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Title: "Systemic Leverage™: Finding Leverage in Complex Systems in the Real World

Give me a lever long enough … and single-handed I can move the world.
-- Archimedes

This paper adds to the current development of resource dynamics (Warren, 1997) by providing the Systemic Leverage™ framework and tool set for using leverage to move systems of resources efficiently, effectively and sustainably. In an increasingly complex and uncertain world, leaders find it ever harder to identify which points offer the greatest leverage to get their organizations moving in the desired direction in a timely fashion. Systemic Leverage bootstraps management ability to design sustainability into an organization by effectively leveraging valuable, key resources.

Leverage has existed for a long time, but its application to business issues is new. Lacking a framework for formalizing and testing leverage, leaders do not define leverage into their job descriptions. In this direction, critical management concerns should include identifying the highest leverage, firm-wide policies, as well as the direction and magnitude for moving targets, and identifying appropriate incentives for all relevant participants. Conventional management tools provide, at best, partial leverage for building cohesive management solutions: by design, they function in stable environments, not dynamic ones.

Current applications of leverage (see Table 1), while forward thinking in application arenas for leverage, use the term leverage loosely, resulting in a confusing mix of ambiguous leverage definitions and methodologies.

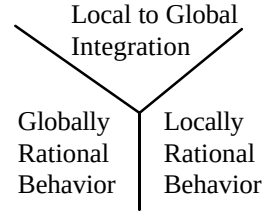
Application	Management Literature	Type of Leverage
Resource Leverage	*Competing for the Future*, Hamel and Prahalad	Direct
Strategic Leverage	*Levers of Control*, Robert Simons	Dynamic, Structural
Product Leverage	*Competitive Advantage,* Michael Porter	Direct
Commercial Leverage	*Co-opetition,* Brandenburger and Nalebuff	Dynamic, Structural
Balanced Leverage	*Balanced Scorecard,* Kaplan and Norton	Direct, Structural
Structural Capital	*Intellectual Capital,* Tom Stewart	Direct, Structural
Learning Leverage	*The Fifth Discipline*, Peter Senge	Direct, Dynamic, Structural
Intervention Points	*Whole Earth Review,* Donella Meadows	Direct, Dynamic, Structural
Team Leverage	*Leverage* magazine, Daniel Kim	Direct, Dynamic, Structural

Table 1: Current applications of leverage.

Systemic Leverage provides a structure, language and process for understanding and implementing leverage, which leaders need to develop more effective solutions to the dynamically complex problems they face every day.

It Provides a Structure
Well-planned actions, within different parts of the organization, often conflict with each other and with the overarching, stakeholder-value maximization goal. Systemic Leverage helps managers structure their interrelated policies and generate effective leverage for value. The Systemic Leverage Analysis toolkit (Ritchie-Dunham, 1998a) integrates and makes explicit all the organizational parts:

1) The system's overarching purpose.
2) How the "global" structure wants to behave.
3) How the "local" structure wants to behave.
4) How global and local rationales affect each other.



Systemic Leverage Analysis Framework

Figure 1: Systemic Leverage Analysis Framework

It Provides a Language
The difficulty with understanding leverage and its application to complex decision making derives from the language used to describe it: much like explaining in English the German understanding of *gestalt* or the equivalent of the Spanish *pundonor*. Try explaining the American sense of *patriotism* evidenced on the Fourth of July in Spanish. The cultural understanding inherent in the language muddles these cross-lingual translations. Likewise, current organization-speak uses a culturally linear language, evolved from years of cohabiting with spreadsheets and heuristics. Organizations need a dynamic language for managing complex systems. The Resource-Based View of the Firm provides a language for resources. Leverage provides a language for moving heavier-than-self systems. System Dynamics provides a language for talking about dynamics. Systemic Leverage integrates the languages of Resource-Based View, Leverage and System Dynamics communicating the power leverage and its specific tools bring to the generation of systemic leverage.

Resource-Based View
The Resource-Based View provides the key jump from thinking about abstract, fuzzy issues (i.e., supplier relationship) to the strategic management of the key assets that determine a firm's ability to achieve the desired organizational results. A firm is endowed with assets, the resources that the firm accesses for achieving its goals (Andrews, 1971). These assets include both tradable and non-tradable resources (Dierickx and Cool, 1989). Tradable resources include assets purchased on the open market, such as land, equipment and employees. Non-tradable resources are assets that cannot be purchased, such as know how, and reputation (Arrow, 1974).

How does the resource-based view affect practicing managers? Experts widely agree that the dynamic structure of the information economy changes the very nature of competition. Many qualitative assets, such as organizational learning, are cornerstone's of innovation and growth. Companies develop these skills and call themselves "learning organizations," providing a serious challenge to accounting for balance sheet items traditionally rolled up in goodwill. The resource dynamics literature argues for changing this static resource perspective, which assumes that resources exist in stable, predictable environments. The dynamic view emphasizes the rate at which resources increase and decrease over time (Dierickx and Cool, 1989; Glucksman, Mollona and Morecroft, 1997). Additionally, we need to address the issue of shared resources.

"Shared resources" are those assets for which multiple groups affect the management of its accumulation and maintenance. Usually these groups manage the same resource with different goals in mind. Yet the responsibility for the resource's performance falls within one group, though various groups may affect it. Group incentives for resource management push the groups to take actions that locally seem logical, yet globally frustrate the efforts of other groups. Many of the key leverage points in an organization, however, lay right on the boundary between functional groups. In many cases these are the points where information, documents and materials cross over into another group's domain, which is often overlooked by the traditional process analysis methodology.

Systemic Leverage provides a resource-based, systems thinking methodology for identifying high leverage policies; management uses these policies to obtain sustainable behavior in dynamically complex environments. Systemic Leverage tools help managers identify intervention points, evaluate what drives specific strategies, and determine the most appropriate actions to take and performance indicators to use in setting policies and strategies. The Systemic Leverage framework allows decision-makers to reintroduce complex side effects, time delays and soft variables into the development of these high leverage solutions.

What is Systemic Leverage?

Systemic Leverage is simply the "leverage to move systems," composed of three distinct yet related types of leverage: direct, dynamic and structural. Like a stool, Systemic Leverage rests on these three legs. Therefore, to design Systemic Leverage into the organization requires attention to building each of the three types of leverage in a balanced way.

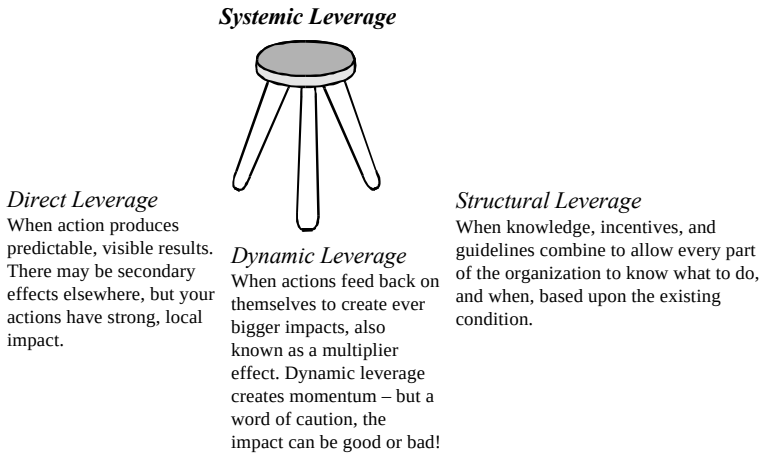


Figure 2: Systemic Leverage component leverages.

Each leverage focuses on one of the three predominant structural characteristics that exist in systems. These characteristics loosely relate to Forrester's structure hierarchies (1968).

Systemic Structural Characteristic	**Applicable Leverage**
All systems have direct cause-effect relationships.	Direct Leverage
All systems have goal-seeking or purposeful subsystems composed of chains of cause-effect relationships that interact over time.	Dynamic Leverage
All systems have multiple subsystems each acting with their own implicit goals, the combination of which determines overall system behavior.	Structural Leverage

Table 2: Systemic structural characteristics and corresponding component leverages.

To leverage a system, in a planned and understood fashion, management must use all three structural characteristics! High direct leverage and high dynamic leverage with low structural leverage lead to low Systemic Leverage. High Systemic Leverage results from the high leverage of all three structural characteristics. Below we examine the three component leverages, their definitions, examples and caveats.

Direct Leverage

Have you ever known that the "right" way to do something would give you strong, immediate results, yet you didn't do it that way for lack of time or limited attention? Leaders often use low leverage mechanisms to move forces, because they "do not have the time," when they could use high leverage to obtain substantially better, immediate results – much stronger output from relatively much less effort. This is Archimedes' famous quotation, "Give me a lever long enough … and single-handedly I can move the world."

Direct leverage focuses on direct cause-effect relationships – those with low dynamic complexity, where the cause is relatively close in time and space to the effect. Being close in time means that actions lead to observable results very soon (or instantly) after we take action. Being

close in space means that actions lead to observable results at or within sight of the place where the initial activity occurred.

The equation for direct leverage (λ_{direct}) relates the results (Y) of a particular effort (X), thus λ_{direct} is the "direct leverage ratio" for X to Y. See the formal derivation in Ritchie-Dunham (1998).

$$Y = \mathrm{I}_{y/x} \times X \qquad \text{Equation 1}$$

From this formulation, high direct leverage results from a high direct leverage ratio λ_{direct}. Turning on the ignition key to start the car, exerts direct leverage. Talking with an employee to praise their work in hopes of motivating them to work harder, exerts direct leverage. What is said (X) affects the resulting motivation (Y). Additionally, how it is said (λ_{direct}) leverages what is said. Conversely, low leverage results from a low direct leverage ratio, λ_{direct}.

Though no hard rules apply, saying, "Your work so far is okay, and you need to work harder!," may result in additional effort or not. By saying, sincerely, "I am very excited about your work so far, and hope to see you continue to improve as well as you have been." Much more inspiring! High leverage which comes from a high leverage ratio, λ_{direct}.

Direct leverage also obeys law of conservation of energy, sometimes. All physical elements must obey this law. If matter moves from place A to place B, it no longer exists in place A, however, this law does not apply to information (Arthur, 1989). As the story goes, if you have a penny and I have a penny and we exchange pennies, you still have one cent and I still have one cent. But if you have an idea and I have an idea and we exchange ideas, you now have two ideas and I now have two ideas. Information can exist in place A and in place B without having to remove it from place B. As demonstrated in the first example of direct leverage, about praising an employee, words are free. It is just as easy to make a derogatory statement as a positive statement. The physical cost in number of words used is independent of how the message is delivered. This means that whether to use high direct leverage over low direct leverage! Said another way, changes in policies change the system behavior more efficiently than do changes in physical flows.

Two closely related caveats of direct leverage deserve mention in this section: (1) its location, and (2) its overall systemic effect. The "location" of direct leverage refers to the location of the leverage point in the overall system. Counterintuitively, it can often be detrimental to a system to apply high direct leverage in certain places within the system. The "overall systemic effect" of the direct leverage point refers to the amount of change in system-wide behavior that is caused by the change in the leverage point. Direct leverage is most effective in creating short-term, local changes. In the short-term, local changes do not tend to change significantly the behavior of other parts of the system. In the long-term, local changes do not tend to change system-wide behavior. See Meadows (1997) for critical exceptions to this. The key is to find and understand how to use those few direct leverage points that do significantly impact system behavior.

Dynamic Leverage

Have you ever tried to change how something behaves, either your child or your stock market portfolio, to see it change temporarily and return quickly back to its previous behavior? As discussed above, all systems have a purpose, yet most corporate designs ask systems to do things that often run against this core purpose. In the language of leverage, low leverage mechanisms act counter to a system's implicit goal. High dynamic leverage takes advantage of the implicit purpose of systems to achieve very strong results over time. Thus, if leaders disagree with the system's implicit purpose, then they must change the system structure.

Dynamic leverage focuses on chains of cause-effect relationships that feed back over time. The cause-effect distance in time increases: it may take a while before the actions taken result in locally noticeable effects. For example, it takes time for the effect of taking a painkiller to relieve the pain of a headache. The distance in space, however, remains relatively near. Though we are waiting, we are seeing the changes occur within sight.

The equation for dynamic leverage ($\lambda_{dynamic}$) relates the results after "n" periods (Y_n) of two separate efforts ($X_{initial}$ and $X_{maintenance}$). See the formal derivation in Ritchie-Dunham (1998). The results of initial and maintenance efforts are measured over a period of time for a specific variable (Mojtahedzadeh, 1997), since it does not make sense to measure change in "the whole system," rather the change in the variable of interest.

$$Y_n = \lambda_{dynamic} \times [X_{initial} + (n \times X_{maintenance})] \qquad \text{Equation 2}$$

In dynamic leverage, the unit of measure is the single feedback loop structure. All feedback loops are goal-seeking structures. A negative feedback loop seeks a homeostatic goal, around which it *negates* perturbations away from its goal. A positive feedback loop seeks an implicit growth goal, thus compounding the perturbations away from its current state.[1] Thus, a key concern in understanding and using dynamic leverage focuses on understanding the implicit "goal" or "set of goals" of the system.

Dynamic leverage leverages the momentum-gaining (accelerating) or momentum-dissipating (decelerating) structures inherent to complex, feedback systems. In other words, leveraging efforts minimizes the amount of initial effort to get the system moving and the amount of maintenance forces required to keep the feedback structure in place.

An example might help clarify. Putting a small snowball in action at the top of the hill ($X_{initial}$), uses natural dynamics such as acceleration and the size of the snowball to grow the snowball's force over time (Y_n). In trying to identify the system's implicit goal, figuratively speaking, the snowball "wants" to roll down the hill – this implicit goal is set by the implicit gravity structure in the system. The maintenance forces ($X_{maintenance}$) allow the snowball to keep rolling down the hill: for a long, clean slope covered with snow, the maintenance forces are negligible. What changes to the above scenario would increase the maintenance forces?

The same snowball example demonstrates low and high dynamic leverage. For Cases A and B, a small force creates a small snowball and pushes it down the hill ($X_{initial}$). As in the previous

example, in Case A, the slope is steep, clean of trees and rocks, and full of snow, thus the maintenance forces ($X_{maintenance}$) are equal to zero. In Case B, the slope is steep, but it has trees and rocks that have to be cleared, and the snow is patchy, thus it needs to be filled in, thus the maintenance forces ($X_{maintenance}$) are high. In Case B, another implicit goal of the system is for the trees, rocks and patchy snow to slow down the snowball's fall – created by the implicit friction in the system. By manipulating the dynamic leverage formula, we see that if we get the same desired snowball at the end of the slope (Y_n), we had to work a lot less in Case A than in Case B. In terms of dynamic leverage, Case A provided significantly higher leverage than Case B.

In summary, dynamic leverage looks at chains of cause-effect relationships that feedback locally, over time. This enhances understanding of the natural feedback systems that exist in the environment around specific key resources. Using dynamic leverage also indicates when and where to focus interventions, or changes in policy, to effect the desired changes in the system's behavior.

Structural Leverage

Many organizations have the Mission written on the wall, and periodically set the objectives, strategies and tactics, yet rarely accomplish them. In the language of systemic leverage, these companies structure their objectives, strategies and tactics to align the multiple resources required to provide the desired product or service, yet the desired results are far from being realized. Large reengineering projects provide evidence for this, where in many cases massive efforts resulted in small improvements – an example of low leverage.

Systems, such as organizations, are aggregations of interrelated groupings, each acting within its rationale.[2] The repercussions of each group's rationale affect other groups, which take actions that in turn affect the original group's rationale over time.[3]

Structural leverage focuses on interrelated feedback loops, the logical consequence of looking at systems for dynamic leverage and asking, "How do these sub-systems truly fit together and though I understand how each one behaves in isolation, how will the group behave when linked?" We have already discussed the goals of the resources. We now look at integrating and aligning the goals of each sub-system with the overarching goal of the entire system. To achieve this "shared vision," the implicit and explicit goals of each part of the system must work together to achieve the overall system's goal.

The structural leverage formulation assumes that aligning the subsystem goals minimizes the effort lost, due to lack of alignment, in attempting to achieve the system's goal (Ackoff, 1971). The system goals network (Keeney, 1992) analyzes the consistency of a set of interlinked system goals and subgoals. In the system goals network, the lower-level goals under any higher-level goal answer the question "How can we achieve the higher-level goal?" Structural leverage compares the value of the change in the overall behavior of the system to the value of the system-wide effort to get it there.

Aligning the goals of a system requires identifying (1) the *actual* goals and subgoals of the system, and (2) the *stated* goals and subgoals of the system (Argyris, 1993). By examining the actual subgoals of each feedback system and how their relationships form the higher-level goals, the system goals network infers the actual goal of the system. Comparing this bottom-up *actual* analysis with a top-down *stated* analysis provides two key measures: (1) goal alignment – are the subgoals working synergistically or antagonistically?, and (2) domination of unwritten rules of the game (Scott-Morgan, 1994) – the level to which the stated and actual goals differ. In the case of a manufacturing company with which the author consulted, the *stated* system goals network showed a profit-maximizing firm, as seen in Figure 3. The *actual* system goals network tells a very different story.

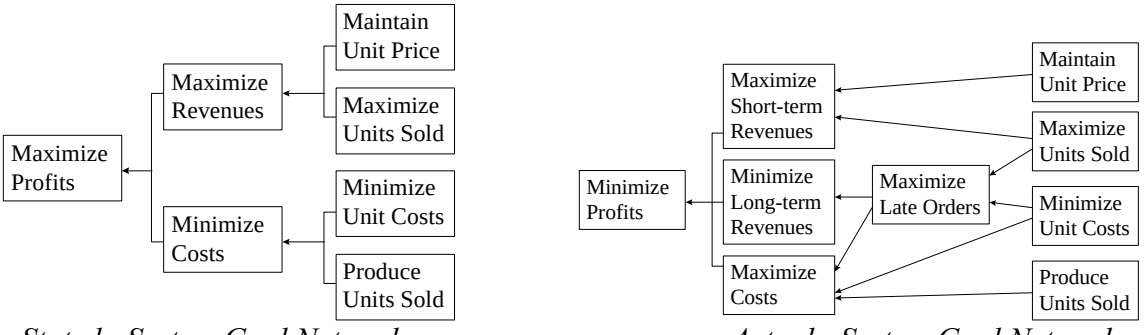


Figure 3: System goal networks

In this analysis, misaligned subgoals provide low structural leverage in consistently and sustainably achieving the system goals. In the example above, the global goal was high sustainable profitability, the initial state of profitability was low, and the actual state of profitability worsened – thus the strategy, as defined by the stated global goal and subgoals, provided very low structural leverage. In summary, structural leverage evaluates the alignment and effectiveness of the actual and stated goals and subgoals.

It Provides a Process

Designing corporate systems in which the ordinarily competent person can be successful
-- Jay Forrester (Keough and Doman, 1992)

Until very recently, the management leadership principles taught at leading educational institutions have focused on the control and command philosophy. This philosophy maintains that once leaders understand what drives the critical areas of the organization, they can roll this knowledge up into the boardroom, and create the business plan for the future. This philosophy further assumes that the organization operates in a linear, or direct cause-and-effect manner. This is simply not true – organizations have been fighting the rule of command and control because they are naturally dynamic.

As argued above, the linkages among the underlying resources of an organization drive the organization's overall behavior. By defining policies, or what to do in a given situation, managers place decision rules that guide decision making in each functional area within the organization. Creating the dynamic systems in which we live and work, requires defining and building the underlying structures that drive overall performance (Ritchie-Dunham, 1998b) – this is corporate design.

Corporate design can be thought of as the design of systems, great or small, in which policies affect the information used to make decisions about activities that affect how the system will attempt to achieve its goals. This perspective fits within the realm of strategic planning, but what is the current state of strategic planning and how does it affect corporate design? Gary Hamel stresses that as a discipline strategic planning is in shambles. Furthermore, "strategy innovation is the only way for newcomers to succeed in the face of enormous resource disadvantages, and the only way for incumbents to renew their lease on success (Hamel, 1998, p 8)." Hamel suggests five "simple roots of strategy creation (see Table 3)":

Hamel s Roots	**Systemic Leverage application**
1. New Voices	Capturing how things work, from the people in the organization that know from experience
2. New Conversations	Discovering and bringing in multiple perspectives on an issue
3. New Passions	Feeling like your understanding of the system is integrated properly into the whole
4. New Perspectives	Integrating all perspectives into a single map, providing new insights from this more complete map
5. New Experiments	Testing and communicating through Learning Environments

Table 3: Roots of strategy creation and applicable Systemic Leverage attributes.

These strategic innovation roots align strongly with the systems thinking tools used for capturing, understanding, analyzing, designing and communicating the complexity inherent to such systems. Based on the Systemic Leverage framework (see Figure 1) and component leverages (see Table 2), the Systemic Leverage methodology (Ritchie-Dunham, 1998a) explores corporate design in four phases:

- "System-wide discovery" maps the relevant relationships among key resources and identifies the strongest leverage points within the system being studied (Ritchie-Dunham, 1997).
- "Key resource dynamics" explores the counterintuitive behavior inherent within the drivers of dynamic behavior for each key resource.
- "Integrated Resource Simulation" quantifies and connects the key resources permitting hypothesis testing and providing a vehicle to communicate the desired policies.
- "Scenario planning" investigates critical concerns across a range of possible futures, as well as the organization's potential ability to survive and thrive in such environments.

In summary, this paper contributes to the dialog on resource dynamics by providing a structure, language and process for implementing this perspective within organizations.

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[1] The literature often refers to negative feedback loops as goal-seeking loops, and that positive feedback loops are reinforcing. Our experience suggests that this terminology confuses the user, thus recommending the terms "compensating" for negative feedback and "reinforcing" for positive feedback.

[2] Complexity theory provides an interesting parallel. Independent agents, each following a few simple rules (our goals), are allowed to interact, creating macro patterns of complex behavior. Resnick (1994) provides practical examples.

[3] This is why optimizing subsystems, suboptimizes the overall system. Subsystem (local) optimization focuses the utilization of locally available resources to maximize the local objective function (local goal). These resource utilization mechanisms affect other, shared resources. This focus leads to "local" perspectives, which ignore local boundaries across which they influence other areas. On the other hand, global optimization focuses on the utilization of globally available resources to maximize the global objective function (global goal). Thus we need to make local performance dependent on the global utilization of resources.