An empirical reflection on the needs for and consequences of operational and technical integration with ERP projects

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Abstract

This research article is set against the background of Enterprise Resource Planning (ERP) as a solution to address operational and technical integration to support daily operations. It aims at characterising ERP projects by their reasons for initiation in particular considering integration criteria and at highlighting connecting implementation consequences based on an empirical survey. In particular, the importance of ERP to solve operational and business integration related problems has increased over time, the catalogue of expectations has expanded and the business related criteria of ERP do not solely dominate initiation of ERP projects. In overall, integration projects were able to meet organisational expectations especially in terms of an integrated flow and a better quality of information. The ERP integration projects were overrepresented in organisational clusters with relatively higher ERP adoption success rates. However, business seeking to integrate with ERP do not believe as much in ERP to provide a competitive edge as compared to other ERP adopters, they also regularly produce unexpected integration issues in the implementation phase and face prolonged performance problems in the operational stage that are not solved over time. New ERP developments in particular in the area of Business Intelligence or Application Integration should further promote ERP solutions as integration drivers.

Key words: Enterprise resource planning, integration, enterprise application integration, empirical survey.

1.   Introduction

Current enterprises' IT infrastructures are facing internal and external IT integration problems [1] [2] and growing e-Business demands further increases the importance of digitally integrated business models, in particular the significance of technical integration [3]. Enterprise resource planning (ERP) systems address operational and technical integration to support daily operations. They constitute comprehensive packaged information systems (IS) comprising several configurable modules that integrate core business activities into one single environment based on an integrated, shared database [4, 5].   ERP adoption is realized by implementing the complex multi-module information system (IS), respectively ERP system, that assists managing the business including the main areas finance, human resources, and manufacturing and logistics. Consequently, the organization achieves an integration of business processes across business units and also a technical integration through the involved ERP system. Often companies replace legacy systems, thereby harmonising their application portfolio. More or less as a side effect, technical integration problems are expected to be reduced. This is one perception on ERP in terms of integration. However, another perception shows that ERP may increase IS integration demands, in particular in terms of so called support ERP projects. If organisations prefer custom built software in their key competence area (primary business functions) and look for standardised, packaged (ERP) software in their support processes only, they increase their need for technical and business functional integration. An example shows [6] that these projects create many interfaces that need to be engaged with so-called glue software code, an known integration and IT related problem domain. They can still be successful and meet business requirements. Depending on the business situation and on the maturity as well as functional depth of ERP solutions, ERP is not able to cover certain business requirements. Consequently, they needed to be met through other means that increase the need for integration, e.g. by third-party applications, custom software developments, or by extending the lifecycle of legacy applications.

This research article views ERP projects as being characterised by their adoption driver and reasons for initiation. It develops an initiation topology based on empirical findings. It connects the topology with business impact in particular regarding integration topics. While ERP is seen as one solution to integrate, with the historic objective to integrate business functions, it remains unclear if this still holds to be true in current business settings. Recent work places ERP and Enterprise Application Integration in context [2, 7] and states that ERP does not go far enough for current integration needs. In this article we focus on ERP projects initiated due to internal and external integration demands

(i) by analysing their historic development, and

(ii) by exploring their ERP related and firm related impact.

With respect to research question (i), we hypothesized that the importance of ERP as one of the many available approaches to solve technical and business integration related problems increases over time, despite the continuous evolvement of distinctive Enterprise (Application) Integration (EAI) products. Regarding question (ii), the impact of ERP integration projects defined by the developed topology in his paper is investigated.

2. Methodology

This paper draws on an industry independent empirical survey that was undertaken in the years 2003 to 2004 with Austrian small-to-medium scale enterprises (SMEs) as well as large scale enterprises (LEs) as target groups. To avoid under representing the large enterprises in the sample, a stratified and disproportional sample with subgroups according to company size was defined. One thousand Austrian SMEs and LEs were randomly selected from firms listed in a comprehensive, pan-European database containing financial information on 7 million public and private companies in 38 European countries [8].

The questionnaire was guided by descriptive and analytical research goals in particular concentrating on ERP success. The questions were developed based on a previously undertaken ERP related study (reference suppressed), on a review of the literature, and on recommendations of a panel of ERP experts from two universities in Austria and the UK. Following an empirical design method, the panel was asked to critique the questionnaire for content validity [9]. According to their suggestions, the questionnaire was revised and used in Pre-Tests applied in the UK and Austria. Responses were examined to optimize the formulation of each question and ensure consistency in the way they were answered. The questionnaire contained a general section assessing the background information on the company especially IT/IS related and performance related questions. The assessed topics were structured in four sections following the ERP system lifecycle: adoption decision, acquisition, implementation, use and maintenance. Companies were contacted through a multi-staged procedure. Finally, 209 valid returns were registered, resulting in an above average response rate of 22%. Some companies could not be contacted, because they had ceased to exist, the address was wrong or could not be found, etc. These neutral dropouts (49 companies) were considered in the calculation of the response rate and therefore did not decrease the return quota. To test for non-response bias, known distributions of three variables available through the used corporate database (legal form, number of employees, number of subsidiaries) were assessed. The analysis revealed no significant different characteristics between non-respondents and respondents in terms of all three aspects as measured by chi-square ($\chi 2$) and two-sample unpaired t tests. The data was analyzed using a statistical package offering the ability to work on complex samples. It should be noted that in practice, most scientific papers utilize the default significance tests generated by software packages based on the assumption of simple random sampling even if multi-stage, cluster, or other complex sampling designs were employed [10-12]. To avoid biased estimates, this work uses a SPSS module called Complex Samples where adjusted tests including chi-square ($\chi 2$) are provided. However, since the range of procedures is limited, analysis was also conducted with the use of sampling weights [13].

3. Classification of ERP projects

3.1 Support and primary ERP projects

ERP projects can be motivated as primary ERP purchases, which are targeted at the primary activities of organisations covering the four functions: research and development, production, marketing and sales, and services [14]. Primary ERP purchases include materials Management (purchasing and inventory Management), production and operations, and sales/distribution modules. There are also ERP acquisitions motivated as support ERP purchases only, which provide inputs that should allow the primary activities to take place [14]. They involve Human resources and/or financial/accounting modules.

3.2 ERP projects by initiation driver

Another way to classify ERP projects would be to focus on their rationale since the adoption initiation is strongly influenced by the expected benefits of an implemented ERP system in the organisation [15]. In general, the recognition of a need or perceived opportunity of ERP initiates the adoption process. It seems important to classify the type of need or opportunity, which can have strong implications on the further stages of the project. As [15] remark, an ERP adoption initiated for mainly technological reasons may configure ERP as a technology-driven project.

Relating to the empirical survey, business management was allowed to mention multiple reasons for initiating their ERP projects. Among SMEs, lowering costs of operations was most frequently mentioned, followed by operational problems due to multiple systems, interfaces and databases. The latter was the most important adoption driver for LEs. This situation demonstrates that many enterprises are turning towards ERP as a means to solve the enterprise application integration (EAI) problems. While both adoption drivers were regarded as most important to both SMEs, and LEs, the frequency differences were nevertheless most pronounced and also marginal significant in contrast to the other assessed adoption drivers.

Table 1   ERP adoption driver

Category		Adoption reason	All (%)	SMEs (%)	LEs (%)	p (χ2)
Internal integration	Int1	Operational problems due to multiple systems, interfaces, and databases	43.9	40.1	59.5	.06
	Int2	Multiple vendors of legacy systems resulting in too high software licensing and maintenance costs	13.7	14.4	10.6	-
External Integration	Ext	Pressure from the value chain (from business customers or partners)	30.7	31.9	25.4	-
Technical	Tec1	Low reliability of legacy system	36.9	38.8	29.3	-
	Tec2	Technical limitation of legacy system	24.8	21.0	33.8	-
Business	Bus1	Lowering costs of operations (higher efficiencies)	52.2	55.5	38.4	.08
	Bus2	Strategic reasons (enhanced decision making, support of management style, etc.)	29.0	28.8	30.2	-
	Bus3	Missing functionality	30.7	25.8	36.9	-
Enforced	Enf	Guidelines from a controlling company	26.6	26.9	25.7	-
Other	Oth	Other	5.0	3.6	10.6	.09

Their answers were clustered in the categories of Table 1 and 2 in particular comprising external and internal integration driver, technical driver, and business driver. Due to possible multiple selections a company may be classified into several groups. The resulting distribution is denoted in Table 2.

Table 2   Classification by project initiation (multiple selections allowed)

No.	Initiation	Percentage
1	Integration (Int. & Ext.)	75.7
1a	Internal Integration	48.4
1b	External Integration	30.7
2	Technical	54.8
3	Business	73.6
4	Enforced	26.6
5	Other	5.0

3.3 ERP projects by impact

This section develops an empirical classification of ERP projects in terms of organisational impact based on analyzing the ratings on 16 attributes given by managers concerning the impact of ERP, i.e. the organisational changes observed after having implemented ERP (see Table 2). The objective was to segment enterprises into groups with similar perceptions of ERP impact. Once identified, this research steps forward to analyze possible relationships between these groups and the typology of ERP projects defined in the previous section. The first primary concern was that these 16 variables used to form the clusters are adequate in scope and detail. Given that the set of variables is metric, Euclidean distance is chosen as the similarity measure. A standardization of variables was not necessary since all are on the same scale, and within-case standardization was not appropriate because the magnitude of the perceptions is an important element of the segmentation objectives.

Table 3   Organisational impact measures of ERP

Id	Name
X_1	Overall IT/IS costs
X_2	Efficiency/Profitability
X_3	Effectiveness/Productivity
X_4	Revenue after switching to ERP
X_5	Profit after switching to ERP
X_6	Transactions (deliveries,...) finished on schedule
X_7	Availability of IT/IS services
X_8	Problems with order processing or management
X_9	Problems with warehouse processes
X_{10}	Problems with standard reports
X_{11}	Problems with reports on demand
X_{12}	Average time to upgrade the system
X_{13}	Communication with supplier
X_{14}	Financial close cycle
X_{15}	Training hours per user
X_{16}	Training hours per developer

Cluster analysis provided a two cluster solution   (2CS) and a three cluster solution (3CS) (see Figure 2a and 2b). Both correlate significantly (Spearman-Rho .718, Sig. 000). It can be seen that the final cluster centres relating to 2CS with respect to the analysed variables (X1 to X16) are in general greater in Cluster 2 as compared with Cluster 1. Since large ratings are considered as positive impacts, Cluster 2 comprises in general organisations with a more favourable ERP impact. The same logic applies to the 3CS solution, where organisations in Cluster 3 have achieved a better outcome as compared to organisations in Cluster 2, which in turn outperform firms in Cluster 1. In terms of two variables (X4 and X5) this interpretation does not apply, they lie approximately on the same level in the mean for all subgroups. They reflect firm level financial impact (revenue and profit), which is often difficult to statistically connect with ERP installations.
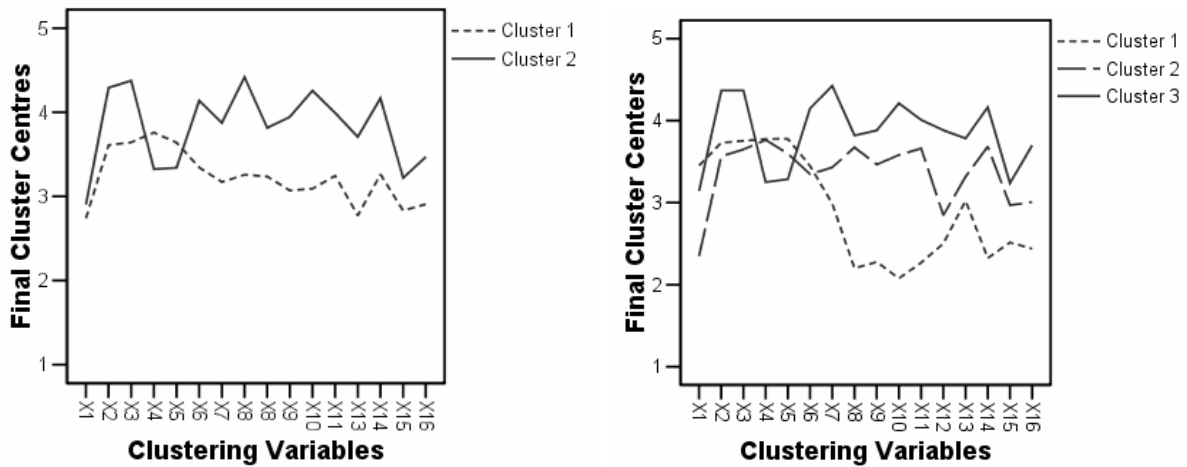
Figure 1a/b   Cluster solutions (2CS, 3CS) according to organizational impact

4.   Research questions

4.1 Sample demographics

Following a commission recommendation of the European Communities concerning the definition of micro, small and medium-sized enterprises [16], this research classified as SME an enterprises which employs fewer than 250 persons and which has an annual turnover not exceeding EUR 50 million. Table 4 denotes the firm size and branch distribution of the data sample. The branch classification was based on the core codes given in brackets of the North American Industry Classification System (NAICS) which has replaced the U.S. Standard Industrial Classification (SIC) system in 1997 [17].

Table 4   Firm size and branch distribution

Size	No. of companies (rel. in %)	No. of companies (abs. unweighted N)
SMEs	92.8	129
LEs	7.2	79
Total	100	208
Branch		
Trade (42,44-45)	22.6	58
Manufacturing (31-33)	21.0	60
Construction (23)	20.5	20
Services (54)	15.7	30
Transportation and Warehousing (48-49)	7.6	8
Information (51)	4.5	8
Health Care and Social Assistance (62)	1.9	4
Management of Companies and Enterprises (55)	1.4	8
Other	4.8	12
Total	100	208

The observed distribution of management structure is given in Table 5. The traditional functional management structure was observed in 64.7% of the cases followed by the project/team structures in 16.1% of the enterprises.

Table 5. Management structures

Management structure	Rel. in %
Functional	64.7
Divisional	5.1
Geographic	1.0
Project/Team oriented	16.1
Matrix	7.6
Network (core and periphery)	0.8
Virtual	0.0
Other	4.7

4.2 Historic development (Q1)

In a historical context, ERP can be seen as the evolution of manufacturing requirements planning (MRP). ERP has expanded from the coordination of manufacturing processes to enterprise-wide business processes integrating activities across functional departments. The ERP market leader SAP released in 1979 their R/2 software system for mainframes and in 1992 their R/3 client/server based software system. While SAP continued to grow rapidly already in the 80ies, the wide diffusion of ERP systems developed during the next century, the 90ies. The following figures 1a and 1b show the time dependent level of ERP projects. Figure 1a captures ERP adoption initiated due to integration, and internal as well as external integration demands separately. As can be seen, external integration has become more important over time as compared to internal integration. In overall, integration demands have become more important over time. The early year 1988 can be seen as an outlier due to the minor number of observations. Figure 1b provides information on the distribution of ERP projects over time considering besides integration also the technology and business projects. As figure 1b shows, all three types of ERP projects have became nearly equally important. In a historic view, integration and technical ERP projects have developed from lower diffusion levels in the 90ies. Currently, ERP integration projects have taken the lead and have overtaken the business related ERP projects.
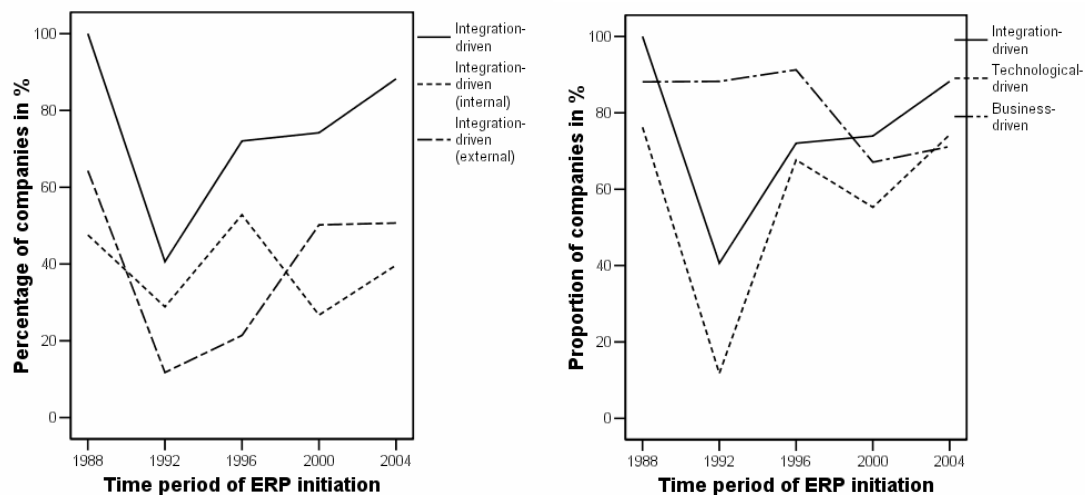

Figure 2a/b   Development of ERP projects over time

4.3 Integration and ERP impact (Q2)

Expectations according to decision making criteria

Managers were asked to assess the level of satisfaction considering pre-selected criteria related to integration issues on a scale between 1 (expectation fell short) and 5 (expectation were exceeded). The value of ERP is demonstrated in terms of an integrated flow and a better quality of information, as can be seen in Figure 3. In particular the external integration projects have surpassed the expectation on information transparency on a high level.   The value of ERP

considering the system's interoperability, connectivity (e.g. for Intra/Extranet or mobile devices) as well as its value as an enabling technology for other applications such as CRM or SCM were according to expectations (lying around the level 3). However, the ERP system's role as an E-Business enabler was expected to be more pronounced.   In general, ERP is being viewed as the backbone for important extensions such as CRM or SCM. This statement is supported by 95% of the companies across all types of ERP projects.
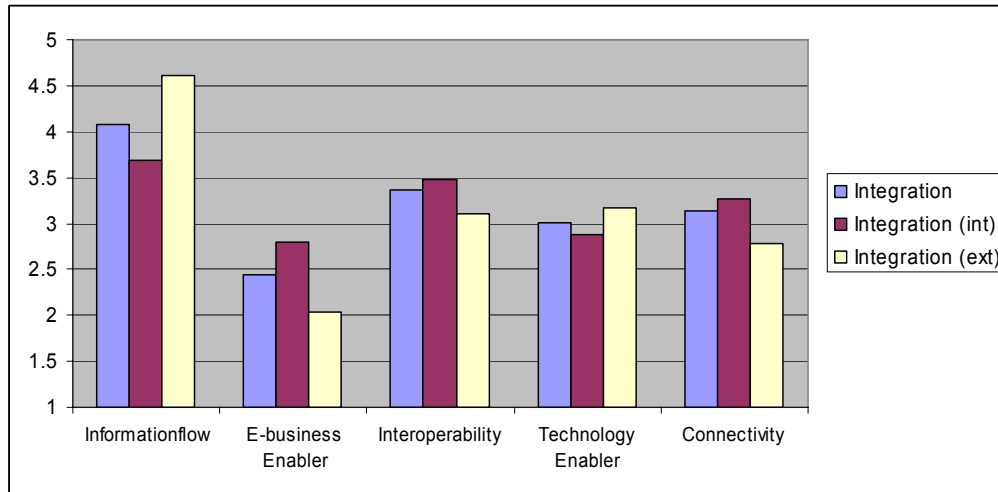

Figure 3 Expectation rates according to Integration related selection criteria

Connection with impact clusters

Table 2 denotes the relationship between the project initiation topology and the impact clusters regarding both solutions (2Cs, 3CS). The data showed, that the integration projects were significantly distributed differently into the cluster solution as expected per chance. The majority of integration projects were assigned to higher level clusters representing more favourable outcomes. Thus, with the exception of financial impact (firm level revenue and profits), all other aspects were seen to be realised relatively better in integration projects. Additionally the data table reveals that enforced projects are distinctively and significantly overrepresented in the C1 group of the Three-Cluster-Solution. Hence, enforced ERP projects (by a controlling company) are often connected with undesirable ERP project outcomes.

Table 6   Project initiation and Impact clusters

No.	Class	Two-Cluster Solution (2CS)		Three-Cluster Solution (3CS)			Significance (Chi-2)	
		C1	C2	C1	C2	C3	2CS	3CS
1	Integration	25.2	74.8	8.4	29.4	62.2	.000	.003
2	Technical	74.7	25.3	27.9	53.2	19.0	.743	.800
3	Business	81.0	19.0	13.5	71.6	14.9	.169	.113
4	Enforced	75.5	24.5	55.5	20.0	24.5	.569	.000
5	Other	70.7	29.3	8.9	61.1	30.0	.967	.351
	ALL	70.3	29.7	20.6	52.8	26.6		

Connection with implementation issues

Companies that seek to integrate with ERP, also experience greater difficulties integrating the ERP system with legacy applications. During implementation in 22.4% of the integration driven ERP projects unexpected problems were encountered in terms of ERP integration with legacy systems. This compares to a rate of only 10% of the cases for all other projects. No other significant connections with implementation issues were found.

Connection with other success metrics

An often mentioned short term effect of large scale software introductions is a decline in process efficiencies,

respectively organisational performance. This was confirmed by data analysis (see Table 7). The results for integration projects is twofold. First, they achieve to be more successful in the short run (no noticed performance lag in 36% of the cases), but less successful in the long run (no recovery in 11% of the cases).

Table 7. Decline in organisational performance after switching to ERP

Decline in organisational performance		Size		Integration / Non Integration	
(in %)	All	SMEs	LEs	Integration	Other
not noticed	30.7	25.1	52.2	35.9	17
experienced over a short period of time	60.6	69.3	26.8	52.9	79.9
experienced over a long period of time	8.3	5.6	18.8	11.2	1.6
experienced and not recovered	.5	.0	2.2	0	1.6

Finally, the question whether ERP is aiding to the organisation to gain a competitive edge was answered with yes by 83.1% of all enterprises. In terms of integrators, the rate is 77,9% compared to 95,7% of all other projects. This states that ERP integration projects do not believe as much in ERP to provide a competitive edge as compared to the others ($\chi2$, p=.01).

5. Conclusions

In general, it is known that operational and technical integration is a highly complex task, associated with high costs and risks, but also with great potentials. ERP can be seen as one solution that addresses integration to support daily operations. This research has shown that historically seen, the majority of ERP projects were initiated due to business related adoption drivers. Beginning in 1992, the reasons for project initiation were influenced more and more by technical and integration related considerations while business reasons have only declined a little. At the present time, it seems that ERP projects do not only need to comprise Business-driven adoption aspects. The ERP concept and the underlying IS should more than equally satisfy technical and integration related problem areas. In particular, the importance of ERP to solve operational and business integration related problems has increased over time (thereby supporting the hypothesis related to research question 1). Consequently, the catalogue of expectations has expanded and the business aspect of ERP does not dominate ERP projects any longer.

This research article viewed ERP projects as being characterised by their adoption drivers and reasons for initiation. It developed an initiation topology based on empirical findings and connected the topology with business impact in particular regarding integration topics. In overall, integration projects were able to meet expectations in terms of decision making attributes reflecting integration aspects with one exception. E-business functionality was not implemented satisfactory in particular concerning organisations that needed external integration. Other aspects comprising the system's interoperability, connectivity (e.g. for Intra/Extranet or mobile devices), and enabler for other applications such as CRM or SCM were around or above targeted expectation levels. One aspect covering integrated flow and a better quality of information was achieved by ERP on a level distinctly surpassing the given expectations. The ERP integration projects are overrepresented in the impact clusters comprising organisations with a more favourable ERP outcome in terms of both defined cluster solutions. On the other hand, ERP integrators do not believe as much in ERP to provide a competitive edge as compared to the others. Furthermore, firms that seek to integrate with ERP face unexpected problems when connecting the ERP solution with remaining other (legacy) applications. They also face the problem of not being able to recover from a operational performance dip after switching to ERP more often than this is the case for the groups of all companies and the companies that not (explicitly) seek to integrate with ERP. This research shows that ERP implementations are often targeted to solve integration problems. However, they also regularly produce unexpected integration problems in the implementation phase and prolonged performance problems in the operational stage that are not solved over time.

Future research will consider that the need for integration is not solved entirely with traditional ERP solutions. It can be addressed by a newer approaches to system integration, e.g. from the fields of Business Intelligence or Enterprise Application Integration (EAI), as well as by new ERP developments in particular addressing both examples given. The EAI approach involves linking existing computer software applications to support and streamline business processes [2]. These days ERP providers have extended their solutions by incorporating frameworks for the exchange of information among various entities internal and external to a company, e.g. the integration server functionality supplied by the market leader SAP. By facilitating interaction between diverse operating systems and applications in their ERP products, providers are incorporating EAI ideas. Thus, the utility of ERP in terms of organisational integration in particular

beyond internal business processes constantly increases with the improvement and extension of ERP packages, i.e. ERP in its classic boundary may soon cease to exist.

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