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ERP architectures in transformation: integration, data quality, and standardization in the modernization of enterprise systems.

ERP architectures in transformation: integration, data quality, and standardization in enterprise system modernization

Transforming ERP architectures: integration, data quality and standardization in the modernization of business systems

Fabiano Aparecido Sandaniel

Computer Science Technologist. Information Technology professional with experience in systems analysis, IT management, SAP implementation and project management.

SUMMARY

The modernization of Enterprise Resource Planning (ERP) systems occurs in environments characterized by dependencies between legacy applications, master data, integrations, organizational processes, and continuity requirements. This article analyzes the modernization of ERP architectures in four interdependent dimensions: integration, data quality, standardization, and evolution towards cloud or hybrid models. A structured narrative review of peer-reviewed scientific and technical literature is adopted, combining classic studies on integration and data quality with research on upgrades and cloud ERP. The analysis shows that modernization is not equivalent to replacing a software version: it requires decisions about the boundaries of the transactional core, the handling of customizations, interfaces, migration, data governance, security, and adherence to processes. The literature also indicates that low-quality data can compromise integrated applications and advanced systems connected to the ERP, while standardization strategies without contextual evaluation can shift complexity to integrations or extensions. It is concluded that sustainable modernization depends on an architecture governed as a socio-technical system, with explicit criteria for preserving, transforming, or discontinuing components, as well as...

Continuous mechanisms for quality and observability.
Keywords: ERP; modernization; systems integration; data quality; standardization; cloud ERP; SAP.

ABSTRACT

Enterprise Resource Planning (ERP) modernization takes place in environments shaped by dependencies among legacy applications, master data, integrations, organizational processes, and continuity requirements. This article analyzes ERP architecture modernization through four interdependent dimensions: integration, data quality, standardization, and evolution toward cloud or hybrid models. This article uses a structured narrative literature review, combining classic peer-reviewed studies on integration and data quality with research on upgrades and cloud ERP. The analysis shows that modernization is not equivalent to replacing a software version: it requires decisions concerning transactional-core boundaries, customization treatment, interfaces, migration, data governance, security, and process fit. The literature further indicates that poor-quality data can compromise integrated applications and advanced systems connected to ERP. At the same time,

standardization strategies without contextual assessment may shift complexity toward integrations or extensions. Sustainable modernization therefore depends on governing architecture as a sociotechnical system, with explicit criteria for preserving, transforming, or removing components and continuous mechanisms for quality and observability.

Keywords: ERP; modernization; systems integration; data quality; standardization; cloud ERP; SAP.

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1 INTRODUCTION

ERP systems have become the central infrastructure for organizations that rely on integration.
transactional between finance, supply, production, sales, and other functions. The consolidation of this
However, infrastructure creates a paradox: the more processes that come to depend on the ERP,
The greater the cost and risk of modifying it tend to be. Light and Wagner (2006) problematize the very...
The idea of integration in ERP environments, showing that the integration promised by the package does not eliminate
Neither organizational tensions nor the need to accommodate local realities.
Modernization occurs when existing architecture no longer adequately meets requirements.
technological, organizational or environmental. Feldman et al. (2016), based on 41 respondents of
23 large organizations show that enterprise systems upgrade decisions are influenced
driven by multiple drivers and stakeholder interests. Thus, technical obsolescence is only one of them.
Possible reasons for modernization.
In mature architectures, legacy systems coexist with ERP, specialized applications, and data.
warehouses, integration platforms, and external services. This heterogeneity makes it inadequate.
A modernization vision based solely on replacing the core. Continuity depends
from dependency mapping, interface contracts, shared data, and business rules.
distributed.

Data quality constitutes another structural dimension. Xu et al. (2002), using SAP as
For example, and studying two large Australian organizations, they demonstrated that problems of
Data quality affects implementation, and its management requires an organizational understanding.
broad, not just technical corrections. Subsequent research maintained this concern and went further.
to treat quality as a phenomenon related to the process that produces information.
The aim of this article is to analyze how integration, data quality, and standardization are interconnected.
In ERP modernization, including upgrades, migrations, and the adoption of cloud or hybrid architectures.
The guiding question is: what principles allow for ERP modernization without transferring complexity?
from one component to another without compromising continuity, governance, and reliability of
information?

2 METHODOLOGY

This work uses a structured narrative review, suitable for integrating studies from different...
Methodological designs on a broad technological and organizational phenomenon. The review is not
presented as systematic, it does not intend to estimate aggregate effects; its objective is to build a

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analytical synthesis with traceable sources.

Peer-reviewed articles and academic books addressing ERP integration were prioritized.

Data quality, enterprise systems upgrades, modernization, and cloud ERP were included.

Classic works capable of establishing enduring concepts, as well as more recent studies.

which analyze contemporary architectures and integrations with advanced systems.

The sources were examined according to six categories: integration and interoperability; systems

Legacy and installed base; data quality and governance; customization and standardization; upgrades and

modernization decisions; and cloud ERP, security, and continuity. This categorization allowed

to compare problems that are often treated in isolation.

The findings were interpreted in order to distinguish between empirical evidence and conceptual proposition.

and managerial implications. The figures reported in the text correspond to the original studies cited.

No project data was created, nor were any professional results attributed to the author.

specific.

Limitations include the heterogeneity of the research, which prevents causal generalizations, and the pace of...

Technological evolution causes products and business models to change more rapidly than

academic literature. Therefore, the article prioritizes architectural and governance principles that

They remain relevant even as specific platforms evolve.

3. ERP MODERNIZATION AND THE INSTALLED BASE

Modernizing an ERP system requires understanding the installed base as a historical set of systems.

Integrations, data, and organizational practices. Grabot, Mayère, and Bazet (2008) discuss ERP and...

Organizational change from a socio-technical perspective, in which software and organization adapt.

mutually. This means that older components may contain operational knowledge that is not mutually exclusive.

documented in the formal specifications.

The upgrade decision, therefore, is not purely technical. Feldman et al. (2016) identified drivers

Technological, organizational, and environmental pressures influence the decision to update business systems.

Support, new features, business requirements, risks, and stakeholder interests may...

coexist and compete.

The installed base also contains invisible dependencies. Reports, batch interfaces, spreadsheets,

Satellite applications and reconciliation routines may have emerged to compensate for limitations of the ERP system.

or address local specificities. Removing the central component without mapping these relationships may

to interrupt processes that apparently did not depend on him.

A modernization strategy needs to distinguish between technical debt and legitimate differentiation. Neither

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All customization is wasteful, and not all legacy items deserve preservation. The analysis should identify the value of the implemented rule, its maintenance cost, the operational risk, and the possibility of replacement with a standard feature or a decoupled service.

Consequently, an architectural inventory should precede migration decisions. Applications, Interfaces, data objects, volumes, owners, and criticality need to be known. This Inventory does not eliminate uncertainty, but it transforms tacit dependencies into governable elements and It allows you to define the transition sequencing.

4. INTEGRATION AND INTEROPERABILITY

Integration is one of the historical justifications for adopting ERP systems, but its practical implementation... It is more complex than the unification of modules. Light and Wagner (2006) argue that the rhetoric Integration can mask contradictions between the standard incorporated into the package and the possibilities. Organizational integration. Technical integration does not guarantee uniformity of meaning or use.

In modern environments, ERP integrates with CRM, WMS, analytics platforms, portals, and services. Fiscal systems, databases, manufacturing systems, and cloud applications. Each interface creates dependencies on format, semantics, frequency, security, and fault handling. The amount of Connections, by themselves, do not measure complexity; critical and tightly coupled interfaces can be... more risky than dozens of simple integrations.

Modernization should favor explicit integration agreements. APIs, messaging, middleware and ETL mechanisms can reduce coupling when employed with governance. Versioning and observability. However, inserting an integration layer without rationalizing the Interfaces simply shift the complexity to another point in the architecture.

Cloud ERP expands on this discussion. Boillat and Legner (2018) identified six relevant issues in Cloud ERP implementations: functional adaptation, integration, data migration, change. organizational structure, data security, and reliability. The authors also highlight the continuity of Installed base and future sustainability as central socio-technical concerns.

Sustainable interoperability therefore depends on architecture and governance. It is necessary define registration systems, data owners, interface standards, synchronization criteria and Recovery mechanisms. Successful modernization does not seek to eliminate all integrations. but rather to reduce ambiguity and unnecessary dependence.

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5. Data Quality and Governance

Data is as much a part of ERP infrastructure as the applications themselves. Xu et al. (2002) demonstrated that...
Data quality is a critical issue in implementation, and problems arising from systems...
Existing issues may compromise the new environment. Migration does not automatically correct these problems.
inconsistencies; without treatment, you can only transport them to a more integrated platform.
Haug, Arlbjørn and Pedersen (2009) proposed a data quality classification model.
in ERP and investigated their causal relationships in three case studies. The contribution is important.
because it shows that quality is not a single attribute: different dimensions are related and
They need to be evaluated in a structured way.
Zong, Wu, and Feng (2019) advance in this direction by proposing a process-oriented approach.
with Information Product Map. The central argument is that causes of poor quality may lie in
The process and the people who produce the information, not just the database. In this way, the
Subsequent correction, without addressing the root cause, tends to produce recurrence.
In advanced integrations, the impact can propagate. The framework of Herrmann et al. (2022) for
The integration between ERP and Advanced Planning and Scheduling is based on the assumption that the data from
ERP systems often lack sufficient quality for the APS system to function as expected.
Required. The authors combine data measurements and expert insights in a network.
Bayesian approach to quality assessment.
Data governance in modernization should include ownership, quality criteria,
Reconciliation, lineage, and change controls. Master data deserves special attention because
They are reused by multiple processes. Migration should be treated as a transformation.
controlled, with documented rules, completeness and consistency tests, and responsibilities.
clear for acceptance.

6. Standardization, Customization, and Complexity

Standardization is often presented as a way to reduce maintenance costs.
and facilitate upgrades. The logic is consistent: the closer the core gets to specific functionalities...
As features are supported by default, the smaller the volume of specific code that tends to be analyzed each time.
Change. However, sociotechnical literature recommends caution regarding universal prescriptions.
Light and Papazafeiropoulou (2008) discuss the contradictions and appropriation of ERP packages,
highlighting that the systems are appropriate for specific organizational contexts. This helps to
to explain why simply imposing a standard can generate parallel solutions when users

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They need to meet requirements that are not covered.

The decision to configure, customize, extend, or modify the process should consider both value and risk.
involved. Regulatory requirements and competitive advantages are distinct in nature from preferences.
historical. Without this classification, projects may preserve low-value customizations or
eliminate capabilities that support essential processes.

Data standardization is also important. Names, codes, units, hierarchies, and rules of
Validation needs to have a shared meaning so that integration produces information.
Consistent. Standardizing technology without standardizing concepts can create the impression of...
Integration, while semantic differences remain.

Modern architecture should therefore strive for intentional simplicity. This does not mean the absence of simplicity.
not extensions, but rather a clear separation between core, integrations, and specific capabilities. The principle
It's about making the exception visible, governable, and justifiable, reducing unnecessary changes to the core.
transactional.

7. Cloud ERP, Hybrid Architectures, and Security

Adopting a cloud ERP system changes operational responsibilities and technical boundaries, but it does not...
eliminates classic implementation problems. Boillat and Legner (2018) show that integration,
Migration, functional suitability, change, safety, and reliability remain central issues.
The cloud changes how we deal with these problems, not their existence.

Hybrid architectures may be necessary when parts of the installed base cannot be...
Replaced simultaneously. In this scenario, coexistence ceases to be an incidental phase and becomes a transitional
architecture. It is necessary to define which data remains in each environment, such as
How identities are managed and which processes cross borders.

Security becomes more important because integrations expand the display areas.
Authentication, authorization, segregation of duties, cryptography, logs, and secrets management are all necessary.
to be incorporated into the design.

Reliability also needs to be addressed end-to-end. ERP availability alone does not guarantee...
Continuity if a critical integration or identity provider is unavailable. Metrics
Service requirements should reflect business processes and dependencies, not just component uptime.
isolated.

The choice between cloud, on-premises, and hybrid should stem from verifiable requirements, including
Criticality, latency, data residency, integration, internal competencies, and evolution strategy.
Treating the cloud as an end in itself can replace a legacy architecture with a new one.

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A poorly understood addiction.

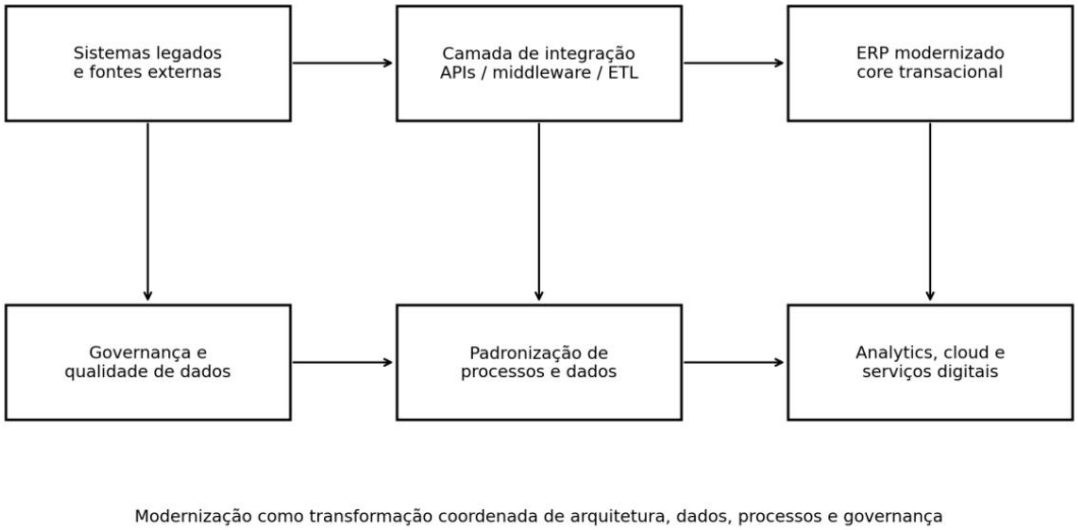

Figure 1 - Conceptual framework for ERP modernization with integration, data governance and separation between core and digital services.

Source: author's elaboration based on the synthesis of Light and Wagner (2006), Feldman et al. (2016), Boillat and Legner (2018), Zong, Wu and Feng (2019) and Herrmann et al. (2022).

8. Migration, Testing, and Operational Continuity

Migration is one of the areas with the highest concentration of risks in modernization because it involves data. processes and technological transition. Defining what to migrate should consider legal requirements, Historical, operational, and analytical data. Migrating everything indiscriminately can lead to redundancy and... Low quality; infrequent migration may compromise traceability.

The data must undergo profiling, cleaning, transformation, loading, and reconciliation. Xu et al. (2002) They already demonstrated that quality needs to be treated as an organizational issue. Zong, Wu and Feng (2019) reinforces that the causes must be investigated in the process that generates the information, the which involves correcting the sources before or in parallel with the conversion.

Testing needs to include end-to-end units, integrations, and processes. In modernizations, Regression is especially relevant because existing functionalities should continue to operate. as new components are introduced. Exception scenarios, volumes, and authorizations must to receive attention proportionate to the risk.

Operational continuity requires a cutover and rollback strategy. The choice between transition

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Concentrated and phased processes depend on the coupling between processes, the capacity for coexistence, and the...
Tolerance for interruption. There is no universally superior strategy; the decision needs to be...
supported by an analysis of dependencies and the capacity for reconciliation.
The period following go-live should be considered part of the modernization process. Monitoring.
Intensive incident management, balance comparison, and interface monitoring enable
Identify deviations early. Terminate governance at the time of entry into production.
It transforms stabilization problems into operational debt.

9. Observability, Metrics, and Continuous Evolution

Modern architectures need to be observable. Isolated technical logs are insufficient when a
The process traverses the ERP, middleware, and external applications. The ability to track a
Transactions between components reduce diagnostic time and allow differentiation between integration failures.
data error and functional problem.
Metrics should combine technical and business indicators. Latency, interface errors and
Availability issues are relevant, but they need to be related to blocked orders and failures.
billing, closing delays, or other operational consequences. This brings the
Business value architecture.
Data quality should also be monitored continuously. Haug, Arlbjørn and Pedersen
(2009) show that the dimensions of quality are related to each other; Herrmann et al. (2022)
They demonstrate the usefulness of combining objective measurement and specialized knowledge in the context of
ERP-APS integration. These findings favor controls that detect deterioration before it occurs.
affect the decisions.
Continuous evolution requires governance of change. APIs, extensions, data models, and rules.
Processes must have designated assignees, versioning, and discontinuation criteria. Without this...
In this cycle, a newly modernized architecture immediately begins to accumulate new technical debt.
Sustainable modernization is therefore an organizational capability, not a one-time event.
An organization needs to learn how to continually decide what to keep, update, replace, or...
Decoupling. This discipline reduces the likelihood of large replacement cycles resulting from
decades of accumulated complexity.

10 DISCUSSION

The literature reviewed converges on one point: ERP cannot be understood solely as software.

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Light and Wagner (2006) and Grabot, Mayère and Bazet (2008) show that integration and change are

sociotechnical phenomena. This perspective remains valid in cloud ERP, as new forms of

Implementation does not eliminate organizational dependencies.

Data quality appears as a cross-cutting element. Xu et al. (2002) identify the

The problem already exists in the implementation phase; Haug, Arlbjørn and Pedersen (2009) structure dimensions and relationships;

Zong, Wu and Feng (2019) shift attention to procedural causes; Herrmann et al. (2022)

These studies demonstrate an impact on advanced systems connected to ERP. Taken together, these studies indicate

Data governance needs to accompany the entire lifecycle.

Standardization should be interpreted as a tool for reducing complexity, not as...

an absolute purpose. An overly customized architecture can hinder evolution.

But a rigidly standardized approach can generate parallel solutions. The challenge is to distinguish the variation.

necessary historical variation without current value.

Studies on upgrades also show that modernization is context-dependent. Feldman et al.

(2016) highlight the multiplicity of drivers and stakeholders. This reinforces the need for a business

A case that explicitly states the reasons, benefits, risks, and dependencies, instead of treating the upgrade as a...

This decision rests exclusively with the IT department.

Finally, cloud and hybrid architectures expand options and responsibilities. The review of

Boillat and Legner (2018) demonstrate that classic issues persist, while recent works

Regarding security, evidence highlights the need for a structured assessment. Modernization plus

A consistent system is one that integrates architecture, data, processes, security, and governance into a single system.

decision-making logic.

CONCLUSION

ERP modernization should be understood as an architectural and organizational transformation, not simply a version replacement. The transactional core is embedded in a network of applications, data, interfaces, and practices that accumulate over time; altering a central component without understanding this network increases the risk of disruption.

Integration remains central, but its purpose needs to be redefined. A modern architecture is not necessarily one that concentrates all functions in the ERP, but rather one that establishes clear boundaries, interface agreements, responsibilities, and observability mechanisms.
Integration without governance can only increase coupling.
Data quality is an architectural requirement. The literature reviewed consistently shows that inadequate data affects the implementation, operation, and systems connected to the ERP. Therefore, migration must be accompanied by ownership, quality rules, reconciliation, and correction of the procedural causes that generate inconsistencies.

Standardization is important for reducing complexity, but it needs to be selective. The organization must differentiate between customizations that merely replicate historical habits and those that meet regulatory requirements or essential capabilities. The same principle applies to processes and...

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data models.

Cloud ERP and hybrid models expand modernization options, but introduce new boundaries of responsibility. Integration, security, identity, reliability, and continuity must be analyzed end-to-end. Migrating to the cloud does not replace architecture; it requires an architecture.

Upgrades and modernization programs should be governed by business and risk criteria.
Studies identified in the literature show that decisions stem from technological, organizational, and environmental factors.
A solid business case needs to make these motivations explicit and measurable.

Modernization must also consider the post-implementation period. Observability, incident management, data quality monitoring, and change governance are necessary to prevent the new architecture from rapidly replicating the complexity that motivated the transformation.
It can be concluded that the sustainability of a modernized ERP depends less on a single technology than on the organizational capacity to continuously manage the relationships between core systems, extensions, integrations, data, and processes. The architecture must remain evolutionary, documented, and governed, allowing the incorporation of new capabilities without loss of reliability, traceability, and control.

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