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The transport sector is vital in today's global economy. It is continuously under pressure to transport goods more efficiently, and effectively, from origin to destination.

The current state of Synchromodality: an application of a synchromodal maturity model on case studies

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INTRODUCTION

The transport sector is vital in today's global economy. It is continuously under pressure to transport goods more efficiently, and effectively, from origin to destination. The pressure originates from different directions. Congestion on road networks has a negative impact on the environment and makes travel times unreliable. Moreover, expected increase of oil prices, road toll, and legislation aimed at achieving greenhouse gas emission targets for 2050 (European Commission, 2011), make it economically profitable to use transport solutions that use fuel more effectively.

One trend that can be observed in making transport more effective is to increase the sizes of intercontinental container vessels. As this obviously, reduces transport costs per container on the intercontinental leg. A downside of this development is that it results in an increased peak demand in the ports in terms of unloading, custom checks, and preparing the containers from transport to the hinterland. This again results in more traffic jams close to the ports.

Moving from road transport to intermodal transport results in (slightly) decreased transport costs but leads to an increase in lead time. Longer lead times mean more inventory in the pipeline, and this was traditionally a reason to select road transport. In 2018 in the Netherlands the number of traffic jams and the delays increased by 20% compared to 2017 (ANWB, 2018). As road transport becomes more expensive, and more unreliable, intermodal transport is becoming more attractive. However, also intermodal transport is not without issues and large delays are common practice. Synchromodal transport aims to overcome these downsides by focusing on transport integrally. SteadieSeifi, Dellaert, Nuijten, Van Woensel, and Raoufi (2014) described synchromodal transport as structured, efficient, and making synchronized use of multiple modalities (SteadieSeifi et al., 2014). This type of transport combines intermodal with road transport and uses it in an optimal way taking into account the current conditions of the network, including the actual situation around the port.

The following definition of synchromodal transport is taken from Somers and Tissen (2015): *'Synchromodality is the transport of maritime freight flows from port to hinterland destination or vice versa – without changing the load unit – whereby real-time changes can be made in the flexible and sustainable use of different transport modalities in a network. The logistics service provider has the control to offer optimally integrated solutions for all parties'.*

The aspects of real-time changes and flexibility are the most important changes compared to multimodal, or intermodal transport. Van Riessen, Negenborn, and Dekker (2015) consider synchromodal transport as intermodal planning with the possibility of real-time switching between the modes or online intermodal planning. To ensure real-time planning it is required that real time information from a lot of sources is combined. This information has to come from different partners in a supply chain. Therefore, a good relationship between partners is required to get the best overview of the current state of the network and plan accordingly.

The benefits of synchromodal transport for shippers result in reduced transport times, better prices, and/or improved reliability, compared to intermodal transport. Shorter transport times can also be achieved by responding adequately to disruptions to increase reliability. Real time insight into available capacity on intermodal transport will increase utilization and therefore reduce costs per shipped container for both the operational service provider and the logistics service provider.

Synchromodal transport has recently seen a large increase in number of scientific publications: over 25 in the period 2012-2018 (van Duin, Warfemius, Verschoor, de Leeuw, & Alons-Hoen, 2019) and the number is growing steadily, see for example Dong, Boute, McKinnon, and Verelst (2018), Lemmens, Gijsbrechts, and Boute (2019), Pérez Rivera and Mes (2019), and Pfoser et al. (2018). In practice, however, synchromodality is implemented only on a limited scale. A synchromodal maturity model has been developed (Alons-Hoen & Somers, 2017) to aid companies in moving towards synchromodal transport. In this article the current state of synchromodal transport of companies is investigated using the synchromodal maturity model. This analysis highlights areas that are well developed and areas in which progress can be made.

This article is structured as follows. The synchromodal maturity model is described in Section 2. Subsequently, the results of 24 interviews with companies are described in Section 3. Lastly, some conclusions are drawn on the current state of synchromodal transport and directions for future research are described in Section 4.

The synchromodal maturity model

The synchromodal maturity has been developed by and first described in Alons-Hoen and Somers (2017). Maturity models are used by companies for the purpose of describing, or benchmarking companies or processes. Here we use the maturity model for companies to indicate the current level they are operating on and identify areas in which improvements can be made to move towards a more mature process. A maturity models consists of levels, and a set of key process areas. The combination of levels and areas is the full description of the model.

A maturity model usually consists of five levels, as is described among others in (Lockamy III & McCormack, 2004; Paulk, Curtis, Chrissis, & Weber, 1993). The synchromodal maturity consists of the following five levels:

1. Ad-hoc intermodal transport
2. Structural intermodal transport
3. Synchromodal transport
4. Synchromodal transport with real-time planning and capacity
5. Extended synchromodal transport

The seven key process areas, or components, for the synchromodal maturity model are:

- Transport execution: the way in which transport is executed.
- Transport planning: the way in which transport is planned (planning horizon, and granularity).
- Data exchange: the data requirements for correct execution of the planning.
- Key performance indicators: the way in which feedback is given about the performance of the operational processes.
- Decision-making power: which stakeholder can decide how and when the transport is executed.
- Type of relationship: degree of horizontal and vertical collaboration in the supply chain.
- Pricing: how the tariffs are set and how payment takes place.
- A summary of the maturity model is given in Figure 1.

	Ad-hoc intermodal Level 1	Structural intermodal Level 2	Synchromodal transport Level 3	Real-time synchromodal Level 4	Extension synchromodal Level 5
Execution of transport	Truck	Train or barge	Train or barge	Train or barge	Train or barge
Transport planning	Ad-hoc	Upfront reservation	Upfront reservation	Real time	Real time and stock
Data exchange	Per container	Forecast per customer	Forecast per customer	Control tower	Control tower
Key performance indicators	Price and time	Price and time per modality	Price, time, reliability	Price, time, reliability and utilization degree	Price, time, reliability, utilization degree and service level
Decision making power	Shipper	Shipper	Logistics orchestrator (a modal booking)	Logistics orchestrator	Logistics orchestrator
Type of relationship	Transactional	Limited vertical	Intensive vertical, limited horizontal	Intensive vertical and horizontal	Intensive vertical and horizontal
Pricing	Spot market	Alignment on tariff (tender)	Tariff per modality	Integral tariff	Integral tariff

Figure 1 Synchromodal maturity model (Alons-Hoen, Somers, van Duin, 2019)

- For each of the seven key process areas the following transitions are observed when moving from level 1 to 5:
- Transport execution: starting at level 2 most transport is intermodal transport, and road transport is only used in case of exceptions.
- Transport planning: starting at level 2 the shippers makes upfront reservations of capacity based on a forecast. Starting at level 4 real-time information about transport orders is shared and planned accordingly. In level 5 stock information is shared real-time for the logistics service provider for transport planning.
- Data exchange: for levels 2 and 3 a forecast is shared between the shippers and the logistics service provider. Real-time information on transport orders is necessary from level 4 to fill the control tower. Additionally, real-time stock information is needed in the control tower at level 5.
- Key performance indicators: reliability is added to the performance indicators at level 3. Utilization is added as a KPI for the service providers. Also service level becomes an important KPI for shipper and logistics service provider at level 5.
- Decision-making power: starting at level 3 the shipper books his transport a-modal, giving the orchestrator the freedom to plan and execute the transport optimally. Real-time information for booking is added at level 4. At level 5, the logistics orchestrator plans the arrival and/or departure time of transport based on real-time inventory levels.
- Type of relationship: starting a level 2 vertical collaboration in the chain is required. At level 4 intensive horizontal collaboration between logistics service providers and operators is required to fully benefit from synchromodal transport.
- Pricing: at level 2 prices are agreed upon by tariff and are quoted per modality. In level 3 prices are estimated up front and adjusted afterwards based on actual usage of modalities. Starting at level 4 an integral price is defined for a trajectory with an average lead time.
- For a more detailed description of the changes for each of the levels and the changes per role per level see Alons-Hoen, Somers, and van Duin (2019).

Research findings

In this section we present the findings from this research. First, some general observations are presented in Section 3.1. Next, the synchromodal scores per role and component are investigated in Section 3.2. Lastly, interesting relationships between two components are discussed in Section 3.3.

General observations

24 companies have been interviewed using a structured questionnaire based on the synchromodal maturity model to determine their scores for each area. No explicit selection criterium has been applied for the selection of companies as it is already hard to get into contact with companies having experiences with intermodal transportation. A structured interview is needed for the identification of the appropriate maturity level for each key process area. For the persons interviewed it was checked whether the persons are indeed responsible for the transport choices in their supply chains. Table 1 shows the roles of the companies and the corridor they are most active on. Out of these 24 companies, the majority are logistics service providers (11), and the majority is involved with intercontinental shipping (11).

Table 1 Company role (a) and corridor (b)

Role	
Logistic Service Provider	11
Shipper	6
Terminal operator	2
Forwarder	5
Overall	24

(a)

Corridor	
Continental (Europe)	8
Continental (Other)	2
Intercontinental	11
Unknown	3
Total:	24

(b)

First, for each company the scores for the key process areas of the maturity model are determined. The summarized results are shown in Figure 2. In this figure it can be observed that the key process areas can be divided in two groups: leaders (mainly score 3 or 4) and laggards (mainly score 1 or 2). The first group consists of relationship, pricing, and KPIs. The second group consists of transport execution, transport planning, data exchange, and decision making power.

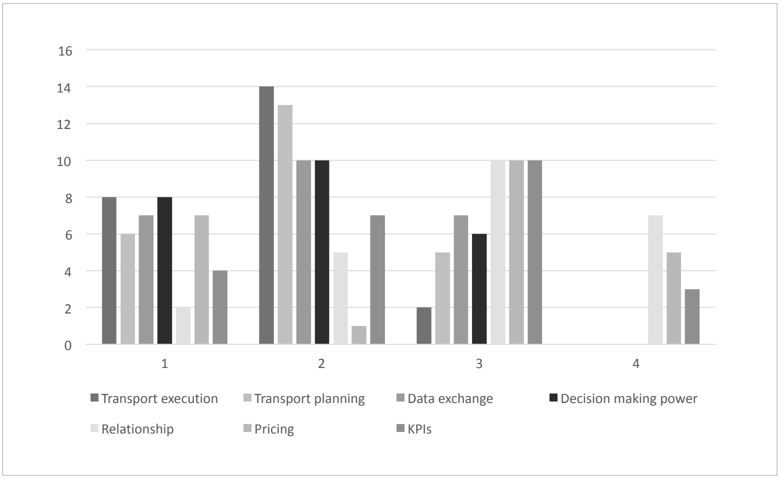


Figure 2 Key process area scores

These results suggest that relationships are already intensive vertically, and limited horizontally. It also can be observed that the planning of synchromodal transport, as well a-modal booking and the necessary data exchange are behind.

Synchromodal scores per role

For each company the overall score for the maturity of synchromodal transport for each company is determined. Finally, an average score was calculated for all companies in the same role. The results are in Table 2. The numbers behind the role indicate the number of interviewed companies in that role.

Table 2 Average maturity scores

Role	Average
Logistic Service Provider (11)	2,30
Shipper (6)	2,14
Terminal operator (2)	2,50
Forwarder (5)	1,89
Overall	2,21

It can be observed that terminal operators have the highest average score and forwarders the lowest. The scores of the logistics service providers and shippers are approximately the same. Based on these results it can be concluded that intermodal transport is used a lot and some companies are obviously moving towards synchromodal transport. It can

be expected that the forwarders score is the lowest as they are intermediaries between shippers and logistics service providers and benefit more from lack of transparency in the transport market that corresponds with the lower levels of the maturity model.
To get more insight into the scores obtained per role, the average score per role for each of the 7 components is calculated. The results are shown in Table 3.

Table 3 Average maturity scores per component

	Transport execution	Transport planning	Data exchange	Decision making power	Relation-ship	Pricing	KPIs
Logistic Service Provider (11)	1,82	2,27	2,18	2,09	3,09	2,18	2,45
Shipper (6)	1,83	1,67	2,00	2,00	2,83	2,00	2,67
Terminal operator (2)	2,00	2,50	2,00	2,00	3,00	3,50	2,50
Forwarder (5)	1,40	1,40	1,60	1,40	2,60	3,20	1,60
Overall (24)	1,75	1,96	2,00	1,92	2,92	2,46	2,50

For each component the role with the highest score (bold) and the role with the lowest (italic) score are represented. Overall, it can be observed that relationship gets a high score and transport execution on average the lowest score. Logistics service providers have a high score on data exchange, decision making power, and relationship. Terminal operators have the highest score for transport planning, execution, and pricing. This is probably explained by the fact that the planning and execution of transport is their core business. Shippers have the highest score for KPIs. At level 3 reliability is added as a KPI and this seems to be very important to companies these days. Possibly caused by possible large delays in intermodal, and road transport. The high score on pricing for the forwarders does not seem to be in line with the other scores. In general it can be concluded that companies have a high score on factors that are in line with the role of the companies and what is most important to them. This provides some validity for the maturity model.

To observe the spread in scores within each role, we have calculated the standard deviation for each of the role-component combinations. The results are presented in Table 4. Please recall that only 2 terminal operators were interviewed. Hence, the standard deviation should be reviewed with care!

Table 4 Component score deviations

	Transport execution	Transport planning	Data exchange	Decision making power	Relationship	Pricing	KPIs
Logistic Service Provider (11)	0,72	0,62	0,72	0,79	0,90	1,11	0,98
Shipper (6)	0,37	0,47	0,82	0,58	1,07	0,80	0,75
Terminal operator (2)	0,00	0,50	0,00	0,00	0,00	0,50	0,50
Forwarder (5)	0,49	0,49	0,80	0,80	0,80	1,17	0,89
Overall (24)	0,60	0,68	0,76	0,76	0,91	1,14	0,91

It can be observed that high deviations are measured for pricing and relationship. This tells us that very different scores were given by the companies. Especially, for the forwarders as there were only 5 companies. This factor is investigated in more detail in Section 5.3.

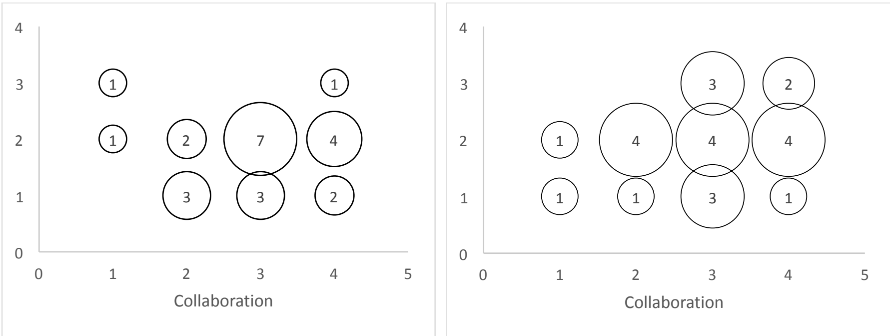
The maturity model consists of 7 components. It is interesting to investigate which of the 7 components is the best predictor of the total score of the company. The total score of the company was based on the modus, i.e. the score that occurred most frequently among the 7 components. To this the end, the share of the companies for which a particular score on the factor matches the overall score is counted. The results are shown in Table 5. The decision making power has the highest score. It means that for 92% of the companies the score on decision making power reflects the total score of the company. It seems a necessary condition for companies to achieve a level of synchromodality.

Table 5 Component versus overall score

Component	Score
Transport execution	0,58
Transport planning	0,79
Data exchange	0,54
Decision making power	0,92
Relationship	0,25
Pricing	0,39
KPIs	0,50

Relation between synchromodal components

A comparison is made between the scores of the companies on two different components to observe the relationship between the components. First of all, the score for collaboration (relationship) and transport execution and planning are analysed (see Figure 3a + 3b). The size of the bubble represents the number of companies with that combination of scores.



(a) (b)

Figure 3 Relationship (collaboration) versus transport execution (a) and transport planning (b)

More companies have a higher score on collaboration than on transport execution and planning, 9 vs. 4, and 14 vs. 1, respectively. This seems to indicate that in most cases the relationship with the supply chain partners is good and there is intensive collaboration, but it seems to be ahead of transport execution in terms of synchromodality. As a result, intensive collaboration seems a requirement for synchromodality, however its predictive value is low.

When comparing the scores of transport planning and transport execution (see figure 4), it is clear that the score of the two components are equal or that companies have a higher score on planning, than for execution. So the planning process is in place to facilitate synchromodal planning of transport but transport is not synchromodal yet. A possible explanation for this is that companies are willing to use intermodal transport but that there are still no suitable options on the required routes available.

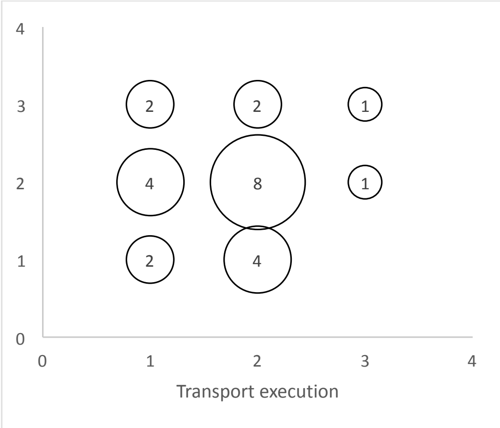


Figure 4 Transport execution versus planning

The following step is to compare the scores on collaboration (relationship) to the scores on decision making power. The results are in Figure 5. It is observed that a higher score on collaboration is required to have a higher score on decision making power. A higher score on decision making power means that the LSP has more freedom to plan the transport. More intense collaboration is indeed a requirement for this. Moreover, companies tend to have a higher score on collaboration than on decision making power. This suggests that a good relationship is necessary for a higher score on decision making power but it is not sufficient.

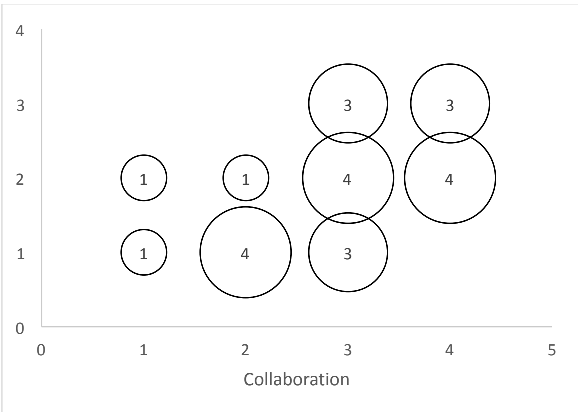
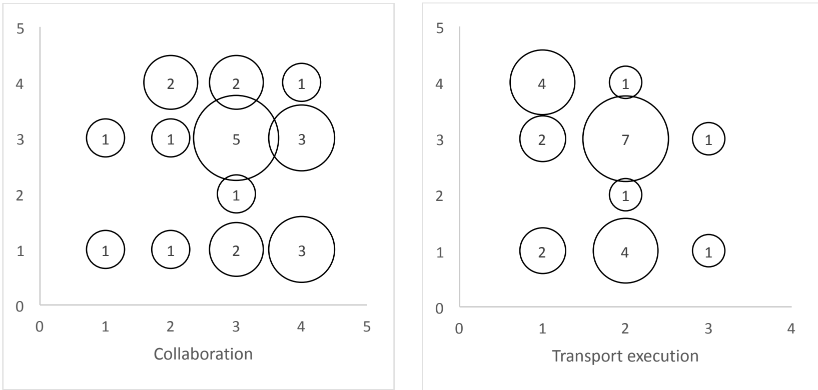


Figure 5 Collaboration vs. decision making power

Lastly, the scores of the factors collaboration (relationship) and transport execution versus pricing are investigated (see Figure 6 a+b).



(a) (b)

Figure 6 Collaboration (a) and transport execution(b) versus pricing

The results are very dispersed. There seems to be almost no relation between the level of collaboration and the price setting process. Moreover, there seems to be a negative relation between transport execution and pricing. This implies that more synchromodal transport corresponds with a less sophisticated pricing policy. Four out of the five companies with pricing level 4 (an integral price policy) use mainly road transport (level 1). This seems to support the conclusion that when intermodal transport is used to a limited extend, companies are more willing to use an integral price. When the share of intermodal transport is higher, companies want to see a post facto price calculation. There are six companies that have a higher score on pricing, than on collaboration, and three out of the six companies are forwarders. This might suggest that forwarders are more likely to use integral pricing.

For all of the factors for which a higher score is obtained than for the others there seems to be an improvement potential. The company already has a high score might make it easier to transform to a higher score on the other level and increase the overall maturity of synchromodal transport. This especially applies to the factors transport execution, transport planning, and decision making power. The preconditions in terms of good collaboration, data exchange and relevant KPIs exist and may help companies progress in the other areas.

Conclusion and discussion

We have observed that most companies are more mature in the areas of collaboration, pricing process, and KPIs. This implies that companies already collaborate intensive vertically and to a limited extend horizontally in the chain, and that prices are often quoted on an integral basis, and that reliability is an important KPI. This supports the claim of Pfoser, Treiblmaier, and Schauer (2016) that collaboration is critical for successful implementation of synchromodality. We have observed that it is critical, but not sufficient. This also implies that road transport is often still the modality of choice and that long-term planning of intermodal transport, and necessary data exchange, are lagging. Decision making most often lies with the shippers.

Terminal operators have the highest average score of maturity and excel in transport execution, and planning, and pricing policy. It has to be noted that for operators it is easier to obtain be more mature as they own the assets and therefore have the necessary information to make real time changes. Logistics service providers have the second highest average score and excel in data exchange, decision making power, and relationship. Logistics service providers are most mature in the area of decision-making power, data exchange, and relationship. Shippers have the third highest score and excel in the area of KPIs. Forwarders have the lowest average score but score surprisingly high on pricing policy. This result is in line with what is most important to these companies.

It can be concluded from the data that the maturity of decision-making power is most informative for the combined maturity score of a company. It seems that the agreement on the ownership of decisions is a necessary requirement for the overall maturity of synchromodal transport. It is observed that companies typically have the required planning processes in place for synchromodal transport but that execution of transport is behind. A possible explanation is that companies are willing to use intermodal (or synchromodal) transport but that the intermodal transport offer is too low or non-existing on certain routes. The results suggest that a less sophisticated pricing policy is used for more mature levels of transport execution. A possible explanation for this can be that an integral price is used more often when the share of intermodal transport is low.

Looking towards the future, most companies can mature in synchromodality by improving decision-making power and corresponding transport planning. Whether transport execution can be improved is greatly dependent on the trajectories used and the availability of intermodal transport. Current scores on pricing are already relatively high. The predominantly negative relation between pricing and transport execution might suggest that a higher score on transport execution results in a lower score on pricing.

Based on the results from this study we propose a change to the maturity model. For transport execution levels 3, 4, and 5 are currently identical. However, for level 4 the synchromodal transport allows for real-time switching of modality during transport execution. This should be reflected in the description of transport execution level 4.

For future research, it is interesting to investigate the role of the size of the company on the maturity score. Also, for data exchange to investigate the shared information as well as the means of data exchange. This might highlight whether the connectivity between companies is lagging, or data sharing is lagging. Lagging data sharing might be a symptom of trust issues between parties. Lastly, it would be interesting to investigate what the restricting factor to use, or allow for more use, of intermodal transport is. It could be due to availability, throughput time, available capacity, or reliability. Furthermore, it is interesting to investigate the willingness of shippers to accept integral pricing as a function of the level of transport execution, and other factors of the maturity model.

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