DIGITAL MATURITY ASYMMETRY OF SUPPLY CHAIN PARTICIPANTS AS A SOURCE OF INTERACTION RISKS

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The digital transformation of supply chains is mostly assessed at the level of an individual enterprise: digital maturity models describe how far a company has advanced in digitalising its strategy, processes, data, staff competencies and technological base [1, p. 162]. Yet the economic effect of logistics digitalisation arises not inside the enterprise but at the interfaces between chain participants – the shipper, the carrier and the logistics service provider. The study of arcs of integration showed that chain performance grows as integration extends towards both suppliers and customers [2, p. 186], but this conclusion implicitly assumes that partners are able to sustain integration at a comparable level. It is precisely this assumption that increasingly fails to hold under present conditions.

We propose to understand *digital maturity asymmetry* as the divergence between the digital maturity levels of interacting supply chain participants along those dimensions that directly shape the interface of their interaction: the mode of data exchange, the degree of automation of joint processes, and the rules of decision-making and execution control. Crucially, asymmetry is a property of a pair or a group of participants rather than of an individual enterprise. Two partners with low but equal maturity may interact with smaller losses than a highly mature logistics provider and a carrier that works with paper documents and telephone calls: in the second case, the more mature party receives incomplete or delayed data, while the less mature one receives requirements it is unable to meet.

In the Ukrainian transport market this configuration is typical: large shippers and logistics providers invest in transport management systems, shipment tracking and electronic document flow, whereas a considerable share of carriers are small enterprises with a few vehicles, for which such investments are economically out of reach. Wartime conditions have deepened the gap: carriers that have lost part of their fleet and staff postpone digital projects, while shippers tighten their requirements for chain transparency.

Digital maturity asymmetry generates at least five groups of interaction risks.

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Information risks. Data at the interface are transferred by manual re-entry, in incompatible formats or with delay, which distorts information on demand and order status. The mechanism is the same as in the bullwhip effect: each link makes decisions on the basis of a distorted signal [3, p. 546], yet the source of distortion here is not the structure of the chain but the inability of the less mature participant to transmit data of the required quality.

Operational risks. A joint process moves at the speed of the least digital participant: automated route planning or loading time windows lose their meaning if the carrier's confirmation arrives by telephone a day later.

Economic risks. The costs of bridging the gap – data format converters, duplicated control, manual reconciliation – are borne, as a rule, by the more mature party or shifted onto the partner. Investments in integration with a specific partner are specific in nature: they cannot be transferred to another counterparty, which creates dependence and room for opportunism [4, pp. 52-56].

Relational risks. Divergent expectations regarding speed, transparency and data discipline undermine trust, while the relational rent from joint investments is distributed unevenly in favour of the party that controls the interface [5, p. 662].

Resilience risks. The less mature participant notices a disruption later and responds to it more slowly; asymmetric chain visibility extends the recovery time, whereas visibility is one of the key conditions of supply chain resilience [6, p. 4].

The central thesis of this paper is the existence of a *compatibility threshold*. Let the digital maturity of participants i and j be denoted by M_i and M_j (in levels of the chosen maturity scale), and the maturity gap by Δ:

$$\Delta = \left| M_i - M_j \right| \tag{1}$$

The net effect of integration E is the difference between the benefits B and the costs C, both of which depend on the gap:

$$E(\Delta) = B(\Delta) - C(\Delta) \tag{2}$$

The benefits of integration are bounded by the ability of the less mature party to use shared data and tools, so B decreases as Δ grows. The costs, on the contrary, increase, and do so non-linearly: each additional level of the gap requires not only technical data converters but also organisational changes at the partner – process redesign, staff training, additional control. Hence there exists a value Δ^* at which $B(\Delta^*) = C(\Delta^*)$; for $\Delta > \Delta^*$ integration yields a loss rather than an effect. This hypothesis is consistent with the finding that the effect of supply chain collaboration arises only where partners possess complementary resources and compatible processes [7, p. 165], whereas digital

integration without such compatibility turns into a source of cost and complexity [8, p. 158].

The practical meaning of the threshold is presented through asymmetry zones (Table 1).

Table 1

Zones of digital maturity asymmetry and the recommended interaction mode

Gap Δ	Zone	Nature of the integration effect	Recommended interaction mode
0-1 level	compatible	positive, grows with the depth of integration	direct integration of systems, shared real-time data
2 levels	transitional	positive only at a limited depth of integration	exchange through an intermediary digital platform, stepwise raising of the partner's maturity
3 levels and more	critical	negative: the costs of bridging the gap exceed the benefits	standardised minimal interface; deep integration only after the partner's maturity has been raised

Source: developed by the author

Several managerial implications follow from the compatibility threshold. First, assessing a partner's digital maturity should become part of the partner onboarding procedure on a par with checking its financial reliability. Second, the depth of integration should be chosen according to the gap rather than on the principle "the deeper, the better": for the transitional zone a limited set of shared data is more appropriate than a full connection of systems. Third, digital platforms act as an equaliser: by providing the less mature participant with ready-made tools – a driver's mobile application, an electronic consignment note, standard status exchange – they reduce the effective gap without capital investment on its part. Fourth, the costs of bridging the gap should be fixed in the contract through data quality requirements, the allocation of integration costs and incentives for information exchange discipline. Fifth, asymmetry has to be monitored over time, since the maturity of participants changes at different rates, and a pair from the compatible zone may find itself in the transitional zone within a few years.

The direction of asymmetry also matters. When the shipper is the more mature party, adaptation costs fall on carriers and become a barrier to access to its orders. When the logistics provider is the more mature party, it is able to turn

the gap into a source of revenue by offering partners its own platform as a service. This corresponds to the logic of viable supply chains, in which resilience is ensured not by maximum integration but by the ability to reconfigure links depending on the state of participants [9, p. 2905].

Thus, digital maturity asymmetry is an independent source of interaction risks that cannot be reduced to the low maturity of an individual participant. The compatibility threshold hypothesis shifts the focus of management from the question "how digital is the enterprise" to the question "how compatible are the partners", and asymmetry zones provide a practical tool for choosing the interaction mode. Further research should focus on the empirical estimation of Δ^* for Ukrainian transport and logistics enterprises and on testing whether intermediary digital platforms reduce the effective maturity gap between chain participants.

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