Overall, Prison Systems, Normal]-Repeat Offender Arrest Rate [Overall, Prison Systems, Normal], Initial Undiscovered Reoffenders*Offender Multiplier between Prison Systems [Prison Systems])*

Undiscovered Reoffenders [Cohorts, Prison Systems, SIB] =

INTEG ("Non-Rehabilitated Prisoner Release Rate- First Offence"[Cohorts, Prison Systems, SIB] +"Non-Rehabilitated Prisoner Release Rate- Repeat Offence"[Cohorts, Prison Systems, SIB]-Repeat Offender Arrest Rate [Cohorts, Prison Systems, SIB], 0)

Undiscovered Reoffenders [Cohort 1, Prison Systems, Normal] =

INTEG ("Non-Rehabilitated Prisoner Release Rate- First Offence"[Cohort 1, Prison Systems, Normal] + "Non-Rehabilitated Prisoner Release Rate- Repeat Offence"[Cohort 1, Prison Systems, Normal]-Repeat Offender Arrest Rate [Cohort 1, Prison Systems, Normal], 0)

Undiscovered Reoffenders [Cohort 2, Prison Systems, Normal] =

INTEG ("Non-Rehabilitated Prisoner Release Rate- First Offence"[Cohort 2, Prison Systems, Normal] + "Non-Rehabilitated Prisoner Release Rate- Repeat Offence"[Cohort 2, Prison Systems, Normal]-Repeat Offender Arrest Rate [Cohort 2, Prison Systems, Normal], 0)

Undiscovered Reoffenders [Cohort 3, Prison Systems, Normal] =

INTEG ("Non-Rehabilitated Prisoner Release Rate- First Offence"[Cohort 3, Prison Systems, Normal] +"Non-Rehabilitated Prisoner Release Rate- Repeat Offence"[Cohort 3, Prison Systems, Normal]-Repeat Offender Arrest Rate [Cohort 3, Prison Systems, Normal], 0)

Undiscovered Reoffenders [Cohort 4, Prison Systems, Normal] =

INTEG ("Non-Rehabilitated Prisoner Release Rate- First Offence"[Cohort 4, Prison Systems, Normal] +"Non-Rehabilitated Prisoner Release Rate- Repeat Offence"[Cohort 4, Prison Systems, Normal]-Repeat Offender Arrest Rate [Cohort 4, Prison Systems, Normal], 0)

Units: People

This represents the people that are in the program that eventually will recommit.

Unpaid Investor Earned Returns [Cohorts] =

INTEG (Investor Earned Return Accumulation [Cohorts]-Earned Investor Return payments [Cohorts], No Initial Worth)

Units: k£

This represents the accumulation of investor earnings through payment based on Cave et al. (2012)

Value Paid Early=

INTEG (paying early, 0)

Units: k£

This represents the amount of money that the MOJ paid for the program before the final cohort closed. This is an Author defined variable.

Yearly Cost of Incarceration=

39

Units: k£/People

This represents the annum cost for each incarceration by the British government per person that is in prison as per Loder et al. (2010).

Stock Flow Diagrams

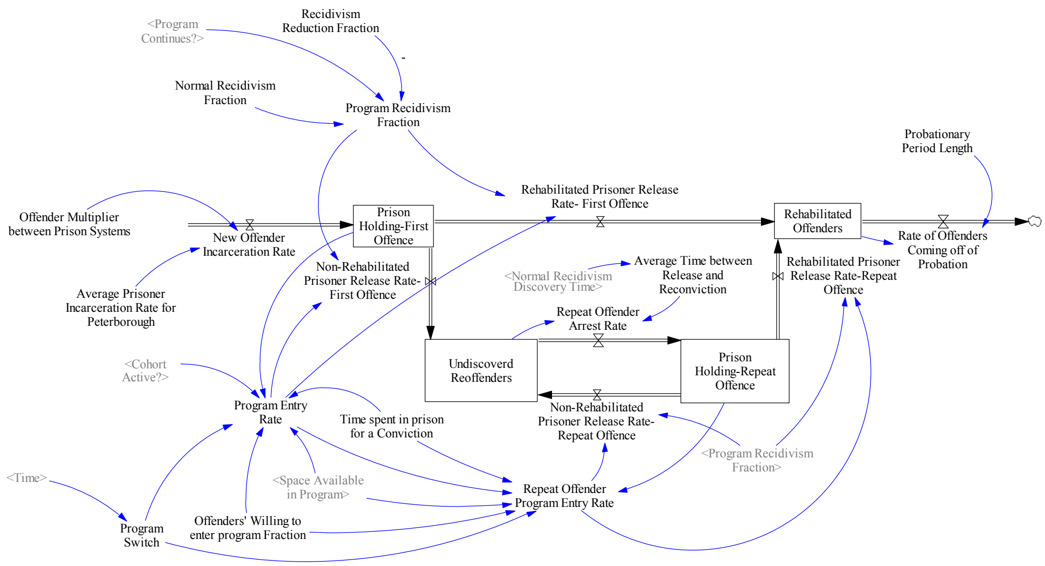


Figure 31: Prison System Model Sector and Variable Relationships

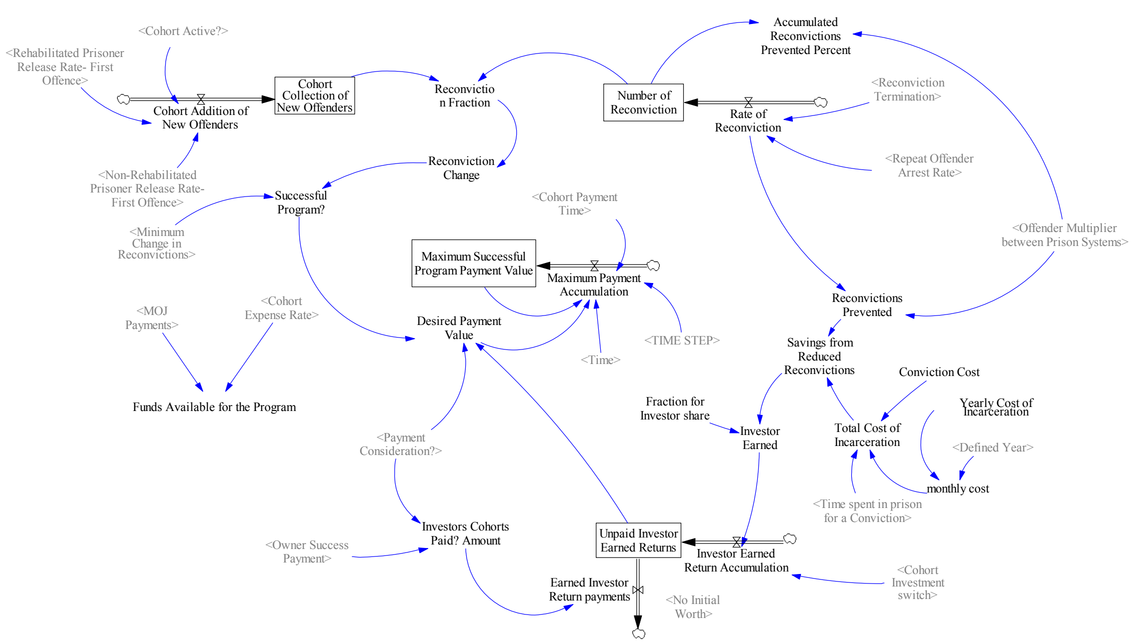


Figure 32: PSM Model Sector and Variable Relationships

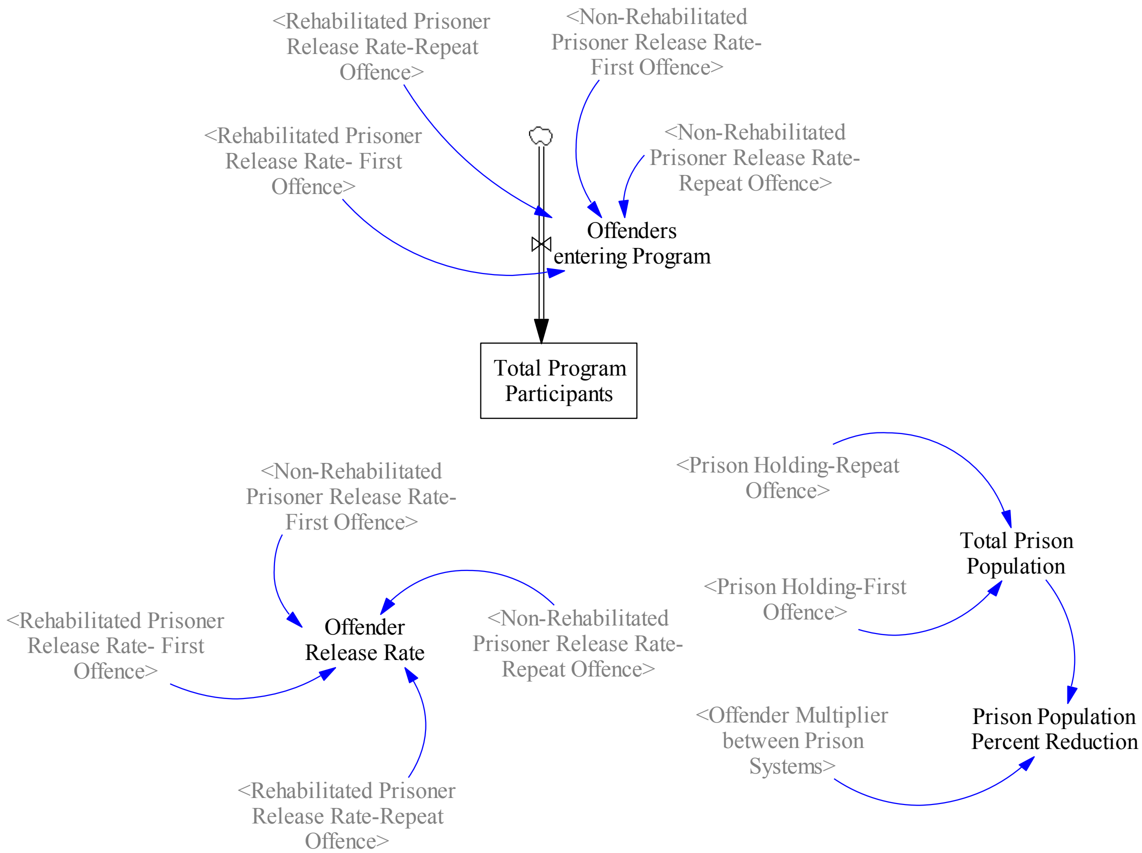


Figure 33: Prison Outcome Model Sector and Variable Relationships

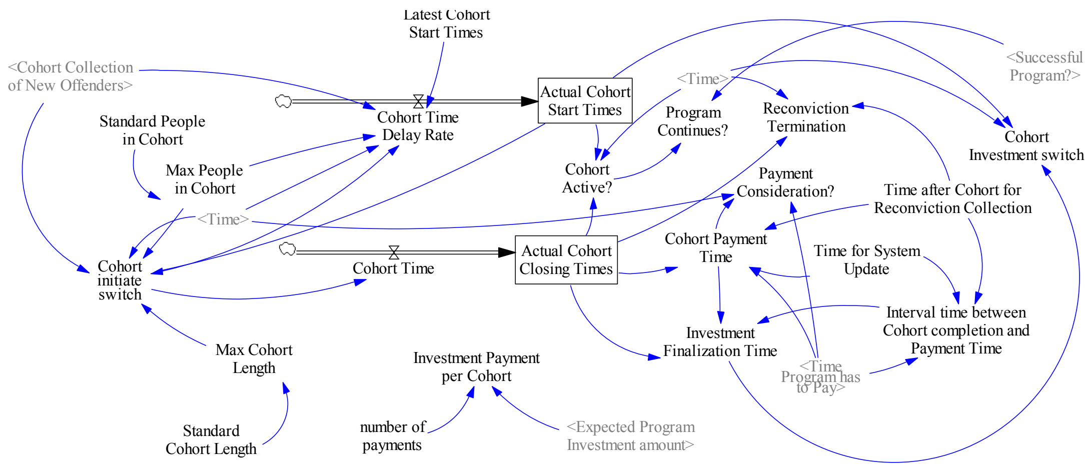


Figure 34: Time Boundaries Model Sector and Variable Relationships

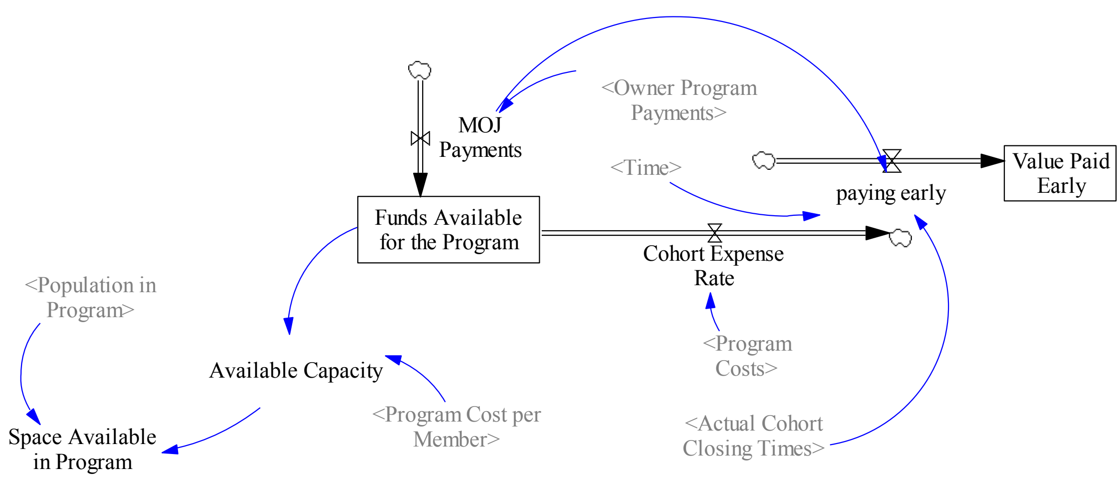


Figure 35: Program Availability Model Sector and Variable Relationships

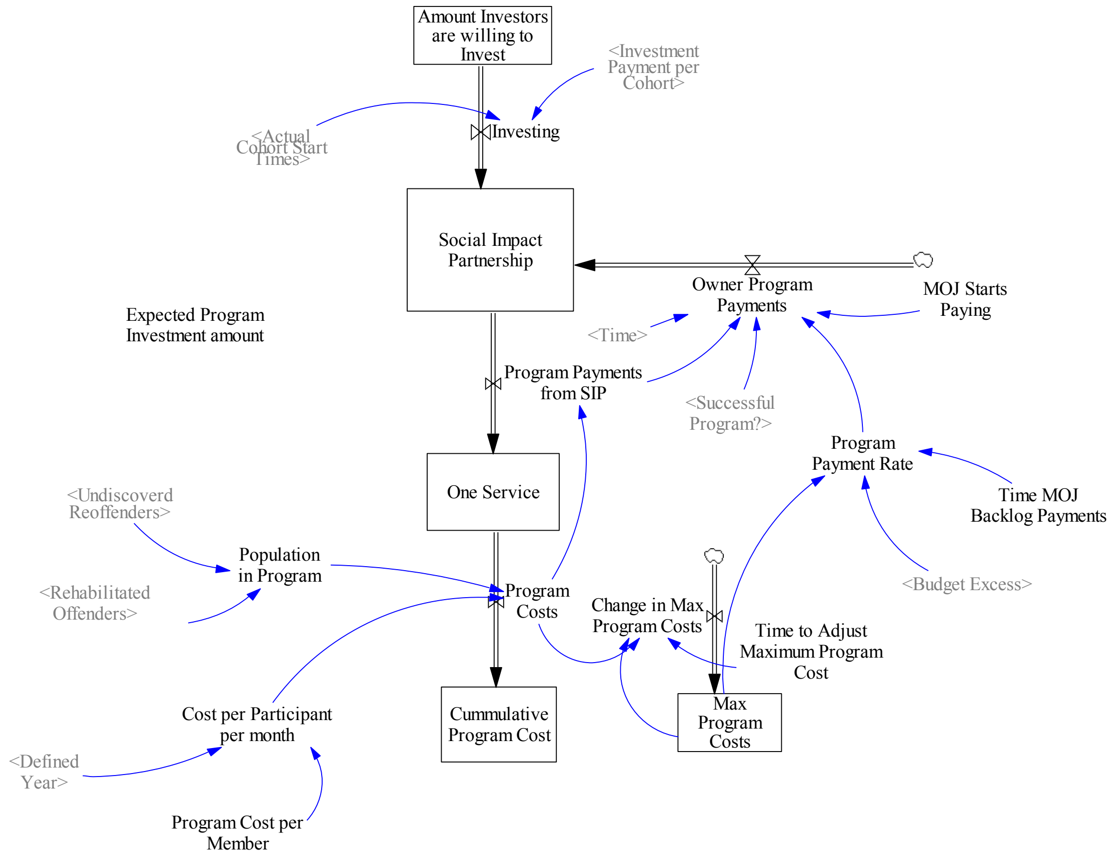


Figure 36: SIB Program Model Sector and Variable Relationships

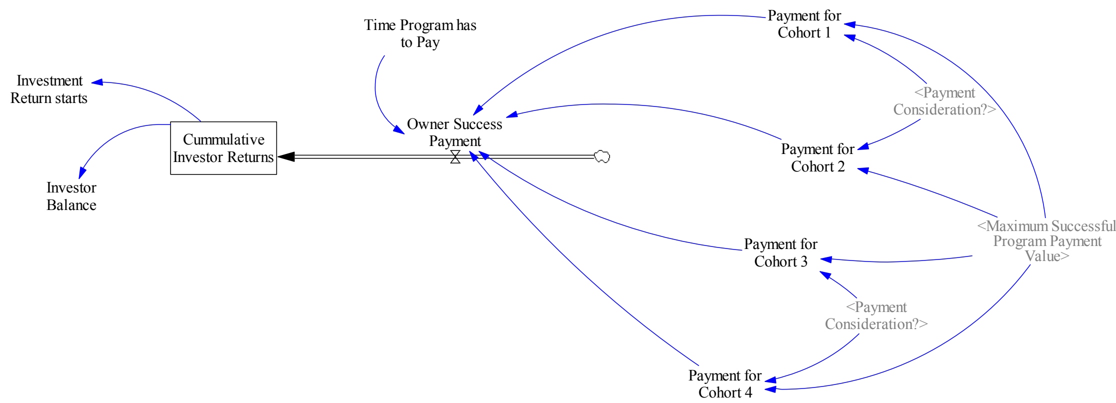


Figure 37: SIB Payment Model Sector and Variable Relationships

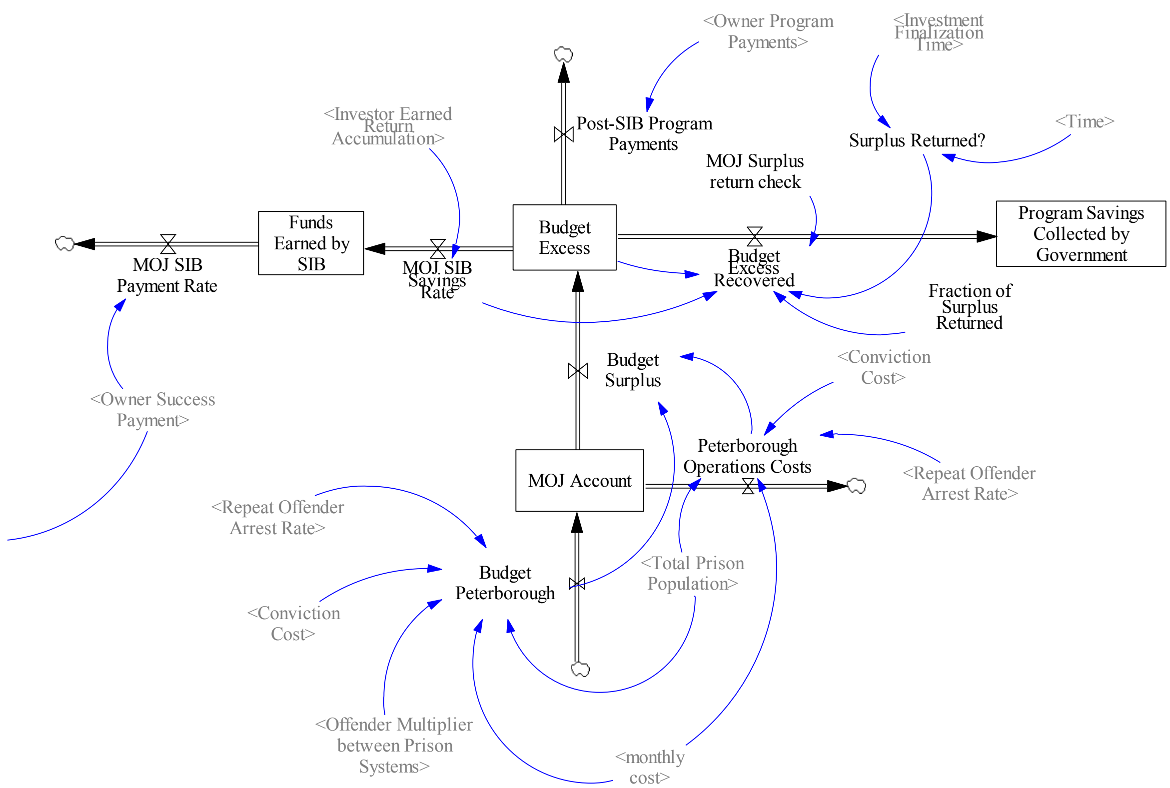


Figure 38: Owner Finances Model Sector and Variable Relationships

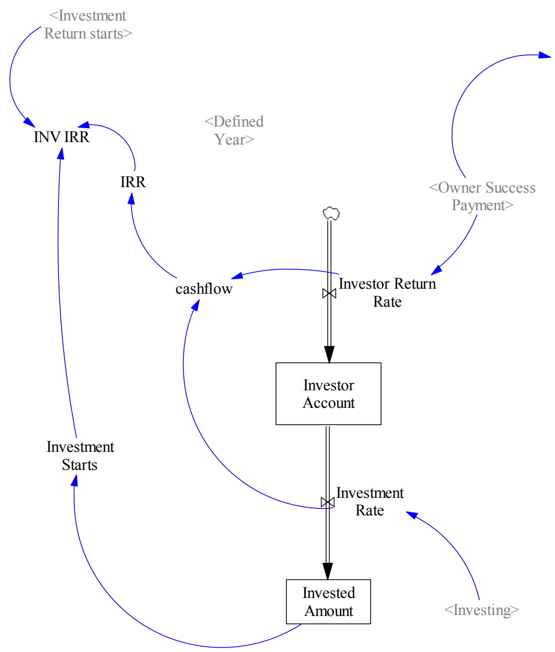


Figure 39: Investor Finances Model Sector and Variable Relationships

Table 12: Exogenous Variable Values (Peterborough)

	Exogenous Variable	Description	Calibration	Units	Source
Peterborough Specific	Average Prisoner incarceration Rate for Peterborough	This represents the maximum number of new people that can be placed in the prison system, all other prisoners must go to a different prison system.	57.83 or 694/12	Offenders/ Month	Cave et al. (2012)
	Minimum Change in Reconvictions	This represents the minimum change in reconvictions for the program to be considered a success.	10% (7.5%)	DMNL	(Strickland 2010, Mulgan et al. 2011, Cave et al. 2012)
	Normal Recidivism Fraction	The normal quality of the system without having the project in play.	75%	DMNL	(Strickland 2010, Loder et al. 2010, Mulgan et. al. 2011)
	Offender Multiplier between Prison Systems	This represents the ratio of people needed in each grouping to have an appropriate power level.	10	DMNL	Cave et al. (2012)
	Probationary Period Length	This represents how long the rehabilitation program lasts and how long prisoners are tracked for reconvictions.	12	Months	(Mulgan et al. 2011, Cave et al. 2012)
	Program Cost per Member	This is the average cost per member for the program.	1.5	k£/ Offender	Mulgan et al. (2011)
	Standard Cohort Length	This is the standard time length of a cohort.	24	Months	Cave et al. (2012)
	Standard People in Cohort	It represents how many new incarceration releases are needed to finish a standard cohort.	1000	First-time Offenders	Cave et al. (2012)
	Time for System Update	This represents the time taken for systems to update any information change in the sysem. This includes both the recording of reconvictions and Budget surpluses.	6	Months	Cave et al. (2012)
	Time after Cohort for Reconviction Collection	This represents the time from when cohort collection ends and the reconviction collection ends.	12	Months	Cave et al. (2012)
	Time Spent in Prison for a Conviction	The average time a short-term offender remains in prison per visit.	1.5	Months	Cave et al. (2012)
	Yearly Cost of Incarceration	This represents the annum cost for each incarceration by the British government per person that is in prison.	39	k£/ Offender	Loder et al. (2010)
	Conviction Cost	This represents the legal costs per conviction. There is a discrepancy of conviction costs.	2.853	k£/ Offender	SEU (2002) & Mulgan et al. (2011)
	Expected Program Investment amount	This represents the minimum required investment from the investors.	5000	k£	Strickland (2010)
	Offenders' Willing to enter program Fraction	This represents the percentage of prisoners that elect to go through the program.	70%	DMNL	Disely et al. (2011)
	Annual Interest Rate for Investment [Maximum]	This represents the maximum interest rate rate that investors can accrue from their investment for a successful case.	13%	DMNL	Cave et al. (2012)
	Annual Interest Rate for Investment [Minimum]	This represents the minimum interest rate that investors can accrue from their invesment for a successful case.	7.5%	DMNL	Cave et al. (2012)
	Recidivism Reduction Fraction	This represents the change in recidivism that occurs from the program.	0.3	DMNL	(Mulgan et al. 2011, Loder et al. 2010)
	Fraction for Investor shares	This represents the percentage share of savings that the investors receive in a successful project. The actual value is confidential and the value listed is estimated.	50%	DMNL	Disely et al. (2011) and Author Defined
	MOJ Starts Paying	This represents the time that the MOJ starts paying and is tuned to the end of offenders collecting in the SIB.	73	Months	Model/ Author Defined
	Normal Recidivism Discovery Time	The average amount of time it takes to convict a recently released offender of a new crime.	6	Months	Cox (2006)
Initial Conditions	Initial Undiscovered Reoffenders	This represents the number of released offenders awaiting their discovery for reconviction that starts the model in steady state.	1041	Offenders	Cave et al. (2012)
	Initial First time Offender Prisoner Holding	This is the tunded value for the initial prisoners that starts the model in steady state.	86.75	Offenders	Cave et al. (2012)
	Initial Reconvicted Prisoner Holding	This represents the initial amount of offenders that have been reconvicted in the prison to start the model in steady state.	260.25	Offenders	Cave et al. (2012)
	Time to Adjus Maximum	Time delay to change the maximum program costs	1	Months	Author Defined

Table 12: Continued

Ini	Initial Reconvicted Prisoner Holding	This represents the initial amount of offenders that have been reconvicted in the prison to start the model in steady state.	260.25	Offenders	Cave et al. (2012)
Author Defined	Average Prisoner Incarceration Rate for Peterborough	This represents the maximum number of new people that can be placed in the prison system, all other prisoners must go to a different prison system.	57.83 or 694/12	Offenders/ Month	Cave et al. (2012)
	Minimum Change in Reconvictions	This represents the minimum change in reconvictions for the program to be considered a success.	10% (7.5%)	DMNL	(Strickland 2010, Mulgan et al. 2011, Cave et al. 2012)
	Normal Recidivism Fraction	The normal quality of the system without having the project in play.	75%	DMNL	(Strickland 2010, Loder et al. 2010, Mulgan et. al. 2011)
	Fraction of Surplus Returned	This represents the fraction of budget surplus between the expected and actual expenses that is returned to the MOJ	50%	DMNL	Author Defined
	Offender Multiplier between Prison Systems	This represents the ratio of people needed in each grouping to have an appropriate power level.	10	DMNL	Cave et al. (2012)
	Probationary Period Length	This represents how long the rehabilitation program lasts and how long prisoners are tracked for reconvictions.	12	Months	(Mulgan et al. 2011, Cave et al. 2012)

Exogenous Variable	Description	Calibration	Units	Source
Time to Adjus Maximum Program Cost	Time delay to change the maximum program costs.	1	Months	Author Defined
Investor Discount Rate	This represents the discount rate for investors as an alternate investment rate of return.	5%	DMNL	Author Defined
MOJ Discount Rate	This represents the discount rate for the MOJ as an alternate investment rate of return.	3%	DMNL	Author Defined
Time Program has to Pay	The time interval across which payments are made to the investors of Social Impact Partnership	3	Months	Author Defined
Time MOJ Backlog Payments	This represents the time delay used by the MOJ to pay the savings of the program for program operations.	12	Months	Author Defined

Extreme Conditions Testing (ECT)

Table 13: ECT Setup Peterborough

		Variable Name	Description	Normal	Test type 1	Test type 2	Maximum	Minimum	Observed Variables		
OD	1	MOJ Discount Rate	This is an interest rate describing the risk, or borrowing cost, for the owner agency.	3.00%	Max	Min	15%	0%	IRR MOJ		
ID	2	Investor Discount Rate	This is an interest rate describing the risk, or borrowing cost, for the investors.	5.00%	Max	Min	15%	0%	IRR Investor		
WR	3	Offenders' Willing to enter program Fraction	The percentage of prisoners willing to participate in the new release program.	70%	Max	Min	100%	0%	Reconviction Rate	IRR (Variables)	Release Rate
RDT	4	Normal Recidivism Discovery Time	This represents the average time that a released offender spends in society before reconviction.	6 mon	Max	Min	12 months	0.1 months	Reconviction Rate	IRR (Variables)	Release Rate
IS	5	Fraction for Investor Share	This represents the percentage of savings that the investor recieves.	0.5	Max	Min	0%	100%	Reconviction Rate	IRR (Variables)	Release Rate
RCF	6	Recidivism Change Fraction	This represents the percentage that the recidivism is reduced from the program.	0.2	Max	Min	-33%	100%	Reconviction Rate	IRR (Variables)	Release Rate
IA	7	Expected Program Investment Amount	This represents the amount of money that the government asks the private sector to finance the SIB or Bond with	5000k£	Max	Min	500k£	50000£	Reconviction Rate	IRR (Variables)	Release Rate
PSRP	8	Post-Program-Savings-Reinvestment Percent per month	In the event of a successful program, this represents the amount of savings that the government is willing to send back as a reinvestment each month.	0.833%	Max	Min	0%	100%	Reconviction Rate	IRR (Variables)	Release Rate
CC	9	Conviction Costs	This represents the cost for a conviction	2.853 k£	Max	Min	0	25k£	Reconviction Rate	IRR (Variables)	Release Rate
PPT	10	Time Program has to Pay	The time allowed between determining the successs of the program and paying investors.	3	MAX	MIN	0.1	6	Reconviction Rate	IRR (Variables)	Release Rate
MPIR	11	Average Prisoner Incarceration Rate for Peterborough	This represents how many people enter the prison system as new incarcerations.	57.83	Max	Min	0	100	Reconviction Rate	IRR (Variables)	Release Rate
IPH	12	Initial First time Offender Prisoner Holding	This represents the initial number of new incarcerations in prison at the start of the model.	86.75	Max	Min	0	150	Reconviction Rate	IRR (Variables)	Release Rate
IUR	13	Initial Undiscovered Reoffenders	This represents the initial number of people in the undiscovered recidivism stock at the start of the model.	1041	Max	Min	0	2000	Reconviction Rate	IRR (Variables)	Release Rate
IRPH	14	Initial Reconvicted Prisoner Holding	This represents the number of reconvicted prisoners in the prison system at the start of the model.	260.25	Max	Min	0	500	Reconviction Rate	IRR (Variables)	Release Rate

Table 14: ECT Expectations Peterborough

Variable Name	Expectation 1	Expectation 2	Expectation 3
MOJ Discount Rate	As the Owner Discount Rate changes, the IRR Owner should also change. The relationship should be inverse and exponential since the discount rate is an interest rate and the IRR is a percentage of net benefits. As the Owner Discount Rate increases the IRR Owner should decrease exponentially.		
Investor Discount Rate	As the Investor Discount Rate changes, the IRR Investor should also change. The relationship should be exponential since the discount rate is an interest rate and the IRR is a percentage of net benefits. As the Investor Discount Rate increases the IRR Investor should decrease exponentially.		
Offenders' Willing to enter program Fraction	The willingness ratio should have a negative correlation with the Reconviction Rate. As willingness ratio increases, Reconviction Rate should decrease.	willingness ratio should have a positive correlation with the IRRs. As Program Choice is increased, the IRRs should increase or stay the same based on where the initial Investor payout occurs.	The willingness ratio should have a negative correlation with the release rates.
Normal Recidivism Discovery Time	Recidivism Discovery Time should negatively correlate to the Reconviction rate.	Recidivism Discovery Time should have an negative effect on the IRRs because more time between reconvictions means fewer reconvictions in the measured time.	Recidivism Discovery Time should have a negative on the release rate because the reconvictions happen less often.
Fraction for Investor Share	As the investor shares changes there should be no change in the reconviction rate.	As the investor share increases, the investors IRR shound increase, the Prisons IRR should not change, the MOJ IRR should decrease.	As the investor share there shold be no change in the release rate
Recidivism Change Fraction	There should be a negative correlation between the recidivism change fraction and the reconviction rate.	The IRRs will have a positive correlation with the recidivism change fraction.	The recidivism change fraction has a negative correlation with the release rate.
Expected Program Investment Amount	As the investment amount increases, the reconviction rate should decrease. If there is too little investment the reconviction rate will drop and then rise as funds are depleted.	The Investor IRR will drop off if the investment is too small, but after a certain threashold the IRR will not change, just the magnitude of the payout. The MOJ IRR will decrease outside an optimal range of investment, because there will either be no benefit or the MOJ will be paying to much in return for the program.	As the investment amount increases, the release rates should decrease to a maximum level.
Post-Program-Savings-Reinvestment Percent per month	In a successful program, the reconviction rate will decrease as more funds are put in the system.	As more money is put into the system the IRR will increase for the MOJ; however, if too much money is reinvested then there will be waste at the SPV. Nothing should change with the Investors IRR.	As more money goes into the system the release rate should drop with the reconviction rate.
Conviction Costs	The cost per conviction should not have any change when increasing, but decreasing the cost per conviction would increase the reconviction rate as there would as much savings to continue the program.	As conviction costs increase from zero there will be a greater IRR for both investors and owner.	The release rate should follow the reconviction Rate
Time Program has to Pay	There should be no change in the reconviction rate due to the Program Pays Time.	As program pays time increases from near zero, the IRR for investors should decrease and the IRR for the owner should increase, because there is no interest collected after the program decision to pay is made.	There should be no impact from the Program Pays Time on the Release Rate.
Average Prisoner Incarceration Rate for Peterborough	The number of reconvictions should increase as the prisoner incarceration rate increases.	There should only be a small change in the IRRs as the stocks and flows try to adjust for the increased average inflow of new prisoners.	As the prisoner incarceration rate increases, the release rates will increase.
Initial First time Offender Prisoner Holding	Increasing the intitial prisoner holding should cause an initial spike in the reconviction rate	Increasing the initial prisoner holding should cause very little effect on the IRRs. There may be some noise as the model tries to stablize around average values.	As the initial prisoner holidng increases the release rates will also temporarily increase.
Initial Undiscovered Reoffenders	An increase in the initial undiscovered recidivism should cause an increase in the reconviction rate.	Increasing the initial undiscovered recidivism should cause very little effect on the IRRs. There may be some noise as the model tries to stablize around average values.	as the initial undiscovered recidivism increases the release rates will temporarily increase.
Initial Reconvicted Prisoner Holding	An increase in the initital reconviction prisoner holding should cause the reconviction rate to increase.	Increasing the initial reconviction prisoner holding should cause very little effect on the IRRs. There may be some noise as the model tries to stablize around average values.	as the initial reconviction prisoner holidng increases the release rate will also temporarily increase.

Key
Other Literature
Author Defined
Inconsistent
Steady State Calibration

Table 15: ECT Results-Summary Peterborough

Variable Name	Reality 1	Reality 2	Reality
MOJ Discount Rate			A greater discount rate allows th and costs that occur early in the p toward the
Investor Discount Rate		Decreasing the Investor Discount Rate causes the Investor IRR to increase.	
Offenders' Willing to enter program Fraction	The lower willingness ratio instills a greater reconviction rate.	If no one is willing then the investors see no return on their investment, other than that there is very little change between Investor IRR and Willingness ratio	The MOJ looses nothing if the n program, but as the willingness increase
Normal Recidivism Discovery Time	As the RDT decreases the Reconviction Rate increases.	As the Recidivism Discovery Time (RDT) increases, the initial Investor IRR decreases. The maximum RDT is lower than the normal at the end because less funds are accumulating from convictions and the normal rests at the maximum.	As the RDT decrease the
Fraction for Investor Share	The IS has no effect on the reconviction rate because the investors are still seeing a return.	As the Investor Share (IS) increases, the Investor IRR increases. (Bound by max and min returns)	As the IS increases the MOJ IRR de minimum re
Recidivism Change Fraction	As the RCF increases, the reconviction rate decreases.	The recidivism change fraction (RCF) only increases to the point of success and then has little effect on the Investor IRR.	As the RCF increases, the
Expected Program Investment Amount	As the IA increases, the reconviction rate decreases.	As the Investment Amount (IA) increases it reaches an optimal investment and then decreases to the minimum payback.	As the IA increases, it reaches ar becomes too e
Post-Program-Savings-Reinvestment Percent per month	As the PSRP increases, the reconviction rate decreases.	The Program Savings Reinvestment Percent per month (PSRP) has no effect on the Investor IRR.	As the PSRP increases, the
Conviction Costs	There is very little change but decreasing CC increases the Reconviction Rate.	As the Conviction Costs increase (CC) the Investor IRR increases within the max and min returns for a successful project.	As the CC increases so
Time Program has to Pay	There is no change	As the program pays time (PPT) increases the investor IRR eventually increases.	As the PPT increases the MOJ
Average Prisoner Incarceration Rate for Peterborough	No min PIR for Reconviction rate, but the Max starts higher than the normal and ends lower.	As the Prisoner Incarceration Rate (PIR) increases, the Investor IRR increases to a point and then decreases.	As the PIR increases the MOJ
Initial First time Offender Prisoner Holding	IPH has a slight disturbance in the end of the Reconviction Rate	Initial Prisoner Holding (IPH) has no effect	IPH has a slight disturbance in t
Initial Undiscovered Reoffenders	As the IUR increases the Reconviction Rate increases	Increasing the Initial Undiscovered Recidivism (IUR) lowers the investor IRR.	As the IUR increases, the
Initial Reconvicted Prisoner Holding	As the IRPH increases there is a slight increase in the reconviction rate	No change from Initial Reconviction Prisoner Holding (IRPH).	As the IRPH increases, the MOJ I decrea

Table 15: Continued

Reality 2	Variable Name	Reality 1 / Reality 3	Reality 2 / Reality 4	Reality 3
		A greater discount rate allows the MOJ to value the benefits and costs that occur early in the project at a greater rate than toward the end.		A greater discount rate allows the MC nd costs that occur early in the proje toward the end
Decreasing the Investor Discount Rate causes the Investor IRR to increase.	Investor Discount Rate			
If no one is willing then the investors see no return on their investment, other than that there is very little change between Investor IRR and Willingness ratio	Offenders Willing to enter program Fraction	The MOJ looses nothing if the noone is willing to enter the program, but as the willingness increases, the MOJ's IRR increases. The lower willingness ratio implies a greater reconviction rate.	If no one is willing then the investors see no return on their investment, other than that there is very little change between Investor IRR and Willingness ratio As the Willingness ratio increases, the release rate decreases.	The MOJ looses nothing if the noone program, but as the willingness incr increases.
As the Recidivism Discovery Time (RDT) increases, the initial Investor IRR decreases. The maximum RDT is lower than the normal at the end because less funds are accumulating from convictions and the normal rests at the maximum.	Normal Recidivism Discovery Time	As the RDT decreases the MOJ IRR increases. As the RDT decreases the Reconviction Rate increases.	As the Recidivism Discovery Time (RDT) increases, the initial Investor IRR decreases. The maximum RDT is lower than the normal at the end because less funds are accumulating from convictions and the normal rests at the maximum. Initially, as the RDT increases the Release Rate decreases, but the final time has an increase in release rate because the measure is captured from cohort 4.	As the RDT decrease the MOJ
As the Investor Share (IS) increases, the Investor IRR increases. (Bound by max and min returns)	Fraction for Investor Share	As the IS increases the MOJ IRR decreases (Bound by the and investors minimum return) The IS has no effect on the reconviction rate	The Investor Share (IS) increases, the Investor IRR increases. (Bound by max and min returns) There is no effect on the release rate	As the IS increases the MOJ IRR decrea minimum return
The recidivism change fraction (RCF) only increases to the point of success and then has little effect on the Investor IRR.	Recidivism Change Fraction	As the RCF increases, the MOJ IRR decreases. As the RCF increases, the Reconviction Rate decreases.	The recidivism change fraction (RCF) only increases to the point of success and then has little effect on the Investor IRR. As the RCF increases, the release rate decreases.	As the RCF increases, the MO
As the Investment Amount (IA) increases it reaches an optimal investment and then decreases to the minimum payback.	Expected Program Investment Amount	As the IA increases, it reaches an optimal MOJ IRR and then becomes too excessive. As the IA increases, the reconviction rate decreases.	As the Investment Amount (IA) increases it reaches an optimal investment and then decreases to the minimum payback. As the IA increases, the Release rate decreases.	As the IA increases, it reaches an opt becomes too exces
The Program Savings Reinvestment Percent per month (PSRP) has no effect on the Investor IRR.	Post-Program-Savings-Reinvestment Percent per month	As the PSRP increases, the MOJ IRR decreases. As the PSRP increases, the reconviction rate decreases.	The Program Savings Reinvestment Percent per month (PSRP) has no effect on the Investor IRR. As the PSRP increases, the release rate decreases.	As the PSRP increases, the MO
As the Conviction Costs increase (CC) the Investor IRR increases within the max and min returns for a successful project.	Conviction Costs	There is very little change but decreasing CC increases the Reconviction Rate. As the CC increases so does the MOJ IRR.	As the Conviction Costs increase (CC) the Investor IRR increases within the max and min returns for a successful project. There is very little change but decreasing the CC increases the release rate	As the CC increases so does
As the program pays time (PPT) increases the investor IRR eventually increases.	Time Program Has to Pay	As the PPT increases the MOJ IRR eventually decreases. There is no change	As the program pays time (PPT) increases the investor IRR eventually increases. There is no change	As the PPT increases the MOJ IRR e
As the Prisoner Incarceration Rate (PIR) increases, the investor IRR increases to a point and then decreases.	Average Prisoner Incarceration Rate for Peterborough	No min PIR for Reconviction rate, but the Max starts higher than the normal and ends lower. As the PIR increases the MOJ IRR eventually increases.	As the Prisoner Incarceration Rate (PIR) increases, the investor IRR increases to a point and then decreases. No min PIR for Release rate, but the Max starts higher than the normal and ends lower.	As the PIR increases the MOJ IRR e
Initial Prisoner Holding (IPH) has no effect	Initial First time Offender Prisoner Holding	IPH has a slight disturbance in the end of the Reconviction Rate IPH has a slight disturbance in the middle of the MOJ IRR	Initial Prisoner Holding (IPH) has no effect There is no change	IPH has a slight disturbance in the m
Increasing the Initial Undiscovered Recidivism (IUR) lowers the investor IRR.	Initial Undiscovered Reoffenders	As the IUR increases the MOJ IRR increases As the IUR increases the Reconviction Rate increases	Increasing the Initial Undiscovered Recidivism (IUR) lowers the investor IRR. As the IUR increases the Release Rate increases.	As the IUR increases, the MO
No change from Initial Reconviction Prisoner Holding (IRPH).	Initial Reconviction Prisoner Holding	As the IRPH increases, the MOJ IRR slight increase, but ends in a decrease As the IRPH increases, there is a slight increase in the reconviction rate	As the IRPH increases there is a slight increase in the release rate. No change from Initial Reconviction Prisoner Holding (IRPH).	As the IRPH increases, the MOJ IRR i decrease

Results-Graphs

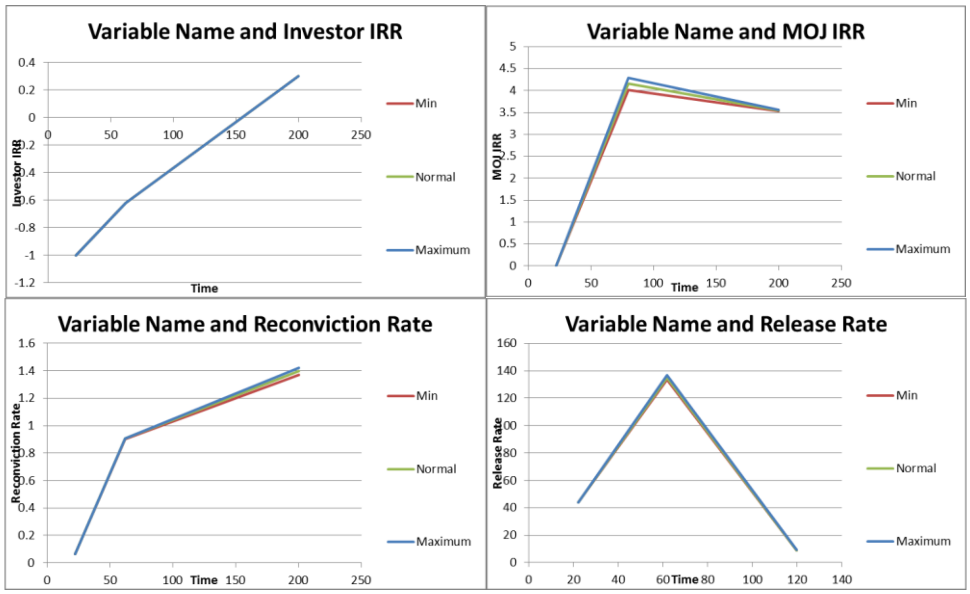


Figure 40: Key ECT Results Graphs Peterborough

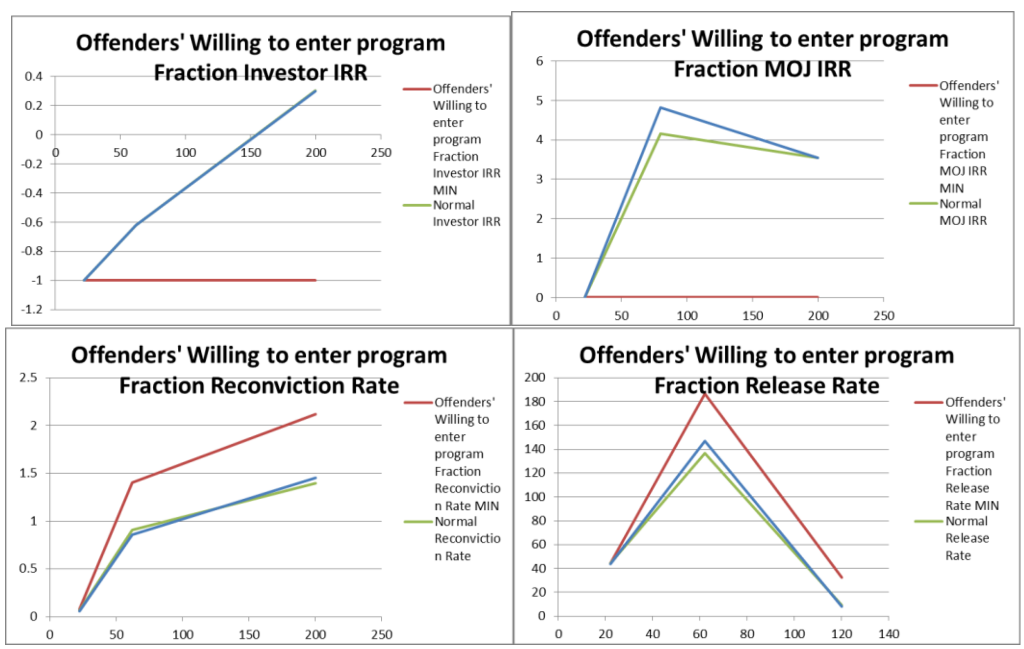


Figure 41: Offenders' Willingness to Enter Program ECT Results Graphs Peterborough

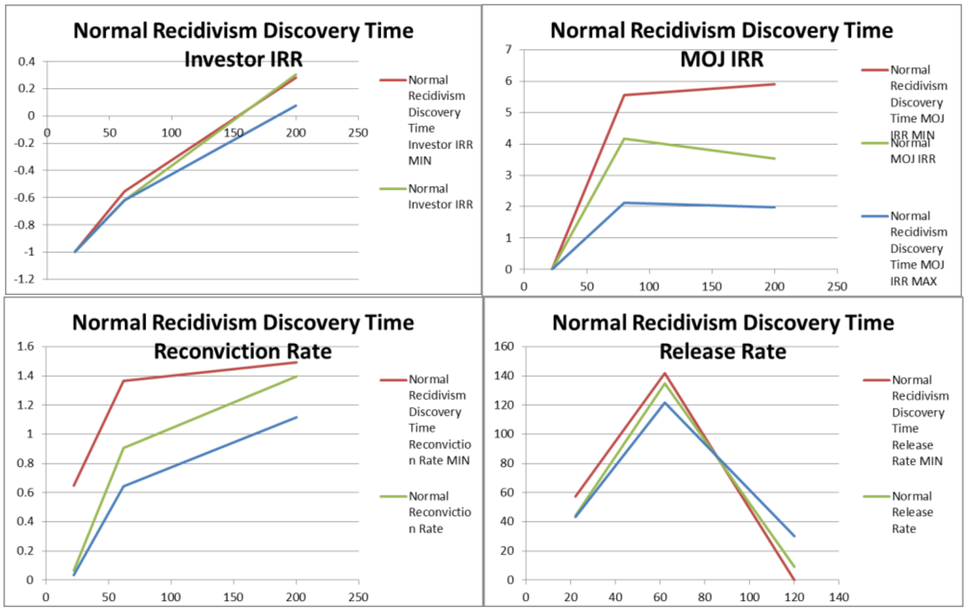


Figure 42: Normal Recidivism Discovery Time ECT Results Graphs Peterborough

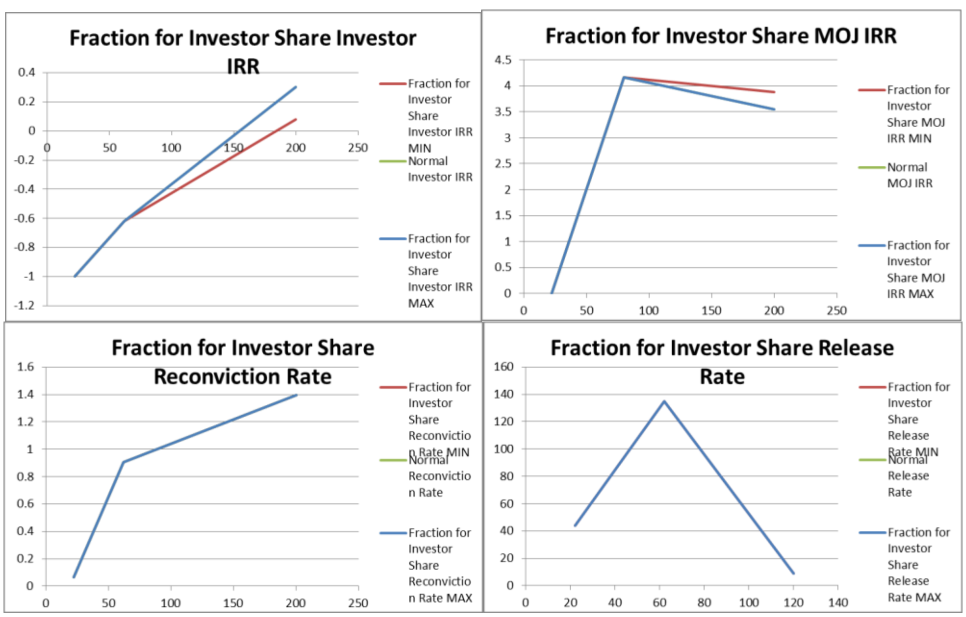


Figure 43: Fraction for Investor Share ECT Results Graphs Peterborough

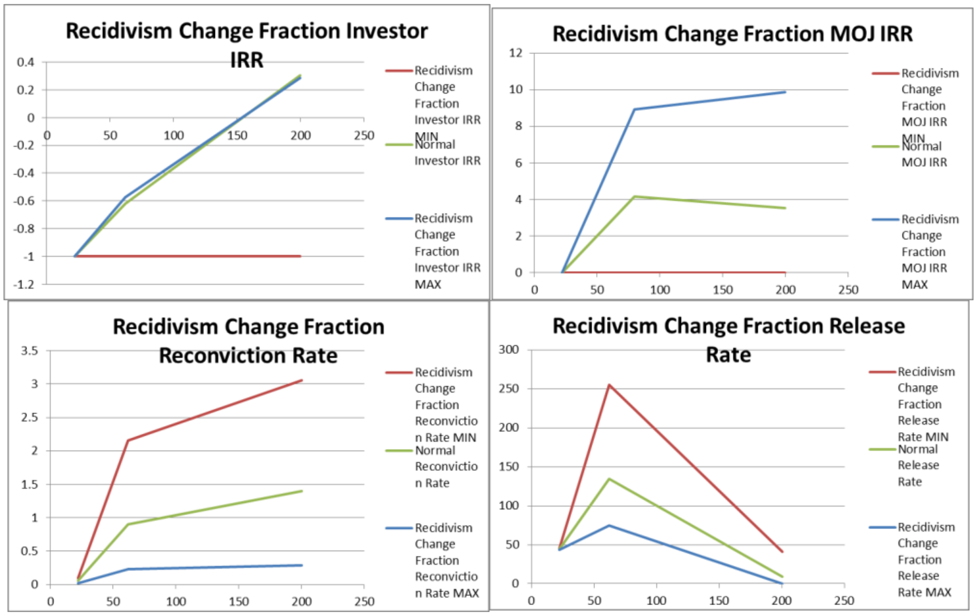


Figure 44: Recidivism Change Fraction ECT Results Graphs Peterborough

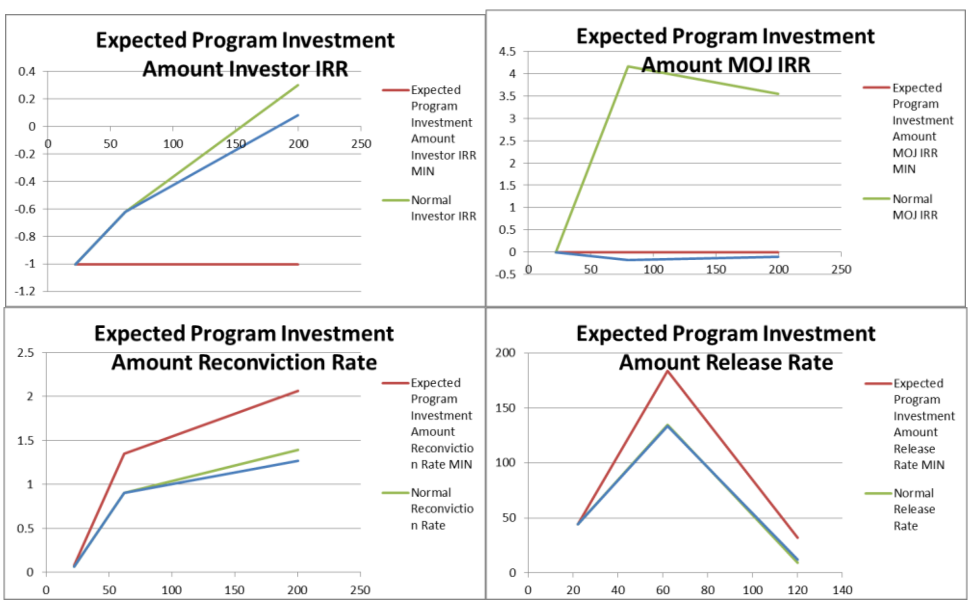


Figure 45: Expected Program Investment ECT Results Graphs Peterborough

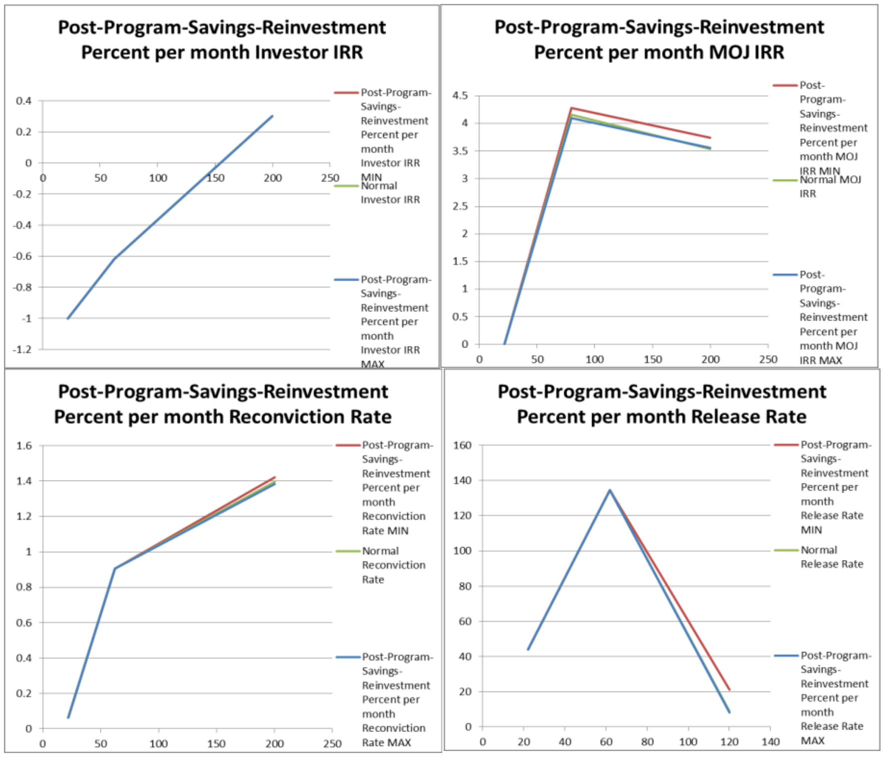


Figure 46: Post-Program-Savings-Reinvestment Percent ECT Results Graphs Peterborough

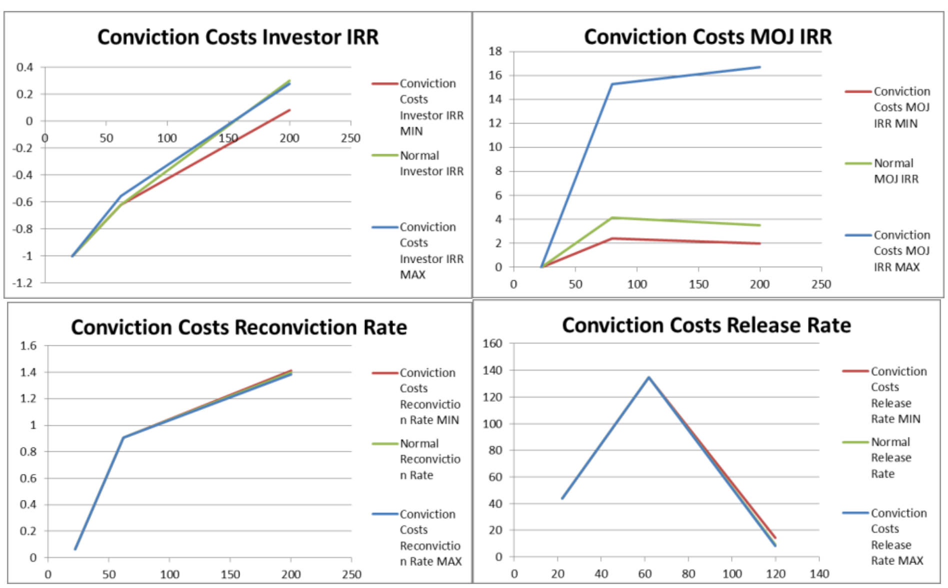


Figure 47: Conviction Cost ECT Results Graphs Peterborough

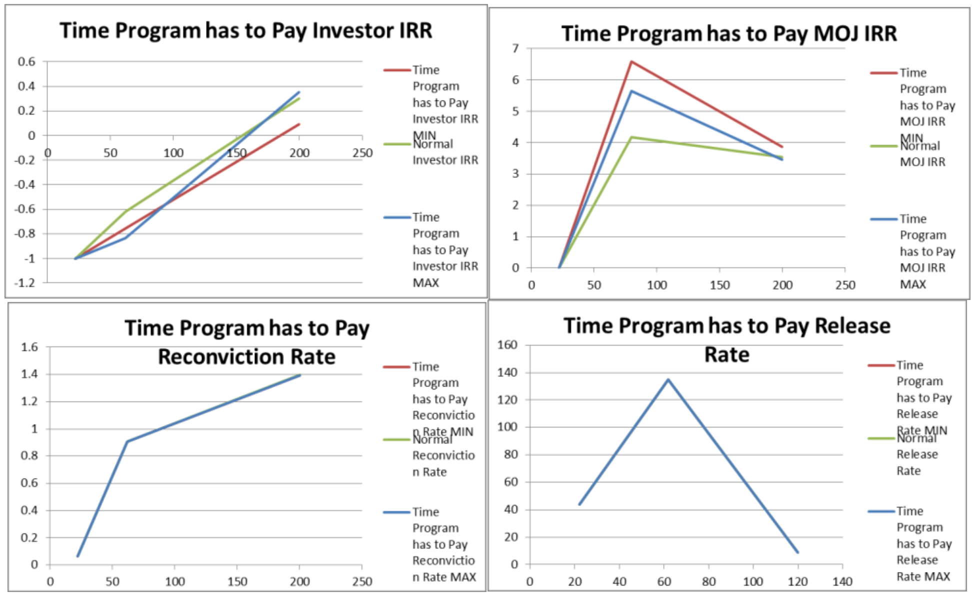


Figure 48: Time Program Has to Pay ECT Results Graphs Peterborough

Figure 49: Average Prisoner Incarceration Rate ECT Results Graphs Peterborough

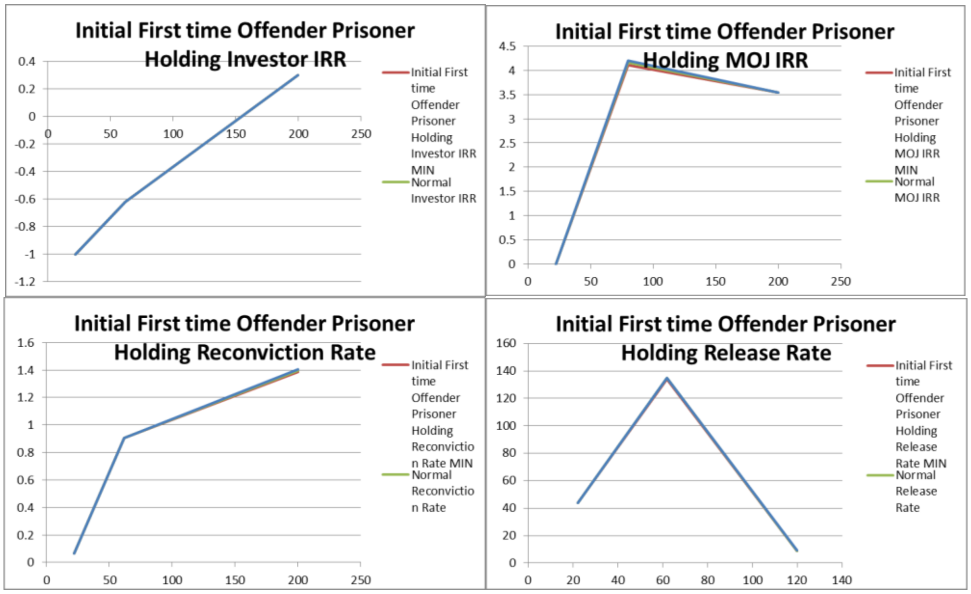


Figure 50: Initial First-time Offender Prison Holding ECT Results Graphs Peterborough

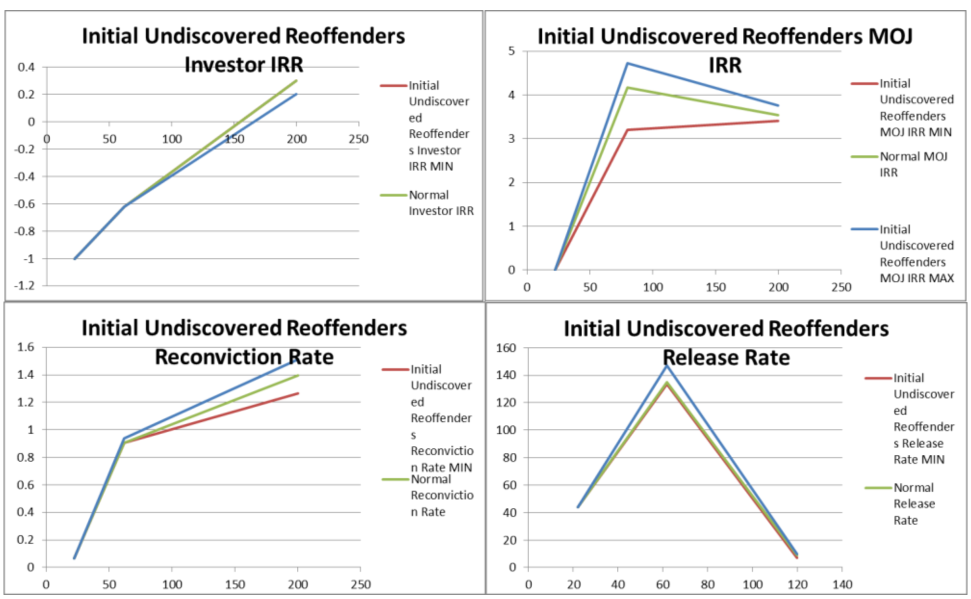


Figure 51: Initial Undiscovered Reoffenders Reconviction Rate ECT Results Graphs Peterborough

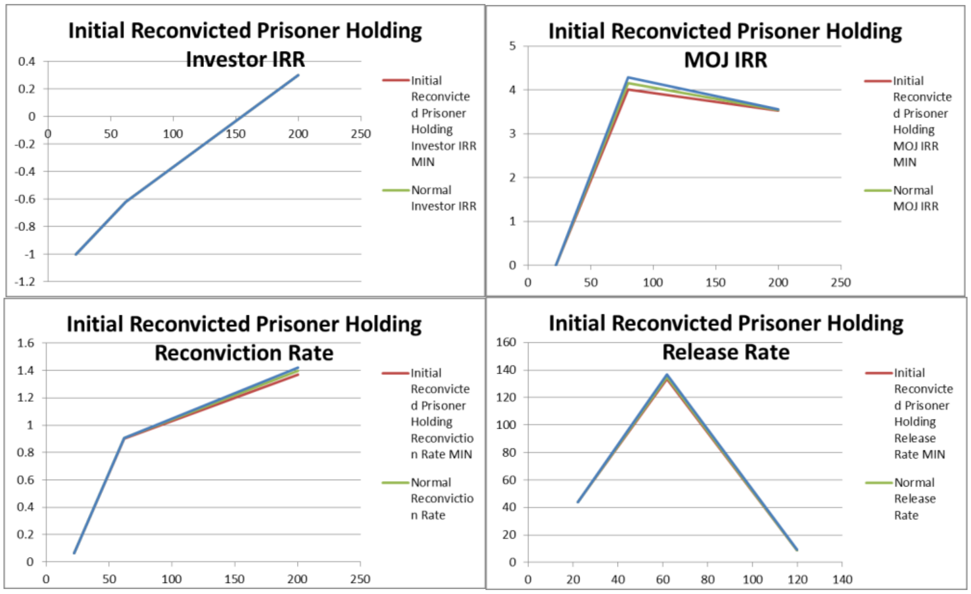


Figure 52: Initial Reconvicted Prisoner Holding ECT Results Graphs Peterborough

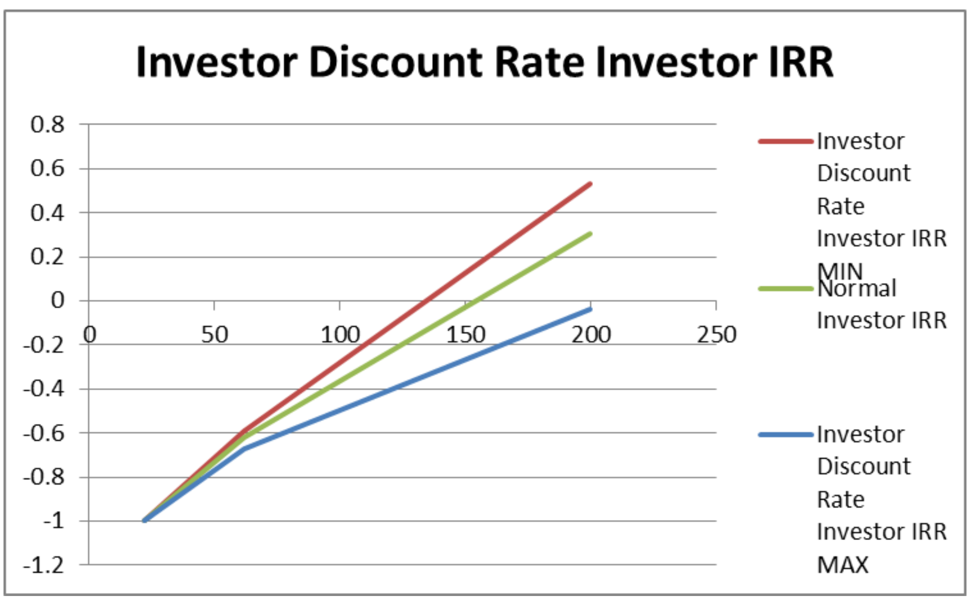


Figure 53: Investor Discount Rate ECT Results Graphs Peterborough

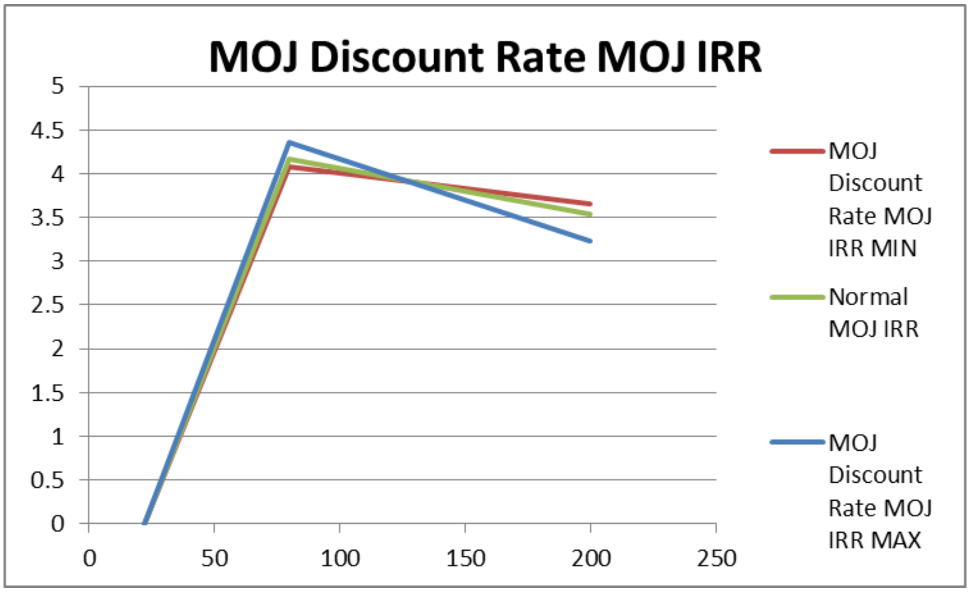


Figure 54: MOJ Discount Rate ECT Results Graphs Peterborough

Table 16: Statistical Screening Setup

#	Variable Name	Expected	Low	High	Standard Deviation	Distribution	Units
1	MOJ Starts Paying	76	46	76		Triangular	percent
2	Fraction of Surplus Returned	50	25	100	50	normal	percent
3	Offenders' Willing to enter program Fraction	70	0	100	10	normal	percent
4	Normal Recidivism Discovery Time	6	1	24	6	normal skew right	months
5	Fraction for Investor Share	50	25	100		uniform	percent
6	Recidivism Reduction Fraction	30	0	50		Uniform	percent
7	Expected Program Investment Amount	5000	2000	8000	1000	normal	k£
8	Conviction Cost	2.853	0	39		uniform	k£/conviction
9	Time Program has to Pay	3	1	6		uniform	months
10	Average Prisoner Incarceration Rate for Peterborough	57.83	10	100	20	normal	people/month
11	Initial First time Offender Prisoner Holding	86.75	10	150	35	normal	people
12	Initial Undiscovered Reoffenders	1041	100	2000	400	normal	people
	Initial Reconvicted						

Table 16: Continued

#		Expected	Low	High	Standard Deviation	Distribution	Units
11	Offender Prisoner Holding	88.75	10	150	35	normal	people
12	Initial Undiscovered Reoffenders	1041	100	2000	400	normal	people
13	Initial Reconvicted Prisoner Holding	260.25	25	500	100	normal	people
14	Standard Cohort Length	24	12	48		uniform	months
15	Standard People in Cohort	1,000	500	2000		uniform	people
16	Time for System Update	6	1	12	2	normal	months
17	Time after Cohort for Reconviction Collection	12	6	24	4	uniform	months
18	Program Cost per member	1.5	0.5	4.5		uniform	k£/people
19	Yearly Cost of Incarceration	39	19.5	78	10	normal	k£/person
20	Time spent in prison for a Conviction	1.5	0.5	6	1.5	normal	months
21	Normal Recidivism Fraction	75	50	100	10	normal	percent
22	Probationary Period Length	12	6	24		uniform	months

#	Expected	Low	High	Standard Deviation	Distribution	Units
1	76	46	76		Triangular	percent
2	50	25	100	50	normal	percent
3	70	0	100	10	normal	percent
4	6	1	24	6	normal skew right	months
5	50	25	100		uniform	percent
6	30	0	50		Uniform	percent
7	5000	2000	8000	1000	normal	k£
8	2.853	0	39		uniform	k£/conviction
9	3	1	6		uniform	months

APPENDIX II

ADDITIONAL TEST RESULTS FOR PETERBOROUGH[1]

This appendix details additional testing results with the Peterborough model. First are the results of varying policy actions for funding the SIB program late in the simulation. The second is an assessment of rescinding savings from the prison system.

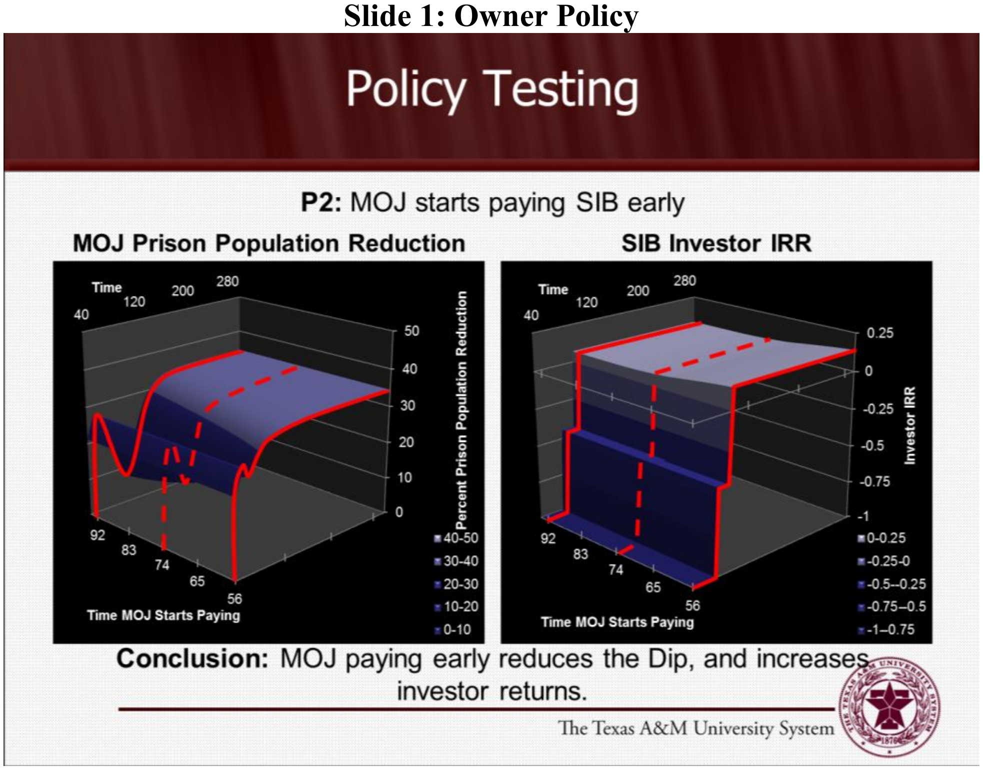
[1] This chapter contains content presented from White III, R. J., & Ford, D. N. (2013) "Dynamic Drivers of Successful Social Impact Bonds," at the 2013 International System Dynamics Conference, Cambridge, MA, System Dynamics Society.
(http://www.systemdynamics.org/conferences/2013/proceed/papers/P1294.pdf)

Improving SIB performance through Policy

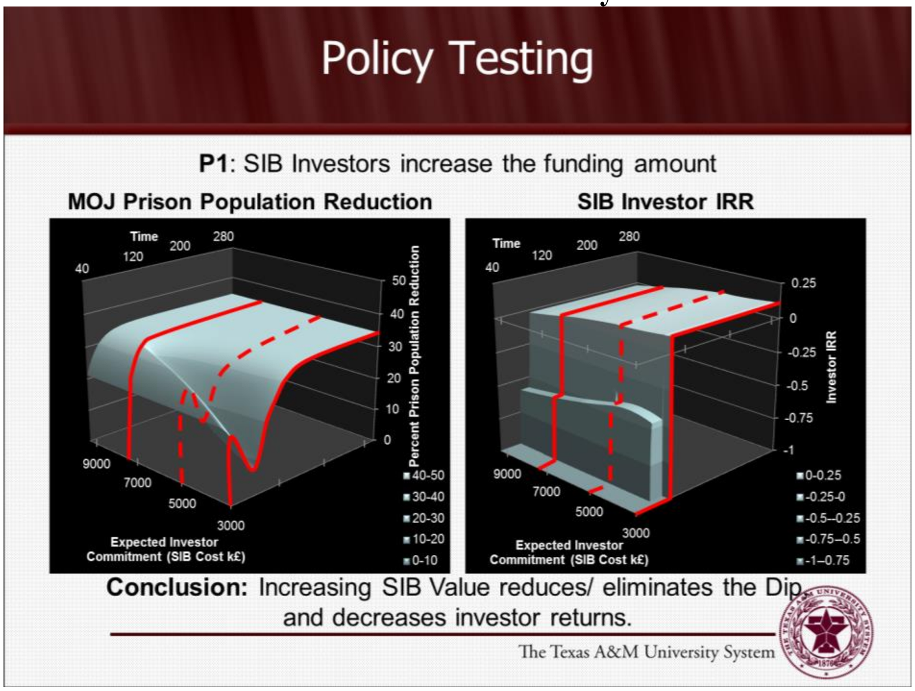
This section explains the results and testing of the Peterborough Prison SIB model for the "Dip" in program effectiveness. As the program is carried out, funds are diminished to a point where further funding is required for the program effectiveness to continue under the improve measures. During the modeling of the Peterborough system, the dip was identified as a possible threat to funding under poor assumptions of system behavior. Therefore, this section seeks to identify strategies for reducing the dip in program effectiveness.

Slides 1-4 show three policy solutions and the conclusion drawn from these policy actions.

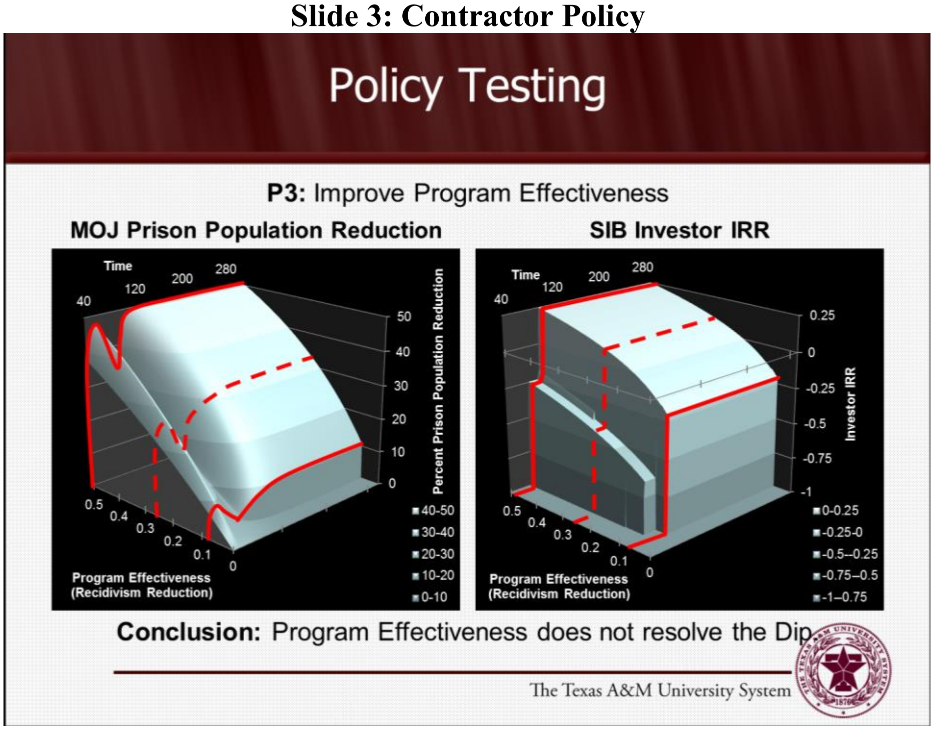
Slide 1: Owner Policy



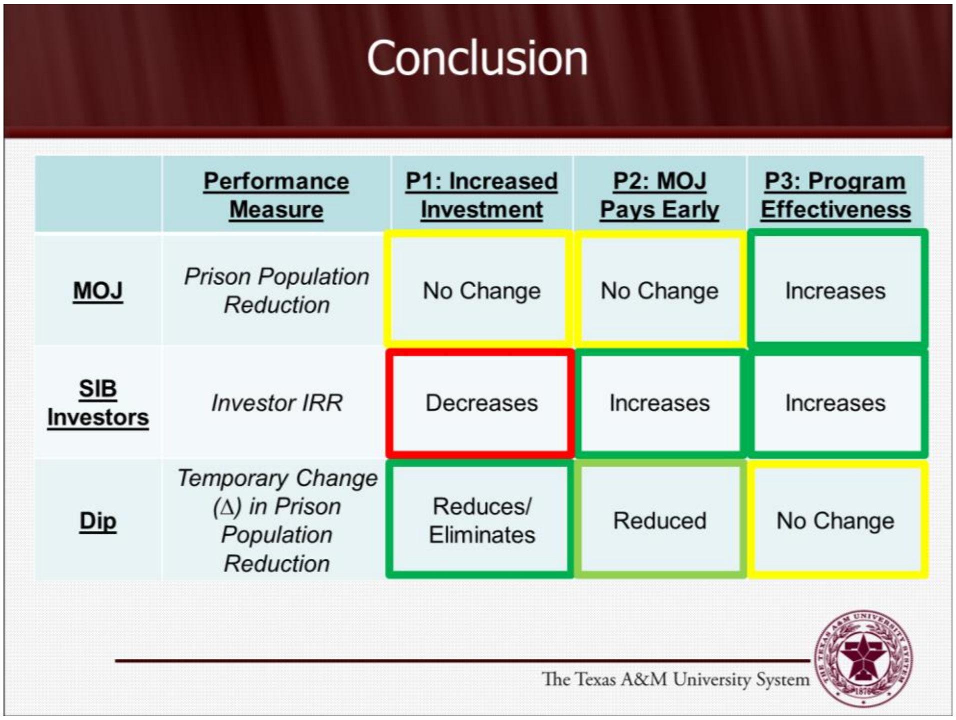
Slide 2: Investor Policy



Slide 3: Contractor Policy



Slide 4: Conclusion



Conclusion

	Performance Measure	P1: Increased Investment	P2: MOJ Pays Early	P3: Program Effectiveness
MOJ	*Prison Population Reduction*	No Change	No Change	Increases
SIB Investors	*Investor IRR*	Decreases	Increases	Increases
Dip	*Temporary Change (Δ) in Prison Population Reduction*	Reduces/ Eliminates	Reduced	No Change

Discussion

In conclusion, not one policy satisfies or improves the system. Increasing the investment amount will reduce the profitability of the program and deter investment. Similarly, if the MOJ starts paying early for the SIB program, the MOJ receives no benefit from increasing the reduction of recidivism, but does reduce the effects from the "Dip". Increasing the program effectiveness improves program outcomes, but the program effectiveness does not act to reduce the cost from a better program. Therefore, if the dip presents a threat to program continuance, then a multi-policy solution should be considered.

SIBs and the Policy of the Goose that laid a Golden Egg

Introduction: The Dip in the Peterborough SIB

This section explains the results and testing of the Peterborough Prison SIB model for question of how much of the savings should the owner rescind. As the program is carried out, funds are diminished to a point where further funding is required for the program effectiveness to continue under the improve measures. The program is useless to the MOJ if it does not allow budget reductions. Therefore, this section seeks to explain relationship between the percent of savings rescinded and the program effectiveness.

The more funds rescinded, the more savings the MOJ sees, and less program availability in the future. As the flow of offenders increases, the funds available from investors decrease. As the available funds decrease, the program availability decreases. This illustrates the similarity between the loops (R1 and R2) as shown in Figure 57. The cycle of prisoners in a prison system create a reinforcing loop between the budget and expenditures that spins in a vicious cycle**.** As funds for a prison rehabilitation program are decreased, the program effectiveness will also decrease to reduce recidivism. In time, higher recidivism increases the reconvicted prisoners in the prison population which consumes more money from the operating budget decreasing the discretionary budget. A drop in the discretionary budget decreases the spending on rehabilitation programs (assuming rehabilitation programs are a normal good/ service). Thus the vicious cycle of the prison system will try to dominate.

The same structure that results in a vicious cycle can be used to provide system managers with a virtuous cycle. The prison system manager might consider decreasing the flow of first time offenders to the prison (a supply side solution), or appealing to the altruism of benevolent donors (a demand side solution). Increasing the rehabilitation program's funds would reduce the recidivism (and reconvictions at a later date), which decreases the prison population. A smaller population means a smaller operating budget that increases the available funds for the program.

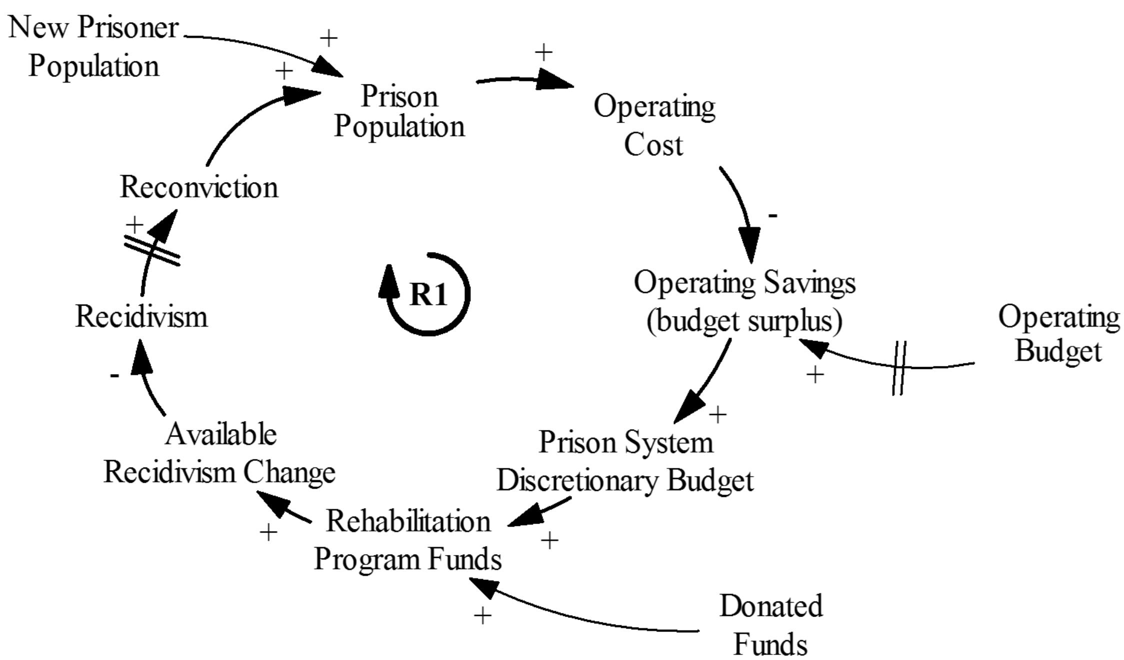


Figure 55: Prison System Reinforcing Structure

Unfortunately, for the virtuous cycle, there are two balancing loops that take precedence over the reinforcing structure. The first of these balancing loops accounts for the limits to program growth through the effectiveness of the program (Senge 1990). The second prevents a budgetary surplus from exceeding predetermined limits by returning the surplus to the upper echelons of government. In a prison system reducing the recidivism would create a virtuous cycle of reduced offending, except that it is balanced by decreasing change in recidivism and a decreasing prison budget.

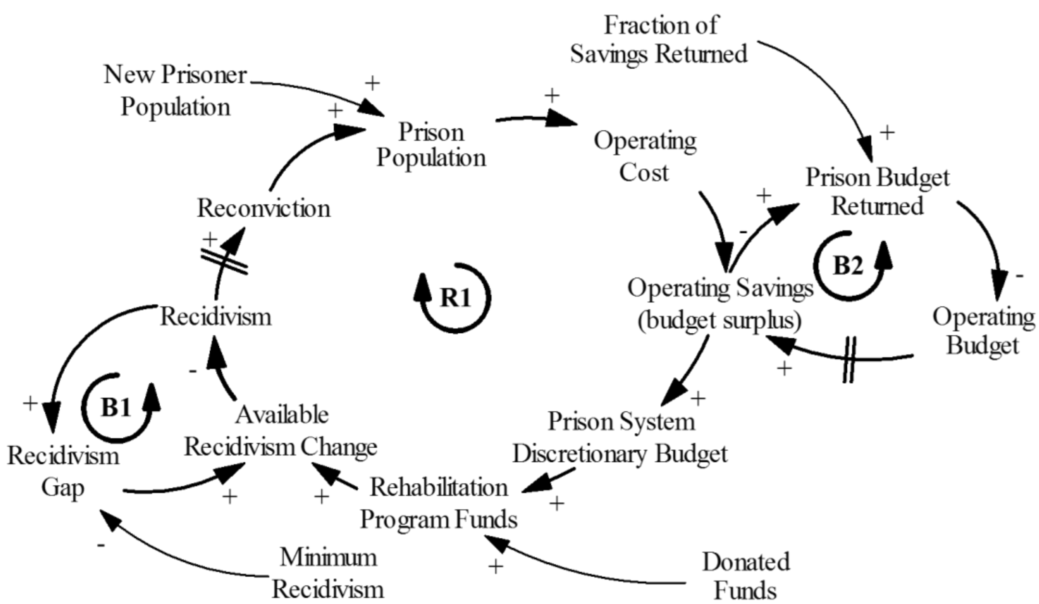


Figure 56: Prison System Reinforcing Structure with Balancing Loops

The Social Impact Bond (SIB) is a new financial tool that can be used for public goods, like prison rehabilitation programs. A SIB initiates an additional virtuous reinforcing structure to improve the stasis of an existing system until the system can reconfigure the controlling balancing loops to account for the effects of the new policy. Her Majesty's Prison (HMP) Peterborough is the first SIB and was initiated in 2010. If the program proves successful the Ministry Of Justice plans to take over the funding for the rehabilitation program. The SIB does not change the structure of the constrained LTG system, as it provides an alternative route for fund availability seen below in Figure 57:

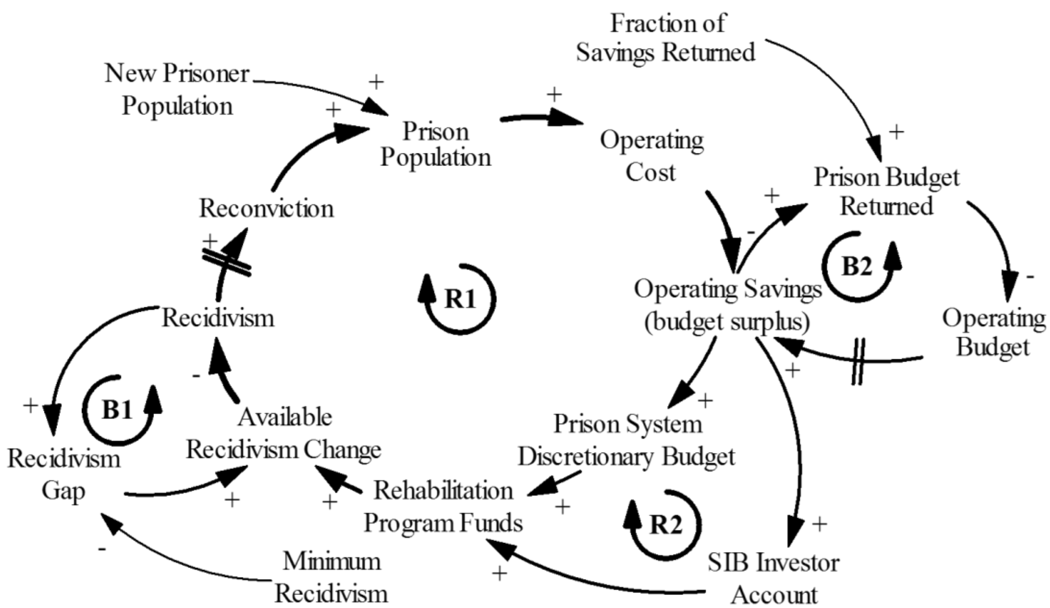


Figure 57: Prison System SIB Constrained LTG Diagram

<u>Legend of Loops:</u>

R1- Golden-Egg: Prison budget funds program which reduces population and generates savings which are used to pay for the program

R2- Goose -Loop: SIB invests in rehabilitation program, reducing population and creating savings, part of which are paid to investors as returns

B1- Rarity of a Golden: Decreased recidivism reduces improvement available, which limits the amount of future recidivism reduction

B2- Farmer: Increases in budget surplus trigger increases in the returned budget from the prison, which limits the amount of future Operating Budgets

Therefore, SIBs provide an alternative source of funding for preventative social issues.

Problem Description

The Peterborough SIB was established as a solution to reduce the ever increasing budget for the MOJ. While the SIB is in effect, the Peterborough system has a legal obligation to set aside a portion of the savings from the program to pay the investors for successful outcomes (Loder, et al. 2010, Mulgan, et al. 2011). In the end, the Peterborough SIB does not benefit the MOJ if it does not reduce/save costs (Glahn and Whistler 2011), yet the program still needs funds in order to function properly.

However, without the proper funds the rehabilitation program loses its effectiveness. Aesop used a tale of a farmer with a goose that could lay golden eggs to depict the need to sustain what is good in our lives over the "I need it now" mentality (Paxton 1988). In Aesop's fable, a farmer is blessed the gods to receive a goose that lays golden eggs (Paxton 1988). The farmer feeds and cares for the goose, and the farmer grows rich, but then the farmer gets greedy and kills to goose to take all the gold inside (Paxton 1988). Referring back to Figure 57, the feedback structure of a prison system displays a similar ideology to Aesop's fable. The SIB is used to initiate the program savings by transferring portions of the risk to investors in exchange for a share of the savings. The structures shown in Figure 57 can be labeled as characters or characteristics from Aesop's tale of the goose that laid the golden egg. The "Paid-from-Success rehabilitation loop" operates as the golden egg because the savings provide funds for reinvestment and additional savings. The "Social Impact Bond loop" operates as the goose because the SIB creates the environment for the golden egg to exist. The "Limits to Improvement loop" signifies the rarity and/or value of the golden egg because the available improvement drives the value savings generated from the program. Additionally, the “Farmer”, seen below as the balancing loop, sells the savings of the golden egg to reduce their expenditures.

It is important for the prison system managers to understand how much of the savings could be rescinded after the SIB is complete. As in Aesop’s fable, practitioners may not want to kill their goose. Instead, practitioners want to know how much of the savings can be returned to the government.

Behavior modes are useful in models where troves of historical data do not exist, because they describe the movement of the system and not the values (Sterman 2000, Hekimoğlu and Barlas 2010). Therefore, the value of savings available for reclamation by owners is defined in the different SIB behavior modes.

Tipping Point Structures

A tipping point is a set of marginally different (internal) conditions that yield very different behavior modes (Taylor and Ford 2008). A tipping point structure is a system of balancing and reinforcing loops that shift behavior modes depending on which loop is controlling (Taylor and Ford 2008). Once a tipping point structure has been identified, the behavior modes can be defined. Therefore, if a tipping point structure exists, then the structure of the tipping point can be used to understand the different behavior modes.

Research Approach and Model Structure

The system dynamics modeling methodology (Sterman, 2000; Forrester, 1961) is used for its ability to formally simulate the dynamic structures and delays of a managed system for the Peterborough SIB.

HMP Peterborough Case

The HMP Peterborough is the first SIB enacted and is currently underway for short-term offenders with high recidivism rates. The Peterborough SIB was created so that the UK and the MOJ could study and understand the drivers and structures of a SIB (Mulgan, Reeder, Aylott, & Bo'sher, 2011). Both the Investors and Ministry of Justice (MOJ) expect the Peterborough SIB to be successful. The Peterborough SIB model has three sectors, the depiction of the prison system, the performance measurement, and the SIB finances. Therefore, the HMP Peterborough case study model was used to define the reference modes.

Model Calibration, Typical Behavior, and Validation

Model Calibration

The model was calibrated to the Peterborough SIB case using publicly available literature as referenced above. Langan & Levin (2002), Loder et al. (2010), Strickland (2010), Mulgan et al. (2011), Disley et al. (2011), and Cave et al., (2012) describe the program impact, costs, assessment process and timing, and magnitude. Mulgan et al. (2011) and Loder et al. (2010) describe the expected impact of the rehabilitation program as well as various costs added to the assessment. Strickland (2010) identifies the value of investment and limits of the investment. Disely et al. (2011) also provide results of a preliminary assessment of the SIB in terms of magnitude and affect. Model values coincide with the information on the SIB and program found in this literature. Values that were not described in the literature were estimated and the model initially set to steady state conditions. For example, Disely et al. (2011) noted that about 315 new offenders entered HMP Peterborough in just over six months and the steady state model uses about 317 in a similar time frame. Cave et al. (2012) noted that the normal reconviction rate for HMP Peterborough was 1.64 persons per month for data collected up to one year after the close of the cohort. The calibrated model calculates about 1.53 persons per month in a similar time frame.

Typical Model Behavior

Typical model behavior is illustrated by the MOJ performance variable. Although recidivism is the metric used in the SIB, a (perhaps ***the***) primary performance measure of the MOJ is the reduction in the Peterborough population. Figure 3 shows the simulated behavior over time of this variable for the calibrated model.

Figure 58: Typical Model Behavior – HMP Peterborough Prison Population

After a period of steady state operations (months 0-20) the program begins and more prisoners are rehabilitated in the Peterborough system, reducing the prison population (months 20-60). However, as available funds decrease, so does the number of prisoners allowed to enter the program, slowing the rate of improvement (months 30-60) and eventually reversing the progress and causing an increase in prison population when SIB funds have been depleted (months 60-75). After the completion of the program funded by the SIB the rehabilitation program is continued by the MOJ (consistent with van Golahn and Whistler, 2011), initially using the savings generated by the SIB funded program. This causes the prison population to reduce again, approaching a steady state at its maximum which is controlled by a minimum recidivism (months 75-200). We later describe the potential dangers of the temporary increase in prison population and use the model to investigate the causes and a possible solution.

Model Validation

Structural Validation

The model contains a total of 141 variables consisting of 23 basic stocks and 24 flows (with five arrays), and 29 exogenous variables. The model structure is based upon the extensive literature specifically about the Peterborough SIB case referenced in the model structure description above. Of the 29 exogenous variables 14 used values taken from the literature specifically about HMP Peterborough or HMP system. The values of four of the remaining exogenous variables were supported from other literature but that literature provided inconsistent values. These ranges were used in extreme conditions testing. Four more were supported by other literature. The remaining seven were used to establish steady state conditions (e.g. initial values of stocks) or estimated by the modelers. The list of equations is found earlier in Appendix I.

Behavioral Validation

The model generated reasonable behavior when each of the 29 exogenous variables was set to extreme values. The Peterborough SIB has not progressed adequately to provide actual behavior data for use in model validation. However, the literature describes the expected behavior for the case. Lang and Levin (2002) describe the perpetual cycle of offence that is created in the program system. Cave et al. (2012)

describe the structure and behavior of the performance sector. Disely et al. (2011) and Mulgan et al. (2011) describe the expected behavior of the financial sector.

Using the rework cycle structure, with offender in place of work, the model behaves as described by Langan and Levin (2002) as a perpetual cycle of offences and re-offences.

The third party assessor of performance defines the limits among the different cohorts and determines cohort success (Cave, et al. 2012). A system of stocks and flows representing the offenders and their reconvictions create similar behavior as defined by Cave et al. (2012).

Disely et al. (2011) reviews the expectations for both how investors earn money as well as how the SIB financially functions. Mulgan et al. (2011) describe the transfer of risk, cost savings to the MOJ, and flows of capital between key stakeholders.

As another example of model behavior validation the model successfully reflects the expectation that the government would continue a successful program, as described by Glahn and Whistler (2011). The model's behavior is consistent with what would be expected in the operation of the actual SIB at HMP Peterborough.

Based on these model validation tests the Peterborough SIB model is considered valid for investigating the impacts of SIB design parameters on system behavior and performance.

Model Use

Identifying the Tipping Point

The Peterborough SIB provides the needed feedback structures to model the tipping points of a SIB under different forms of duress from a fraction of savings returned. Rescinding all of the savings causes the program to fail as seen in Figure 4. The farmer loop from Figure 59 causes the virtuous cycle to grind to a halt and then spin viciously back to the previous state of stability. The increase in prison population implies an increase in the total prison system budget.

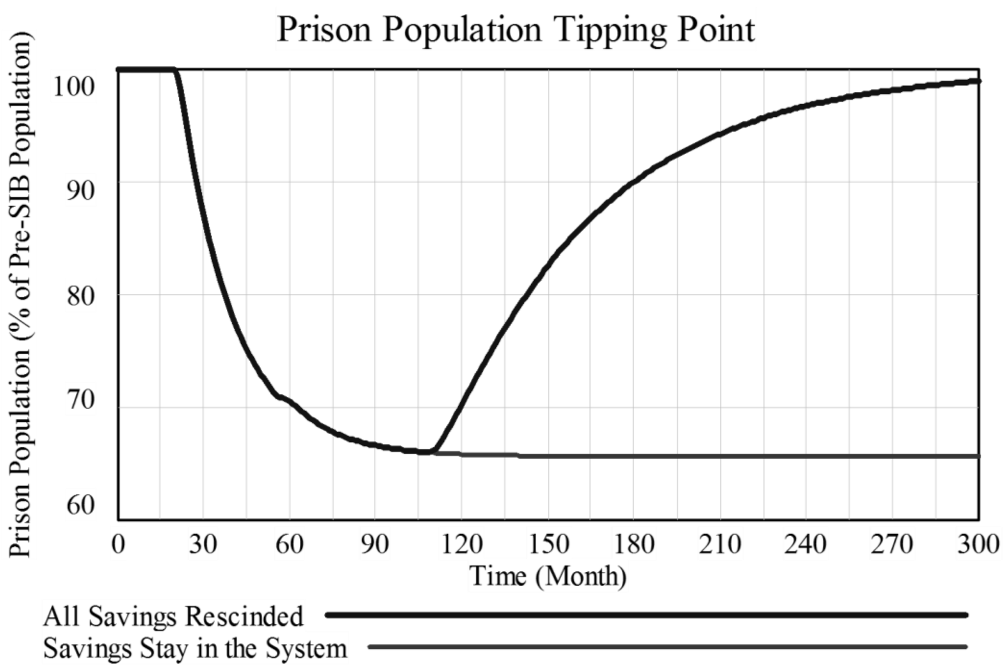


Figure 59: Difference between Rescinding All or None of the SIB Savings

Varying the fraction of savings returned changes the amount of savings that is returned to be repurposed. This varies the program funds which turns the program on and off. When the program shuts down for a long enough period of time, the “Farmer Loop” extinguishes the “Golden-Egg Loop.” Therefore, a tipping point structure for a SIB exists between the “Farmer Loop” and the “Golden-Egg Loop” because the recapturing of savings causes the system to revert.

Defining Behavior Modes for the Tipping point

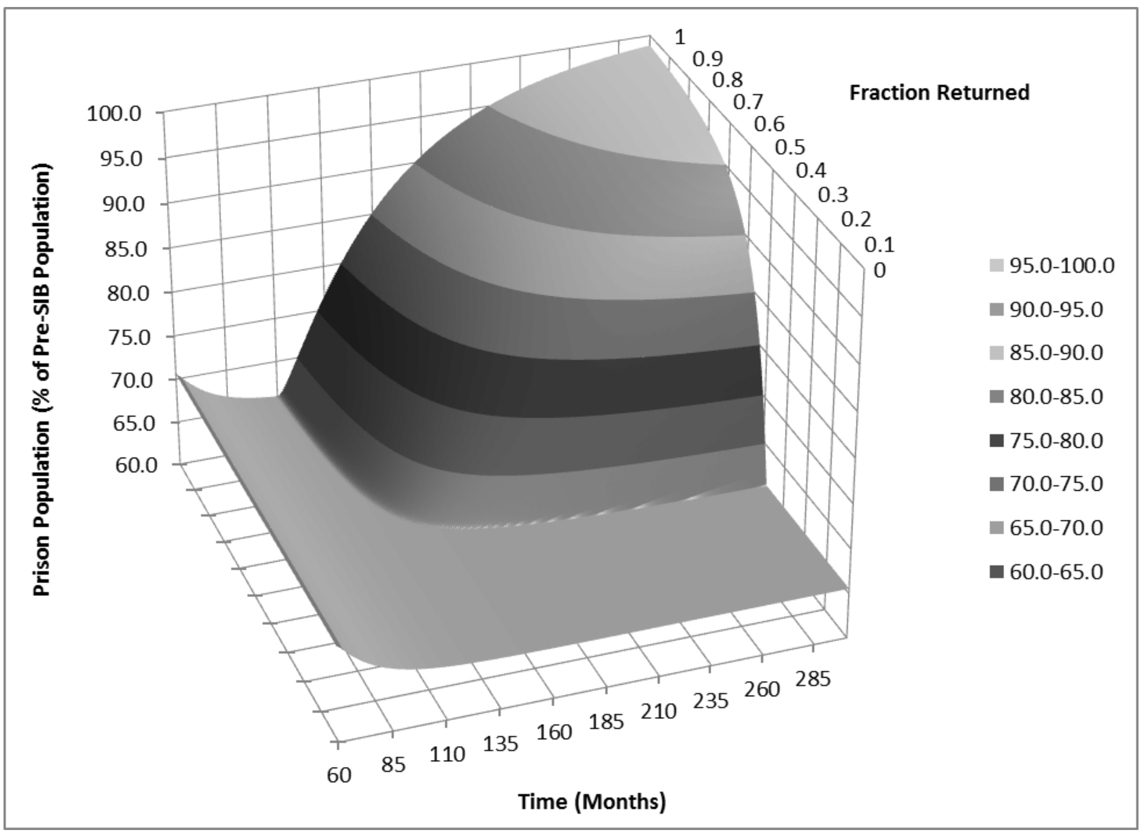


Figure 60: 3D plot of “Fraction Returned's” Effect on Prison Population

Figure 60 and Figure 61 show how increasing the fraction of savings returned causes the prison population to increase and the cumulative government savings to decrease. Figure 60 shows the prison population behavioral change when 40-50% of the savings are rescinded. Figure 61 shows a similar change for the accumulation of owner returns after 10 years. Therefore, the MOJ could capture the savings that have thus far been invested, or the MOJ could continue to reinvest in the program and continue to see net benefits.

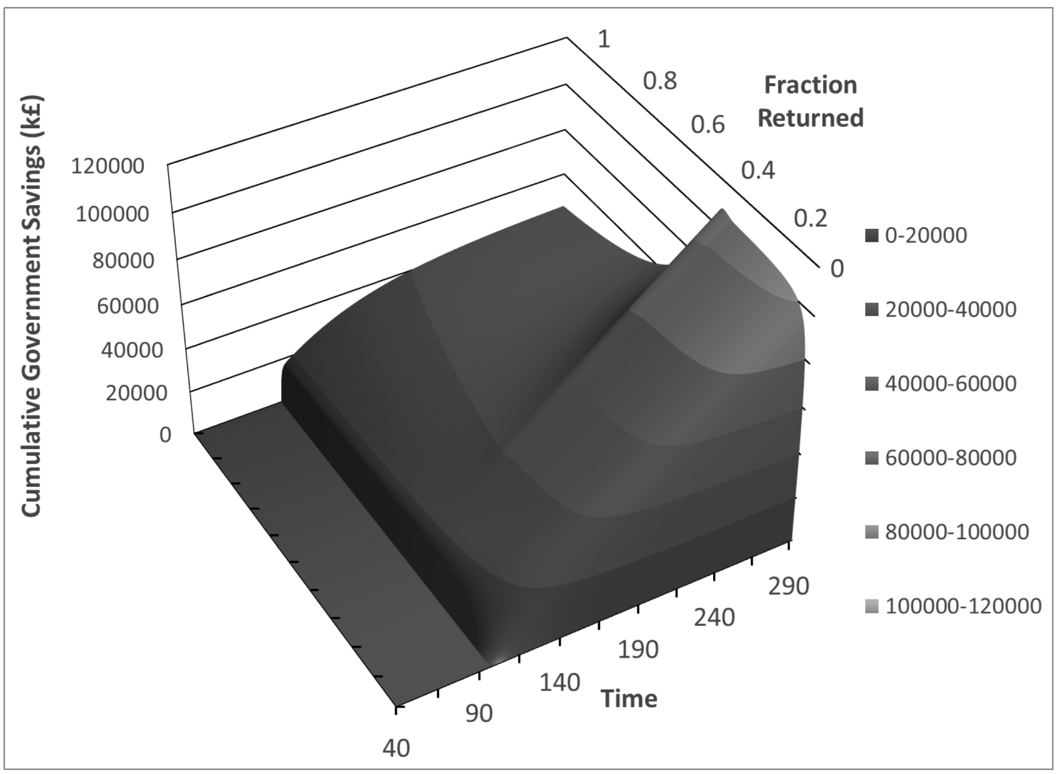


Figure 61: 3D plot of "Fraction Returned's" Effect on Cumulative Government Savings

Conclusion

In conclusion, the SIB has an inflection in owner savings based on the percent of savings the owner captures. The change is not seen for more than 10 years after the start of the program. The change is seen in both the program savings and the prison system performance. If governments rescind too much of the savings, then the program performance collapses and the savings stop collecting. The government can use the prison population as a precursor to future savings and as a measure program funding.

APPENDIX III

TAMU MODEL SUPPORTING DOCUMENTS[1]

This appendix details the supporting documents for the TAMU Model including the Equations, Stock Flow Diagrams, Tables from the Excel file used in conjunction with the model, values used for Statistical Screening Analysis, and additional testing results.

[1] This Appendix uses the case study documented in Kim, Hessami, Vahid and Ford (2011) unless otherwise noted.

Equation List

Legend

Variable Name

Equation or Value

Units

Description

Equations[1]

"% Energy (type) Reduction for Bldg (name) due to Efficiency"[Buildings, Energy Types]=

GET XLS CONSTANTS('Model_AVA.xls', 'Buildings Data', 'F4')

Units: kWh/Month

This is how much electricity Bldg consumes after the improvement (i.e. reduced electricity consumption) based on contract.

"% Reduction in Conservation Improvement Due to Automation of Bldg (name) for Energy (type)"[Buildings, Energy Types]=

IF THEN ELSE("Invested in Bldg (name)"[Buildings]<=0,0,0)

Units: Dmnl

The reduction amount in BM impact before and after hardware improvements in the building between 0 and one.

---

[1] Author defined where the document used had voids.

"% Reduction of energy use due to Conservation installation for Bldg (name)"[Buildings]=

*IF THEN ELSE("Invested in Conservation for Bldg (name)"[Buildings]<=0, 0, "Assigned % reduction in energy use for the Conservation tools for Bldgs") *"Conservation Rebound Effect (name)"[Buildings]*

Units: Dmnl

If there has been investment for BM in a building, then its value will be equal to the assigned percentage otherwise will be zero, meaning that the BM has no effect for the building.

"Actual Efficiency Installation Month for Bldg (name)"[Buildings]=

INTEG (IF THEN ELSE("Spending to Improve Bldg (name)"[Buildings]>0, Time , 0), 0)

Units: Month

This represents the month where improvements are made.

"Assigned % reduction in energy use for the Conservation tools for Bldgs"=

GET XLS CONSTANTS('Model_AVA.xls', 'Extra Variables', 'C7')

Units: Dmnl

Assigned percent reduction in energy use for the Behavior Modification tools for each buildings

---

"Bldg (name) Basecase Energy (type) Usage Intensity"[Buildings, Energy Types]=

GET XLS CONSTANTS('Model_AVA.xls', 'Buildings Data', 'C4')

Units: kWh/Month

This is how much electricity Bldg A consumes before the improvement (i.e. baseline electricity consumption)

"Bldg (name) Energy (type) Savings"[Buildings, Energy Types]=

"Energy (type) Usage Reduction for Bldg (name)"[Buildings, Energy Types]"Cost of Energy (type)"[Energy Types]*

Units: $/Month

The cost of saved energy for each building for each type of energy per month

---

"Bldg (name) Energy Cost Savings"[Buildings]=

INTEG ("Bldg (name) Energy Savings"[Buildings]-"Owner's Savings from Bldg (name)"[Buildings] -"Sust. Savings from Bldg (name)"[Buildings], 0)

Units: $

Savings from energy consumption improvement from building

"Bldg (name) Energy Savings"[Buildings]=

SUM("Bldg (name) Energy (type) Savings"[Buildings, Energy Types!])(1+"O&M Saving Ratio")*

Units: $/Month

This is the total cost of energy saved by implementing the change (i.e. improvement) to Bldg.

"Calculated Bldg (name) Energy (type) Usage"[Buildings, Energy Types]=

"Bldg (name) Basecase Energy (type) Usage Intensity"[Buildings, Energy Types](1- "% Energy (type) Reduction for Bldg (name) due to Efficiency"[Buildings, Energy Types]* "Efficiency Depreciation Rate for Bldg (name)"[Buildings])*

<u>Units: kWh/Month</u>

This is the calculated amount of how much electricity Bldg consumes after the improvement (i.e. reduced electricity consumption).

"Conservation Effects Life-span"=

GET XLS CONSTANTS('Model_AVA.xls', 'Extra Variables', 'C12')

<u>Units: Months</u>

This represents the duration of decay for conservation or behavioral modification effects.

"Conservation Rebound Effect (name)"[Buildings]=

*IF THEN ELSE("Invested in Conservation for Bldg (name)"[Buildings]<=0, 1, IF THEN ELSE(Time>=Stopping Month of Conservation Effect, IF THEN ELSE(1-(Time-Stopping Month of Conservation Effect)*Switch Rebound Effect/"Conservation Effects Life-span">0, 1-(Time-Stopping Month of Conservation Effect)*Switch Rebound Effect/"Conservation Effects Life-span" , 0), 1))*

<u>Units: Dmnl</u>

This represents the percent energy reduction due to behavioral modification efforts.

"Cost of Conservation Tools for Bldg (name)"[Buildings]=

*Installment Real Discount Rate*Cost of Conservation tools Installment per Bldg*

<u>Units: $</u>

Cost associated for BM tools installment.

Cost of Conservation tools Installment per Bldg=

GET XLS CONSTANTS('Model_AVA.xls', 'Extra Variables', 'C8')

<u>Units: $</u>

Total cost for installing BM tools.

"Cost of Energy (type)"[Energy Types]:=

GET XLS DATA('Model_AVA.xls' , 'Extra Variables' , 'I' , 'J4')

<u>Units: $/kWh</u>

This is the current electricity price (Cent per kWh) /*GET XLS DATA(Model_AVA.xls' , 'Extra Variables' , 'I' , 'J4')*/

"Cost of Improving Bldg (name)"[Buildings]=

GET XLS CONSTANTS('Model_AVA.xls', 'Buildings Data', 'I4')

<u>Units: $</u>

Initial cost of improving Bldg A from 1990 Fort Leavenworth report (INCANDESCENT LIGHTING).

"Current Bldg (name) Energy (type) Usage"[Buildings, Energy Types]=

IF THEN ELSE("Invested in Bldg (name)"[Buildings]<=0,"Bldg (name) Base case Energy (type) Usage Intensity"[Buildings, Energy Types],"Calculated Bldg (name) Energy (type) Usage"[Buildings, Energy Types])(1 -"% Reduction of energy use due to Conservation installation for Bldg (name)"[Buildings]*(100-"% Reduction in Conservation Improvement Due to Automation of Bldg (name) for Energy (type)" [Buildings,Energy Types])/100)*

<u>Units: kWh/Month</u>

This is the amount electricity Bldg A consumes after the improvement.

"Current Cost for Bldg (name) Improvement"[Buildings]=

Real Discount Rate"Cost of Improving Bldg (name)"[Buildings]*

<u>Units: $</u>

Total required fund to implement the decided improvement to the building A.

Depreciation Lag=

GET XLS CONSTANTS('Model_AVA.xls', 'Extra Variables', 'C10')

<u>Units: Months</u>

This represents the time before depreciation occurs.

"Efficiency Age for Bldg (name)"[Buildings]=

IF THEN ELSE("Actual Efficiency Installation Month for Bldg (name)"[Buildings]>0 ,IF THEN ELSE("Actual Efficiency Installation Month for Bldg (name)"[Buildings] +Depreciation Lag<Time ,Time-"Actual Efficiency Installation Month for Bldg (name)"[Buildings]-Depreciation Lag, 0) , 0)

Units: DMNL

This represents the value of improvements during their use.

"Efficiency Depreciation Rate for Bldg (name)"[Buildings]=

IF THEN ELSE(Switch Efficiency Depreciation=1, IF THEN ELSE(1-"Efficiency Age for Bldg (name)"[Buildings]/"Efficiency Devices Life-span">0 , 1-"Efficiency Age for Bldg (name)"[Buildings]/"Efficiency Devices Life-span",0),1)

Units: DMNL

This represents the rate of improvement depreciations.

"Efficiency Devices Life-span"=

GET XLS CONSTANTS('Model_AVA.xls', 'Extra Variables', 'C11')

Units: Months

This represents the length of efficiency improvements

"Energy (type) Saved"[Energy Types]=

SUM("Energy (type) Usage Reduction for Bldg (name)"[Buildings!,Energy Types])

Units: See Table 8

Monthly energy saved added to total amount, calculated separately for each energy type.

"Energy (type) Usage Reduction for Bldg (name)"[Buildings,Energy Types]=

"Bldg (name) Basecase Energy (type) Usage Intensity"[Buildings,Energy Types]-

"Current Bldg (name) Energy (type) Usage"[Buildings,Energy Types]

Units: kWh/Month

Monthly Energy saved for Building A.

"Excel Order?"=

1

Units: Dmnl

Use Excel data for ordering the building improvement or not.

External Fund Received=

*Incoming Funds+"Total External Fund Received (Total Debt)"*Interest Rate*

Units: **undefined**

Monthly calculated external fund received, added to the total amount.

"External Funds (source)"[External Funds]=

GET XLS CONSTANTS('Model_AVA.xls', 'External Funds', 'C3')*

Units: $

Amount of money received from the external resource as funding to the project.

"Fraction of Savings to Sust. Fund"=

GET XLS CONSTANTS('Model_AVA.xls', 'Extra Variables', 'C2')

Units: Dmnl/Month

% of rewards payments from sustainability.

"Fund for Installing Conservation Tools (source)"[External Funds]=

GET XLS CONSTANTS('Model_AVA.xls', 'External Funds', 'C9')*

Units: $

Amount of money received from the external resource as funding to the BM tools.

HI=

1

Units: Dmnl

This represents whether the sustainability improvements are being run in the simulation.

Installment Real Discount Rate=

*(IF THEN ELSE(Time<12,1,1+(0.05*Time)/12)*0+1)*

Units: Dmnl

The real discount rate for cost increment in BM tools base on the literature review.

Incoming Funds=

SUM(IF THEN ELSE(Time="Month of Receiving External Fund (source)"[External Funds!], 1, 0)("External Funds (source)"[External Funds!]*HI+"Fund for Installing Conservation Tools (source)"[External Funds!]*Switch Conservation))*

Units: $/Month

Monthly incoming fund to the system.

"Install Order?"=

1

Units: Dmnl

Use Excel data for ordering the building BM improvement or not.

Install Prerequisites Order[Buildings,Prerequisites]=

GET XLS CONSTANTS('Model_AVA.xls', 'Extra Variables', 'AH3')

Units: Dmnl

Order of improvement for buildings.

Interest Rate=

GET XLS CONSTANTS('Model_AVA.xls', 'Extra Variables', 'C3')

Units: Dmnl/Month

This represents the interest rate.

"Invested in Bldg (name)"[Buildings]=

INTEG ("Spending to Improve Bldg (name)"[Buildings],0)

<u>Units: $</u>

Total cost of investment to Bldg.

"Invested in Conservation for Bldg (name)"[Buildings]=

INTEG ("Spending for Conservation for Bldg (name)"[Buildings], 0)

<u>Units: $</u>

Total cost of BM investment to Bldg.

"Is Bldg (name) improved?"[Buildings]=

IF THEN ELSE("Invested in Bldg (name)"[Buildings]>0, 1, 0)

<u>Units: Dmnl</u>

Changes from initial zero to 1 if the fund is invested in the building for improvement or remains the same if not.

"Is the tools for Bldg (name) installed?"[Buildings]=

IF THEN ELSE("Invested in Conservation for Bldg (name)"[Buildings]>0, 1, 0)

<u>Units: Dmnl</u>

Changes from initial zero to 1 if the fund is invested in building for BM improvement or remains the same if not.

"Month of Installment for Bldg (name)"[Buildings]=

GET XLS CONSTANTS('Model_AVA.xls', 'Buildings Data', 'K4')*

Units: Month

The month number in which the BM improvement should be added to the building.

"Month of Performing Improvement in Bldg (name)"[Buildings]=

GET XLS CONSTANTS('Model_AVA.xls', 'Buildings Data', 'J4')*

Units: Month

The month number in which the improvement should be added to the building.

"Month of Receiving External Fund (source)"[External Funds]=

GET XLS CONSTANTS('Model_AVA.xls', 'External Funds', 'D3')*

Units: Month

Number of the month in which the external fund is received.

Monthly Conservation Maintenance Cost per Bldg=

GET XLS CONSTANTS('Model_AVA.xls', 'Extra Variables', 'C9')

Units: $/Month

This represents the monthly cost of behavioral modifications for conservation efforts.

"Monthly Conservation Maintenance Costs for Bldg (name)"[Buildings]=

Monthly Conservation Maintenance Cost per Bldg"Is the tools for Bldg (name) installed?" [Buildings]*"Switch On/Off Conservation Effects"*

Units: $/Month

Monthly cost for maintaining the BM tools.

Negative Balance Fine=

*IF THEN ELSE(Sustainability Fund<0, Sustainability Fund*Negative Balance Interest Rate/12, 0)*

Units: $

Calculating the extra money to be paid when the sustainability fund gets negative. This is simulating short term loan receiving which should be paid back with its defined interest rate.

Negative Balance Interest Rate=

GET XLS CONSTANTS('Model_AVA.xls', 'Extra Variables', 'C6')

Units: Dmnl

Interest rate for the amount of additional loan to overcome negative balance of the Sustainability Fund.

"O&M Costs":=

GET XLS DATA('Model_AVA.xls' , 'External Funds' , 'L' , 'M3')

Units: $/Month

Operation and maintenance costs based on the contract.

"O&M Saving Ratio"=

GET XLS CONSTANTS('Model_AVA.xls', 'Extra Variables', 'C4')

Units: Dmnl

Operation and maintenance savings indicated in the contract

Owner's Fund=

INTEG (SUM("Owner's Savings from Bldg (name)"[Buildings!]), 0)

Units: $

Depository for rewards payments.

"Owner's Savings from Bldg (name)"[Buildings]=

"Bldg (name) Energy Cost Savings"[Buildings](1-"Fraction of Savings to Sust. Fund")*

Units: $/Month

Percent of the savings spent for rewards.

Payback Deductions Amount:=

GET XLS DATA('Model_AVA.xls' , 'External Funds' , 'H' , 'I3')

Units: $

Monthly payback amount based on the contract.

Paybacks and Costs=

*(IF THEN ELSE(Sustainability Fund>=Payback Deductions Amount, Payback Deductions Amount, Payback Deductions Amount)+"O&M Costs")*HI+SUM("Monthly Conservation Maintenance Costs for Bldg (name)"[Buildings!])*Switch Conservation*

Units: $/Month

Total payback needed per month.

Prerequisites Order [Buildings, Prerequisites]=

GET XLS CONSTANTS('Model_AVA.xls', 'Extra Variables', 'O3')

Units: Dmnl

Order of improvement for buildings.

Real Discount Rate=

*(IF THEN ELSE(Time<12,1,1+(0.05*Time)/12)*0+1)*

Units: Dmnl

The real discount rate for cost increment base on the literature review.

"Spending for Conservation for Bldg (name)"[Buildings]=

IF THEN ELSE(Sustainability Fund>="Cost of Conservation Tools for Bldg (name)"

[Buildings], "Cost of Conservation Tools for Bldg (name)"[Buildings], 0)"Start Invest for Installing for Bldg (name)"[Buildings] * Switch Conservation*

<u>Units: $/Month</u>

Should be less than the Sustainability Fund since we cannot invest if we don't have enough funding, accumulates per month but actual investment may not be made until the minimum required amount is available.

"Spending to Improve Bldg (name)"[Buildings]=

IF THEN ELSE(Sustainability Fund>="Current Cost for Bldg (name) Improvement" [Buildings], "Current Cost for Bldg (name) Improvement"[Buildings], 0) "Start Investing in Bldg (name)"[Buildings]*HI*

<u>Units: $/Month</u>

Should be less than the Sustainability Fund since we cannot invest if we don't have enough funding, accumulates per month but actual investment may not be made until the minimum required amount is available.

"Start Invest for Installing for Bldg (name)"[Buildings]=

VMIN(IF THEN ELSE(Install Prerequisites Order[Buildings, Prerequisites!], IF THEN ELSE("Install Order?"=1,"Is the tools for Bldg (name) installed?"[Prerequisites!] , 1), 1))(1-"Is the tools for Bldg (name) installed?"[Buildings]) *IF THEN ELSE(Time>= "Month of Installment for Bldg (name)"[Buildings], 1, 0)*

<u>Units: Dmnl/Month</u>

Gets 1 if bldg should be invested for BM and 0 otherwise.

"Start Investing in Bldg (name)"[Buildings]=

VMIN(IF THEN ELSE(Prerequisites Order[Buildings, Prerequisites!], IF THEN ELSE("Excel Order?"=1, "Is Bldg (name) improved?"[Prerequisites!], 1), 1))(1-"Is Bldg (name) improved?"[Buildings])*IF THEN ELSE(Time>="Month of Performing Improvement in Bldg (name)"[Buildings],1,0)*

Units: Dmnl/Month

Gets 1 if bldg should be invested and 0 otherwise.

Stopping Month of Conservation Effect=

GET XLS CONSTANTS('Model_AVA.xls', 'Extra Variables', 'C13')

Units: Month

This represents the month that conservation efforts stop.

"Sust. Savings from Bldg (name)"[Buildings]=

"Bldg (name) Energy Cost Savings"[Buildings]"Fraction of Savings to Sust. Fund"*

Units: $/Month

As long as the Bldg fund is larger than 0, the savings go back to the Sustainability Fund.

Sustainability Fund=

INTEG(SUM("Sust. Savings from Bldg (name)"[Buildings!]) - SUM("Spending to Improve Bldg (name)"[Buildings!]) -SUM("Spending for Conservation for Bldg (name)"[Buildings!]) + Incoming Funds - Paybacks and Costs - Negative Balance Fine, 0)

<u>Units: $</u>

Depository as sustainability fund which would be used to invest for building improvements.

Switch Conservation=

1

<u>Units: Dmnl</u>

Switch the Behavior Modification loop on/off.

Switch Efficiency Depreciation=

1

<u>Units: DMNL</u>

This determines whether the efficiency is depreciating in the model.

"Switch On/Off Conservation Effects"=

IF THEN ELSE(Time>=Stopping Month of Conservation Effect, (1-Switch Rebound Effect), 1)

<u>Units: DMNL</u>

This switch controls whether conservation efforts are used for behavior modifications.

Switch Rebound Effect=

0

Units: DMNL

This switch controls the conservation rebound effect.

"Total Energy (type) Saved"[Energy Types]=

INTEG ("Energy (type) Saved"[Energy Types], 0)

Units: kWh

Total Energy saved from all Buildings.

Total Energy Saved=

0.0034"Total Energy (type) Saved"[Electricity]+"Total Energy (type) Saved"[Chilled Water]+"Total Energy (type) Saved"[Heating Hot Water]*

Units: MMBtu

Some of all the energy type savings.

"Total External Fund Received (Total Debt)"=

INTEG (External Fund Received, 0)

Units: $

Total external funding received considering interest rate.

Total Investment=

SUM("Invested in Bldg (name)"[Buildings!])

Units: $

This is the accumulated investment in building improvements.

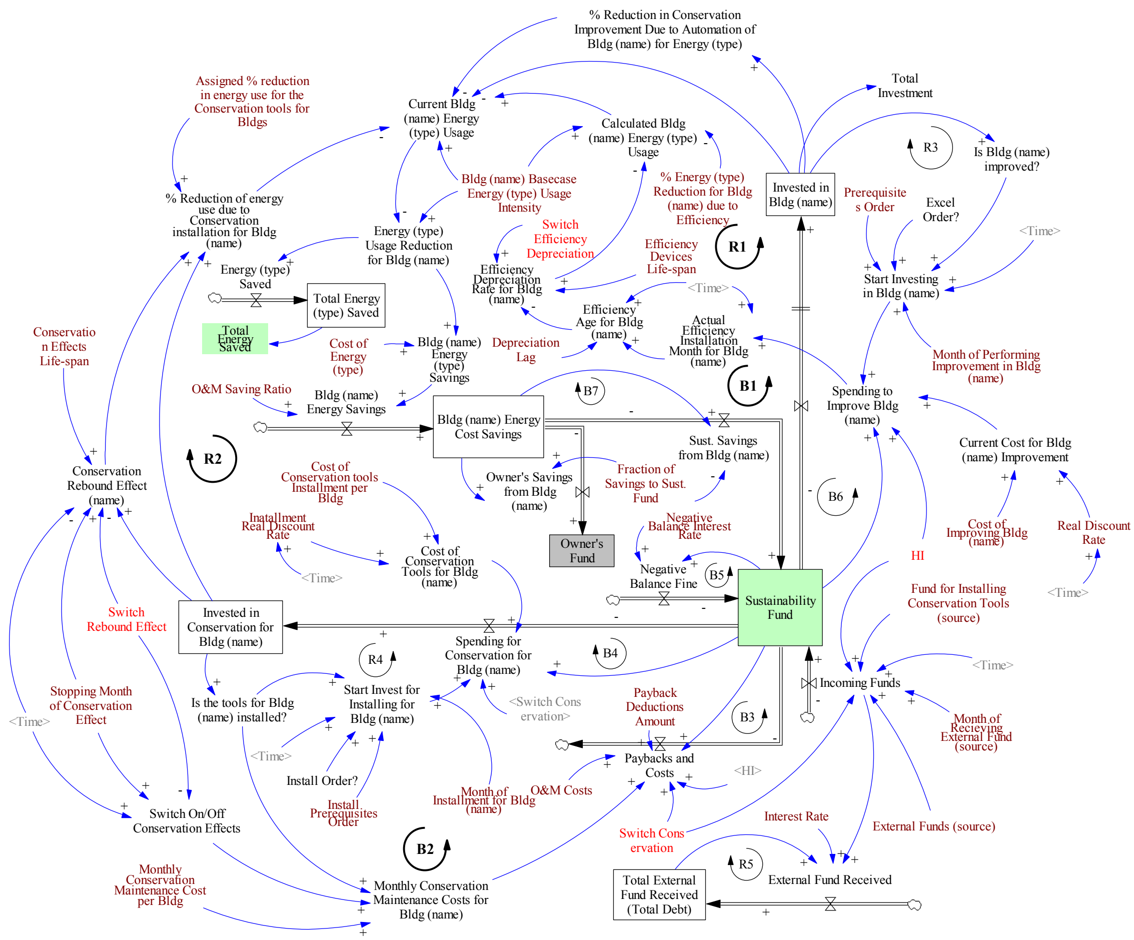


Figure 62: Stock Flow Diagrams TAMU Case

Excel File

Table 17: Building Data (Yearly)

	Bldg # Basecase Energy ## Usage Intensity			Improvement in Bldg # Energy ## Usage			Cost of Improving Bldg #
Building Name	Electricity	Chilled Water	Heating Hot Water	Electricity	Chilled Water	Heating Hot Water	
378	1,314,525	-	-	600,418	-	-	299,910
379	663,823	-	-	244,015	-	-	205,850
388	1,329,573	-	-	670,353	-	-	420,550
469	590,234	518	178	230,167	-	-	169,060
1559	2,580,321	1,233	176	1,050,097	-	-	675,890
386	7,626,621	50,473	14,030	255,207	6,722	2,843	398,220
387	2,070,470	19,695	8,768	125,476	5,007	3,018	567,640
391	2,193,433	13,328	3,980	189,429	2,659	1,278	336,420
392	893,313	5,428	1,621	80,242	865	601	297,816
446	1,872,562	9,700	6,046	219,246	1,374	2,427	591,065
463	810,416	5,564	1,956	67,050	665	754	292,150
518	5,028,997	24,161	4,674	170,429	877	812	688,090
1194	2,478,276	29,928	10,677	228,386	3,381	2,346	471,500
1501	3,745,173	26,634	13,962	416,730	8,038	5,774	691,750
1504	4,564,034	35,036	7,744	511,925	3,626	3,499	785,430
1507	4,840,192	53,138	20,856	150,294	5,899	6,466	1,192,755
1508	434,985	2,057	196	726	387	53	141,270

Table 18: Building Data (Usage)

	Bldg # Basecase Energy ## Usage Intensity (per Month)		
Building Name	Electricity (kwh)	Chilled Water (mbtu)	Heating Hot Water (mbtu)
1501	387,235.27	2,466.06	1,080.96
1507	500,455.67	4,920.09	1,614.71
378	135,916.40	-	-
388	137,472.30	-	-
1559	266,794.43	114.16	13.63
1194	256,243.40	2,771.05	826.63
469	61,027.73	47.96	13.78
379	68,636.53	-	-
392	92,364.84	502.58	125.50
463	83,793.63	515.17	151.44
518	519,977.32	2,237.08	361.87
1508	44,975.63	190.46	15.17

Table 19: Building Data (Percent Improvement)

Building Name	Predicted % Improvement in Bldg # Energy ## Usage (per Month)		
	Electricity (kwh)	Chilled Water (mbtu)	Heating Hot Water (mbtu)
1501	11.13%	30.18%	41.36%
1507	3.11%	11.10%	31.00%
378	45.68%	0.00%	0.00%
388	50.42%	0.00%	0.00%
1559	40.70%	0.00%	0.00%
1194	9.22%	11.30%	21.97%
469	39.00%	0.00%	0.00%
379	36.76%	0.00%	0.00%
392	8.98%	15.94%	37.08%
463	8.27%	11.95%	38.55%
518	3.39%	3.63%	17.37%
1508	0.17%	18.81%	27.04%

Table 20: Building Information (Costs and Savings)

Building Name	Cost of Improving Bldg # ($)	Month of Performing HI in Bldg #	Month of Performing BM in Bldg #	Total Savings per Year	Benefit / Cost	Building Type
1501	840,996	9	0	12949.77924	0.015398	Buildings
1507	1,450,094	9	0	10105.4766	0.006969	Buildings
378	364,616	9	0	4780.215219	0.01311	Buildings
388	511,284	8	0	5337.001244	0.010438	Buildings
1559	821,714	9	0	8360.325075	0.010174	Buildings
1194	573,227	9	0	5801.480453	0.010121	Buildings
469	205,535	7	0	1832.469707	0.008916	Buildings
379	250,262	7	0	1942.720266	0.007763	Buildings
392	362,070	9	0	1658.567389	0.004581	Buildings
463	355,182	8	0	1558.837613	0.004389	Buildings
518	836,546	10	0	2558.074803	0.003058	Buildings
1508	171,749	7	0	283.7442437	0.001652	Buildings

Table 21: Payback Schedule

Loan Payback	Payback Month	Amount
01/01/2011	0	0
02/01/2011	1	0
12/02/2011	11	0
01/02/2012	12	0
02/02/2012	13	0
12/01/2012	23	0
01/01/2013	24	375,934.49
02/01/2013	25	0
12/01/2013	35	0
01/01/2014	36	375,934.49
02/01/2014	37	0
12/01/2014	47	0
01/01/2015	48	375,934.49
02/01/2015	49	0
12/02/2015	59	0
01/02/2016	60	375,934.49
02/02/2016	61	0
12/01/2016	71	0
01/01/2017	72	375,934.49
02/01/2017	73	0
12/01/2017	83	0
01/01/2018	84	375,934.49
02/01/2018	85	0
12/01/2018	95	0
01/01/2019	96	375,934.49
02/01/2019	97	0
12/02/2019	107	0
01/02/2020	108	375,934.49
02/02/2020	109	0
12/01/2020	119	0
01/01/2021	120	375,934.49
02/01/2021	121	0
12/01/2021	131	0
01/01/2022	132	375,934.49
02/01/2022	133	0.00
09/02/2027	200	0.00
01/01/2051	480	0.00

M&V Cost	Payback Month	Amount
01/01/2011	0	0
02/01/2011	1	0
12/02/2011	11	0
01/02/2012	12	0
02/02/2012	13	0
12/01/2012	23	0
01/01/2013	24	10,000.00
02/01/2013	25	0
12/01/2013	35	0
01/01/2014	36	10,000.00
02/01/2014	37	0
12/01/2014	47	0
01/01/2015	48	10,000.00
02/01/2015	49	0
12/02/2015	59	0
01/02/2016	60	10,000.00
02/02/2016	61	0
12/01/2016	71	0
01/01/2017	72	10,000.00
02/01/2017	73	0
12/01/2017	83	0
01/01/2018	84	10,000.00
02/01/2018	85	0
12/01/2018	95	0
01/01/2019	96	10,000.00
02/01/2019	97	0
12/02/2019	107	0
01/02/2020	108	10,000.00
02/02/2020	109	0
12/01/2020	119	0
01/01/2021	120	10,000.00
02/01/2021	121	0
12/01/2021	131	0
01/01/2022	132	10,000.00
02/01/2022	133	0.00
09/02/2027	200	0.00
01/01/2051	480	0.00

Table 22: TAMU Model (Base Case) Funding

Funding Source Name	Funding Amount	Month	Payback ratio
A	3,371,638	0	0.111499072
B	0	0	
PA:			
Funding Source Name	Funding Amount	Month	Payback ratio
A	58,500	0	0.111499072
B	0	0	

Table 23: Extra Variables in TAMU Model

Fraction of Savings to Sust. Fund	0.5
Interest Rate	0.02
Operational (O&M) Savings Ratio	0.0421
Base case Saving at Month 200	9737849
Interest rate for Negative SF	0.02
Assigned % reduction in energy usage	0.12
Cost of installing tools per building	4833.33
BM Maintenance Monthly Cost	41.67
HI Depreciation Lag	0
HI Device Life-span	240
BM Effects Life-span	24
Stopping Month of BM Effect	50

Cost of Energy

$$C_{i+1} = C_i(1 + 0.03/12)$$

Table 24: Sustainability Improvement Matrix Order

	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	
building no	HI Prerequisites Order																	month
1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
6	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	5
7	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	5
8	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	6
9	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	6
10	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	6
11	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	7
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11

Table 25: Improvement Matrix Order

building no	BM Prerequisites Order																	month
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11

Additional Testing Results[1]

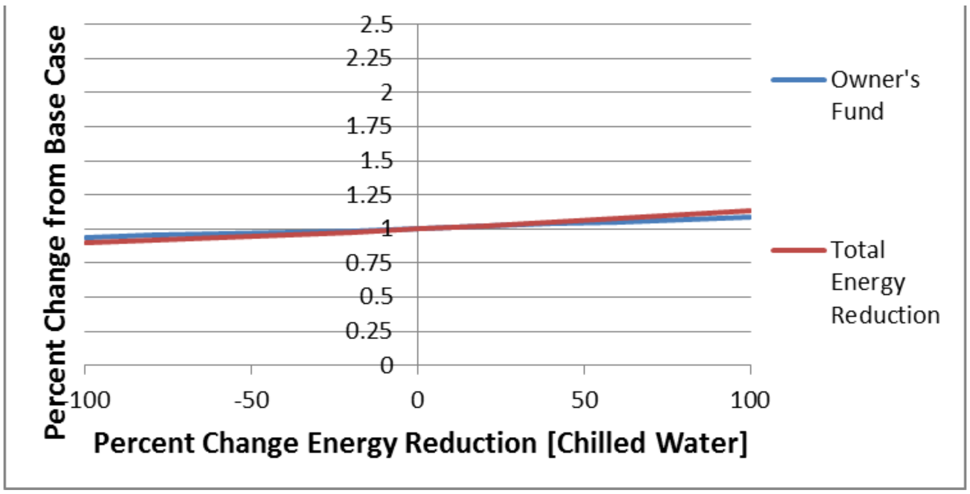


Figure 63: Energy Reduction [Chilled Water]

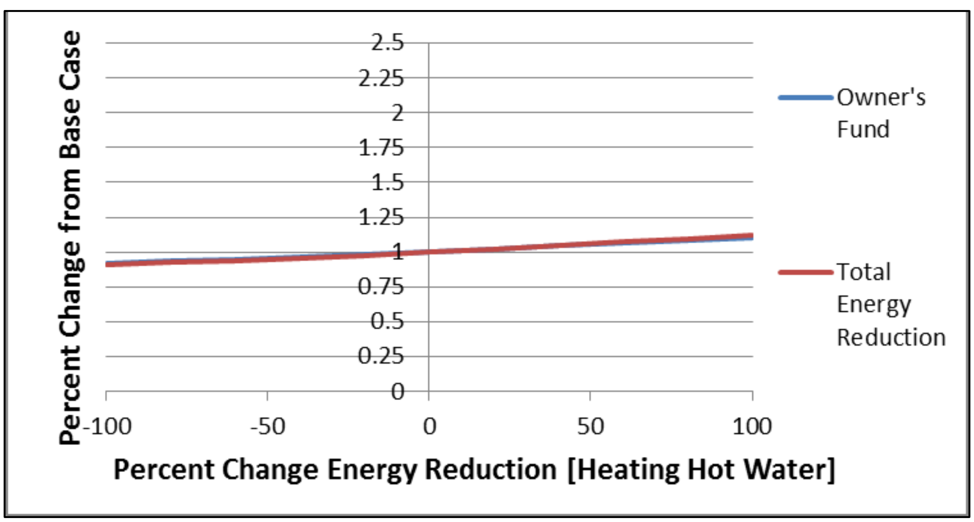


Figure 64: Energy Reduction [Heating Hot Water]

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[1] These graphs are the additional univariate sensitivity plots from the body of the dissertation and performed in this study.

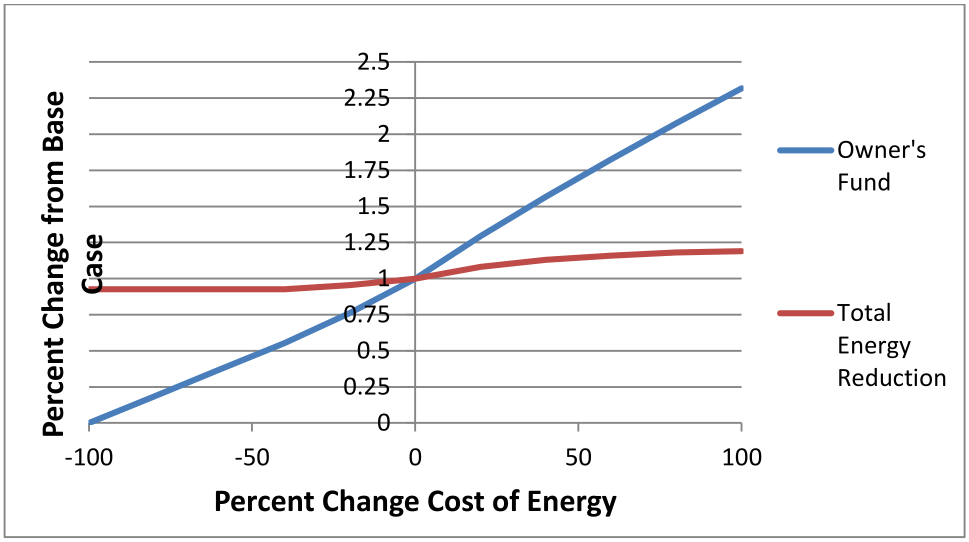

Figure 65: Cost of Energy