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Implications of digitalization for value chains

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Abstract:

The primary goal of the article is to cover the implications of digital technologies for value chains. The hypothesis of the article is as follow digital technologies driving exponential growth translate into companies' efforts to be both lean and agile. The problem raised in the study is of being both lean and agile facing the digital disruption. The topic of the impact of digital technologies on value chains has gained an increasing attention from business practitioners. Scholars also have heavily discussed capabilities required for adaptation to technologies driving nonlinear growth. The applied methods encompasses the literature review combined with diagnostic participant action research. The understanding of lean and agile practices was a starting point to build a tool for covering impact of digital technologies on value chains. The literature review allows us to explain reasons for the fast progress in digitalization, defining the digital technologies driving the exponential growth, providing explanation of what is lean, agile and leagile supply chain. Building on the literature review the diagnostic participant action research was applied. The latter allows to verify the assumed hypothesis. While technology and the digital world grow exponentially, the manner in which we operate and organize ourselves is still based on linear models, hierarchical structures and bureaucratic processes. For a reason of this, the deployment of the lean and agile practices would be of benefit to build customer centric solutions. The article provides contribution to models of adaptation of multinationals supply chains towards digital technologies. Whilst the practical study proved that absorption of digital technology is in its infancy, the built diagnostic tool allows us to map the absorption of digital technologies with regards to logistics needs of customers. The conducted study proved existing more than two practices defined by covering logistics customers' requirements. As a recommendation for the further work would be covering transformation from linear to exponential organization.

Keywords: digitalization; agile; lean; value chain; flexibility; organization; exponential organizations
JEL codes: O32, L26, L29

1. INTRODUCTION

The Moore's Law telling us that the computing power is doubling every 18 months is one of the drivers of the digital revolution. The Metcalfe's law suggesting that the value of a communication network increases with the number of its members in line with law of decentralization saying that decentralization is an approach to manage (increasingly) complex systems could be also considered as triggers of the digital revolution. 3D printing, internet of things, augmented reality, drones, robots, artificial intelligence, mobile application, cloud computing are amongst the technologies fuelling the digitalization wave. We understand digitalization in a simply way as a use of digital technologies in order to add value to business. It is worth noting that terms of digitalization and Industry 4.0 or Revolution 4.0 overlap each other. The meaning of term Industry 4.0 has been under discussion amongst scholars (Pfohl, Yahsi & Kurnaz, 2016).

Technologies that could have non-linear impact on organizations growth are classified as exponential ones. The book on the exponential organizations attracts a high attention from the business practitioners side and has been a source of inspiration for implementing new business models. The Massive Transformative Purpose is a model of organizational change to reach non-linear – exponential growth (Ismail, 2014).

The digitalization drives also the widespreading of new business models of sharing economy. The latter has been changing the way we think about assets and manifest itself by business models like sharing platforms, product as a service and consequently translates into businesses like Uber, Airbnb, Instacart.

The main goal of the article is to cover the implications of digital technologies for value chains. The understanding of value chains is narrowed to value supply chains (Ketchen & Hult, 2007).

The assumed hypothesis is as follow digital technologies driving exponential growth translate into companies' efforts to be both lean and agile.

The applied methodology encompasses the literature review combined with diagnostic action research (Coghlan & Brannick, 2014). The latter is amongst tools to be in use to map and solve supply chain problems (Coughlan & Coghlan, 2002). Whilst the literature review focuses on understanding of digital technologies and phenomena of leanness, agility, leagility; interpretation of value supply chains and covering impact of digital technologies on value chains are based on diagnostic action research.

The article encompasses the parts as follow:

- covering reasons behind the fast progress in digitalization;
- defining the digital technologies driving the exponential growth;
- explaining understanding of lean, agile and leagile supply chains;
- discussing a research methodology;
- mapping the lean and agile practices within one of the value chain;
- providing a diagnostic tool helping to map how to approach the adaptation towards digital technologies;
- conclusions and suggestions for further studies.

2. LITERATURE REVIEW

The plummeting costs of digital technologies means that the world is becoming more connected. The table number 1 highlights costs decline in technologies that potentially would drive the exponential growth.

Table 1. The decrease in prices of technologies having potential for triggering exponential growth of organization

Technology	Average cost for equivalent functionality	Scale
3D Lidar Sensors	20 000 USD (2009) to 79 USD (2014)	250 X in 5 years
3D Printing	40 000 USD (2007) to 100 USD (2014)	400 X in 7 years
Industrial robots	500 000 USD (2008) to 22 000 USD (2013)	23 X in 5 years
Drones	100 000 USD (2007) to 700 (2013)	142 X in 6 years
Smartphone with similar specifications	499 USD (2007) to 10 USD (2015)	50 X in 8 years

Source: based on Ismail (2014).

3D Lidar Sensors are amongst the key components building the solutions called Internet of Things. It could be conceptually defined as a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual things have identifies, physical attributes, and virtual personalities, use intelligent interfaces, and seamlessly integrated into the information network (Vermesan, Friess, Guillemin, Gusmeroli, Sundmaeker, Bassi, et al., 2011). Internet of Things is the internetworking of physical devices, vehicles, buildings and other items—embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data. In the Internet of Things, “smart things/objects” are active participants in business, information and social processes where they are enabled to interact and communicate among themselves and with the environment by exchanging data and information “sensed” about the environment, while reacting autonomously to the “real/physical world” events and influencing it by running processes that trigger actions and create services with or without direct human intervention. (Vermesan, Friess, Guillemin, Gusmeroli, Sundmaeker, Bassi, et al., 2011).

Augmented reality is an area of research that aims to enhance the real world by overlaying computer-generated data on top of it. There are three key characteristics of Augmented Reality systems: mixing virtual images with the real world, three-dimensional registration of digital data interactivity in real time (Schmalstieg, Langlotz & Billinghurst, 2011; Zhang & Wen, 2016). Augmented reality is a live direct or indirect view of a physical, real-world environment whose elements are augmented (or supplemented) by computer-generated sensory input such as sound, video, graphics or GPS data.

3D Printing was originally developed as an automated method of producing prototypes. Although there are several competing technologies, most work on the basis of building up layers of material (sometimes plastic, ceramics or even metal powders) using computer aided design. Hence, it is referred to as “additive” process; each layer is “printed” until a three dimensional product is created. The logic for using 3D printing for prototype is compelling. Traditional “reductive” manufacturing techniques (where materials are removed) can take longer and are much more expensive. Mechanical parts, shoes, fashion items and accessories and other consumer goods, can all be printed for review by the designer or engineers and revisions printed equally as easily. Whereas mass production is viable due to economies of scale, it is uneconomical for “one offs” and prototypes. 3D Printing will remove this differential, where every item produced is an original (or perfect) copy and tooling for one is as cheap as tooling for many (Manners-Bell & Lyon, 2012). The term “cloud” originates from the world of telecommunications when providers began using virtual private network (VPN) services for data communications. Cloud computing deals with computation, software, data access and storage services that may not require end-user knowledge of the physical location and the configuration of the system that is delivering the services. Cloud computing is a recent trend in IT that moves computing and data away from desktop and portable PCs into large data centres. The definition of cloud computing provided by National Institute of Standards and Technology (NIST) says that: “Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction”. With the large scale proliferation of the internet around the world, applications can now be delivered as services over the internet. As a result this reduces the overall cost (Jadeja & Modi, 2012).

Industrial robot is a constructed replication of something that uses robotics for the purpose of mimicking something else or achieving a task. Robots can be guided by an external control device or the control may be embedded within. Robots may be constructed to take on human form but most robots are machines designed to perform a task with no regard to how they look.

Assuming that digitalization could be a trigger of building customer centric value supply chains, discussion on the customers’ needs and their links with the concepts of agility and leanness would build understanding on how approach adaptation towards digitalization (Sambamurthy, Bharadwaj & Grover, 2003).

Agility could be called as the ability to renew itself, adapt, change quickly, and succeed in a rapidly changing, ambiguous, turbulent environment. A key characteristic of an agile organization is flexibility. Indeed the origins of agility as a business concept lies in flexible manufacturing systems. However, agility should not be confused with leanness. Lean is about doing more with less. The term is often used in connection with lean manufacturing. Many companies that have adopted lean manufacturing as a business practice are anything but agile in their supply chain (Christopher, 2000).

While leanness may be an element of agility in certain circumstances, by itself it will not enable the organization to meet the precise requirements of the customer more rapidly. Webster’s Dictionary makes the distinction clearly when it defines lean as “containing little fat,” whereas agile is defined as “nimble.” One of the biggest barriers to agility is the way that complexity tends to increase as companies grow and extend their marketing and logistics reach. Often, this complexity comes through product, brand proliferation, logistics including transportation, warehousing and customer service, but it also can come through the organizational structures and management processes that have grown up over time (Christopher, 2000).

The simultaneous work of lean and agile principles can support the effective and efficient management (Olhager, 2003; Narasimhan, Swink & Kim, 2006) and relationships within a supply chain (Wikner & Tang 2008), balancing efficiency and responsiveness (Olhager, Selldin & Wikner, 2006). Researchers have addressed differently the links between agility and leanness. Agility was defined as a 'post-lean paradigm' (Jain, Benyoucef & Deshmukh, 2008), which incorporates lean principles to cope with a turbulent environment. In some other studies, we can find an approach which highlights the difference between agility and leanness (Goldsby, Griffis & Roath, 2006) where leanness is a philosophy essentially focused on eliminating all waste including time, while agility is a way to use market knowledge to exploit profitable opportunities in a volatile, uncertain, ambiguous and complex environment. Some authors point to the differences between lean and agile models by covering criteria as follow: typical products, marketplace demand, product variety, product life cycle, customer drivers, profit margins, dominant costs, stockout penalties, purchasing policy, information enrichment, forecasting mechanism (Bruce, Daly & Towers 2004; Mason-Jones, Naylor & Towill, 2000; Gaudenzi & Christopher, 2016). The summary of attributes of lean and agile options are on the table 2.

Table 2. The attributes of lean and agile solutions

Attributes	LEAN	AGILE
CONCEPT	Savings	Finding market opportunities
GOALS	Gain a larger effect by using less resources	Ensuring growth and winning competitive advantage
BACKGROUND	Improving of manufacturing processes	Volatile, Uncertain, Ambigious and Complex environment
DRIVER	Supply	Demand
METHODOLOGY	Covering "as-is" physical stream value chain	Information based value chain Vertical and horizontal integration
PROCESS	Standarization	Selforganization
FORECASTING MECHANISM	Alghoritmic	Consultative; Implants
MARKETPLACE DEMAND	Predictable	Volatile
PORTFOLIO	Constant portfolio, Big packaging sizes, large volumes	Products adjusted to consumers' needs
PRODUCTION	High efficiency; High capacity utilization	Modularity
PROCUREMENT	Long term contracts	Spot market
STOCKS	Minimalization	Buffers
TRANSPORT	Low costs lanes	Responsive lanes
WAREHOUSING	Central warehouse	Shared storage capacities
ORDER MANAGEMENT	Static relationships; Electronic Data Interchange	Orders per store; Orders by sales representative; Orders during weekend; Urgent orders
CUSTOMER SERVICE	Reactive	Proactive, incentivize new activities
KPIs	Productivity and costs	Customer satisfaction

Source: based on (Bruce, Daly & Towers, 2004; Mason-Jones, Naylor & Towill, 2000; Gaudenzi & Christopher 2016).

Following the content of the Table 2 the question would be if lean and agile solutions should be applied simultaneously or the behaviours should be differentiated for example with regards to some customers we should deploy lean solutions and for some customers we should apply agile solutions.

3. METHODOLOGY

The applied methodology is an effect of including in thinking on the topic under study a few factors. First of all, the relations between ontology and epistemology. For example, we could address questions as follow: is what do we see constructed by our cognition or world we observe is an objective reality? or what are our cognitions patterns? do we approach a world we study by following system or linear thinking? how do we approach complexity – by applying keep it simply stupid rule or seeking complicated patterns within complexity?

Including in our thinking interrelations of basic epistemological and ontological aspects we decided to deploy a method of research that follows the diagnostic action research requirements.

Action research diagnosis is a collaborative effort between practitioners and the researchers. The researchers concentrate on establishment of a sound theoretical framework, a scientific hypothesis that might explain behaviours in the social problem space. The practitioners, relying on their intimate familiarity with the problems, help eliminate unreasonable hypothesis and unlikely theoretic constructs (Baskerville, 1997).

Problems that face the diagnostic action research are actually problems that face social science research. In reality action research shares these problems with the other methods. There are three dilemmas in action research: ethics – personal overinvolvement with research, goals – the two taskmasters in social research (subject and science) and initiatives – the practical pressures that interfere with the conduct of “a disinterested pursuit of knowledge” (Rapoport, 1970). Scientists who employ other methods, even survey research also know three dilemmas. These are not peculiar to action research, but could be stronger in action research.

On the other hand action research has been linked closely to systems theory from its inception. These ideas recognize that human activities are systemic and that action researchers are intervening in social systems. Checkland not only used the action research extensively in developing the soft system methodology but action research concepts for gaining professional knowledge permeated the soft systems approach itself (Baskerville, 1997). In this sense action research could be perceived as an approach towards analysing “complexity in complexity” which is sometimes called complex sophistication.

What is more we assume that having an option of observing and participating in a real business life case builds an opportunity to get in-depth view on researched processes and omit disadvantages of anonymously filled surveys. On the other hand the study will miss the confirmation and potential validation by other peers. However due to the accelerating pace of change in a business life, up to date insights could make contribution to the theory. In this study insights derived from diagnostic action research could help to build theory on a digitalized value chain.

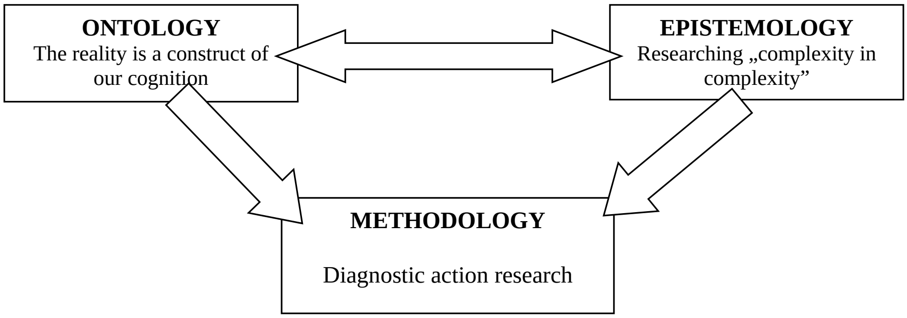

Figure 1. Methodology resulting from the assumed ontological and epistemological interrelations
Source: own elaboration.

We made efforts to follow a scientific regime and make sense of sense making. With the respect of this we played the educational role for practitioners (Baskerville, 1997).

4. ANALYSIS

After discussing assumed hypothesis on the topic of digitalization, covering the areas of competency, explaining the understanding of basic terms, conceptualization, we decided to cover logistics requirements of customers and with the respect to the latter we covered impact of exponential technologies on value chains.

As we can see on the Table 3 there are more than two practices of logistics behaviours within supply chain. Apart from lean and agile options we also identified very agile and standard options. Mapping logistics customers’ requirements was not only of a reactive character but also proactively covered customers logistics needs that potentially could be required. However the covered numbers and the detailed description of logistics requirements of customers are only indicative.

From this mapping exercise came out that creating full flexibility for customers requires four options – very agile, agile, standard, lean.

As the next step we attributed the capabilities based on covered technologies to identified four practices.

The findings of mapping exercise proved that digital freight matching based on mobile applications and cloud computing would be an appropriate capability for particularly very agile and agile practices but also standard and lean practices on logistics requirements for lead time, delivery notification, the frequency of deliveries, urgent orders ratio, logistics window, delivery point complexity, order placement, visibility of order status. Digital freight matching means deploying scalable and cost-efficient Software as Service architecture to achieve complete information interaction in systems, applications and processes (SAP) and point of sale (POS). Connecting all transport

Table 3. Mapping logistics behaviors

Category	Very Agile	Agile	Standard	Lean
Lead Time	<6h	<12h	24 or 48hours	72hours
Delivery notification	The same day	One day	One day	Two days
The frequency of deliveries	Every day including weekends	20-23 times a month	Two days a week	Once a week
Urgent orders ratio	10%	5%	1-3%	0.50%
Logistics window	One hour slot	One hour slot	Four hours slot	Same day (or freedom to choose slot)
Delivery preparation	Separated by stock keeping unit and shops	Separated by Stock Keeping Units	Mixed pallets	Full pallets only
Order Size	Case(s) or Items	>2 pallets	>5-10 pallets	Full Trucks
Picking ratio	Items	Cases	Full layers	Full pallets only
Delivery point complexity	Direct Consumer Deliveries	Direct Stores Deliveries	Customer Distribution Centres or Cross Dock	Customer Distribution Centres only
Pallet heights	N/a	Detopped pallets	Standard pallets	Standard pallets
Information on pallets	Label per package or per SKU	Label on picked pallets as well	Label on full pallets	No special labelling
Order placement	Telesales call center	Vendor management Inventory, fax,	e-mail	100% Electronic Data Interchange
Visibility of order status	Access to real time order/truck status	Automatic, real-time alerts on delays	Order confirmation with Estimated Time of Arrival	No
Data/Forecast exchange	Full Electronic Point of sales data	Full Electronic Point of sales data	Promo/Full forecast shared	No

Source: own elaboration.

flows end-to-end would give overview of the actual status of deliveries in real time and allow to react to real time issues. With digital freight matching transportation footprint is fully digitized, providing structured data which could be used to optimize transport flows. Equally important is establishing a transport procurement-to-billing process that ensures customers pay accurate invoices. This is now achieved with reciprocal contracting and billing functionality. The verification process is reduced to mere minutes or hours, compared to days or weeks in a traditional not digital model. The further potential benefits would be long-standing customers experience from the new management systems, which enable a much more rapid response.

Augmented reality for warehouse operations was pointed as required capability for very agile, agile, standard and lean practices. Augmented reality allows seeing the digital picking list in a field of vision and – thanks to indoor navigation capabilities – see the best route, reducing travel time by efficient path planning.

Table 4. Mapping potential applications of digital technologies

Category	Very Agile	Agile	Standard	Lean
Lead Time	Digital Freight Matching Applications /Cloud computing/Mobile Applications	Digital Freight Matching Applications /Cloud computing//Mobile Applications	Digital Freight Matching Applications /Cloud computing//Mobile Applications	Digital Freight Matching Applications /Cloud computing//Mobile Applications
Delivery notification				
The frequency of deliveries				
Urgent orders ratio				
Logistics window				
Delivery point complexity				
Order placement				
Visibility of order status				
Delivery preparation	Augmented Reality for warehouse operation; Internet of Things for forklifts	Internet of Things for forklifts; Augmented Reality for warehouse operation; Cobots for picking	Automated layer picking; Internet of Things for forklifts; Augmented Reality for warehouse operation; Cobots for picking	Augmented reality for warehouse operations; Internet of Things for forklifts
Order Size				
Picking ratio				
Pallet heights	Internet of Things for forklifts; Virtual Reality for warehouse operation	Internet of Things for forklifts;Virtual Reality for warehouse operation	Internet of Things for forklifts;Automated layer picking; Virtual Reality for warehouse operation	Not digital capabilities
Information on pallets	Printers/existing solution	Printers/existing solution	Printers/existing solution	Printers/existing solution
Data/Forecast exchange	Digital Freight Matching Applications /Cloud computing/Mobile Applications	Digital Freight Matching Applications /Cloud computing/Mobile Applications	Digital Freight Matching Applications /Cloud computing/Mobile Applications	Digital Freight Matching Applications /Cloud computing/Mobile Applications

Source: own elaboration.

Using automated barcode scanning capabilities, the system's image recognition software can check whether the worker has arrived at the right location, and guide the worker to quickly locate the right item on the shelf. The other capability for all mapped practices is installing sensors on forklifts to make maintenance and task as well as distance info visible, which then drives improvements – reduced maintenance time and cost, reduced empty kilometres thus reduced forklift numbers.

For standard and lean practices automated layer picking is also pointed as an appropriate capability. Automated layer picking based on robots enables lead times to be shortened and inventories to be reduced. For agile and standard practices an easy-to-teach co-robot, capable to do repeating tasks, but not moving was pointed as a capability.

The conducted study raised the awareness of existing digital solutions and provided impulses for discussion on implementation digital technologies.

5. DISCUSSION

The article contributes to a discussion on models of adaptation of supply chains towards digital technologies. The built diagnostic tool allows us to map the absorption of digital technologies with regards to logistics requirements of customers. In this way the paper contributes to existing tools on building and improving customer centric value supply chains and helps the organization to adapt to exponential digital technologies.

We should also verify assumed hypothesis as following the presented study the differentiation of activities embracing very agile, agile, standard and lean options goes further than the approach of being simultaneously lean and agile in other words leagile. In this way a paper provides the approach which expands the thinking of Gattorna (2010) who suggests existing full flexible and collaborative models additionally to lean and agile practices.

From the methodological perspective, the study shows that including in research "complexity in complexity" approach could provide us with outcomes that extend existing models on lean and agile practices. On the other hand, the findings are presented in a linear way by using matrixes. The latter reflects a simplification in thinking on finding concrete business solutions.

The further study should be on interrelations between the concept of leagility and flexibility. This area should provide promising results both for business practitioners and scientists. Strategic, tactical, operational as well as external and internal flexibilities should be discussed with regards to legality or lean, agile, very agile, standard practices. Covering the interrelations between the concept of legality and flexibility should provide also recommendations for building solution that could help to adapt to digital exponential technologies.

What is more the further discussion on agility with respect to interrelations amongst mindset, values, principles, practices, tools and processes should bring good results.

The potentially dynamic capabilities concept should be further discussed on its applications in flexibility and leagility studies (Lawson & Samson, 2001; Helfat, Finkelstein, Mitchell, Peteraf, Singh, Teece & Winter, 2009, Rindova & Kotha, 2001).

The next question would be if exponential solutions should be built in a parallel way to lean, agile, standard, and very agile practices or all practices should be included within one separate, integrated model. On the way from physical towards digitalized assets at least temporary co-existing of old existing approaches and new ones is assumed to be necessary.

6. CONCLUSIONS

In order to adapt to driven by digital technologies disruptive changes companies should build appropriate capabilities. One of these assumed needed capabilities was co-existing of lean and agile practices in a value chain. The conducted diagnostics action research proved existing more than two practices defined by covering logistics customers' requirements.

Hence the paper makes a contribution to existing theory on both conceptualization and building a diagnostic customer-centric model for mapping impact of digital technologies on value supply chain.

As a recommendation for the further studies would be covering models of transformation from linear capabilities to exponential ones. The question with this respect to answer would be if the organization needs to be the first mover, fast follower, late adopter in order to adapt to digital exponential technologies.

The next studies should also cover the differentiation of the digital-born organization and organizations that should transform into digital ones. With the respect of digitalization the digital sceptics, operation focused, staged and secure, strivers and digital differentiators models of could be discussed.

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