

Aligning RFID applications with supply chain strategies



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ABSTRACT

Many large retailers decided to adopt RFID as their new supply chain technology, but RFID adoption by all industries did not spread as rapidly as initially expected. We believe that its benefits constituted the major barrier to its adoption, and argued that a major contributor to the delay has been its inappropriate implementation. Our study reports the result of six in-depth case studies, which, together with case content analysis of 88 reported RFID applications, provided us with a clear view of the RFID implementation landscape, suggesting that organizations often mindlessly adopted RFID applications that were misaligned with their supply chain strategies, leading to unsatisfactory benefits. Insights into how organizations should adopt RFID were developed from our results and were discussed.

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1. Introduction

RFID technology holds the promise of revolutionizing supply chain (SC) management by providing automatic real-time SC visibility. Wal-Mart, Metro Group and other major retailers gave RFID impetus by mandating that their top suppliers tag cases and pallets with RFID in 2005. Wal-Mart subsequently reported that this reduced out-of-stocks by 21%, achieved up to three times faster replenishment of out-of-stock orders and reduced manual orders. RFID adoption also helped Metro Group to realize significant time and labor cost savings. But although RFID has shown great potential to improving SC performance, the technology is still far from reaching mass adoption. Indeed, the RFID adoption rate has been disappointing except from the RFID mandates issued by the major retailers. The question then is: what are the barriers to RFID's widespread diffusion?

The literature suggests that a lack of standards, privacy and security issues, high cost, and unclear benefits are the main barriers. The lack of standardization is currently being addressed by international standards committees and groups such as EPCglobal, and the cost should lessen with further technological developments. The RFID privacy and security issue is a major concern, and has been covered by numerous studies. But the technology's benefits remain elusive. Few cases have been

reported, leaving managers to make adoption decisions without having a clear understanding of the potential benefits and how to achieve them.

The literature has suggested that organizations should evaluate RFID with respect to their own strategy before adopting it. However, many organizations have been greatly influenced by Wal-Mart's highly publicized RFID application. Lee and Özer [15] suggested that the initial overly positive publicity may have encouraged organizations to adopt RFID for their SC without proper consideration, but following others, possibly due to institutional pressure. In our study, we investigated whether organizations had followed RFID pioneers, and thus determine why RFID adoption has not lived up to its expectations. We investigated the phenomenon by analyzing whether SC strategies are misaligned with RFID applications and thus how SC practices are affected. The alignment of SC practices with SC strategies has been widely discussed in the SC management literature, with aligned SCs reported to confer significantly more benefits than those that were misaligned.

2. Literature review

2.1. Mindfulness

This is a state that brings vigilance to bear on actions. For *individuals*, it is a cognitive ability, whereas for *organizations* it is the outcome of the collective minds of the involved participants. Organizations in a mindful state make justified decisions, while those in a mindless state tend to make decisions without a well-thought-out process of evaluation. However many organizations

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Table 1
Choosing the right SC strategy by product characteristic and marketplace.

	Functional product	Innovative product
Predictable marketplace	Match (lean)	Mismatch
Volatile marketplace	Mismatch	Match (agile)

still act mindlessly. Many factors have been identified as leading to mindlessness, such as social or external pressure.

Naturally, organizations try to remain vigilant, but institutional pressure can lead to mindless behavior. Following others' leads may not suit the organizational mode of doing business, leading to less than desirable results. Mindful decisions prevent organizations from following first or early adopters unless doing so is aligned with their own interest.

In addition, organizations may act mindlessly by making unwise decisions. This can be attributed to a lack of managerial attention, e.g., when resources are not available to evaluate a decision carefully. Swanson and Ramiller [27] applied mindfulness theory to the IS context, arguing that organizations should make decisions grounded in their own organization's mode of operation. They also averred that mindlessness can occur in all innovative processes, that is comprehension, adoption, implementation, and assimilation.

2.2. Supply chain management

The literature generally categorizes SC strategies into whether they are lean or agile [1]. The purpose of lean SC strategies is to be as efficient as possible by reducing waste. Agile SC strategies, in contrast, are intended to be flexible in meeting changing customer demands. A lean SC strategy should be adopted for functional products in a predictable marketplace, whereas an agile SC strategy is appropriate for innovative products in a volatile marketplace (see Table 1). Combinations have also been suggested, such as *leagile* strategy: a combination of a lean upstream (for economy of scale) and an agile downstream (for flexibility) [16].

A common way to assess the effectiveness of both SC strategies and organizations is to verify whether an organization utilizes SC practices that match its SC strategy. Organizations can expect significantly better results when they match; e.g., a common best SC practice for a lean SC is to reduce inventory, whereas a common best SC practice for an agile SC is to satisfy customer requirements. A list of common SC best practices in accordance with SC strategies is illustrated in Table 2, drawn from the work of [3] and [25].

3. Mindlessness effects of innovation with IT

Prior studies suggest that a mindful state influences decisions and their outcomes. Swanson and Ramiller suggested that IT innovation involved multiple processes during which mindfulness

Table 2
Lean and agile supply chain practices.

Lean practices	Agile practices
Pull approach	Close supplier relationship
Inventory reduction	Enterprise integration
Quick setups/orders	Concurrent business activities
Quality at source	Customer requirement satisfaction
Supplier networks	Rapid development cycles
Continuous improvement	Customer driven innovation
	Use flexible production technology

may occur, although they did not discuss the factors determining the mindful or mindless state occurring during different innovation processes.

We depict the different mindfulness effects in operation during the different IT innovation processes in Fig. 1, adopting the four innovation processes posited by Swanson and Ramiller, though we argue that mindfulness does not occur during the comprehension process. The initial scanning in comprehension can affect the mindfulness in subsequent decisions, as more references are available and better judgments can be made. The actual decision that leads to either a mindful or mindless state is thus delayed until the adoption process, which subjects the IT innovation to in-depth consideration and provides a supportive rationale for its adoption or lack thereof. We term the mindlessness effect during the adoption process a *bandwagon* effect.

Mindful implementation can still turn a mindless adoption decision into a useful IT application and vice versa. The implementation process develops the IT application according to the organization's needs. Mindful implementation carefully evaluates the IT innovation and aligns it in a way that fits the organization's needs. Mindless implementation, in contrast, ignores the alignment issue and thus may lead to less than satisfactory results [4]. For instance, many organizations have developed an e-business platform that does not fit their existing resources and operations. We term the mindlessness effect during the implementation process a *misalignment* effect.

Once an IT innovation has been implemented, the organization still has to accept and assimilate it. This process involves how the innovation is absorbed into the organization. A mindful assimilation process integrates and converges the IT application with existing operations, often requiring adjustment to both the new IT application and existing working practices. ERP systems often face this dilemma, with the organization forced to choose between changing its business processes to accommodate the ERP system and customizing the ERP to suit its existing business.

4. Methodology

Our aim in this study was to validate the mindlessness effects of the innovation framework by examining a series of RFID

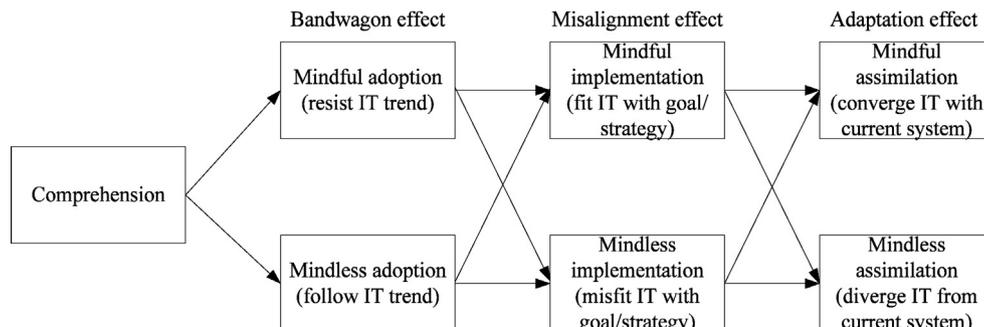


Fig. 1. Effect of innovation with IT.

application case studies. We wished to investigate whether mindfulness played a role in RFID adoption and implementation. We also conducted a case content analysis to verify the effects of mindlessness in the IT innovation process.

4.1. Sampling

We selected six cases from prior academic papers. The cases covered different industries and SC parties, along with multiple information sources.

For our secondary content analysis, we selected cases with real-life RFID applications for SC management. Five well-accepted electronic databases were searched for cases: ABI/INFORM, Academic Search Premier, Emerald Fulltext, Science Direct, and IEEE Xplore. We also searched for material in two prominent and well respected trade magazines: *RFID Journal* and *RFID Update*. The full text of all possible articles (1541) were reviewed to ensure the inclusion of only those matching our criteria. The final sample consisted of 15 studies. Our search of the full text from the news archives of *RFID Update* resulted in 38 articles out of 1311, and that of the *RFID Journal's* "Worldwide RFID Deployment Map" resulted in 44 articles out of 87.

4.2. Analysis

We coded the SC strategy for each case based on its product characteristics and demand uncertainties. Cases were classified as having a *lean* SC strategy when a predictable marketplace was combined with a functional product, and as having an *agile* SC strategy when a volatile marketplace was combined with a fashionable product. We investigated only these two SC strategies, omitting *leagile*, as the secondary cases did not provide sufficient information to identify them; also lean and agile characterize the vast majority of SC strategies [22]. We classified RFID applications according to the SC practices they supported. An RFID application was therefore classified as lean when it affected lean SC practices and agile when it affected agile SC. In the case of an RFID application affecting both lean and agile SC practices, we referred to the designated SC strategy. For instance, we considered an RFID application as agile when it supported both lean and agile SC practices and the SC strategy was deemed to be agile. Furthermore, we classified the cases according to their:

- Product type
- Number of SC parties
- Role in the SC
- Application characteristics

Case study analysis was performed by a panel of three reviewers, one of the authors, a research assistant, and a postgraduate student. All three had extensive knowledge and experience in the SC and logistics field. They first reviewed the cases independently and then consolidated and verified their findings. They thoroughly discussed any discrepancies, with each reviewer explaining how he or she had coded the case. A majority vote was used, except for SC strategies, which had been classified as *leagile*, which were removed from further analysis in the absence of unanimous agreement: nine cases were excluded for this reason.

We expected that many RFID applications followed in the footsteps of the RFID pioneers, which typically employed a lean SC strategy with lean RFID applications [14]. Therefore, if mindlessness existed we should expect to encounter numerous lean RFID applications, regardless of the SC strategy. With respect to the mindless misalignment effect, we expected that the ratio between

lean/agile SC strategies and between lean/agile to differ significantly.

5. In-depth case analysis

5.1. Within-case analysis

Case A: Delen et al. developed a model based on actual RFID data gathered from Wal-Mart (a first mover, implementing the technology across 1400 stores in 2007) to study the "Mean Time Between Movement" [7]. This RFID application involved the placement of RFID tags at the pallet and case level, with items tracked from the time they enter Wal-Mart's distribution centers until the pallets/cases were crushed at retailer outlets. RFID data was collected continuously to improve SC performance and reduce inventory. The authors' test results suggested that RFID can ensure the freshness of perishable products, identify redundant processes, assess SC partners' performance, reduce inventory, and improve business processes.

Case B: Ngai et al. [20] developed an RFID application combined with mobile commerce to better manage a container depot in Hong Kong. Most documented RFID applications concerned large organizations, with very little reported on small and medium sized enterprises. To address this gap, the authors investigated how RFID can aid SMEs.

RFID readers were installed on stackers and RFID tags were placed on each container. This allowed the RFID application to keep track of container movements and automatically allocate empty spaces for incoming containers, rather than relying on instructions from operators over congested communication channels. Workers used wireless handheld devices for navigation to locate customers' requested containers, which substantially reduced the time needed to fulfill the customers' requests. In addition, customers gained the additional benefit of being able to retrieve information on their containers and usage. This RFID application was found to eliminate inefficient operations and improve coordination between employees.

Case C: Gaukler and Hausman [9] investigated how RFID compared with existing systems in the automobile industry based on Volkswagen's experience. The paper offers customizable models, posing obvious difficulties for its manufacturing plants, whose typical setup consisted of a large conveyer belt with employees assembling parts at different stations. The study investigated how RFID can support a mass customization assembly line.

The implementation design of both RFID and existing systems was evaluated to ensure that workers picked and assembled the right parts. RFID tags were placed on the chassis and the parts, with RFID readers installed next to the chassis and bins containing the parts. When a chassis reached a workstation, a screen showed the worker which parts were needed, and the reader on the bin then verified that the correct parts has been picked. Furthermore, a reader near the chassis checked that the correct parts had indeed been assembled on the chassis, thus ensuring that incorrect parts were detected in the early stages and that continuous improvements were realized in the assembly processes. The advantages of RFID over the company's existing solutions included 97% total quality cost savings and \$20.6 million better net value of cost savings over five years.

Case D: Kim et al. showed how a relatively new third party logistics provider (3PL), CJ-GLS, in Korea differentiated itself from its competitors by using RFID [13]. They argued that CJ-GLS employs a blue ocean strategy to differentiate from others, rather than trying to capture market share from its competitors. This application was designed to automate many labor-intensive barcode scanning processes. The company installed readers for

Table 3
Overview of the case studies.

	Case A	Case B	Case C	Case D	Case E	Case F
Firms/industry	Wal-Mart	Container depot	Volkswagen	CJ-GLS	Auto industry	LCD/TFT industry
Strategy	Lean	Lean	Agile	Lean	Agile	Agile
RFID app.	Inventory reduction; continuous improve	Quick setups/orders; customer req.	Continuous improve; quality at source	Quick setups/order Customer req.	Quick setups/orders; customer req.	Inventory reduction; pull approach
SC entities	DC & retail	Internal	Internal	Internal	Suppliers & OEM plant	Entire SC
Benefits	Improve SC analysis; ensure quality	Improve efficiency; additional reports	Reduce cost; improve quality	Improve efficiency; reduce processes	Improve efficiency; accurate time	Reduce inventory
Complex	Readers at DC and retail outlets; tags on cases/pallets	Readers on stackers; tags on containers	Readers on chassis and bin; tags on parts	Readers at several processes; tags on containers	Readers at suppliers & OEM plant; tags on parts	Readers on all SC partners; tags on TFT monitors

the goods stocking, picking, inspecting, and documenting processes, which reduced its original seven business processes to four, thereby improving its order processing time. RFID tags were placed on all goods that the 3PL received; readers were placed at the location of the all processes. The RFID application led to 70% faster stocking, 99.5% faster documenting, and 70% quicker picking/inspecting. In addition, customers obtained more accurate data and reporting on their shipments).

Case E: Mourtzis et al. described how RFID provided visibility to an upstream SC in the automobile industry [18]. They argued that the automobile industry was still largely based on mass production and therefore could not meet current build-to-order requirements. They proposed a system to reduce delivery time by mounting RFID readers and attaching RFID tags to major parts to gather data from upstream SC partners. They also developed a web service to monitor and analyze the parts available in the upstream SC. This allowed dealers to check whether a customer's order was available and to determine a more accurate delivery date. The RFID data also allowed OEM plants to develop more accurate production plans, leading to a reduction in costs and delivery time.

Case F: Wang et al. [30] demonstrated how RFID was used to reduce inventory in a Taiwanese LCD-TFT SC. This industry can be described as a demand-driven supply network, and these are known to be prone to severe information distortion. The study investigated how RFID can alleviate the Bullwhip effect by improving SC visibility. RFID readers were installed at the incoming and outgoing dock gates of all SC partners, and RFID tags were attached to each monitor. The application was designed to monitor the inventory of regional distributors, branch warehouses, and retailers. The resulting inventory transparency greatly reduced the SC inventory and allowed the SC to manage procurement orders better. The results showed that RFID can reduce the total SC inventory by 2.7–6.6% and increase the inventory turnover rate by 6.9–10.8%.

5.2. Cross-case analysis

Of these six cases, three were lean (cases A, B, and D, as they concern functional products in predictable markets, which can be easily substituted) and three were agile SCs (C, E, and F, as their products were highly customizable and demand-driven in volatile markets). A summary of our cross-case analysis is provided in Table 3. It can be seen that there is a strong probability of the bandwagon effect being present, as the majority of cases lean toward lean RFID applications (83%), which only 50% of the cases should be using given their SC strategy. This tendency to adopt lean RFID applications can be explained by the organizations mindlessly following RFID pioneers.

The cases also showed that the ratio between lean and agile SC strategies (50:50) differed significantly from that between lean and agile RFID applications (83:17), which suggested the existence

of a mindless misalignment effect, as various RFID applications were misaligned with the SC strategy (see Fig. 2). The RFID applications of cases A, B, and D were aligned with their SC strategies, but that may be an after-effect of a bandwagon effect; lean SC can mindlessly follow RFID pioneers and coincidentally adopt lean RFID applications, thereby appearing to be mindful during the implementation process. Cases C and F, in contrast, implemented RFID applications that are clearly misaligned with their SC strategies; they implemented lean RFID applications despite having agile SC strategies. Case E clearly illustrates a mindful implementation. Its RFID application was aligned with its agile SC strategy, rather than imitating the RFID pioneers' lean RFID applications.

Unfortunately, we were unable to investigate whether the mindful cases achieved significantly better performance than the mindless cases, as most of the cases failed to quantify the benefits of the application. Further, the unit of analysis differed among the cases. However, resisting the bandwagon and IT/business alignment are both essential for success.

In three of the cases the RFID application was used internally, whereas in the other three it involved other SC partners. Analysis also showed that RFID application complexity to differ across the cases. In some, a few RFID readers were used to replace a manual barcode-reading process (e.g. case C), whereas in others a large number of readers were placed at different locations and IT platforms were developed to facilitate information sharing (e.g. case A). Taking these characteristics into account, we can classify the RFID applications as: automation, assertion, synchronization, and innovation (see Fig. 3).

Automation is the simplest RFID application, allowing automatic capture of item identity. This automates and improves certain processes at the operational level (e.g. barcode scanning). Furthermore, it is usually applied internally and involves a single or a few RFID readers. Case C is an example of this; the organization

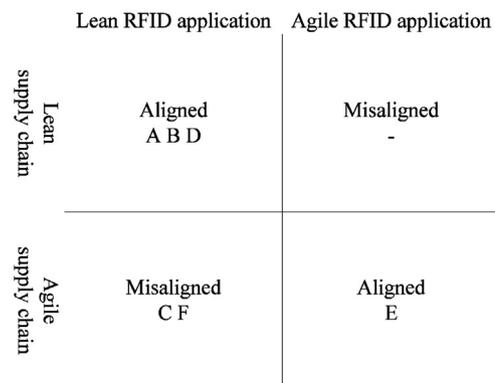


Fig. 2. The IT alignment effect in the six case studies.

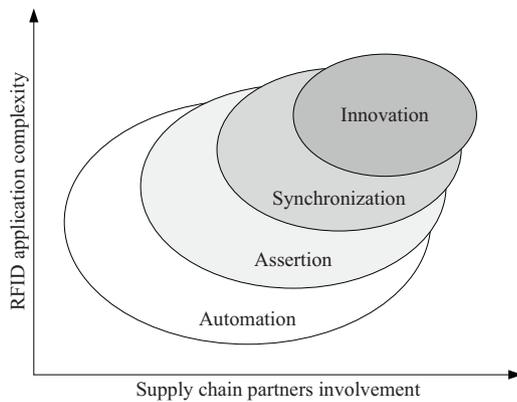


Fig. 3. RFID applications typology.

under study used RFID to increase efficiency and accuracy. *Assertion* allows items to be tracked by associating the item’s identity with its location. Items are typically monitored at several points, and the RFID information is shared among SC partners, providing such tactical benefits as inventory reduction. Cases E and F demonstrate assertion, with the organizations concerned using RFIDs to reduce their inventory, resulting in more efficient SC planning. *Synchronization* involves item tracing by keeping a record of the event time of the RFID readings. RFID information must be gathered from different points and aggregated to provide a holistic view of an item’s whereabouts, requiring the involvement of various SC parties and a platform to aggregate and item data. Cases A and B utilize synchronization to trace and pinpoint the exact movements of items, allowing the organization to manage and correct their SCs to improve SC visibility. *Innovation* occurs when RFID is used to develop a new way of doing business. The degree of RFID complexity is greatest here, as the technology needs to be absorbed in numerous processes to provide a new way of doing business. Moreover, organizations currently compete on SCs rather than just products. We therefore believe that innovation requires close SC partner involvement to succeed. Case D illustrates how seven business processes were reduced to four and how RFID provided additional value-added services to the organization’s customers.

The cross-case analysis offers support for our supposition that many organizations are mindlessly adopting and implementing RFID applications. As six cases may not be sufficient to conclude

that mindlessness exists in RFID applications in general, we analyzed additional RFID application cases.

6. Secondary case content analysis

Eighty-eight RFID applications (15 from academic journals and 82 from trade magazines from 2004 to 2009) were selected for further analysis. A summary of the RFID applications that appeared in academic journals is provided in Table 4, and an overview of those covered in trade magazines is included in the Appendix.

An overview of the RFID mindfulness results can be found in Table 5. The data provides evidence of a bandwagon effect in RFID applications, suggesting mindlessness in the adoption process. The results showed that 86.4% of the cases used RFID to address lean SC practices when only 52.3% had lean SCs. The implication is that the majority of organizations concerned adopted lean RFID applications, although they did not practice lean SC strategies. Apparently many of the cases involved organizations who were simply following RFID pioneers and adopting lean RFID applications.

The McNemar test was used to test the misalignment effect by analyzing whether the ratios between SC strategies (52:48) and RFID applications (86:14) were statistically different. This particular test was chosen over the traditional chi-square test and Fisher’s exact test, as it is a test for paired samples, SC strategy and RFID applications here, and uses a binomial distribution, e.g., lean and agile. This test verifies whether the first row total (lean SC strategies) is equal to the first column total (lean RFID applications), and the same verification is performed for the agile strategies and agile RFID applications. The results showed that firms’ SC strategies differed significantly from their RFID applications: McNemar test, $\chi^2 (1, N = 88) = 23.4, p < 0.01$ with Yates’ continuity correction. Hence, there are an abnormal return number of lean RFID applications, and the misalignment effect does indeed exist.

In addition, the results in Table 5 illustrated that three of the 47 (6.4%) organizations running a lean SC strategy had RFID applications that supported agile practices, indicating mindlessness owing to misalignment in the implementation process. Such mindlessness is even more evident among organizations running an agile SC strategy, as 33 out of the 42 (78.6%) exhibited misalignment effects. The probable cause of this misalignment effect is a prior bandwagon effect in the adoption process. Overall, 40.9% of the 88 cases exhibited misalignment effects on the RFID implementation process.

Table 4 Overview of RFID applications from academic journals.

Case	RFID type	Product	Party	Role	Strategy	Practice
[10]	Automation	Auto parts	>1	Factory	Agile	Continuous improve
[26]	Synchronization	Engineered pipe spools	1	Factory	Agile	Quick setups/order Inventory reduction Rapid development cycles
[29]	Automation	Containers	1	3PL	Lean	Quick setups/orders
[2]	Automation	Medicine	1	Factory	Lean	Quality at source
[5]	Synchronization	Electronic components	>1	3PL	Lean	Enterprise integration Inventory reduction
[8]	Synchronization	Pre-cast comp.	1	Factory	Agile	Pull approach
[11]	Synchronization	Calibrated tools	1	Factory	Agile	Continuous improve
[23]	Synchronization	Semi-conductors	>1	Factory	Agile	Continuous improve
[12]	Synchronization	Automobiles	1	Factory	Agile	Quick orders/setup
[19]	Synchronization	Airplane parts	1	3PL	Lean	Continuous improve Quality at source
[24]	Assertion	Seasonal products	1	Retailer	Agile	Inventory reduction
[28]	Synchronization	Semi-conductors	1	Factory	Agile	Quick setups/orders
[6]	Assertion	Groceries	1	Retailer	Lean	Inventory reduction
[17]	Automation	FMCG	1	3PL	Lean	Continuous improve
[21]	Synchronization	e-dictionaries	1	3PL	Agile	Continuous improve

Table 5
Evidence of bandwagon effect and misalignment effect.

	Lean RFID application	Agile RFID application	Total
Lean strategy	43 ^a	3 ^b	46 (52.3%)
Agile strategy	33 ^{a,b}	9	42 (47.7%)
Total	76 (86.4%) ^a	12 (13.6%)	88 (100%)
McNemar test, $\chi^2(1, N=88)=23.4, p<0.01$			

^a The abnormal number of lean RFID applications indicates that there is a strong probability that organizations are mindlessly adopting such RFID applications, leading to a bandwagon effect.

^b Indicates thoughtless misaligned RFID applications with their respective SC strategies.

Table 6 shows the secondary case content analysis in a chronological order. The data show that RFID applications increased annually between 2004 and 2009. They also show that more than two-thirds of the cases constantly adopted lean RFID applications over the years, whereas the proportion of lean SC strategies was much less than two-thirds. These results suggest the presence of the bandwagon effect in the adoption process over the years, with no strong indication of any decrease in it over time. The misalignment effect was illustrated by the two “misaligned” columns, which showed it to be particularly prominent in agile SCs, a majority of which had implemented lean RFID applications. The data showed that thoughtless RFID applications via IT misalignment began in 2006 and slowly declined from 2007/2008 onwards. The latter observation supports Swanson and Ramiller’s proposition that: “organizations will be more prone to thoughtlessness in [their] early engagement with the innovation and less prone to thoughtlessness the longer [they have] been engaged with the innovation”. The results suggest that organizations have better understood RFID since 2007/2008, with more organizations starting to use the technology mindfully.

Decomposing the cases by SC party types leads to the results presented in Table 7. All three SC party types tend toward lean RFID applications, suggesting the existence of the bandwagon effect. Moreover, the ratios between lean/agile SC strategies and lean/agile RFID applications indicated that the misalignment effect was present for both manufacturers and retailers. Further

investigation for 3PLs shows misalignment to be less evident, but still existent (10.0%), although the ratios are the same. One 3PL with a lean SC strategy implemented an agile RFID application and one with an agile SC strategy implemented a lean RFID application, which evened out the ratios. A possible explanation of mindful implementation among 3PLs is that the mandates of the RFID pioneers were from retailers to suppliers (manufacturers). Therefore, 3PLs have been less affected by institutional pressure from their direct supply chain partners and competitors.

Our proposed RFID typology is able to classify all 88 RFID applications, as shown in Table 8, which suggests that most of these applications are of the synchronization type. Automation RFID applications are mostly used internally, whereas their assertion and synchronization counterparts are more complex and likely to involve SC partners. Unfortunately, we had too little data on innovation to comment on this type. The results show that RFID applications are already being implemented at an inter-organizational level.

The data also suggested that the simpler an RFID application, e.g., automation by one party, the more likely that organizations will be thoughtless in terms of the bandwagon effect, although they can still become mindful in terms of the misalignment effect. The more complex the RFID application, e.g., synchronization with more than one party, the less likely that they will jump on the RFID bandwagon, but also the less likely they are to become mindful in the implementation process (misalignment). The implications is that organizations can afford to be thoughtless in adopting simple RFID applications, as these are often trivial and can bring quick benefits that suit most contexts, whereas complex RFID applications are difficult to imitate. Finally, the data showed that inter-organizational RFID applications were consistently more thoughtless (0.52) in terms of the misalignment effect compared to internal RFID applications (0.37). It is thus likely that inter-organizational decisions have factors affecting thoughtlessness. In addition, group decision-making can lead to compromised solutions that are not ideal or even suitable for all SC partners.

Overall, the secondary case data confirms that organizations are thoughtlessly using RFID applications. Our analysis suggests that the number of RFID applications has increased every year and bandwagon and misalignment effects are still persistent.

Table 6
Bandwagon effect and misalignment effect throughout 2003–2009 period.

	Lean SC strategy			Agile SC strategy			
	Lean RFID	Agile RFID	Misaligned	Lean RFID	Agile RFID	Misaligned	Total lean RFID
2004	2	0	0.0%	0	1	0.0%	66.7%
2005	2	0	0.0%	0	0	0.0%	100.0%
2006	5	2	28.6%	4	1	80.0%	75.0%
2007	6	1	14.3%	9	1	90.0%	88.2%
2008	7	0	0.0%	10	2	83.3%	89.5%
2009	21	0	0.0%	10	4	71.4%	88.6%
Total	44	3	6.4%	33	9	78.6%	89.0%

Table 7
Mindlessness effects by supply chain party.

	Manufacturer			3PL			Retailer		
	Lean RFID	Agile RFID	Total	Lean RFID	Agile RFID	Total	Lean RFID	Agile RFID	Total
Lean SC strategy	16	1	17 (41.4%)	17	1	18 (90.0%)	10	1	11 (40.7%)
Agile SC strategy	22	2	24 (58.6%)	1	1	2 (10.0%)	10	6	16 (59.3%)
Total	38 (92.7%)	3 (7.3%)	41 (100.0%)	18 (90.0%)	2 (10.0%)	20 (100.0%)	20 (74.1%)	7 (25.9%)	27 (100.0%)

Table 8
Mindlessness effects by RFID application type and partner involvement.

RFID type	Partners								
	Cases			Bandwagon effect			Misalignment effect		
	1	>1	Sum	1	>1	Avg.	>1	>1	Avg.
Automation	11	2	13	1.00	1.00	1.00	0.09	0.50	0.15
Assertion	18	9	27	0.94	0.89	0.93	0.28	0.44	0.33
Synchronization	33	13	46	0.82	0.85	0.83	0.49	0.62	0.52
Innovation	1	1	2	0.00	0.00	0.00	1.00	0.00	0.50
Total	63	25	88	0.87	0.84	0.86	0.37	0.52	0.41

Table 9
Guidelines for mindful innovation with RFID.

Process	Description
Comprehension	Investigate existing RFID applications
Adoption	Avoid blindly following what others are doing Identify which existing RFID applications match your organization
Implementation	Determine a suitable and feasible RFID application type Match the RFID application with your SC strategy
Assimilation	Blend the RFID application with your work-life Evaluate and adjust the RFID application/work-life when necessary

7. Discussion and recommendations

We investigated why RFID applications have not been widely implemented despite initial high expectations. Our results suggested that the technology's disappointing outcomes and slow diffusion were the result of incorrect implementations. We developed a model to identify and articulate the mindfulness effects of IT innovation. A detailed overview of current RFID applications suggested that many organizations adopt RFID applications to improve typically lean SC practices, disregarding their SC strategies. This further suggested that many were following RFID pioneers that have adopted RFID applications to address typically lean SC practices. Moreover, the ratio between lean/agile SC strategies and lean/agile RFID applications differed significantly, suggesting a misalignment effect between the SC strategies and RFID applications. These two mindlessness effects explain why the potential benefits of RFID remain elusive, as the literature suggests that mindful IT innovations reap significantly greater benefits.

Our study provided insights into how and why mindlessness occurs, leading to less than satisfactory returns. We also proposed guidelines based on our model of the effects of mindlessness on IT innovation for organizations to follow throughout the IT innovation process to more mindfully adopt RFID (see Table 9). Organizations must first understand themselves before following the guidelines, i.e., be aware of their SC strategy, as it is a prerequisite for the mindful identification or design of an RFID application that suits organizational needs.

First, in the comprehension process, we recommend that organizations evaluate the RFID applications available on the market and determine how their peers are using them. Organizations are starting to have a better understanding of the technology, and more useful references can be taken from others.

Second, in the adoption process, we recommend that organizations carefully consider whether the RFID application in question fits their needs. This phase is particularly important when the aim is to develop a complex RFID application, which often results in mindless RFID implementation. Although organizations may be able to follow others and still have mindful RFID implementation in simple RFID applications, their needs must be carefully taken into account. This is especially true for manufacturers and retailers, who are inclined to follow RFID pioneers.

Third, in the implementation process, we recommend that organizations analyze the RFID application type that is suitable and feasible, in terms of complexity, SC partner involvement, and whether any changes will be needed. Operational changes can be satisfied with automation, usually implemented internally. This can improve the efficiency of manual processes. Tactical changes require assertion or synchronization, which require more resources and usually involve other SC partners. These two types can reduce assets/inventory and improve SC visibility. Strategic changes require innovation, the most resource-intensive RFID type which often requires collaborative initiatives with SC partners. The SC strategy can be determined by analyzing the organization's product characteristics and the market environment. Particular care is needed when the organization is mindless in the adoption phase, as this often leads to mindless RFID implementation.

Finally, in the assimilation process, we recommend that organizations carefully blend the RFID application with their work-life or vice versa. Even when the RFID application is blended with the organization's work-life, the organization must remain resilient and take corrective actions when necessary.

We used secondary cases in our study; these did not allow us to investigate the comprehension and assimilation processes. In addition the secondary cases also failed to quantify the benefits of RFID. Another limitation is that the academic journals and trade magazines we consulted reported no failures. Such cases would provide further insights into why mindlessness occurs in RFID applications and allow more thorough analysis of the critical factors involved in successful RFID applications. Inter-organizational cooperation is becoming increasingly important in the world economy, as competitive advantage is usually gained with SC integration.

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Appendix

Case	RFID type	Product/industry	Party	Role	Strategy	Practice
2004						
Metro Group	Assertion	FMCG	>1	Retailer	Lean	Inventory reduction Cust. req. sat.
UPS	Automation	3PL	1	3PL	Lean	Quick setups/orders
M&S	Synchronization	Garments	>1	Retailer	Agile	Cust. req. sat.
2005						
Wal-Mart	Assertion	FMCG	>1	Retailer	Lean	Inventory reduction Continuous improve Cust. req. sat.
Tesco	Assertion	FMCG	>1	Retailer	Lean	Continuous improve
2006						
Mondi Group	Assertion	Paper	1	Factory	Lean	Inventory reduction Continuous improve
Starbucks	Synchronization	F&B	1	Retailer	Leagile	Quality at source
Gillette	Assertion	Razors	>1	Factory	Leagile	Continuous improve
Nissan	Synchronization	Automobiles	1	Factory	Agile	Quick setups/orders Continuous improve
Metro	Synchronization	FMCG	>1	Retailer	Lean	Quick setups/orders Inventory reduction
BGN	Assertion	Books	1	Retailer	Lean	Quick setups/orders Continuous improve Cust. req. sat.
Chep	Assertion	Books	1	3PL	Lean	Cust. req. sat.
Jobstl	Synchronization	Containers	1	3PL	Lean	Quick setups/orders
Honda	Synchronization	Automobiles	>1	Factory	Agile	Close supplier rel.
P&G	Assertion	FMCG	>1	Factory	Lean	Cust. req. sat.
Roex	Synchronization	Nutrition	1	Factory	Lean	Quality at source Continuous improve
2007						
Daisy Brand	Synchronization	Dairy products	>1	Factory	Lean	Quick setups/order Continuous improve
Martori Farms	Assertion	Perishable products	>1	3PL	Lean	Continuous improve
Safeway	Synchronization	FMCG	>1	Retailer	Lean	Cust. req. sat.
Sam's Club	Assertion	FMCG	1	Retailer	Lean	Continuous improve
Kimberley Clark	Assertion	FMCG	>1	Factory	Leagile	Cust. req. sat.
NP Collection	Synchronization	Garments	>1	Retailer	Agile	Quality at source Quick setups/orders Cust. req. sat.
Metro Group	Synchronization	Garments	>1	Retailer	Agile	Quick setups/orders
Lemmi Fashion	Synchronization	Garments	>1	Factory	Agile	Quick setups/orders Continuous improve
Throttle Man	Synchronization	Garments	>1	Retailer	Agile	Quick setups/orders
Griva	Synchronization	Textiles	1	Factory	Agile	Continuous improve
Thyssenkrup	Automation	Steel slabs	1	Factory	Lean	Quick setups/orders Continuous improve
Toshiba	Synchronization	Notebooks	1	Factory	Agile	Quick setups/orders
Sony	Synchronization	Electronics	1	Factory	Agile	Quality at source
Shaw Ind.	Synchronization	Carpets	>1	Factory	Leagile	Cust. req. sat.
2008						
American Apparel	Synchronization	Garments	1	Retailer	Agile	Cust. req. sat.
Continental	Synchronization	Auto parts	1	Factory	Agile	Continuous improve
Eastpack	Synchronization	Packaging	1	3PL	Lean	Continuous improve
Custom Cupboards	Synchronization	Cupboards	1	Factory	Agile	Continuous improve
Staples	Synchronization	FMCG	1	Retailer	Lean	Continuous improve
Walgreens	Synchronization	Healthcare products	1	Retailer	Lean	Quality at source Continuous improve
LCWaikiki	Assertion	Garments	1	Factory	Agile	Continuous improve
Sonicwall	Synchronization	Computer equipment	>1	Factory	Agile	Inventory reduction Quick setups/orders Close supplier rel.
Automaker	Synchronization	Automobiles	1	Factory	Agile	Quality at source
Boboli	Assertion	Garments	1	Factory	Agile	Quick setups/orders
Metro Group	Automation	Fresh meat	1	Retailer	Lean	Quality at source Continuous improve
Gelal	Automation	Socks	1	Factory	Lean	Quick setups/orders Continuous improve
Land Rover	Assertion	Automobiles	>1	Factory	Lean	Continuous improve Close supplier rel.
Diakinisis	Synchronization	Pallets	1	3PL	Lean	Continuous improve Quick setups/orders
Byblos Amoreiras	Synchronization	CDs	1	Retailer	Lean	Cust. req. sat.
2009						
A.S. Shipping	Synchronization	Containers	1	3PL	Lean	Cust. req. sat.
Aston Martin	Synchronization	Automobiles	1	Factory	Agile	Quality at source Cust. driven inno.

Appendix (Continued)

Case	RFID type	Product/industry	Party	Role	Strategy	Practice
Bhima & Bro	Assertion	Jewelry	1	Retailer	Agile	Cust. req. sat.
Bionest	Synchronization	Strawberries	>1	3PL	Lean	Quality at source
BMW	Synchronization	Automobiles	1	Factory	Agile	Continuous improve
Bosch	Assertion	Auto parts	1	Factory	Lean	Quick setups/orders Pull Approach Continuous improve
Caterpillar	Synchronization	Hydraulics	1	Factory	Lean	Quality at source
Charles Vögele	Assertion	Garments	>1	Retailer	Agile	Inventory reduction
Cimko Cement	Automation	Cement	1	Factory	Lean	Continuous improve
Color Point	Automation	Gardening	1	3PL	Lean	Continuous improve
Coscon	Synchronization	Containers	1	3PL	Lean	Cust. req. sat.
DP World	Automation	Trucks	1	3PL	Lean	Quick setups/orders
DFS	Innovation	Garments	>1	Retailer	Agile	Cust. req. sat.
Eren Holding	Assertion	Garments	>1	Retailer	Agile	Quick setups/orders
GKB Lenses	Synchronization	Lenses	1	Factory	Leagile	Quality at source Continuous improve
H&M Bay	Synchronization	Cold storage	1	3PL	Lean	Quick setups/orders
Marigold	Assertion	Gloves	1	Factory	Lean	Quick setups
Metal Finishing	Synchronization	Metal products	1	Factory	Agile	Cust. req. sat.
Metro Group	Automation	FMCG	>1	Retailer	Lean	Continuous improve
Muller Martini	Assertion	Book bindings	>1	Factory	Lean	Continuous improve
New Belgium Brewing	Assertion	Beer	1	Factory	Lean	Inventory reduction
Ortrander Eissenhutte	Synchronization	Iron foundry	1	Factory	Lean	Quick setups/orders Continuous improve
Osram Sylvania	Synchronization	Light bulbs	1	Factory	Lean	Quick setups/orders
PLS	Assertion	Pallets	1	3PL	Lean	Inventory reduction
Plandent	Assertion	Oral hygiene products	1	3PL	Leagile	Cus. req. sat. Quick setups/orders
Rewe Group	Assertion	FMCG	1	Retailer	Lean	Continuous improve
Ringnes	Assertion	Beverages	1	3PL	Lean	Quick setups/orders
Sole	Assertion	Footwear	>1	Retailer	Agile	Continuous improve
Southeastern Containers	Synchronization	Containers	1	Factory	Lean	Quality at source Continuous improve
Toyota	Assertion	Auto parts	1	Factory	Agile	Continuous improve
Tan Chong	Synchronization	Automobiles	1	3PL	Agile	Quick setups/orders Cus. req. sat.
Telstra	Synchronization	Mobile phones	>1	Retailer	Agile	Inventory reduction Quick setups/orders
Thermo King	Assertion	Air conditioners	1	Factory	Leagile	Pull approach Inventory reduction
Vasep	Synchronization	Seafood	>1	3PL	Leagile	Quality at source
Volkswagen	Assertion	Automobiles	1	Factory	Agile	Continuous improve
ZF Friedrich Schafen	Automation	Auto parts	1	Factory	Agile	Quick setups/orders Continuous improve
Hansgrohe	Automation	Sanitary ware	>1	Factory	Leagile	Pull approach

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