Modeling the Influence of Positive Incentives on Insider Threat Risk Reduction

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Abstract

Traditional insider threat practices involve negative incentives that attempt to force employees to act in the interests of the organization and, when relied on excessively, can result in negative unintended consequences that exacerbate insider threats. Positive incentives that attempt to encourage employees to act in the interests of the organization can complement negative incentives. In our research, we identified and analyzed three avenues for aligning the interests of the employee and the organization: job engagement, perceived organizational support, and connectedness with co-workers. Based on an analysis of three insider threat incidents and an exploratory survey of organizations, we developed a preliminary model of the disgruntled insider threat problem as it relates to dissatisfaction with the employing organization and the potential benefits associated with positive incentives that improve perceived organizational support. The system dynamics model is based on previous research results, published data, and simple (but arguable) assumptions showing how positive incentives can increase a program's operational efficiency with reduced investigative costs and fewer incidents involving disgruntled or exploitive insiders. Our incident analysis and survey work provided validation of the simulation model structure. We will continue to refine and calibrate our model based on future research and expect to demonstrate similar benefits as our work progresses.

Keywords: insider threat, cybersecurity, modeling and simulation, system dynamics, perceived organization support, positive incentives

1 Introduction

Insider threat is the threat to an organization's critical assets posed by individuals—including employees, contractors, and business partners—who are authorized to use the organization's information technology systems [Cappelli 2012]. Insider threat programs within an organization help it to manage the risks due to these threats through specific prevention, detection, and response practices and technologies. Traditional guidance regarding how to defend against insider threats focuses primarily on *negative incentives*, which constrain employee behavior or detect and punish misbehavior. These traditional security practices are necessary to reduce insider threats, but their excessive use can result in counterproductive constraints on employees' actions, overreliance on after-the-fact responses that fail to prevent damage, and alienation of staff that can exacerbate insider threats [Moore 2015].

Fortunately, traditional practices are only part of the suite of management practices that organizations have available to reduce insider threats. Figure 1 provides an abstract view of the spectrum of insider

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threat countermeasures, with more abstract objectives to the right and the means for achieving them to the left.

The bulk of insider threat research has focused on the bottom two branches: the prevention, detection of, and response to insider misbehaviors. Security policies and technical measures provide negative incentives that are intended to prevent, detect, and respond to insider misbehavior. Recent research has focused on the detection of at-risk behaviors of insiders, such as conflict with co-workers or personal indebtedness, which have been shown to be pre-cursors of serious insider threat activity (the third branch).

The research described in this report involves the top branch: positive incentives as a means to reduce insider threats without the use of monitoring and detection mechanisms. *Positive incentives* can complement traditional practices by encouraging employees to act in the interests of the organization either extrinsically (e.g., through rewards for following security policies) or intrinsically by fostering a sense of commitment to the organization, the work, and co-workers.

Instead of solely focusing on making sure employees don't misbehave, positive incentives create a work environment where employees are internally driven to contribute to the organization only in positive ways. This approach may seem idealistic, but there is a solid scientific basis for this perspective. Our research is making inroads into the second branch of Figure 1 by elaborating conditions within *organizations* that are conducive to insider threat and a means for transforming organizations to be more resistant to insider threats. Preliminary evidence suggests that positive incentives can deter insider misbehavior in a constructive way from the outset of the employee-organization relationship. In combination with traditional practices, positive incentives offer the possibility of a more balanced and constructive organizational approach to reducing the insider threat with fewer negative consequences.

This paper describes the results of a research effort to establish and model the influence of positive incentives on reducing insider threats. For U.S. Government organizations and their contractors that handle classified information, Executive Order 13587 requires establishing formal insider threat programs. Many non-governmental organizations are also establishing insider threat programs as a means to reduce their risk of insider theft, fraud, and sabotage. With organizations starting to recognize the downsides of negative incentives, the need for this research has never been more pressing [Moore 2015]. It can be a means to *prevent* employee alienation from their employer that can spur insider threats, and to complement organizational detection and response capabilities.

The rest of this section provides relevant background on previous research and an overview of our research in 2016 on positive incentives. Section 2 presents our preliminary system dynamics model based on the findings from previous research and some key findings from the simulation-based analysis. We model the disgruntled insider threat problem as it relates to dissatisfaction with the employing organization and the potential benefits associated with positive incentives that improve perceived organizational support and justice. We also extend the model in a way that permits analyzing potential cost savings associated with fewer insider threat incidents and counterproductive behaviors generally. Finally, section 3 summarizes our preliminary results and provides an outline of workforce management practice areas based on positive incentives that promote perceived organizational support among employees. Our future work will involve extending the basic model presented as we get more experience piloting workforce management practices in the field. We also present our vision for the future of insider threat defense and our research plans that move us toward this vision. The appendix provides an overview of the method and notation associated with system dynamics for readers unfamiliar with the approach.

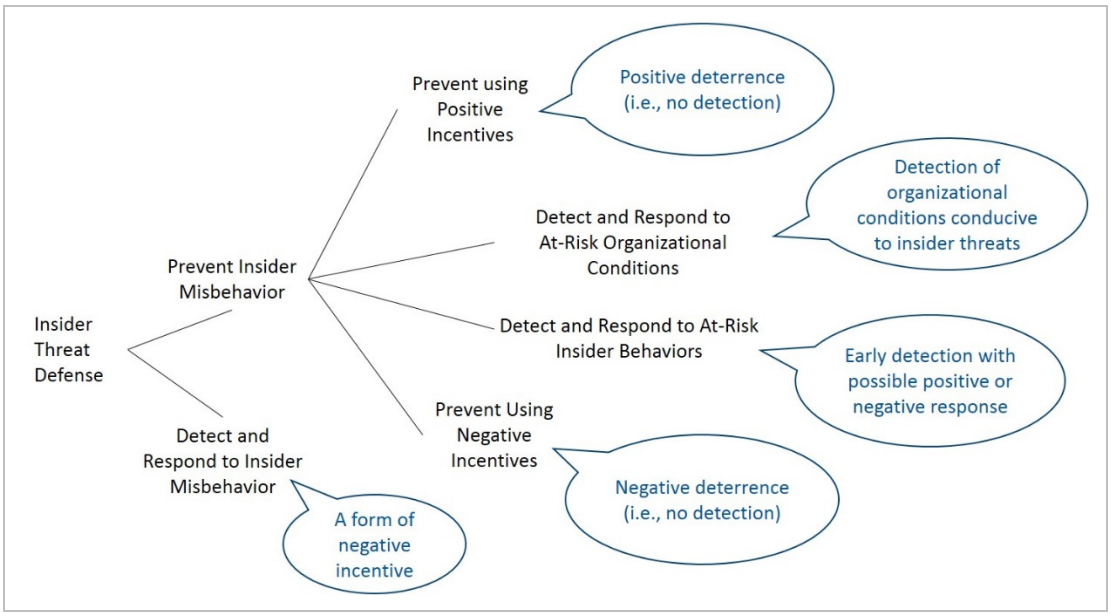

Figure 1: Insider Threat Defense Options

1.1 Background

The subject of our research intersects issues important to both human resources (HR) and cybersecurity professionals. We identify two types of workforce management practices relevant in our research:

- ***Negative incentive-based practices (negative incentives, for short)***: workforce management practices that attempt to *force* employees to act in the interests of the organization
- ***Positive incentive-based practices (positive incentives, for short):*** workforce management practices that *encourage* employees to act in the interests of the organization

While a balanced approach focuses on a combination of positive and negative incentives, positive incentives have been studied extensively in the modern era [Levy 2013, Smither 2009]. By far, most of this research focuses on the benefits of this approach for improved productivity, performance, and retention, including a relatively recent focus in an area called "positive psychology" [Seligman 2012]. While much of the recent practice-based literature focuses on a concept called "work engagement," researchers have noted that this concept is actually a conflation of many previously established social science theories and domains of research [Meyer 2013].

We believe there are three dimensions along which we can align an employee's interests with their employer's interests: the employee's *job*, their *organization*, and the *people* they work with.

- **Job Engagement** involves the extent to which employees are excited by and absorbed in their work. Strengths-based management[1] and professional development are practices known to boost employee job engagement. Measurement scales for employee engagement have a

[1] Strengths-based management focuses primarily on identifying and using an individual's personal and professional strengths in directing their career and managing their job performance [Buckingham 2009].

considerable history, including their use by both the U.S. Government [OPM 2015] and academic researchers [Schaufeli 2004].

- **Perceived Organizational Support** involves the extent to which employees believe their organization values their contributions, cares about their well-being, supports their socio-emotional needs, and treats them fairly. Here, programs promoting flexibility, work/family balance, employee assistance, alignment of compensation with industry benchmarks, and constructive supervision that attends to employee needs can boost perceived organizational support. Extensively validated measures have been widely used since the 1980s [Eisenberger 1986], culminating in a seminal publication that summarizes that research in book form [Eisenberger 2011].

- **Connectedness at Work** involves the extent to which employees want to interact with, trust, and feel close to the people they work with. Practices involving team building and job rotation can boost employees' sense of interpersonal connectedness. One important scale is the one associated with Self Determination Theory (SDT), in particular, the relatedness aspects of the Basic Psychological Needs at Work Scale [Brien 2012]. Another scale is associated with the Theory of Belongingness [Malone 2012].

Although there has been extensive research in these areas that demonstrate their value in terms of employee satisfaction, commitment, performance, and retention [Levy 2013], a related body of research exists that helps to determine their value for reducing insider threats.

Literature with a strong connection to our research includes studies that show that positive employee attitudes about their work are linked to reduced counterproductive work behaviors. Counterproductive work behaviors include malicious insider threat behaviors as well as other less egregious, but still counterproductive, behaviors. A well-established body of research on psychological contracts that employees (often implicitly) have with their organizations can, if breached, serve as the reason for negative attitudes and behaviors by employees [Rousseau 1995, Restubog 2015].

Research on psychological contract breaches aligns with modeling research conducted at the SEI that shows patterns of insider IT sabotage rooted in the insider's unmet expectations [Cappelli 2012]. Generally, counterproductive work behaviors are found to be negatively correlated with the following:

- job engagement (e.g., [Sulea 2012, Ariani 2013])
- connectedness at work (e.g., [Sulea 2012])
- perceived organizational support (e.g., [Bordia 2008, Sulea 2012, Shoss 2013])
- organizational citizenship behavior (e.g., [Ariani 2013])
- conscientiousness (e.g., [Shoss 2013])
- employee empowerment (e.g., [Afsheen 2013])

Especially significant is that perceived organizational support is strongly correlated with organizational commitment [Rhoades 2001].

1.2 Our Recent Data Collection and Analysis

Research conducted by the CERT Program at the Software Engineering Institute in 2016 involved both insider incident analysis and organizational surveys [Moore 2016a]. The incident analysis involved

analyzing several high-profile insider incidents for the levels of job engagement, co-worker connectedness, and perceived organization support evident during the incident timeline. Perceived organizational support was found to be extremely negative, while job engagement and co-worker connectedness were found to be low, but not necessarily in the extreme. These incident case studies suggested focusing on organizational support in our survey research.

We conducted a survey with members of the Open Source Insider Threat Information Sharing Group (OSIT), a group of individuals responsible for establishing insider threat programs in organizations. The organization's membership is growing, in part because the executive order that requires organizations that handle classified information to establish an insider threat program. At present, there are approximately 100 organizations that are members of OSIT. Supporting and extending previous research, as shown in Figure 2, the 23 responses to the survey that we received indicate a significant negative correlation between perceived organizational support and intentional (primarily malicious) counterproductive work behaviors. A somewhat weaker negative correlation was also found between organizational justice and these behaviors. The relationships were found to be statistically significant at the 95% confidence level [Moore 2016a].

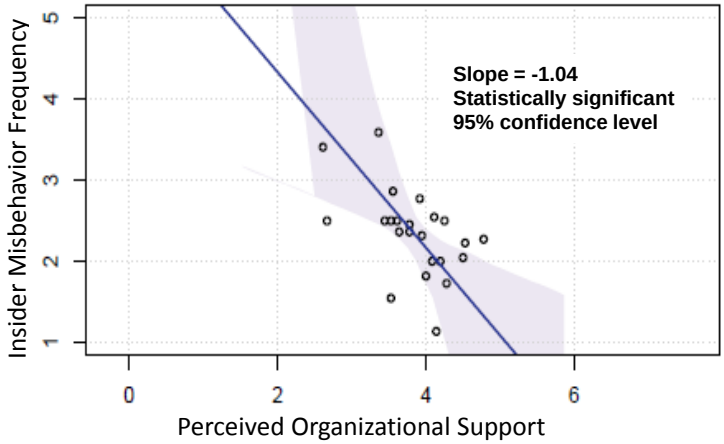

Figure 2: Negative Correlation between Perceived Organizational Support and Insider Misbehavior

It is somewhat surprising that organizational justice is less negatively correlated than perceived organizational support. One might expect that unfair treatment would be a strong reason for insider misbehavior. However, perceived organizational support includes aspects of fair treatment as part of the standard instrument for measurement. It also includes other aspects, such as effective communication and supervisor supportiveness. A plausible conclusion to draw is that breadth of coverage across the various aspects of perceived organizational support is more important than in depth coverage, at least as it relates to organizational justice. While the exploratory nature of our initial analysis does not permit us to generalize this relationship to the larger population of organizations establishing insider threat programs, it provides a good basis for developing a simulation model for what we know so far.

2 The System Dynamics Model and Analysis

This section describes a simulation model of the problem associated with employees' dissatisfaction with their employer and how that dissatisfaction may lead to disgruntlement-spurred insider threats such as insider cyber sabotage, information theft, and unauthorized leakage of classified information.

The preliminary model presented focuses on the primary stock and flow structure and a simulation that exhibits the relative constancy that other surveys of employee satisfaction has demonstrated over the years. The purpose is to explore what a simple (stock and flow) model suggests would be the value of greater employee satisfaction with their employer in terms of reduced insider threat and associated investigative costs. Our basic model is based on data on the U.S. federal government workforce showing that employee dissatisfaction with their employer remains fairly constant over time. The model reflects the relationships found in our data, as shown in Figure 2, which illustrates the threat-reducing value of practices that increase perceived organizational support. We do not explore in this paper possible or plausible feedback dynamics associated the problem. While important, such feedback will involve understanding the dynamics associated with workforce management practices with which we have little practical experience and for which there is sparse literature. Refinement of the basic model will include feedback dynamics especially as we work with organizations to better understand the pros and cons of specific positive incentives.

2.1 The Model

The core stocks and flows associated with an employee's changing satisfaction with their employing organization is shown in Figure 3. We take a simple view that employees are either satisfied with the organization or not, represented as the two primary stocks involved. We assume that newly hired employees may be dissatisfied with the organization, perhaps as a result of a negative hiring or onboarding process.

The user-settable variable ***percent satisfied at hire*** represents the percentage of those hired that are satisfied. Of course, satisfied employees can become dissatisfied at some rate; ***percent becoming satisfied*** represents the percentage per month of satisfied individuals that become dissatisfied. Likewise, there is a user-settable percentage per month of dissatisfied individuals that become satisfied; however, we assume there is some percentage of the workforce that is perpetually dissatisfied that is not included in the flow of employees becoming satisfied.

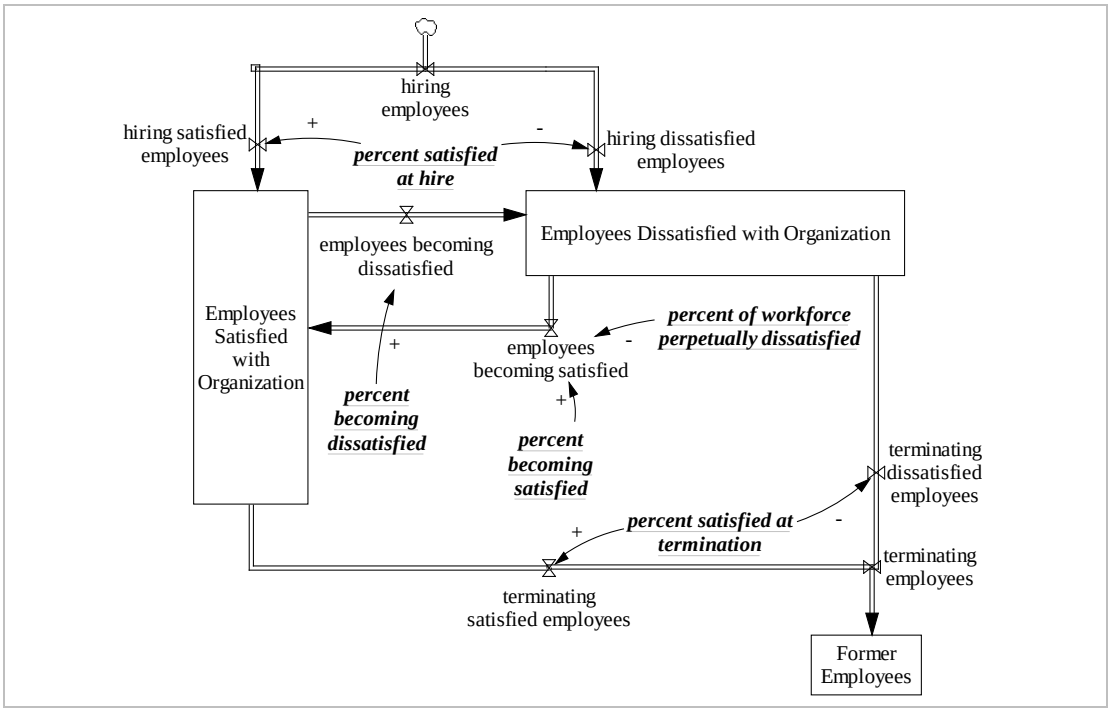

Figure 3: Core Stocks and Flows in the Organizational Context

Finally, while employees leaving the organization may be either satisfied or not, we expect a larger percentage of dissatisfied employees will leave. The next section discusses factors involved with setting the variables in the execution of the model based on existing data and our project analysis.

Figure 4 extends the model to include the potential for dissatisfied employees to become disgruntled and potentially become insider threat actors. We separate the stocks of dissatisfied employees, disgruntled employees, and insider incidents as coflows so that we don't have to duplicate the termination flows and artificially estimate termination rates from every stock. Notice that once someone causes an incident, there is no turning back; they may be stopped from causing further harm, but they will forever be seen as insider threat actors by their employers.

However, those that are only disgruntled may get pulled back from the brink either through their departure from the organization or by their re-engagement in the mission of the organization. We make the following simplifying assumptions:

- The rate of re-engagement is proportional to the rate of dissatisfied employees becoming satisfied.
- The rate of departure is proportional to the rate of termination of dissatisfied employees.

While these assumptions are debatable, they seem reasonable for an initial approximation. We discuss the interpretation and measurement of various aspects of the model in the next section.

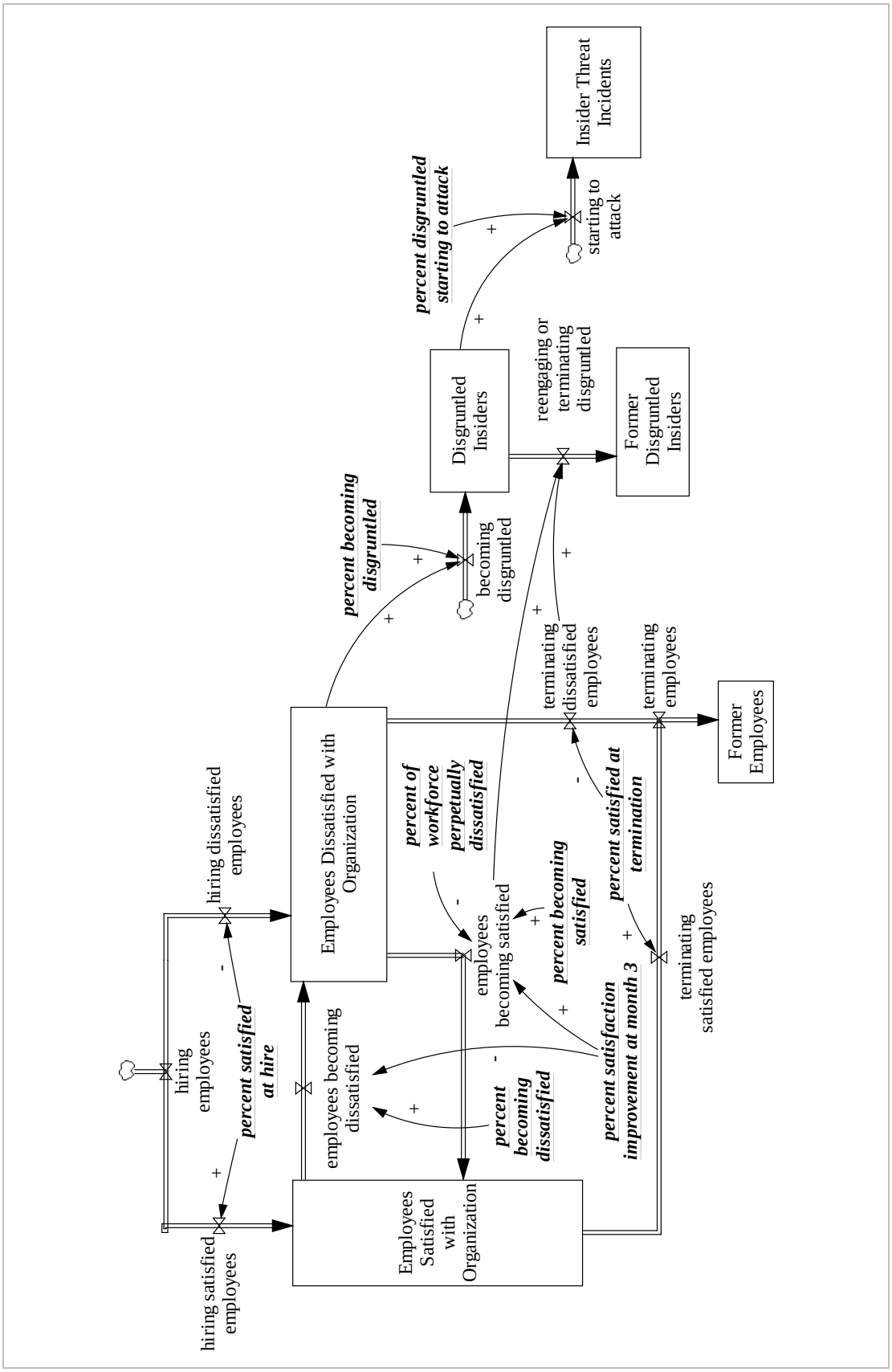

Figure 4: **Emerging Physics of Organization Dissatisfaction and the Disgruntled Insider**

Model Execution

The model described in the previous section raises the question of what the values should be for all of the input variables during model execution. We used the following values in model execution, at least initially:

- ***percent satisfied at hire*** = 90%
- ***percent satisfied at termination*** = 20%
- ***percent becoming satisfied*** = 10%/month
- ***percent becoming dissatisfied*** = 10%/month
- ***percent of workforce perpetually dissatisfied*** = 5%
- ***percent becoming disgruntled*** = 10%/month
- ***percent disgruntled starting to attack*** = 0.2%/year

So how did we derive these values? We started by determining values from previous research that we could use with sufficient confidence and then directed our research to determine reasonable values for other variables of interest. We developed a preliminary version of this model prior to conducting the research described in this report and used it to decide what additional data to collect.

As a starting point, we reviewed several studies that are regularly conducted to assess employee attitudes. Because of our focus on the U.S. Government, a very important study for us is the Federal Employee Viewpoint Survey Results [OPM 2015]. This report shows that employee satisfaction within their organization has been steady at about 55% over the past several years. For simplicity, we assume these survey results mean that 55% of the employees are satisfied with their organization and 45% are dissatisfied.

Finally a Gallup study has fairly consistently found that about 18% of the workforce is actively disengaged, which means that the employee is “more or less out to damage their company” [Gallup 2013]. This actively disengaged employee is also what we refer to as the disgruntled insider in the model. The values for the input variables listed above were derived by a combination of identifying plausible values and getting the percentages in the previous paragraph to work out as a result. We’ll describe the application of sensitivity (Monte Carlo) simulation in the next section to analyze the behavior of the model over a range of parameter values that represent the uncertainty associated with those values.

Simulation results are described with respect to a model equilibrium, which is shown in simulation graphs as a “baseline” simulation run. The equilibrium of the model described in this paper ensures that the rate of change of all stocks remains at a constant value (possibly zero). In equilibrium, a model is easier to experiment with since the analyst can more easily determine how small changes in input affect the overall behavior of the simulation. Any change in behavior (as seen in the behavior-over-time graphs) can be attributed to that single changed input and only that change. It is analogous in scientific experiments to keeping all variables constant (i.e., the independent or controlled variables) except the ones being studied (i.e., the dependent variables).

The baseline run of our model represents an organization with the percentages of the total workforce described above: specifically, about 55% of the employees are satisfied with the organization and 45% are dissatisfied. In addition, 18% of the total workforce are disgruntled. These simulation results are shown in Figure 5 and Figure 6. The simulated size of the organization is somewhat arbitrary, but in this execution is about 1,000 people. It is important to remember that the equilibrium of the baseline run fits the data that we have from the Gallup study [Gallup 2013].

Figure 5: Employee Satisfaction Levels[2]

Figure 6: Employee Classification Levels

Figure 7 shows the accumulation of insider threat incidents under the above conditions. The baseline run shows about six incidents occurring over a 20-year period. The major factor here, given our assumptions, is the variable ***percent disgruntled starting to attack***. This variable is set at 0.2% per year. Put another way, every year *0.002 Disgruntled Insiders* are responsible for insider threat incidents. In equilibrium, there are about 150 disgruntled insiders, so this is about one incident every 3-1/3 years, accumulating to about six over 20 years.

[2] In this behavior-over-time graph, the X-axis for the graphs is specified in months (240 months—twenty years—is the duration of this simulation). The legend below the graph shows each variable and the name of the simulation run graphed in the format "variable: simulation run". The variable simulation runs are distinguished with a number label (1 and 2 in Figure 6) and in color copies also specified in the legend below the graph.

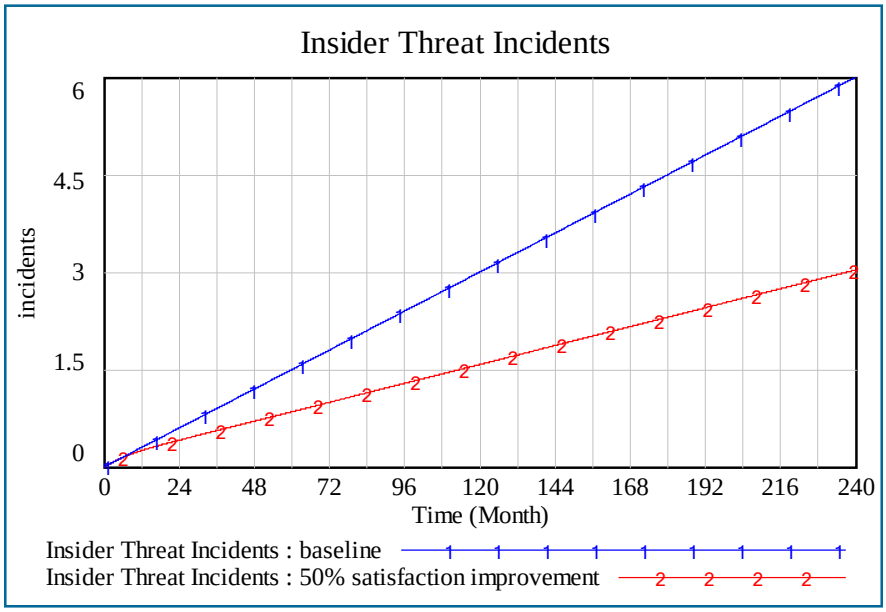

Figure 7: **Individuals Responsible for Insider Threat Incidents**

The simulation run named "50% satisfaction improvement" shows that the number of insider threat incidents drops in half over the twenty-year timeframe of the simulation when the rate of employees becoming dissatisfied drops by 50% and the rate of employees becoming satisfied increases by 50%. This change, possibly due to workforce management practices to improve employee attitudes about their satisfaction with the organization, takes place in the simulation at month three, moving the accumulation of insider threat incidents off its baseline trajectory to fewer such incidents. This should not be surprising given the linear nature of our basic model. While this illustrates what might be possible, there is likely to be policy resistance to the incorporation of positive incentives that we will need to explore in future refinement of the model.

As we might expect in our simple model, the actual decline is sensitive to both the percentage improvement as well the percentage of disgruntled employees starting to attack. Figure 8 shows the potential decline in incidents for various values of these two variables in three dimensions.

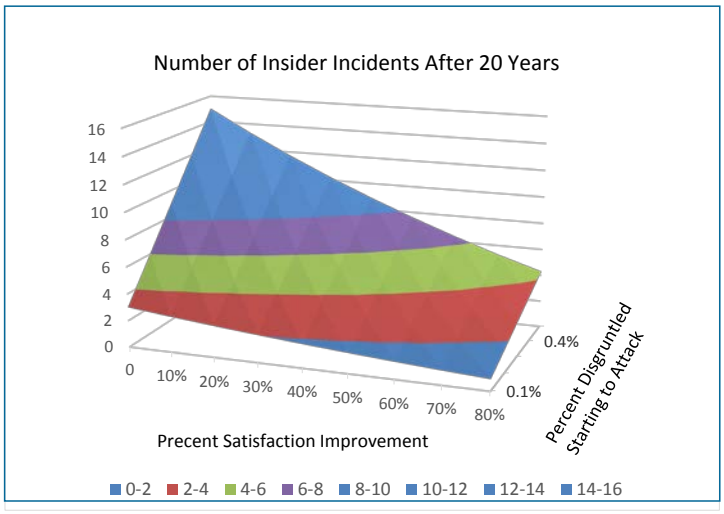

Figure 8: **Sensitivity Simulation Results on Insider Threat Incidents**

2.2 Extension of the Model

We can now extend the model to better understand the potential cost savings from efforts to improve employees' satisfaction with the organization. In the upper right corner of the model extension shown in Figure 9, we include model variables to estimate the number of counterproductive work behaviors of satisfied employees and a multiplier of that number of behaviors for dissatisfied employees. Costs are estimated both as a cost per counterproductive work behavior, in terms of lost productivity, and the costs associated with insider threat incidents.

The following values are assumed for these variables in our analysis:

- ***CWB per satisfied*** = 0.5 CWB/month
- ***multiplier CWB rate per dissatisfied*** = 4.0
- ***cost per CWB*** = $500
- ***cost per incident*** = $1M

We calculate the yearly costs as the simple sum of the costs of productivity loss due to CWBs and the costs due to disgruntled insider threat incidents. We form a yearly cost index based on the costs associated with no satisfaction improvement (i.e., where percent satisfaction improvement at month 3 is 0).

Figure 10 shows the decrease in relative cost from the baseline due to various levels of satisfaction improvement. For example, with the 50% satisfaction improvement that we analyzed previously, we get a 25% reduction in yearly costs associated with egregious insider threat incidents and other counterproductive work behaviors. In our hypothetical organization, this level of improvement takes a program that spends $6 million per year to one that spends $4.5 million per year in investigation costs and lost productivity.

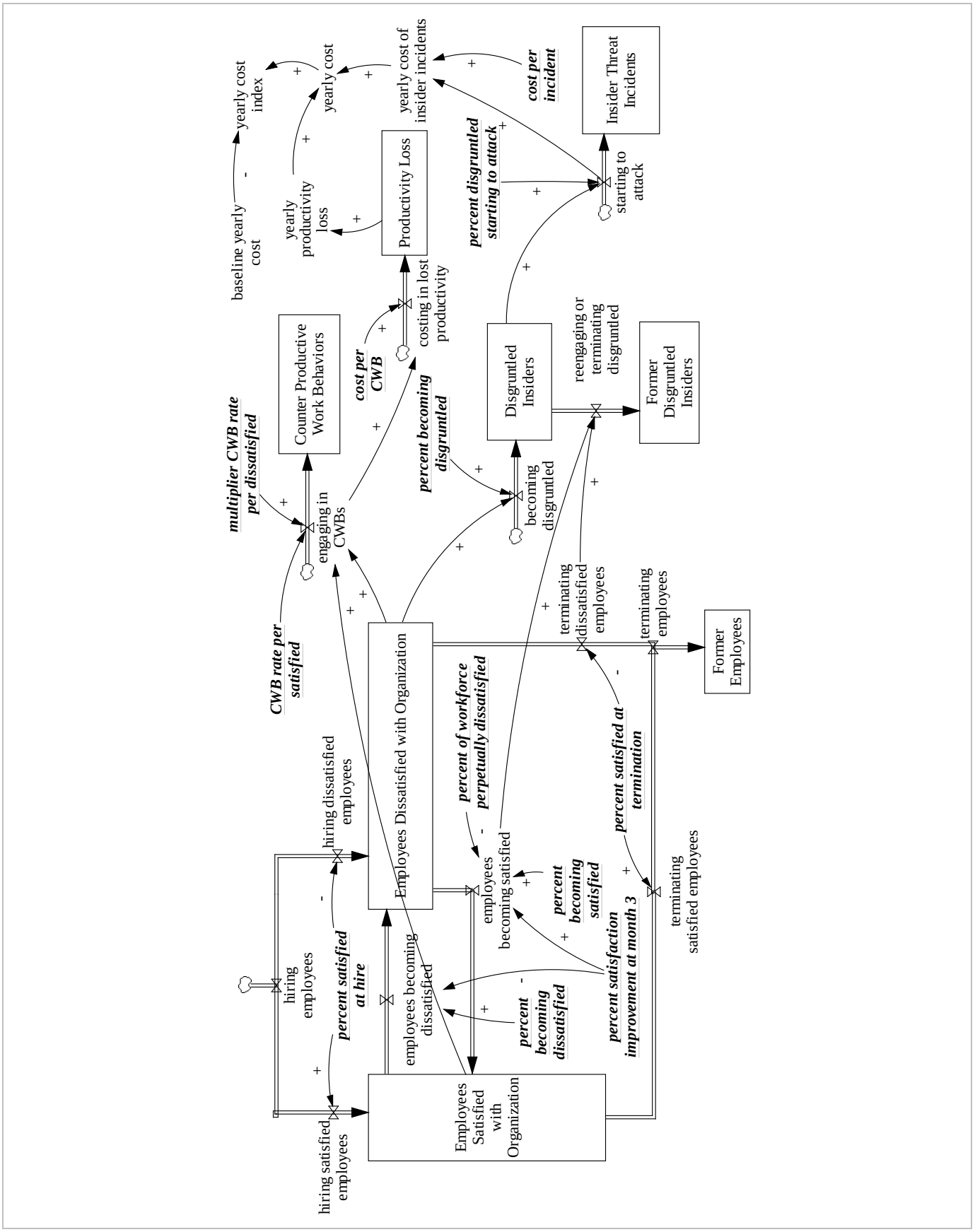

Figure 9: Model Extension to Estimate Potential Cost Savings

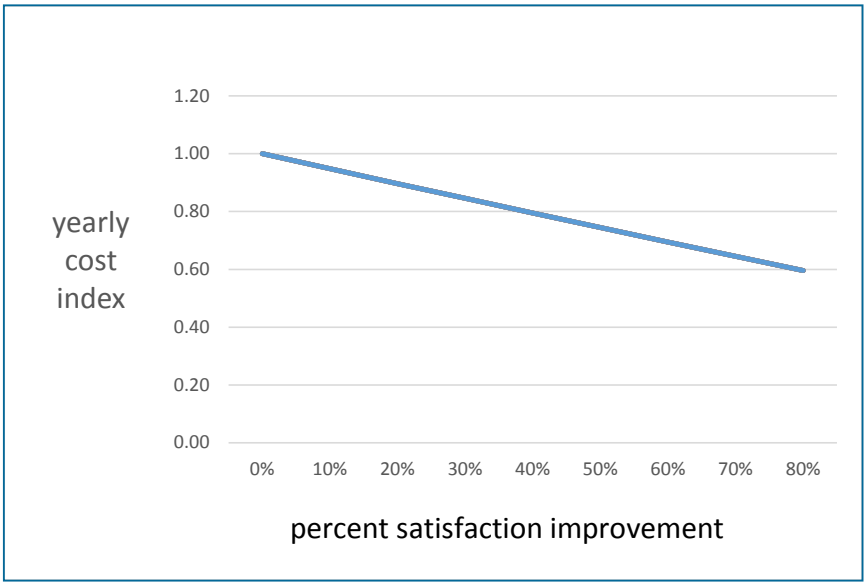

Figure 10: Decrease in Yearly Costs Due to Satisfaction Improvement

3 Conclusions

Our research raises many questions about how an insider threat program can or should incorporate positive incentives that improve employees' perceptions of support by the organization. The model that we present develops a simple (stock and flow) model suggesting the value of greater employee satisfaction with their employer in terms of reduced insider threat, associated investigative costs, and counterproductive work behaviors. Our basic model is based on data on the U.S. federal government workforce showing that levels of employee dissatisfaction with their employer remain fairly constant over time. The model also reflects the negative correlation found in our research that illustrates the threat-reducing potential of practices that increase perceived organizational support.

Our modeling work motivates future work to refine the feedback dynamics associated with incorporating positive incentive-based workforce management practices into organizations in order to reduce the threat. The next section elaborates practice areas specifically intended to increase employees' perceptions of organization support. These practice areas will be the focus of our future work with organizations to better understand the pros and cons of specific positive incentives.

3.1 Practice Areas for Organizational Supportiveness

Figure 11 provides a breakdown of practice areas relevant to developing and retaining staff to achieve an organization's mission, with a particular focus on positive incentives. The first two branches off the root node at the left side of the figure involve workforce management practices, including hiring and retaining the appropriate staff with the right job responsibilities and ensuring that they are positively motivated to execute responsibilities that support achieving the organization's mission.

The third branch acknowledges the fact that employees can act counter to the organization's mission even if they perform their job well in other respects. This branch, which traverses the red node in the figure, makes this partitioning particularly appropriate for guiding the development and refinement of insider threat programs. The second and third branches, in combination, show that practices can benefit the organization in terms of employee satisfaction, performance, and retention as well as reducing the insider threat.

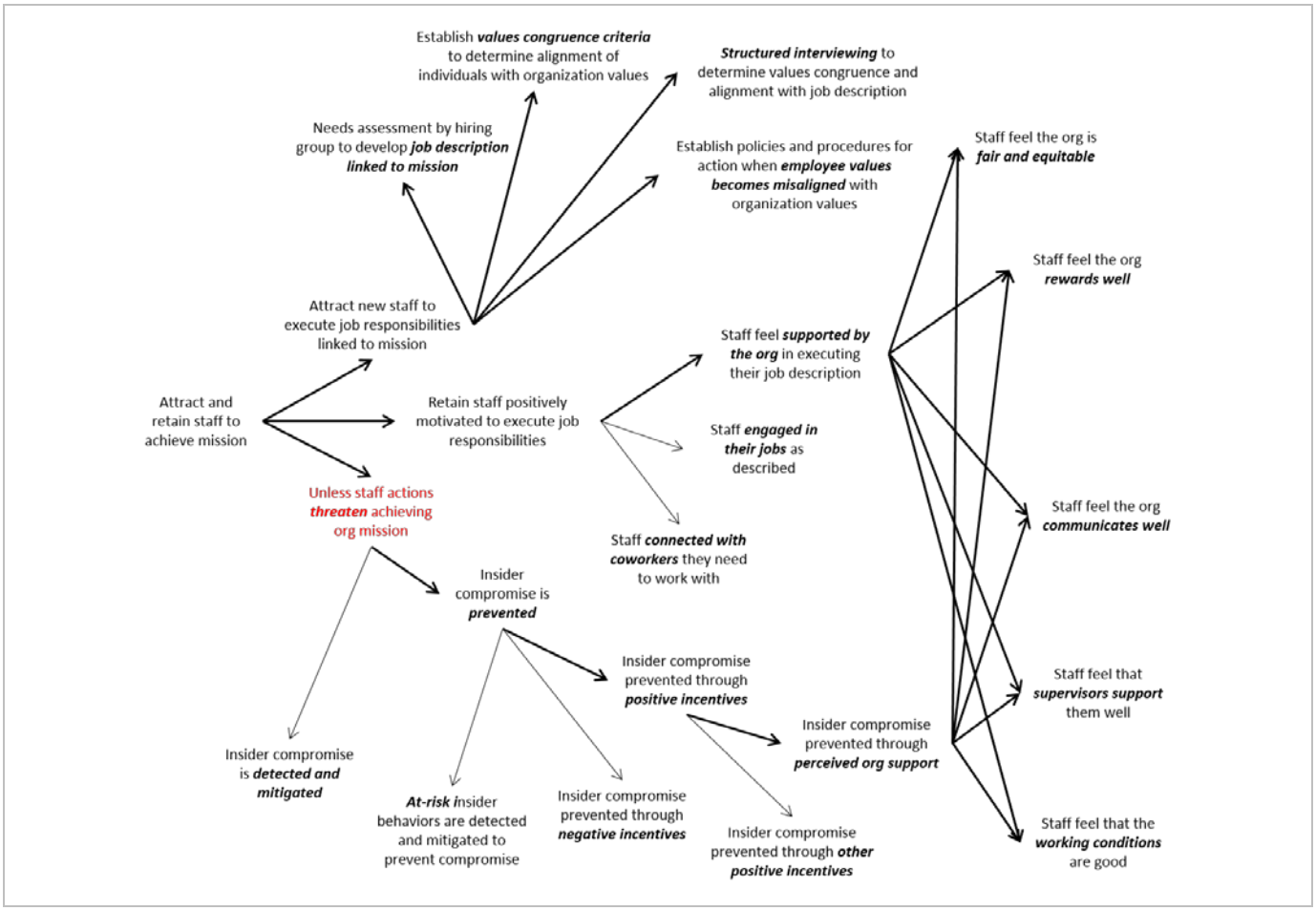

Figure 11: Taxonomy of Positive Incentive Workforce Management Practice Areas

The taxonomy presented in the figure is elaborated in our full report [Moore 2016a].

3.2 Vision for the Future

We believe that continuing the research started in this report is critical to establishing and managing effective insider threat programs. Our vision is the extension of the traditional security approach shown in Figure 12. The right side of the figure depicts the traditional approach focused on negative incentives that restrict employees to prevent abuse and detects and punishes abuse when it occurs. This approach is based on a negative form of deterrence as promulgated in Deterrence Theory, which says that people obey rules because they fear getting caught and being punished. Restricting, detecting, and punishing employees reinforces the deterrence (negative) of abuse.

Our extension of security through positive incentives is shown on the left side of the figure. In its current form, as supported by our research, organizational support (including organization justice) is shown as the foundation of positive deterrence. With this foundation in place, connectedness with co-workers and job engagement serve to strengthen an employee's commitment to the organization. Organization support and connectedness also strengthen overall engagement in a feedback effect.

This form of positive deterrence complements the use of negative deterrence by reducing the baseline of insider threat in a way that can improve employees' satisfaction, performance, and commitment to the organization. As illustrated in our modeling effort, fewer incidents and counterproductive behaviors

reduces costs through fewer investigations and greater staff productivity. Employing the right mix and ratio of positive and negative incentives in an insider threat program can create a net positive for both the employee and the organization—moving an insider threat program from a "big brother" program to a "good employer" program that actually improves employees' work life.

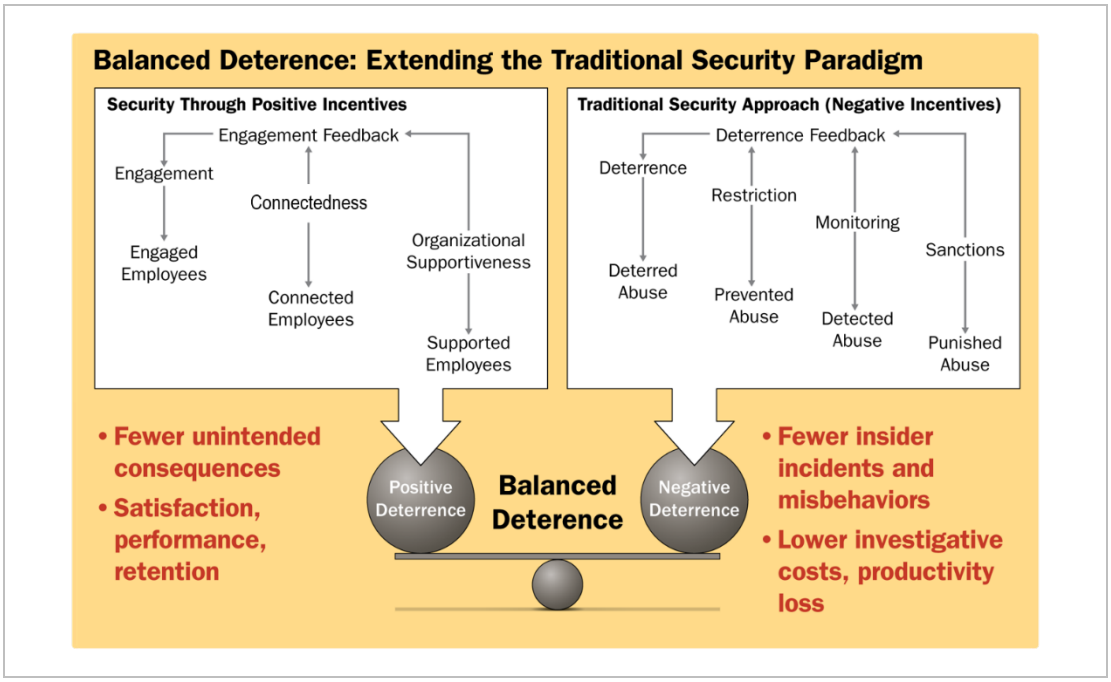

Figure 12: Extending the Traditional Information Security Paradigm

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References

[Afsheen 2013]
Afsheen, Fatima; Iqbal, Muhammad Zahid & Imran, Rabia. Organizational Commitment and Counterproductive Work Behavior: Role of Employee Empowerment. Pages 665-679. In *Proceedings of the Sixth International Conference on Management Science and Engineering Management*. London. 2013. http://link.springer.com/chapter/10.1007%2F978-1-4471-4600-1_57

[Ariani 2013]
Ariani, D. W. The Relationship between Employee Engagement, Organizational Citizenship Behavior, and Counterproductive Work Behavior. *International Journal of Business Administration.* Volume 4. Number 2. March 1, 2013. Page 46.

[Bordia 2008]
Bordia, P.; Restubog, S. L. D.; & Tang, R. L. When Employees Strike Back: Investigating Mediating Mechanisms between Psychological Contract Breach and Workplace Deviance. *Journal of Applied Psychology. Volume 93.* Number 5. September 2008. Page 1104.
http://psycnet.apa.org/journals/apl/93/5/1104/

[Brien 2012]
Brien, Maryse; Forest, Jacques; Mageau, Geneviève A.; Boudrias, Jean-Sébastien; Desrumaux, Pascale; Brunet, Luc; & Morin, Estelle M. The Basic Psychological Needs at Work Scale: Measurement Invariance Between Canada and France. *Applied Psychology: Health and Well-Being*. Volume 4. Number 2. July 1, 2012. Page 167.

[Cappelli 2012]
Cappelli, Dawn M.; Moore, Andrew P.; & Trzeciak, Randall F. 2012. The CERT Guide to Insider Threats: How to Prevent, Detect, and Respond to Information Technology Crimes (Theft, Sabotage, Fraud). Addison-Wesley.

[Eisenberger 1986]
Eisenberger, R.; Huntington, R.; Hutchison, S.; & Sowa, D. Perceived Organizational Support. *Journal of Applied Psychology*. Volume 71. Number 3. 1986. Page 500.

[Eisenberger 2011]
Eisenberger, R. & Stinglhamber, F. 2011. *Perceived Organizational Support: Fostering Enthusiastic and Productive Employees*. American Psychological Association. ISBN 978-1-4338-0933-0. http://www.apa.org/pubs/books/4316128.aspx

[Gallup 2013]
Gallup. *State of the American Workplace: Employee Engagement Insights for U.S. Business Leaders*. Gallup. 2013. http://www.gallup.com/services/178514/state-american-workplace.aspx

[Levy 2013]
Levy, P. *Industrial/Organizational Psychology: Understanding the Workplace*. Worth Publishers. 2013. ASIN B00HTK33PS.

[Malone 2012]
Malone, Glenn P.; Pillow, David R.; & Osman, Augustine. The General Belongingness Scale (GBS): Assessing Achieved Belongingness. *Personality and Individual Differences.* Volume 52. Number 3. February 2012. Page 311. http://www.sciencedirect.com/science/article/pii/S019188691100482X

[Meyer 2013]
Meyer, John P. The Science–Practice Gap and Employee Engagement: It's a Matter of Principle. *Canadian Psychology/Psychologie Canadienne*. Volume 54. Number 4. November 2013. Page 235.

[Moore 2016a]
Moore, A.P.; Perl, S.J.; Cowley, J.; Collins, M.L., Cassidy, T.M.; VanHoudnos, N.; Buttles P.; Bauer, D.; Parshall, A.; Savinda J.; Monaco, E.A.; Moyes, J.L.; Rousseau, D.M. "The Critical Role of Positive Incentives for Reducing Insider Threat," SEI Technical Report CMU/SEI-2016-TR-014, December 2016.
http://resources.sei.cmu.edu/asset_files/TechnicalReport/2016_005_001_484929.pdf

[Moore 2016b]
Moore, A.P.; Kennedy, K.; & Dover, T. Introduction to the Special Issue on Insider Threat Modeling and Simulation. *Journal on Computational and Mathematical Organization Theory*, September 2016.

[Moore 2015]
Moore, A.P.; Novak, W.E.; Collins, M.L.; Trzeciak, R.F.; & Theis, M.C. *Effective Insider Threat Programs: Understanding and Avoiding Potential Pitfalls*. White paper. Software Engineering Institute, 2015.

[OPM 2015]
Office of Personnel Management (OPM). *Federal Employee Viewpoint Survey Results: Employees Influencing Change*. U.S. Office of Personnel Management. 2015. https://www.fedview.opm.gov/2015/

[Restubog 2015]
Restubog, Simon Lloyd D.; Zagenczyk, Thomas J.; Bordia, Prashant; Bordia, Sarbari; & Chapman, Georgia J. If You Wrong Us, Shall We Not Revenge? Moderating Roles of Self-Control and Perceived Aggressive Work Culture in Predicting Responses to Psychological Contract Breach. *Journal of Management.* Volume 41. Number 4. May 2015. Page 1132. http://jom.sagepub.com/content/41/4/1132.short

[Rhoades 2001]
Rhoades, L.; Eisenberger, R.; & Armeli, S. Affective Commitment to the Organization: the Contribution of Perceived Organizational Support. *Journal of Applied Psychology.* Volume 86. Number 5. October 2001. Page 825.

[Rousseau 1995]
Rousseau, Denise. *Psychological Contracts in Organizations: Understanding Written and Unwritten Agreements*. Sage Publications. 1995. ISBN 978-0803971042.
https://us.sagepub.com/en-us/nam/psychological-contracts-in-organizations/book5077

[Schaufeli 2004]
Schaufeli, Wilmar B. & Bakker, Arnold B. Utrecht Work Engagement Scale: Preliminary Manual. Occupational Health Psychology Unit, Utrecht University. 2004.
http://www.wilmarschaufeli.nl/publications/Schaufeli/Test%20Manuals/Test_manual_UWES_English.pdf

[Seligman 2012]
Seligman, Martin E. P. *Flourish: A Visionary New Understanding of Happiness and Well-Being*. Reprint Edition. Atria Books. 2012. ISBN 978-1439190760.
http://www.simonandschuster.com/books/Flourish/Martin-E-P-Seligman/9781439190760

[Shoss 2013]
Shoss, Mindy K.; Eisenberger, Robert; Restubog, Simon Lloyd D.; & Zagenczyk, Thomas J. Blaming the organization for abusive supervision: The Roles of Perceived Organizational Support and Supervisor's Organizational Embodiment. *Journal of Applied Psychology*. Volume 98. Number 1. January 2013. Page 158.

[Smither 2009]
Smither, James W. & Manuel London, eds. *Performance Management: Putting Research into Action*. *First Edition.* Wiley. 2009. ISBN 978-0470192320.
http://www.wiley.com/WileyCDA/WileyTitle/productCd-0470192321.html

[Sulea 2012]
Sulea, C.; Virga, D.; Maricutoiu, L. P.; Schaufeli, W.; Dumitru, C. Z.; & Sava, F. A. Work Engagement as Mediator between Job Characteristics and Positive and Negative Extra-Role Behaviors. *Career Development International.* Volume 17. Number 3. June 2012. Page 188. http://www.emeraldinsight.com/doi/full/10.1108/13620431211241054

Appendix : System Dynamics Modeling Overview

System dynamics helps analysts model and analyze critical behavior as it evolves over time within complex socio-technical domains. It is one of several modeling methods applicable to insider threat and has been used extensively in that domain [Moore 2016b, Cappelli 2012]. Figure 13 summarizes the notation used in our system dynamics model.

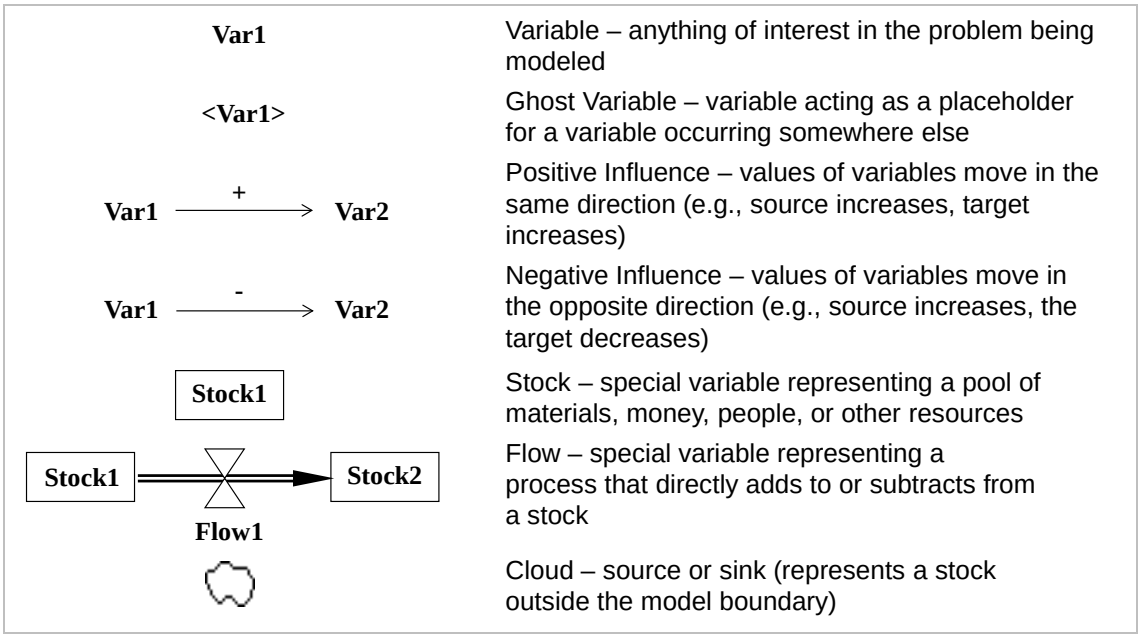

Figure 13: System Dynamics Notation

The primary elements are variables of interest, stocks (which represent collections of resources, such as dissatisfied employees), and flows (which represent the transition of resources between stocks, such as satisfied employees becoming dissatisfied). Signed arrows represent causal relationships, where the sign indicates how the variable at the arrow's source influences the variable at the arrow's target. A positive (+) influence indicates that the values of the variables move in the same direction, and a negative (–) influence indicates that they move in opposite directions.

A connected group of variables, stocks, and flows can create a path that is referred to as a feedback loop. At this stage in our modeling effort, we have not identified any significant feedback loops.

As a convention in our model, we format model input variables with ***italics, bold, and underline*** since these variables can be dynamically manipulated during model execution.