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TNO report

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Scalability and agility of the Smart Connected Supplier Network approach

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Summary

Digital collaboration in the supply chain is one of the means for manufacturing companies to increase efficiency and reduce costs. However, various supply chain partners do not collaborate in a digital way yet since they use different and non-interconnected ICT systems.

In order to solve this challenge, the partners of the Smart Connected Supplier Network (SCSN) digital innovation hub developed a standard for information sharing based on semantic technology, thereby ensuring optimal interoperability between the supply chain partners for the most prominent information streams.

The SCSN standard builds on the International Data Spaces[1] (IDS) standard. This is a European standard for data sharing that enables data sovereignty developed by the partners of the International Data Spaces Association.[2] SCSN and IDS bring a “connect-once -reach the entire supply chain scenario” to manufacturing companies. [3] This is differing from traditional bilateral EDI connections or the use of centralized (cloud) platforms. Manufacturing companies need to establish a single connection, once, with an ICT Service Provider. There are multiple ICT Service Providers, which are fully interconnected amongst each other using IDS technology. In this way, a manufacturing company can connect to any other company reachable in the SCSN network.

This approach makes the supply chain collaboration easier to implement and scale, enables manufacturing companies to reduce the administrative burden and helps them to prevent errors. It also enables agility of the entire supply chain and a more successful risk management. In turn, this reduces the time-to-market for manufacturing companies and suppliers, enabling them to respond quicker to changing market demands.

In this report we measured the added value of the SCSN standard, compared to more traditional approaches, based on a simulation of the evolution of the supply network, while introducing the SCSN standard for interoperability. A total ‘market’ of 1.200 manufacturing companies was assumed with 3 ICT Service Providers connecting them to the network. We assumed a timeframe of 5 years for the companies to adopt the standard and the approach.

The main conclusion from the simulation is that the SCSN standard will realize the benefits of the digitalization of the manufacturer-customer connection much faster and provides manufacturing companies access to a wider network of customers and suppliers.

The *value of a digitalized connection between two parties* itself is based on the savings realized by automation of manual orders and information handling as well as avoidance of some order and information correction handlings in case of errors or change, adding to over 6k Euro per connection per year. The connection year,

[1] https://www.internationaldataspaces.org/the-principles/
[2] https://www.internationaldataspaces.org/
[3] www.smart-connected.nl

defined as a connection for one year between a party and an ICT Service Provider, is thus a good indicator of the value.

The total value of realizing the digitalized connections *faster* enabled by the SCSN standard amounts to **21M Euro** according to our simulation. And over the period of five years, the introduction of SCSN realizes **86% more connection years *equivalent*** than the conventional approach. This is because parties connected to one ICT Service Provider can now do digital business with parties connected to another ICT Service Provider, so a virtual connection. In practice, this means that for example for one order the number of parties involved in the supply chain can be higher, i.e. producing smaller batches, faster, while amounting to the same total quantities.

The SCSN network serves **30% more typical supply chains** in 5 years. This is important, because only if substantial parts of a supply chain are digitalized the organizations can collaborate in a more or less automated way using only connected systems.

Besides this increased growth level, other benefits can materialize as well, which were not quantified in this report. For an individual company, we expect for instance benefits such as less inventory, faster delivery, increased production capacity as production can be coordinated much more timely using these connections. SCSN would realize these benefits faster and ‘SCSN-compliant solutions’ become available for a larger group of companies due to the network growth.

Also, on the network level we expect benefits that are not quantified here: we expect that network growth can be faster, due to standardization and network attraction, based on the benefits for individual participants.

Careful interpretation

The reported benefits of a digitalized connection are based on a simulation of the reality that builds on modest assumptions, that have been validated with practitioners.

Contents

1 Introduction

1.1 Supply chain collaboration

Ever since the introduction of electronic connection and planning software like ERP (Enterprise Resource Planning), MRP (Material Requirement Planning) and CRM (Customer Relationship Management) the need in industry for automated sharing of production and sales related data in the supply chain has been increasing. Connectivity in combination with information systems has turned supply chains into collaborative business networks, supported by software packages that can handle and align varying data sources and connect organizations.

Often the exploitation of such software is organized as a platform or multi-sided business model. A multi-sided business model supports interactions between interdependent customer groups or between supply and demand. In a supply chain this can for example be a supplier and a manufacturing company.

Such platform business models have network effects. If a manufacturing company is customer of such a platform, the more interesting it becomes for suppliers to become a customer of that platform too. This is often even required in order to do business with a powerful manufacturing company. A strongly connected and integrated supply chain is efficient as it allows for reliable transmission of order and production information. However, for suppliers it can be impractical and expensive to link to multiple platforms, which also creates a lock-in to the platform.

Specifically, in situations where demand changes rapidly, products become more personalized and require smaller batches, potentially from different producers and suppliers that can participate in multiple supply chains, agility is of strategic importance. In order to achieve that, a higher level of interoperability between the manufacturing companies and suppliers in supply chains is needed to form a *supply network*.

This points to an overarching interest. The supply network *as a whole* benefits from efficient utilization of production capacity and responsiveness to changing conditions and demand. This requires the platforms to support optimization, growth and agility in the interest of the whole supply network. Interoperability and governance of these platforms as a network of platforms, each supporting and connecting parts of the supply network, is needed to flourish the whole supply network.

1.2 Conventional approaches for digital collaborations

Digital collaboration in the supply chain is one of the goals to increase efficiency and reduce costs. However, it is not easy to involve firms with a lower digital maturity level (e.g. SMEs with limited resources) and link at the same time different ICT systems between companies with a higher digital maturity level. Smaller manufacturing companies still do a lot of business processes administration manually (e.g. making stock overviews in Excel).

Most larger companies (i.e. > 50 employees) today use Enterprise Resource Planning systems (ERP). This software supports companies in all kinds of business processes such as stock management and order processing. Almost every large supply chain partner currently has its own ERP supplier, which makes it more challenging to connect the companies since these ERP systems do not match (do not speak each other's language). That means that many companies currently solve this in a time consuming way: employees for instance enter information from an incoming order manually into their own system. However, nowadays there are also several so-called ICT Service Providers. These are *intermediaries* who make the connections between the ERP systems of the supply chain partners. That leads to the following challenges:

- All connections must be maintained with all involved suppliers to serve one manufacturing company, with additional costs for each connection.
- The scaling effect is limited to a few connected supply chain partners using the same ERP system or cooperating with the same ICT Service Provider.
- Suppliers delivering to manufacturer companies or OEMs results in high connectivity costs when looking at the required connections between each ERP system and ICT Service Provider.

This will result in the multiplication of the (connectivity) costs if you want to have more suppliers (each with their own costs), for example for more capacity and flexibility. See Figure 1 for an example how the conventional situation leads to complexity and a cost increase.

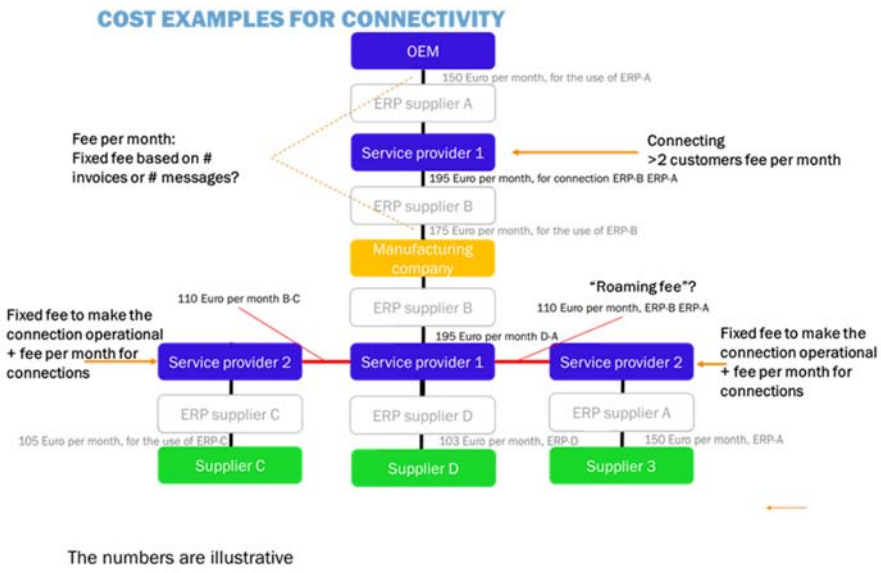


Figure 1 Cost examples for connectivity in the conventional situation and their related complexity

The potential consequence is that the manufacturing company focuses on suppliers within a certain ecosystem using the same ERP system and or ICT Service Provider (e.g. because of cost savings). That might result in a lock-in effect as expanding the network results in a cost increase which prevents manufacturing companies to access other ecosystems of suppliers. This situation also limits the growth and agility of the supply network due to path dependence caused by the

choice for a specific ERP system or ICT Service Provider. Unless the growth will be realized within fixed supply chains with partners that use the same ERP system. However, in an ideal situation supply chain partners want to be able to connect with each other without necessarily using these connections more often (e.g. for intensive exchange of orders and invoices).

1.3 Towards the new situation in the Smart Connected Supplier Network

In order to solve these challenges, the partners of the Smart Connected Supplier Network digital innovation hub joined forces to develop a standard for data sharing. Three types of supply chain partners are affiliated with the Smart Connected Supplier Network:

1. manufacturing companies;
2. software companies that offer ERP systems;
3. ICT Service Providers (intermediaries) who make the link with the SCSN network and between the ERP systems.

The goal of the digital innovation hub is to enable improved cooperation in the supply chains of thousands of manufacturing companies behind large high-tech companies such as ASML, Thales and Philips Healthcare, as well as in other sectors like the furniture sector to exchange necessary and more reliable data and improve timetables, with lower costs.

Chapter 2 contains a more detailed description of the approach of the Smart Connected Supplier Network.

1.4 Research question

The objective of this research was to answer the following question:
What is the difference between a traditional approach for supply chain collaboration and the approach as proposed by the Smart Connected Supplier Network digital innovation hub?

A simulation is used to analyze the potential impact for the network of manufacturing companies (in terms of improved connectivity and resulting benefits) and ICT Service Providers (in terms of adoption, scalability and – hence – marketability of their solution).

1.5 Reading guide

- Chapter 2 explains the approach of the Smart Connected Supplier Network.
- Chapter 3 describes the added value of the SCSN standard. Chapter 3 also shows the results of a network simulation to quantify the added value of the SCSN standard.
- Chapter 4 provides the conclusions.
- Recommendations and next steps are included in Chapter 5.

2 Smart Connected Supplier Network approach

2.1 SCSN standard

To solve the aforementioned challenges the partners of the SCSN digital innovation hub developed a standard (based on the International Data Spaces (IDS) standard[4]) for information sharing, in combination with a semantic standard for supply chain data.

A semantic standard was developed for the following prominent information streams:

- invoices;
- production schedules/planning;
- orders;
- logistic data;
- certificates;
- product specifications incl 3D drawings;
- product measurement data (in the future).

Technically, SCSN builds on the International Data Spaces (IDS) standard[5]. The IDS standard is a European standard for data sharing that enables data sovereignty. SCSN and IDS brings a “connect-once -reach the entire supply chain scenario” to manufacturing companies.

Within SCSN, ICT Service Providers connect manufacturing companies in the supply chain to the SCSN network. This connection is established by implementing a single connection, usually with the ERP system of the manufacturing company, using the SCSN semantic specification and/or translators for the specific ERP system. The ICT Service Providers communicate amongst each other using the SCSN semantics and the IDS technical standard. This solution enables that each supply chain partner can continue to use its own ERP system and its own ICT Service Provider. Since all ICT Service Providers involved in SCSN are interconnected, a manufacturing company can do business with any other manufacturing company, even when the other partner uses a different ICT Service Provider.

This is a different approach as the bilateral EDI connections or the use of centralized platforms: within traditional EDI connections a bilateral connection needs to be established between any two partners. Within centralized platforms a manufacturing company needs to connect to a single (cloud) platform, containing all data of all manufacturing companies involved. This is less feasible given commercial sensitivity and market structuring, resulting in a situation whereby manufacturing companies need to connect to multiple cloud platforms.

The SCSN approach therefore makes the supply chain collaboration easier to implement and scale. This potentially enables manufacturing companies to achieve

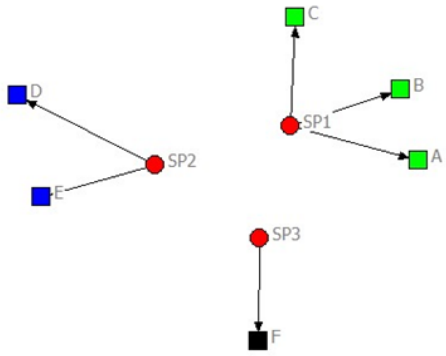
[4] The standard of the International Data Spaces Association: https://www.internationaldataspaces.org/the-principles/
[5] https://www.internationaldataspaces.org/the-principles/

the desired benefits of digital collaboration faster: it provides a reduction of the administrative burden and the prevention of errors. It also enables agility of the entire supply network and a more successful risk management, which in its turn reduces the time-to-market for manufacturing companies and suppliers.[6]

2.2 Evolution: from existing sub ecosystems to SCSN

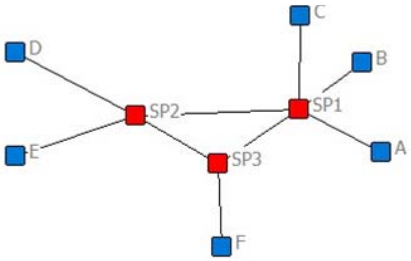
Before the introduction of the standard separate sub ecosystems, each with their own ICT Service Provider and ERP systems are present (see the first Figure of Figure 2). After the introduction of the standard these separate ecosystems can be easily connected into one larger ecosystem via the ICT Service Providers (see the Figure in the middle of Figure 2). The third Figure of Figure 2 indicates what these ICT Service Providers enable – the connections between all relevant supply chain partners. This can be compared with the connections in a telecom network.

[6] www.smart-connected.nl



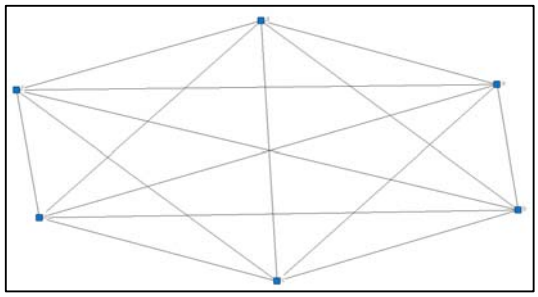
Before the implementation of the standard

3 supply chains with 1, 2, 3 connections



After the implementation of the standard

1 “merged” supply chain with 6 connections



What the service providers enable

~Telecom interconnection

The red dots are the ICT Service Providers. The other colored dots are the other supply chain partners that needs to be connected such as suppliers and manufacturing companies .

Figure 2 Example scalability

2.3 How does it work technically?

The SCSN approach is based on the following principles:

1. The connections that the ICT Service Providers enable with the help of the SCSN standard are based on the *"connect-once -reach the entire supply chain scenario"*. This means that if you are connected via one ICT Service Provider you can connect with all other supply chain partners involved. So, for instance supply chain partner A, B and C were only connected with each other via ICT Service Provider 1 before the introduction of the standard. After the introduction of the standard A, B and C can also connect with D, E and F without extra investments in additional ICT Service Providers and or ERP systems (see Figure 2).
2. An independent *"address book"* for discovering active participants in the network and to support the data and information exchange between the partners in the supply network.
3. The idea is that the manufacturing companies can use their own ERP system and can *choose the for them most suitable Service Provide* who enable their access to the whole supply network only once. That means that for instance supply chain partner A can chose ICT Service Provider 1 who enables the access to the supply chains partners B, C, D, E and F. This solution increases the scalability of the supply network and it limits the costs for additional ERP systems and service provides to be able to extend the supply network. This principle is based on the so called four corner model (See Figure 3).

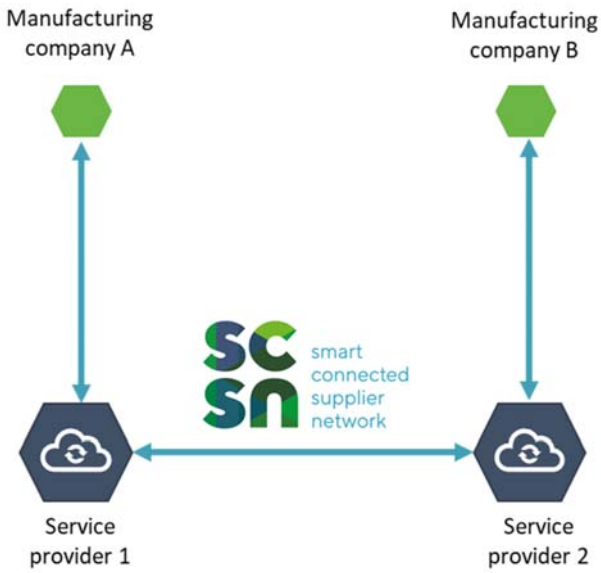


Figure 3 Four corner model

When the manufacturer company is integrated in the supply network, the firm is registered in the SCSN address book. The address book will be maintained by an independent governing body. A summary of the SCSN approach and the related principles are provided in Figure 4.

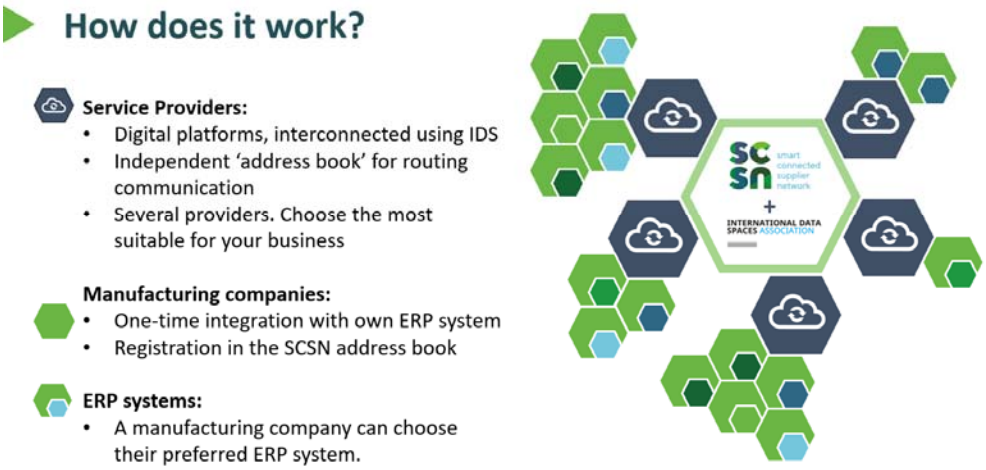


Figure 4 SCSN approach and the related principles

3 Simulation of the impact of SCSN

3.1 Impact of SCSN

The introduction and implementation of the SCSN standard changes the landscape from multiple digitized supply chains to a collaborative network in which participants can reap the benefits of digitized business.

Figure 5 illustrates how the SCSN standard ensures interoperability between ICT Service Providers, which turns the connected subsets of manufacturing companies into a collaborative supply network. The network of ICT Service Providers in fact acts as a *distributed platform* to which the manufacturing companies connect. The interest of their joint customers, the supply network, is served if the network grows and communication is flawless. The value of what one ICT Service Provider provides to its manufacturing companies depends on the level of interoperability, performance and size and nature of the customers of other ICT Service Providers and vice versa.

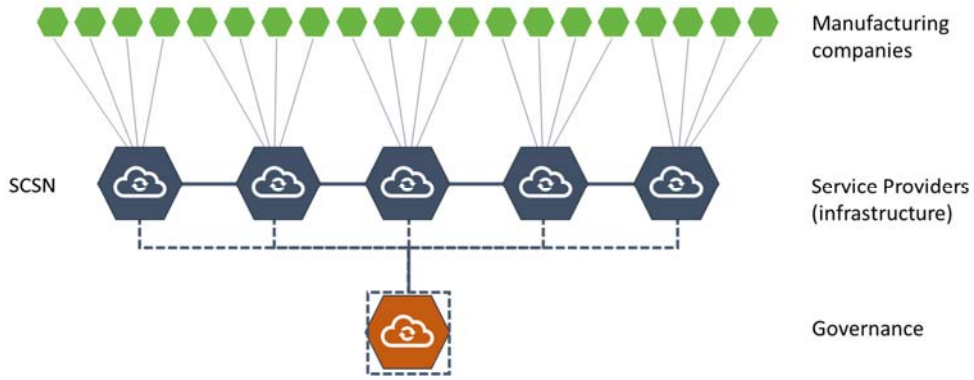


Figure 5 Interoperability between ICT Service Providers

This brings forward a number of common challenges for governance and value creation for the distributed platform of the SCSN ICT Service Providers:

- growing the network of customers (manufacturing companies);
- increasing use of the core elements (SCSN standard and technology);
- ensuring that the “supply” of required infrastructure is sufficient.

To be able to further design this governance, we need to understand the individual perspectives of the potential participants better. Both suppliers and manufacturing companies can fulfill a buyer or a supplier role on the platform, depending on the context and where they are in the supply chain. Therefore the individual perspective will be explained based on a network simulation in which the focus is on three types of participants:

1. ICT Service Providers;
2. suppliers of products/equipment;
3. buyers of products/equipment.

3.2 Reading guide

In section 3.3 we introduce the simulation model of the network and the related assumptions. The purpose is to investigate what benefits the SCSN standard brings. In order to do so we modelled a supply network with three different ICT Service Providers. We simulated developments for a five year period. In this period each ICT Service Provider would grow its own set of customers (both suppliers and buyers), by means of acquisition. This is also happening today. We also modelled the synergy that the interoperability between the ICT Service Providers brings.

In section 3.4 we describe the results of the network simulation.

In section 3.5 the advantage of SCSN for the supply network will be explained in comparison to the conventional situation.

Section 3.6 gives insights in the intermediate value of a digital connection, followed by a quantification of the added value of SCSN by indicating the savings in section 3.7.

Section 3.8 presents the required financial investment in SCSN (e.g. for maintaining the standard).

Section 3.9 explains the differences per individual ICT Service Provider (e.g. savings, connections served etc.).

3.3 Assumptions of the network simulation

The simulation model is based on the following six assumptions:

- The *first assumption* describes the starting point for three ICT Service Providers. Showing the customers they are serving in the beginning.
- The *second assumption* defines how quickly the number of customers of the ICT Service Providers increases.
- The *third* and *fourth assumptions* define the actual and expected potential overlap between the customers of the ICT Service Providers. (Actual) Overlapping parties are parties that are connected to more than one ICT Service Provider. Potential overlapping parties are relevant to the parties of another SP. They form the key motivation for interconnection between ICT Service Providers.
- The *fifth* and *sixth assumption* define the total market size and what a typical supply chain looks like.

The simulation is then as follows: for each year we calculate how many customers each ICT Service Provider serves. Based on the starting and growing actual and potential overlap between the customers of the ICT Service Providers, we can calculate the benefit of interconnection between ICT Service Providers (i.e. how large the total supply network has become, and how many subscriptions can be avoided using the “connect-once -reach the entire supply chain principle”, which means that you only need to be connected once to get access to the whole network). The simulation stops when the whole market is satisfied, i.e. when all parties are connected to the network via a ICT Service Provider. We also calculate the number of typical supply chains covered. The idea here is that a typical supply

chain is better off if all involved stakeholders are connected and digitalized. In that case, all parties can respond more quickly to changes and requests. In other words, the supply chain is more agile. If one or a few parties are not digitally connected, then the supply-chain as a whole cannot react with agility.

First assumption: starting point

The first assumption, an illustrative starting point, is that there are 503[7] buyers and suppliers connected based on the standard and connected by three ICT Service Providers (see Table 1). We simplified the typical tier structure in supply chains to buyer-supplier relationships. A crucial underlying assumption is that buyers and suppliers require a ICT Service Provider to serve their connection.

Table 1 Buyers and suppliers connected to their ICT Service Provider at T0

Connections T0	SP I	SP II	SP III	Total
Connected Buyers	60	5	10	75
Connected Suppliers	3	25	400	428
Total connections	63	30	410	503

Second assumption: network growth

As second assumption there is an expected network growth per ICT Service Provider per year and a total network growth per year of 115 connections (see Table 2). This represents the regular acquisition of the ICT Service Providers. This also implies that the market is not yet satisfied.

Table 2 Growth of connections to ICT Service Provider per year

Connections / yr	**SP I**	**SP II**	**SP III**	**Total**
BuyerConnectSpeed (c/yr)	20	2	2	24
SupplierConnectSpeed (c/yr)	1	10	80	91
Total	21	12	82	115

Third assumption: overlap

The third assumption is based on the number of actual *overlapping* parties between the ICT Service Providers at T0 (see Table 3). An overlapping party is a buyer or supplier that is currently a customer of two (or more) ICT Service Providers. This is the case if this party wants to participate, via these ICT Service Providers, in multiple supply chains. Of the 75 connected buyers there are in total 4 overlapping connections between the ICT Service Providers at T0. Of the 428 suppliers there are 8 overlapping connection between the ICT Service Providers. These double connections would be avoided using the “connect-once -reach the entire supply chain principle”.

[7] The assumption is based on 3 types of ICT Service Providers (medium, small and large) each based on a different Buyer-Supplier ratio: SPI mainly connects Buyers (60 of the 75), SPIII mainly connects Suppliers (400 of the 428) and SPII connects a limited number of Buyers (5 of the 75) and Suppliers and (25 of the 428) that leads in total to 503 connections (Buyers and Suppliers) (see Table 1). The numbers are illustrative.

Table 3 Overlap of connections between the ICT Service Providers at the start

Connections	SPI-II	SPII-III	SPI-III
75 Buyers	-	2	2
428 Suppliers	-	7	1

Fourth assumption: potential overlap

The fourth assumption is based on the idea that the network growth of the network of ICT Service Provider I is relevant for the parties in the network of the ICT Service Providers II and III. Or formulated in another way: the buyers and suppliers connected to ICT Service Provider I are relevant for the buyers and suppliers of ICT Service Providers II and III because they want to exchange orders and invoices among each other. We refer to this as *potential* overlap and it applies to the growth. In the conventional situation, if buyers and suppliers of different ICT Service Providers want to do business, they would have to link to two ICT Service Providers. Using the “connect-once -reach the entire supply chain principle”, these parties only have to link to one ICT Service Provider only once. We count a party in the potential overlap as if they were connected to two ICT Service Providers, because the equivalent benefits are realized. It thus can be seen as a virtual connection. From table 4 below: of the parties that are acquired by and connected to SPI in a given period, we count 75% as having a connection to SPIII. However there are also some situations in which the buyers and or suppliers from ICT Service Provider I are *not* relevant for ICT Service Provider II. A buyer involved in a supply chain for bikes may not necessarily be relevant for a supplier active in the automotive industry. Table 4 gives the percentages to indicate how relevant the parties of each of the ICT Service Providers are for each other. In our simulated case ICT Service Provider I and ICT Service Provider II have no overlap or potential overlap.

Table 4 Potential relevance

SPI-II	SPII-I	SPI-III	SPIII-I	SPII-III	SPIII-II
0%	0%	75%	95%	75%	80%
0%	0%	100%	50%	60%	40%

Fifth assumption

The fifth assumption is related to the total network/market. We assume in this simulation that there are 1200 potential network connections on the total market that can potentially be connected to the SCSN network (see Table 5). Based on the growth speed, this market size is not entirely reached within five years. This assumption appeared not to be limiting.

Table 5 Total network/market

Total network / market	
Buyers	200
Suppliers	1000
Total	1200

Sixth assumption

The sixth assumption is related to the buyer supplier ratios per ICT Service Provider presented in the table below (see Table 6). This ratio represents a typical supply chain for a ICT Service Provider. For ICT Service Provider I 20 buyers and 1 supplier make up one supply chain. ICT Service Provider I is thus a typically wholesale supporter. ICT Service Provider II has 1 buyer and 5 suppliers. ICT Service Provider III represents one supply chain for 1 buyer and 40 suppliers, so this is typically a supporter for higher level tier players.

Table 6 Supply chain ratios per ICT Service Provider

Supply Chains / Ratios			
Initial ConnectionRatios T=0	**SP I**	**SP II**	**SP III**
Buyer	20	1	1
Supplier	1	5	40

3.4 Results of the network simulation

Based on the aforementioned 6 assumptions we conducted a network simulation. Figure 6 provides an illustration of the results for three services providers (called SPI, SPII and SPIII) after 5 year (at T5):

- ICT Service Provider I connected 160 buyers of which 115 buyers could be relevant for ICT Service Provider III;
- ICT Service Provider II connected 15 buyers of which 7 could be relevant for ICT Service Provider III;
- and ICT Service Provider III connected 20 buyers, of which 14 could be relevant for ICT Service Provider I and 11 for ICT Service Provider II;
- ICT Service Provider I and III have 5,1 overlapping connections with buyers and ICT Service Provider II and III have 4,7 overlapping connections with buyers.[8]

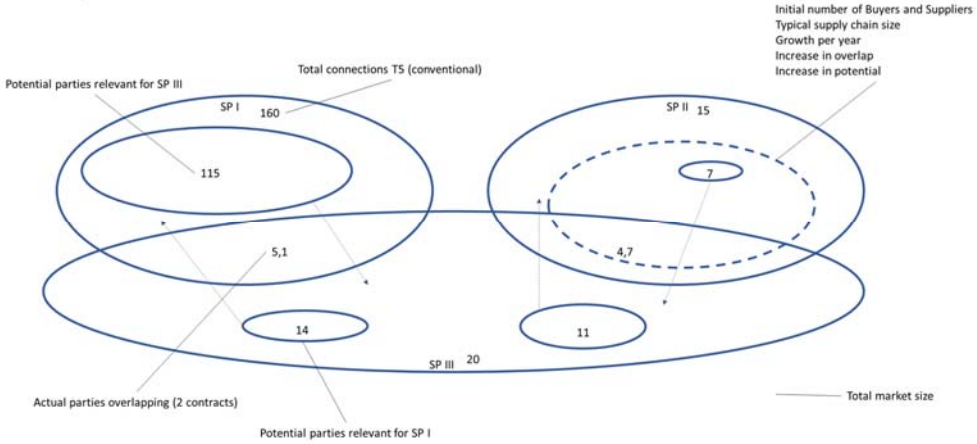
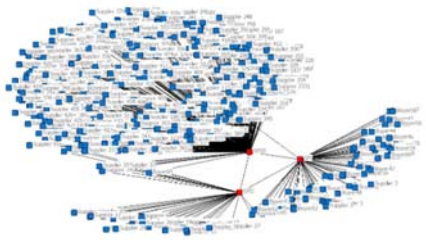


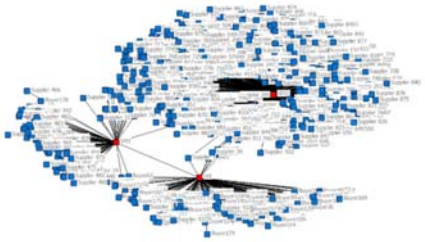
Figure 6 Supply chain size and (potential) overlap

[8] The overlapping connections are calculated based on an overlap ratio. That is the reason why the numbers are not rounded.

Figure 7 illustrates the network growth within 5 years between T0 and T5 per ICT Service Provider. In this simulation different network sizes are used per ICT Service Provider. The ICT Service Providers III and I have the largest networks both at T0 and T5.



Connections T0	SP I	SP II	SP III
Connected Buyers	60	5	10
Connected Suppliers	3	25	400



Connections T5	SP I	SP II	SP III
Connected Buyers	160	15	20
Connected Suppliers	8	75	800

Figure 7 Network growth of connected buyers and suppliers per ICT Service Provider

Figure 8 gives a comparison of the buyers network growth of ICT Service Provider I in the conventional situation compared to the network growth in new situation when the SCSN standard will be used. The growth, and value, is expressed in connection years. A connection *year* is defined as a connection for one year between a party and an ICT Service Provider. Each year the benefits of having a digital connection (as compared to the conventional situation) are realised. A simple count of the connections at T5 does not take into account the ICT Service Provider value of a connection in the intermediate time. In general, it should be understood that each month a digital connection is available it adds value to the connected parties. The advantages of a digital connection are discussed in section 3.4.

When using the SCSN standard there is an important *headstart* since the ICT Service Providers start with a larger total connected network (all former sub networks together 60+5+10= 75 buyer connections at the start) compared to the conventional situation, in which there were 3 separate sub networks (of 60, 5 and 10 connected buyers). This means that upon establishing interoperability via a connection between two ICT Service Providers, their customer groups immediately benefit. It is thus important to distinguish that the “physical” connection between two ICT Service Providers enables ‘virtual’ connections between parties. We however count a connection as a link between a party and a ICT Service Provider. This headstart can be expressed as an *equivalent* of connecting Y new parties during one year.

The standard also enables a faster network growth because more ICT Service Providers are able to connect more buyers simultaneously (three ICT Service Providers are growing the joint network instead of one ICT Service Provider acquiring network growth for its own). One could say that ICT Service Provider I is

acquiring (the potential overlap) for the sake of the customers of ICT Service Provider II, and vice versa. So, in the model, it's not the number of *parties* that grows fast, but the number of relevant *connections*, because of the potential overlap. The explanation is that the number of parties in the total network is assumed to grow with the summed acquisition speed of the three ICT Service Providers. That is equal to the conventional situation. However, a percentage of the parties acquired for ICT Service Provider I is relevant for the parties served by ICT Service Provider II. Without physically interconnecting the ICT Service Providers, this connection between the relevant parties would not be realized. Thus, each party in overlap counts twice for the connections.

Another reason why the standard will enable a faster network growth is due to the network effect; the larger the connected network the more attractive it will become for not yet connected buyers and suppliers to become connected as well. Furthermore, it could also be reasoned that due to the standard, the ease and speed of connecting new parties increases. These two effects are however *not* modelled. Figure 7 displays a dotted red line, indicating the overlap between two ICT Service Providers. In the "connect-once -reach the entire supply chain SCSN scenario", these parties would connect once, not twice. So, as compared to the conventional situation, the double counting connections have to be subtracted.

Figure 8 Growth of the buyers network for ICT Service Provider 1

3.5 Advantage of SCSN compared to the conventional situation

The SCSN standard enables a headstart and a larger total network size of 929 connections compared to the conventional situation with a network size of 503 connections. The network grows per year with 93 (208-115=93) connections more when using the SCSN standard. That results in a total top up at T5 of 893 connections (see Table 7). Note that the number of parties is equal in both scenarios (the conventional scenario and SCSN scenario). As a result of the "connect-once -reach the entire supply chain-principle" the number of revenue years slightly drops. Revenue years are the number of years that a manufacturing company has a subscription with an ICT Service Provider.

In the introduction of this chapter we introduced the number of connection years and the number of supply chains served as indicators for the value of the network. The SCSN standard also enables the connection of more supply chains (56-43=13 in this simulation) (+30%) and there are 3395 (7348-3953) (+86%) connection years (number of years that there is a connection) more when using the standard.

Table 7 Value of the SCSN network after 5 years[9]

	Conventional	**SCSN**
Connections[10] served (T0)	**503**	**929**
Connection growth per year	115	208
Connections served (T5)	1.078	1.971
SCSN top up at T5		893
Paying Parties (T5)	1.052	1.052
Supply Chains served (T5)	43	56
Connection Years (period)	**3.953**	**7.348**
		186%
Revenue Years (period)	3.953	3.857

3.6 Intermediate value of a digital connection

In this section we quantify the value of a connection year in order to monetize the 86% increase in connection years as a result of the introduction of the SCSN standard in the network. We focus on one connection first, before aggregating. We do this by calculating an assumed number of orders and the avoided manual work, thus person hours, plus a number of avoided errors and consequent correction time.

Table 8 shows how the orders per connection per year are calculated. In this simulation 500 orders per connection per year are expected. Note that this is the connection between the party and a ICT Service Provider; thus the 500 orders refer to the sum of all orders that this party receives from its customers together.

[9] The numbers in the table are rounded

[10] Connection *equivalent*. In the SCSN scenario 'connect-only-once' principle applies. So, there will be one physical connection, delivering the value of two, if the connected parties of business interest.

Table 8 number of orders per year connection

How many orders in a connection year?	
= workable weeks*days per week*average orders per day	
workable weeks per year	48
workdays per week	5
average orders per day	2,08[11]
orders per connection per year	500

Table 9 shows the Euro savings per connection per year. These savings are based on two components: 1. The automation time savings and 2. The correction time savings. This leads in total to 6.261 Euro savings per connection per year. It is important to realize that each digitized connection produces these savings per year compared to the conventional (manual) process. It requires thus that all assumed orders could be processed digitally, regardless from whom they came. Note that this is not due to the SCSN standard, but due to automation and interconnection. However, as we have demonstrated in the previous section, the value of SCSN is expressed also in connection years.

Table 9 Euro savings per connection per year

What is the value of 1 connection year?						
Automation time saving		**Repair savings**				
		Failure rate	3%			
10	Minutes per order	Repair time	25	Minutes per order		
83,2	Hours		6,24	Hours		
70	Euro/hour		70	Euro /hour		
5.824	Euro automation saving per year per connection		**436,8**	Euro failure saving per year per connection	**6.261** (5.824+436,8)	Euro savings per connection per year

3.7 Added value of SCSN

Figure 9 illustrates that each connection produces this yearly digitization benefit of 6.261 Euros savings per year. These digitization benefits are realized *earlier and faster* when using the SCSN standard. This is visible in the Figure 8, as the number of connections is reached much earlier (steep blue), as compared to the conventional growth (less steep blue) after x year. The benefits calculated above start as soon as the connection is available. In theory, eventually all connections will be digitized, which would lead to market saturation. This is illustrated by the dotted line in Figure 8, to illustrate that the same level is reached earlier. (In the given assumptions, the market saturation is not reached in 5 years.)

[11] 2,08 = 500/(48 weeks *5 days)

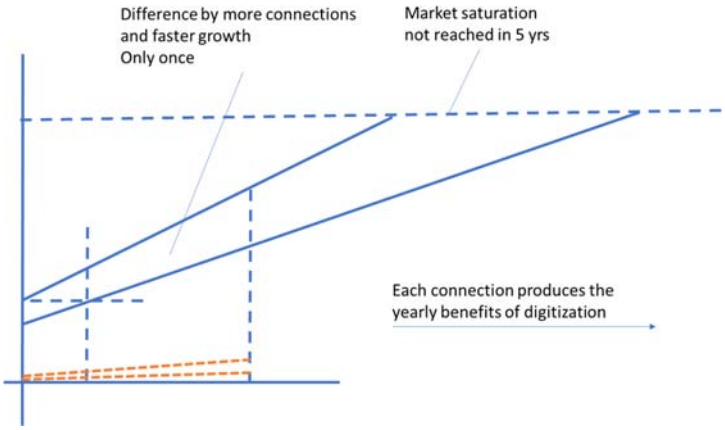


Figure 9 SCSN savings

This benefit of the implementation of the SCSN standard appears *only once*, whereas the benefit of the connection itself and automation are yearly savings. The implementation of the SCSN standard just allows the benefit to start earlier. **Connecting 1 month earlier brings the yearly savings of having a digital connection earlier, thus an equivalent of 1/12th of the yearly savings of the digital connection (6261/12 =) 522 Euro per connection.** This is equivalent to 6.261 Euro for each year that a party has a digital connection earlier. The value of SCSN by realizing the connections faster, is for the whole network thus is the difference in connection years of SCSN versus the conventional growth. This is a total saving of (7.348 – 3.953)* 6.261 = 21 million Euros (see Table 10). This difference is reached in 5 years and appears only once for a given network.
The assumptions, on top of the model parameters discussed above, for achieving this benefit are that:

1) the parties are sufficiently automated (i.e. are able to process order information using information systems);
2) they are connected through ICT Service Providers, following the SP's regular acquisition process;
3) the SPs establish interoperability enabled by the SCSN standard and allow parties of different SPs to communicate among each other.

Table 10 Total value of realizing the connections faster

	Conventional	SCSN
Connections served (T0)	**503**	**929**
Connection growth per year	115	208
Connections served (T5)	1.078	1.971
SCSN top up at T5		893
Paying Parties (T5)	1.052	1.052
Supply Chains served (T5)	43	56
Connection Years (period)	**3.953**	**7.348**
		186%
Revenue Years (period)	3.953	3.857
Benefit per connection per year (Eur)		6.261
Extra savings by SCSN (kEur)		**21.255.669**

3.8 Required investment in SCSN

To be able to realize the aforementioned savings some investments will be needed for an independent governing body (e.g. foundation) to maintain the standard and the address book. Current estimations of the cost of a governing body for SCSN that manages the standard are around 200k Euro per year (1.000k in 5 years), which are about 4-5% of the estimated savings. The SCSN governing body will support the connected ICT Service Providers and manufacturing companies by creating improvements of the standard, alignment with other organizations/standards, awareness creation and marketing and communication.

3.9 Differences per ICT Service Provider

In the previous sections we discussed the results of the simulation on a total network level, but when observing the different SP's 'own' networks and the results of the three ICT Service Providers some differences can be distinguished. Figure 10 shows the growth in connected parties, where the number of parties served at T0 in the conventional situation is set to 1.

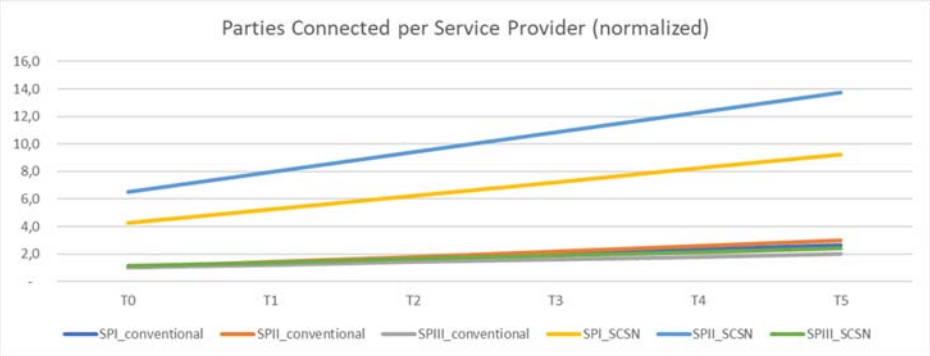


Figure 10 Connections per ICT Service Provider

Clearly, the virtual network of ICT Service Provider II grows most. This means that the customers of ICT Service Provider II have many relevant parties in the networks of the others (in this case ICT Service Provider I). Also, ICT Service Provider II was relatively small. **This illustrates that the benefit of interconnecting networks favours the smaller networks most**. This is to be expected. In this simulation we chose for relatively extreme differences between the ICT Service Provider's to study their differences. From this we can derive that the value of connecting additional SP's and corresponding networks depends on their absolute size (in number of parties) and more specifically the number of relevant parties in it (i.e. they must be potential business partners).

In table 11 a comparison is made between the three ICT Service Providers and indicates that ICT Service Provider I has the largest savings, followed by ICT Service Provider III. Based on the potential overlap from table 4 in section 3.1 the assumed relevance of the parties among the ICT Service Providers varied between 0%, 40% and up to 100% and was asymmetrical. Currently we have no clear indication to what extent these values are in line with practice, however these assumptions were not questioned by the experts with whom we discussed these assumptions.

Table 11 Overview of the savings simulation per ICT Service Provider

				SP I		SP II		SP III	
		Conventional	SCSN	Conventional	SCSN	Conventional	SCSN	Conventional	SCSN
Connections served (T0)		**503**	**929**	63	270	30	195	410	465
Connection growth per year		115	208	21	62	12	44	82	103
Connections served (T5)		1.078	1.971	168	580	90	413	820	978
SCSN top up at T5			893		412		323		**158**
	Share				46%		36%		18%
Paying Parties (T5)		1.052	1.052	168	165	**90**	**74**	820	812
Supply Chains served (T5)		43	56	8	9	**15**	**26**	20	21
Connection Years (period)		**3.953**	**7.348**	578	2.138	300	1.542	3.075	**3.667**
			186%		370%		514%		119%
	Share				46%		37%		17%
Revenue Years (period)		3.953	3.857	578	568	300	241	3.075	**3.048**
				15%	15%	8%	6%	78%	79%
Benefit per connection per year (Eur)	6.261								
Extra savings by SCSN (kEur)			**21.255.669**		9.769.549		7.777.663		3.708.457
					46%		37%		17%
SCSN Contribution Eur by revenue years			1.000.000		147.245		62.378		790.377

					15%		6%		79%
			259		259		259		259
SCSN contribution by T5 top up			1.000.000		461.305		361.696		176.998
					46%		36%		18%
SCSN contribution by T5 top up per revenue year			259		812		1.503		58
SCSN contribution by T5 top up per connection year			136		216		235		48

4 Conclusion

The analysis, based on a simulation of three different ICT Service Providers, reveals the value of introducing the SCSN standard for interoperability. The key understanding is that the SCSN standard will **realize the benefits of automation and digitalization** of the manufacturing companies much ***faster*** than the conventional approach of independent ICT Service Provider platforms. We estimated that the total value of realizing the digitalized connections *faster* by SCSN amounts to **21M** Euro.

The key driver of this value is that potential manufacturing supply chain partners linked to one ICT Service Provider can now be integrated into the automated ordering and information updating of manufacturing supply chain partners linked to another ICT Service Provider. For manufacturing supply chain partners this means that as soon as the SCSN interoperability is operational, there are a lot of parties more to automatically interact with each new connected party, regardless of which ICT Service Provider enables this set. That makes that the growth of the potentially relevant parties is powered by the acquisition power of all ICT Service Providers together, rather than that of the 'home' ICT Service Provider on its own. Thus, from the perspective of the individual manufacturing company, the value of having a digitalized connection with a substantial set of supply chain partners, can be realized much faster.

The value of automation and connection

The *value of automation and connection* itself is based on the savings realized by automation of manual orders and information handling as well as avoidance of some order and information correction handlings in case of errors or changes, adding to over 6k Euro for each year the connection is up and running. For each month that SCSN is able to realize these benefits earlier, because the relevant partners are available through SCSN, over 500 Euro of value is created per connection. For the network as a whole, the simulation shows that the same number of connections can be achieved in 2 years and 9 months, compared to 5 years in the conventional situation.

From the perspective of the network, we see that the introduction of the SCSN standard allows for more connections between supply chain partners. It allows to transfer and process ordering and production information much quicker and more reliable. As a result of achieving the aforementioned savings, we expect attraction to participate. Furthermore, a widely deployed SCSN standard also ensures that the market for SCSN based innovations is larger than the scope of one ICT Service Provider on its own. This allows for valuable future innovations, e.g. less inventory, faster delivery, increased production capacity, balanced resource utilization or speed up of production by producing in parallel as production can be coordinated much more timely using these connections. These network effects are however not quantified in our simulation.

Headstart

We simulated three ICT Service Providers, serving different types of supply chains with different numbers of buyers and suppliers in a total ‘market’ of 1200 manufacturing companies for a period of 5 years. The simulation required to make assumptions on the starting point, profile and growth speed of the network (e.g. the connected buyers and suppliers) of the ICT Service Providers. As well as crucial assumptions on the relevance of parties linked to one ICT Service Provider for the parties linked to another ICT Service Provider. Based on assumptions on the number of orders and manual work, we estimated the value of the savings of automation and digitalization.

As reported above, we estimated the total value of realizing the digitalized connections faster by SCSN amounts to 21M Euro. As compared to the conventional situation, this is based on a *“headstart”* and a *network growth speed increase*. - The “headstart” is based on the idea that for any given party the introduction of the SCSN standard allows that party to connect to all other parties with whom the party can do business using the digitalized connection, regardless to which ICT Service Provider those parties are connected. *Upon introduction* the number of relevant potential connections *jumps* immediately (+84%). Also the *speed* of growing the network in terms of connections increases (to +81%), with the same amount of acquisition effort as expressed in connected parties per year. This is because each party *added* to the network of one ICT Service Provider is potentially relevant to some of the parties connected to another ICT Service Provider.

More connection years and supply chains served

The introduction of SCSN realizes **86% more connection years** than the conventional approach in the period of five years. This implies a dense network. In practice this means that for example that for one order the number of involved parties in the supply chain can be larger, i.e. producing smaller batches, faster, while amounting to the same quantities in total or brokering and utilizing spare capacities.

The simulation indicates that SCSN network serves **30% more typical supply chains** in 5 years. This is important, because only if substantial parts of a supply chain are digitalized the involved parties can collaborate in a more or less automated way using only the connected systems.

On the individual connection level, we expect additional benefits such as that SCSN would realize these benefits faster and ‘SCSN-compliant solutions’ become available for a larger group of companies due to the network growth.

Different benefits per ICT Service Provider

Because we modelled the ICT Service Providers heterogeneously, these benefits differ per ICT Service Provider network as well. This calls for a *careful allocation* of any variable costs associated with implementing SCSN. Current estimations of the cost of a governing body that maintains the SCSN standard and manages the

address book are around 200k Euro per year, which are slightly over 4-5% of the estimated benefits.

Well-connected “archipelago”

All in all, the SCSN transforms a landscape of “islands of networks, centered around the platform of one ICT Service Provider” into a well-connected archipelago, a supply network. However, this connectivity and interoperability is only meaningful if it enables the supply network to achieve higher levels of production. And, although based on the analysis, the benefits are convincing, they don’t come by themselves. The following measures are needed to establish and sustain the benefits:

- The SCSN standard has to be maintained by an independent governing body which carefully weights all the interests of all the different stakeholders involved.
- The broader the standard will be applied, the higher the value for the participants.

Being relevant to connect with

Part of the value of SCSN relies on parties of one ICT Service Provider network ‘being relevant’ to parties of the network of another ICT Service Provider. This relevance is basically determined by having production capabilities or components that are relevant to a supply chain. This relevance can only be leveraged if these parties can find each other. The ICT Service Providers and the governing body can play an important role here. Hence, a central service provided by the aforementioned independent governing body, which enables manufacturing companies to find relevant supply chain parties is recommended.

- The network as a whole benefits from growing, as that increases the opportunities to collaborate in (temporary) supply chains. In order to leverage the attracting power of this network, marketing and communication efforts by the governing body (e.g. “If you need flexibility in your supply chain? Ask for SCSN at your local ICT Service Provider”) as well as the ICT Service Providers (e.g. “powered by SCSN”) should be considered. Establishing network effects for the SCSN is probably the key priority.
- As the networks of the ICT Service Providers are different in nature, the benefits that one network has versus the other, differs too. In general, the largest subnetwork benefits least when a smaller joins the archipelago. And connecting one company has not the same value as connecting a couple of companies. The growth strategy should be carefully devised, monitored and addressed in the governance of the network. Such growth strategy can vary over time and be incentivized.

Careful interpretation

The reported benefits of a digitalized connection are based on a simulation of the reality that builds on modest assumptions that have been validated with practitioners.

5 Recommendations and next steps

Based on the research presented above, we formulate a number of recommendations for the different stakeholders in this research: manufacturing companies, suppliers, ICT Service Providers, the SCSN governing body (foundation) and relevant practitioners and researchers in general.

Manufacturer/suppliers

As illustrated the introduced interoperability between the ICT Service Providers is an important enabler to benefit faster from more digital connections. This however requires a level of automation in the administration and order handling. The efficiency and savings this brings can outweigh investments in available information systems relatively soon, if these are not already in place. Once connected, the SCSN standard allows to find and interact with new partners and supply chains, and to respond more quickly to new information. This, without being locked-in to the ICT Service Provider. This has benefits of not only individual companies, but for a healthier industry as a whole. The simulation illustrates that by means of this interoperability enabled by the SCSN standard, more complete supply chains can become digital. Moreover, interoperability allows to benefit from innovations, e.g. supply chain coordination and optimization, much faster. As the deployment requires less configuration and because software providers can reach larger scale.

Therefore, as industry (manufacturing companies, suppliers, as well as industry association) it is important to push for an “connect-once -reach the entire supply chain”-solution to be available from your ICT Service Providers, as well as demand participation of your peers in the supply chains.

ICT Service Providers

The introduced interoperability standard is of great value to the customers of the ICT Service Providers. It can only be established through the ICT Service Providers. The potential to connect with many other supply chain partners, may attract new customers, if the advantages of participation in SCSN is well known. This can be stimulated by awareness creation (“powered by SCSN”). Expansion of the network as a whole can also be achieved by onboarding of new ICT Service Providers.

Adoption of the standard also brings the opportunity to expand with complementary services between the ICT Service Providers. Furthermore innovations based on the standard will face a larger audience, increasing the potential of returns. The independent governing body should promote and facilitate such transparency and innovation in a neutral way.

SCSN governing body (foundation)

Whereas the basis for the foundation is the maintenance of the SCSN standard to enable interoperability, the potential to add value to the network as a whole, as a neutral and governing body is immense. We will discuss a number of related opportunities that are related to either the neutrality or the general growth of the

network. An opportunity that is closely related to the interoperability is to facilitate the matchmaking and interaction between parties that are connected to different ICT Service Providers, e.g. like the Yellow Pages, or using search functionality. In order to be able to steer in new directions, monitoring and stimulating the growth and responsiveness of subnetworks and parties may help to identify weak spots. It may help to incentivize by means of transparency and rewarding, e.g. in the form of badges or certification – to indicate what level of support and performance parties deliver. It is also important to promote the increase of the digital maturity of the parties that are not yet connected, as automation of the administrative processes is a basic requirement to participate in agile supply networks. Industry associations should join forces in this, as well as ICT Service Providers that can provide accessible solutions.

Next to network expansion and stimulating performance close to the functionalities provided by the standard, the standard itself, and a wide adoption also serves as a basis for new developments. As all connected parties are able to communicate along the same data and formats, digital services based on this face a potential wider audience (e.g. automated seeking of capacity, stepping in for a competitor). As such innovations are likely to be created by currently active ICT Service Providers to create a unique and attractive profile, the foundation should provide incentives and conditions for the further development and adoption of such innovations. In order to generate mass and focus, the foundation could set out a multi-annual roadmap for innovation with its stakeholders.

Although the expansion of the scope of SCSN to other types of supply chains may not be directly of benefit to the parties of the current domain (as these are not likely to become business partners), it may be a sound way to lower the overhead the foundation incurs as well as it may be a sound way to create innovation.

The manufacturing companies, the ICT Service Providers and the foundation together form a collaborative network around the SCSN standard. This collaborative network has established a practical integration of a decentralized platform business model and a governance model for commonalities (i.e. the joint production capacity and agility). This may serve as a leading example in comparable cases, e.g. as in scope of the International Data Spaces Association.

Appendix 1 Methodology

In this research a three step approach has been used (see Figure 10).
In the first step we started with desk research about comparable cases like on the telecom market. Followed by interviews with the experts involved in the SCSN digital innovation hub and the development of the SCSN standard. This resulted in an overview of the lifecycle of the data exchange within the supply network.
During the second step we conducted a network simulation. For which we made calculations about the costs and network effects based on scaling scenario's and UCINET software. This second step was required to come to the cost overview and an overview of the network effects.
Step three was used to align the end results and present the options to strengthen the scalability, agility and to provide suggestions to increase the savings .

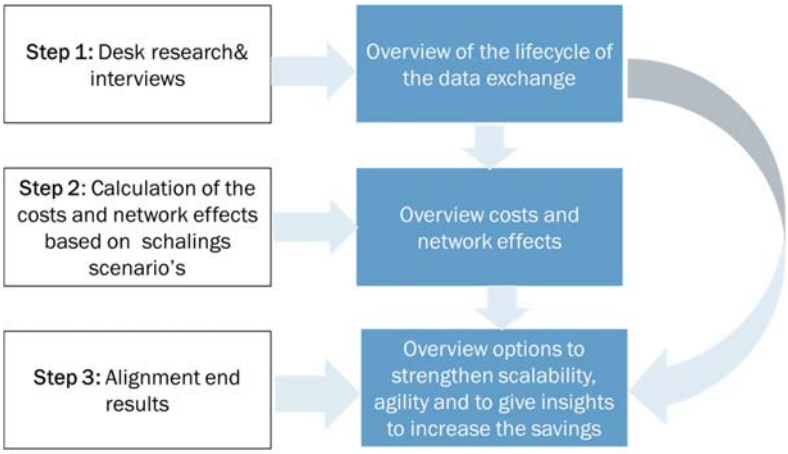


Figure 11 Research approach