The Dynamics of Trust: Path Dependence in Interpersonal Trust

—J. D. CADDELL
School of Systems and Enterprises, Stevens Institute of Technology, Hoboken, NJ 07030 USA

—ROSHANAK NILCHIANI
School of Systems and Enterprises, Stevens Institute of Technology, Hoboken, NJ 07030 USA

(Corresponding author: J. D. Caddell.)

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***Abstract*—*Interpersonal trust is a critical factor in the success and effectiveness of organizations, influencing information sharing, decision-making, task distribution, and overall team performance. However, trust levels within organizations often exhibit a bimodal distribution, with some relationships characterized by high trust and others by low trust. This study seeks to understand the factors and dynamics contributing to this bimodal distribution and explore how leaders can positively influence the development of trust in their organizations. Using an abductive approach to theory development, we map artifacts from the interpersonal trust literature using Distinctions, Systems, Relationships, Perspectives, i.e., DSRP to identify essential components for constructing a system dynamics model. Our analysis of the resultant model explores the dynamics of various interpersonal scenarios commonly encountered within professional organizations. We find that the initial assessment of trustworthiness plays an important role in the development of interpersonal trust and provides a leverage point for the resulting dynamics. The objective of this study is to provide leaders with a deeper understanding of interpersonal trust development, equipping them with the knowledge to effectively foster trust and positively impact their organizations.*

Key words: Distinctions, systems, relationships, perspectives (DSRP), system dynamics, systems thinking, trust

I. INTRODUCTION AND BACKGROUND

INTERPERSONAL trust is paramount to the success and effectiveness of organizations, and should be a primary focus of leaders. Trust within teams significantly influences information sharing, decision-making, task distribution, and overall team performance. However, research reveals that trust levels within organizations often exhibit a bimodal distribution, with some relationships characterized by high trust and others by low trust [1], [2], [3]. Understanding the factors and dynamics contributing to the development of these distinct trust levels is essential for leaders to cultivate a positive organizational culture and achieve optimal outcomes. This study aims to address the following questions:

- What causes trust relationships to display a bimodal distribution?
- How can leaders positively influence the development of trust in their organizations?

Numerous reviews and surveys of trust across various domains have been conducted [4], [5], [6], [7], [8], [9], [10], [11]. Although not formally limited by their respective disciplines, focal trends from these studies are presented in Figure 1 to highlight common themes in the literature. All reviews recognize that different disciplines have explored specific aspects of trust, occasionally presenting conflicting ideas [6], [12], and often advocating for a multidisciplinary approach to examine this phenomenon [4], [6], [7].
Most interpersonal trust models emphasize trust antecedents [8], [13],

[14], measurement [15], effects [8], [16], [17], or prediction [18]. Burt [1] applied network theory to investigate tie strength and network closure, demonstrating that trust typically emerges in strong ties and structures embedded in strong third-party ties. Lee et al. [18] developed a machine learning model that predicted trust levels between novel partners by analyzing nonverbal cues. Luna-Reyes et al. [19] contributed an intriguing paper on interpersonal trust, constructing a system dynamics model that displays bimodal behavior, but lacks an adequate framework for leaders to identify leverage points within the system.

Although these studies provide valuable insights into trust effects and antecedents, no research to date has explained the bimodal behavior of trust in a way that enables organizational leaders to focus on relevant actions to benefit team development. This article employs an abductive approach to theory development to elucidate the bimodal distribution of interpersonal trust. Utilizing the Distinctions, Systems, Relationships, Perspectives (DSRP) method [20], we map artifacts from the trust literature to identify the essential components for constructing a system dynamics model. We then analyze the resultant model to explore the dynamics of various interpersonal scenarios commonly encountered within professional organizations. The objective of this study is to characterize the development of interpersonal trust in a manner that leaders can readily understand and apply to positively impact their organizations.

II. Literature Review

Researchers have placed significant focus on interpersonal trust modeling in recent decades. Colquitt et al. [8] amalgamated several empirical findings to create a comprehensive model comprising 10 variables and 30 causal links. This model, which combines cognitive and emotional aspects of trust, was commended by Lewis and Weigert [21], though they pointed out the absence of feedback loops and the influence of trust behaviors on future trust. Luna-Reyes et al. [19] addressed this gap by developing a system dynamics model that examined the path dependence of trust. However, their model's applicability to management scenarios remained limited. Van der Werff [22] used structured equation modeling to measure the dynamics of attribute strength on trust, discovering that the significance of attributes changes as a relationship progresses. Castelfranchi and Falcone [23] later explored these trust dynamics, presenting a model that emphasized feedback loops and path dependence, but its practical application for leaders remained limited.

Despite their insights, current models of interpersonal trust often fail to provide leaders with practical guidance for fostering trust within their teams. These models typically concentrate on the causal mechanisms of a dyadic relationship over a one-time or short-term period, neglecting the wider team and organizational contexts that leaders must contend with. Moreover, these models frequently depict trust as a static attribute, failing to account for its dynamic evolution over time in response to changing circumstances and interactions [21]. This static portrayal complicates leaders' efforts to predict and manage changes in trust within their teams. The inherent complexity and subjectivity of interpersonal trust also pose challenges for applying these models directly to real-world team settings. Consequently, leaders may struggle to utilize these models effectively to consider the impacts of trust on the integration and long-term development of their teams.

In summary, while there have been significant advancements in the modeling of interpersonal trust, our understanding of this complex phenomenon remains incomplete. Future research should continue to investigate the diverse factors

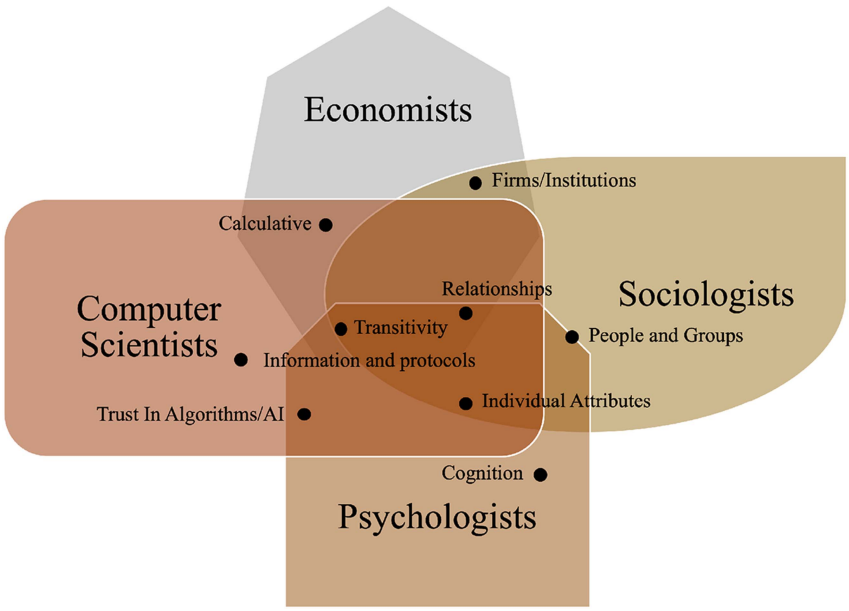

Figure 1. Venn diagram of trust literature trends by discipline.

influencing trust, the mechanisms and feedback loops driving its evolution over time, and the ways in which trust can affect the outcomes of interpersonal interactions [21], [24], [25].

III. Method Overview

This article uses systems thinking and system dynamics to develop a preliminary theoretical model that helps leaders consider the dynamics of interpersonal trust. In the following section, the interpersonal trust literature is captured graphically with the systems thinking DSRP method [20], highlighting the relationships and dependencies identified by previous researchers. The DSRP method denotes distinctions (concepts, ideas, people, etc.) with blocks, that can be nested to account for subcomponents and draws relationships between distinctions with arrows. This mapping is then converted into a systems dynamics model for simulation. Systems dynamics is a modeling technique that was developed by Professor Jay Forrester in the 1950s and has been applied to varies problems over the subsequent decades [26]. While a powerful method to capture mental models through causal tracing, it also uses differential equations to capture and simulate the changes of systems across time. The form is similar in convention to DSRP, variables are captured in text, stocks are identified with boxes, causal relationships are indicated with arrows, and the nature of that relationship is denoted with positive or negative signs as appropriate. Negative (balancing) and positive feedback loops are labeled and named as a means to help explain the resulting behavior. This model is leveraged to explore common interpersonal trust conditions experienced by leaders during the development of teams. We discuss the results of the model and their implications for leaders, helping tie the theoretical model to practical application.

IV. Mapping Interpersonal Trust With Systems Thinking

In this section, we will highlight the key components of the interpersonal trust literature and begin mapping them with the DSRP method. These will be captured in Figure 2 and be referenced in stride. Our goal is not to capture all aspects, but identify the common structures of interpersonal trust as this will help set the lens through which we will build a system dynamics model.

A. Trust A metaanalysis of trust definitions by Castaldo [27] in 2010 identified 36 different definitions for trust, with marketing researchers [28], [29], [30] topping the citation counts. While definitions varied, research works focused on the nature of trust, the subjects/actors, and the associated behaviors. Some researchers found it easier to focus on the components or attributes of trust to distinguish their definitions. Cunningham and MacGregor [31]

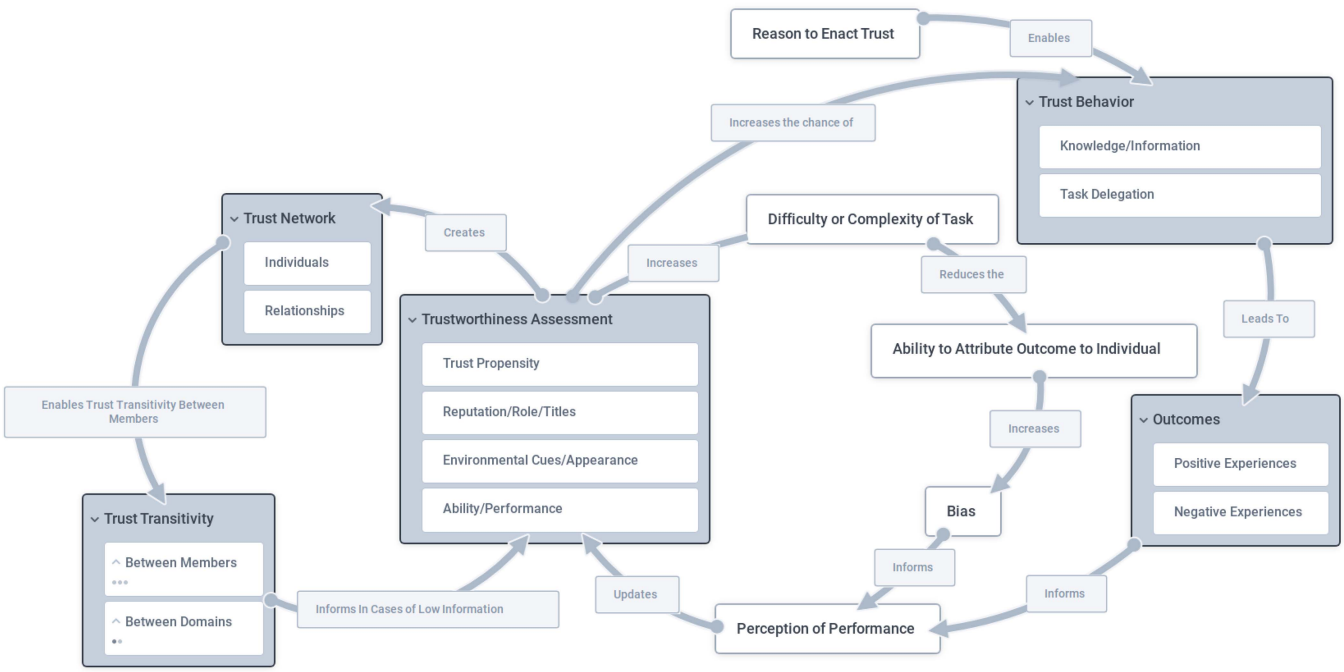

Figure 2. Systems thinking overview of interpersonal trust. Each block/square represents a distinction (idea, concept, person, thing, etc.) that can be connected by a set of relationships (arrows). These distinctions can be further decomposed into subcomponents and nested in accordance with the DSRP method.

focused on predictability, benevolence, and fairness. Thielmann and Hilbig [4] synthesized the literature on trust into four attributes of trust—uncertainty and risk, expectation, vulnerability toward betrayal, and choice of depending (or relying) on another. Sztompka [32] states that "trust is a bet about the future contingent actions of others." While definitions of trust abound, we have settled on a definition of trust attributed to Mayer et al. [24] with the "willingness to be vulnerable." We feel that the inclusion of both willingness and vulnerability is key to the idea of interpersonal trust within a professional environment. Willingness in this phrase suggests that the trustor has a choice. It also infers that this is an active and conscious decision. Vulnerable suggests an element of risk—the outcome is uncertain and has implications [33]. We will use this concise definition to guide us.

B. Trustworthiness Assessment

Prior to granting trust, an individual must judge another in terms of trustworthiness. Trustworthiness is an assessment of the characteristics of a thing or person that is framed by the situation in which trust will occur [34]. While some researchers viewed trustworthiness as a personality trait that is more constant than trust [35], we view it as more dynamic across the tenure of a relationship.

Sztompka [32] identifies three components of trustworthiness—reputation, performance, and appearance/demeanor. He expands on reputation as a mixture of past actions, associations, and credentials. Performance refers to the current state of conduct. Appearance and demeanor refer more to the aesthetics of an individual or situation that allows the subject to make assumptions about their character or possible behavior.

Similarly, Thielmann and Hilbig [4] subdivide trustworthiness into three components—trust cues, prior trust experience, and social projection. They describe trust cues as things available in the environment (traits of the trustee, context of the situation, etc.). Prior trust experience refers to the trustor's experience in similar situations. Social projection accounts for the expectation that others will behave, to some degree, in the same manner as the trustor. The idea of social projection is a notable concept that fails to materialize in most other decompositions of trustworthiness.

Borum [34] argues that the trustworthiness literature can broadly compartmentalize into ability, benevolence, and integrity. Ability represents the trustor's perception of the trustee's competence and predictability. Benevolence is based on "perceptions and demonstrations of caring, goodwill, and empathy, responsibly fulfilling obligations, and goal commitment." Integrity refers to a trustee's fairness, honest communication, and commitment to a goal.

When two strangers meet, they must begin with a certain level of trustworthiness—be it zero or complete. This initial trustworthiness assessment (often referred to as trust propensity) has garnered much attention [14], [22], [36] though notably a more recent focus in the adoption of products [37], [38], [39], [40] and AI [10], [41], [42].

Some work suggests that while intraindividual trust varies greatly, individuals may harbor a general trust propensity [24]. Das and Teng [33] elaborate on this concept, describing it as a personality trait and using it in their framework, which explores the concepts of risk and trust. In their model, trust propensity is a baseline condition (trait) that influences an individuals likelihood of believing in the goodwill or competence of others. Colquitt et al. [8] identified a similar concept of trust propensity, though with weak effects after controlling for trustworthiness. Thielmann and Hilbig [4] caution us, suggesting that attempting to characterize trust behavior into a single personality trait "may well be an oversimplification given the complexity of trust behavior." In our model, we view *Trust Propensity* as part of an initial condition with which a person synthesizes an initial assessment of trustworthiness and adjusts it based on other sources of information. These other sources could be information from their *Trust Network* through *Trust Transitivity* or through their experiences with another person (*Outcomes*).

While many researchers will argue about the components and their relative importance to trust, evidence supports the growing conclusion that these trustworthiness assessments are part cognitive (rational) and part affective (emotional) [21], [39], [43], [44]. The split and degree of importance placed on these two perspectives generally falls along the academic discipline boundaries, though most research recognizes the complex and uncertain nature of this aspect of trust.

In Figure 2, we have labeled the trustworthiness assessment and identified several relationships. Trustworthiness can decompose in several fashions depending on context, but inside our model we have highlighted the impacts of the perception of performance and trust transitivity. While the attributes of an individual has a significant impact on their trustworthiness, these attributes are generally static and unchanging—which stands in stark contrast to the perception of their performance during a continued relationship. The trustworthiness assessment converges to some

degree based upon the observations of the object's performance. Accordingly, high performance increases trustworthiness and low performance lowers it. Trust transitivity and networks will be covered in a subsequent section.

C. Dimensions of Trust and Trustworthiness The relevant aspects of a trust situation depend on the individual and will vary between situations. Thielmann and Hilbig [4] summarize this nicely, stating "individuals are commonly assumed to condition their trust on situation-specific variables suggesting an intraindividual variability of trust behavior across situations." Different situations between the same two actors can exhibit significantly different levels of trust [45]. Sztompka [32] elaborates that even reputation (one of his components of trustworthiness) "may be quite specific, limited to one area of activity." Lewis and Weigert [21] lamented that while many researchers agree that trust is complex, many models remain unidimensional. Johnson-George and Swap [15] illustrated this point stating "the individual you trust to feed your cat while you are on vacation may not be trusted to repair your car, and your trusted mechanic may not be your chosen target for intimate self-disclosures." When trustworthiness is assessed, the context of the trust behavior dictates which set of attributes and experiences most appropriately map to the assessment. This phenomenon, the multiple dimensions of trustworthiness, is a likely reason for the plethora of different decompositions of trustworthiness in the literature.

D. Trust Behaviors Recent research has tried to reinforce the distinction between trustworthiness and trust behaviors. Occasionally confused, a person's trustworthiness is antecedent to the action or trust behavior [33]. This is a helpful distinction as situations may appear where an individual may have high trustworthiness, but it may not result in a trust behavior for a reason external to their perceived trustworthiness. This may not be a reflection of that individual and decoupling the notions of trustworthiness and trust behaviors helps decouple these ideas in discussion and modeling. Because of this we had added the *Reason to Enact Trust* entity in Figure 2. This helps capture those exogenous forces on the trust relationship that may influence the release of trust behaviors (i.e., lack of task availability, more trustworthy candidates, external restrictions). We have also characterized *Trust Behaviors* as both a task or the sharing of knowledge or information.

E. Trust Transitivity and Networks Some trust research, primarily from the information and computer science disciplines, addresses the role of networks and transitivity. They explore the impact of trust transitivity or the extension of trust through recommendations [46]. This allows individuals to augment their trustworthiness assessments with information from individuals that may have better knowledge [11], [46], [47]. Trust transitivity models seek means to quantify and aggregate the role of trust recommendations as well as the relative decay of this impact as distance between members increase [48]. While some researchers may overstate the importance of this transitivity, Christianson and Harbison [49] provided thoughts on the need for the "localization" of trust and the dangers of extending this transitivity to the extremes. Regardless of the extent of influence, we must view these relationships as existing within a larger network of members, each with their own experiences and assessments.

F. Bias in Trust and Performance Evaluation We have come to understand there are limits in our ability to accurately and consistently evaluate and assess people. When performance is clear, we are able to distinguish this easily [50]. However, as situations become more complicated it becomes more difficult to assess performance [51], [52]. Unfortunately, most professional contexts fall within this complicated and dynamic state that is difficult to assess. As situations become more difficult to interpret we expect bias to play a more important factor in individual's assessment of trustworthiness—traditionally antecedent to a trust behavior [53]. There is no shortage of biases and their ability affect our judgement [54], though we suspect that as members develop relationships and forms of attachment things like ingroup belief [55] and halo effects [56], [57] may provide noteworthy obstacles. Taking these pieces into account, we can see how as trustworthiness increases, we had expect to see an increased reliance on trusted members—resulting in the selective funneling of trust behaviors or preferentially assigning more difficult or complex tasks. When this difficulty or complexity increases, it reduces our ability to objectively assess outcomes, leading to an inflation of bias, and ultimately influences our trustworthiness. We capture this dynamic in Figure 2, by connecting the *Trustworthiness Assessment* to itself through the *Difficulty or Complexity of Task*, *Ability to Attribute Outcome to Individual*, *Bias*, and *Perception of Performance* elements.

G. Dynamics of Trust While most trust work focuses on single decisions, some notable pieces highlight the changing nature of trust throughout the length of a prolonged relationship. Lewis and Weigert [21] identified feedback loops and state the importance of capturing these

because "trust relationships have histories." Jonker and Treur [58] described the dynamics of trust as the "evolution of trust over time." They provide a modeling framework that explores the reciprocity of trust as well as the development and decay of trust between agents from an experiential perspective. Danek et al. [59] explored differences in computational trust and reputation systems, exposing the differences in how changing trust models helps improve decision models in a repetitive selection system. Figure 2 captures some of this dynamic expectation as we have identified two prominent feedback loops. The first feedback loop starts as an increase in the *Trustworthiness Assessment* increases the chances of yielding *Trust Behaviors*, which leads to *Outcomes*, which inform the *Perception of Performance*, and update an individual's *Trustworthiness Assessment*. The second loop begins with the *Trustworthiness Assessment*, which increases the *Difficulty or Complexity of Tasks* yielded, which reduces the *Ability to Attribute Outcomes to an Individual*, subsequently increasing the *Bias*, which informs the *Perception of Performance*, and updates the individual's *Trustworthiness Assessment*. This will be helpful as we attempt to formalize this systems overview into a systems dynamic model.

V. Creating a Systems Dynamics Model of Interpersonal Trust

A. Interpersonal Trust Model Overview

Starting with the distinctions and relationships captured in Figure 2, we can develop a functional systems dynamics model that will allow us to mathematically interrogate these relationships. The resulting model, Figure 3, represents the trust relationship between member A on member B—that is how trustworthy member A finds member B, and how this translates into the release of trust behaviors from member A to member B. Admittedly, this model only represents a singular trust context and assumes the possibility for reoccurring trust behaviors through an extended relationship. The frame taken for the formation of this model resembles those situations that would commonly occur in a close professional relationship between coworkers. The focal point of this model is the *Member A's Perception of Trustworthiness of Member B* stock in Figure 3. Let $T(t)$ be this stock (*Member A's Perception of Trustworthiness of Member B*), where t indicates the time step and let $c(t)$ be the *Change in Trustworthiness*. With this convention, we can express the calculation of the stock with (1). *Change in Trustworthiness* $c(t)$ is expressed in (2), where θ represents the *Difference Between Current and Expectation*, ω expresses the *Difference Between the Maximum and Current Trust*, and λ stands as the *Trust Adjustment Time*

$$T(t) = \int c(t)\, dt \tag{1}$$

$$c(t) = \min\left\{\frac{\theta}{\lambda}, \frac{\omega}{\lambda}\right\}. \tag{2}$$

This sets the basis of the model, where $T(t)$ accumulates changes based upon the perceived differences between Member B's performance and Member A's expectations. The following sections will detail the important variables, feedback loops, and their resulting behavior.

B. Initial Trustworthiness of Member B

As previously discussed in Section IV-B, there is an assumed level of trustworthiness that member A has for member B. This may be the result of some combination of member B's attributes or through the extension of trust transitivity within the trust network. Within this model the origin of that value is not fully explored, but its effect is crucial in the resulting dynamics. This value stands as the

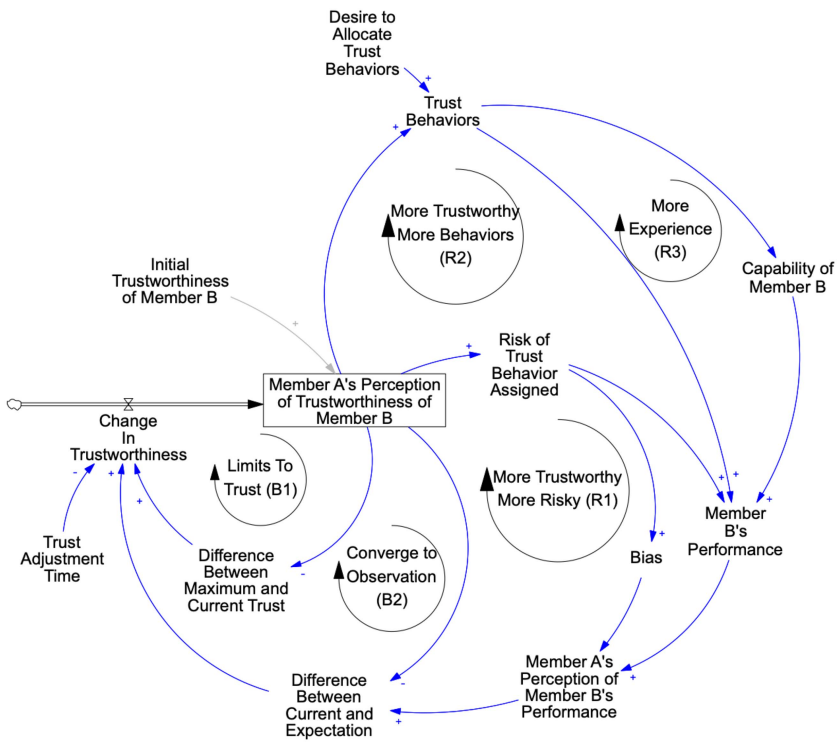

Figure 3. Interpersonal trust system dynamics model.

initial condition for the model's primary stock (*Member A's Perception of Trustworthiness of Member B*). It encapsulates all member A's requisite components of trustworthiness—that is how member A has determined to measure member B's trustworthiness.

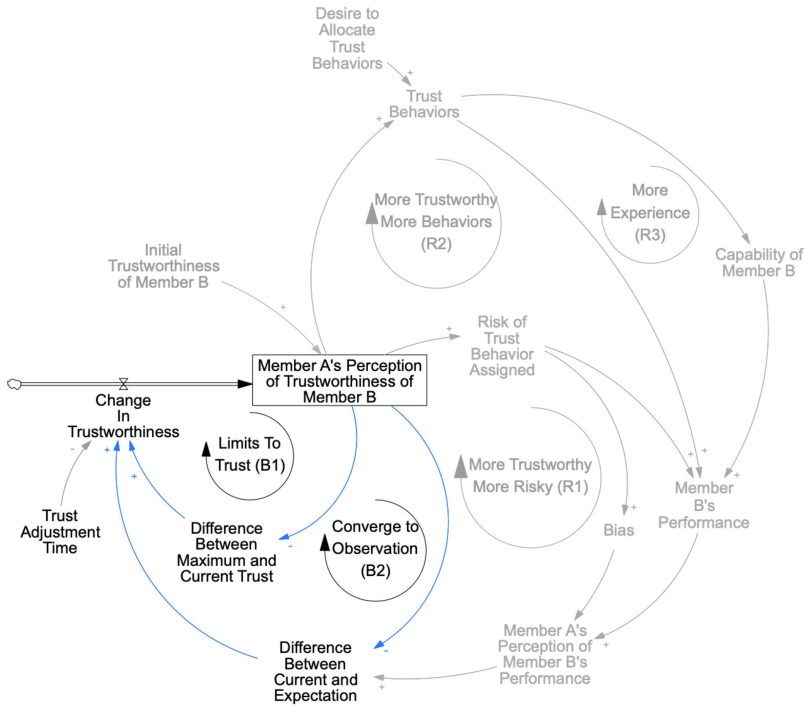

Figure 4. Balancing loops.

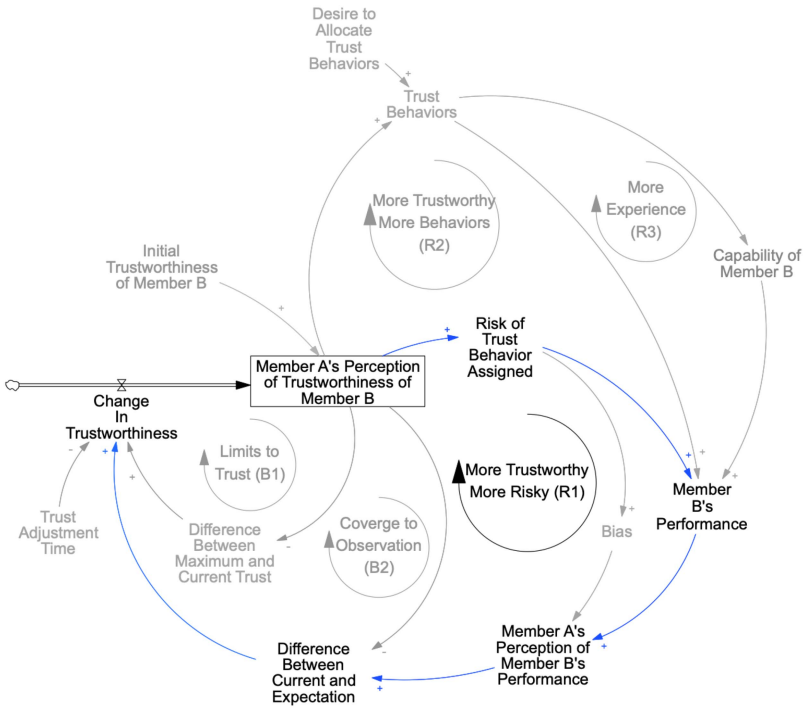

Figure 5. R1—More trustworthy more risky.

Changes to the stock are a result of performance and its perception as opposed to any other change in the components trustworthiness.

C. Balancing Loops This system contains two prominent balancing loops, which influence its behavior. The first balancing loop, labeled *Limits to Trust (B1)* in Figure 4, represents the limits to trustworthiness. As trustworthiness grows, the difference between it and the maximum level of trustworthiness reduces, resulting in less change in trustworthiness, and limiting the growth of trustworthiness between member A and member B. This loop creates a first-order control that ensures that trustworthiness can never grow beyond the maximum—there is a limit to how much a person can find another trustworthy.

The second balancing loop, *Converge to Observation (B2)*, initiates with a change in member A's perception of trustworthiness, which reduces the difference between the current and expectation, reducing the change in trustworthiness, and finally resulting in less change to member A's perception of trustworthiness. This loop allows member A's perception to adjust to their observations of member B. While the rate of adjustment could be dependent on many factors, this model simplifies the dynamic by taking the difference between the current and expectation and dividing it by an adjustment time. This variable, *Trust Adjustment Time* is covered in a subsequent section.

D. More Trustworthy More Risky (R1) Our first positive reinforcing loop is *More Trustworthy More Risky (R1)*, seen in Figure 5. When trustworthiness increases, we increase the riskiness or importance of the trust behaviors assigned, allowing member B to demonstrate increased performance (assuming they retain this capability), resulting in

an increase in the perception of member A on member B, an increase in the difference between the current and expectation, an increase in the change in trustworthiness, and terminates in an increase in member A's perception of trustworthiness of member B. This reinforcing loop remains active as long as member B can maintain a level of performance that exceeds or matches member A's perception.

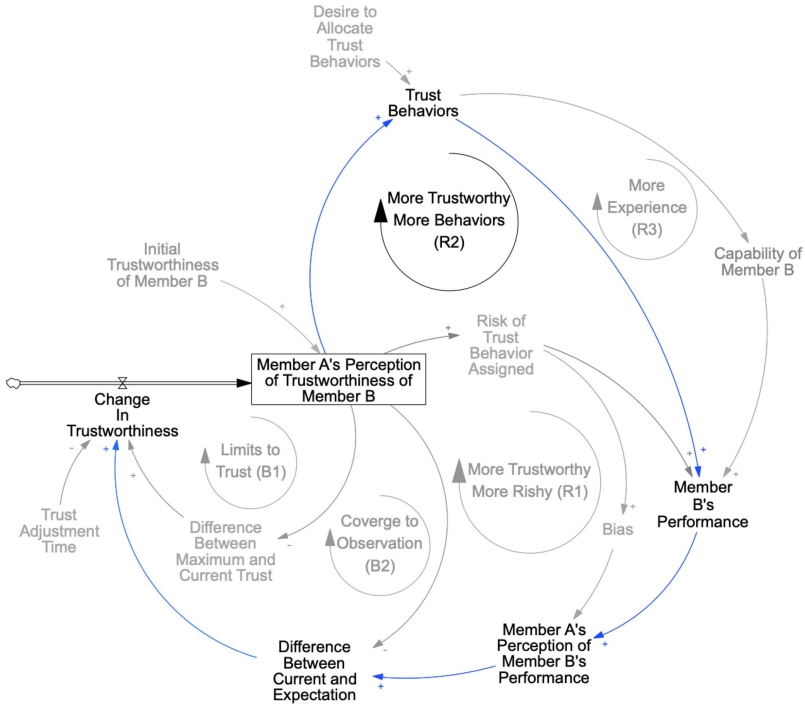

Figure 6. R2—More trustworthy more behaviors.

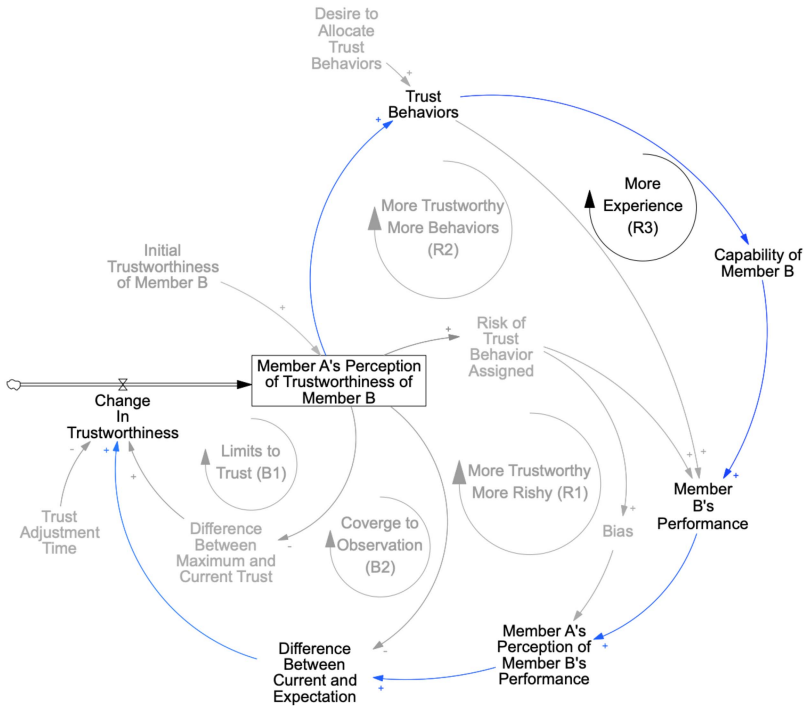

Figure 7. R3—More experience.

E. More Trustworthy More Behaviors (R2) When someone performs well, we tend to give them more tasks. This relationship is captured in the loop *More Trustworthy More Behaviors (R2)* in Figure 6. As member B's trustworthiness increases, more trust behaviors are yielded, which correspondingly allows member B to perform, enhancing member A's perception of them, increasing the difference between their current appraisal and the expectation, and ultimately results in an increase in member A's perception of member B's trustworthiness. Similar to R1, this condition holds so long as the capability of member B is sufficient. In cases were their capability is outstripped, the perception and performance will converge by means of the B2 balancing loop.

F. More Experience (R3) The final reinforcing loop represents the effect of experience within the system, see Figure 7. As member B receives more trust behaviors, their capability will increase (assumed with some delay), resulting in increases in performance, improved perception, an increase in the difference between the current and expectation of member A, an increase in trustworthiness, and ultimately concluding with more trust behaviors. This loop is important and unique for a couple of reasons. The first is that there is some delay. Learning does not happen instantaneously and often comes from the accumulation of mistakes and mentorship. It should also be noted that there are limits to this feedback loop as well. Some people may not be able to achieve certain levels of capability despite high degrees of exposure and development.

G. Moving Adjustment Time and Lock-In In order to capture the idea that the rate of an individual's

trustworthiness assessment adjustment does not remain static, we developed an expanded structure of *Trust Adjustment Time* to more accurately reflect an evolving relationship. This structure, see Figure 8, depicts the *Trust Adjustment Time* as a stock that adjusts to some nominal level when an the *Difference Between Current and Expectation* of Member B's performance is below some determined level, ρ. This means that when the current and the expected performance begin to converge the system adjusts to a nominal state; however, in cases of notable deviation, for example, the expectation is much higher than the observed performance, the difference triggers a reduction in the adjustment rate. Equation (3) depicts this relationship, where $a(t)$ represents the *Change in Trust Adjustment Time* at time t, θ is the *Difference Between Current and Expectation*, λ_{Trust} stands for the *Trust Certainty Adjustment Time*, λ is the *Trust Adjustment Time*, and S portrays the *Adjustment Time at Steady State*. The effect of this structure aims to represent the certainty of an individual's trustworthiness assessment. At the beginning of a relationship, an assessment can vary quickly, but as observations begin meeting expectations it becomes more difficult to quickly adjust an assessment. Once a relationship is established, it takes time to change an assessment despite increasing differences between observations and expectations. People tend to anchor to their established assessment and make only slight modifications

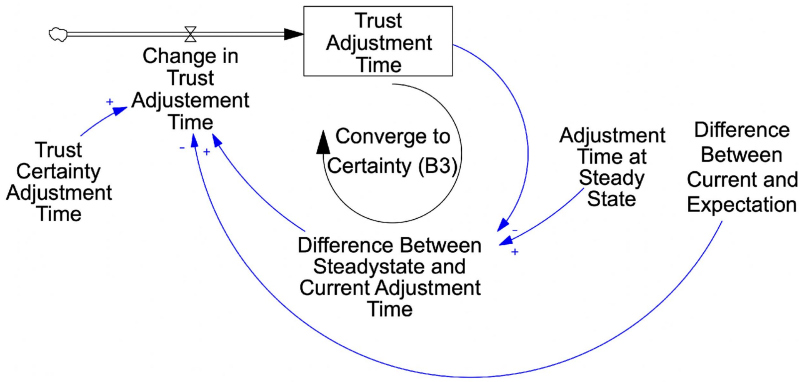

Figure 8. Variable trust adjustment time structure.

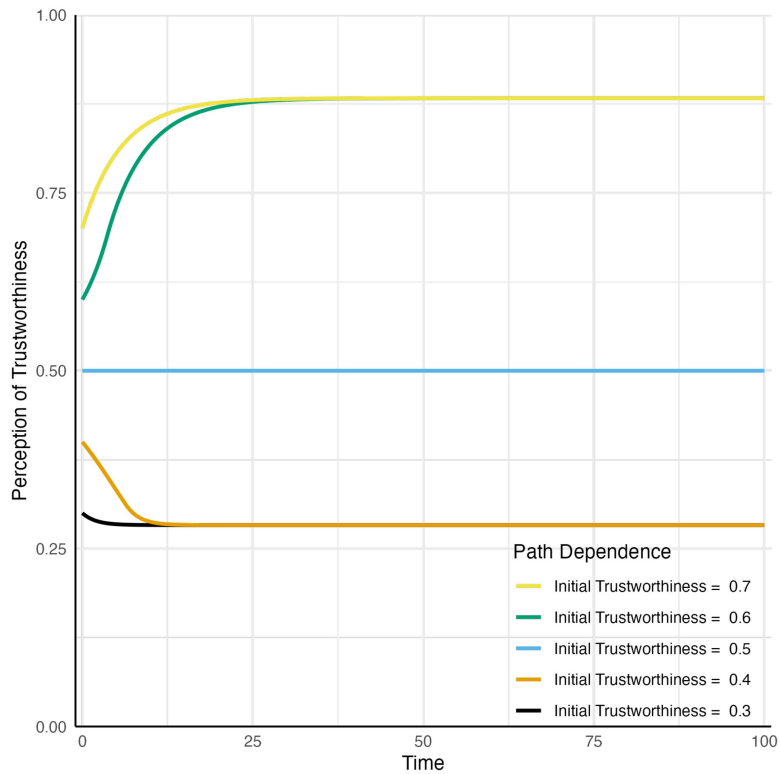

Figure 9. Varying initial levels of trustworthiness.

$$a(t) = \begin{cases} \frac{-|\theta|}{\lambda_{\text{Trust}}}, & \text{if } \theta > \rho. \\ \frac{S-\lambda}{\lambda_{\text{Trust}}}, & \text{otherwise.} \end{cases} \quad (3)$$

H. Exercising the Model With Simulation While decomposing this model into loops helps build intuition and familiarity, it is only through simulation that we can confirm these structure's resultant behavior. When the model is run at equilibrium, that is that member B retains some nominal level of capability that matches member A's initial perception of trustworthiness (0.5 for example on a scale, where 0 represents no trustworthiness and 1 complete trustworthiness), we observe no change. The model is in a state of equilibrium. However, varying the degree of initial trustworthiness, perhaps the result of a recommendation from within the trust network, returns wildly different behavior. Adjustment away from the equilibrium state results in the activation of our reinforcing loops which, despite member B retaining the same level of initial capability, creates different dynamics—see Figure 9. In this model, Figure 3, members marked with higher levels of

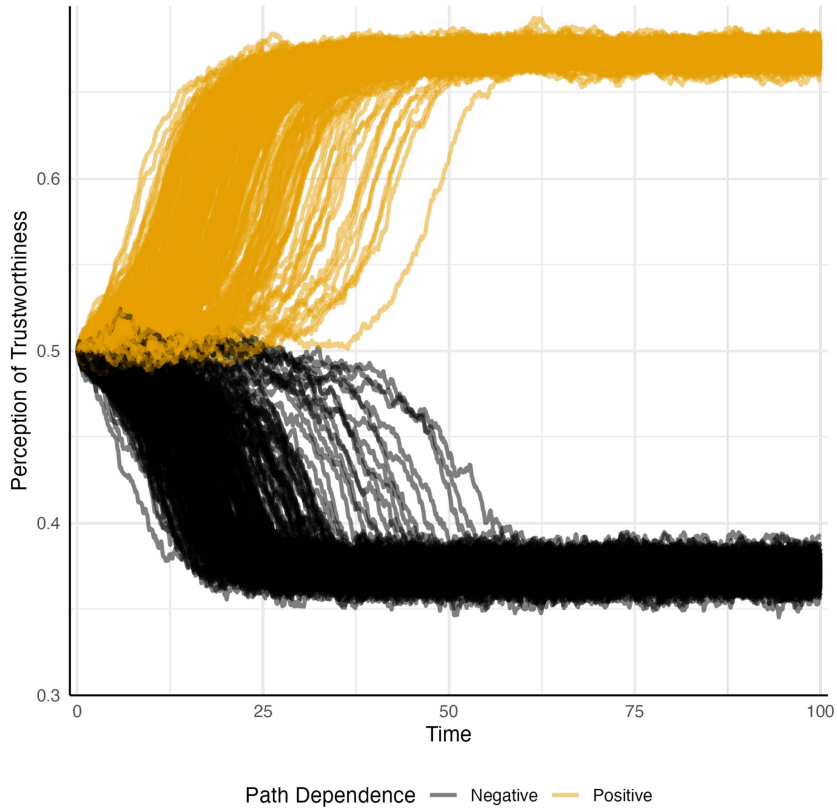

Figure 10. Effect of noise at equilibrium.

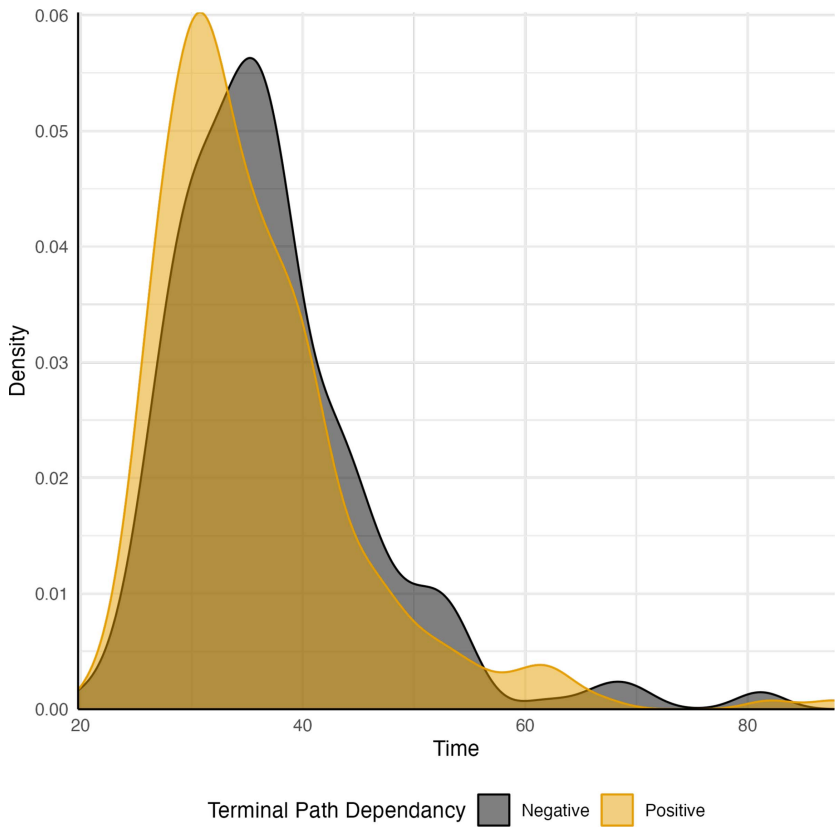

Figure 11. Density plot of time to reach terminal point.

trustworthiness are able to generate more important assignments (R1), additional trust behaviors (R2), and gain more experience (R3). Those members with lower than nominal levels of trustworthiness *activate the same reinforcing loops but negatively*. This results in a sort of path dependence, where the structure of the system and its initial condition drives its terminal point [26]. The behavior mimicks the path dependent nature of trust explored by others [19], [21], [23] and the resulting bimodal distribution [1], [2], [3]. It also maps to intuition and professional experience as members with high trust get leaned on and, if capable, that trust relationship grows positively to some bound. Members with low trust get discounted, and eventually stop receiving trust behaviors. While not a formal validation of the model (through the fitting of historical data), it does build confidence that the structures developed through a synthesis of the interpersonal trust literature result in behavior described and presented in the literature.

Interestingly, the model responds similarly to uncertainty or noise. Performance, task difficulty, and perception rarely split neatly into a series of continuous static numbers. The most mechanical of individuals will have some variance in their performance—even if the task and conditions remain the same. To explore this, we took the model at equilibrium and added a small fraction of normally distributed noise to member B's performance. As expected the path dependence of the system emerges at both extremes, Figure 10. In this simulation, the initial conditions of capability and trustworthiness are equal, but the small amount of noise in the performance of member B causes the system to diverge from this unstable equilibrium point. The take away for this emergent feature is that even in cases where trustworthiness could be "perfectly" assessed, the noise experienced in life will most likely

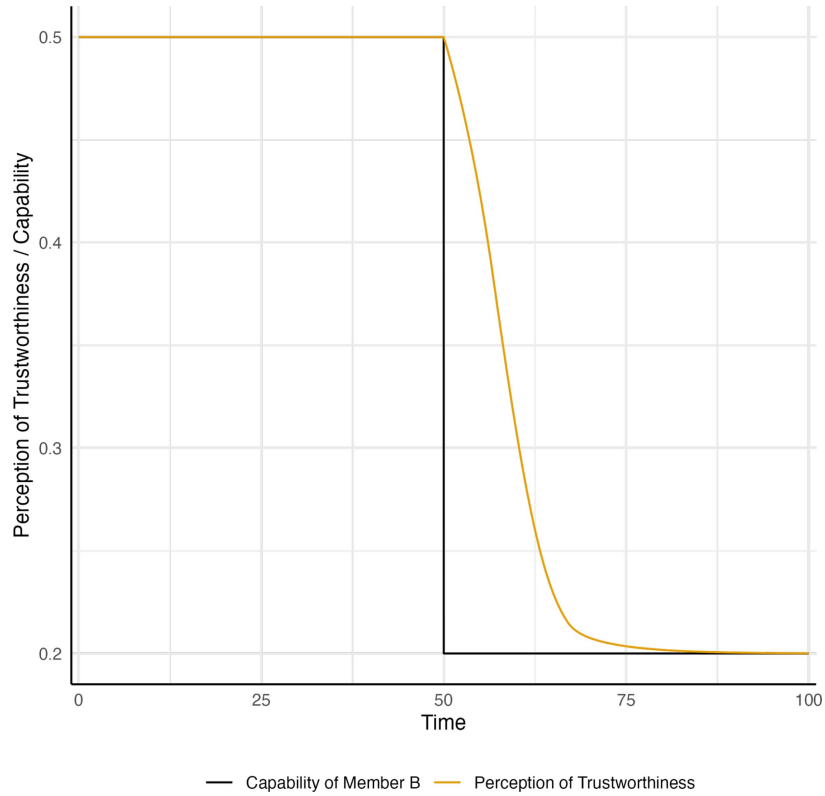

Figure 12. Change in trustworthiness with step change in capability.

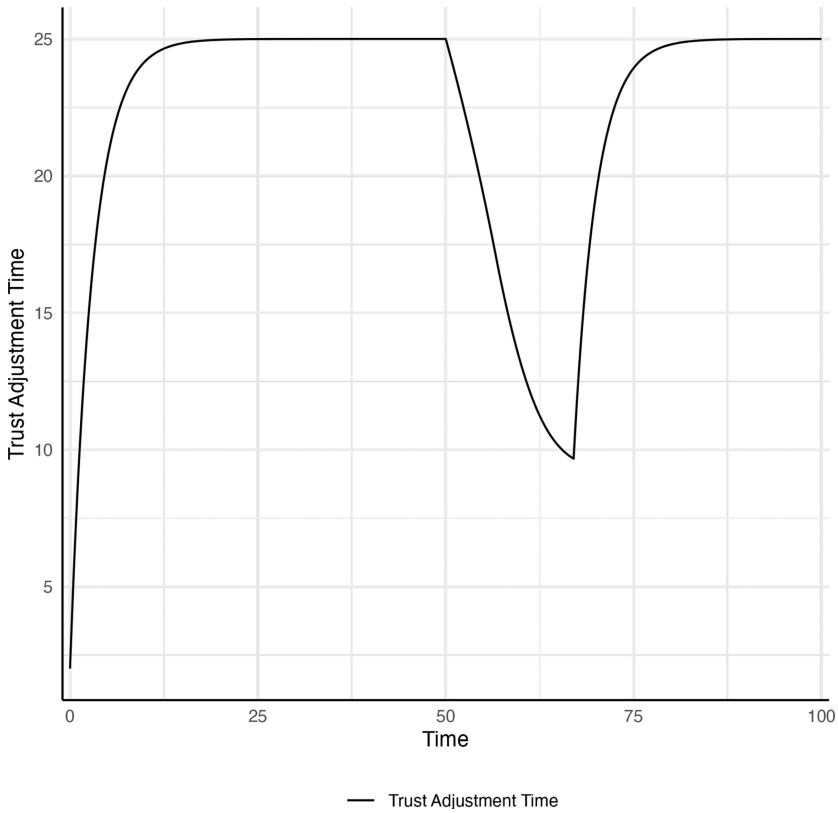

Figure 13. Behavior of adjustment time to step change in capability.

activate the path dependant nature of the system and result in a skewed perception of reality.

We also noticed that the model converges to its terminal path dependent regions with apparent symmetry, see Figure 10. Plotting the frequency of time to reach this terminal path results in a long tailed distribution for both cases, see Figure 11. This is an artifact of the equal biases encoded in the model. The speed at which a person converges to an assessment and the biases in play will depend upon the trust context and their own personal mechanisms for evaluating trustworthiness. Some individuals may display a skewed bias—yielding trust slowly but quickly degrading their evaluation at the first sign of trouble. Others may allow for trustworthiness to grow quickly, but negative events are deeply penalized.

All of the previous simulations held the capability of member B constant, or with slight deviations of random noise, but we wanted to see how it behaved with drastic change in capability. To test this scenario, we initiated the simulation at equilibrium and then reduced member B's capability at time step 50 (from 0.5 to 0.2). This resulted in an adjustment in the perception of trustworthiness to this new level of capability, see Figure 12. While this dynamic resembles the previously simulated behavior of varying initial levels of trustworthiness (see Figure 9), we notice a slight deviation in the adjustment rate. Because the simulation ran at equilibrium prior to the step adjustment, member A reached a state of certainty in the trustworthiness assessment. This change to the adjustment time, see Figure 13, reflects the growing certainty of the trustworthiness assessment, which the member is then forced change once there was a drop in capability. The certainty drops, reflected in the precipitous decline in *Trust Adjustment Time*, which allows

the member to more quickly update their assessment. Once their perception and member B's new capability converge, the adjustment time subsequently increases—locking in their new assessment. This behavior enables established relationships to be more resilient to deviations in performance when compared to new relationships where the member is still developing their assessment.

After gaining familiarity with the general behavior of the model, we developed a set of scenarios the exemplify common conditions experienced in the workplace (high, low, and perfect assessments of a member's capability). These scenarios each have a different set of initial conditions, see Table 1, which define the scenario and create unique behavior. We intentionally held constant the initial capability of member B and generated a constant learning improvement for all scenarios besides *Equilibrium*. Learning improvement was determined by increasing the capability of member B with a base 90 logarithmic growth by 0.125 at time step 90 to represent the expected improvement in member B's performance, but with diminishing returns. The following section will describe the individual scenarios and their resultant behavior. The behavior is captured graphically in Figure 14.

1) *Equilibrium*—Member B joins the team with nominal capability and is correctly assessed prior to joining, making their *Initial Capability* equal to the *Initial Trust*. Member B does not improve at all during their tenure and the model remains at equilibrium with the *Perception of Trustworthiness* remaining at 0.5.
2) *Perfect Assessment + Learning*—Member B joins the team under the same conditions as the *Equilibrium* scenario, but gains experience during their tenure and increases in capability (an increase from 0.5 to 0.625 by Time 90—a 25% increase). Over the course of their relationship, Member B's performance garners a substantial gain in trustworthiness from Member A, with a terminal point that approaches. 8.
3) *Bad First Impression + Learning*—Member B joins the team under less than ideal conditions with an *Initial Trust* lower than their *Initial Capability*. Member B gains experience during their tenure and increases in capability (an increase from 0.5 to 0.625 by Time 90—a 25% increase). Over the course of their relationship, Member B's performance garners only marginal gains in trustworthiness from Member A, failing to breach even their *Initial Capability* by Time Step 100. Because of the relatively low levels of trustworthiness in this scenario, any variance in Member B's performance will be more punitive than the other scenarios. This is because of the unstable equilibrium point of the system, see Figure 10.
4) *Highly Recommended + Learning*—Member B joins the team under the favorable conditions with an *Initial Trust* higher than their *Initial Capability*. This condition came from an extremely supportive recommendation from Member A's trust network (trust transitivity). Member B gains experience during their tenure and increases their capability in the same fashion as the other scenarios, but their *Perception of Trustworthiness* always remains higher than their *Capability*. Over the course of their relationship, Member B's performance garners a gain in trustworthiness from Member A initially higher assessment, with a terminal point that approaches 0.85.
5) *Highly recommended + learning + coasting*—Member B joins the team under the same favorable conditions as the *Highly Recommended + Learning* scenario; however they decide to reduce their effort after establishing themselves. This does reduce their relative *Perception of Trustworthiness* in comparison to the *Highly Recommended + Learning* scenario, but they still retain higher trustworthiness when compared to the *Perfect Assessment + Learning* scenario at Time 100. This reflects the effects of the lock in the *Trust Assessment Time*.

We expect this path dependent dynamic to hold in cases of improved

Table 1. Trust Scenario Parameters of Interest.

Scenarios	Parameters			
	Initial Capability	*Initial Trust*	*Learning Improvement*	*Notes*
Equilibrium	0.5	0.5	0	
Perfect Assessment + Learning	0.5	0.5	0.125 (25%)	
Bad First Impression + Learning	0.5	0.3	0.125 (25%)	
Highly Recommended + Learning	0.5	0.7	0.125 (25%)	
Highly Recommended + Learning + Coasting	0.5	0.7	0.125 (25%)	Cuts performance by 0.125 at Time 50

or high trust. In conditions of low trustworthiness or low levels of *Desire to Allocate Trust Behaviors*, we expect the state of the relationship to have dramatic implications. When trustworthiness drops below some personally determined threshold, informed by the context of the situation, and there are alternatives to yielding trust behaviors (removal from team, firing, ability to shift work), member A will no longer yield trust behaviors to member B. This is what happens in groups when someone is labeled a low performer. Work and trust is shifted to other members within the group as appropriate. The implications for this are noteworthy. Groups and teams tend to evolve, members join and leave for various reasons. In cases where a group has identified "highly trustworthy" members, new members may have difficultly gaining trust behaviors. This can lead to situations where members can feel undervalued, working on tasks well below their capability and desired importance, and increasing the chance of self-selected churn. Additionally, the "highly trustworthy" may tire from their disproportionate workload. This state, if not designed against, can create a situation were a group has a core set of highly trusted individuals and a rotating cast of new members who struggle to join the core group.

VI. Discussion

The results from these scenarios lead us to draw the following conclusions for leaders when considering trust within an organization.

1) *Initial Assessments Matter:* Because of the sensitivity of the model to initial condition, the components of trustworthiness that enable us to make initial assessments of trustworthiness can dictate the long term outcome of a professional relationship. This confirms research findings on the importance of first impressions, where first impressions often dictate the manner in which we treat new employees [60] and the effect of accurate first impression on long run relationships [61]. We see this explicitly when we look at the difference outcomes between the *Bad First Impression + Learning*, *Perfect Assessment + Learning*, and *Highly Recommended + Learning* scenarios. Organizations that have transparent and structured hiring practices and work roles will limit much of the uncertainty that can be experienced when joining an organization. Individuals that are properly screened and assigned into a well-defined role will generally retain a certain amount of initial trustworthiness due to the alignment of the components of trustworthiness and context. Additionally, well thought out and tailored on boarding procedures can also help with this precarious initial period—allowing new members to gain knowledge about work culture and norms before joining their professional teams.
2) *Promote Trust-Building Behaviors.* The willingness to display trust behaviors serves as a leverage point in this process. When individuals are given opportunities to perform, their "true" capabilities become more apparent. Creating such opportunities helps to avoid situations, where team members seldom have the chance to showcase their potential. In instances where certain tasks are deemed too critical or risky, alternative mechanisms to foster trust can be explored. Reducing the perceived or actual risk associated with an activity can lower the level of trust required [33]. Evidence suggests that training can be effective in various contexts [62]. For example, sports teams use scrimmages and drills to mimic

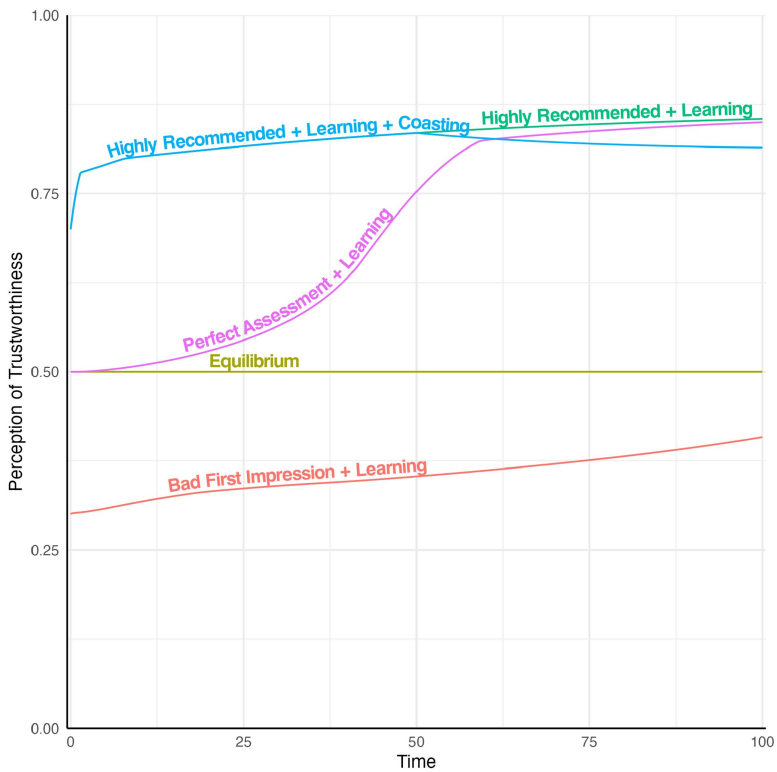

Figure 14. Trust scenario results.

real games, while military units conduct simulations and rehearsals before deployments. When suitable, organizations might consider implementing more formal methods to ensure that team members are given opportunities to demonstrate their abilities.

3) *Prioritize Team Development.* A short-term, risk-averse focus may lead managers to rely heavily on those team members who have already proven their potential. This approach, however, can result in situations where new, highly capable team members are not given the chance to perform, or their integration into the team is unnecessarily prolonged (as illustrated in the *Bad First Impression + Learning* scenario). Managers who concentrate on nurturing individuals through tailored opportunities can build a deeper talent pool within their organization and expedite the discovery of new talent. Recent research supports the notion that training not only enhances teamwork but also improves overall team performance [63].

VII. Contributions to Theory

This model builds upon prior attempts at modeling interpersonal trust by specifically addressing its path-dependent nature within a professional context. It does so by integrating elements such as bias and feedback loops related to task scale and difficulty. This expanded model underscores the implications of path dependence and pinpoints key leverage points, such as the initial assessment of trustworthiness and the yielding of trust behaviors.

The degree of path dependence in this model is primarily influenced by perception-related sensitivities. These sensitivities, which are methods for assessing various model variables, are extensively discussed in the literature reviewed in Section IV. It should be noted that there is no universal set of values that can accurately represent all scenarios, as the factors that matter in a trust situation depend on the individuals' history and the context [4], [6].

The current model does not explicitly incorporate context, which limits its direct applicability to specific situations. However, its structural design and the path-dependent behavior are largely generalizable. While specific contexts may necessitate particular numeric sensitivities, the structure of the trust relationship in most cases will align with the model depicted in Figure 3. Variations in these sensitivities may alter the extremes of the model's output, but the fundamental behavior remains consistent.

VIII. Contributions to Practice

While theoretic in nature, this model can offer valuable insights for organizations and leaders. First, the initial trustworthiness assessment of a member can play an important role in the development of their trust relationships. This assessment can be greatly influenced by the formalization of roles, responsibilities, and hiring procedures. Second, the lending of trust behaviors ensures that employees have the ability to demonstrate their true performance. By providing mechanisms that enable employees to demonstrate their actual performance, leaders can ensure that trust assessments are based on accurate and up-to-date information. Finally, the model reminds us that an individual's capabilities are seldom static. Leaders should anticipate and monitor changes in team members' abilities. By focusing on the *R3- More Experience* feedback loop, leaders can create opportunities for team development. This contrasts with a common tendency among leaders to rely on a small group of trusted individuals for critical tasks. Such an approach can hinder the development of potential talent, as individuals may not have the opportunity to demonstrate their true capabilities due to possibly misguided perceptions of trustworthiness.

IX. Limitations and Future Research

The current model does not explicitly incorporate the influence of institutional or organizational trust, which are crucial elements in organizational functioning and performance. While the model does not have specific features that capture these aspects, it could potentially be extended to investigate the impact of organizational culture and trust on the *Desire to Allocate Trust Behaviors* and on mechanisms promoting capability development. However, these elements may be more context-specific than what would be suitable for a generalized model, but they are crucial for direct application.

It is important to note that this model represents a single directed dyadic relationship within a specific context—from member A to member B. Essentially, the model serves as a basic unit of an interpersonal trust relationship that would need to be replicated across multiple trust dimensions and for every possible pair of members within a context to fully capture a comprehensive trust network. While this is theoretically feasible, it would likely result in a complex and potentially unwieldy model, possibly exceeding the capabilities of conventional system dynamics modeling. Future research could explore the integration of these dynamics within member networks,

investigating how network structure can influence or amplify behavior.

X. Conclusion

This study provided a novel perspective on the emergence of bimodal distributions of interpersonal trust within organizations, offering valuable insights for leaders aiming to foster a positive trust culture within their teams. By employing an abductive approach to theory development with the DSRP method, we have constructed a system dynamics model that captures the complex dynamics of interpersonal trust. This model, while theoretical, provides a framework for understanding the factors that contribute to the development of high and low trust relationships within professional contexts.

Our analysis of the model has revealed key leverage points that leaders can utilize to positively influence the development of trust within their organizations. By directing attention to the initial assessments of trustworthiness and appropriate delegation of tasks, leaders can influence trust outcomes. Examples include the formalization of roles and responsibilities, the provision of opportunities for demonstrating trust-related behaviors, and the anticipation and monitoring of changes in team members' capabilities.

While the model does not capture all aspects of interpersonal trust, such as the influence of organizational culture and trust, it provides a foundation for future research in this area. Future studies could extend this model to explore these aspects and their impact on trust development. Additionally, the model could be adapted to represent more complex trust networks within organizations, providing a more comprehensive understanding of interpersonal trust dynamics.

This study underscores the critical role of trust in organizational success and effectiveness, and highlights the need for leaders to actively engage in the cultivation of trust within their teams. By understanding the dynamics of interpersonal trust and implementing strategies to foster trust, leaders can enhance team performance and drive organizational success.

Acknowledgments

The trust system overview in Figure 2 was made with the plecitca software tool (https://www.plectica.com), System Dynamics modeling was conducted in Vensim, and data analysis was conducted in R with the help of the tidyverse [64]. The views expressed herein are those of the authors and do not reflect the position of the Department of the Army or the Department of Defense. This work was supported in part by a General Omar N. Bradley Fellowship in Mathematics.

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