Systems Thinking as a core competence
for Sustainable Development and
Digital Transformation

SYSTEMA Project - Funded under the Erasmus+ KA2- 2020-1-IT02-KA204-080082

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SYSTEMA
SUSTAINABLE DEVELOPMENT - SYSTEMS THINKING - DIGITAL TRANSFORMATION
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4° module – Systems Thinking and Digital Transformation

- Introduction
- The concept of Digital Transformation
- EU and Digital Transformation
- Recap of Systems Thinking and System Dynamics main concepts
- Systems Thinking, System Dynamics and the SYSTEMA Project
- SD/ST literature for Digital Transformation
- Simple example of ST/SD for Digital Transformation
- SD-based ILE and Digital Transformation
- Discussion
- Digital Transformation + Sustainable Development

Kompass Zentrum für Existenzgründungen
the academy of code
intellegere per capire, per capirsi.
System Dynamics Italian Chapter
ΠΑΝΕΠΙΣΤΗΜΙΟ ΜΑΚΕΔΟΝΙΑΣ
Center for Social Innovation
ASVIS Alleanza Italiana per lo Sviluppo Sostenibile

Introduction

- Digital Era & Fourth Industrial Revolution

- SMEs attempt to follow:
  - An increasing trend to operate online
  - Use of Artificial Intelligence for tasks
  - Integration of social media to their operations
  - Increasing dependence on cloud technology

Introduction

- SMEs need to:

1) Fundamentally change their business models
2) Digitize their operating models
3) Attract and retail people with the necessary, diverse skills to succeed in the Fourth Industrial Revolution
4) Develop new digital metrics of success

The concept of Digital Transformation

Increasing application of digitization and/or automation that has important impacts on structure or characteristics of individual work, internal processes, communication, infrastructure, business ecosystems and products/services for internal and/or external customers. The core of Digital Transformation is the overall digitization and cross-linking of the value creation process.

The concept of Digital Transformation

- Digital Transformation is not only digitization, but:
  - adopting a broader mindset
  - encompassing Big Data, cutting-edge technology and human-centered design
  - transforming traditional business models

The concept of Digital Transformation

- Digital Transformation is not only digitization, but:
  - Finding new ways of combining products and services
  - Changing the meaning of productivity

The concept of Digital Transformation

- Thus, Digital Transformation can offer tremendous opportunities for success, but there are also challenges that hinder the digital transition:

1) Lack of innovation
2) Lack of technical expertise
3) Difficulties in implementing new technologies
4) Underestimation of the effort to push innovation

The concept of Digital Transformation

- Thus, Digital Transformation can offer tremendous opportunities for success, but there are also challenges that hinder the digital transition:

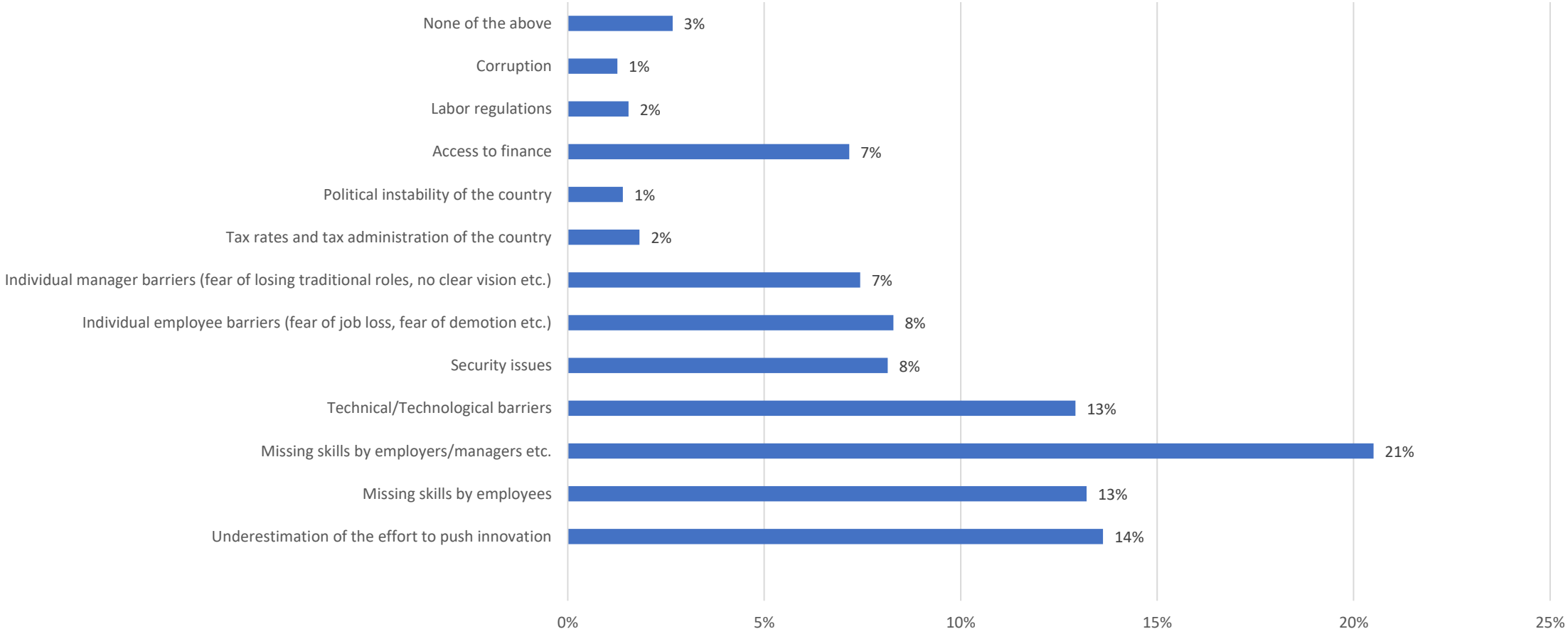
5) Technical barriers (dependency on other technologies)

6) Individual barriers (loss of data, fear of transparency and fear of job loss)

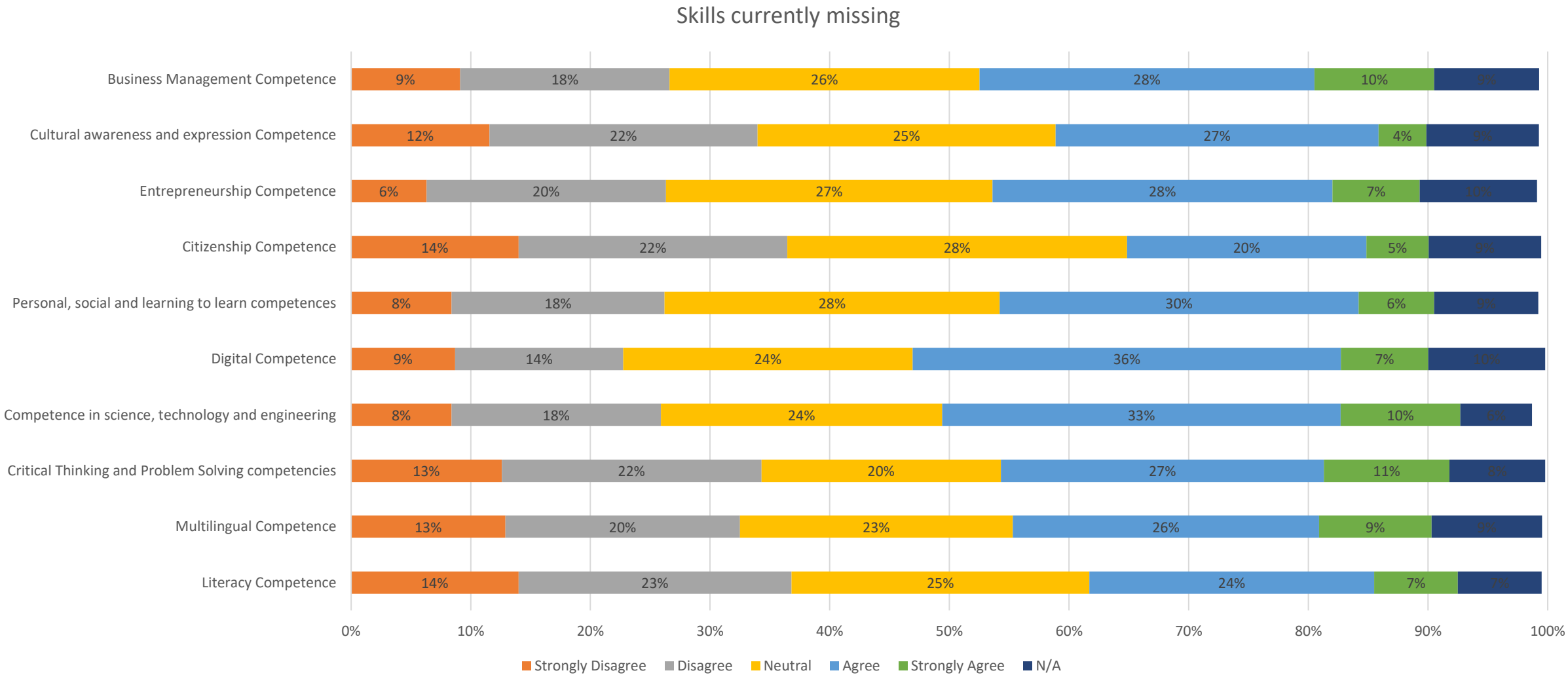
7) Organizational and cultural barriers (keeping traditional roles….)

8) Legal Framework (lack of standards, lack of laws)

- In the SYSTEMA project, we developed a survey to identify the types of barriers that people/managers/employees across Europe believe that hinder Digital Transformation:



- One of the most important barriers to Digital Transformation was Missing Skills from managers **AND** employees



EU and Digital Transformation

- Digital Compass

- **Skills:**
  - **ICT Specialists**
  - **Basic Digital Skills:** min 80% of the population
- **Secure and sustainable infrastructure**
  - **Connectivity**: Gigabit for everyone, 5G everywhere
  - **Cutting edge Semiconductors**: double EU share in global production
  - **Data- Edge and cloud**
  - **Computing**: first computer with quantum acceleration

EU and Digital Transformation

- Digital Compass

- **Digital Transformation of businesses:**
  - **Tech up-take:** 75% of EU companies using cloud/AI/Big Data
  - **Innovators**
  - **Late adopters:** More than 90% of SMEs reach at least a basic level of digital intensity
- **Digitalisation of public services**
  - **Key public Services**: 100% online
  - **e-Health**: 100% of citizens having access to medical records
  - **Digital identity**: 80% of citizens using digital ID

EU and Digital Transformation

- UNDP Digital Strategy
- Pathway 1

It focuses on using digital technologies to improve experiences and solve development challenges with the aim for innovation in delivery, co-creation, collaboration and advocacy.

EU and Digital Transformation

- UNDP Digital Strategy
- Pathway 2

It focuses on the use of digital technologies to improve the quality, relevance and impact of UNDP's work. The aim is for knowledge sharing, improved data usage and greater efficiency.

- In conclusion, Digital Transformation:

1. Complex process
2. It involves many processes of an organization
3. It is centered on human behavior, abilities and skills
4. Both external and internal factors could hinder the transition
5. It involves different stakeholders with different objectives

- Systems Thinking and System Dynamics are ideal candidates to assist in a **successful** Digital Transformation:

1. It allows the analysis of large-scale systems
2. It is easy to use and communicate
3. It allows the experimentation of different scenarios and “what if” analyses
4. It can account for different perspectives
5. It can incorporate aspects of human behavior

Recap of Systems Thinking and System Dynamics main concepts

- ST/SD are computer-based methodologies that facilitates the understanding of complex systems over time
- Main elements:
  - Flows
  - Stocks
  - Feedback loop
  - Time delays

Recap of Systems Thinking and System Dynamics main concepts

- ST/SD employ another qualitative tool to reveal insights about the systems under study:

Causal Loop Diagrams (CLDs)

Recap of Systems Thinking and System Dynamics main concepts

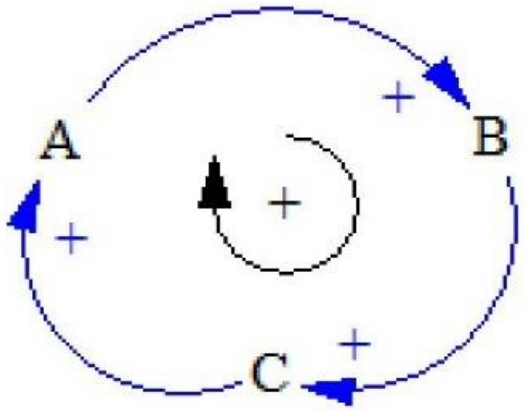
- Causal Loop Diagrams:
  - Mental maps
  - Causal links among system elements
  - Visualization of how system elements interact with each other
  - A graph with nodes (system elements/variables) and edges (causal links)

Recap of Systems Thinking and System Dynamics main concepts

A causal link can be of two types:

- **Positive**. It is marked as + and it means that the two variables change in the same direction. For example, if variable A increases then variable B also increases. Or if variable A decreases then variable B also decreases.
- **Negative**. It is marked as – and it means that the two variables change in opposite directions. For example, if variable A increases then variable B decreases. Or if variable A decreases then variable B increases.

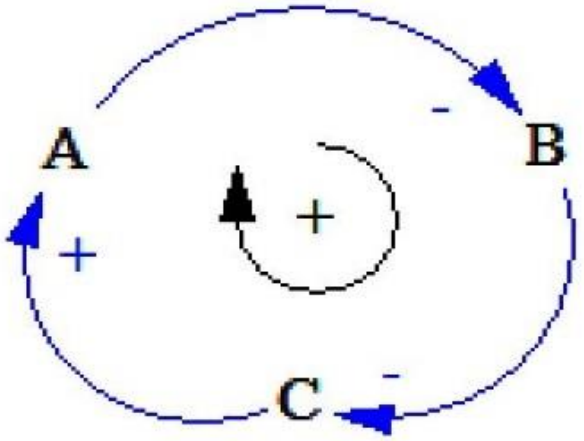
Recap of Systems Thinking and System Dynamics main concepts



In a CLD, closed cycles are usually formed which are called feedback loops and are one of the essential aspects of Systems Thinking. Similar to causal links there can be two types of feedback loops:

Positive feedback loop: assume that variable A increases. This increase is followed by an increase in variable B, which increases variable C and in turn further increases variable A.

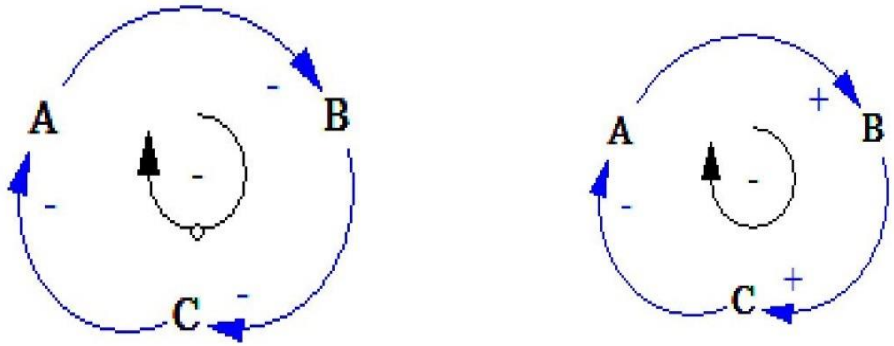
Recap of Systems Thinking and System Dynamics main concepts



In a CLD, closed cycles are usually formed which are called feedback loops and are one of the essential aspects of Systems Thinking. Similar to causal links there can be two types of feedback loops:

Positive feedback loop with negative signs: Assume an initial increase in variable A. Consequently, variable B will decrease which will cause an increase in variable C. The increase in variable C will cause a further increase in variable A. A rule of thumb of how to recognise a positive feedback loop in the presence of negative links is to count those negative links: if their number is even then the loop is positive.

Recap of Systems Thinking and System Dynamics main concepts

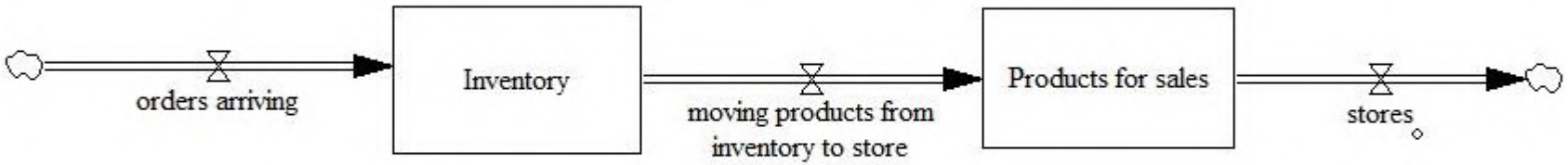


In a CLD, closed cycles are usually formed which are called feedback loops and are one of the essential aspects of Systems Thinking. Similar to causal links there can be two types of feedback loops:

Negative feedback loop: it is formed when all links are negative (or when their number is odd). For example, in figure 10 on the left, an increase in variable A will cause a decrease in variable B, which will increase variable C that will cause a decrease in variable A. This final decrease of variable A might cancel the initial increase of the variable and for that reason negative feedback loops are also called balancing loops.

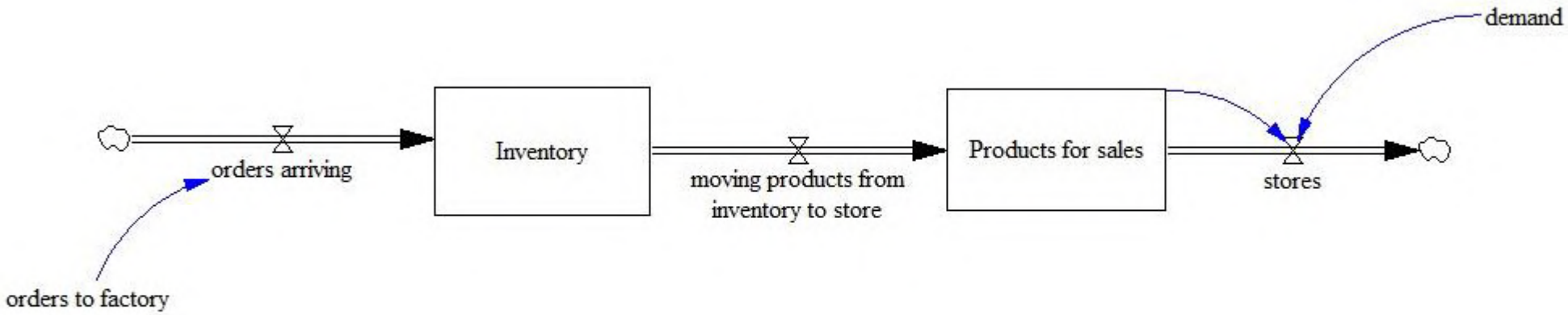
Example Systems Thinking and System Dynamics and Digital Transformation

- In supply chain:



Example Systems Thinking and System Dynamics and Digital Transformation

- In supply chain:



Example Systems Thinking and System Dynamics and Digital Transformation

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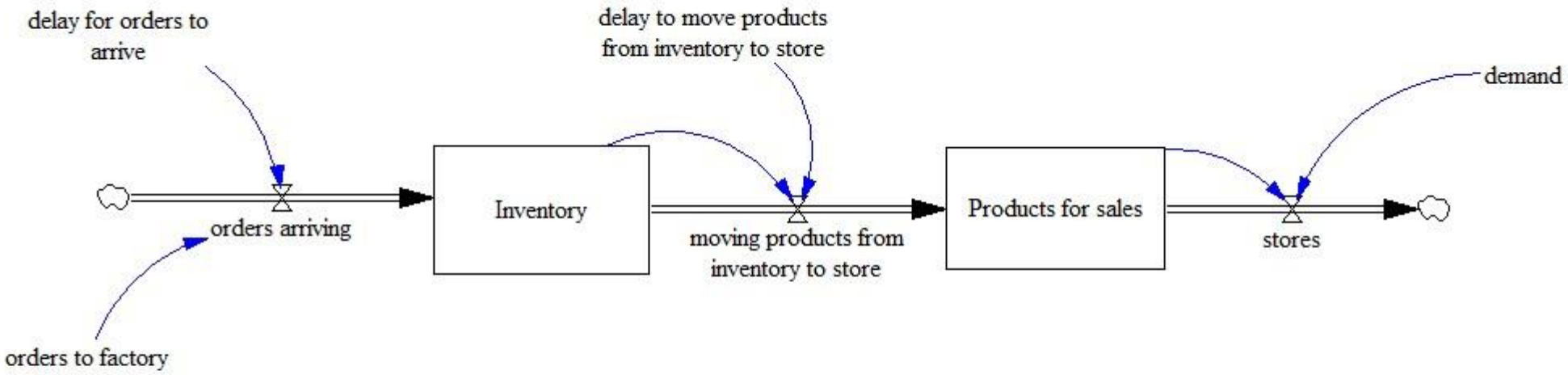
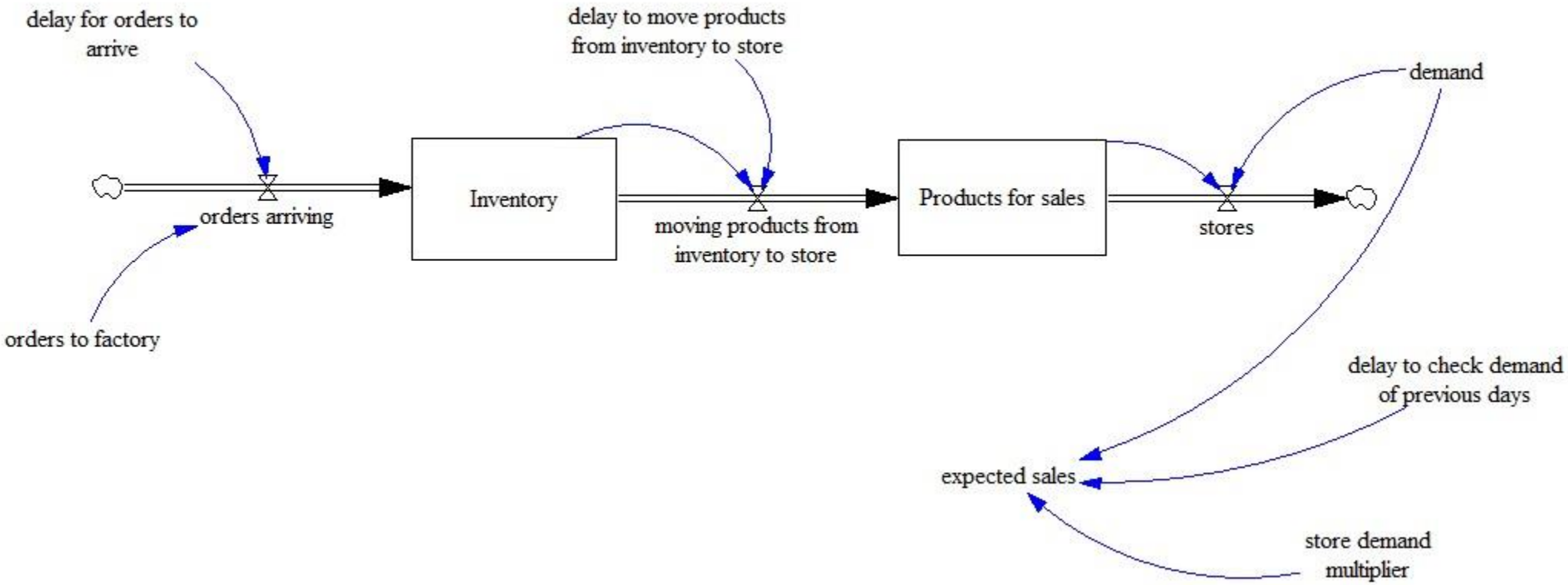


Example Systems Thinking and System Dynamics and Digital Transformation

- In supply chain:



Example Systems Thinking and System Dynamics and Digital Transformation

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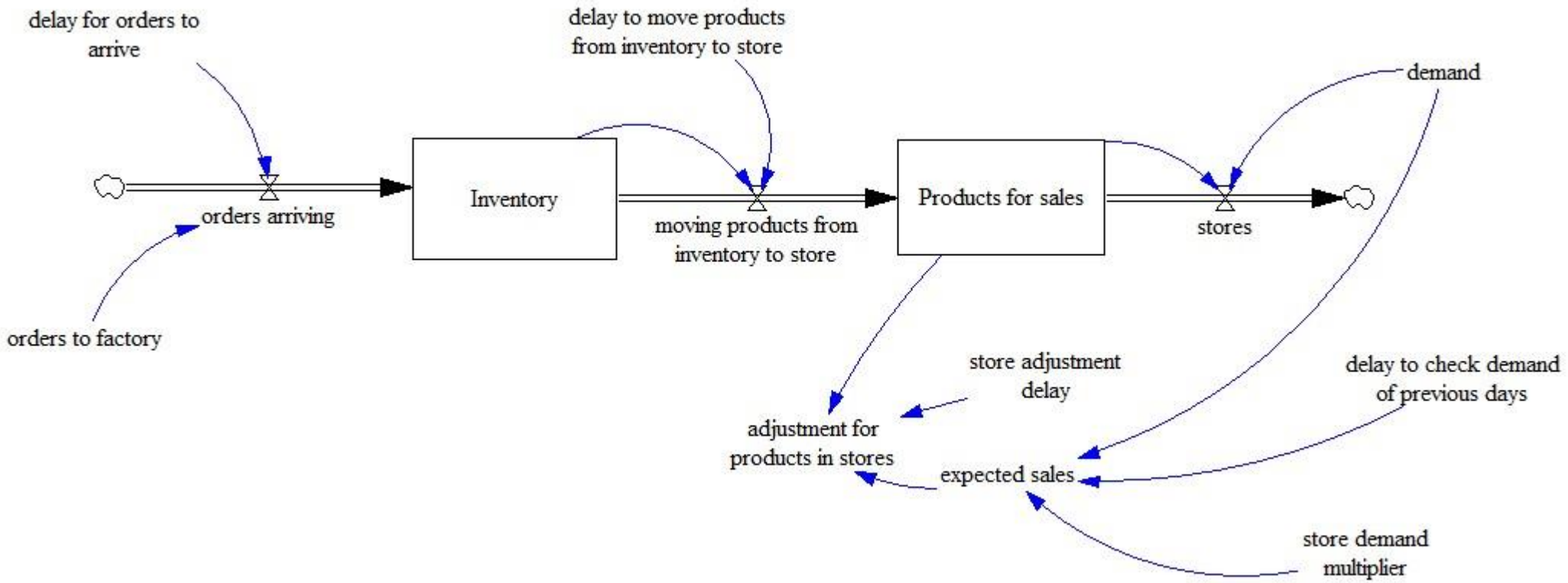

Example Systems Thinking and System Dynamics and Digital Transformation

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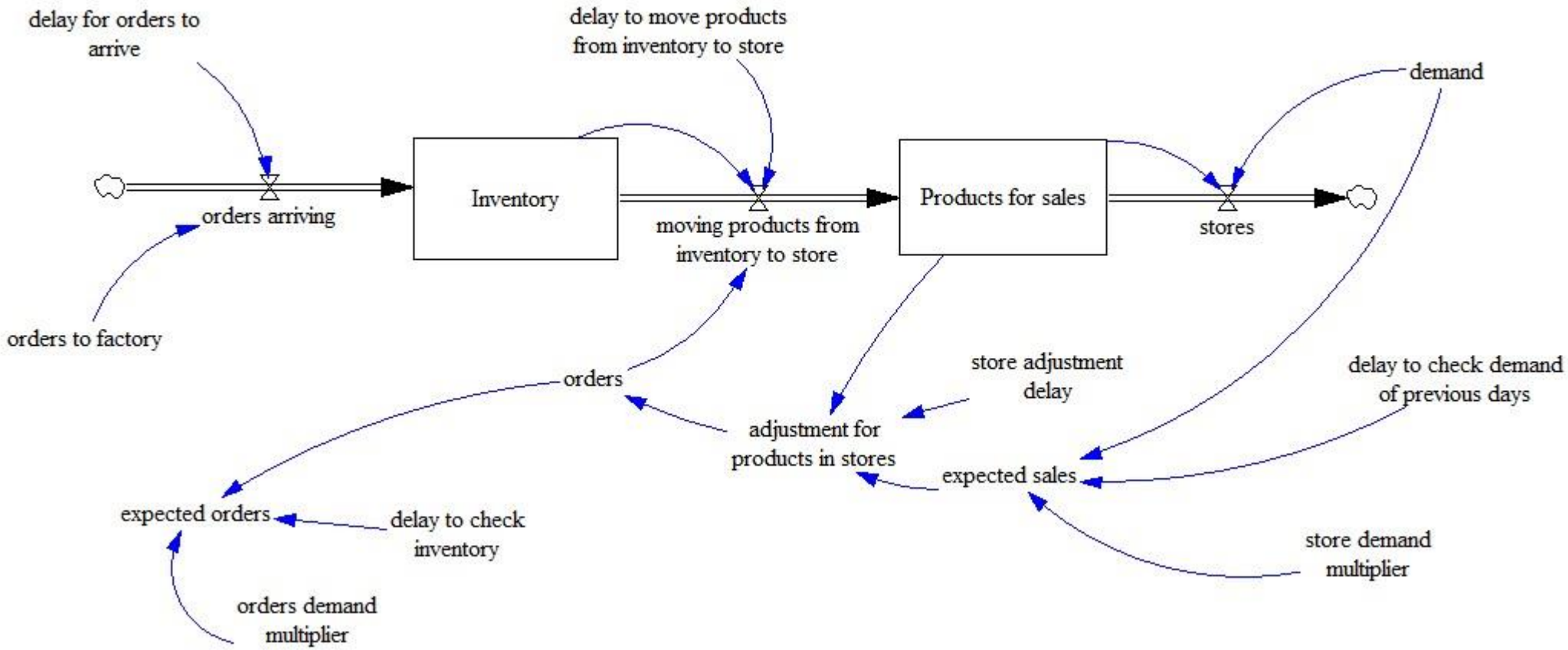

Example Systems Thinking and System Dynamics and Digital Transformation

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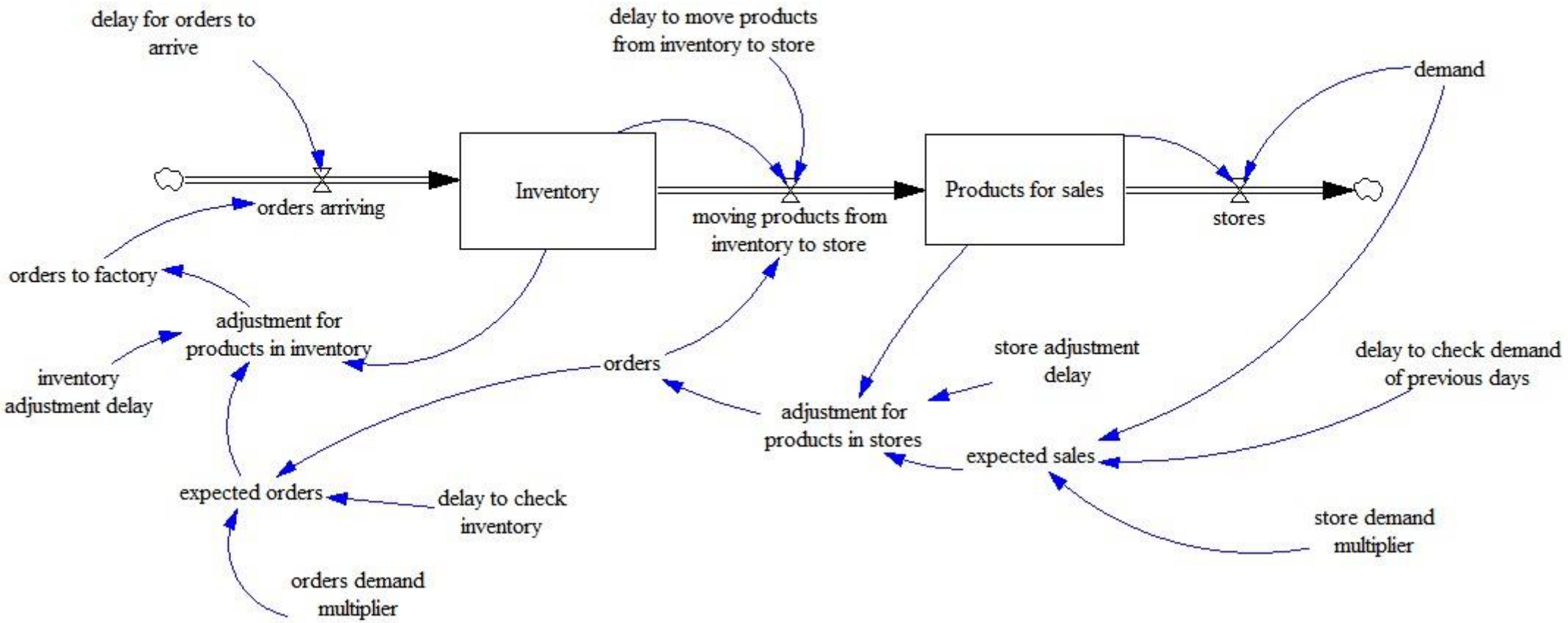

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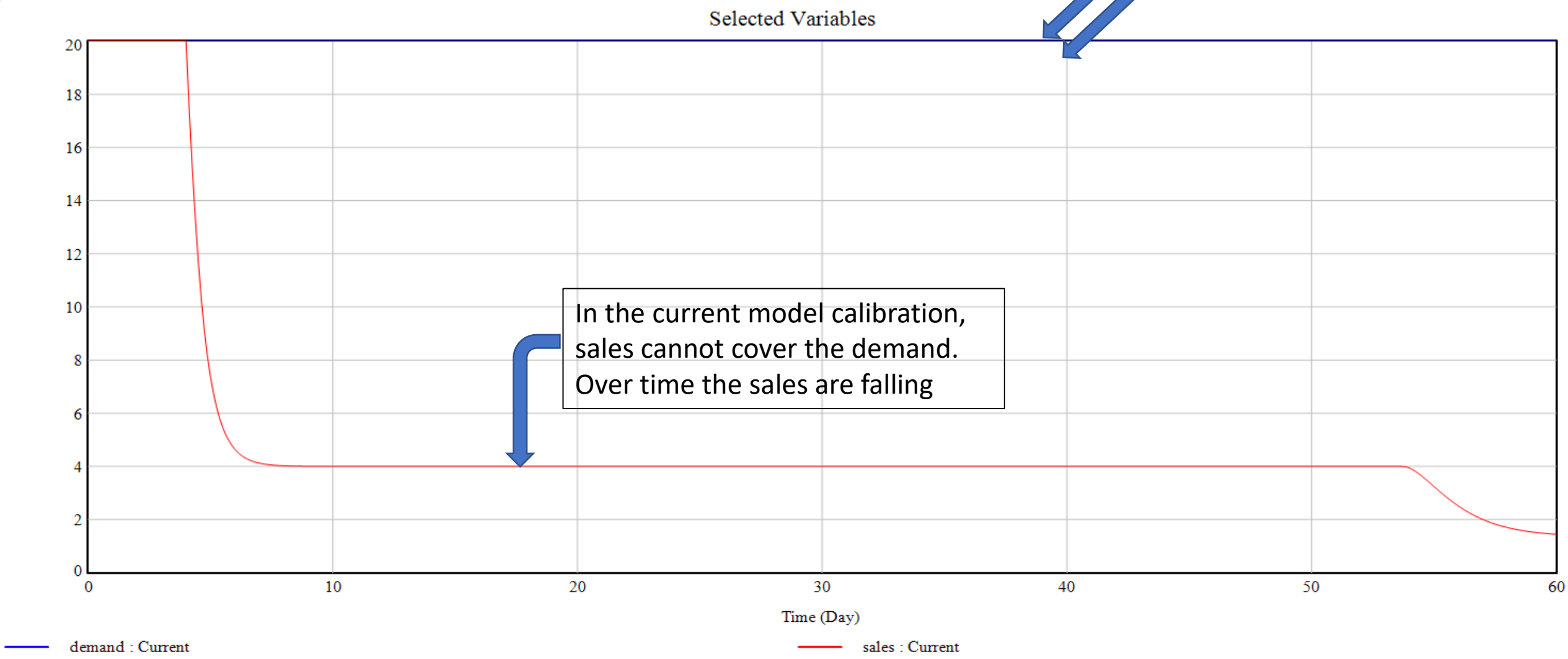
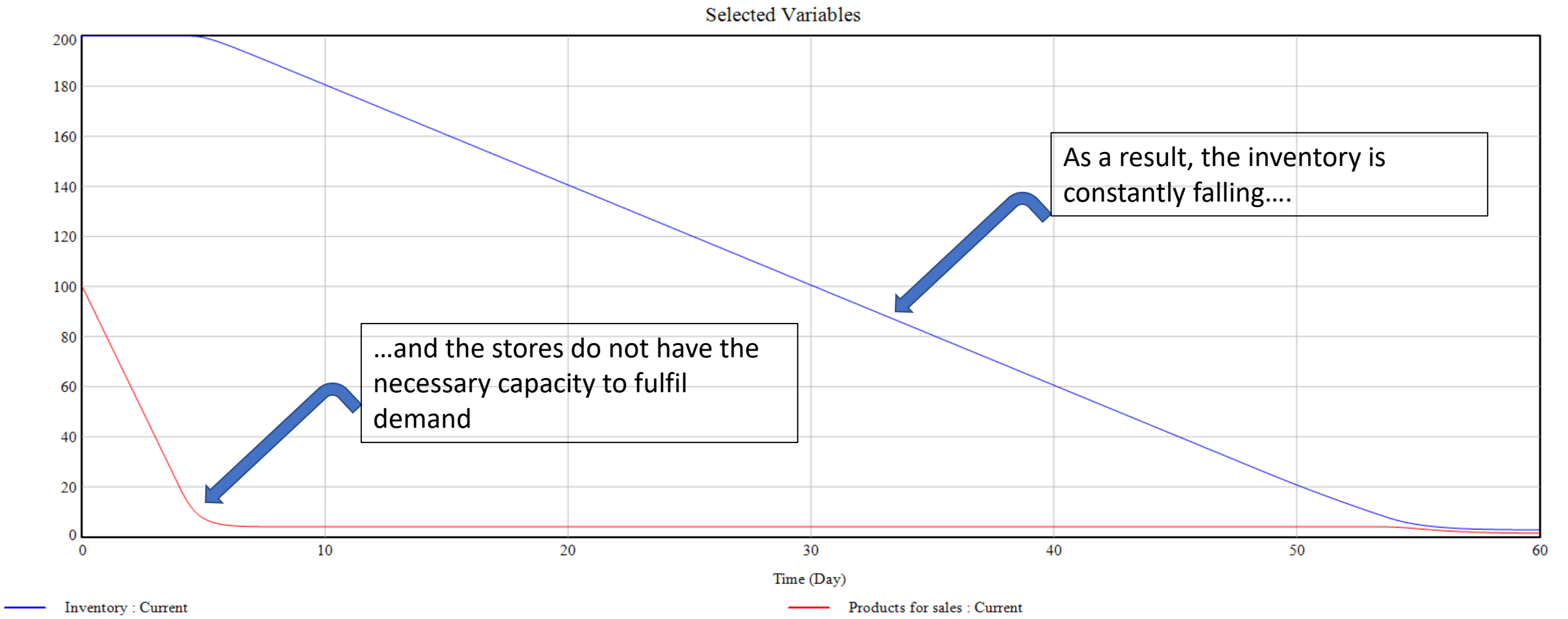


Example Systems Thinking and System Dynamics and Digital Transformation

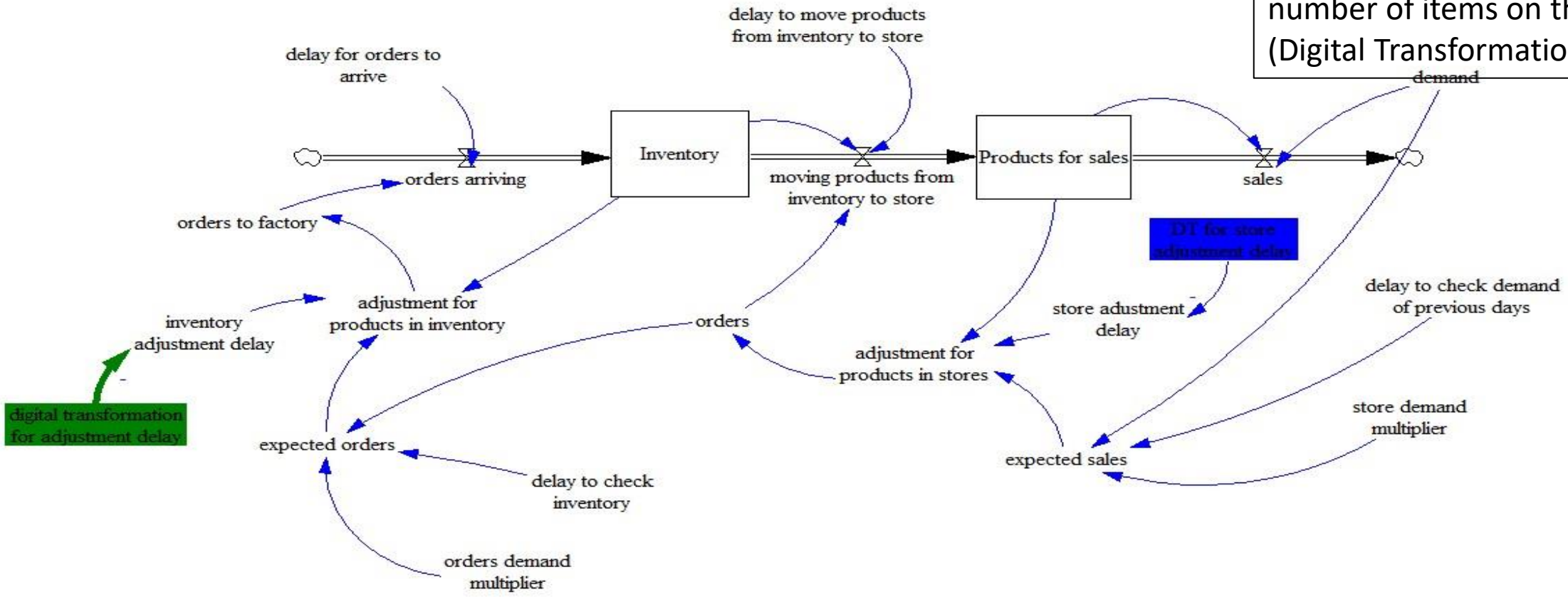
- In supply chain:



Example Systems Thinking and System Dynamics and Digital Transformation

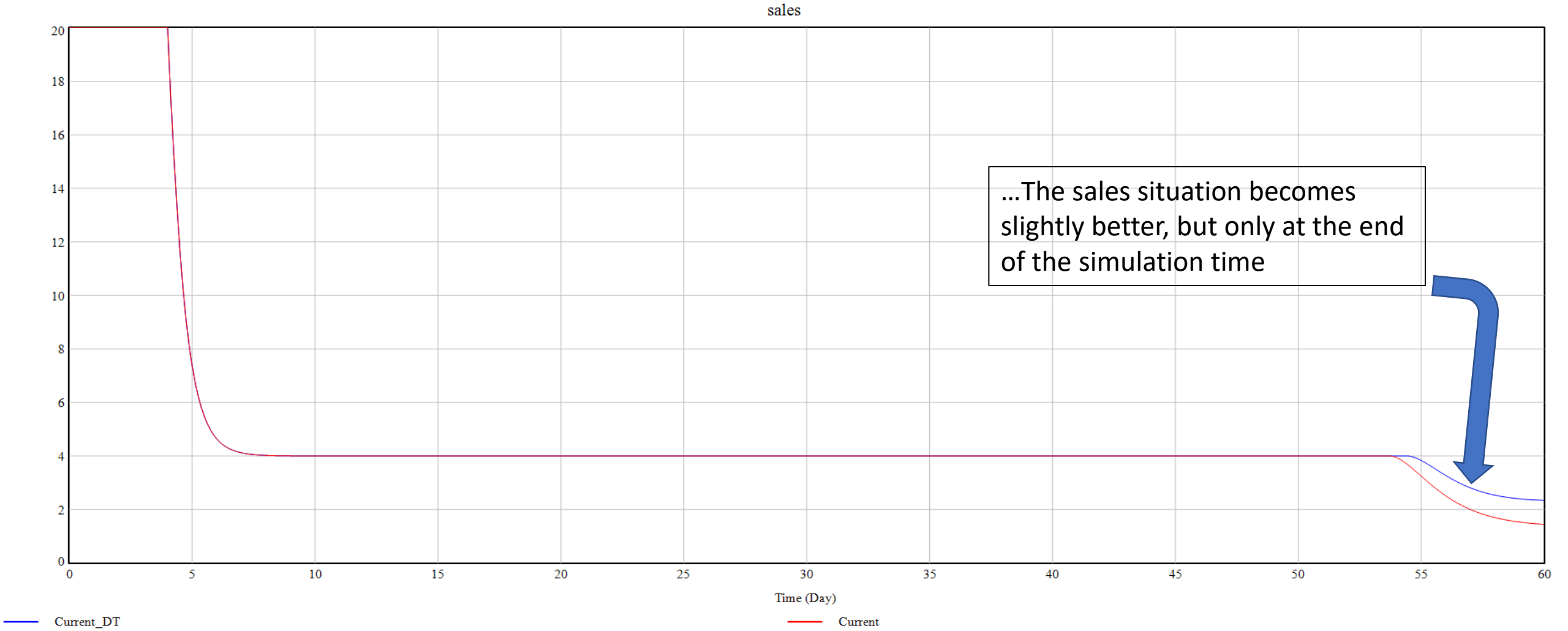
- In supply chain-where can Digital Transformation help?:

If we apply a digital adjustment for the check of inventory and the number of items on the shelves (Digital Transformation)….



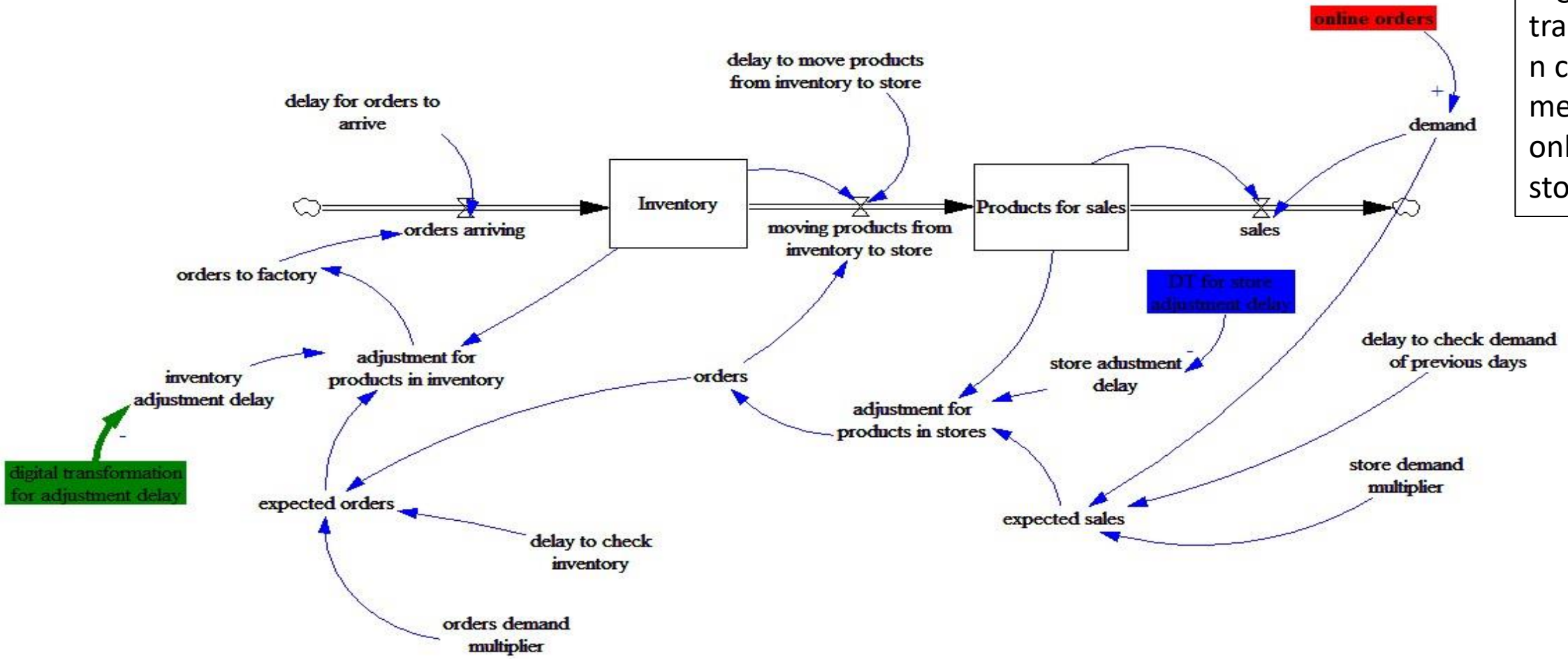
Example Systems Thinking and System Dynamics and Digital Transformation

- In supply chain-where can Digital Transformation help?:



Example Systems Thinking and System Dynamics and Digital Transformation

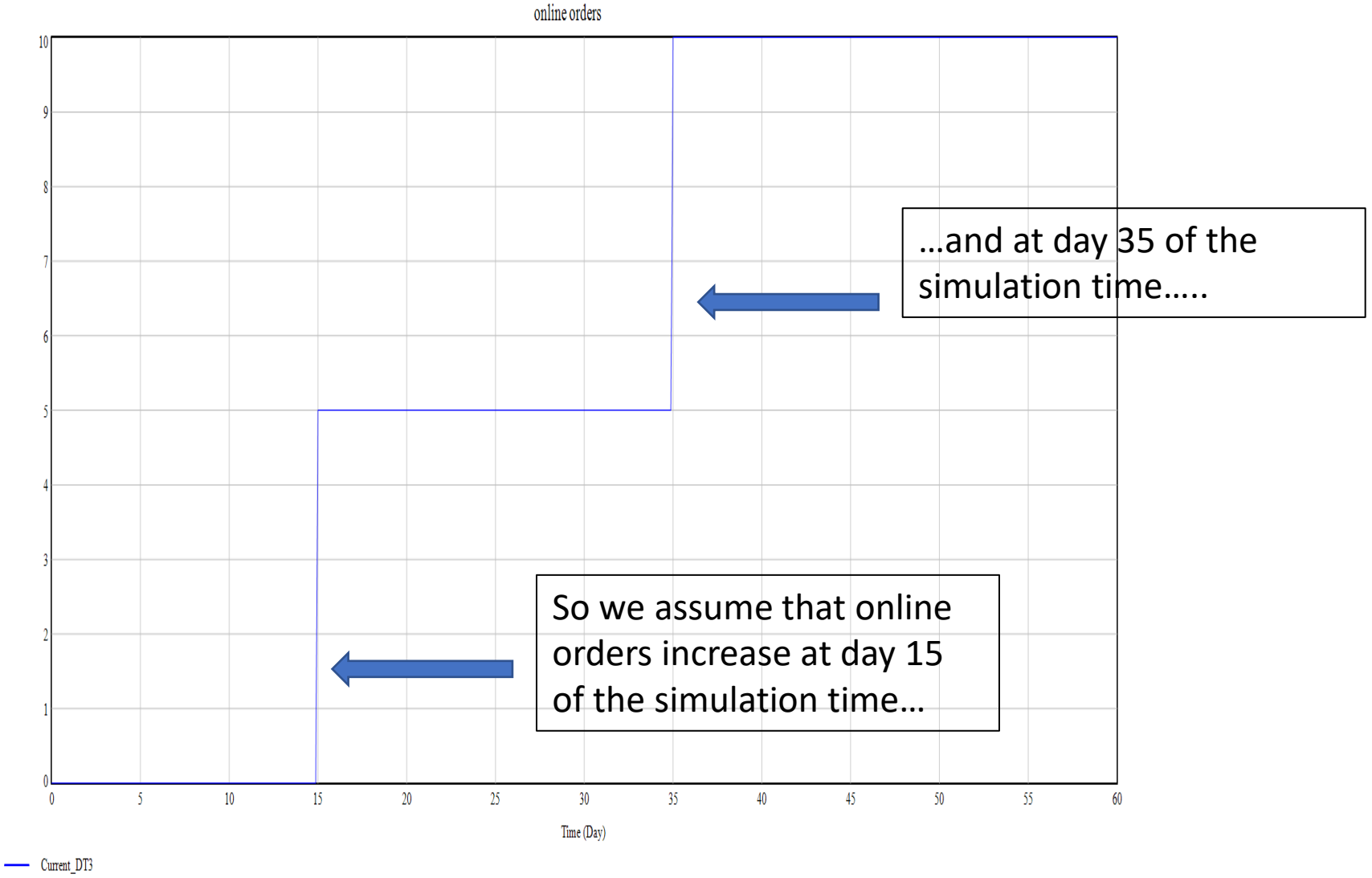
- In supply chain-where can Digital Transformation be challenging?:



Digital transformation could also mean an online store….

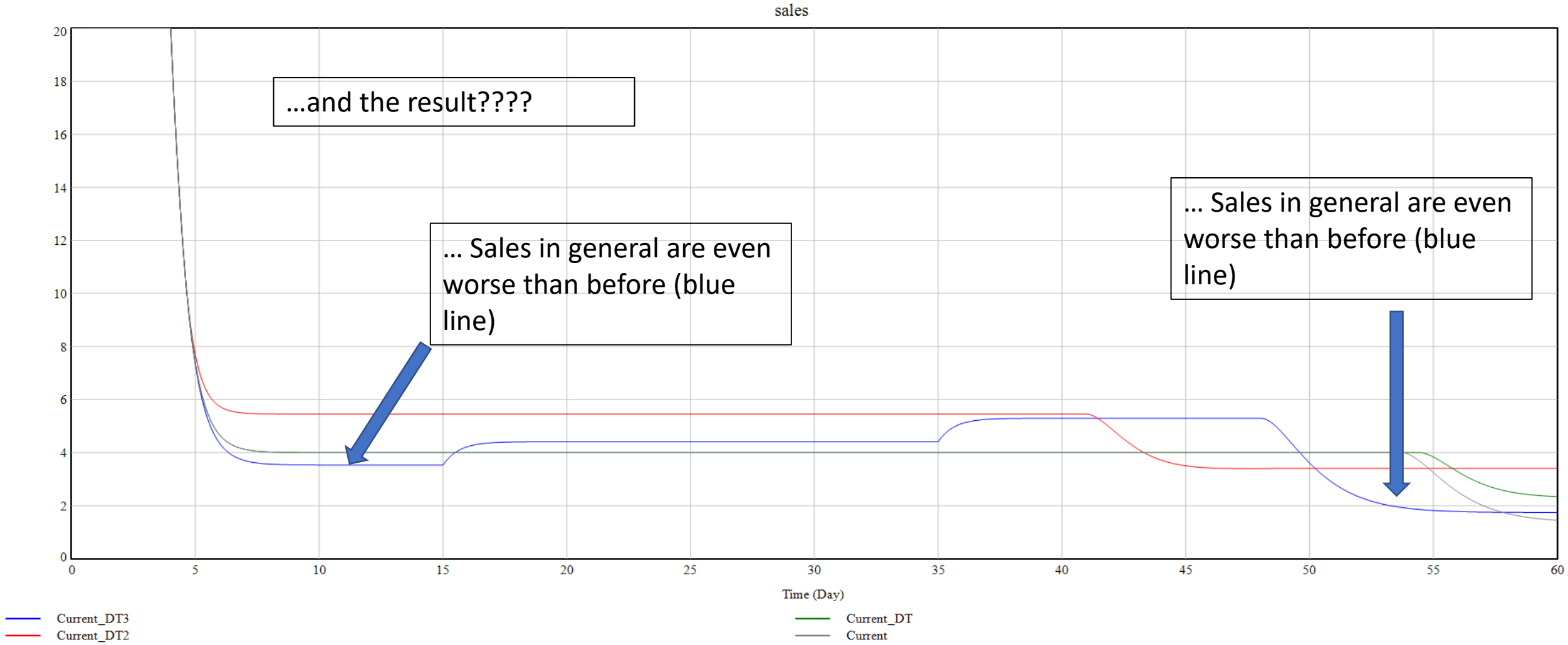
Example Systems Thinking and System Dynamics and Digital Transformation

- In supply chain-where can Digital Transformation be challenging?:



Example Systems Thinking and System Dynamics and Digital Transformation

- In supply chain-where can Digital Transformation be challenging?:

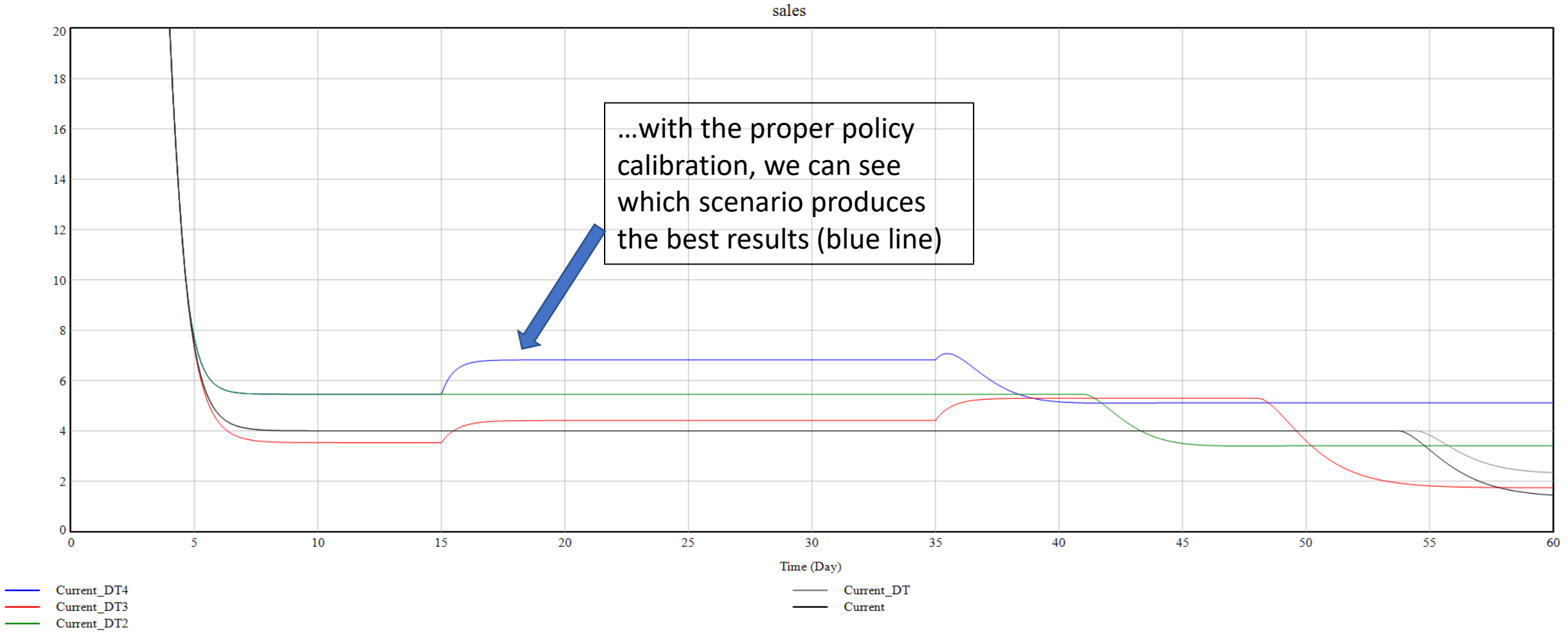


Example Systems Thinking and System Dynamics and Digital Transformation

- Thus, Digital Transformation does not necessarily mean a successful business/organization
- There is the need for policy design and strategy
- Only robust and well-thought off policies can release the potential of Digital Transformation
- Systems Thinking and System Dynamics can assist managers, policy makers, stakeholders in general to formulate robust strategies and test them in a consequence-free environment

Example Systems Thinking and System Dynamics and Digital Transformation

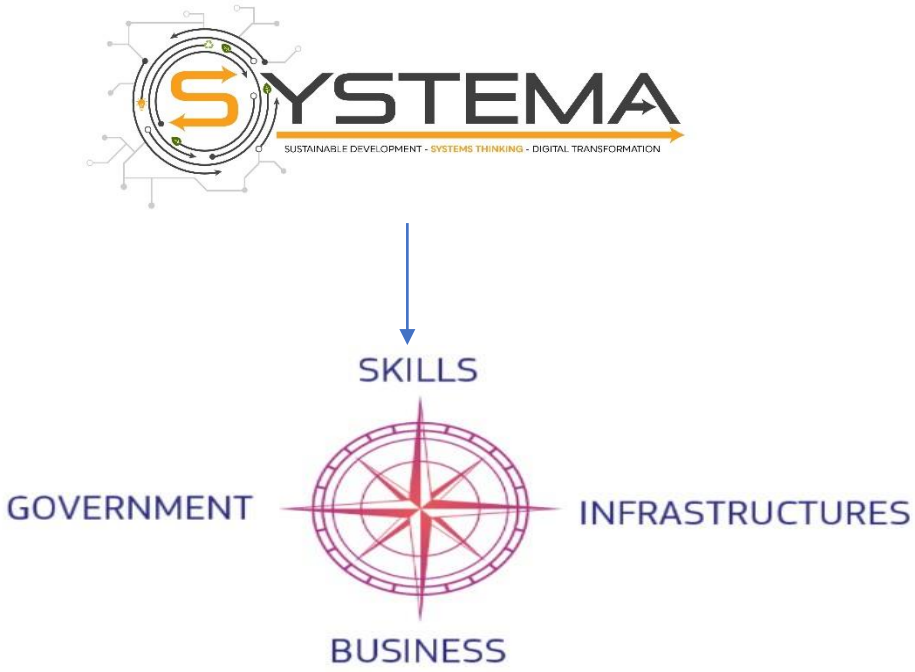
- For example, in supply chain-with the help of ST and SD we can calibrate and find the appropriate mix of policies:



Systems Thinking, System Dynamics and the SYSTEMA project

The SYSTEMA project was conceived to address the incentive of the European Commission, focused on Sustainable Development and Digital Transformation. The partners of the SYSTEMA project believe that the **core ability to achieve the transversal skills necessary in the 21st century is to fully understand the dynamics of such problems by means of Systems Thinking**

Systems Thinking, System Dynamics and the SYSTEMA project



Systems Thinking, System Dynamics and the SYSTEMA project

At its core, the SYSTEMA project is focused on providing advanced training that will include:

- the ability to know how to observe and grasp the “circular” nature of the world we live in
- building a higher awareness of the role of the "systems" structure in determining their behaviour
- understanding the role and impacts on the behaviour of a system due to its feedback loops
- understanding of the presence of systemic delays between actions and impacts
- understanding that there are potentially unexpected consequences for actions

Systems Thinking, System Dynamics and the SYSTEMA project

The SYSTEMA target groups are driven by the Compass:

Teachers, trainers, academia etc.

Policy makers

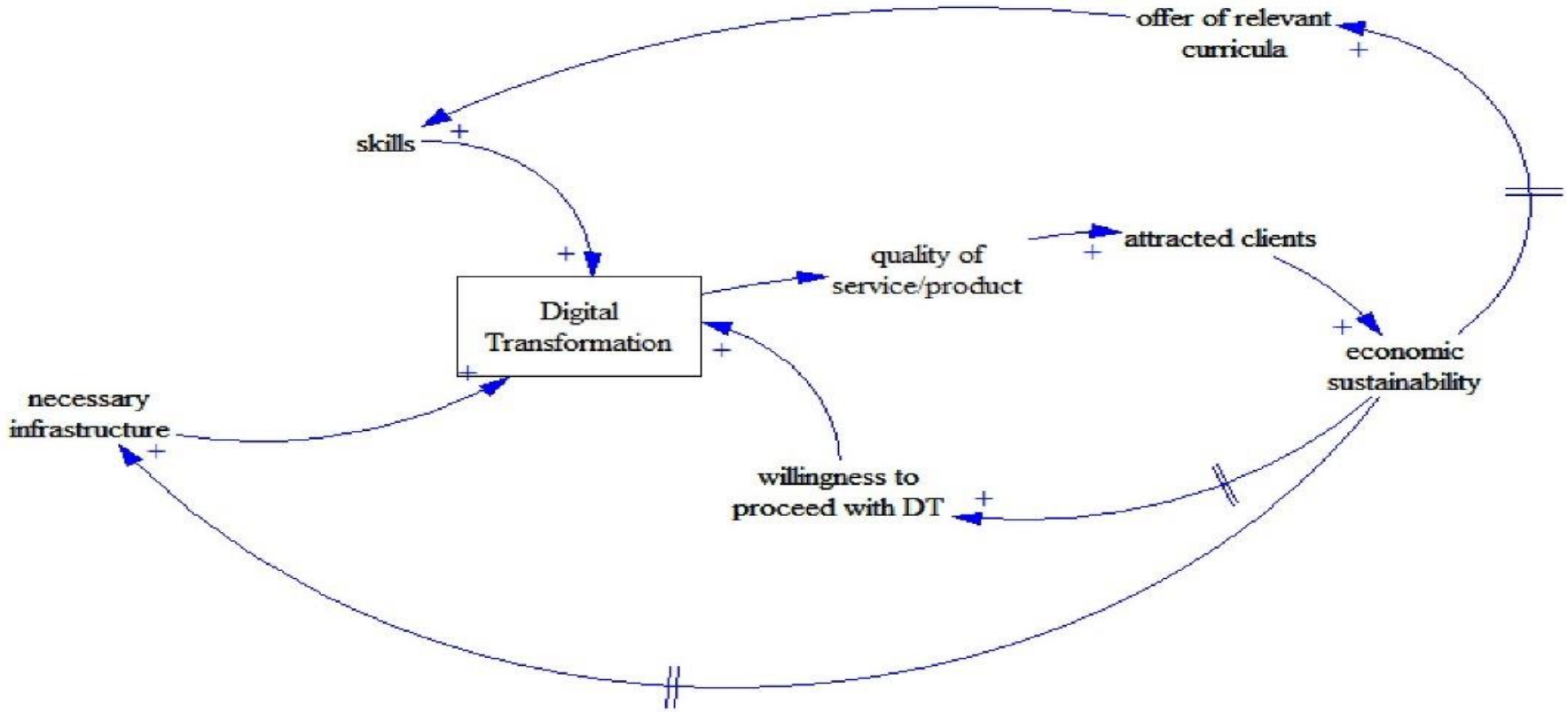
Managers, Researchers

Managers, employees, consultants etc.

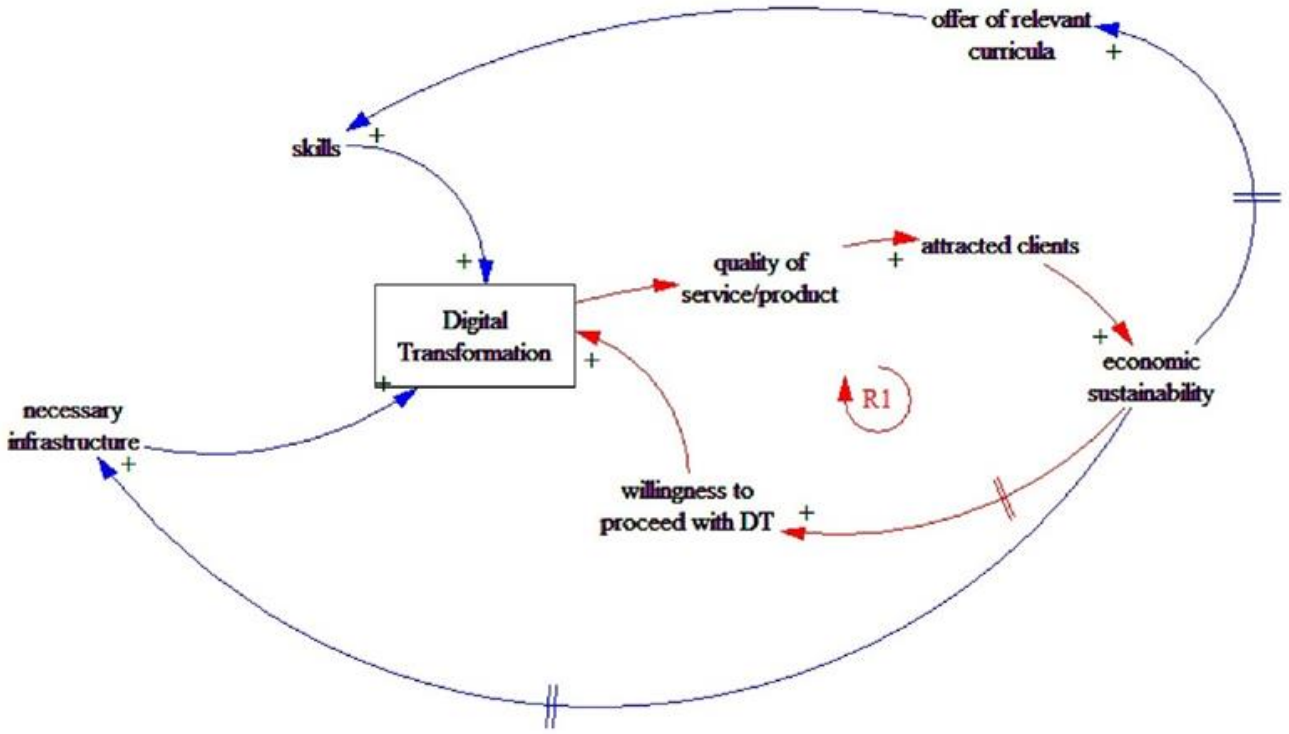
Simple example of ST/SD for Digital Transformation

A general, top-down CLD of the role Digital Transformation can have for an organization

- Derived from the literature and EU Frameworks
- Not based on data
- Simple exercise to understand how DT can be achieved, what can offer and which are the challenges



Simple example of ST/SD for Digital Transformation

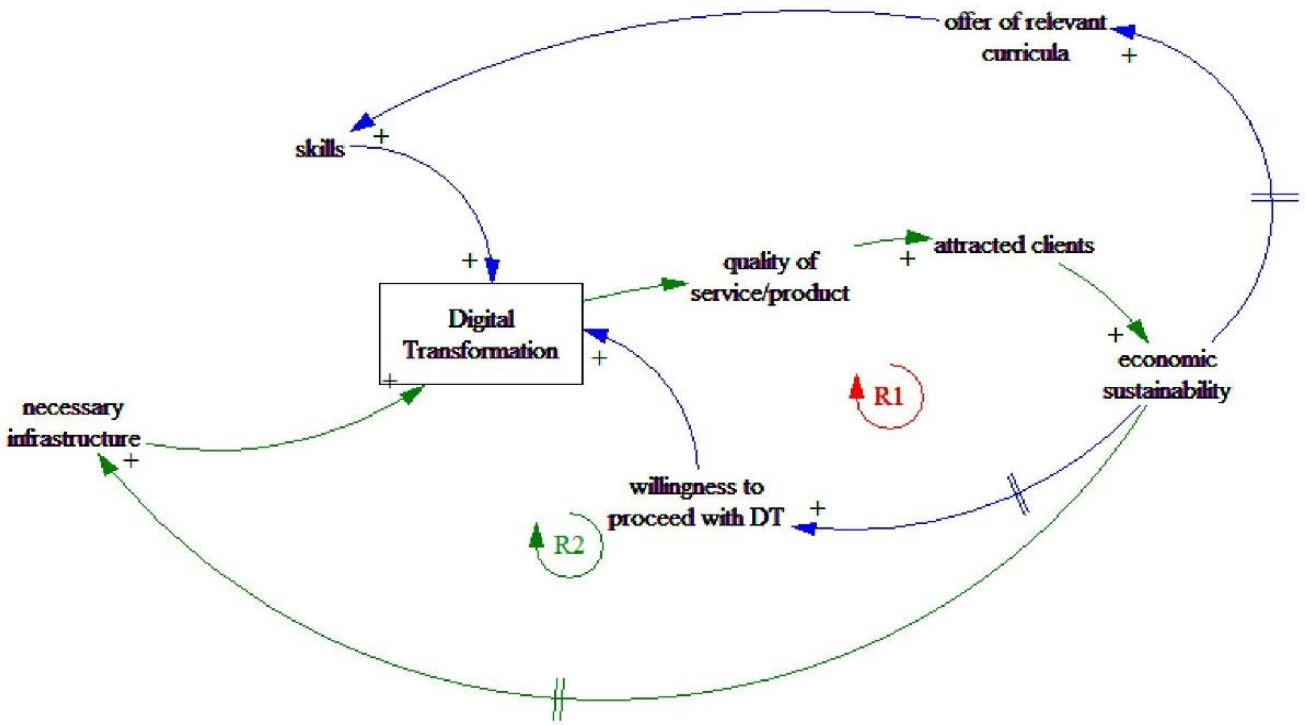


The more successful the Digital Transformation is, the higher the quality of the products or services offered will be.

In turn, high quality will attract more clients (in the broadest of terms) which can increase the sustainability of the organisation.

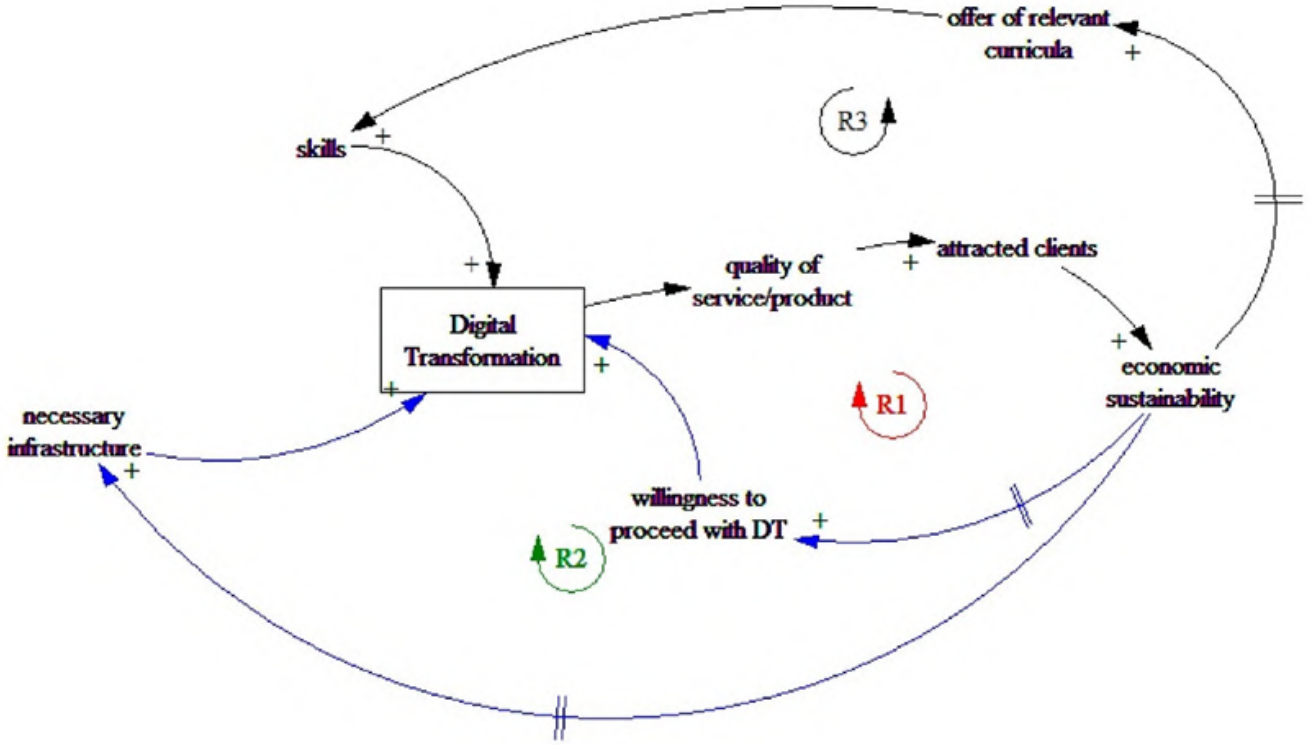
Increased sustainability means that managers will be more willing to proceed with DT, which can then increase the DT of the organisation

Simple example of ST/SD for Digital Transformation



An increase in Digital Transformation increases the quality of the service/product,
which increases the attractiveness to clients that in turn acts positively in the economic sustainability of the organisation.
This sustainability can result in improvement of the necessary infrastructure which further increase the Digital Transformation of the organisation

Simple example of ST/SD for Digital Transformation



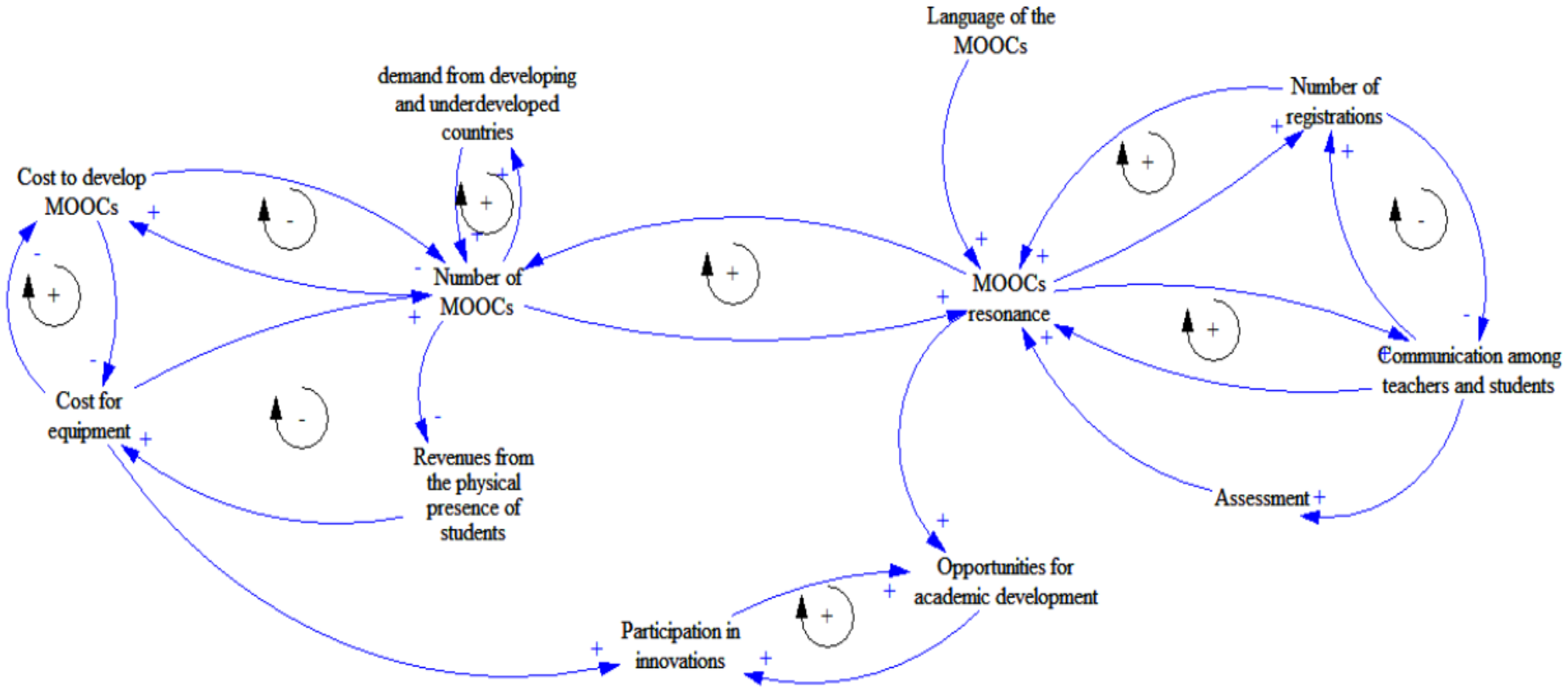
Finally, economic sustainability and general success can increase (after a delay) the number of education opportunities that would increase the skills of personnel which can result in increased Digital Transformation

Concrete example of ST/SD for Digital Transformation

Tsaple, V., & Tzionas, P. (2019). Qualitative system dynamics models to assess the effect of MOOCs on the system of tertiary education. *Journal of Contemporary Education, Theory & Research*, *3*(1), 3-8.

The objective of the paper is to study the structure of the higher education system with the presence of MOOCs and to investigate the behaviour that may occur in time, using Systems Thinking

Concrete example of ST/SD for Digital Transformation



Concrete example of ST/SD for Digital Transformation

Lessons:

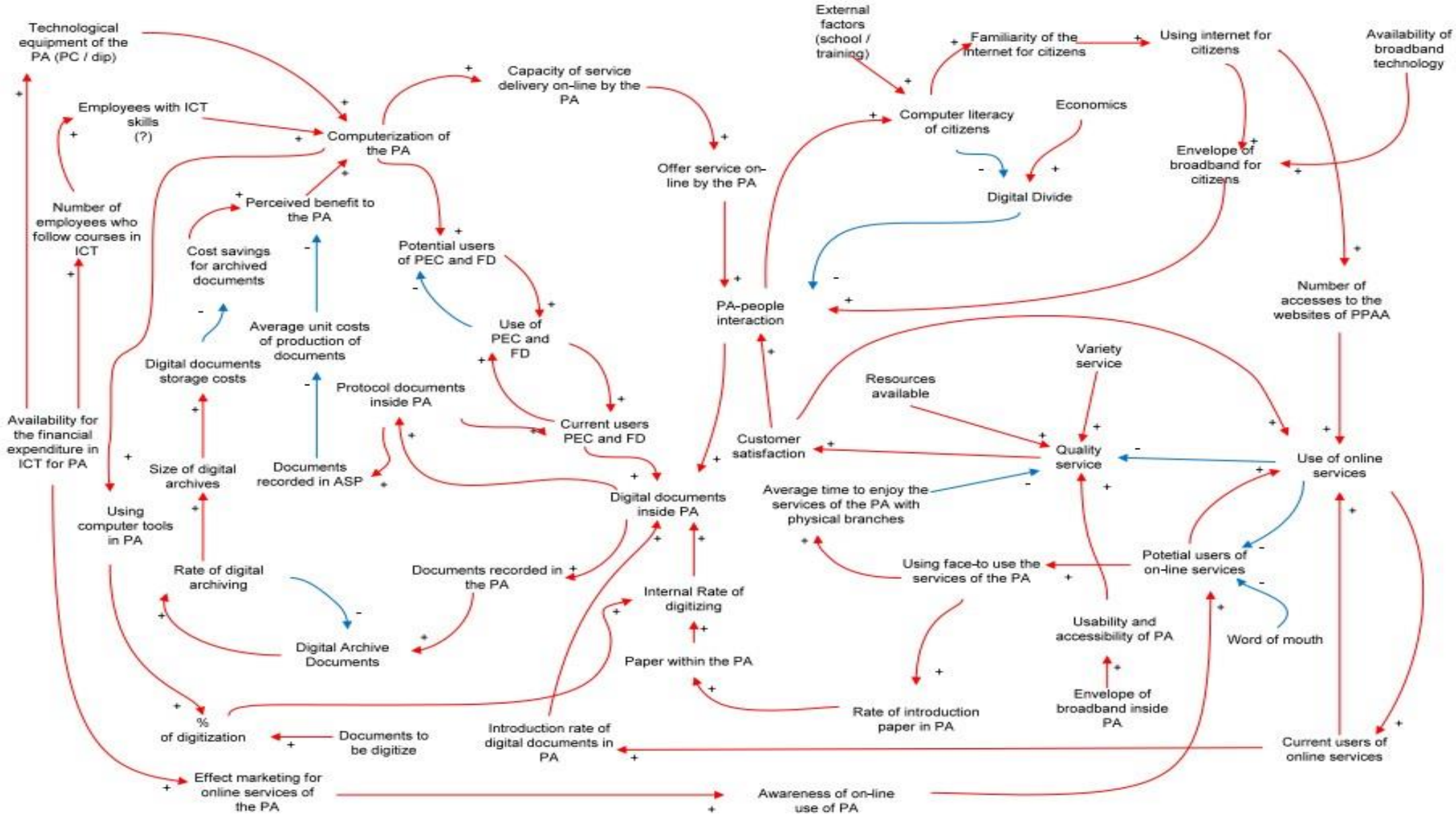
The CLD illustrates in a clear way the complexity of the system. Since MOOCs are an innovative approach to education in its early stages, it is not easy to understand their long-term effect, due to that complexity of the system

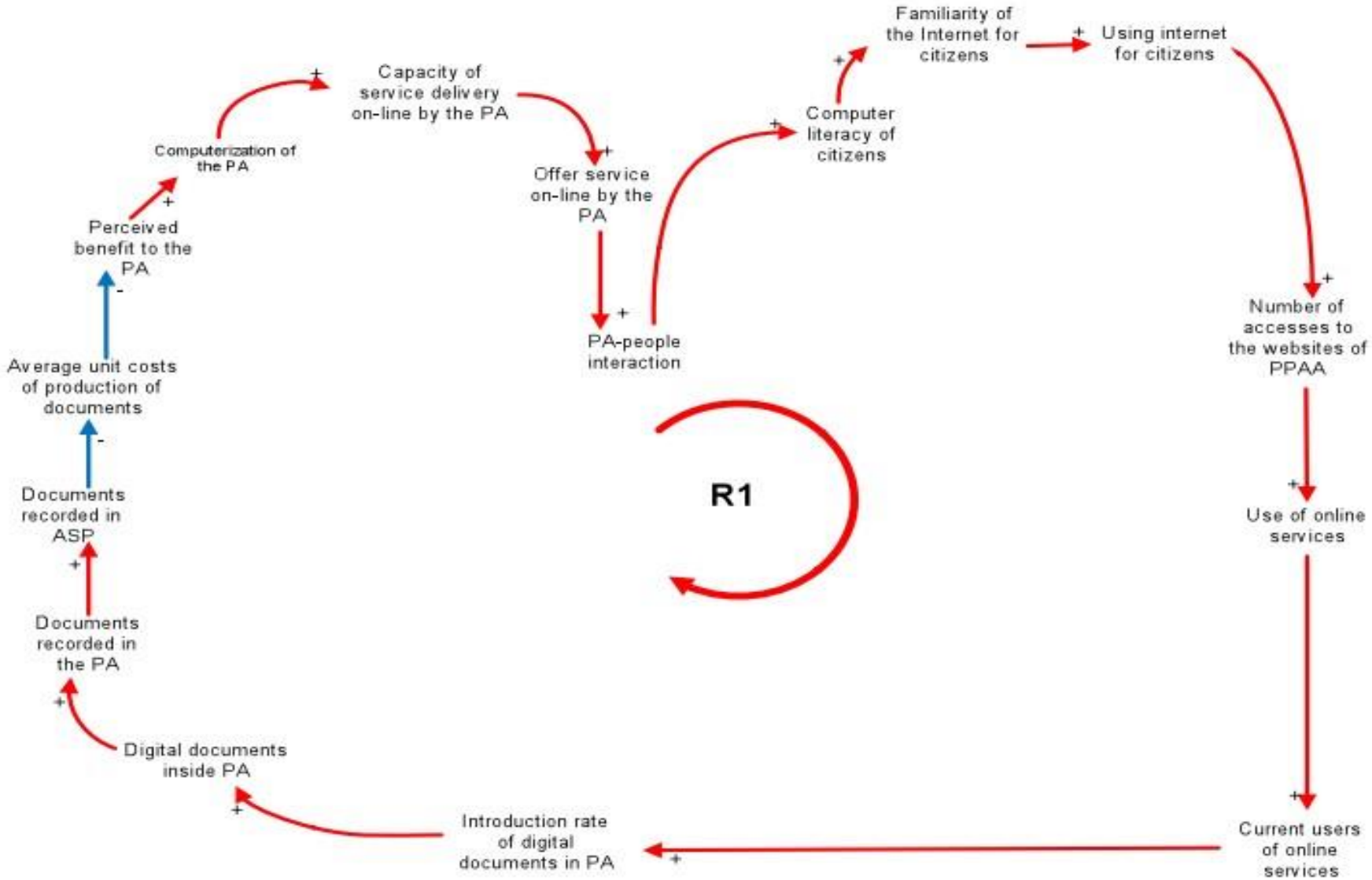
Cost is a variable that appears in all the CLDs either the cost to enroll (for students) or the cost to make a MOOC (academics and literature review). However, to fully comprehend the effect of cost, more research is necessary especially with quantitative methods

Concrete example of ST/SD for Digital Transformation

Casalino, N., Armenia, S., Medaglia, C., & Rori, S. (2010). A new system dynamics model to improve internal and external efficiency in the paper digitization of Italian Public Administrations. European Academy of Management, EURAM 2010..

How paper documents can be replaced from full electronic ones without necessarily breaking any term of law

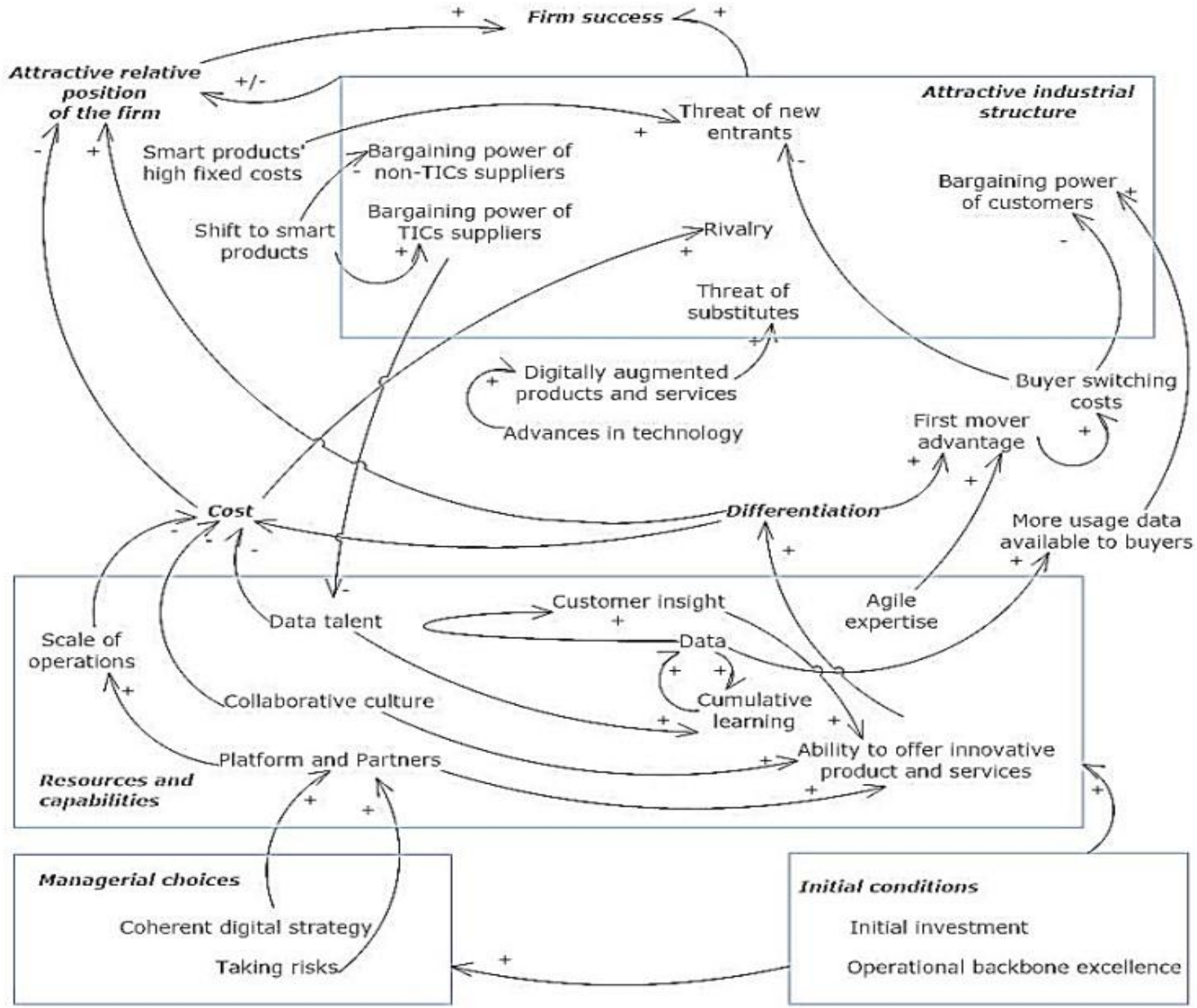

Technological equipment of the PA (PC / dip)
Employees with ICT skills (?)
Computerization of the PA
Capacity of service delivery on-line by the PA
External factors (school / training)
Familiarity of the internet for citizens
Using internet for citizens
Availability of broadband technology
Computer literacy of citizens
Economics
Digital Divide
Envelope of broadband for citizens
Offer service on-line by the PA
Number of employees who follow courses in ICT
Perceived benefit to the PA
Cost savings for archived documents
Potential users of PEC and FD
Average unit costs of production of documents
Use of PEC and FD
PA-people interaction
Number of accesses to the websites of PPAA
Digital documents storage costs
Protocol documents inside PA
Current users PEC and FD
Variety service
Resources available
Availability for the financial expenditure in ICT for PA
Size of digital archives
Documents recorded in ASP
Customer satisfaction
Quality service
Use of online services
Digital documents inside PA
Average time to enjoy the services of the PA with physical branches
Using computer tools in PA
Rate of digital archiving
Documents recorded in the PA
Internal Rate of digitizing
Using face-to use the services of the PA
Potetial users of on-line services
Digital Archive Documents
Usability and accessibility of PA
Word of mouth
Paper within the PA
% of digitization
Documents to be digitize
Introduction rate of digital documents in PA
Rate of introduction paper in PA
Envelope of broadband inside PA
Current users of online services
Effect marketing for online services of the PA
Awareness of on-line use of PA

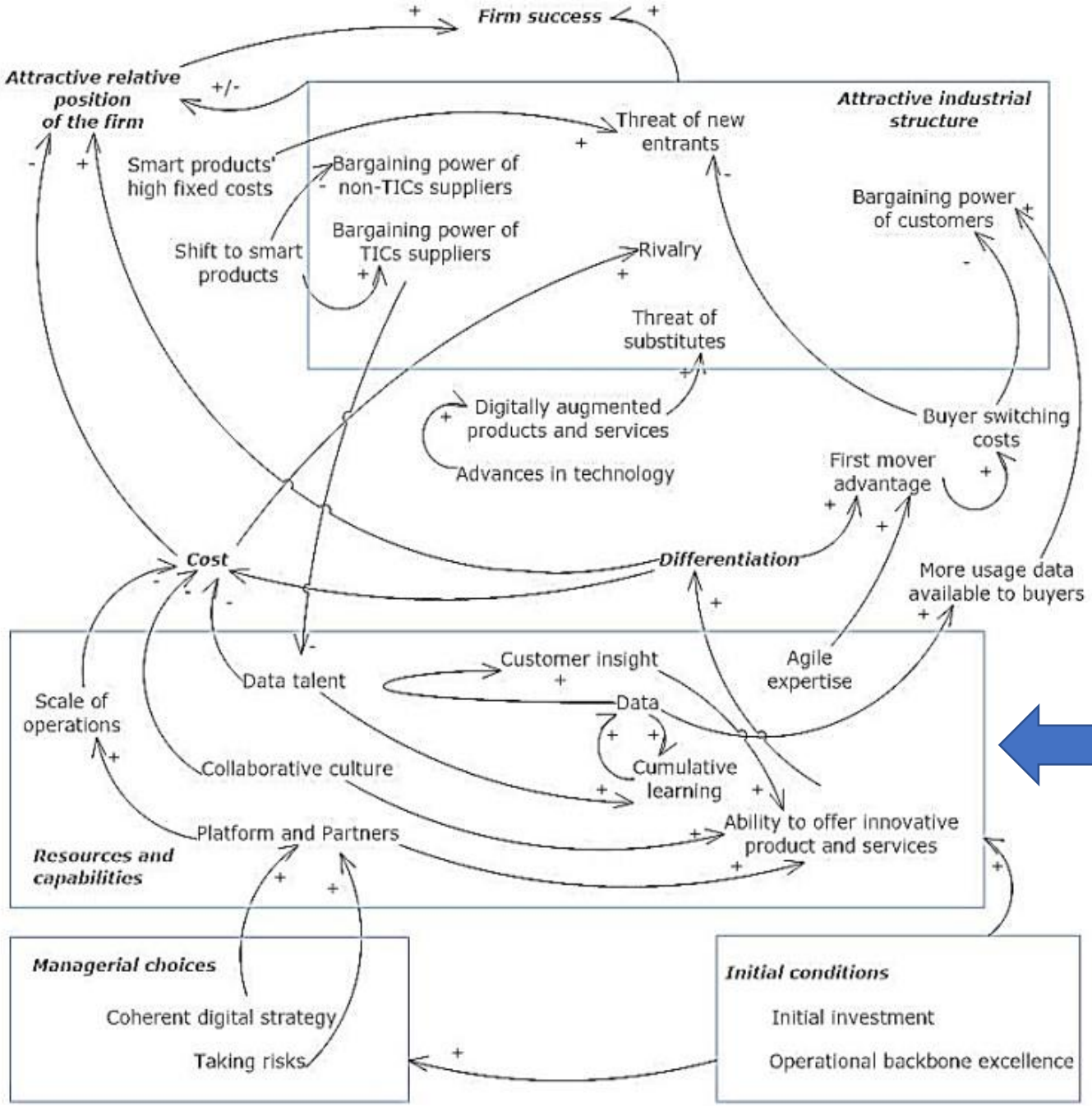

Familiarity of the Internet for citizens
Using internet for citizens
Capacity of service delivery on-line by the PA
Computer literacy of citizens
Computerization of the PA
Offer service on-line by the PA
Perceived benefit to the PA
PA-people interaction
Number of accesses to the websites of PPAA
Average unit costs of production of documents
R1
Documents recorded in ASP
Use of online services
Documents recorded in the PA
Digital documents inside PA
Introduction rate of digital documents in PA
Current users of online services

Concrete example of ST/SD for Digital Transformation

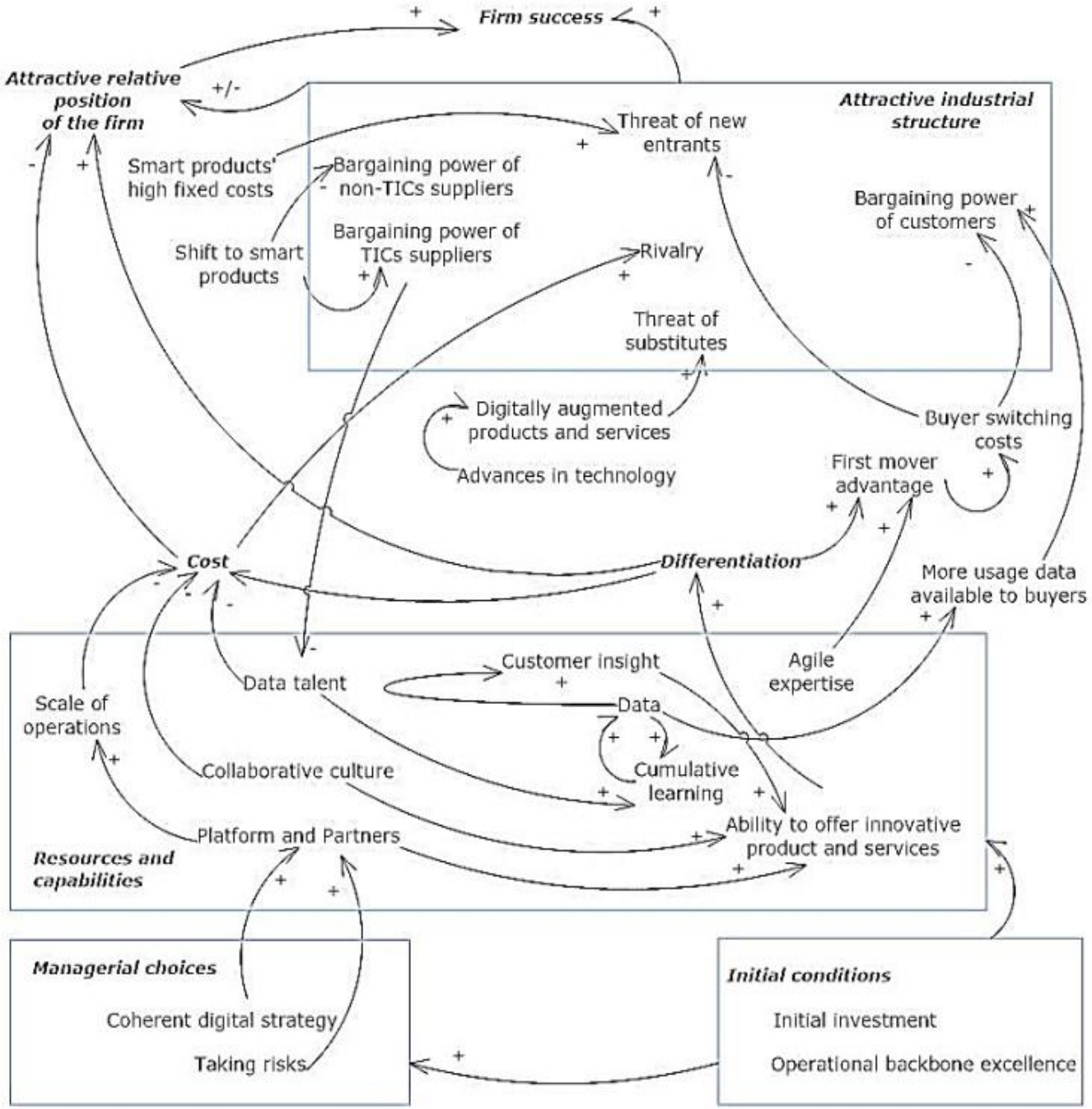
Sánchez, M. A. (2017). A framework to assess organizational readiness for the digital transformation. *Dimensión Empresarial*, *15*(2), 27-40.

The aim of the paper is to formulate a framework that explains resources, capabilities and
management choices to assess readiness for Digital Transformation


Firm success
Attractive relative position of the firm
+/-
Attractive industrial structure
Threat of new entrants
Smart products' high fixed costs
Bargaining power of non-TICs suppliers
Bargaining power of customers
Shift to smart products
Bargaining power of TICs suppliers
Rivalry
Threat of substitutes
Digitally augmented products and services
Advances in technology
Buyer switching costs
First mover advantage
Cost
Differentiation
More usage data available to buyers
Customer insight
Data talent
Agile expertise
Data
Scale of operations
Collaborative culture
Cumulative learning
Ability to offer innovative product and services
Platform and Partners
Resources and capabilities
Managerial choices
Coherent digital strategy
Taking risks
Initial conditions
Initial investment
Operational backbone excellence



A cycle of positive feedback loops is given by the increase of data and cumulative learning about customers' experience. This cycle model depicts the ability of firms to improve products and services based on data.

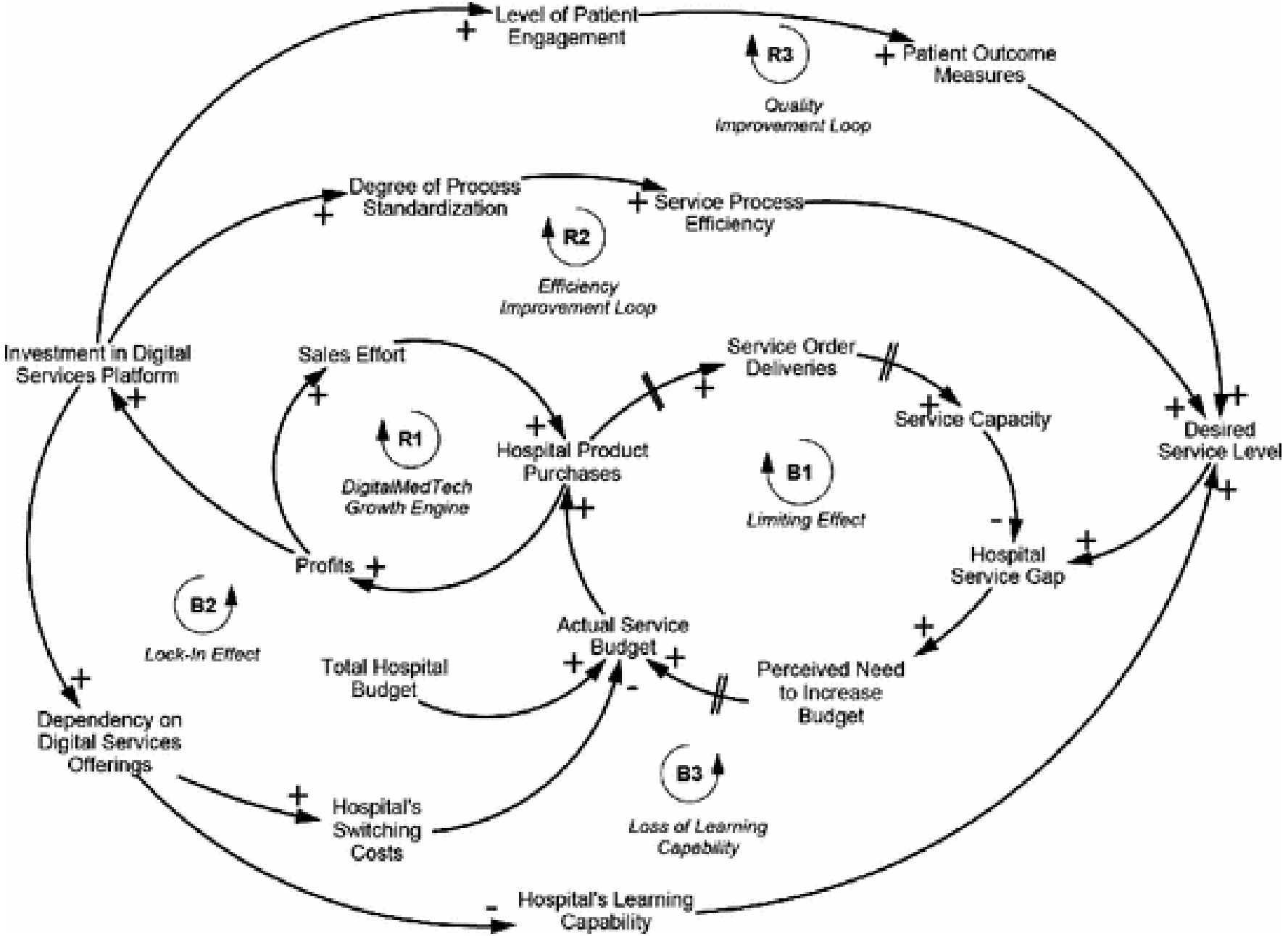


The selection of the resources that account for firm success depends on the presence of a coherent digital strategy and easiness to take risks

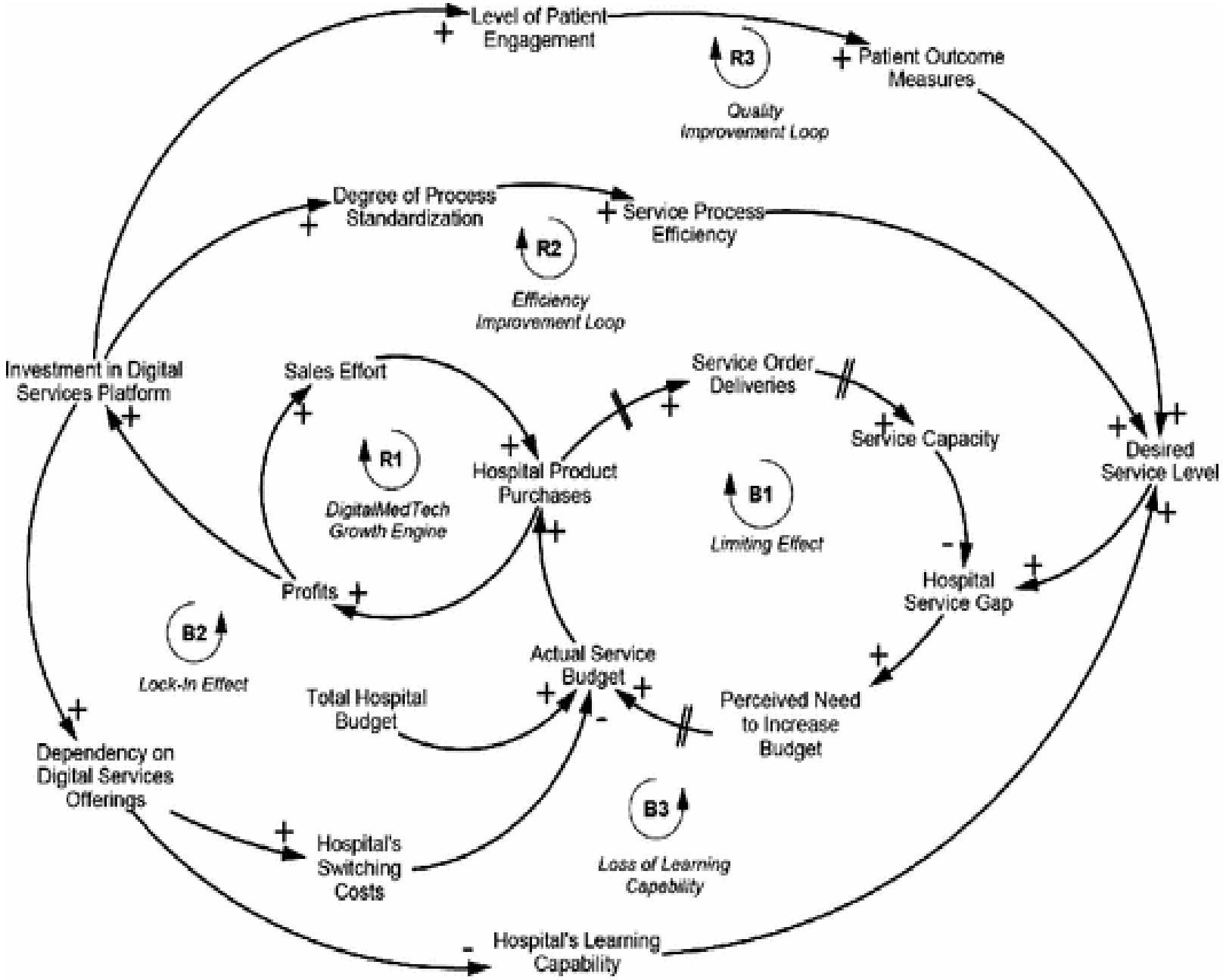
Concrete example of ST/SD for Digital Transformation

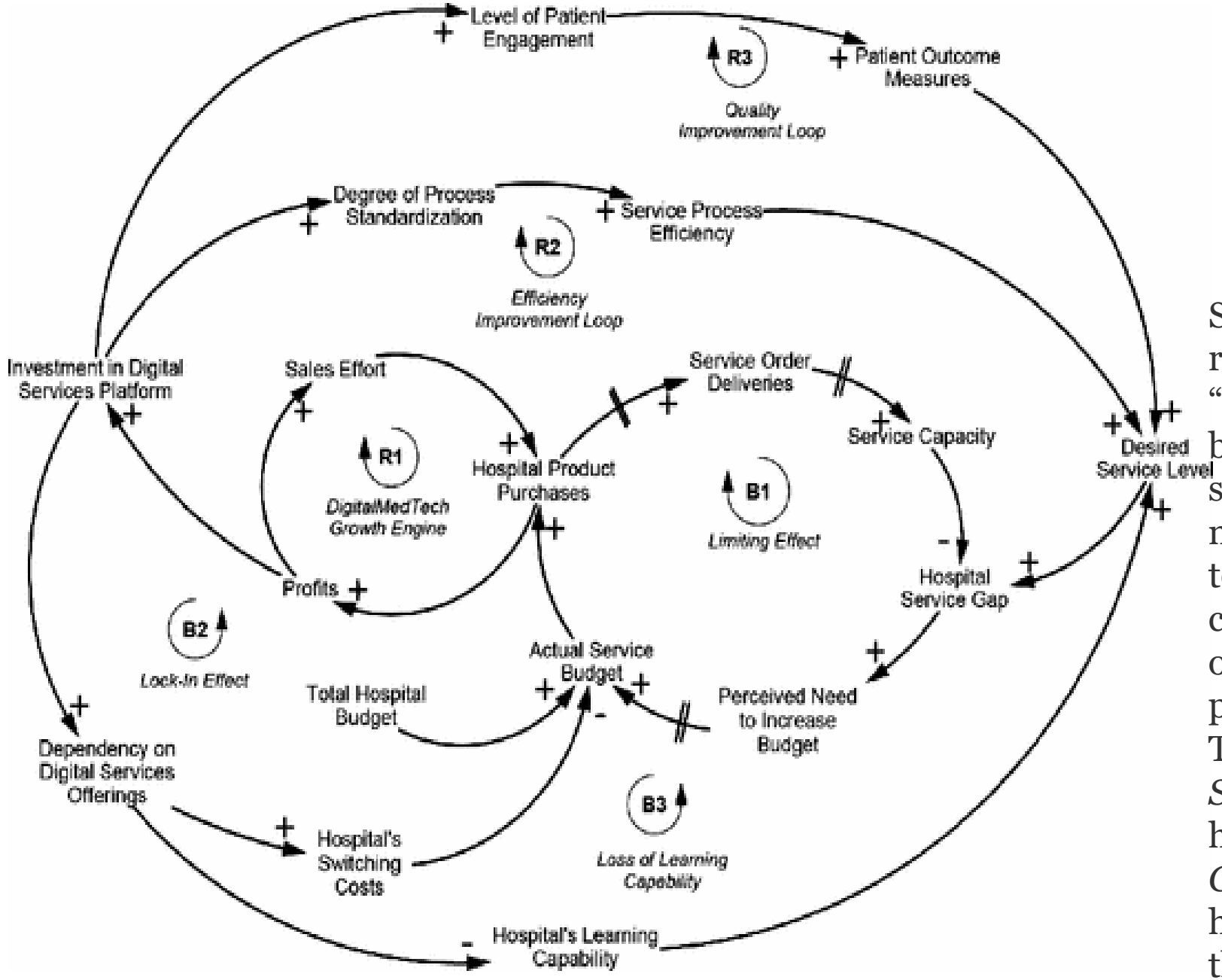
von Kutzschenbach, M., Schmid, A., & Schoenenberger, L. (2018). Using feedback systems thinking to explore theories of digital business for medtech companies. In *Business Information Systems and Technology 4.0* (pp. 161-175). Springer, Cham.

A case example was developed which illustrates a medical device technology manufacturer (medtech company) that is planning to revise its strategic position.


Level of Patient Engagement
R3
Quality Improvement Loop
Patient Outcome Measures
Degree of Process Standardization
Service Process Efficiency
R2
Efficiency Improvement Loop
Investment in Digital Services Platform
Sales Effort
R1
DigitalMedTech Growth Engine
Hospital Product Purchases
Service Order Deliveries
B1
Limiting Effect
Service Capacity
Desired Service Level
Profits
Hospital Service Gap
B2
Lock-In Effect
Actual Service Budget
Total Hospital Budget
Perceived Need to Increase Budget
Dependency on Digital Services Offerings
Hospital's Switching Costs
B3
Loss of Learning Capability
Hospital's Learning Capability

For example, negative loop "B2" shows the costs of being technically bound by increasing the "*Hospital's Switching Costs*" to another platform provider. This affects the hospital's budget, the "*Actual Service Budget*" because switching from established technology and connected services can be costly, and sometimes nearly impossible without starting from scratch





Second example, loop "B3" is related to the limitations on the "*Hospital's Learning Capability*" by being bound to a single digital services supplier. Being locked-in makes it difficult for the hospital to invest in its own learning capability and to facilitate organizational learning, in particular double-loop learning. This can affect the "*Desired Service Level*" provided by the hospital. The "*Hospital Service Gap*" is the key driver in the hospital's budgeting process so this is an important relationship.

Discussion

Lessons that were learned:

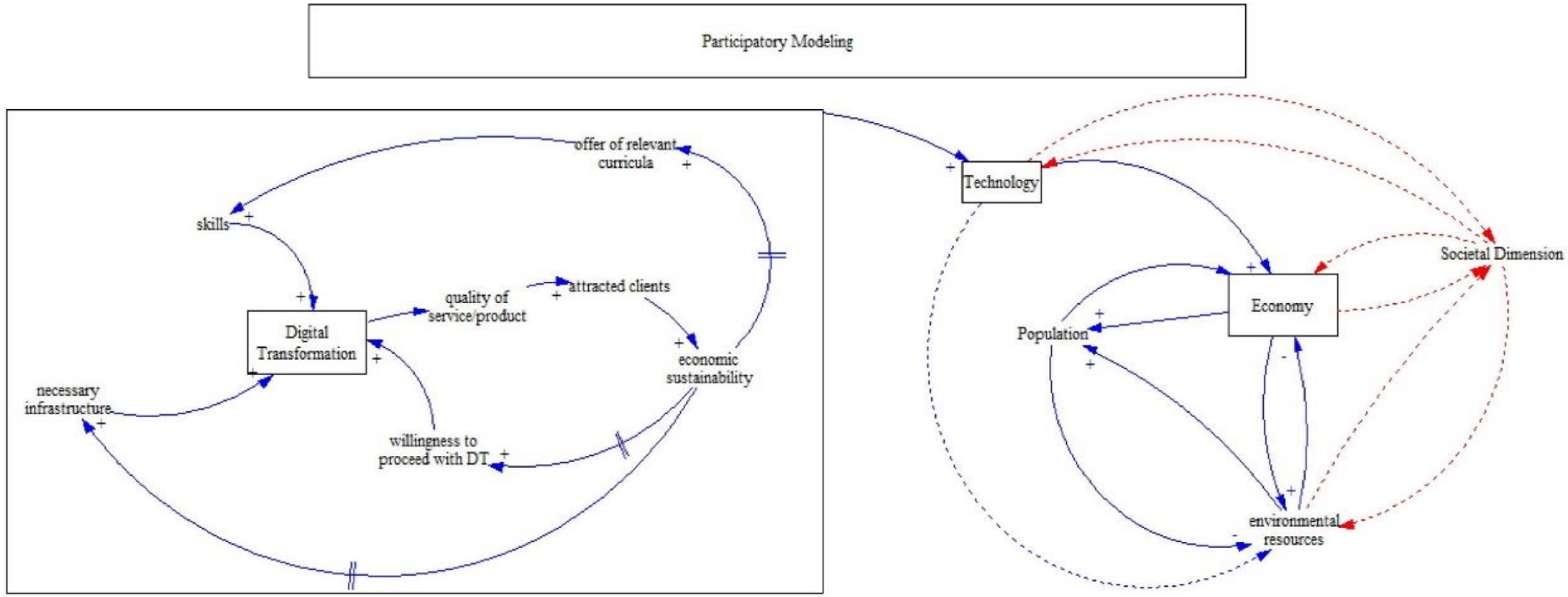
- Although Systems Thinking and System Dynamics are suitable to study Digital Transformation, a limited number of papers was found that address the issue explicitly
- Systems Thinking and System Dynamics have been recognised as valuable educational resources which can assist in understanding the behaviour of complex systems over time. However, more practical applications are necessary in the domain of Digital Transformation. A SD course/curriculum/training could assist managers, students, employees etc. to better understand how Digital Transformation can help them and their organisation, thus equipping them with the skills to better structure their decision-making process

Discussion

Lessons that were learned:

- The missing skills are not solely Digital Skills: they are a set of competences that can assist an organization to achieve a successful Digital Transformation
- A mix of policies, such as the establishment of a learning culture in the organization, the inclusion of digital processes and procedures as part of the digital infrastructure can have a positive effect on Digital Transformation and hence in the economic sustainability of the organization
- Digital Transformation is not is not a static process but it needs constant investment and effort.

Looking ahead: the link between Sustainable Development and Digital Transformation



Resources

- System Dynamics Society
  - https://www.systemdynamics.org/
- Italian Chapter of the System Dynamics Society
  - http://www.systemdynamics.it/new/
- Journals
  - System Dynamics Review
    - https://onlinelibrary.wiley.com/journal/10991727
  - Simulation&Gaming
    - https://journals.sagepub.com/home/sag
- Software
  - Vensim, Stella, Powersim, SYSDEA, Forio, Netlogo

Resources (MFSs)

No.	Description	Link
1	Bass Model Experience	https://exchange.iseesystems.com/public/barnaf/bass-model-experience
2	Fish Banks FORIO/MIT	https://forio.com/simulate/mit/fishbanks/simulation/login.html
3	Rethink Health	https://forio.com/work/rethink-health/
4	The COVID-19 Simulator (by ISEE systems)	https://exchange.iseesystems.com/public/isee/covid-19-simulator/index.html#page1
5	SUSTAIN Project ILE	https://exchange.iseesystems.com/public/ale25/sustain/index.html#page1
6	Global Supply Chain	https://forio.com/work/harvard-global-supply-chain-simulation/
7	Inventory Management	https://www.silicoai.com/blog/achieving-foresight-in-inventory-management

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Zentrum für Existenzgründungen

the academy of code

intellegere
per capire, per capirsi.

System Dynamics Italian Chapter

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SD/ST literature for Digital Transformation

Work	Details
Sanchez, 2017	used the methodology to explain the management choices that are necessary to achieve digital transformation
von Kutzeschenback et al. , 2018	developed a System Dynamics model to understand what consequences can be generated with a shift in digital strategy.
von Kutzeschenback and Brønn, 2017	developed a System Dynamics framework to explain the drivers and constraints of digital transformation for Uber
Jungthawan et al., 2019	used systems thinking as a framework to explain digital supply chain transformation

SD/ST literature for Digital Transformation

Work	Details
Moellers et al. , 2019	investigated five cases within the BMW industry
Ghadge et al., 2020	analysed the impact of Digital Transformation in the supply chain.
Casalino et al. , 2010	developed a System Dynamics model to identify the benefits from the digitisation of the Italian Public Administration.
Vogelsang et al., 2019	employed a System Dynamics model to understand the causal relationships among enablers and barriers of Digital Transformation of SMEs in South Africa

SD/ST literature for Digital Transformation

Work	Details
Lu et al. , 2020	developed a Systems Thinking framework to investigate the integration and exploration of China's scientific and technological resources in order to achieve Digital Transformation.
Belolipetskaya et al. , 2020	attempted to study the skills that are necessary in the context of DT to teach (HR) managers that seek talent
Robu and Lazar, 2020	present an example in practice led by knowledge management within Alberta Health Services, while the Systema Research Center constructed and used in a pilot a digital marketing itinerary for the secondary school curricula through practice on a System Dynamics model