DIGITAL VALUE CHAINS –
AN EXPLORATORY STUDY OF THE PHARMA
AND HEALTHCARE INDUSTRY

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Abstract: *This research assesses what impacts digital solutions can have in the value chains of the pharma and healthcare industry once being used across different players. As research in this area is yet emerging, research was conducted via mixed methods/ triangulation approach, reviewing state of the art literature, expert interviews with ten experts in pharma and healthcare and case studies of six digital solution examples in practice. The research could validate that tracking seems to be an important topic but also gave indication that pharma players will move closer to patients and can improve their innovation cycles. Additionally, it provides insights on the potential evolution of value chain players and their offerings which will relate much more to personalised treatments and services.*

Keywords: *Value Chains, Healthcare, Pharma, Digital, IoT, Blockchain*

As in almost all industries, digitalisation has triggered several changes also for the pharma and healthcare industry and its value chains. Digital technologies are in use across several areas of the these value chains and more recently are used across different players. Most recently, also decentral digital technologies such as blockchain and Internet of Things are used in the pharma and healthcare industry in order to manage interactions across different players and help to support efficient coordination and supply of goods (Schofield & Thasarathakumar, 2021). In general, the pharma and healthcare value chain is rather complex with many players interacting. Pharma producers source raw materials from many different suppliers in order to manufacture their products. Afterwards, products are passed on to distributors who supply pharmacies. So called over-the-counter products (OTC) can be directly sold to patients from there whereby prescribed medications are provided based on a prescription by a medical practitioner.

Consequently, medical practitioners are important actors in the value chain for pharma and healthcare and many marketing activities of pharmaceutical producers focus on them. Issues in this value chain area are manyfold: 90% of pharmaceutical innovation projects fail, data sources are not efficiently connected and data analytics consumes a lot of time which impacts time-to-market for new products and fraud happens in many areas along the value chain. Consequently, significant effort is spent of quality management activities, fraud protection and communication between key stakeholders. In this context, some authors foresee a big potential of newer digital technologies, stating that for example technologies such as blockchain could have the potential to account for more than 20% of cost saving in a market where pharma let along accounts for 500 bn $ sales p.a. globally (Iredale, 2021). Nonetheless, research around digital solutions along the value chain of the pharma and healthcare industry is still very limited and this research field is yet emerging (Hoppe, et al., 2021). Thus, this paper aims to shed light and give insights of what can

happen if digital solutions are used across different players in the pharma and healthcare value chain and how the value chain could evolve once those digital solutions across different players are implemented.
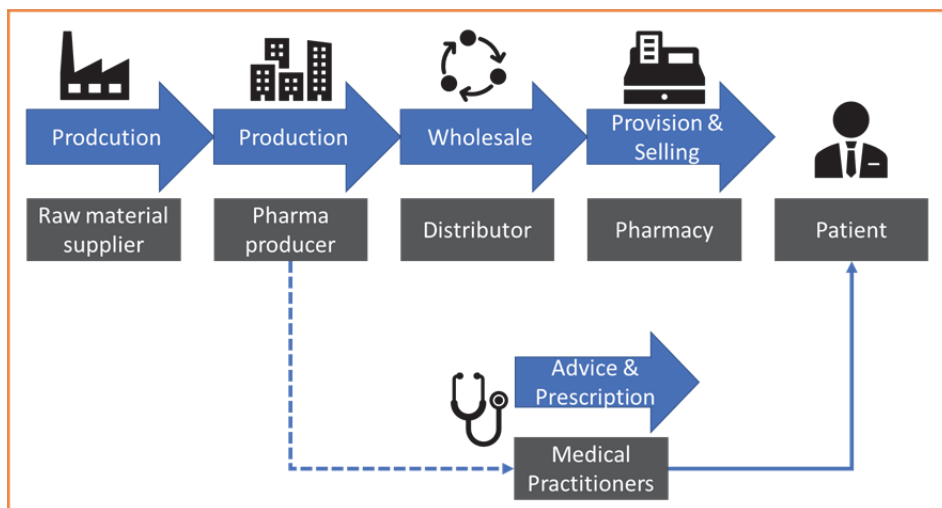
Figure 1: Schematic graph of pharma & healthcare value chain,
Source: created by author, 2022

1. Research approach

The current field of research on the impact of (decentral) digital technologies on the value chains of the pharma and healthcare industry is very premature. Hence, research is exploratory and aims to identify first indications on what impact these technologies could have. More in-depth research will be required afterwards to analyze particular elements in detail. To tackle exploratory research impactfully and comprehensively, a mixed methods approach was chosen to conduct the research adequately. For this purpose, three different methodologies are used to research the same field:

1. Extensive literature research
2. Case studies of recent use cases
3. In-depth expert interviews

This mixed methods-approach allows triangulation of the research field and enables a comparison between the findings of the different methodologies to ensure validity and reliability of these findings, especially for exploratory research (Johnson, et al., 2007).

To assess the question which impact (decentral) digital technologies can have on value chains of the pharma and healthcare industry, three elements are researched:

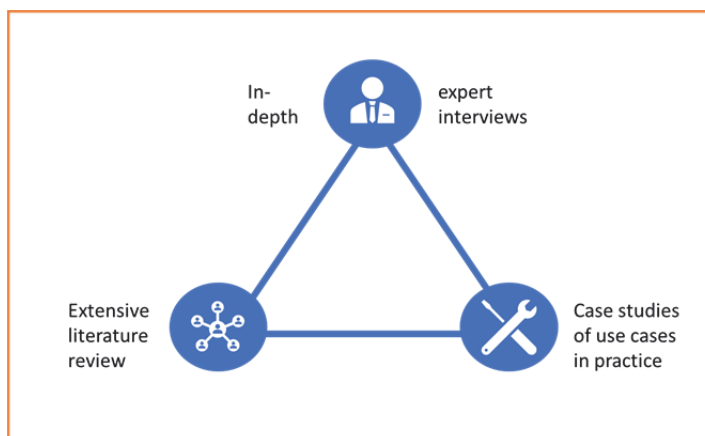- Trust
- Coordination
- Business Models

Figure 2: Schematic graph of research approach via mixed methods/triangulation,
Source: created by author, 2022

Based on this, 5. key research questions have been defined:
1. Can (decentral) digital technologies help to overcome issues related to trust and transparency?
2. Can (decentral) digital technologies help to allocate resources more efficiently and/or generally optimize flow of goods and processes within the value chains?
3. Can (decentral) digital technologies enable new business models, i.e., new forms of value creation and/or value capture and if so who is creating and capturing it?
4. Can the deployment of (decentral) digital technologies change the way how value chain players interact with each other and how would this influence their relationship among each other then?
5. Can (decentral) digital technologies trigger the rise of new players in the value chains or the disappearance of others and how would this influence the distribution of power along the value chains?

To conduct the research along the mixed-methods/triangulation approach, at first recent literature is researched for the respective areas to detect initial insights around the research questions. Secondly, case studies of real-life examples of (decentral) digital technologies in practice in the pharma and healthcare industry are researched. Lastly, exploratory in-depth expert interviews are conducted to address the research questions from an expert point of view. Finally, the findings of all three research methods are compared in order to identify consistencies and detect discrepancies of the different methodologies. The questions have been validated via a pre-test with an expert for (decentral) digital technologies for the pharma and healthcare industry.

2. Literature research
Recent literature is researched around four different areas in order to assess what impact digital technologies across different payers can:
- Trust and trust-related issues
- Efficiency and coordination across different players
- Business model evolution
- Obstacles to implementation

This clustering shall provide multi-perspective and comprehensive insights and help to derive potential implications on the evolution of the value chains of the pharma and healthcare industry.

2.1. Trust-related issues

The management of supply chains, in particular temperature management is an essential topic for the pharma and healthcare industry as many medications need to be stored and transported along strict temperature regimes. Thus, many authors see great potentials of utilising decentral digital technologies such as blockchain in conjunction with sensors and other Internet of Things technologies to improve this topic (Hulea, et al., 2018). Herby parallels are drawn to the nutritional industry that has similar quality requirements to its value chains and flow of goods management (Yang, et al., 2021). Recent studies show that technologies like blockchain can eventually be very useful to manage temperature within the supply chains of pharmaceuticals (Hosseini Bamakan, et al., 2021). As temperature management is also essential to meet regulatory requirements, distributed ledgers and IoT sensors can be instrumental to improve effectiveness in the pharma and healthcare industry (Bocek, et al., 2017). In fact, product tags that can be used by digital technologies, e.g., bar codes, already exist for many products, so authors rather state that the difficulty to implement tracking technologies is rather a question of how to manage data flows but not tagging goods, as currently data is handled in insular system by respective players along the value chain in rather insular systems (Clark & Burstall, 2018)

What can distinguish the pharma and healthcare industry might be its high degree of fragmentation that can make fraud much easier compared to other industries. So, beyond managing information sharing around origin and processing of goods along the value chain, some recent studies also put new digital technologies such as distributed ledgers in context of intellectual property management (Clark & Burstall, 2018).

2.2. Coordination & process efficiency

The usage of digital technologies across different players in the pharma and healthcare industry is associated in most cases with increased efficiency. Strong benefits are seen by integrating different systems which seems to be very beneficial as the industry is very complex and has lots of stakeholders interacting with each other in parallel (Trenfield, et al., 2022). Currently, many larger players operate their own systems which makes it difficult to bring them together in an efficient way and valuable time is lost, i.e., inefficient communication and data flow slow down time-to-market of pharmaceutical research projects and thus innovations. In the past, key players were trying to implement larger overarching systems that seem to have a rather centralised character but this has triggered questions around data privacy and data ownership, so that most recently some authors do see decentral technologies as potential alternative to manage efficient exchange between stakeholders but to overcome potential issues around data privacy and ownership that might come with rather centralised systems (Mirdad & Khadeer Hussain, 2021). This was also shown in a most recent study that examined the implementation of a circular concept for pharma supply chains. The authors clearly mention that the complexity with many different actors in the value chains of pharma and healthcare makes it difficult to implement such systems effectively (Khan & Ali, 2022). Nevertheless, great benefits of digital technologies across different players in this industry are mentioned in context of supporting more individualisation of medication and healthcare service delivery and also by faster innovation circles in context of decentral clinical studies that are supported by digital technologies (Woods & Iyengar-Emens, 2019).

2.3. Business model evolution

Generally, research on business model evolution in context of digitalisation is very limited for the pharma and healthcare industry. Moreover, authors rather mention that business models that are enabled by digital technologies, such as sharing economy-related business models, are also applied in the healthcare context as shown by a recent study for healthcare delivery transportation services in Italy (Schiavone, et al., 2021).

Notwithstanding, some authors see opportunities for business model innovation in context of digital technologies in the healthcare and pharma industry especially for information exchange platforms that enable co-creation of different players and connectivity of service offerings. Although enabling co-creation on digital platforms is nothing new, this notion seems to be beneficial in the pharma and healthcare industry as so many stakeholders are interacting and proper connectivity between key actors can thus yield some significant benefits, especially if such platforms can connect public and private stakeholders (Su, et al., 2021).

Some authors state that often larger players such as pharma companies have key roles in the pharma and healthcare industry, whereby those larger incumbent larger players rather trigger incremental innovation and stick to their existing business model, while mostly start-ups are the ones that trigger actual business model innovation in healthcare (Herrmann, et al., 2018). In line with this, most recent research states that a majority digitalisation efforts in the pharma and healthcare industry rather relate to digitising existing processes, predominantly communication processes, so that digitalisation is rather supporting efficiency gains but not so much the rise of actual new types of business models (Kraus, et al., 2021).

2.4. Obstacles to implementation

As improving communication between different stakeholders via digital systems is seen as major benefit, the integration between different systems is key. Hereby research sees major issues regarding the lack of interoperability of different systems especially for the pharma and healthcare industry that is highly fragmented with many different actors interacting at the same time with each other (van Velthoven, et al., 2019). This lack of interoperability was also confirmed by recent research although digital technologies are constantly improving (Trenfield, et al., 2022). Other authors refer to the ethical dimension that needs to be considered when triggering digitalisation in pharma and healthcare and thus ethical questions might slow down the rise and implementation of new digital solutions across different player although being technically feasible (Vial, 2019).

2.5. Results of literature research

In essence, digitalisation activities in the value chains of the healthcare and pharma industry are mainly considered by recent research in context of efficiency gains. In most cases those efficiency gains relate to improving the communication and information exchange among different stakeholders. Hereby two areas seem to be standing out, first those digital technologies seem to create some improvement for tracking goods along supply chains and secondly, digital solutions can be used to make patient data fast accessible and trust support innovation and more precise and individualised treatment. Obstacles are seen in many areas, referring to potential issues around data privacy management and ethical discussion but also to technical issues such as the interoperability of systems that are used by different players. As a consequence, digital technologies that are used across different players are not so much seen by researchers as key enabler of new business models but as potentially strong contributor to efficiency and quality improvement for existing process flows.

3. Case studies

To assess the research questions in practice, the deployment of digital technologies across different players in the healthcare and pharma value chains is examined. Although the research is exploratory and the usage and deployment of (decentral) digital technologies for cross-value chain systems and initiatives is yet emerging, these use cases have been chosen with the aim to cover a broad range of applications. Thus, these different examples have been selected in order to draw conclusions and provide guidance for further research.

3.1. PharmaLedger

PharmaLedger, a blockchain-based project was started in 2020 by a consortium of 29 member including 12 large pharmaceutical companies such as Pfizer, Bayer and Novartis and various other players of the pharma and healthcare industry. The project aims to realise a broad range of use cases based on distributed ledger technologies, referring for example to patient data management and support of clinical studies. By this consortium approach, players also strive to shape certain market standards, i..e, technological standards, where every player can benefit individually and to enable a more streamlined and smooth interaction. The initiators see the incentive to join as quite important for the project to be successful and thus see this as major topic (Morris, 2020). One of the first use cases of the project is to manage leaflets that are packaged together with drugs, in order to overcome the issue of communicating any changes on those leaflets. Up until now, it seems to be rather tricky and complicated to communicate any changes on those leaflets once the drugs leave the production on pharma producer level. With the new decentral digital technology those communication hurdles towards patients should be overcome, i.e., pharma producers should be connected more swiftly to patients. Technically, this use cases utilises a code on the drug´s packaging so that patients can scan this code and then receive most recent information on the respective drug. Also, the producer can prove via this solution that the respective patient got the right information which adds to compliance for pharma producers. On the flipside, the distributed ledger technology secures the personal data of the patient, i.e., so that network participants do not know who is asking for the information on that particular medication (as this person is likely also the user of the medication). The aim of this initial use case of PharmaLedger is not only to improve the communication and information flow – and by this also compliance – between pharma producers and patients, but also to reduce costs that are associated with drug recalls that are triggered by faulty leaflets or faulty information on packages which account for a two-digit percentage of all drug recalls. Also, the project received support from the European Union as public governance body in order to ensure that legal requirements are considered and the public support for such initiatives is given (Jennings, 2021).

3.2. BlockMedX

In 2018 the distributed ledger-based BlockMedX has been created with the aim to improve safety for taking painkillers and avoid drug abuse in the USA, mainly caused by overprescription. One enabler of overprescription by medical practitioners is the lack of a proper tracking solution about how much prescribed painkillers a patient already received and used. This is due to the fact that one patient can consult multiple doctors at the same time and receive multiple prescriptions accordingly. Also, handwritten prescriptions and the lack of a proper cross-practitioner tracking system pay into a significant share of drug abuse and overprescription, in many cases even leading to patients´ deaths. With BlockMedX a blockchain-based solution was established where patient, physicians and pharmacies participate. Physicians have access to the patients prescription history and can issue

prescriptions accordingly. Technically, the medical practitioner who alone can issue a prescription via a dedicated key functionality, is realising a prescription that is still pending until it gets validated by BlockMedX Pharmacies also have access to the prescriptions issued by the physician and the history of the patient, whereby each transaction is validated on the blockchain accordingly. By this, transparency increases significantly on both medical doctors but also pharmacy level in order to support a more drug usage for patients (Jindal, 2018).

3.3. Adveva® platform

The pharma company Merck has partnered with smartpatient, a digital service provider, to create a digital interaction platform with patients that suffer from Multiole Sclerosis. The platform was called Adveva® as part of the my patient platform and started in 2017. The platform was aiming to give personalised advice and intended to be complementary to the treatment by medical practitioners who do not have sufficient time to manage patients that frequently. The ultimate goal was to support patient compliance, i.e., ensuring that the right medication is taken at the right time and to increase patient knowledge and transmit important content for their therapy. By this, relevant content can be shared highly scalable, e.g., via videos. Smart digital technologies provide the content in a tailored way, based on specific needs, which is patients the perception that this service is personalised. The Adveva® platform is interlinked with other digital offerings of Merck that target patients, for example platforms that help to manage injections. By this, patients can utilise a comprehensive offering for their treatment needs and likewise Merck is gathering more and more data and insights. Patients do not neccessarily need to register and by this Merck aims to manage data privacy obstacles. Nowadays, the platform has more than 100 million interactions with patients on a regular basis (Gaede, 2021).

3.4. VaccineLedger

In 2021, the two Asian tech companies StaTwig and Tech Mahindra were creating the project VaccineLedger in context of the Covid crisis. The project is based on a distributed ledger technology and shall support the tracking of vaccines along value chains from producers, throughout logistics and up to healthcare delivery providers, i.e., patient level. The tracking solution should support the reduction of vaccine shortages, temperature management along logistics, e.g., cold chain management and shelf-life management as well. Participants of the tracking scheme can use their smartphones to scan codes on packages in order to validate their progress along the value chain (Manly, 2021). The approach has been piloted by StaTwig in India and now both parties seek to scale the solution by establishing a consortium including many players and stakeholders of the pharma and healthcare industry (Taylor, 2021).

3.5. Decentralised clinical studies and Medidata platform

Throughout the last years, decentralised clinical trials were on the rise whereby participants of such studies interact with the organisers of the respective study via digital means. This can include the usage of certain wearables, telemedical interactions or online surveys. Some authors project a strong growth rate, i.e., almost doubling the amount of decentralised studies in 2022 compared to 2020 (Parkins & Hillman, 2021). Digital solution like Medidata support the organisation and execution of decentralised clinical studies and also engage patients to join similar studies after they joined a particular one. Other digital platforms like Castor allow researchers to create clinical trials within easy-to-use solutions and also match with suitable patients that have joined the platform, in order to create faster outcomes (Parkins, 2021).

3.6. BRUINchain

The project BRUINchain was established in 2020 as an digital solution between UCLA health, a system of different hospitals and health institutions around Los Angeles, California, and a pharma producer using decentral digital distributed ledger technologies. The project was set up within a public program that should support traceability of pharmaceuticals along the value chain for improved compliance and reliability of the value chain. The digital solution utilises codes on the packaging of each drug in order to validate its origin with the pharma provider (Chien, et al., 2020). Hereby the pharma provider does not have to reveal to many details and data points such as all serial numbers of the respective drug, but the user in the hospital simply scans the code and asks for validation be the pharma producer (Jennings, 2021). If the code is validated, the drug package is processed, if not then being sorted out in order to avoid fraud. After this, each transaction across different persons at the pharmacies and hospitals at UCLA health are tracked whereby each person scans the product via smartphone app. By this, medical doctors can check at a glance where the drug comes from and how it was processed. As quality checks bear significant costs, i.e., personnel costs, utilising such approaches might bear significant cost saving potentials. In fact, the project was initiated in context of a new public regulation by the US federal authorities FDA, the so called Drug Supply Chain Security Act, requiring healthcare providers to validate the origin of medications more thoroughly (Chien, et al., 2020). Notwithstanding, this system of connecting different players across the value chain of pharma and healthcare were initiated as closed system between a pharmaceutical provider and a healthcare institution.

3.7. Results of case studies

The case studies of the two areas pharma creations and healthcare delivery give insights and diverse perspectives on the research questions as follows:

1. *Can (decentral) digital technologies help to overcome issues related to trust and transparency?*

There are many indication in the mentioned case studies that digital solutions across different players in the pharma and healthcare value chain can help to improve trust and compliance and overall support quality management in related supply chains. The case of Pharmaledger shows that digital technology can be used to protect against fraud and manage compliance by sharing the right information to the right person at the right time. The examples of BlockMedX shows that digital solutions between various stakeholders in healthcare delivery, i.e., patients, medical doctors and pharmacies, can help to ensure compliance and avoid drug abuse by potential overprescription, whereby especially decentral digital technologies where chosen to manage data privacy safely. The example of VaccineLedger showed that seamless tracking of value chain steps across different players via digital technologies can help to manage quality issues and thus trust between them and also the example of BRUIN chain shows that digital technology can help to manage quality of drug delivery in healthcare delivery institutions and thus improves compliance and trust between different players effectively. In many of these cases decentral technologies where used and it can be derived that those technologies can play a vital role for trust and compliance.

2. *Can (decentral) digital technologies help to allocate resources more efficiently and/or generally optimize flow of goods and processes within the value chains?*

The example of PharmaLedger has shown that relevant information can be shared much more efficiently among different players than before, i.e., leaflets are automatically

updated once changes happen. Also, this example shows that effectiveness can be improved as the digital solutions ensures that everyone who participates in the system is receiving information once issued which might not have been the case before. The case study of the Adveva® platform by Merck makes patient interaction much more scalable and thus efficient, also it provides comprehensive advice to patients very frequently which is an extent of therapeutical advice that was not possible before by means of the healthcare delivery system, i.e., by using purely medical doctors and pharmacies for advice. Vaccine ledger has shown that temperature management can be improved and thus improve the effectiveness of the supply chains for pharmaceuticals and corresponding raw materials as well as BRUIN chains that showed that costs for quality checks can be saved and that quality management can be run comprehensively and not only by sample tests. Looking at the examples, it can be seen that especially decentral digital technologies can help to improve efficiency and effectiveness for supply and delivery related topics whereas for more efficient communication they can be useful (e.g., PharmaLedger) but also other digital technologies can create efficiency and effectiveness benefits (e.g., Merck´s platform Adveva®). Overall, there is a clear indication that digital solutions across different players in the pharma and healthcare value chain can strongly support efficiency and effectiveness.

3. *Can (decentral) digital technologies enable new business models, i.e., new forms of value creation and/or value capture and if so who is creating and capturing it?*

The example of the Adveva® platform enables Merck as pharma player to interact with patients much more, i.e., to an extent that was not possible before for pharma players. By this, Merck can offer additional services and can make use of data points and related insights for themselves but maybe also sell data points (if compliant with data privacy) to others. Also, healthcare delivery, in this case tailored therapeutical advice, is enabled which was not possible before to this extent and frequency by the existing healthcare delivery system. Nevertheless, looking at other example cases, most of digital solutions help to improve the effectiveness, e.g., by better or more personalised support, and/or efficiency of existing business models in the pharma and healthcare value chain.

4. *Can the deployment of (decentral) digital technologies change the way how value chain players interact with each other and how would this influence their relationship among each other then?*

Generally, the example cases show that data is shared much more comprehensively once those digital solutions are deployed between different players and actors of the pharma and healthcare value chain. The example of PharmaLedger shows that decentral digital technologies can be useful to support data sharing in compliance with data privacy regulations whereas the case of the Adveva® platform by Merck shows that that utilising other approaches can also work whereas patients are not registered in this case which can be an indication that decentral digital technologies can play a supportive role for data privacy management. Also, this example shows that incumbent players such as pharma company Merck can act in new roles in addition to their current role, meaning that Merck acts in addition to its role as pharma suppliers also as medical advisor which was done by medical practitioners and pharmacies before only.

In essence, most examples show that by using digital technologies along the pharma and healthcare value chain, pharma players move much closer to patients and get many more insights. Traditionally, there had been a few intermediate players between pharma companies and patients such as distributors and pharmacies and also medical institutions. This line seams to get blurred and more direct interaction between pharma companies and patients can be observed. On the other hand, the example of the Medidata platform for

decentralised clinical studies also shows that new types of intermediates can arise as those decentralised clinical studies were enabled by digital technologies. Besides the fact that interaction between different stakeholders can be enabled by digital technologies that was not possible before (i.e., between pharma companies and patients), digital solutions in the pharma and healthcare value chain help to improve the existing communication between different players, as shown in the example of BlockMedX by medical doctors, pharmacies and patients for drug prescriptions.

5. *Can (decentral) digital technologies trigger the rise of new players in the value chains or the disappearance of others and how would this influence the distribution of power along the value chains?*

The example of Medidata as platform for decentralised clinical studies shows that new players can emerge once digital solutions have enabled new forms of interaction between different players along the value chain. On the contrary, the example of the Adveva® platform by Merck shows that also incumbent players like pharma company Merck can take over a similar role by interacting with patients directly. Thus, there is no clear indication and it might be subject to further research if this is new players will rise significantly. Also the cases have no clear indications if certain players will be gone once those new digital solutions are in use, although the stronger interaction between pharma companies and patients directly can be interpreted as potential opportunity to make certain intermediaries between both players redundant.

4. Expert Interviews

The third method as part of the mixed methods/triangulation approach is related to experts for using (decentral) digital technologies in the value chains of the agri-food industry. These experts are a diverse group of people and comprise decision makers and experts and from digital health companies, decision makers and digital experts of pharma companies as well as medical practitioners and doctors in order to ensure comprehensive insights. In total, interviews with 10 different experts took place in order to create initial insights as part of exploratory research along three research areas: transparency, cooperation and business models.
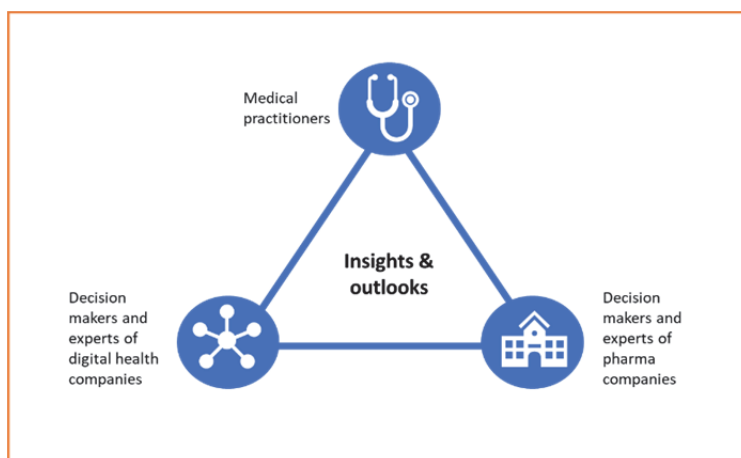

Figure 3: Schematic graph of expert panel for interviews.
Source: created by author, 2022.

The questions have been pre-tested with one expert and tested for validity and reliability. The interviewees have been informed that the interviews are recorded and that their participation is voluntarily and then can end the interview anytime if they wish. Also, the interviewees have been encouraged so speak openly about their experiences and views.

After taking place, the interviews have been transcribed and analysed using the qualitative research analysis method from Mayring. Accordingly, superior themes have been identified and the interview content was assessed accordingly in order to find communalities and inconsistencies and also to identify potential directions for future developments as the research field as entirely exploratory (Mayring, 2015). Based on the expert interviews, the following themes around the research objects trust, coordination and business models as well as the research questions were identified:

4.1. Traceability to avoid fraud

Almost all interviewed experts point out the importance of digital solutions that are used across various players along the value chain for improved traceability of goods. Especially, traceability was mentioned in the context of fraud protection whereby some interviewed experts clearly state that this topic is relevant especially outside Europe, i.e., for the African market, larger parts of Asia such as China and also partially the United States of America were mentioned in this context. In the past, so called agents had been used that do sample checks in various markets in order to validate that each drug package does really contain the product that is mentioned on the packaging. Hereby those agents had to visit individual pharmacies and check individual packages, resulting in a costly and workload-intense procedure. Nowadays, digital solutions can be utilised to manage this topic whereby pharmacists and patients can check with their smartphone if the drugs in a package do match what the package claim to be. Hereby decentral digital technologies are in use that also allow to connect to legal authorities and potentially report any deviations from expected quality standards or potential fraud allegations. Especially this connection was reported by an expert to be not possible to this comprehensive extent and that efficiently, utilising the traditional approach with agent screenings on pharmacy level. By this, new digital technologies connecting various players along the value chain of the pharma and healthcare industry have enabled to swiftly connect different stakeholders of the industry.

Technically, experts report that such digital solutions often utilize codes on packages, e.g., bar codes, that are unique and allow tracking all along the value chain up to drug producer level. Generally, counterfeit and fraud seems to be a big issue according to the experts, also selling pharmaceuticals online on marketplaces such as Amazon seems to have boosted this issue. Meanwhile, not only tags on packages are used but also drugs, i.e., pills, are tagged as well according to the experts. Hereby holograms or codes printed on pills are used, yet those approaches are still somehow niche applications. Asked about potentially scalability of this methos, experts told that this might be quite costly and resource-intense but seems to be a matter of economies of scale whereby such printing technologies can get more affordable once being used more broadly. Y

The interviewed experts state that in most cases such traceability initiatives have been initiated by pharma players, mostly to avoid any damage to brand reputation. Being asked, experts mention especially brand reputation in this context and not only or not especially the motivation to reduce commercial losses of pharma companies due to such fake drugs and black market developments. Notwithstanding, experts also mention that digital solutions are also utilised by raw material suppliers for the pharma and healthcare industry,

not only by the pharma producers themselves. Nevertheless, most experts see those approaches being driven mainly by the pharma producers, especially by the originators, i.e., those who have intellectual property on certain drugs.

In addition, an expert also mentions potential trust issues to be existing between pharma players and regulatory bodies and institutions of the public healthcare system, so traceability might also be beneficial in this context. Also the notion of "customers" was discussed by the interviewed experts, whereby one experts points out that especially for prescribed medicine rather medical doctors serve as customers from a pharmaceutical producer perspective as patients anyhow need to take the medicine they get described from their physician in order to treat their medical issue. Thus, the medical doctor acts as decision maker which drug to prescribe (if several different drugs exist with the same active performance ingredient). Generally, the notion of marketing towards patients was discussed controversially, as for prescribed drugs usually patient marketing is not permitted legally and/or morally. Although this does not affect over the counter-drugs that can be bought by patients without any advice or subscription from medial doctors, generally, according to the experts, it seems that digital solutions for traceability are not so much used to support any marketing claims. In contrary, one experts reports that it can be observed that in context if sustainability, patients might be more interested where drugs are coming from. Nevertheless, most experts see digital solutions for traceability mostly in the context of fraud protection in order to avoid any issue related brand reputation and product quality.

4.2. Efficiency gains

Generally, the interviewed experts did strongly refer to potential efficiency gains in context of digital solutions that are used across different players of the pharma and healthcare value chain. Among them, digital solutions for improved traceability along the value chains of the pharma and healthcare industry were mentioned by the experts also strongly in the context of potential efficiency gains. In particular, the experts referred to certain quality checks that need to be performed at individual stages of the value chain. For example, ingredient suppliers need to perform quality checks for the raw materials that they receive and pharma producers need to perform quality checks for the ingredients that they receive. In particular, experts point out that those quality checks are important but likewise exhaustive as many raw materials can go into one ingredient and many ingredients can go into one pharmaceutical. According to the experts, it seems not only to be important that the right products are delivered in the expected quality, but also that certain quality criteria along the logistics are met. For example, for some products it seems to be important that they do not exceed certain temperature thresholds throughout logistics which is the reason why some products ad purpose are not shipped via air freight or other logistical ways. Notwithstanding, it seems not to be easy to validate if the framework conditions, that have been pre-defined, were met along the logistical ways. Hereby digital technologies can be instrumental, i.e., sensor technologies or similar that can be used throughout the logistical routes between different players.

Once goods arrive at the next stage of the value chain, one expert explains, often samples are taken and checked in the lab while the product is already being used in production. If this quality check reveals that quality of the received good is not as expected, the whole production batch for which the arrived good was used, needs to be wasted. For this case, digital solutions that are based on sensors can be used, whereby they check in real-time once goods arrive of the quality of the goods is as expected. If goods do not comply with those quality standards, they can be immediately sorted out and will not be

used for production. Hence, via this approach misproduction can be reduced effectively, leading to less resources being wasted along the production process.

In this context, experts also mention the necessity of sharing data across different players, as those data points can also support to minimize any production-related issues. The experts mention that for this purpose currently data logs are shared between different players along the value chain, for example temperature data of the production of ingredients are shared by ingredient suppliers to pharma producers. Although experts point out that sharing data between different players of the value chain strongly improves the effectiveness and efficiency of the value chain, they also mention that this does not work perfectly due to cultural issues and concerns around the overall sensitivity of those data points. Nevertheless, they mention that collecting data points has been simplified by applying (decentral) digital technologies such as sensors, so more and better data could be shared. In context of potential efficiency gains via digital technologies in the pharma and healthcare industry, experts do not only mention the substitution of improvement of quality checks but also the potential substitution of validity checks being embodied by four- or eight-eyes principles. Hereby digital technologies could be used to validate information without the necessity of various actors to perform the validation themselves. Aside from this, efficiency gains by digital solutions are mentioned by the experts as lever to manage costs more smartly. For examples, the experts state that medical doctors can become more efficient if initial assessments are supported by digital tools and patient data records are available comprehensibly and conveniently for various stakeholders in healthcare delivery. In fact, proper management and availability of digital patient records was mentioned several times by the interviewed experts as key enabler for an efficient healthcare delivery. Other solutions being mentioned are telemedical services that can help to serve more patients at the same time.

4.3. Improved patient compliance

Another element that was associated by the experts with digital solutions being utilised across different players along the value chain is related to patients´ drug-taking compliance. In particular, experts mention that due to digital technologies, pharma players can interact with patients and check if they are taking the right drugs at the right time, which is the ultimate goal of any successful medical treatment. For this purpose, pharma players utilize for example smartphone applications that remind patients of taking their respective medicine. More recently, also newer sensor-based technologies have been used as mentioned by an expert whereby 6G-enabled technologies utilize microchips that are attached to tablet blisters and send a signal once a tablet leaves the blister. This approach does not only help patients to improve their intake compliance but also supports pharma producers during clinical trials in order to validate those studies. In essence, those digital technologies enable pharma players to move closer to patients, as highlighted by the experts.

4.4. Improved precision and individualised treatment

Most interviewed experts highlight that digital technology that is used across different players of the value chain significantly contributes to effectiveness for the value chains of pharma and healthcare, i.e., support precision in medical care. Some experts even mention improved precision as main benefit of digitalised value chains in the healthcare industry. Examples often include certain feedback loops from patients to treatment providers or developers, e.g., one expert mentions the benefit of knowing a patients´ blood type in order

to prescribe the right medicine. In this context, also personalised medicine is discussed whereby the interviewed experts rather state the truly personalised medicine might be rather unrealistic but providing treatment to patients based on certain biomarkers that are transmitted via digital tools might already bear a great benefit, e.g., for cancer treatment. In fact, individualised treatment could mean that a certain drug is manufactured differently for each blood type, as mentioned by one expert, and by this can be much more effective at patient level compared to a broader all-blood type treatment. Digital technologies are mentioned in this context as transmitter and storage technologies, whereby not only individual patient track records seems to be interesting for pharma producers and healthcare providers but also the spread of certain bio markers across populations, e.g., in one geography might already be beneficial for pharma producers in order to provide more tailored medicine. Some experts mention that pharma producers and players of the pharma and healthcare industry would also be willing to pay for such data points, opening up perspectives on potential new revenue streams.

Also the interviewed experts mention that precision can be supported by digital technologies in the pharma and healthcare value chains by more effectively coordinating different players to support more precise development and delivery of the right pharmaceuticals at the right time. In essence, one expert also mentions that digital technologies that connect patients with other players in the pharma and healthcare industry can also support pre-emptive evaluation of health risks and thus support faster action, maybe even before certain diseases arise. Some experts see medical devices being instrumental hereby if they can submit data to relevant stakeholders accordingly. This would enable real-time treatment of certain issues and by this eventually help that certain diseases do not emerge that heavily or at all and thus enable a stronger focus on prevention by the healthcare system. In addition, the interviewed experts also mention that this might be the case not only for pharmaceuticals but also for healthcare equipment. One expert raises the example that digital technology and data feedback could reveal that the effectiveness of one medication was not given as the equipment to apply the medication was not warm enough and thus needs to be pre-heated. This insight was obviously new to the equipment manufacturer and thus helped to improve the medication by providing more clear advice to patients.

4.5. Improved usage of patient data for innovation

Another important topic that was highlighted by many experts is related to using patient data, in particular from clinical studies, for innovation purposes whereby digital technologies can be supportive to transmit and share data among many different players. On one hand, the interviewed experts mention digital technologies in context of improving validity and reliability of clinical studies with patients while on the other experts state that via support digital tools clinical trials can be run much more efficiently and thus innovation can be driven much faster. Also, studies can be shared more easily and international comparison between results will be simplified according to the experts.

In fact, experts mentioned that Covid served as booster of utilising digital technologies as efficiency driver in this area. For example, digital tools were used to perform clinical studies with much shorter time required than usually, as patients could provide data points via digital means to pharma companies and medical institutions. Perspectively, experts see great benefit of digital solutions for research and innovation as many more data points can be created and gathered.

Nevertheless, many experts mention that data privacy plays and important role in this context and especially certain decentral digital technologies such as blockchain could be useful to manage data privacy from a patient perspective, i.e., to support patients in making conscious decisions about what data to share with whom and what not. In this context, also decentral digital technologies such as blockchain are mentioned as potential support for data privacy and data ownership management for patient data. Nevertheless, it was also stated that blockchain and similar decentral technologies can be instrumental but there will likely be other technologies coming in future that will then substitute such approaches based on decentral technologies like blockchain.

Also, experts see a potential downside in the significantly increasing amount of available data points throughout digitally supported medical studies which is related to quality concerns. In particular, experts mention that currently quality-ensuring systems such as peer reviews are in place that support the validity of clinical studies. If more and more data points will be gathered via digital solutions and more and more clinical study data is available, it can be hard to navigate for researchers and medical practitioners and become more difficult to assess what is relevant and meaningful and what not.

On the contrary, experts state that the current systems of clinical studies and medical publications is rather focussed on publishing results of clinical studies that show positive results whereby especially those studies with no positive results might be very insightful as well. Accordingly, if due digital solutions it gets much easier to collect and process patient data, also these types of studies can be made available and used by relevant stakeholders.

In addition, the experts mention certain obstacles of data being created by clinical trials currently, for example that data points cannot be used across different departments at one pharma player or cannot be used for similar projects due to certain restrictions in data privacy regulations. If digital technologies would enable a more broad usage of patient data, this would yield a massive benefit for innovation management in pharma creations in particular, as mentioned by the experts.

Besides insights on patient data, the topic of patient co-creation was discussed somehow controversially as some experts state that this might be less relevant especially for prescribed drugs and if feedback of patient around certain (side) effects is provided, this is mostly associated with lots of bureaucracy to be managed. Some pharma producers and similar players in the pharma and healthcare industry look specifically for patient feedback via digital tools, for example via social listening on online forums around certain (side) effects or particular drugs. Other experts see this topic of patient feedback rather less relevant and – if anyhow – rather relevant for over the counter-products. Notwithstanding, the interviewed experts point out the benefits of digital solutions for open innovation projects whereby pharma producers open up their innovation projects for external researchers and experts.

According to the interviewed experts, Covid served as strong lever for more digitalisation of the value chains in the pharma and healthcare industry and in particular for faster innovation cycles supported by digital technologies. For example, one expert mentions the so called project "lightspeed" by the two pharmaceutical companies Biontech and Pfizer, whereby the clinical trial period was not more than one year compared to usually a minimum of three years until sufficient data is being collected. In fact, experts state that managing clinical studies actually means managing data points, thus digital tools that connect patients with other players along the value chain can be very supportive.

4.6. Enabling of new business models via data monetisation

Generally, the data that is gathered within clinical studies remains in the ownership of patients as these are very personal data points. As these data points might not only be relevant for the pharma player that operates one particular clinical trial but can also be beneficial for other pharma producers or similar players of the value chain, patients could also sell them to those other players as mentioned by the interviewed experts. By this, data monetisation would be enabled, for example one expert explicitly mentions the OCEAN protocol in this context that is used to commercialise on data points via shared and distributed digital technologies. In particular, patients can store their data points as tokens on distributed ledger technologies and offer them on digital platforms to other parties, i.e., other players of the pharma and healthcare value chains. Although being technically feasible, the experts mention that such approaches are yet premature and still many pharma players might still be reluctant to utilise such approaches for getting data points as they are afraid around any potential data privacy issues that are associated with sensitive patient data. Some experts state that maybe other industries might be more bold to utilise such approaches near-term but generally see a big opportunity for improved and more efficient innovation of pharma players by participating in such data monetisation economies.

On the contrary, other experts mention successful examples of patients that sell their data points for specific purposes in Switzerland and the USA. In this context, the interviewed experts clearly state that sharing data by patients as part of a rising data economy in pharma and healthcare might not only relate to selling data for money, but can also mean that patients share their data if they get other types of benefits such as a more personalised treatment of healthcare delivery service and medicine can be tailored to their needs or they get a discount on certain medications if the commit to share their data points. In fact, many experts mention that patients are much more willing to share their data digitally if the see the ultimate benefit of their data sharing, i.e., if it improved certain therapies such as cancer treatment but they might be less willing to share and sell if it is for pure commercial purposes.

Although shared data play an important role for the pharma and healthcare industry, many experts point out that culturally this industry is rather conservative and proper data sharing does still not happen to a larger extent. In this context, experts point out that data sharing is actually an enabler to create more meaningful data points, as other players can make use your data and enrich it whereby the insights on the enriched data set has much more value than the isolated data sets would have. Some players seem to facilitate data sharing via their own digital services, e.g., one experts mentions a digital solution that is being offered to players in the pharma and healthcare value chain in exchange of data insights and if those players do not want to share data they have to pay subscription fees. In essence, such approaches whereby users of services can either pay via money or via data seem to be a serious hint on a rising data economy. According to the experts, respective players in the industry already understood the value of data that they can share, as one expert mentions that certain data points of raw material suppliers can simplify work with regulatory bodies (e.g., for registering drugs in certain geographies) of pharma players which are the customers of those ingredient suppliers. In this context, according to the expert, those ingredient suppliers do not give away those data points for free but try to commercialise them somehow.

In context of data sharing, the interviewed experts anticipate the evolution of only few data sharing standards that are used across the industry, whereby being able to share data might serve as differentiator for players for some time and then could be hygiene factor to

participate later on. Also distributed ledger technologies such as blockchain have been mentioned by the interviewed experts whereby these technologies are not seen to be vital for data storage but their smart contracts are seen eventually instrumental to be useful to manage a data sharing-economy. Generally, data monetisation is seen as major topic whereby (decentral) digital technologies can serve as strong enabler.

Generally, the experts foresee that data aggregating companies will benefit from this evolution and eventually a new market can be established that is based on shared data whereby service providers put more focus on prevention than before which can potentially lead to a decrease of treatment measures to be required, e.g., pharmaceuticals. Nevertheless, one experts mentions that already today plenty of relevant data is available but the tricky part is rather to draw meaningful conclusions out of those data points. Based on this, some experts see that likely larger tech companies will play a vital role in this areas as they have they technical expertise to deal with larger sets of data and it will be hard for pharma companies that need to insights for their innovation management to keep up to speed with those tech players.

4.7. Obstacles to implement new digital solutions across value chains

The interviewed experts also refer to certain obstacles to implement new digital solutions across different players in the pharma and healthcare industry´s value chains. In particular, many experts refer to cultural resistance whereby the culture of most players and actors in this industry is rather conservative in context of data sharing, i.e., a pro-active data sharing-culture is not yet evolved sufficiently. Next to this, many interviewed experts state that associations, e.g., associations of medical practitioners, want to hinder the rise of digital solutions among different players as this creates more transparency, also about value chain profit pools. Generally, the experts see that key players are resistant to change and see this resistant and major reason why larger, value chain-wide digital solutions fail. Also, the experts mention a lack of proper organisation between different key stakeholders of the pharma and healthcare industry to implement new digital solutions across different players such as patient records that can be accessed by a number of relevant players in the industry. Here, the experts state that not the lack of suitable technical solutions hinders progress, but ineffective organisation between key players to define common standards and cultural resistance to change. In this context also budget constraints are mentioned, especially for healthcare providers such as hospitals. In essence, experts also see that an ineffective communication between healthcare providers and public institutions and administrations contribute to a slow adoption of new digital solutions.

In fact, some experts mention that the actual technical implementation of new digital solutions is not so expensive but the trickier part is often to get the new solution approved by respective authorities and to make them comply with respective regulations. Hereby the experts refer to the current regulatory system not being ready for the implementation of new digital solutions across different players of the value chains in the pharma and healthcare industry. Especially Covid was showing, according to the experts, that data points as basis for studies can now be gathered much faster via digital solutions but that the technical feasibilities of those solutions where often clashing with the existing regulatory standards.

In addition, experts mention the strong need for technical capabilities of various players in the industry in order to technically implement all those new digital solutions, including technical talents experts. For example, some experts mention that major pharma and healthcare players do not have the technical capabilities to make their systems robust

against hacking which contributes to a slow adoption of digital solutions across different players in the industry. In this context, experts also refer to the complexity of the value chains in the pharma and healthcare industry, mentioning examples where one player has lots of different suppliers, often ranging from smaller to larger entities, so that implementing comprehensive data sharing systems can be quite complicated.

Nevertheless, the experts also mention that Covid strongly accelerated the rise and usage of digital solutions, although still a lot of basic work has to be done to create an infrastructure for new digital solutions across different players to unfold. One expert states that many regulatory bodies where driven by the fast development during Covid that were enabled by new digital technologies, i.e., gathering relevant data points for permitting new vaccines as these data points have been gathered much faster than expected by the regulatory authorities. In order to deal with the situation, regulatory bodies committed to certain practices in a rush due to the high pressure for releasing new medications during Covid, whereby the expert anticipates that Covid has opened a new age in terms of dealing with digital solutions and regulatory bodies. Generally, most concerns relate to the usage of patient data for innovation purposes, i.e., clinical trials and studies, and then finally also the permission of new medications by regulatory institutions. Hereby experts also mention new decentral digital technologies such as distributed ledger (e.g., blockchain) to support the patients in managing their own data and eventually limiting visibility as they would like to. Hence, some experts see new decentral technologies as potential enabler for managing patients data within new systems of data sharing across different players of the pharma and healthcare industry´s value chains.

In fact, data privacy and related regulations and public governance bodies are mentioned as major obstacle for new digital solutions to be implemented across different players. Some experts state that data privacy regulations are overdone and are not required to ensure a safe handling of patient data among various institutions and players. In some cases, experts also describe that existing rules can be hard to understand for practitioners, one example being mentioned is the processing of patient records which is very tricky from a legal perspective even via secure emailing systems but can easily be done via fax, whereas fax machines can be accessed by many people and secure email program require comprehensive authorisation checks. However, the experts describe the legal situation around data privacy as complex and heterogenous across different countries, whereby Switzerland was mentioned as bet practice example of safeguarding patient interests but also enabling innovative digital solutions to be implemented fast and effectively.

4.8. Value chain evolution

Being asked about potential a evolution of the industry´s value chains in light of new cross-value chain digital solutions, the experts believe that the role of some players might change whereas other players might not be required anymore. For examples, existing validation institutions such as quality assurance bodies, will likely not be substituted by digital solutions but their work might change according the some experts. One expert mentions that maybe they will rather validate the processes that lead to a certain final outcome but not the outcome itself anymore in the future. In addition, also the role of market intelligence institutions might change as they usually compile data sets of on insights of the pharma and healthcare industry and these insights can also be created and gathered somewhere else, maybe more efficiently.

In fact, experts anticipate that certain roles will change as the availability of data will make rather basic tasks more redundant, so that experts do not need to spent time on

gathering data but spent more time on interpreting them and taking action upon the interpretation. In essence, this would make operations of certain players in the pharma and healthcare industry more efficient.

Generally, the experts foresee the evolutions of data management standards including data governance frameworks and data literacy, whereby those who set those standards can become very powerful. With many decentral digital technology projects happening at the moment in parallel, according to one expert, this evolution might take more time as such decision are now with many different players and actors in the industry. Consequently, the experts foresee such an evolution rather mid-term, i.e., not happening within the next five years. It this context, it was mentioned by some experts that they see decentral digital technologies being instrumental to manage data confidentiality for new digital solutions but not so much as sharing infrastructure along the value chain.

Furthermore, experts perceive already now a stronger consolidation also for digital platforms in the pharma and healthcare industry, whereby the experts anticipate that only two or three powerful platforms will remain after a period of further consolidation. On the contrary, one expert anticipates that new business models with smaller, more specialised digital platforms will evolve, especially in context of bio-pharma.

In terms of current value chains players, the interviewed experts mention that newer digital technologies can make incumbent players redundant as those digital solutions can connect various players much easier without major support by intermediates. Examples were raised during the interviews for software companies that support invoicing of medical practitioners and also for service companies that connect doctors to pharmacies for prescribed medication as this can be handled via e-prescription. Generally, the experts see that many activities of those intermediaries are not required in the future once those new technologies are in use across different players. Hence, if those players don't change their role and offering, they might turn out as losers from such developments. Hereby some experts could foresee that pharmaceutical companies could make use of digital interaction channels with patients and directly provide their products and medications to them without pharmacies as intermediaries. One expert explained that although being technically possible, pharmaceutical players are currently hesitant to implement such solutions as they do not want to harm their relationships to pharmacies. In this context, e-prescription is seen as major digital innovation and key enabler of this development. Nevertheless, in near- to mid-term future pharma players will make use of such opportunities with a high likelihood. On the contrary, one expert states that providing medication might also require human interactions for some patients that appreciate personal contact and advice by pharmacies whereby very likely patients will reveal a heterogenous behaviour with some utilising more efficient and convenient e-commerce channels whereas others might appreciate using (local) pharmacies and their expertise. Either way, most interviewed experts state that generally pharma companies will move much closer to patients once data is shared more comprehensively in various initiatives. In addition, most experts also highlight that the role of medical practitioners will likely not be substituted by digital means but their work will become more precise and efficient by using digital technologies.

Also, the interviewed experts highlight the increasing importance of prevention that is enabled in a personalised and tailored way by digital means. If more prevention measures are realised, much less disease treatment might be required and many diseases will likely not emerge or expose a much less harmful development than today. As a consequence, this will impact key players of the value chain that operate their business based on medical treatment needs, most prominently pharma companies. In this context, one expert states that

prevention measures will increase being supported by digital technologies and treatment will become less relevant, but very likely the industry will end up in a kind of more balanced hybrid of prevention and treatment measures and treatment applications will not be fully substituted by prevention.

If enabled by public legislation, some experts foresee a more stronger steering role of healthcare insurances that utilise digital solutions across the value chain to support patients more and foster prevention measures in order to reduce costs. Also, they can offer patients more tailored services and solutions based on their individual needs in this context.

Once more and more of those cross-value chain digital solutions are implemented, some experts see that tech companies which are not traditional players of the pharma and healthcare value chain, can become very powerful as they have all required competencies and economies of scale to manage those digital solutions fast and effectively. Regarding pharma players, experts see that they might struggle to adopt to such a technology leader role although currently they would be the natural players due to their powerful position and access to data via clinical studies. Thus, it might be likely that new powerful players enter the pharma and healthcare value chain.

Due to increased connectivity between different players along the value chain via digital solutions, experts mention that very likely the different sectors of the industry will likely move closer together, for example primary and secondary care and research and medical practitioners. In essence, experts state that most of those incumbent players will remain but their work will become more connected and thus efficient.

4.9. Results of expert interviews

Efficiency gains are seen in many areas, among them traceability of goods along the value chain, more efficient healthcare delivery services such as more efficient work of medical doctors and especially in context of sharing patient data across different players. Also digital solutions will help to become more effective, i.e., by enabling more precise and individualised treatment and medication for which data sharing across different players along the value chain is key.

Digital solutions are used to track product flows across different players and can help to avoid costs, optimise production and perform quality management tasks at several players along the value chain much cheaper and more comprehensively (not only sample testing by agents). Aside from fraud protection that is especially relevant in Africa, Asia and partially also the US, pharma players want to protect their brand reputation via utilising such digital solutions. Such digital quality management solutions are not only used by pharma but also by various other players such as raw material suppliers, distributors and up to pharmacy level.

Innovation cycles can be much faster using digital tools as just proven with the digitally supported clinical studies during Covid where pharma players required only a fraction of the time that is usually required to perform those activities. However, data privacy seems to be a serious issue and many opportunities cannot be captured due to existing data privacy regulations. Governance bodies and legal regulations in this context are perceived to have outdated rules that hinder innovation to unfold. Although the increased availability of patient data is much appreciated by the experts, also by medical doctors, some concerns around quality management of clinical studies were raised once many more data points are available and published.

The connectivity that comes with cross-value chain digital solutions in pharma and healthcare might foster the evolution of a data economy where patients can share their data

and get something in return, initial cases in Switzerland and the US have been mentioned by the experts. In this context, the experts see a higher likelihood for a potential data economy to unfold if patients see the clear value of their data sharing and this value might be connected to some health benefits, for example by contributing to the innovation of a new medication that might be relevant to them or by offering more personalised services, than purely offering monetary compensation for data sharing. Decentral technologies can be an enabler to manage data access for patients but are not seen as vital instrument for data storage.

Although data sharing is key for all those development, experts see a strong cultural resistance for this in many areas of the value chain, i.e., between raw material suppliers and pharma companies but also between patients and healthcare delivery institutions. In this context, also a lack of proper organisation and lack of common ground between key stakeholders in the industry are mentioned as major obstacle for digital solutions to be implemented effectively across different players, e.g., for digital patient records. Generally, mindset, culture and cooperation between different key players are seen more as an obstacles than the lack of suitable digital technologies.

Digital technologies will enable more preventive measures which can shift value from treatment to prevention. This can create a new market but also this can mean that the market for treatment providers will decrease which would have a significant impact on pharma companies. Although pharma payers are quite powerful in the pharma and healthcare value chain, they are not considered as key players for those digital developments due to lack of expertise. Rather larger tech companies are seen in this role.

Generally, the experts see that most value chain players will remain and become more connected and thus work more efficient together. Although digital solutions could make significant parts of the work of some players redundant, the experts see that some roles such as medical doctors and pharmacies or also quality assurance institutions will remain but only their work will change whereas other players such as invoicing support service providers are likely to be substituted by digital technologies that increase the connectivity across different players.

5. Evaluation & Discussion of findings

The mixed methods/triangulation research that comprises state of the art literature reviews, 10 expert interviews and 6 case studies of digital solutions that are used across different players within the value chains of the pharma and healthcare industry reveal interesting insights. Some statements and hypothesis of recent literature could be validated, some could be enriched and some new findings could be gathered. To enable a proper comparison of the results, they have been clustered into 3 different clusters with 3 themes each:

- **Motivation** with finding related to tracking of goods, research and innovation and more individualisation and precision
- **Implementation** with findings related to data privacy, obstacles and efficiency gains
- **Evolution** with findings related to existing and new roles, business models and winners and losers.

All findings are captured in the Figure 4.

The motivation to use digital technologies across different actors in the pharma and healthcare value chains are manyfold. Especially, track and trace of goods along the value chain is considered in literature as key benefit of using digital solutions among various

players. In this context, literature also strongly considers newer decentral digital technologies such as distributed ledgers. Tracking is mainly useful to protect against fraud and also for quality management purposes such as temperature management. These statement from other researches could be validated by both, case studies and expert interviews. In particular, experts see reputation management as key driver of pharma players as strong rationale. Also other motivational elements to use digital solutions across different players that were mentioned in recent literature – such as more individualised treatment and thus precision as well as faster innovation cycles – were validated by both case studies and expert interviews. For those two motivational aspects data sharing, especially patient data, is key. In this context recent literature suggests that in particular decentral digital technologies such as blockchain could play a vital role to manage data privacy smartly. This could only be partially validated by the case studies and expert interviews as some case studies do show that decentral digital technologies can be instrumental for this purpose, but also other ways exist that can enable processing of patient data across various stakeholders. In essence, it needs to be subject to further research if decentral digital technologies will be a key enabler of data sharing, especially patient data, or it is a technology that is hyped by researchers. Notwithstanding, data privacy management was mentioned in all sources, literature, case studies and expert interviews as prominent obstacle for digital solutions to be implemented along the value chain effectively. In addition, the expert interviews revealed that also cultural adaptiveness can serve as major obstacle for digital solutions to work effectively across different players. In particular, this relates to a culture of information sharing which is rather pre-mature in the pharma and healthcare industry. As research also mentions the lack of proper interoperability of different systems and ethical issues as potential obstacles, there was no evidence in the expert interviews of the case studies that could neither validate nor falsify these statements.

Generally, digital solutions across different players in the pharma and healthcare value chain are considered as strong contributor for efficiency, i.e., more efficient communication and information flow between different stakeholders. This could be validated by the case studies and also the expert interviews but also the expert interviews showed that not all tasks are likely to be substituted by digital technologies for efficiency gains although this would be possible technically. Thus, statements of recent research could be validated only partially.

There is limited research available on the potential evolution of value chains in the pharma and healthcare industry once digital technologies are used across different players. Both case studies and expert interviews reveal that many digital solutions that are used by different players will likely move pharma companies closer to patients. Hereby incumbent pharma players could take over new roles, i.e., by providing medical advice, in addition to their existing roles. Although digital technologies enable that more players can interact directly with each other without intermediaries, e.g., pharma companies with patients, the case studies suggest that also new intermediaries such as matchmaking platforms can arise. Expert interviews confirmed the opportunity of direct interactions between pharma companies with patients and highlighted in this context also the fact that at some point in time eventually pharma companies could be able to provide medications directly to patients. Nevertheless, other interviewed experts state that medical practitioners will still be required – at least for some patients – in the future although it will be technically possible that pharma players directly supply patients with their products. As this research clearly shows that pharma companies can much more interact with patients via digital means, it will be subject to further research how this will impact the relation of pharma companies to pharmacies and the supply of pharmaceutical products to patients will look like in the future.

Theme	Topic	Research area			Validation, falsification & new findings	
		Literature research	Case studies	Expert interviews		
Motivation	Tracking to prevent fraud and improve quality	High importance, especially for temperature management	High importance, various cases exist in this area	High importance	☑	Confirmed
	Faster research and innovation	High importance, sharing of patient data as key enabler	High importance, sharing of patient data as key enabler	High importance, sharing of patient data as key enabler	☑	Confirmed
	More precision and personalised treatment	High importance	Uses cases are given, sharing pf patient data as key enabler	High importance	☑	Confirmed
Implementation	Role of decentral digital technologies to manage data privacy	Decentral digital technologies as key enabler to manage data privavcy	Decentral technologies play vital role In some use cases whereas in other cases other approaches are chosen	Decentral technologies are seen by some experts as vital to manage data privavcy but also other systems might be compliant and be used by players along the value chain	(☑)	Only **partially confirmed**
	Obstacles to implement new solutions across different players	Data privacy, lack of interoperability & ethical questions that slow down progress	Data privavcy	Data privavcy and lack of clutural openess to adopt new digital solutions	☑↗	Confirmed & new finding
	Efficiency gains	More efficientt communication and data sharing, more effcient connectivity between different stakeholders	Substitution of validation tasks and efficiency gains effective	Reduction of admin tasks can be effective but not fully be substituted by digital technologies	(☑)	Only **partially confirmed**
Evolution	Existing relationships and new roles	No clear indication	Pharma players move closer patients and thus can act in new roles in addition but also new intermediaries such as platforms can arise	Some incumbent players (e.g., pharma) can have new roles but very likely tech players will play key role for new digital platforms and solutions. Digitally-supported provision of mediactions by pharma players directly to patients can happen but human touch of medical pratitioners still seen as relevant for some patients.	↗	New finding
	Business model evolution	No clear indication, likely rather focus on optimising existing business models and processes or adopting digitally-enabled business models to pharma & healthcare industry	New types of services can be offered, e.g., by pharma players that provide personalised advice based on patient data but most use cases relate to process effciency	Data econnomy can arise but patients ery likely rather give away data if they see actual health benefit but not so much for pure commercial value	↗	New finding
	Winners & Loosers	No clear indication	Pharma players can benefit with faster innovation cycles and more reliable supply chains	Quality management institutions likely to remain but change their role, invoicing support providers likely not needed anymore. Role of existing healthcare providers might become more efficient but very likely will remain. Digital platforms will likely consolidate so that market is dominated by few powerful ones. Healthcare insurance companies can benefit from more data transparency and play more active role in healthcare system.	↗	New findings

Figure 4: Results of mixed methods research

In terms of business model evolution, literature rather states that digitalisation efforts in the pharma and healthcare industry focus on improving efficiencies of existing processes and thus optimising existing business models. Only some authors relate to digitally-enabled business models that can also be observed in other industries, such as sharing economy platforms, that are applied to the pharma and healthcare industry. In this context, the case

studies create new insights as also new types of offerings could be created that were not possible before digital solutions are used. Examples relate to medical advice that is given by pharma players to patients based on their data inputs. Furthermore, the expert interviews also state that a potential data economy could arise whereby patients provide their data points to relevant stakeholders and get something in return. For this purpose, there are indications that also decentral digital technologies could play a vital role. Nevertheless, expert state that very likely patients rather share data if they can get some health benefits out of this, e.g., by contributing to research for a new medication or by getting more personalised treatment and services, than simply getting money in return. As this was not considered in recent research, it can be considered as new finding that needs to be explored further in future research. Also relating value chain evolution in terms of winners and losers, there is no clear indication in literature how roles of players will evolve once digital solutions are used among many of them. The case studies show that especially pharma players might benefit as they can be much faster for innovation purposes. The expert interviews reveal that some players such as quality institutions and medical practitioners will likely not be substituted by digital technologies but there role will likely change whereas some players, such as invoicing support institutions, might become redundant and eventually being replaced by digital solutions in the future. Also healthcare insurance providers could play a more active role in the healthcare system if they can utilise more patient data and likely existing digital platforms will consolidate so that only a few comprehensive and powerful platforms will coexist. As this research is exploratory, these findings need be assessed by future research but already provide hints on a potential evolution of the pharma and healthcare industry in context of digitalisation.

6. Conclusion & Outlook

Generally, it was proven that systems of (decentral) digital technologies can have a major impact for the pharma and healthcare industry. Although recent research puts those digital solutions predominantly in context of efficiency gains within existing process flows and business models – which was proven by expert interviews and case studies – there are some new offerings that could be established via digital means. Much more important, digital solutions enable a much easier interaction between different players and by this also enable relationships that were not there or only to very limited extent in the past, which then results into potential new offerings and services. First indications on a rising data economy are given but very likely this will relate much more to health benefits than to commercial value. As many of those digital solutions are at a very early stage, it needs to be observed and carefully assessed by researchers how this topic around data economy will evolve. The role of decentral digital technologies in this context can be manyfold and impactful, although this research shows that there might be other suitable digital solutions as well that create significant improvements for the value chains of the pharma and healthcare industry. This research also gives some indication how the roles of incumbent players will evolve, in particular who is benefitting and who not, but this might be assessed more in-depth once those digital solutions are used more broadly and for a longer period of time. Especially, it will be interesting of pharma companies can build on their improvement potential in terms of closer contact to patients and faster innovation cycles and thus foster an even more powerful position in the value chain or if digital players from outside will take over such a role and become the powerhouses of the pharma and healthcare value chain as indicated via the expert interviews.

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