Information sharing in multi-tier supply chains: A Delphi study on contingencies

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Abstract

We conduct a Delphi study with 29 supply chain experts, to explore contingencies for implementing information sharing across multiple supply chain tiers. Twelve contextual factors are identified, and are categorised as either product and market aspects or supply chain aspects. The Delphi study identified importance and feasibility as two key perspectives, and a quantitative assessment round revealed that these exhibit a negative relationship for most contingency factors, such that information sharing is difficult to achieve in important contexts, but is unimportant in feasible contexts. Herein lies a paradox, which is discussed.

Keywords: Feasibility, Importance, Paradox.

Introduction

The importance of information sharing has been reported in numerous qualitative and quantitative research studies over the past decades (Sahin and Robinson, 2002; Cousins et al., 2006; Kembro and Näslund, 2014). Particularly, demand-related information sharing is recognised to help decreasing the bullwhip effect, which can lead to improved production planning and scheduling and reduced inventory levels throughout the supply chain (Bourland et al., 1996; Lee and Whang, 2000).

As the research area has matured, a growing stream of research however submits that increasing information sharing in supply chains is not universally beneficial (Vanpoucke et al., 2009; Wong et al., 2012). Companies struggle with and avoid demand-related information sharing across their supply chain (Moberg et al., 2002; Angulo et al., 2004; Taylor and Fearne, 2006; Fawcett et al., 2009). Kim et al. (2005) argued that information sharing should not be increased in supply chains with stable demand of products that represent low complexity in terms of technical specifications, since the receiving unit may have to waste its time sorting out the relevant information from the received data. Thus, the level of electronic integration should be appropriate for the contextual factors surrounding the supply-channel relationships – no more, no less.

Furthermore, research that explicitly discusses the role of contexts for information sharing has typically focused on the dyadic relationships (Yigitbasioglu, 2010; Kembro et al., 2014). Hence, we have limited knowledge of how organisations best approach the task of adapting information sharing to extended supply chains. Caridi et al. (2010) supported this notion and submitted that organisations often fail to match information sharing to the particular supply chain context and generally have very little information sharing with second-tier partners. The understanding of contingency factors in this context is limited and more qualitative research is needed to investigate the complex relationships between contextual factors and information sharing in supply chains (Wong et al., 2011).

In this study, we explore contextual factors in supply chains. We move beyond the commonly researched dyadic relationships (cf. Autry et al., 2014; Kembro and Näslund 2014) and consider information sharing across multiple tiers in extended supply chains (e.g. supplier – manufacturer – customer). We seek to answer the following research question: *Which contingency factors affect information sharing in multi-tier supply chains, and how?* To answer the research question, we conduct a Delphi study with an international panel represented by researchers, consultants and supply chain executives. Since there is no consensus in the literature on whether increasing levels of information sharing in supply chain is beneficial or not, but the issue is important for managers and thus deserve further attention, we wanted to use a novel approach to shed new light on the problem. Therefore, the Delphi study was selected, which has not been used in this context before.

Related literature

Information sharing is recognised as one of the flows that should be integrated to improve planning and coordination in the supply chain (Mentzer et al., 2001; Fawcett et al., 2009). Previous research studies have to a large extent focused on analysing and confirming the value of sharing demand-related information between supply chain partners. Benefits include, for example, coordinated business processes (Premus and Sanders, 2008), improved demand forecasting and better production planning (Sahin and Robinson, 2002), reduced inventory levels and improved reliability of deliveries (Bourland et al., 1996; Chen et al., 2000). Melnyk et al. (2009) emphasised the seamless exchange of information within the supply chain "by involving the entire supply chain (both upstream and downstream) and working together collaboratively with secure and timely information flows between the parties" (ibid, p. 4643). The notion that it can be beneficial to increase information sharing between all supply chain partners is supported in several studies (Kaipia and Hartiala, 2006; Sepulveda Rojas and Frein, 2008; Caridi et al., 2010). Following a similar line of reasoning, Autry et al. (2014) investigated connectivity in supply chains discussing that "the effort to connect the triad – and perhaps the broader supply chain, at further tiers – is worthwhile" (ibid, p. 62) in order to achieve higher effectiveness and efficiency in the supply chain.

Despite the recommendations to increase multi-tier information sharing there is a lack of practical cases from industry. The lack of empirical evidence can partly be explained by the fact that most studies investigating supply chain exchange relationships have focused on the dyadic unit of analysis (Autry et al., 2014). This observation is striking considering that triadic structures (e.g. supplier – manufacturer – customer), according to several researchers, represent the smallest unit of supply chain analysis (Mentzer et al., 2001; Autry et al., 2014). Turning to the few empirical studies that have considered the supply chain as the unit of analysis, it appears that companies do not pursue multi-tier information sharing in reality but rather focus resources on increasing dyadic information

sharing (Kaipia and Hartiala, 2006; Taylor and Fearne, 2006; Kembro and Näslund, 2014).

Recognising that increasing information sharing in supply chains is not universally beneficial, a growing stream of research emphasises the role of contextual factors (Caridi et al., 2010; Yigitbasioglu, 2010; Wong et al., 2011; Kembro et al., 2014). For the purpose of this paper, we reviewed the literature that explicitly have discussed contextual factors for information sharing in supply chains. We performed a structured literature review in two selected databases (EBSCOhost and ISI Web of Science) following the guidelines in e.g. Tranfield et al. (2003). Overall, we identified 20 papers that explicitly discuss contextual factors for information sharing. Table 1 summarises these sources and identifies the type of supply chain (dyad or extended) that is treated as well as the specific contextual factors that are explicitly discussed in relation to information sharing. Most papers in Table 1 (17 of 20) are concerned with buyer-supplier relationships (i.e. dyads), but three papers treated extended supply chains. All three papers used case-research methodology, but treated different factors. Caridi et al. (2010) discussed supply chain complexity, Kembro and Selviaridis (2015) treated demand uncertainty, product life cycle, product volume, and supply base, and van Donk and von Doorne (2016) investigated customer-order decoupling point as influential factors for information sharing in multi-tier supply chains.

Table 1 – Contextual factors that influence information sharing in supply chains and related literature sources.

Source	UoA	Contingency factors	#
Sahin and Robinson (2005)	Dyad	Customer order decoupling point (CODP)	1
Kim et al. (2005)	Dyad	Demand uncertainty, product complexity	2
Li and Lin (2006)	Dyad	Demand uncertainty, technology uncertainty, supply uncertainty	3
Samaddar et al. (2006)	Dyad	Supply chain complexity	1
Grover and Saeed (2007)	Dyad	Demand uncertainty, product complexity	2
Zhou and Benton (2007)	Dyad	Product innovation	1
Welker et al. (2008)	Dyad	Demand variability, product complexity, CODP	3
Frazier et al. (2009)	Dyad	Environmental uncertainty	1
Vanpoucke et al. (2009)	Dyad	Demand uncertainty, technology uncertainty	2
Caridi et al. (2010)	Ext. SC	Supply chain complexity	1
Yigitbasioglu (2010)	Dyad	Demand uncertainty, environmental uncertainty, product life cycle	3
Wong et al. (2011)	Dyad	Environmental uncertainty	1
Jonsson and Mattsson (2013)	Dyad	Demand variability	1
Lei et al. (2014)	Dyad	Demand uncertainty	1
Kembro and Selviaridis (2015)	Ext. SC	Demand uncertainty, product life cycle, product volume, supply base	4
Li and Zhang (2015)	Dyad	Demand uncertainty, CODP	2
Tsinopoulos and Mena (2015)	Dyad	Product life cycle, CODP	2
Mirkovski et al. (2016)	Dyad	Environmental uncertainty	1
van Donk and van Doorne (2016)	Ext. SC	CODP	1
Kaipia et al. (2017)	Dyad	Demand uncertainty	1

(UoA: unit of analysis; Ext. SC: extended supply chain; #: number of factors)

The conclusions we can draw from the related literature are threefold. First, numerous factors can affect information sharing in supply chains; twelve factors are identified through these literature sources. Second, most research studies have focused on one or a few factors rather than considering a range of factors simultaneously (the average number of factors in a paper is 1.7, the mode is one, and the median is one). Third, previous research has predominantly focused on the dyad as the unit of analysis. Therefore, this research addresses these aspects by applying the extended supply chain as the explicit

unit of analysis and by considering multiple factors, to contribute to the understanding of information sharing in multi-tier supply chains.

Research design and methodology

The research method used in this study is the Delphi study, which is a systematic group communication process where invited experts anonymously provide input on a complex problem through multiple rounds of questionnaires (Dalkey and Helmer, 1963). The usefulness of the Delphi study for exploratory theory building has been demonstrated through its application in several supply chain areas (e.g. Akkermans et al., 2003; MacCarthy and Atthirawong, 2003; Lummus et al., 2005; Ogden et al., 2005; Melnyk et al., 2009). In this study, we follow general Delphi guidelines (see e.g. Linstone and Turoff, 2002; Okoli and Pawlowski, 2004) in four stages: (i) panel recruitment, (ii) round 1 – exploring the subject, (iii) round 2 – reaching an understanding, and (iv) round 3 – assessing opinions, which are described in the following sections. In each round, we designed the questions with the purpose to avoid compounded events and ambiguous statements, and to avoid imposing bias or lead the respondents in any direction. All questionnaires were sent as Word-documents and were provided through a link to SurveyMonkey to make it easy for respondents to provide their answers. We also pre-tested all rounds involving three practitioners and three researchers.

Panel recruitment

To capture a variety of perspectives on information sharing in multi-tier supply chains, we invited three categories of experts: supply chain executives, SCM academics, and SCM consultants. The executives had at least ten years of experience from global supply chain management. Academic researchers were invited based on their publication record with relevance to the topic of the study; all are well known and well cited. Consulting professionals were identified based on top-ten listings of consulting firms representing global and European firms. A total of 32 supply chain executives, 30 researchers, and 36 consultants were invited. Well in line with Delphi guidelines (Akkermans et al., 2003; Ogden et al., 2005), 29 experts (12 executives, 5 researchers, and 12 consultants) agreed to participate in the Delphi study. The respondents come from around the world, but a majority of the supply chain executives and consultants are based in or operate out of northern Europe. All of them participated in the entire study, which helps to eliminate the potential issue of non-response bias (Okoli and Pawlowski, 2004).

Round 1 – exploring the subject

The first round consisted of two open-ended questions: (i) is there any difference regarding demand-related information sharing across independent companies representing three or more supply chain tiers (e.g. supplier – manufacturer – retailer) in comparison with information sharing between dyadic partnerships (supplier – buyer)? and (ii) is there any particular supply chain context, where it is more likely that companies could benefit from information sharing across three or more tiers? The three researchers conducted independent content analyses resulting in a list of keywords, emerging themes and unique insights. We identified 14 contextual factors that are highly relevant for multi-tier information sharing, which were carried forward to the second-round questionnaire.

Round 2 – reaching an understanding

In the second round, the respondents were given an opportunity to consider and comment on the list of contextual factors identified in round one. The respondents were specifically asked to state whether each factor is important to consider or not when designing

information sharing across three or more supply chain tiers. To allow for additional insights, the respondents were also asked to provide commentary input in the second round. Based on the analysis of round two answers, the respondents did not consider four of the contextual factors to be relevant for multi-tier information sharing: production capacity, flexibility in production capacity, start-up times in production, and product margins. These four factors were therefore excluded from the list. Meanwhile, many respondents suggested that two new factors should be added to the list: supply-chain flexibility and demand variability. Based on the comments from the respondents, we also identified two dimensions or perspectives that should be considered for the contextual factors: (i) importance in terms of perceived benefits, i.e. in which contexts would it be beneficial to engage in multi-tier information sharing, and (ii) perceived feasibility, i.e. in which contexts would it be possible to implement and maintain multi-tier information sharing. Finally, we noted different settings for each contextual factor for which multi-tier information sharing ought to be adapted. For example, the respondents contrasted high versus low demand uncertainty, long versus short lead times through the supply chain, introduction versus maturity stage of the product life cycle, high versus low product complexity as well as high versus low structural complexity of the supply chain. In total, 12 factors were brought forward to the third round (i.e. 14 minus four plus two; cf. above).

Round 3 – assessing opinions

The updated list of contextual factors also included quantitative assessments. The respondents were asked to compare contrasting contexts (e.g. high versus low demand uncertainty) and rate which of the contexts they perceive as (i) relatively more important in terms of potential benefits; and (ii) relatively more feasible for implementing and maintaining multi-tier information sharing, along a seven-point scale.

The final data analysis included content analysis of the commentary input from each round as well as quantitative data from the third round. Throughout the Delphi study process, we checked all responses across the three respondent groups (researchers, executives, and consultants) to identify if there were structural differences between groups. However, we only found similarities, which emphasises the uniform perception of the Delphi panel concerning the existence and effect of contingency factors for information sharing in multi-tier supply chains.

Results and analysis

We identified twelve contextual factors for information sharing in multi-tier supply chains: six product and market factors, and six supply chain factors. The product and market aspects were (i) demand variability, (ii) demand uncertainty, (iii) product life cycle stage, (iv) product complexity, (v) product life span, and (vi) time-to-market, while the supply chain factors were (i) supply chain complexity, (ii) number of companies in the supply chain, (iii) supply chain strategy, (iv) lead times, (v) supply chain flexibility, and (vi) customer order decoupling point.

We explored in which contexts multi-tier information sharing is perceived to be relatively more important in terms of potential benefits and relatively more feasible to implement and maintain, cf. Figure 1. This assessment was carried out by contrasting two significantly different settings for each contextual factor (e.g. maturity vs. introduction stage in product life cycle; high vs. low demand uncertainty). The contrasting settings of each factor are then arranged such that the right hand side contains the settings that are considered to be relatively more important than those on the left hand side.

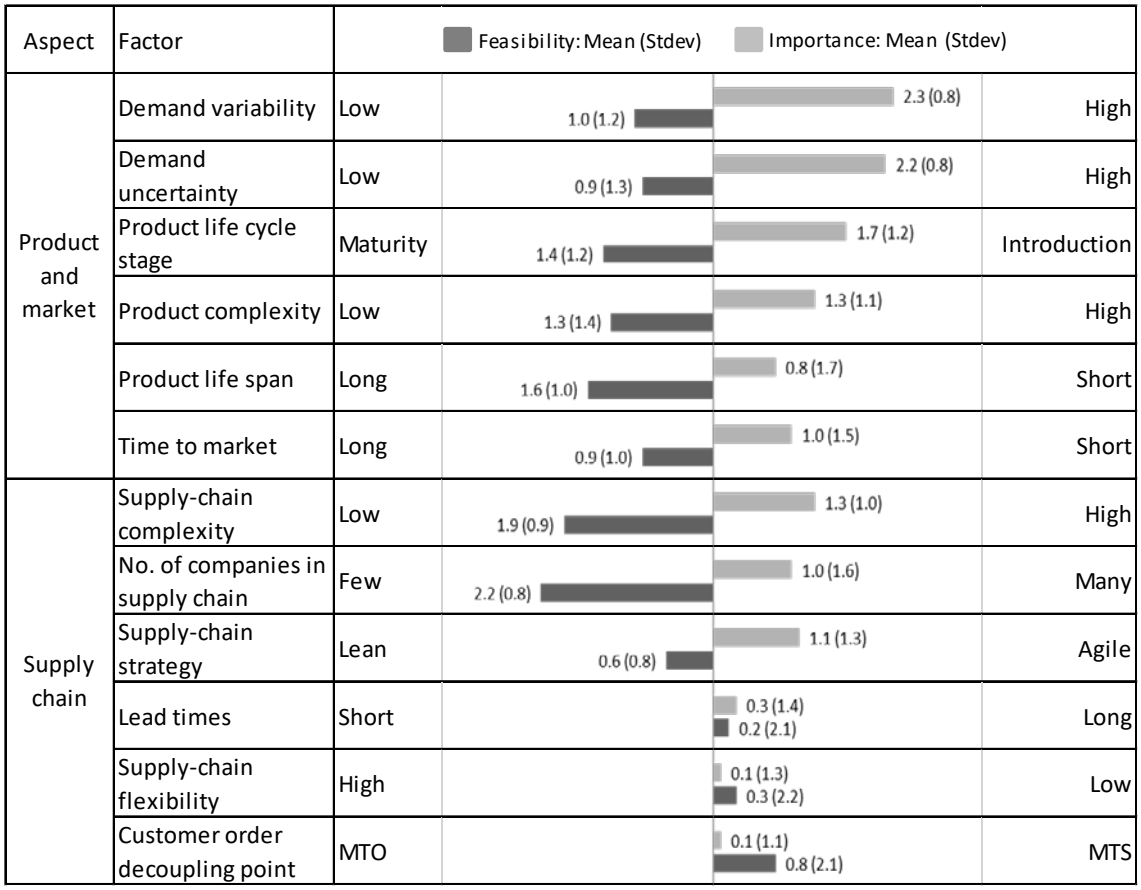

Figure 1 – The result of the Delphi study in terms of importance and feasibility of twelve factors for multi-tier information sharing related to the product, market, and supply chain (0 = no difference; 1 = slightly more; 2 = more; 3 = much more).

From Figure 1 we can identify three important findings. First, there are a number of contexts that are regarded as more important for sharing information across multiple supply chain tiers, e.g. high demand variability and uncertainty, and the introduction stage in the product life cycle. One of the supply chain executives exemplified: *"In the introduction stage of a product it is an absolute must to have full transparency upstream in the supply chain because of the many design changes and considering that the suppliers must be able to produce according to the latest information"*.

Second, a number of contexts are regarded as more feasible for implementing multi-tier information sharing, such as low demand variability. One of the supply chain executives combines some of these factors: *"It is much simpler with a mature product. If, in addition, the demand represents low variation and low uncertainty it would be easier for all partners in the supply chain. In other words, it becomes more feasible to implement information sharing across the supply chain"*.

Third, when comparing the contexts that are perceived as important and those that are perceived as feasible it is clear that these largely represent different scenarios. This implies that, in general, the contexts that are perceived as important are not considered feasible for implementing multi-tier information sharing, and vice versa, i.e. those that are feasible are not of high importance. All product and market factors and three supply chain factors exhibit this dilemma. The largest differences between importance and feasibility are found for demand variability (3.3, i.e. 2.3 + 1.0), supply chain complexity (3.2), number of companies in the supply chain (3.2), demand uncertainty (3.1), and product life cycle stage (3.1). One of the consultants elaborates on the combination of

important but difficult scenarios: *"I believe that an important consideration for the topic of information sharing in supply chains is the planned changes that different partners in the supply chain carry out, and how the information regarding these planned changes can be shared beforehand in an effective way. Based on my experience, it is precisely in these situations where information sharing is of highest importance, but at the same time the most difficult to implement and manage because sales data such as POS is not enough"*. Conversely, some scenarios that are perceived as more feasible for implementing multi-tier information sharing are considered as less important for employing multi-tier information sharing. A supply chain executive provides additional details: *"I am for example considering a supply chain for a particular dairy product, a mature product with stable sales figures and predictable demand variations over the year. However, while it would be highly feasible to implement, I would still argue that the value of multi-tier information sharing in such a supply chain is low"*.

Discussion and conclusions

Comparison of the related literature with the findings from the Delphi study

The structured literature review identified twelve contextual factors; cf. Table 1. It should be noted that six of these were solely based on literature concerned with dyadic relationships. The other six factors were identified through research on extended supply chains; see Caridi et al. (2010), Kembro and Selviaridis (2015), and van Donk and van Doorne (2016). Five of the latter also appear in the Delphi study, which is explicitly concerned with multi-tier information sharing in supply chains (the only exception is product volume). This Delphi study also identified twelve factors, but a slightly different set of factors.

Overall, seven factors (demand variability, demand uncertainty, product complexity, product life cycle stage, customer order decoupling point, supply base, supply chain complexity) are acknowledged as contextual factors in both the literature review and the Delphi study. The literature identified five factors (environmental uncertainty, product innovation, product volume, technology uncertainty, supply uncertainty) that did not appear in the Delphi study, i.e. the panel members did not identify them as being influential contextual factors. Furthermore, the Delphi panel identified another five factors (product life span, lead-times in SC, SC strategy, SC flexibility, time to market) that were considered as relevant contexts for information sharing.

This research thus contributes in the following respects. First, we identify on five contextual factors: (i) product life span, (ii) time-to-market, (iii) supply chain strategy, (iv) lead times, and (v) supply chain flexibility, that have not been acknowledged in previous research. Second, we find support for seven contextual factors that have been identified in previous research. Two of these (demand uncertainty, product complexity) have only been discussed for information sharing in dyadic relationships previously, while this research find support for the consideration of these factors in multi-tier supply chains as well. Overall, this study provides support for a contingency approach to information sharing in supply chains by identifying twelve contextual factors.

The importance-feasibility paradox

In the situation where a supply chain context is considered important but not feasible for multi-tier information sharing, the possibility to increase feasibility should be explored. Here lies a challenge. There is little that companies can do about the external product and market factors. For example, the stage and length of the product life cycle are difficult to influence in the short term. Demand variability is also more or less a given, for example related to seasonality and demand peaks. Reducing demand uncertainty may be possible

in some situations, for instance, by investing resources to implement or improve joint forecasting among supply chain partners. However, a reduction in demand uncertainty implies a move from a high importance/low feasibility context towards a high feasibility, but low importance context.

As opposed to market aspects it should be possible to affect some supply chain aspects, e.g. by reducing the impact of the contexts that are important but less feasible, such as a complex supply chain, high number of supply chain companies, and an agile supply chain strategy. For example, this can be achieved by the following actions: (i) by focusing on strategic partners to reduce the complexity of the supply chain, (ii) reducing the number of companies in the supply chain by only including selected key partners, and (iii) initiate lean manufacturing and supply chain improvements that support a lean supply chain strategy. However, such changes imply a move from a high importance/low feasibility context towards a high feasibility, but low importance context.

These examples illustrate the importance-feasibility paradox. A paradox denotes contradictory yet inter-related elements – elements that seem logical in isolation but absurd and irrational, when appearing simultaneously (Lewis, 2000). An attempt to improve the feasibility of a context that is regarded as "high importance – low feasibility", implies that the importance simultaneously is reduced; hence, leading to a new combination of "high feasibility – low importance". Thus, we have two situations: when information sharing in multi-tier supply chains is perceived to be more important, the feasibility is lower, and vice versa, i.e. in contexts where information sharing is perceived to be more feasible, the importance is lower. This importance-feasibility paradox at least partially explains the relative absence of multi-tier information sharing in supply chains in practice, which per se has clear implications for both managers and researchers.

Managerial and research implications

For managers, the findings in this study show that it is not only one or two, but many factors that influence multi-tier information sharing. Since many specific contexts for these factors are considered to be either important or feasible rather than both (the importance-feasibility paradox), and since a supply chain can be characterised by all twelve factors, the combined challenges to create favourable multi-tier information sharing are substantial. Consequently, it becomes essential for managers to carefully evaluate if and how information should be shared with supply chain partners to avoid situations where resources are wasted without achieving any benefits for the supply chain partners (Butterman et al. 2008; Roh et al. 2008).

For researchers, the importance-feasibility paradox offers a new perspective on information sharing in multi-tier supply chains. By taking both importance and feasibility into account simultaneously, we can identify that there is indeed a non-trivial relationship. To the best of our knowledge, the interaction between the two concepts has not been explored before. For example, Mena et al. (2013) as well as Autry et al. (2014) found evidence for both benefits and downsides of information sharing beyond the dyad level, focusing on the importance – but they did not study feasibility. The conclusion of this research is that the notion that more supply-chain information sharing is beneficial for supply-chain performance is generally misleading, and with respect to the importance-feasibility paradox, that information sharing in multi-tier supply chains is generally not plausible (although it may exist in very special circumstances).

Limitations and future research

This study has certain limitations; one is a potential selection bias in the sample and the geographical location of the panel experts. While the study involves respondents from

around the world, a majority of the supply chain executives and consultants are based in or operate out of northern Europe. However, all respondents have more than ten years of experience from global supply chain operations. A second limitation concerns the possibility to generalise the findings beyond the Delphi study; but considering how the panel was set up, it is unlikely that another panel would reach significantly different agreements, as argued by Ogden et al. (2005).

There are several opportunities for future research based on the results from this study. One possibility is to investigate whether the twelve factors are independent or if some of the factors co-vary systematically such that the number of unique supply chain contexts is limited. In addition, the importance and feasibility of these factors can be tested in a broad-scale survey; however, it is essential to assure that the respondents truly assess multi-tier supply chains and not just dyadic relationships. Another research opportunity is to conduct in-depth case studies to unearth successful examples of multi-tier information sharing with rich descriptions of many or all twelve factors, addressing the inter-relationships and influence of these factors. Finally, attempts to find further empirical support for the importance-feasibility paradox are warranted.

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