VIEWPOINT

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WHAT IS THE RELATIONSHIP BETWEEN SYSTEMS THINKING AND LEAN?

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What is the relationship between systems thinking and lean? That's a fascinating question, one not so easily answered, because we're talking about two very different approaches, one a philosophy as well as a set of tools, the other, a practice. In its broadest sense, systems thinking is a framework that takes into account the interconnected nature of systems. It is also a thinking tool, which helps us look at the impact of feedback loops on how a system behaves; analyze specific situations to explain otherwise puzzling behaviors; and design interventions with an eye for potential unintended consequences.

Lean, on the other hand, is strictly a practice, not a philosophy. It is based on hands-on know how about how to teach people to improve their own processes in terms of both customer satisfaction and cost management by eliminating waste. Taiichi Ohno, a key figure in developing the lean approach, would often say things like: "Don't look with your eyes, look with your feet. Don't think with your head, think with your hands." As a practice-oriented movement, lean is by and large wary of abstract thinking and generalizations.

Nonetheless, although systems thinking and lean operate at these two different levels, I have learned from personal experience that they are complementary and are based on similar insights. An understanding of system thinking dramatically improves the learning curve of lean techniques. Having worked with systems thinking concepts and system dynamics simulations for years before studying lean practices in detail, I immediately saw the purpose (if not the application) of lean, which wasn't the case for my colleagues without a systems thinking background.

Conversely, at the time, I was part of a group tasked with figuring out ways to practically apply systems thinking concepts in day-to-day operations. Although we experimented, we generally floundered. What we did find was that the lean techniques offered a hands-on way to apply systems thinking concepts. Because lean practices have been developed over several decades, an entire field of experience exists in terms of how to make them work.

The bottom line: *Without an understanding of systems thinking, it's hard to get lean right, and without the practice of lean techniques, it's difficult to make systems thinking a day-to-day reality to concretely improve system performance.*

The Bullwhip Effect

To make my case, I shall focus on comparing a singular dimension that has been at the origin of both movements: *supply chain systems dynamics* and *just-in-time*. One of the seminal applications of early systems thinking was Jay Forrester's modeling of the "bullwhip" effect (also known as the Forrester effect) in a supply chain. Anyone who has played the famous "Beer Game" knows that minor variations in customer demand can amplify throughout the supply chain to create huge instabilities in demand for rank three or four suppliers.

Suppliers work based on forecasts because they aren't able to quickly change their product mix or capacity—and they often get the forecast wrong. From a systems thinking perspective, the main driver of the bullwhip effect is the delay in the information loop. Since suppliers can't see what is going on at the final customer purchase point, they build forecasts based on the information they receive from their own immediate customers—information that is necessarily delayed and distorted.

The bullwhip effect is by now well known, and most supply chain systems try to moderate it, generally by increasingly sophisticated computer systems. Unfortunately, half a century after Jay Forrester first described the problem, the bullwhip effect is still alive and well—as anyone affected by the latest financial crisis or working for a third-tier supplier will testify.

In the 1930s, Kiichiro Toyoda, the founder of Toyota Motor Company, wrote a lengthy pamphlet in which he coined the term "just-in-time." He explained how each station of the assembly process should only manufacture what is required, when it is required, and in the exact quantity required. In other words, he described a remedy to the bullwhip effect that was plaguing Toyota's early operations. Other automotive manufacturers compensated for the effect by creating massive inventories. Toyota, however, was so strapped for cash in its early years that it constantly sought practical ways to deliver the cars customers wanted with the least inventory possible—they simply could not afford to carry large stocks.

The company abandoned the initial attempt at just-in-time and many other innovations during WWII, when Toyota

TEAM TIP

What methodologies or approaches does your organization use that would be enhanced by a systems perspective?

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operations were more or less taken over by the government. During the 1950s and 1960s, Toyota engineers resumed their efforts to make the just-in-time dream a reality. To do so, they latched onto the idea of the *supermarket*.

The Supermarket

The supermarket concept was (and, strangely, still is) a revolutionary idea. Every operation in the supply chain would "own" its finished stock (as opposed to sending it to a warehouse, where it's owned by "the system") and would lay it out as on a supermarket shelf (in a fixed location). In the next process, the "customer" would then come and take what it needed, when it needed it, in the quantity it needed. The production operation would then replace what had been withdrawn and *no more*.

In attempting this deceptively simple discipline, Toyota hit upon a number of intractable problems that most industrial companies still haven't resolved to this day. First, there was variation at the customer end, both in the total volume of orders and in the mix of specific products and their component parts (models, options, etc.). In order to avoid the bullwhip effect, Toyota had to learn to buffer and smooth this variation through a mixture of planning and the targeted use of finished product stock—a practice that became known as *leveling*.

Second, being able to resupply what had been withdrawn as well as provide for a wide variety of components on the same equipment required far greater flexibility than industrial processes can typically provide. Industrial processes are designed to optimize the parts, not the system, and machines are generally easy to run but hard to change. Toyota had to learn to change tools or assembly sequences frequently and painlessly to make its supermarket system work. More than 60 years later, the company is still working on it.

"And the Kanban"

In the process of developing this capability, Toyota has found that the *information* the production process receives is at least as important as its delivery capability. This is pure systems thinking. The company started by focusing on the impact of feedback loops on "lead time." Lead time is the interval from the moment the customer gives an order to the point when the company collects the cash; it encompasses production and stocking time. Lead time is a good measure of the delays in the chain, which create the instability. Toyota developed a unique method called the "Material and Information Flow Analysis" to visualize where information flows impacted the process and how. (This technique became known outside of Toyota as "Value Stream Mapping," from John Shook and Mike Rother's bestselling book, *Learning to See*).

On the shop floor, information is represented by cardboard cards (the famous *kanban*), which symbolize production or withdrawal instructions. No crate of parts can be moved without being ordered to by a kanban card; no parts can be made without a kanban production instruction. To Toyota engineers, the link between leveling (smoothing demand variation) and kanban (production instructions) is intuitive, but to external observers, it can be hard to catch. My father recalls visiting a Toyota plant in the 1980s and studying their efforts to build several different car models on the same line to improve flexibility. Instead of scheduling runs of the same model in batches, they would mix models so no two cars on the line would be the same. Puzzled, my father, then head of manufacturing engineering for Renault, looked hard at the line and finally figured out: "You're scheduling a vehicle with a lot of work next to a vehicle with less work to stabilize the overall operator cycle," he told them. "Yes, they answered—and the kanban."

My father spent some time clarifying his understanding that to maintain productivity and limit variation on the line, they would first program a high-content vehicle, with more work than average, and then a low-content vehicle, with less work that average. The result was that operators would work at a steady rhythm overall. "That's right," they would insist. "And the kanban."

When he finally asked managers what the kanban had to do with it, they explained that the sequence of cars was calculated so that the kanban instructions to suppliers of individual parts would be leveled. In doing so, they avoided demand variation on the parts supply. Managers tried to schedule the final assembly line so that each parts supplier would get the most stable, regular order message possible—something that remains a daily challenge, considering the complexity of building an automobile. Toyota has been remarkable both in understanding the dangers of demand variation on the whole supply chain and in developing the technical ability to be able to schedule at that level of detail. Very few industrial companies are lean yet, because most still have trouble understanding the fundamental link between information and production—let alone know how to deal with it.

Information Flows

The damage caused by the lack of systems thinking in attempts to apply lean shows starkly in two typical cases. Many companies have latched onto Value Stream Mapping as a great tool to analyze their processes (which it is). But when you look at their maps more closely, you often find that the production process is sketched in painful detail, whereas the information flow is barely suggested. Most people use the maps to clarify and simplify their material processes (mostly in terms of flow), not to optimize how the production process works as a whole.

What Toyota engineers have learned from their long experimentation with these ideas is that the lead time of planning, production, distribution, and sales is a good indicator of the overall performance of the process. The Material and Information Flow Diagram is one element of a full lead-time analysis, in which the information flow is largely as important as the material flow. Indeed, experienced lean practitioners tell you that their main headache, once the obvious flow problems have been solved, is leveling, leveling, leveling: managing the information flows to reduce the lead time in the feedback loops and minimize variation in all aspects of production.

Similarly, countless companies have tried kanban scheduling only to finally

give up and go back to their ERP computer systems. Implementing kanban without a clear idea of the goal in terms of information management is doomed to fail. Kanban is about taking all ambiguity out of the information flow to make sure that the final assembly schedule is reproduced "mechanically" throughout the supply chain, avoiding the need for the individual judgments that contribute to the bullwhip effect. Indeed, when you play the Beer Game, you discover that communicating customer demand without trying to create forecasts reduces unwanted variation in your ability to produce and deliver.

Building on this insight, in the kanban system, if the final assembly has been scheduled so as to be properly leveled, the entire supply chain will behave smoothly by blindly following the cards; the cards mechanically reproduce the final customer signal. Interestingly, kanban is also a great tool for revealing the real leverage points for improvement in delivery systems—which rarely are those one expected at first. Most "bottlenecks" turn out to stem from mistakes in information and planning policies that wreak havoc on the shop floor.

Experimenting with these various techniques has led Toyota to address the other main causes of the bullwhip effect. For instance, the company offers far fewer rebates than its competitors and refuses promotions from suppliers in the aftermarket parts businesses. The company's logisticians understand the impact of pricing fluctuations on the behavior of actors in the supply chain and have convinced their purchasing and procurement colleagues to try to minimize them. In the same manner, Toyota frequently provides its suppliers with running forecasts, which help vendors throughout the supply chain to anticipate demand. The forecasts also limit the incentives for suppliers to game the system; since there is little ambiguity in the information chain, gaming strategies are less attractive and have a much higher risk of angering the customer.

Improving the System as a Whole

Plants that supply Toyota in the U.S. have 14 percent higher output per worker, 25 percent lower inventories, and 50 percent fewer defects than operations that supply other automakers (A. Iyer, S. Seshadri, and R. Vasher, *Toyota Supply Chain Management,* McGraw-Hill, 2009). Efforts to get rid of the bullwhip effect (among other industrial problems) clearly pay off. So why don't most industrial companies get such benefits from their lean programs? My personal belief is that without a strong foundation in systems thinking, people find it hard to understand the purpose of the lean tools, which is to improve the behavior of the system as a whole.

Furthermore, since Toyota developed these practices with a strong practical bias (it is said there is no expertise in lean, only experience), the underlying thinking behind the tools is hard to piece together. Using Value Stream Mapping without looking for the effects of feedback loops misses the point. Trying out kanban without understanding how ambiguous information can cause oscillation in a system will produce disappointing results.

On the other hand, trying to affect system behaviors without the hands-on practice of lean can be equally discouraging. The experience of lean reveals that key leverage points are often hidden and counterintuitive—a fact well recognized by systems thinkers. Most bottlenecks turn out not to be so in practice. The lean field has a lot of experience to offer both in terms of know how to change systems and in terms of leadership practice to convince the people in charge of processes to make modifications. Without this practical perspective, a systems thinking approach to a problem can seem daunting. Realizing how everything is interrelated doesn't help much when one wants to change the global behavior of a supply chain.

To Understand and to Change

The rapid progress of science since the Industrial Revolution has been driven by the close interplay of theoretical and practical advances. I believe that the mutual interdependence of systems thinking and lean offers a true opportunity here. By recognizing the synergies between these two fields, we can drastically increase our capacity to improve systems.

The bad news is that integrating these two approaches means more work. If I'm correct, system thinkers must acquire the discipline of lean practice. This has been my own particular path: fun, interesting, but never easy. And lean practitioners must make the effort to understand systems thinking, which is a significant intellectual investment.

Still, I believe this challenge is worthwhile. In today's hypercompetitive markets, companies needs the performance improvement promised by lean. Furthermore, the strong systems thinking undercurrent of lean makes it focus on reducing waste of all kinds, including externalities such as pollution and garbage. Since its humble beginnings to its recent 2020 global vision, Toyota has continuously aimed to offer value to society overall. Considering the problems we collectively face in this new century, a proven method of industrial improvement also intent on reducing waste in all its forms should not be dismissed lightly.

One of the enduring puzzles of the lean movement is why it hasn't spread more quickly through industry: Many try, few succeed. Systems thinking, I believe, could contribute significantly to solving this conundrum by providing an overall framework to lean practice. To paraphrase Karl Marx, the point is not merely to understand the world, but to change it. Systems thinking offers the means to understand; lean, the practice to change. By pursuing both jointly, we can learn faster how to change the world in the right way to face our global challenges. ◘

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