

Education for Managing Digital Transformation: A Feedback Systems Approach

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ABSTRACT

"*Digital transformation*" is becoming the newest mantra of business leaders. It is clear that there are tremendous business opportunities resulting from this revolution, but there is also a price to be paid. Most management literature focuses on the benefits of digitalization, reflecting the desire to increase performance and efficiency in selected business activities. However, digital transformations may lead to the disruption of established ways of doing the work of the firm, stakeholder power may be fundamentally changed, and there is the potential for redefining the nature of the firm itself. Consequently, the decision to "go digital" requires managers to develop perspectives that have the requisite variety to cope with these challenges. Feedback systems thinking is a powerful means for managers to develop and communicate business models that include those aspects of digitalization that affects their firm's theory of success. The Uber case illustrates the principles of applying feedback systems thinking to the radical changes that it has presented the public transportation sector. This paper analyzes Uber's platform business by presenting an endogenous explanation of the drivers and eventual constraints to growth of the theory of success upon which the firm is based. This type of analysis has implications for all firms considering implementing a significant digital transformation process.

Keywords: Digital Transformation, System Dynamics, Business Model, Theory of Success, Management Flight Simulators, Platform Business, Growth Strategy.

1. INTRODUCTION

Managing digital transformations and, more fundamentally, the consequences of digital business transformations are becoming increasingly difficult in today's business environment where neither competition nor technology is static. Disruptive information technologies impose significant challenges both on business organizations' markets and on their internal processes. Creative use of information and other technologies facilitates development of innovative network-based businesses in a synthesis of firms and markets. This type of business (often called "*platform business*") deploys business models that are fundamentally defined by information technology and consequently redefine the boundaries of the established business

environment. In offering new ways of thinking, these technologies generate a different set of strategic choices [1] about how to understand the basic value creation process and how to manage the potential flood of new data that becomes available. Relationships with traditional and new stakeholders may also be redefined (see, for example, [2] for an extreme perspective).

Companies initiate digital transformation programs in order to optimize their existing business model, but often do not follow through, leaving the innovative potential of information technologies untouched. A recent survey [3] found that fully two-thirds of the respondents strongly agreed with the statement "*[d]igital technologies have the potential to fundamentally transform the way people in their organization work.*" However, the same survey indicated that the greatest barriers to leveraging the potential of digital technologies came from not "*[k]nowing the business and being able to conceptualize how digital technologies can impact current business processes/models*" (44%) and low "*[w]illingness to experiment and take risks*" (44%).

The essence of the digital transformation challenge was well captured by Schön [4], "*In the swampy lowland, messy, confusing problems defy technical solution. The irony of this situation is that the problems of the high ground tend to be relatively unimportant to individuals or society at large, however great their technical interest may be, while in the swamp lie the problems of greatest human concern.*"

The quotation highlights a fundamental feature of organizations. They are comprised of tightly inter-related systems that must operate harmoniously for proper performance. In this system, making changes to one subsystem (the technical) will also affect the other (the social). Digital transformations have significant implications for both subsystems with the consequences of "going digital" becoming apparent only after some time delay and in unexpected areas of the firm. Three ways the organization can react includes generating unintended consequences, demonstrating counterintuitive behaviors, and pushback, or policy resistance, from key stakeholders [5]. The primary reason for these dysfunctions lies in employing a linear, event-oriented perspective on managing digital transformation that relies on many unrealistic assumptions about how an organization functions. The net effect of these systemic reactions often diminishes the benefits from the transformation process.

One potential explanation for these dysfunctions can be found in the perspectives that the people in charge have on the system and their understanding of how it functions. The cognitive organizing structures that decision makers rely upon, called mental models, are the collection of assumptions, routines, and networks of causal relations that describes how a system operates. Consequently, the quality of planning and decision making activities depends on the adequacy of the mental models in the problem context. While there is no foolproof method for avoiding the undesirable reactions to change, one effective antidote to linear thinking is to adopt a feedback systems [6] view of the firm. This is an effective alternative perspective that enables managers to recognize the importance of relationships between and among organizational stakeholders and to identify the interaction dynamics of actions, results, and reactions in a closed loop system.

Systems are pervasive; humans live and work within both social and technical systems. IT 'solutions' create complex technical systems, but often ignore the effects of technology on the social aspects of work. The effect digital transformation has on a business can be understood along two dimensions: efficiency and effectiveness. Efficiency relates to performing essentially the same business functions, but with less resource usage. The question is how to perform better. This is the common technical interpretation - doing more for less cost. Effectiveness has deeper implications and addresses the issue of what the firm should do and how the business model needs to be adapted to accomplish it. In either perspective, digital transformations have significant impacts on the firm and on the market environment, but many applications deal primarily with the efficiency aspect.

2. THE SYSTEMS PERSPECTIVE ON DIGITAL TRANSFORMATION

Systems thinking is both a philosophy and a methodology for understanding behavior of complex dynamic systems, of which business organizations are an important exemplar [7]. The feedback systems thinking approach (see [8], [6], [9]) is a rich and evolving discipline that adopts a holistic perspective on complex organizational systems. The non-linear feedback interactions of system elements invalidate the notion that optimizing individual system components will optimize the whole system. Performance improvement is neither reductive nor additive. It follows from the systems principle that individual performance improvements do not necessarily improve the performance of the entire system.

Complex and adapting systems make learning about them difficult and consequently ordinary policy designs become fraught with problems. Policy designers usually do not have the time to wait and see if their interventions are going to work well, and then readjust accordingly. Systems thinking offers a set of tools that support conversations and dialogue and processes for learning and designing actions within these complex systems.

The disciplinary roots of feedback systems thinking are information and control theory, behavioral decision theory, and descriptive knowledge of the system under study. A systems-based analysis 'steps back' from the level of specific events and attempts to develop structural explanations of system behavior, a "theory of success". A unique key characteristic of systems thinking is its focus on endogenous explanations of behavior. Selecting the boundary of the system is thus a critical part of the analysis. The endogenous perspective enables decision makers to take a proactive, rather than reactive, approach to problem solving.

Systems are comprised of interlocking feedback loops whose interactions over time give rise to systemic behaviors. There are two types of feedback loops: reinforcing (or positive) loops and balancing (also called negative) loops. Systems analysts employ two types of tools to capture complexity: causal loop diagrams (CLD) and stock-and-flow diagrams (SFD). The CLD is a flexible and useful tool to illustrate the basic feedback structure within a system in a problem domain while the SFD is a more formal representation of the variables that sets the stage for computer simulation of the system. The CLD is simply a map that identifies the variables of interest and the causal links between them. Arrows show the direction of causality and the '+' and '-' signs indicate the polarity of the relationship between pairs of variables. A '+' sign shows that the variables move in the same direction - increasing the cause results in an increase in the effect, and vice versa. The '-' sign means that increasing the cause will decrease the effect, and vice versa.

The overall behavior of any loop is simply determined by counting the number of negative polarities that the loop contains. If the number is positive, the resulting loop behavior will be reinforcing. Reinforcing feedback loops are self-enhancing and result in exponential growth if the variables are increasing or to run-away collapse if they are decreasing. Respectively, these behaviors are often described as "virtuous cycles" and "vicious cycles." Reinforcing loops are generally indicated by labeling the loop with "R" inside it. An odd number of negative polarities within the loop results in a balancing feedback loop, which is indicated by "B." Balancing feedback loops are equilibrating or goal-seeking structures in systems and are both sources of stability and sources of resistance to change.

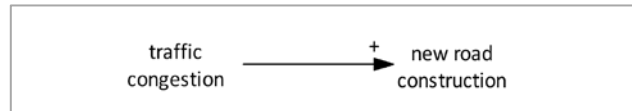


Fig. 1a: Linear, event-oriented representation without feedback

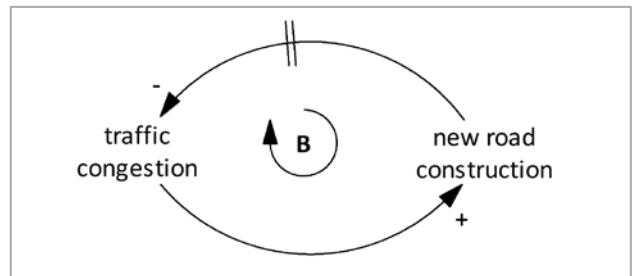


Fig. 1b: Dynamic feedback representation including time delay between cause and effect

From the loop relationship of Figure 1b, one would expect that the long-term relationship of congestion and construction would find an equilibrium state, consistent with the behavior of a balancing feedback loop. However, most experience in the real world of traffic shows that this is not generally the case; construction is ongoing. Compared with the event-driven perspective, the feedback view enables more information to be brought into the analysis. This deepens the understanding of what is actually driving the system. Figure 2 expands the basic feedback model of Figure 1b to include a new variable called "number of cars on the road." This variable provides a plausible explanation for why new road construction generally only provides temporary relief from traffic congestion.

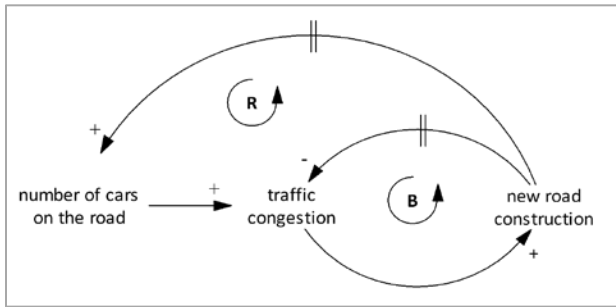


Fig. 2: Expanded traffic model with multiple feedback loops

The availability of new roads activates a reinforcing feedback loop that increases the number of cars on the road, thus negating the benefits of construction after some time. One common result can be oscillations of free flow and congestion, with time delays measured in years. This simple example illustrates how CLDs can be used to explore and expand understandings of a well-known system. Visually representing the system in terms of key variables and their relationships enables decision makers to share their perspectives and to surface and test assumptions about the issue under study.

Barnett [10] states that “[d]isruption is not just about changing technology; it is about changing the logic of a business.” Most transformation initiatives fail due to their fragmented view and outdated theories of change that ignore the dynamic relationship aspects of organizations. In order to implement and realize the benefits of digital transformations, we must both understand the intended consequences of the socio-technical change and be able to identify the potential unintended consequences of the digital transformation. The common ways of (linear, event-oriented) thinking hampers our ability to generate effective mental models, thus limits our view on the planned change. This often leads to inappropriate theories of managing digital transformations and more fundamentally does not address unexpected (side-) effects of these initiatives. Systems thinking provides a powerful language for representing and operationalizing the mental models that strategic decision makers bring to the table.

Systems thinking interprets structure in the broadest sense of encompassing material flows as well as information flows. Specific combinations of reinforcing and balancing feedback loops give rise to characteristic system behaviors that are described as system archetypes [11]. They are a basic tool of feedback systems thinking that contribute to diagnosing the causes of organizational behaviors. The archetypes describe commonly observed behavioral patterns and correlate them with potential feedback structures that can generate these behaviors.

A shift of mind (from event-oriented thinking to feedback systems thinking) in digital strategy management is not easy to achieve. An effective way to make progress is through examples of feedback systems approach applied to real-world situations. Using the case of Uber [12], we show how a feedback systems approach can illustrate how digital transformation affects both the business model and the established business environment.

3. BUSINESS MODELS OF “THEORIES OF SUCCESS” IN COMPLEX, DYNAMIC ORGANIZATIONS

Business models are the blueprint of how a firm does business. It translates strategic issues into goals and actions and specifies how the conceptual model is converted into a viable operational

form [13]. Implementing business models based on systems thinking principles and methods have two important advantages over traditional implementations.

The first benefit is that the business model explicitly incorporates the dynamic relationships among the primary value creating components. The causal loop methodology captures the overall feedback relationships and identifies the nature of the growth engine (see [7], chapter 10 for a comprehensive discussion of various growth engines). Growth is generated by a reinforcing feedback loop. Balancing feedback loops define constraints on the system that may limit the growth potential, and identifies opportunities to overcome them.

At the level of causal loop diagram modeling, decision makers have an environment that makes mental models behind the theory of success explicit and contributes to dialogue by encouraging reflection and inquiry about the basis of the firm’s operations. Furthermore, it provides the decision makers an environment, where they can test out their planned change without harming the business.

The second benefit can be realized by converting the causal loop model into an operational model using the stock and flow language. This enables the construction of a computer simulation-based virtual world model of the organization ([7], [11] and others). The virtual world model is also called a management flight simulator. Similar to actual aircraft simulators, the management flight simulator allows decision-makers to experiment with the consequences of proposed strategic decisions. In the computer, the model simulates the firm’s feedback performance for a specific time that is long enough, usually years for strategic analyses, to allow delayed effects to be manifested. This allows a more systematic analysis and comparison of different strategic initiatives, which leads to richer discussion of the path to select.

The business model is central to how organizations successfully navigate in these dynamic and complex environments. Business models represent the specification of how a firm conducts its transactions with the external and internal environments. They represent the organization’s managerial understanding of how things are done, essentially their theory of success on how to manage in a digital environment. Digital technology-driven transformation represents a challenge with enormous potential for organizational growth and development. At the same time, it presents managers with significant organizational risks. Externally, it affects the organization’s strategic position in the industry; internally, it influences the nature of the relationships between both individuals as well as organizational units.

By their nature, disruptive transformations cannot be foreseen and accounted for in a traditional business model. For example, mapping the business model, the theory of success, can provide managers with deeper understanding about the true nature of the transformation or disruption. In the case of digital technology, the technology itself may be revolutionary but that in itself is not sufficient for it to be disruptive in the market (see the video lecture [14]). Rather the effect of the technology on the users defines whether it becomes disruptive. The interaction between advanced technology and a market that is primed to accept it is the basis for disruption. The follow-up question is whether the firm with the technology is able to sustain and grow from the initial advantage it has gained. This reflects the importance of being able to balance external demands with internal capabilities to meet them. As we discuss in the following section, Uber must confront and manage this challenge. We have to acknowledge to our theories of success are incomplete or outdated. Consequently,

business model development needs to be less of a detailed roadmap to success and more of a flexible tool to support managerial inquiry.

4. THE EXAMPLE – UBER - AN ON-DEMAND TRANSPORTATION SERVICE

Uber is a child of the extreme forms of new organizations that digital technologies can enable. Started in 2009 as a response to the difficulty the founders experienced in a Parisian snowstorm, Uber has become a contentious thorn-in-the-side of a traditional taxi industry in cities around the world. Enabled by smartphone technology, Uber’s radically different business model has dramatically increased consumer efficiency improvements and company revenues through effectivity improvements. The result is today known as one of largest point-to-point transportation network. Uber has become known as a “*sharing economy business*.” However, the basic model is not unambiguously seen as a good thing. The consequences of Uber’s break with traditional taxi traditions continue to emerge as market competitors and institutional regulators begin to respond to the challenges.

Uber is an example of a platform organization. Technology plays the central role in providing consumers with ‘me-here-now’ logistics services that drives the efficiency gains. Customers’ waiting times and access to some urban areas has been significantly improved through the information supplied by the smartphone customer app. By relying on well-paid, independent contract drivers and equipping them with sophisticated app-based decision support systems, the traditional business structures must deal with a competitor that refuses to play by the old rules. Its business model is outpacing many of the laws regulating of the taxi industry as it addresses future customer benefits and new customer relationships [12]. One of Uber’s core challenges is that it must manage satisfaction on both sides of a two-sided market (riders and drivers).

Uber originated from a simple idea: Kalanick and Camp’s notion that they could disrupt the taxi business by replacing the outdated centralized dispatch system with an app. Despite the market’s initial acceptance of the business model, “*Uber should feel magical to the customer. They push the button and the car comes. But there’s a lot going on under the hood make it happen.* - CEO Travis Kalanick” ([12], p. 3). Thus, Uber provides a unique opportunity to illustrate the use of feedback systems view to operationalize the theory of success of a platform business.

The founders soon realized that Uber users’ satisfaction depended on rapid availability of cars and drivers. If an Uber user summoned a driver and the driver appeared within minutes, user satisfaction was extremely high. By contrast, if it took a driver a long time to pick-up a passenger, user satisfaction decreased. Consequently, in order to ensure high user satisfaction, Uber always had to ensure that a large number of drivers were always available in the city. On the drivers’ side, the amount of information about users enabled development of applications that would support driver decisions aiding their siting decisions.

Uber’s business model reveals that the company relies on a series of reinforcing feedback loops that reinforce the power of the system from one side of the market to the other, thereby creating a growth engine (see Fig. 3). The most important component of this growth engine is also known as ‘get-big-fast’ (GBF) strategy [15].

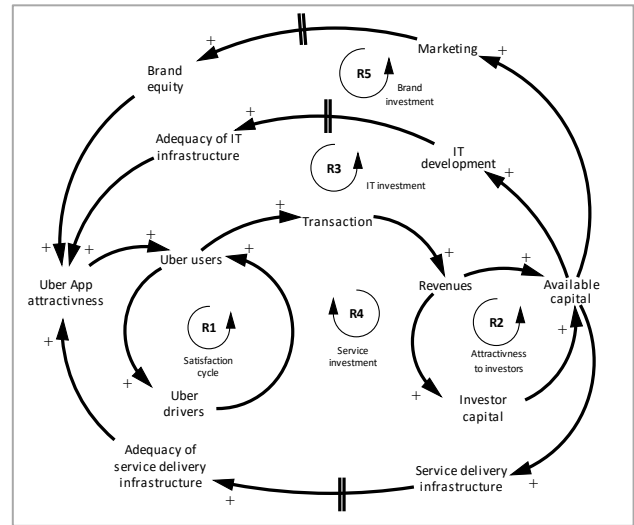


Fig. 3: Reinforcing feedback loops driving Uber’s growth (modified from [15], p. 102)

Reinforcing feedback loop (R1: *Satisfaction Cycle*): It became quickly apparent that Uber user satisfaction with the Uber app depends almost entirely on the rapid availability of a car. At the same time, the more that people use the Uber app, the more Uber drivers will be able to do business with Uber. The more Uber drivers in a city, the shorter the waiting time. The shorter the wait the greater the satisfaction of the Uber user.

Reinforcing feedback loop (R2: *Attractiveness to Investors*): Rapid revenue growth drives high stock valuations during the honeymoon period when investors are not troubled by losses. Higher stock prices lower the firm’s cost of capital and bring in additional resources. New capital increases spending, which leads to better performance, greater user acquisition and a further increase in revenue. Growth attracts investors, and in the case of Uber, these capital providers have enabled the company to spend heavily to further grow the business. Uber has been able to raise an extraordinary amount of capital at a relatively low cost, and thus can essentially operate at a loss as necessary, spending money to win markets. It is similar to Amazon in its willingness to lose money in order to win market share and achieve scale.

Reinforcing feedback loops (R3-5: *Investment Loops*): Investment in adequacy of IT infrastructure (speed, data analysis and security, etc.), adequacy of service delivery infrastructure (access to necessary technical and legal expertise, fulfillment speed, etc.), and brand equity (awareness, reputation, etc.) improves the attractiveness of the Uber app. Furthermore, investments in these attributes are driven by the availability of capital, which are in turn increased by the attractiveness of Uber, thus creating the growth engine that drive the growth of the organization.

Finally, regardless of how compelling Uber’s service is, there are also a number of limiting feedback loops to Uber’s GBF strategy (see Fig. 4).

Balancing feedback loop (B1: *Drivers on Hold*): Insufficient working conditions will cause a poor fulfillment experience, eroding attractiveness and limiting organizational growth. Uber is repeatedly facing lawsuits because its drivers are classified as independent contractors instead of employees. Some even claim that Uber’s entire business model is based on an improper and even unethical exploitation of labor.

Balancing feedback loop (B2: *Disrupting Trends*): Uber is clearly a disruptive company. On the one hand Uber's success illustrates the latent discontent that customers have historically experienced with existing transportation alternatives, while on the other hand, it illustrates how dramatically changes in behavior affects the attractiveness of an internet solution. The behavioral change, resulting in different customer demands, is the disruption, enabled by technology.

Balancing feedback loop (B3: *Cyber Security*): More users means more access to sensitive data. This opens the opportunity for cyber-crime, which negatively affects the adequacy of the existing IT infrastructure. At the same time, some users may not be willing to share their private data, thus limiting the attractiveness of the Uber app.

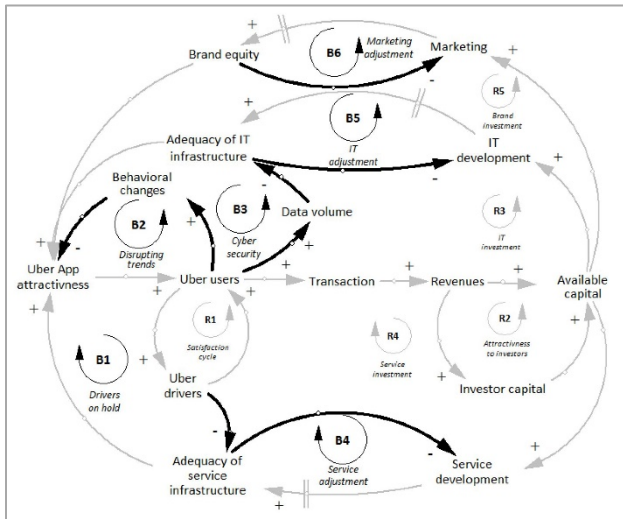


Fig. 4: Main balancing feedback loops that constrain growth (modified from [15], p. 103)

Balancing feedback loop (B4: *Service Delivery Adjustment*): Uber is waging a battle on multiple fronts: against city and state regulators, and against entrenched taxi interests. The complicating issue is that laws regulating these industries were written before the advent of ubiquitous mobile technologies. In any case, adjusting the service delivery infrastructure can consume significant resources that will affect the company's ability to develop its service offerings.

Balancing feedback loop (B5: *IT Adjustment*): Uber is continuously improving their IT infrastructure, including smartphone integration, GPS-tracking, wallet-less payment, and ratings-based reputation systems. However, delays in improving IT infrastructure to support the growing number of riders and transactions will decrease the app attractiveness and limit the growth of the user base.

Balancing feedback loop (B6: *Marketing Adjustment*): A challenge facing Uber is the tension over surge pricing. The public relations around Uber's surge pricing policy was very negative. Although surge pricing is common, what makes Uber's version particularly aggrieving is that it is significantly more precise than other dynamic pricing models. Pricing is experienced by consumers in deeply emotional ways, and companies whose pricing is perceived to be randomly variable are often the subject of brutal consumer complaints.

5. DISCUSSION AND CONCLUSIONS

"The digital economy is real - and it is here to stay." Advanced information technology is significantly affecting the development of organizations in all businesses. Managers have found that to survive and prosper in the 21st century they need to understand the opportunities and forces that digital transformation imposes on organizations. When answering this question, business models become of vital importance. According to our understanding, business models represent the managers' operationalized theory of success concerning successful management of the consequences of digital transformation.

Applying a feedback systems approach decision makers learn how to map and interpret the underlying causal structure of different business models. This is important in order to manage organizations and to understand and cope with the consequences of socio-technical changes caused by digital transformation. In doing so, decision makers need to answer how efficiently and effectively available technologies and infrastructure is used to satisfy stakeholders and to achieve organizational goals. Beyond efficiency considerations, managers can utilize these models to identify and exploit new opportunities for other types of customers.

Recent literature confirms [3] that companies often initiate digital transformation programs in order to optimize their existing business model. Reasons for doing so include risk avoidance in experimenting with new ideas and an addiction to solving business problems that worked well in the past. Thus, digital transformation initiatives lead to digitization, changing from analogue to digital, in order to increase the efficiency of existing business.

In the taxi industry, taxi companies heavily invest in new cars and dispatching equipment but still do business the traditional way. Historically, it has been easier to summon transportation from a centrally organized firm like a taxi organization than it has been to scour the streets yourself for a driver. However, in recent years, technology has turned this logic on its head. Now that most people carry smart devices (in form of cellphones) in their pocket, it has become easier for companies to develop systems in which potential taxi riders are matched with potential drivers on a real-time basis via a platform company.

Platform companies like Uber provide a matching system for riders and drivers, which is more efficient than the service provided by a traditional taxi company. Uber addressed the effectiveness question "Are we doing the right thing?" by taking advantage of advanced information technology in order to change behavioral trends. This increased the attractiveness for on-demand transportation for a new customer segment.

Uber's underlying strategy can be described as a 'get big fast' (GBF) strategy, which is well known in e-business. GBF strategies promote a strong focus on reinforcing feedbacks that create a large customer base and the acquisition of capital for rapid growth.

A successful GBF strategy requires that managers be aware of the relationship between two critical feedback loops. One loop describes the growth process. In Uber's case, this is represented mostly by "R4: *Service Investment*". This loop generates revenues in the form of fares paid to drivers and their commission payments to Uber. However, in order for transport services to be delivered, there must be sufficient capacity to deliver the service,

which is Uber drivers. Recruiting new drivers is a key element of Uber's theory of success. The system archetype called "Growth and Underinvestment" [19] captures the dynamics of quality service provision and the need for timely investment in provision capacity to maintain service quality. Capacity adjustment takes more time than earning revenues. An uncritical GBF strategy may result in managers seeing only the benefits of meeting demand for service while ignoring the need for adding more drivers, perhaps well in advance of the demand for service. This shortsightedness will lead to demand falling off and financial problems for the firm.

Modeling the theory of success of Uber applying a GBF strategy enables the decision makers to investigate the potential side effects of digital transformation. The model captures the interplay of the powerful reinforcing feedbacks that drive Uber's rapid growth and their interaction with limits to growth arising from the behavioral changes of major stakeholders, potential decline of the customer base resulting from limited availability of capital and the delays in deploying the capabilities and competencies needed to provide an attractive Uber app. Thus, decision makers will be empowered to better understand the interdependencies of socio-technical changes and how balancing feedback loops can limit growth, e.g. service erosion.

However, driving digital business transformation requires a delicate balancing act between fundamental change of business by advanced technologies and disruptive business models on the one hand, and developing infrastructure required to serve a changing customer demands, keep customer attracted as well as managing the resulting frictions with the established environment.

This paper has not discussed the second systems thinking tool, the stock and flow diagram (SFD). The natural next step in a systems thinking based analysis is to convert the CLD into a format that enables decision makers to experiment with different change initiatives in a software environment. Using a SFD model, decision makers can create computer-based virtual micro-worlds, also known as management flight simulators [16], to visualize and operationalize their mental models. These virtual worlds have many advantages. They enable decision makers to discuss, test, and experiment with their knowledge in a more scientific manner. The immediate feedback of the short- and long-term consequences of their plans encourages learning that is more effective and supports the development of robust and realistic theories of success. This provides digital business transformation manager to experiment and test their strategy in a risk-free environment.

The CLD-model shows the difficulties of succeeding in digital transformations even when there are reinforcing feedback loops that can lead to rapid growth. Educating decision-makers about the opportunities and application of a feedback systems approach enriches their strategic choices about digital technology-driven transformations and their potential long-term consequences.

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