The Promises of Digital Revolutions: A Historical-Analytical Study of IT Predictions and Societal Transformations in the Netherlands (1945–2025)

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Abstract

This study analyses the extent to which information technology (IT)-based societal transformations are predictable. The central question is which characteristics of future-oriented claims and their institutional embedding are associated with structurally adequate predictions. To this end, a systematically delimited canon of digital episodes in the Dutch context is constructed, ranging from mainframe automation and network regimes to platformisation, algorithmic decision-making and generative AI.

The analysis employs three conceptual lenses: (1) a claim-oriented lens, focusing on the predictive quality of articulated future-oriented claims; (2) a transformation-oriented lens, focusing on the nature and depth of realised societal transformation; and (3) a causal lens, focusing on the attribution of technological influence within open, multicausal configurations. To avoid success bias, the episodes are structured in a 2×2 matrix based on the retrospective accuracy of predictions and the realisation of transformation.

The findings show that structurally adequate predictions are rarely purely technological in nature. They are characterised by scale consistency, the explicit specification of conditional boundary conditions, and a configurative articulation of the relationship between technology and institutional context. Inadequate predictions, by contrast, often exhibit underspecification of conditions, overestimation of scale robustness, or the instrumentalisation of technology without regard to its constitutive effects on coordination and information architectures.

The analysis also shows that digital transformations systematically generate second-order effects, including privacy regulation, the institutionalisation of cybersecurity, and administrative oversight. These reflexive interventions point to structural patterns of serendipity and cumulative dependence that are difficult to predict in detail but occur systemically as a category.

The study concludes that predictability in the digital domain depends not primarily on technological foresight, but on analytical precision in identifying configurative dependencies, levels of scale, and institutional embedding. It thereby provides a methodological framework for the historically grounded assessment of digital future-oriented claims.

Management Summary

The Promises of Digital Revolutions: A Historical-Analytical Study of IT Predictions and Societal Transformations in the Netherlands (1945–Present).

1. Problem Statement and Positioning

This dissertation examines the extent to which IT-driven societal transformations are predictable. In policy arenas, academic publications and public debates, digital technology is consistently surrounded by future-oriented claims: promises of efficiency, innovation and democratisation, but also warnings about loss of control and systemic risks. Actual societal developments, however, regularly diverge from these expectations—sometimes because of overestimation, sometimes because of underestimation, and often because of shifts in scale or configuration.

The societal relevance of this study lies in the growing dependence on digital infrastructures in government, the economy and everyday life. Policy choices and investments are partly legitimised by future-oriented claims concerning technological impact. When such claims structurally lack precision or misjudge scale, this may result in institutional vulnerability or the misallocation of resources. Academically, the study addresses a gap between futures studies, the sociology of technology and innovation, and public administration. Whereas the existing literature often focuses on individual cases or abstract theorising, this dissertation systematically compares multiple waves of ICT development within a single national context.

The central research question is: 'To what extent are IT-based societal transformations predictable, and which characteristics of predictions and predictors are associated with structurally adequate predictions?' This question is elaborated through four sub-questions concerning the analysis of future-oriented claims, the nature of realised transformations, the role of technology within broader configurations, and the identification of recurring patterns of adequate prediction.

Chapter 1 accordingly positions the study as a methodological and historical-analytical investigation of the relationship between expectation and transformation in the digital domain. Its purpose is not to assess individual projects, but to reconstruct systematically the conditions under which digital future-oriented claims prove structurally adequate or inadequate.

2. Conceptual Framework and Theoretical Positioning

Chapter 2 develops the conceptual foundation of the study. The central problem—the predictability of IT-driven societal transformation—requires an analytical framework capable of systematically assessing both future-oriented claims and realised institutional changes. The chapter therefore positions the study at the intersection of the sociology of technology and innovation, public administration, and theories of societal modernisation.

The first step is to distinguish between technological innovation as an artefact and as a process of regime formation. Digital technology is not regarded as an isolated tool, but as part of broader socio-technical configurations in which infrastructure, regulation, organisational routines and user practices converge. In this respect, the study draws on insights from the literature on socio-technical transitions

and path dependence, in which technological choices may generate cumulative institutional consequences.

The distinction between future-oriented claims and societal transformation is subsequently elaborated. Future-oriented claims may be policy-based, visionary or theory-informed, but vary in the extent to which they make causality, scale and boundary conditions explicit. Societal transformation is defined as the durable reconfiguration of institutional, organisational or socio-technical structures, rather than as temporary adoption or a passing trend.

On the basis of this conceptualisation, three analytical lenses are introduced.

The claim-oriented lens (X) analyses the quality of future-oriented claims. Predictive quality is understood as multidimensional and includes structural adequacy—whether the causal structure is explicit and plausible—conditional sensitivity—whether boundary conditions and dependencies are specified—and scale consistency—whether the assumed level of impact is coherent.

The transformation-oriented lens (Y) examines the nature of realised societal transformation. It distinguishes between sectoral optimisation, regime shifts and system-level reconfiguration, as well as between temporary changes and changes that have become durably embedded.

The causal lens (X–Y) analyses the role of technology within open, multicausal configurations. Technology is not treated as an autonomous cause, but as a potentially necessary, facilitating or constitutive factor within broader institutional and economic dynamics.

Combining these three lenses produces a systematic framework through which diverse digital episodes can be compared without losing their context-specific character. The chapter emphasises that predictability is not equivalent to exact forecasting, but concerns the extent to which articulations are structurally and configuratively adequate in relation to subsequent developments.

Chapter 2 thus provides the conceptual instruments used to analyse the historical cases in later chapters. It constitutes the methodological backbone of the dissertation: without this differentiation between claim, transformation and causal configuration, comparisons between waves of ICT development would remain analytically arbitrary.

3. Research Design, Analytical Method and Quality Assurance

Chapter 3 justifies the empirical approach used for the historical analysis of ICT-related future-oriented claims and societal transformations. Its central message is that the study does not consist of a series of separate narratives, but follows a standardised analytical cycle: (i) delimitation of a canon and selection of episodes; (ii) reconstruction of claims and developments on the basis of verifiable sources; (iii) application of a uniform analytical framework for each lens; and (iv) synthesis through comparable forms of output.

Research strategy and design choices. The chapter positions the study as qualitatively dominant and analytically comparative. Its purpose is not statistical generalisation, but the identification of recurring characteristics of adequate and inadequate prediction across different waves and outcomes of ICT development. The design is therefore variation-oriented: cases are selected to enable systematic comparison between types of outcome, scale and regime-related subject matter, rather than to reconstruct a single ‘best case’ or ‘worst case’.

Canon formation and selection as methodological delimitation. In Chapter 3, canon formation functions as a form of methodological delimitation, rather than as a comprehensive historical overview or a normative ranking. A development is considered eligible only when: (1) it involves a relevant IT configuration; (2) explicit future-oriented claims or programmatic articulations are available; (3) observable societal developments can be identified; and (4) its relevance to the Netherlands can be demonstrated. This prevents the retrospective attribution of significance to episodes for which no comparable claim was articulated at the time.

Structuring through the 2×2 matrix and avoiding success bias. The canon is subsequently structured along two retrospective dimensions—the accuracy of the claim and the realisation of transformation—in a 2×2 matrix. The purpose is to ensure explicit variation in the empirical basis: the analysis includes not only 'successes' and 'failures', but also underestimated transformations and overestimated interventions. Success bias is thereby explicitly neutralised as a principle of selection.

Purposive sampling and case delimitation. A second selection is made within the canon through purposive sampling of episodes for in-depth analysis. This selection is analytically motivated by variation in scale, type of claim, outcome and source availability. Alternative cases are not allowed to disappear without explanation, but are excluded on stated grounds in order to limit implicit selection bias. Case delimitation also clearly defines the unit of analysis: a future-oriented claim, a technological cluster or an institutional configuration.

Procedural description and reproducibility. The chapter makes the selection and analytical process explicit through a sequence of steps: inventory → assessment → provisional classification → selection → documentation. Reproducibility is understood here in a methodological sense. Others are not expected to construct exactly the same canon, but should be able to determine why particular choices were made and which criteria were applied.

Operationalising the 'conceptual lenses' as concrete analytical steps. Crucially, Chapter 3 specifies not only what is analysed, but how the analysis is conducted. For each lens, it explains how claims are reconstructed, which dimensions are assessed and how outputs are recorded to make the cases comparable. The chapter thereby bridges the conceptual framework of Chapter 2 and its application in Chapters 5–8: each episode is examined through the same analytical grid, ensuring that the subsequent synthesis is methodologically derived rather than ad hoc.

Quality assurance and the prevention of interpretative arbitrariness. Finally, the chapter describes the internal quality-assurance procedures: transparent decision rules, traceability to sources and consistent output formats, including the explicit specification of claims, conditions and scale, as well as lens-specific conclusions. The central argument is that interpretative judgements are unavoidable in qualitative historical research, but can be disciplined through explicit procedures, fixed categories and verifiable substantiation.

In summary, Chapter 3 provides the procedural infrastructure of the dissertation: a verifiable route from source material to comparable outcomes for each analytical lens. This makes the case-study chapters, Chapters 5–8, mutually comparable and provides the necessary basis for the systematic pattern analysis in Chapter 9.

4. Canon Formation and Positioning

Chapter 4 justifies the delimitation of the empirical domain. Canon formation does not serve here as a historical overview or an assessment of technological importance, but as a methodological selection of cases suitable for the systematic comparison of future-oriented claims and societal transformation. The chapter operationalises the selection criteria developed in Chapter 3 and determines which digital interventions qualify for further analysis.

Two gateways to inclusion. Admission to the canon proceeds through two complementary gateways. Political articulation (P1) concerns the explicit formulation of digital ambitions or problem diagnoses in parliamentary or administrative arenas. This enables the reconstruction of original future-oriented claims. Ex post structural transformation (P2) concerns demonstrable and durable reconfiguration of institutions, markets or everyday practices, irrespective of prior political visibility. This prevents market-driven or client-side innovations from remaining outside the analytical field. A case, or 'episode', may be included through either or both gateways; neither takes precedence over the other.

Systematic inventory. To avoid arbitrariness, the longlist is generated through a regime × domain grid. Regime types, such as mainframe, client-side, network, platform, digital identity and algorithmic decision-making, are cross-tabulated with domains of application, including the state, the market, citizens, intermediary organisations and crisis contexts. The grid functions both as an inventory instrument and as a means of identifying gaps: empty cells are explicitly assessed for their relevance.

Reduction and delimitation. The longlist generated in this manner is subsequently reduced on the basis of analytical utility. Episodes are combined when they form a single technological cluster with a comparable claim structure, and separated when their claim logic or type of transformation differs substantially. Policy codifications without independent regime effects are not included as primary episodes, but are assigned to a peripheral layer.

Quadrant distribution. The resulting corpus is provisionally positioned within the 2×2 matrix of predictive accuracy × realisation of transformation. This classification is analytically provisional: the definitive assessment takes place in Chapters 5–8. The purpose of the quadrant distribution is not to confirm success or failure, but to create conditions for comparison.

Peripheral layer of the canon. In addition to primary regimes, a peripheral layer is distinguished, consisting of corrective and normative interventions, such as privacy legislation, the institutionalisation of cybersecurity and oversight mechanisms. These are not placed within the 2×2 matrix, but function as second-order responses to earlier digital transformations.

The result is a transparent, systematic and verifiable corpus that provides the starting point for the case analyses in Chapters 5–8. Canon formation is not an endpoint here, but a methodological precondition for empirical analysis.

5. Quadrant Q1: Accurately Predicted and Realised

Chapter 5 analyses episodes in which explicitly articulated future-oriented claims correspond to a substantial degree with the societal transformation that was ultimately realised. This category is not a normative list of successes, but an analytical reference point: it reveals the conditions under which predictions prove structurally adequate.

The cases examined within this quadrant mainly concern core infrastructural and institutional regimes, including large-scale administrative automation at the Dutch Tax and Customs Administration and within the Municipal Personal Records Database, network development through SURFnet and broadband, and digital identification through DigiD. In these cases, the technological intervention was positioned as a solution to specifically articulated problems: the increasing scale of administrative processes, the need for reliable data exchange, or secure digital access to public services.

Characteristics of the predictions. The future-oriented claims in the cases within this quadrant are characterised by: (1) relatively clear problem definitions; (2) explicit causal chains; (3) the absence of inflated assertions about the scale of impact; and (4) attention to institutional boundary conditions. Predictive quality is based here not on visionary ambition, but on configurative precision: the claims remained close to the concrete domain of application and rarely exceeded the articulated level of scale.

Characteristics of the transformations. The realised transformations concern the durable reconfiguration of administrative infrastructures and digital access systems. These changes are deeply embedded institutionally and display lock-in effects. Their societal impact manifests itself primarily at regime or system level within specific domains, such as taxation, population registration and digital identification, without a broader morphological revolution having been either claimed or realised.

Causal structures. In these episodes, technology does not function as an autonomous driving force, but as a necessary component within a coherent institutional configuration. Causality is multicausal but relatively stable: organisational need, technological capacity and administrative implementation reinforce one another.

Interpretation. The cases in Chapter 5 show that structurally adequate predictions occur primarily when: (1) the domain of application is clearly delimited; (2) claims about scale are proportionate; (3) institutional dependencies are explicitly incorporated; and (4) the technology is not presented as a generic solution to diffuse societal problems. The cases within this quadrant demonstrate that predictability in the digital domain is possible, but mainly under conditions of institutional embedding and discipline in the articulation of scale. Quadrant Q1 therefore serves as the reference point for comparison with the other quadrants.

6. Quadrant Q2: Accurately Predicted, but Realisation Falls Short

Chapter 6 examines cases in which the original future-oriented claim was epistemically adequate—proportionate, scale-consistent and plausible—but in which the realised societal transformation fell short in depth, speed or institutional embedding. Quadrant Q2 therefore marks a crucial analytical category: an accurate diagnosis does not guarantee structural realisation.

ERP technology and digital chain integration. The promise of ERP systems concerned the integration of core processes, real-time information provision and the harmonisation of organisational silos. This claim was substantively coherent and formulated with an appropriate awareness of scale. Integration as a principle has indeed been realised: ERP systems now form the backbone of administrative and logistical processes in both private and public organisations. The realised benefits, however, proved less linear and less strategically transformative than the original articulation suggested. Implementations were costly, complex and organisationally conflictual. Institutional absorptive capacity proved more limited than anticipated. The claim was adequate, but its realisation remained fragmented and often incremental.

Electronic Patient Record/LSP: digital healthcare information exchange. An explicit system-level claim was formulated for the Electronic Patient Record: nationwide interoperability would improve the quality, safety and efficiency of healthcare. Epistemically, this claim was proportionate and technically plausible. Its societal realisation nevertheless remained limited. Political resistance, privacy concerns and institutional fragmentation within the healthcare sector prevented full implementation. Digital information exchange has been realised, but in a reduced and fragmented form through the LSP, the National Exchange Point. The transformation fell short of the scale and institutional depth of the original ambition.

Platform work. The rise of digital labour platforms was recognised relatively early in policy and academic contexts as a structural shift in the organisation of work. Claims concerning flexibilization, the transfer of risks and the redefinition of employment relations were substantively adequate and conditionally formulated. Institutional realisation, however, remains ambivalent. Although platformisation is clearly occurring, its legal and social embedding remains unstable and contested. Case law and policy responses follow the development, but institutional stabilisation remains incomplete. The prediction was substantively robust; institutionalisation is still in progress.

The three cases reveal a consistent pattern: (1) epistemic adequacy is present; (2) structural transformation remains dependent on institutional absorptive capacity; (3) multicausality and implementation complexity moderate realisation; and (4) political and legal configurations partly determine the outcome. For the central research question, this implies that predictive quality is necessary but not sufficient for societal reconfiguration. The cases in Q2 show that structural transformation is not a direct function of accurate prediction, but of configurative congruence between technology, governance and institutional structure.

7. Quadrant Q3: Inadequate Predictions and Durable Transformation

The cases analysed in Chapter 7 demonstrate that far-reaching societal reconfiguration may occur even when, during the introductory phase, no proportionate or scale-aware predictions were articulated. The dominant claims surrounding commercial internet access, general-purpose AI and the historical mainframe transformation were predominantly instrumental, fragmented or cautious in policy terms. Explicit system-level hypotheses concerning shifts in coordination or legitimation structures remained limited or were entirely absent.

In practice, however, a structural reorganisation of information and decision-making architectures occurred. Network logic became constitutive of market and administrative processes; the use of mainframes led to centralisation and stabilised administrative regimes; and generative AI is reshaping knowledge practices and assessment structures within already digitalised environments. These transformations did not manifest themselves as abrupt ruptures, but as cumulative shifts across several layers simultaneously—technical, organisational, legal and normative. It was precisely this layered character that complicated early system-level articulation.

For the central research question, this implies that predictability in the ICT domain depends not solely on technological foresight, but on the capacity to recognise the configurative reordering of existing structures as a coherent pattern at an early stage. When change presents itself as optimisation or capacity expansion within familiar frameworks, the constitutive trajectories of regime change remain analytically underexposed. The Q3 cases thus show that under-articulation is not an incidental failure of communication, but a structural characteristic of layered and cumulative transformations.

8. Quadrant Q4: Inadequate Predictions and the Absence of Durable Embedding

Chapter 8 examines cases in which the relationship between expectation and realisation proves fundamentally problematic. In these cases, the articulated future-oriented claim was epistemically underspecified or overstated in terms of scale and robustness, while the realised societal outcome likewise failed to produce durable structural embedding consistent with the original ambition. Quadrant Q4 therefore represents not a simple failure, but a systematic discrepancy between claim formation and institutional development.

The Dutch Childcare Benefits Scandal illustrates that technical plausibility does not amount to structural adequacy in claims concerning societal impact. The assumption that large-scale data linkage and risk selection would produce more objective and efficient enforcement proved insufficiently sensitive to legal boundary conditions, error margins and the effects of scaling up. Digital classification functioned constitutively within the logic of implementation, but the institutional configuration in which it was applied generated effects that had not been articulated proportionately. The discrepancy between the claimed rationalisation and the disruption actually produced points to the underspecification of conditions and an overestimation of scale robustness.

In the CoronaMelder case, the procedural functioning of the technology was largely consistent with its design, but the claim concerning societal impact proved dependent on behavioural and institutional boundary conditions that had been made explicit only to a limited extent. Its assumed substantial contribution to reducing transmission depended on adoption rates, compliance and organisational

embedding. The contribution actually realised remained supplementary and temporary, without producing durable effects in infectious-disease control. The inadequacy lay not in the technical functionality itself, but in the insufficient specification of the configuration within which effectiveness could plausibly be achieved.

The comparison between Viditel in the Netherlands and Minitel in France shows that comparable classes of technology may follow divergent institutional trajectories. In France, a coherent configuration of distribution, standardisation and tariff mechanisms led to durable embedding, whereas the ecosystem conditions in the Netherlands remained fragile. In the Dutch context, the future-oriented claim concerning interactive digital services was not supported by a congruent institutional infrastructure. The inadequacy therefore concerned not the feasibility of the system, but the underestimation of the scale and adoption conditions required.

The case of digital electoral infrastructure confirms that technical modernisation becomes structural only when it is congruent with the existing institutional architecture. In the Netherlands, electronic voting remained procedural and temporary; in Estonia, internet voting was embedded in an already established digital state infrastructure. This divergence demonstrates that claims concerning the impact of digital infrastructure are structurally adequate only when they explicitly incorporate the institutional configuration in which implementation takes place.

Taken together, these episodes show that inadequate predictions in the digital domain rarely result from obvious technical error. More often, they involve an overestimation of scale robustness, the underspecification of institutional boundary conditions and the insufficient articulation of multicausal configurations. The structural lesson of Q4 is therefore that an accurate assessment of technological possibilities is insufficient: predictive quality requires precision in identifying the conditions under which technology may become constitutive of durable reconfiguration. Quadrant Q4 shows that, when such configurative precision is absent, both claim and realisation lack structural coherence.

9. Cross-Case Analysis and Patterns of Predictive Quality

In Chapter 9, the perspective shifts from individual episodes to systematic comparison across the four quadrants. Whereas the preceding chapters analysed the relationship between expectation and transformation for each case, this chapter examines which characteristics of predictions and predictors are repeatedly associated with structural adequacy. The analysis does not seek to reclassify the episodes, but to identify recurring patterns in the articulation of claims, the outcomes of transformation processes and causal structures.

Within the epistemic dimension, structurally adequate predictions are characterised by the explicit elaboration of causal mechanisms, scale-aware positioning and conditional precision. Where system changes were articulated proportionately and boundary conditions were specified analytically, the relationship between expectation and realisation proved more robust. By contrast, the underspecification of conditions and the overestimation of scale robustness are associated with implementation outcomes that systematically fall short of the claims. Predictive power lies not in visionary rhetoric, but in configurative precision.

Analysis of implementation outcomes shows that the depth and durability of transformation vary according to the extent to which technology becomes constitutive of institutional architecture. Infrastructural regimes characterised by broad diffusion and strong lock-in effects prove relatively stable, whereas interventions that remain dependent on voluntary adoption or limited organisational

absorptive capacity rarely produce structural reconfiguration. The analysis confirms that regime formation is determined primarily not by intention, but by institutional embedding and cumulative dependence.

From a causal perspective, monocausal attribution is rarely tenable. Almost all episodes involve configurative causality, in which technological capabilities, legal frameworks, organisational capacity and political priorities mutually reinforce or constrain one another. Structurally adequate predictions are distinguished by their explicit recognition of this multicausality and by their refusal to reduce it to a linear technology–effect model. Where technology is positioned as an autonomous driver, the risk of derailment increases.

In addition to these patterns within primary regimes, the chapter considers second-order effects and peripheral corrective mechanisms. Digital infrastructures systematically generate normative, legal and security-related responses. Privacy legislation, cybersecurity architectures and oversight mechanisms emerge not as incidental additions, but as reflexive stabilisation mechanisms within advancing digitalisation. This serendipity is not random, but structurally probable, although difficult to predict.

For the central research question, the cross-case analysis implies that the predictability of IT-based societal transformation depends not primarily on technological foresight, but on insight into causal structures. Structurally adequate predictions combine scale consistency, the explicit specification of conditions and recognition of layered causality. At the same time, complete predictability remains constrained by emergent second-order effects and institutional dynamics. The ICT domain is therefore not fundamentally unpredictable, but it is systematically vulnerable to oversimplification.

10. Conclusions, Discussion and Recommendations

Chapter 10 brings the research questions together in a systematic set of answers and positions the findings within their methodological and theoretical limits. In answering RQ0, canon formation is understood not as an inventory, but as an epistemic filter that disciplines the field of assessment by restricting it to cases in which both explicit future-oriented claims and observable societal effects can be reconstructed analytically. The 2×2 quadrant does not function as an ex post classification, but as a predefined instrument of variation that prevents success bias and enables analysis independently of quadrant membership. The answer to the first research question shows that the structural adequacy of future-oriented claims is associated primarily not with temporal precision or rhetorical persuasiveness, but with proportionate articulation of scale, the explicit formulation of causal assumptions and the identification of institutional boundary conditions. Claims that situate their impact within recognisable institutional structures and make dependencies explicit display greater structural congruence with subsequent developments than claims that postulate system-level reconfiguration without further specification.

The answers to the second and third research questions establish that realised digital transformation occurs predominantly at regime and domain level, and that technology rarely functions as an autonomous or sufficient cause. Attribution therefore requires a configurative reconstruction of mechanisms and complementarities within open societal systems. The analysis of variation across the quadrants confirms that structural adequacy does not coincide with successful outcomes: realisation may fail despite adequate articulation, while transformation may occur without an accurate prior prediction. The answer to the fourth research question identifies recurring characteristics of robust prediction: discipline in the articulation of scale, explicit specification of causality and boundary conditions, avoidance of assumptions of linear diffusion, and restraint in relation to timing. The central

research question is therefore answered by the proposition that the structural adequacy of technological future-oriented claims has historically depended not on successful outcomes or temporal accuracy, but on the articulation of scale and causal assumptions, with boundary conditions being explicitly identified and remaining proportionate to the intended level of impact.

The subsequent discussion in §10.2 examines whether these conclusions are methodologically tenable. The execution of the study is evaluated against the principles formulated in Chapter 3: a historically grounded analysis based on abductive reasoning and directed towards configurations of causal factors.

The discussion explicitly addresses hindsight bias, retrospective coherence construction, selection bias and confirmation bias. These vulnerabilities are acknowledged as inherent in historical research, but are mitigated through transparent selection, explicit analytical categories and a strict separation between claim-oriented, ontological and causal dimensions. The validity of the findings therefore rests on conceptual clarity and the consistent application of predetermined criteria, rather than on experimental control. In §10.3, the identified limitations are translated into targeted recommendations for further research, including international comparison, quantitative operationalisation of predictive quality, actor-oriented approaches and prospective application of the assessment framework. These extensions do not imply revision of the core findings, but are intended to deepen and further test the analytical instruments developed in this study.

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Chapter 1 — Introduction

1.1 Context and Rationale

Since the introduction of large-scale computers in the 1940s and 1950s, information technology has repeatedly been presented as a force capable of fundamentally reordering societal structures. Across successive waves—mainframes, personal computers, the internet, mobile technology and artificial intelligence—expectations have been articulated concerning productivity growth, the democratisation of information, the reorganisation of labour and administrative innovation. Such expectations align with broader theorising about the 'information society' (Castells, 1996; Bell, 1973) and with economic analyses linking digital technology to productivity and prosperity growth (Brynjolfsson & McAfee, 2014).

At the same time, historical-sociological approaches show that technological development rarely dictates societal change autonomously. Technology is embedded in institutional structures, power relations and cultural practices (Bijker, Hughes & Pinch, 1987; Orlikowski, 1992). Institutional theory emphasises that organisational and systemic change depends on regulatory, normative and cognitive structures (DiMaggio & Powell, 1983). Diffusion theory points to variation in adoption patterns (Rogers, 2003), while the change management literature emphasises that technology becomes effective only in conjunction with social interventions.

Historical reality therefore presents a mixed picture: some expectations prove visionary, others exaggerated or premature, while still others fail not because of technical shortcomings but because societal conditions change. The relationship between expectation and outcome is complex, layered and multicausal.

1.2 Problem Statement

The literature on prediction and the literature on digital transformation have largely developed along parallel trajectories.

Forecasting research focuses on methods for projecting and evaluating future developments (Armstrong, 2001; Makridakis et al., 2018). Studies of forecasting accuracy reveal systematic limitations in expert judgement (Tetlock & Gardner, 2015). Scenario thinking emphasises uncertainty and multiple possible futures (van der Heijden, 1996). Sociological approaches to expectations highlight the performative character of visions of the future: predictions may themselves contribute to producing the reality they describe (Merton, 1948; Borup et al., 2006; Beckert, 2016).

In parallel, the literature on digital transformation examines how technology affects societal structures. The network society (Castells, 1996), the platform economy (Srnicek, 2017) and digital governance (Dunleavy et al., 2006) are analysed as empirical phenomena. Economic analyses focus on productivity paradoxes and the complementarity between technology and organisation (Brynjolfsson & Hitt, 2000).

What remains largely absent, however, is a systematic historical connection between these two fields: an assessment framework in which predictions are retrospectively confronted with actual societal transformations, while both the scale of change and the attribution of a causal role are explicitly analysed.

Without such a connection, there is a risk, on the one hand, of technological determinism (Winner, 1980) and, on the other, of relativising technological influence to such an extent that specific attribution becomes impossible. Moreover, failures—both in predictions and in transformations—often receive insufficient attention, even though they may provide important insights into the limits of technological optimism.

1.3 State of the Debate

1.3.1 Strands of Research on Prediction

The forecasting literature develops methods for prospective assessment, ranging from statistical models to expert-based judgements (Armstrong, 2001; Makridakis et al., 2018). Research on expert judgement identifies both systematic errors and the conditions under which predictions are relatively robust (Tetlock & Gardner, 2015). Scenario approaches emphasise uncertainty and alternative futures (van der Heijden, 1996).

Within Science and Technology Studies (STS), a 'sociology of expectations' has emerged in which visions of the future are understood as performative forces that structure innovation processes (Borup et al., 2006). Beckert (2016) emphasises that economic actors act on the basis of 'fictional expectations', which shape investment and policy choices.

Although this literature provides insight into how expectations arise and function, it rarely focuses on systematic retrospective assessment in relation to realised societal change.

1.3.2 Strands of Research on Digital Transformation

Digital transformation is interpreted in divergent ways. Information-society and network-society approaches (Castells, 1996) emphasise the structural reconfiguration of the economy and communication. The economic literature points to complementarity between technology and organisation (Brynjolfsson & Hitt, 2000). Institutional and socio-material approaches underline the interdependence of technology and social practices (Orlikowski, 1992).

Critical literature warns against technological determinism and emphasises the social construction of technology (Bijker et al., 1987; Winner, 1980). Public administration studies analyse digital reforms of government (Dunleavy et al., 2006), but rarely confront them explicitly with earlier expectations concerning their impact.

1.3.3 Positioning of This Study

This study is positioned at the intersection of the forecasting literature and the transformation literature, but differs from both in two respects. First, it explicitly adopts a historical-retrospective approach in which expectations are systematically confronted with empirical

outcomes. Second, it treats successes and failures as analytically equivalent, unlike literature that focuses primarily on success stories or emblematic failures.

1.4 Research Gap

Although forecasting research devotes extensive attention to forecasting methods and accuracy (Armstrong, 2001; Tetlock & Gardner, 2015), and the digital transformation literature analyses societal restructuring (Castells, 1996; Orlikowski, 1992), an integrated historical assessment framework that systematically analyses expectations, realised transformation and attribution in conjunction remains absent.

Moreover, existing studies often treat failures selectively, leaving the full range of combinations between adequate and inadequate prediction, on the one hand, and realised or unrealised transformation, on the other, insufficiently examined. Consequently, there is limited insight into the recurring characteristics of structurally adequate forms of prediction.

This gap is particularly relevant in light of recent discussions concerning artificial intelligence, in which powerful expectations are once again being articulated, often without systematic historical comparison.

1.5 Aim

The aim of this study is to develop and apply a historical-analytical assessment framework through which predictions concerning the societal impact of information technology can be systematically evaluated in relation to actual, layered transformations in Dutch society. In doing so, the study seeks to provide insight into recurring characteristics of structurally adequate forms of prediction, without resorting to deterministic claims or claims based on statistical generalisation.

1.6 Research Questions

The central research question is: ‘How can historical predictions concerning the societal impact of ICT on Dutch society be systematically assessed for their structural adequacy, how do these assessments relate to the actual layered transformations that have occurred in the Netherlands, and which recurring characteristics of structurally adequate forms of prediction can be reconstructed historically?’

To answer this central research question, the following sub-questions have been formulated:

RQ0 — Canon formation and field delimitation: Which ICT developments were articulated in Dutch public and political sources between 1945 and the present as potentially transformative at the societal level, and on the basis of which explicit or implicit impact claims can these developments be selected as cases for analysis?

RQ1 — Transformations (actual outcome): To what extent, and at what level of technological and societal layering, did the selected ICT developments produce sectoral, multi-sectoral or system-level transformations within a delimited historical trajectory?

RQ2 — Structural adequacy of predictions: To what extent were historical predictions concerning these ICT developments structurally adequate when assessed in terms of direction, scale and conditional sensitivity, irrespective of literal timing or accuracy of detail?

RQ3 — Attribution: What role did the ICT development concerned play in the observed transformation—constitutive, catalytic, enabling or marginal—and how robust is this attribution in light of multicausal explanations?

RQ4 — Patterns in robust prediction: Which characteristics of predictions and predictors recur in structurally adequate predictions, and how can these characteristics be interpreted historically across different waves of ICT development?

1.7 Scope

This study focuses on the societal impact of information technology in the Netherlands between 1945 and the present. It is not concerned with the national origins of technologies, but with their effects within the Dutch context. International predictions are included insofar as they demonstrably became part of Dutch public, political or academic discourse. The study is predominantly qualitative and prioritises analytical consistency over quantitative generalisation.

1.8 Societal and Academic Relevance

Academically, this study contributes to connecting the forecasting literature with studies of digital transformation by systematically relating the two. Methodologically, it provides an explicit historical assessment framework that accommodates multicausality and variation in scale. Societally, the study may contribute to a more reflective engagement with technological expectations, particularly in light of recent developments in artificial intelligence.

Recent developments in artificial intelligence raise questions that also arose during earlier waves of ICT development: when can a technology be regarded as societally constitutive rather than merely facilitating? In policy and academic debates, AI is regularly presented as a technology with system-level reach, comparable to earlier digital breakthroughs (Brynjolfsson & McAfee, 2014; Floridi et al., 2018). Historical analysis, however, shows that such qualifications are rarely unambiguous.

It may be hypothesised that several ICT developments in the post-war period played a distinctive and possibly constitutive role in subsequent digital transformations. The introduction of large-scale mainframe computers created a precondition for large-scale data processing in government and business. Similarly, it may be argued that the emergence of internet technologies created a new communications infrastructure that restructured multiple sectors simultaneously (Castells, 1996).

At the same time, the personal computer—often analysed as a discrete innovation—may also have played an enabling role in making subsequent network transformations possible. Without the widespread diffusion of individual computing power, the internet revolution might not have achieved the same societal depth. In this sense, waves of ICT development cannot be understood solely as successive innovations, but as potentially layered and interdependent stages of development.

Within this perspective, artificial intelligence may be regarded as a contemporary candidate for constitutive or restructuring technology. Whether AI will actually attain a system-level reach comparable to that of earlier digital infrastructures is not an established fact, but an empirical question. Economic analyses point to potential productivity effects (Brynjolfsson & McAfee, 2014), while other studies emphasise that institutional embedding and policy choices determine societal effects (Acemoglu & Johnson, 2023).

It is therefore analytically productive not to classify AI in advance as a constitutive rupture, but to treat it as a hypothesis within a historically comparative framework. The question of whether AI will, in retrospect, prove to have had a layered impact comparable to that of earlier waves of ICT development underscores the need for a systematic assessment of expectations and realised transformations.

1.9 Structure of the Dissertation

Chapter 2 presents the conceptual framework for assessing predictions, transformations and the relationship between them. Chapter 3 elaborates the research design and methodology. A canon of successful and unsuccessful digital transformations is then constructed in Chapter 4, answering RQ0. In the subsequent chapters, a number of cases from this canon are selected and analysed in order to answer the remaining sub-questions. Chapters 5–8 address RQ1, RQ2 and RQ3 from four different perspectives. The four perspectives are then brought together to answer RQ4. The dissertation concludes with the findings, a discussion of the validity and reliability of the research results, and recommendations for further research in Chapter 10.

Chapter 2 — Conceptual and Theoretical Framework

2.1 Theoretical Reformulation of the Problem

The problem situated historically and empirically in the preceding chapter can be reformulated theoretically as the convergence of three interconnected fields of tension: an epistemological tension concerning the assessment of predictions (X), an ontological tension concerning the nature and scale of societal transformation (Y), and a causal tension concerning the attribution of change to technology (the relationship between X and Y). The absence of an integrated framework in which these three dimensions are systematically analysed in conjunction constitutes the core of the research gap addressed here.

2.1.1 The Epistemological Tension: Prediction and Retrospective Assessment

The literature on prediction focuses primarily on prospective adequacy. Forecasting research develops methods for projecting future developments and evaluates these in terms of accuracy (Armstrong, 2001; Makridakis, Spiliotis & Assimakopoulos, 2018). Research on expert judgement identifies systematic biases and examines the conditions under which predictions prove relatively robust (Tetlock & Gardner, 2015). Scenario approaches emphasise uncertainty and alternative futures (van der Heijden, 1996).

Within Science and Technology Studies, attention has also been drawn to the performative character of expectations: visions of the future function not merely as descriptions of possible developments, but influence investment decisions, policy choices and innovation processes (Merton, 1948; Borup et al., 2006; Beckert, 2016). From this perspective, a prediction is not merely true or false, but also constitutes a social mechanism. What this literature develops less systematically, however, is the question of how predictions can be assessed retrospectively in relation to actual societal outcomes. Forecasting studies generally measure numerical deviations or probabilistic accuracy, but offer limited guidance for the historical evaluation of qualitative, normative or scale-specific impact claims. At the same time, a purely discursive approach to expectations risks relativising any form of evaluation. The epistemological tension therefore lies between correspondence and performativity: between the question of whether a prediction was ‘correct’ and the recognition that predictions may themselves be constitutive of the reality they describe.

A historical-analytical approach must acknowledge both dimensions without lapsing into either relativism or positivism. This requires an assessment framework that considers both correspondence with outcomes and the articulation of boundary conditions and multicausal configurations.

2.1.2 The Ontological Tension: Change and Transformation

Parallel to the epistemological tension, an ontological question arises concerning the nature of societal change. The literature on digital transformation varies considerably in its

conceptualisation. Some authors refer to revolution or paradigm change (Castells, 1996), whereas others point to gradual reconfigurations within existing institutional structures (DiMaggio & Powell, 1983; Orlikowski, 1992). Economic analyses emphasise the complementarity between technology and organisation (Brynjolfsson & Hitt, 2000), suggesting that the introduction of technology is rarely sufficient in itself to produce fundamental restructuring. In policy and media debates, the concept of 'transformation' is often applied broadly, creating a risk of conceptual inflation: every significant change is presented as revolutionary.

From an analytical perspective, however, a distinction is required between sectoral adaptations, broader intersectoral shifts and possible system-level reconfigurations. Without such a distinction, the scale of change becomes blurred and comparison between different technological waves becomes problematic. The ontological tension therefore concerns the question of what should be understood by societal transformation and the level at which it manifests itself. This question bears directly on the interpretation of technological significance.

2.1.3 The Causal Tension: Attribution and Multicausality

Finally, the causal question of attribution arises. Even when it has been established that a prediction adequately anticipated certain developments and that societal change occurred, the question remains of the extent to which this change can be attributed to the technology concerned. Historical and institutional literature emphasises that societal transformations are almost invariably multicausal (Mahoney & Rueschemeyer, 2003). Technology generally operates in interaction with regulation, organisational forms, cultural norms and economic structures. Economic studies point to the complementarity between technological innovation and organisational adaptation (Brynjolfsson & Hitt, 2000). Sociomaterial approaches emphasise the mutual constitution of technology and social practice (Orlikowski, 1992).

At the same time, critics warn against technological determinism: the notion that artefacts independently dictate societal outcomes (Winner, 1980). The attribution problem therefore lies between two extremes: attributing transformation to technology as an autonomous driving force, and dissolving technological influence entirely into broader social processes. A systematic approach must accommodate necessary, facilitating and contingent roles of technology without resorting to monocausal explanations.

2.1.4 The Need for Integration

The three fields of tension—epistemological, ontological and causal—are generally treated separately in the existing literature. Forecasting research concentrates on predictive methods; the transformation literature analyses societal restructuring; and institutional and socio-technical approaches problematise causal attribution. What remains absent is an integrated theoretical framework in which expectations, realised transformations and attribution are systematically analysed in conjunction within a single historical perspective. The conceptual framework developed here provides an integrated approach in which the articulation of claims, ontological restructuring and causal configuration are analysed jointly, without reducing the complexity of any individual field of tension or granting explanatory primacy to one dimension.

2.2 Prediction and Predictive Quality

2.2.1 Prediction and Explanation: A Problematic Symmetry

Within the philosophy of science, explanation and prediction were long assumed to be structurally symmetrical. In Hempel's deductive-nomological model, a correct explanation, provided that it incorporates the correct initial conditions, should in principle also enable a correct prediction. This assumption implies that predictive capacity is essentially derived from explanatory power. This symmetry has, however, repeatedly been criticised. Scriven argued that explanation is often retrospective and does not necessarily entail prospective predictability. Complex social processes may be explained coherently in retrospect without having been predictable in advance with comparable precision. This demonstrates that predictive quality cannot be reduced to the internal consistency of an explanatory model.

For historical research into technological future-oriented claims, this distinction is fundamental. Future-oriented claims operate in a context of open systems, multiple causes and institutional contingency. It is therefore methodologically untenable to assess predictive quality solely on the basis of correspondence with outcomes. The epistemological status of a future-oriented claim is also determined by the nature of its assumptions, the explicit articulation of conditions and the extent to which it formulates a causal structure that clarifies the relationship between an intervention and its intended outcome. It follows that predictive quality should be understood not as binary, but as a matter of degree: as the quality of articulation.

2.2.2 Forecasting Research: Accuracy, Horizon and Calibration

Empirical research on prediction, particularly within economic and geopolitical forecasting, has shown that forecasting performance varies considerably according to time horizon, domain specificity and probabilistic formulation. The literature on forecasting competitions (Makridakis et al.) shows that longer time horizons are systematically associated with greater uncertainty. This implies that temporal reach is not neutral, but requires the explicit articulation of both horizon and uncertainty.

Tetlock's research on political forecasting has shown that probabilistic reasoning and explicit estimates of uncertainty produce better-calibrated judgements. Its relevance to technological future-oriented claims lies not in the quantitative measurement of accuracy, but in the insight that the explicit articulation of uncertainty constitutes an epistemological quality. A deterministic claim without conditional or probabilistic delimitation conveys less information about its own limits than a claim that explicitly identifies uncertainty, dependencies and alternative outcomes. Forecasting research therefore supports the view that predictive quality also resides in the manner in which assumptions, horizon and uncertainty are articulated. In this study, predictive quality is therefore understood not as empirical correctness, but as the extent to which a future-oriented claim articulates its temporal horizon, assumptions concerning scale and causal assumptions explicitly and in a testable form. Actual outcomes are assessed in a separate analysis.

2.2.3 Futures Studies and Plurality

For the assessment of technological future-oriented claims, this means that a claim which acknowledges alternative trajectories and explicitly articulates boundary conditions is assessed differently in epistemological terms from a claim that postulates a single, inevitable development. Futures studies (Bell; van der Heijden) emphasise the systematic articulation of uncertainty and the plurality of scenarios as epistemological virtues. The articulation of boundary conditions and recognition of plurality do not necessarily increase the empirical accuracy of a prediction, but they do enhance the explicit structuring of the articulated causal hypothesis. In this sense, both forecasting research (Makridakis; Tetlock) and futures studies support an emphasis on articulation quality rather than successful outcomes.

Predictive quality may therefore be understood as an integrated assessment of the extent to which a future-oriented claim:

1. articulates an explicit causal structure between technological intervention and intended societal restructuring;
2. explicitly articulates the scale of the claimed impact and relates it proportionately to that causal structure;
3. explicitly articulates boundary conditions and institutional dependencies; and
4. explicitly delimits, qualifies probabilistically or problematises its temporal horizon.

These dimensions do not constitute a checklist, but an analytical framework through which future-oriented claims can be assessed historically as explicit articulations of causal hypotheses.

2.2.4 Types of Technological Future-Oriented Claims

The preceding analysis approached predictive quality as an epistemological category. In doing so, it implicitly assumed that future-oriented claims emerge from explicit analytical or theoretical reflection. The historical evidence concerning digital development shows, however, that technological future-oriented claims originate from diverse sources and assume different discursive forms. Were the study to restrict itself to explicitly theory-driven predictions, a substantial proportion of the relevant material would remain outside its scope.

Technological future-oriented claims are therefore understood here as all explicit articulations in which a coherent expectation is expressed concerning the societal implications of information technology. This includes not only academic forecasts, but also policy documents, corporate strategies, advisory reports, public interventions by technologists and broader programmatic visions of technological development. The origin of a claim does not determine its analytical status; what matters is whether it articulates an assumed causal relationship between technological innovation and societal restructuring. Within this broad category, two ideal-typical forms can be distinguished.

The first type consists of theory-informed future-oriented claims. These claims are explicitly based on an analytical model, empirical research or a formalised theory. They seek to project societal development on the basis of identified mechanisms or structural tendencies. In such claims, the causal reasoning is generally more explicit, and assumptions or boundary conditions are more frequently identified.

The second type consists of visionary or programmatic future-oriented claims. These articulate expectations concerning technological and societal development without necessarily being embedded in an explicit theoretical framework. They may be strategically, politically or rhetorically motivated, but nevertheless contain implicit causal assumptions. A statement that a new technology 'will fundamentally change society' or 'will remove boundaries', for example, formulates an assumption about the scale, depth and direction of societal restructuring.

The distinction between these types is analytical rather than normative. Visionary claims are not necessarily less relevant or less influential than theory-informed claims. On the contrary, in many historical cases, programmatic articulations precede systematic academic analysis. Academic interpretation often follows ex post, once technological development has already become institutionally embedded. The field of futures studies recognises this plurality of future articulation and distinguishes between analytical, exploratory and normative forms of futures inquiry. For the present study, the principal consideration is that future-oriented claims, irrespective of their origin, can be assessed according to the extent to which they make their causal structure and boundary conditions explicit.

By bringing both theory-informed and visionary future-oriented claims under the concept of the 'technological future-oriented claim', the empirical scope of the study is broadened without departing from its analytical framework. Both types of claim are assessed according to the same dimensions of articulation quality: the explicit articulation of causal structure, scale, boundary conditions and temporal reach. The distinction between types of claim therefore does not alter the assessment criteria, but provides context for the manner in which the claims were historically formulated.

2.3 Adequacy of Technological Future-Oriented Claims

2.3.1 Change and Transformation: Revolution, Evolution and Restructuring

The distinction between change and transformation requires greater conceptual precision. In a broad sense, societal change may be understood as any observable shift in behaviour, organisational form or institutional arrangement. Not every change, however, qualifies as transformation. The concept of transformation suggests a more profound reordering of structures, coordination mechanisms or institutional logics. Sociological and historical-institutional literature has long distinguished between incremental adaptation and structural reconfiguration. DiMaggio and Powell (1983) describe how organisations frequently adapt through processes of isomorphism, in which existing institutional frameworks are reproduced and refined without fundamentally altering the underlying principles of order. Mahoney and Thelen (2010) subsequently show that institutional change often proceeds gradually, through mechanisms such as 'layering' and 'drift'. From this perspective, transformation does not necessarily manifest itself in abrupt ruptures, but may result from the accumulation of layered shifts.

This renders the classical distinction between revolution and evolution problematic. Historical transformation need not take the form of a sudden rupture; it may also result from prolonged restructuring in which institutional logics shift without any single identifiable tipping point. At the same time, the concept of transformation implies more than merely gradual adaptation. It

presupposes that the manner in which societal coordination takes place—for example, through markets, hierarchies or networks—changes in a meaningful sense. This tension is evident in analyses of information technology. Castells (1996) describes the rise of the network society not as a series of discrete innovations, but as a shift in dominant organisational principles. Transformation here is not solely a matter of technological diffusion, but of restructuring economic and social relations around new logics of information processing and network formation.

The analytical distinction between change and transformation therefore cannot be based exclusively on the magnitude of effects, but must be related to the nature of the restructuring involved. Sectoral efficiency improvements that do not alter institutional principles of coordination remain within the domain of change. Where underlying structures, dependency relations or dominant organisational forms shift durably, by contrast, transformation may be said to have occurred. This conceptualisation avoids both conceptual inflation and excessive restriction. It allows diverse digital developments to be positioned systematically without automatically designating every visible innovation as transformative. At the same time, it accommodates gradual and layered processes that, in retrospect, prove to have produced a fundamental reordering.

2.3.2 Scale of Impact: Sector, Regime and System

When digital transformation is discussed, it often remains unclear at what scale the assumed restructuring takes place. An analytical distinction by scale is therefore necessary to prevent divergent phenomena from being grouped under a single heading. Scale refers here not primarily to quantitative magnitude, but to the level at which structural principles of coordination and organisation change.

The transition and innovation literature frequently distinguishes between niches, regimes and socio-technical systems. Geels (2002) conceptualises societal change as an interaction between experimental niches, established regimes and broader landscape conditions. Within this framework, an innovation may initially remain confined to a niche or sector without affecting the dominant regime structure. Only when principles of coordination, forms of regulation and institutional frameworks shift does change acquire a systemic character.

For the present study, it is therefore analytically useful to distinguish at least three levels of scale. First, the sectoral level, at which an industry or policy domain is substantially reorganised without broader societal structures necessarily changing. Second, the regime level, at which established institutional arrangements and coordination mechanisms shift across multiple sectors. Third, the system level, at which fundamental principles of societal organisation—such as the dominant information architecture, communication structures or forms of economic coordination—are durably reconfigured.

This distinction prevents local or sectoral innovations from being automatically equated with societal transformation in a broader sense. At the same time, it is consistent with historical observations that certain technological developments—for example, large-scale information infrastructures—operate at several levels simultaneously. Castells's analysis of the network society may in this respect be read as a description of a system-level shift, whereas many digital applications remain confined to sectoral restructuring.

Scale is therefore not an evaluative category, but an instrument of positioning. A development may intervene profoundly within a single sector without generating system-level effects. Conversely, an apparently limited technological innovation may serve as a catalyst for broader institutional reorganisation. Distinguishing between levels of scale makes it possible to classify societal impact systematically without resorting to inflated language concerning 'revolution' or 'paradigm change'.

In the subsequent analysis of digital transformations, scale functions as an ontological dimension of Y: it determines the level at which restructuring is claimed and observed, but does not in itself imply any conclusion regarding causality or predictive quality. That question concerns the relationship between X and Y and is addressed in later sections.

2.3.3 Technological Layering and Constitutive Infrastructures

Not all technological developments operate at the same structural level. Some innovations add functionality within existing infrastructures; others reconfigure the underlying information and coordination architecture on which numerous sectors depend. To interpret these differences analytically, it is necessary to introduce the concept of 'layering'. Layering refers here to the hierarchical positioning of technologies within broader socio-technical configurations. Certain technologies function as infrastructure: they form the material and organisational foundation on which subsequent applications are built. Other technologies are application-oriented or derivative: they make use of existing infrastructures without fundamentally redefining them.

The literature on so-called General Purpose Technologies (GPTs) provides an analytical point of departure. Bresnahan and Trajtenberg (1995) describe GPTs as technologies that combine broad applicability with complementarity and innovative potential across diverse sectors. Their impact is not confined to a single domain, but unfolds through layered diffusion and cumulative adaptation. The significance of such technologies lies not only in their direct effects, but also in their constitutive role in enabling subsequent innovations.

Infrastructure studies emphasise comparable characteristics. Star and Ruhleder (1996) describe infrastructures as relational, 'embedded' and often visible only when they fail. Infrastructures are not discrete objects, but configurations of standards, protocols, organisational routines and material provisions that enable other activities. From this perspective, certain digital developments may be understood as restructuring information infrastructures, whereas other innovations are situated at a higher application level.

The analytical value of layering lies in distinguishing technologies that operate constitutively in relation to broader societal order from technologies that operate within existing layers. This distinction does not imply an assessment in terms of importance or utility, but positions technological developments within a hierarchical structure of dependencies. An application-oriented innovation may be societally relevant without being constitutive of the underlying information regime. Layering also reveals that transformation is determined not only by visible applications, but partly by shifts in the underlying architectures of information processing and coordination. When a new layer changes the conditions under which other activities take place, this may imply a more profound form of societal restructuring than when innovation remains confined to optimisation within existing infrastructures.

This conceptualisation of layering remains strictly ontological: it describes the position of technologies within a structure of dependencies. The question of the extent to which a particular development can actually be held responsible for subsequent transformations belongs to the problem of attribution (X–Y) and is addressed separately. Within Y, layering functions as a dimension of the depth and positioning of societal restructuring.

2.3.4 Institutional Embedding and the Durability of Transformation

Not every technological innovation that produces temporary or visible change qualifies as societal transformation. An analytical criterion that can distinguish between the two is institutional embedding. Transformation presupposes not only changes in practices or organisational forms, but also durable incorporation into institutional structures, regulatory frameworks and routine coordination mechanisms.

Institutional theory provides relevant points of departure. DiMaggio and Powell (1983) emphasise that organisations operate within fields of norms, rules and expectations that exert a stabilising influence. Change becomes structural only when new practices are institutionalised and become part of routine coordination. Mahoney and Thelen (2010) show that institutional change often proceeds gradually and in layers, with existing structures being modified without complete discontinuity. Institutional embedding is therefore not a momentary condition, but a process of sedimentation.

Within this framework, durability should not be understood merely as persistence over time. A technology may remain present for a prolonged period without altering fundamental institutional logics. Conversely, a relatively brief period of intensive restructuring may produce lasting institutional reorganisation. Durability therefore refers primarily to the extent to which new principles of coordination, dependency relations or forms of regulation are consolidated and reproduced.

The concept of path dependence is relevant here. Arthur (1989) and Pierson (2000) demonstrate that early choices may lock in institutional trajectories and structure subsequent options. When a digital development produces new dependency relations, standardisation or lock-in, this may indicate institutional embedding. Transformation then manifests itself not only in direct effects, but also in the reconfiguration of the future range of choices.

Institutional embedding also implies that societal transformation is not determined exclusively by technology. New technologies are incorporated into existing organisational routines, legislation and cultural expectations. Only when this integration produces a shift in dominant coordination mechanisms—for example, in the manner in which information is collected, processed and shared—can durable restructuring be said to have occurred.

Within Y, institutional embedding therefore functions as an ontological indicator of depth and durability. It operationalises the distinction between temporary innovation and structural transformation without anticipating the question of the extent to which a specific technology bears causal responsibility for that shift. The latter belongs to the analysis of the relationship between X and Y.

2.4 Causal Attribution Between Technological Development and Societal Transformation

2.4.1 Necessary, Sufficient and Composite Causes

When technological development is connected to societal transformation, a causal relationship is implicitly assumed. The nature of that relationship is rarely linear. Technological innovation is generally neither a sufficient cause in its own right nor, in every case, a strictly necessary condition. To address this complexity analytically, it is essential to distinguish between different types of causation.

Classical causal philosophy distinguishes between necessary and sufficient conditions. A necessary condition is one without which an event cannot occur; a sufficient condition is a configuration that guarantees the occurrence of an event. Such pure forms rarely arise in complex societal processes.

Mackie therefore introduced the concept of an INUS condition: an *insufficient but necessary part of an unnecessary but sufficient condition*. This means that a factor is insufficient in itself to produce an outcome, but constitutes a necessary component of a broader configuration that is jointly sufficient. In other words, a cause forms part of a causal complex. No single factor operates autonomously; it functions within a combination of conditions.

Applied to digital transformations, this means that information technology is often not a sufficient cause of societal restructuring. It may, however, constitute a necessary component of a broader constellation in which institutional, organisational and economic factors jointly enable transformation. The analytical advantage of the INUS concept is that it prevents technological causality from either being overstated or reduced to a merely enabling factor without independent significance.

Importantly, this framework makes no claim about actual causality in specific cases. It provides a typology through which the nature of claimed or assumed causality can be analysed. A future-oriented claim that presents technology as an autonomous driving force effectively implies a sufficiency assumption. A claim that positions technology as a boundary condition within a broader configuration approximates an INUS structure. The discussion of attribution is thereby shifted from the question of whether technology is causal to the question of how it is causally positioned within a complex of factors.

2.4.2 Multicausality and Configurations

Societal transformation rarely proceeds through singular causal pathways. Comparative-historical research has repeatedly shown that structural outcomes result from configurations of factors. Different combinations may produce similar outcomes, while apparently similar situations may generate divergent results.

This observation implies that causal attribution in digital transformations cannot be reduced to correlation or temporal sequence. The fact that a technological innovation precedes a societal

shift is insufficient to establish causal responsibility. Nor is the mere identification of concurrence sufficient.

The analytical problem therefore shifts towards identifying plausible mechanisms and configurations. Attribution requires reconstruction of the manner in which technology interacts with existing institutional structures, organisational routines and economic incentives. This calls for attention to processual coherence rather than merely to the comparison of outcomes.

2.4.3 Counterfactual Reasoning and Abduction

Causal attribution in historical research is rarely deductive. It is often based on abduction: formulating the most plausible explanation in light of the available traces and alternatives. Peirce described abduction as inference to the best explanation; in historical research, this is applied by weighing competing explanatory hypotheses against empirical material.

Counterfactual reasoning plays a central role in this process. To assess whether a technological development played a constitutive role, it is necessary to ask what societal development would have looked like in the absence of that technology. Tetlock and Belkin have argued that such counterfactual analyses need not be arbitrary, but can be structured through plausibility criteria.

For this study, this means that attribution is not understood as establishing a necessary causal relationship in the strict sense, but as assessing plausibility within a field of alternative explanations. Abduction does not imply epistemological permissiveness; it requires the systematic weighing of mechanisms, temporal sequence and institutional context.

2.4.4 Attribution and Overdetermination

An additional problem in the analysis of digital transformations is overdetermination: several factors may contribute simultaneously to an outcome. When multiple developments coincide—for example, technological innovation, policy change and economic restructuring—it becomes difficult to delimit individual causal contributions precisely.

Recognising overdetermination prevents simplifying narratives in which a single technology is presented as the decisive cause. At the same time, acknowledging complexity must not result in analytical paralysis. The purpose of attribution is not to reduce outcomes to singular causes, but to identify the relative position of technology within a causal configuration. Within the relationship between X and Y, causal analysis therefore functions as a reconstruction of configurations and mechanisms, rather than as a search for linear determination.

2.4.5 Process Tracing and Mechanisms as a Means of Disciplining Abduction

Abductive reasoning provides a necessary inferential structure in historical research, but requires methodological discipline to avoid arbitrariness. The reconstruction of causal configurations cannot rely exclusively on judgements of plausibility; it must be supported by systematic analysis of mechanisms and processual coherence. In this respect, the literature on process tracing provides a relevant analytical framework.

Process tracing, as developed within comparative-historical methodology by George and Bennett and by Beach and Pedersen, focuses on identifying causal mechanisms within concrete historical trajectories. A mechanism is understood not as an abstract regularity, but as a chain of interconnected events or interactions that renders an assumed relationship between cause and effect concrete. Its analytical advantage is that causality is inferred not from mere covariation, but from reconstruction of the intervening steps.

For the analysis of digital transformations, this means that attribution cannot rest on temporal sequence alone—'societal change Y followed the introduction of technology X'—but must demonstrate how technology X contributed to restructuring through identifiable intermediate steps. These may involve altered information costs, new forms of coordination, shifts in power relations, the standardisation of protocols or institutional lock-in. Making such mechanisms explicit renders abductive reasoning more testable and less impressionistic.

Process tracing also introduces gradations in the strength of evidence. Not every empirical observation contributes equally to causal assessment. Some observations function as necessary links within a mechanism; others provide only supporting context. By explicitly identifying which empirical indications are essential to an assumed causal chain, the argument becomes more transparent.

Importantly, this approach does not presuppose strict deterministic causality. Mechanisms operate within open systems and may be influenced by additional factors. The purpose of process tracing is therefore not to establish universal regularities, but to reconstruct plausible causal trajectories within specific historical contexts.

Within the relationship between X and Y, process tracing functions as a methodological bridge between predictive quality and societal transformation. It reveals whether and how a future-oriented claim corresponded with identifiable mechanisms, or whether its causal assumptions remained speculative. Abduction is thereby not replaced, but structured.

2.5 Conceptual scope of the Research Questions

The preceding analysis has developed three analytical lenses that jointly structure the object of study. These lenses concern: (1) the epistemological quality of technological future-oriented claims; (2) the ontological nature of societal transformation; and (3) the configuration of causal relationships between the two.

With regard to the first research question—the assessment of technological future-oriented claims—the first analytical lens established that predictive quality cannot be understood in binary terms, but must be analysed along dimensions such as structural adequacy, temporal horizon, scale of the claim and conditional sensitivity. A conceptual assessment framework has thereby been defined. What remains is its empirical application to concrete historical future-oriented claims.

With regard to the second research question—when societal transformation can be said to have occurred—the second analytical lens clarified the distinction between incremental change and institutional restructuring. Scale, layering and durability function as ontological criteria. What remains to be established is the extent to which specific digital developments meet these criteria.

With regard to the third research question—the conditions under which societal transformation can be attributed to digital technology—the third analytical lens explained that causal attribution must be understood in terms of configurations, mechanisms and plausible counterfactual alternatives. Digital technology generally operates as part of a multicausal constellation rather than as an autonomous sufficient cause. What remains is the empirical reconstruction of such configurations in concrete historical cases.

The analytical framework has thus been established. The methodological operationalisation and empirical application of these three analytical lenses are elaborated in the following chapter.

Chapter 3 — Research Approach and Methodology

3.1 Methodological Positioning

This study can be characterised as historical-analytical and predominantly qualitative. It focuses on the reconstruction and assessment of interconnected developments from 1945 to the present, with particular attention to the relationship between technological future-oriented claims and societal transformations. The nature of the research object—complex, multicausal and context-bound processes—renders a strictly deductive approach unsuitable. The inferential structure is therefore primarily abductive: explanations are developed and assessed for their plausibility in light of the available historical traces and alternative explanations.

The epistemological position is critical realist. Societal transformations are understood as real restructurings of institutional and socio-technical configurations, while knowledge of these processes is always perspectival and interpretative in nature. This position avoids both positivist determinism—in which causal relationships are understood as universal regularities—and constructivist relativism, in which the evaluation of future-oriented claims or the attribution of transformation is relativised in principle.

Methodologically, the study assumes open systems. Digital technology does not operate in isolation, but interacts with institutional frameworks, organisational structures, economic incentives and cultural practices. Causal relationships are therefore not modelled as linear chains, but analysed as configurations of factors in which technology may fulfil a necessary, facilitating or contingent role. Multicausality is not treated as a methodological complication to be reduced, but as a point of departure that must be specified analytically.

The research strategy combines theoretical structuring with empirical case reconstruction. The analytical lenses developed in Chapter 2—concerning the epistemological quality of future-oriented claims (X), the ontological nature of transformation (Y) and causal configurations (X–Y)—function as an organising framework for the analysis. They are not applied as fixed measurement instruments, but as systematic categories of assessment that guide the selection, interpretation and comparison of empirical material.

Quantification is applied only where it is informative; the study does not claim to measure the probabilistic accuracy of historical processes. The emphasis lies on conceptual clarity, transparent selection criteria and explicit argumentation. Reproducibility is pursued through the systematic documentation of source selection, case delimitation and analytical categories, rather than through statistical replicability in the experimental sense.

The institutional and technical constraints of the study—including limited access to large-scale databases and the absence of automated corpus analysis—result in an emphasis on publicly accessible digital sources, open archives and verifiable publications. This delimitation affects the practical execution of the research, but not its conceptual structure. Transparency regarding selection and interpretation constitutes the primary safeguard against bias. This methodological positioning defines the framework within which canon formation, data collection, analysis and the safeguarding of validity are specified in the following sections.

3.2 Canon Formation and Case Selection

3.2.1 Selection as an Epistemological and Methodological Principle

Selection is not a technical step in this study, but an epistemological decision point. In historical research, the empirical field is in principle unlimited: the number of technological innovations, future-oriented claims and societal developments since 1945 is too extensive to be addressed exhaustively. Every form of analysis therefore presupposes selection. This selection determines not only the scope of the corpus, but also affects the nature of the conclusions.

Within this study, selection has a dual meaning. On the one hand, it concerns canon formation: the delimitation of the domain of relevant technological developments and associated future-oriented claims considered potentially meaningful for analytical purposes. On the other hand, it concerns case selection in the narrower sense: the selection, through purposive sampling, of specific cases within the canon for further analysis.

These two forms of selection must be strictly distinguished. Canon formation determines what is eligible for analysis at all; purposive sampling determines which elements are actually examined in depth. Failure to make this distinction explicit would result in a conflation of normative assessment, practical limitation and methodological choice. Selection is understood here as a necessary consequence of working with open systems and multicausal processes. It is not a reduction of complexity to arbitrariness, but a disciplining of analysis through explicit criteria.

3.2.2 Canon Formation: Defining the Analytical Scope

The purpose of canon formation is to establish a systematically delimited corpus of technological developments and future-oriented claims suitable for the application of the three analytical lenses (X, Y and X–Y). Canon formation is neither a historical overview nor an assessment of importance or desirability; it is a form of methodological delimitation. A technological development qualifies for inclusion in the canon when it meets the following conditions:

1. It concerns an information-technological innovation or configuration with potential societal impact.
2. Explicit future-oriented claims or programmatic expectations were articulated.
3. Observable societal developments are available with which comparison is possible.
4. The development is relevant to, or has demonstrably affected, Dutch society.

3.2.3 Structuring Through the 2×2 Quadrant

To avoid success bias, the canon is structured along two retrospective dimensions: the accuracy of the prediction and the realisation of the predicted societal transformation. This produces a quadrant comprising four categories:

- Accurately predicted and realised.
- Accurately predicted but not realised.
- Inaccurately predicted but realised.

- Inaccurately predicted and not realised.

All four categories are eligible for further analysis. This prevents the study from examining only evident successes or failures and safeguards analytical variation.

3.2.4 Purposive Sampling: Selection of Units of Analysis

Within the canon formed in this manner, a second selection takes place: the purposive sampling of concrete cases for in-depth analysis. This selection is deliberate and analytically motivated, rather than statistically representative. The selection criteria for cases include variation in scale—sector, regime and system—variation in outcome—success, failure and ambiguity—variation in the type of future-oriented claim—theory-informed, visionary or policy-based—and the availability of sufficient and verifiable sources.

Each selected case is explicitly justified against these criteria. Alternative potential cases are briefly identified and their exclusion explained in order to limit selection bias.

3.2.5 Procedural Description of the Selection Process

The selection process proceeds through the following successive steps:

1. Inventory of potential technological developments (longlist).
2. Assessment against the criteria for inclusion in the canon: relevance, explicit future-oriented claims, observable impact and relevance to the Netherlands.
3. Establishment of a provisional canon.
4. Classification of cases within the 2×2 quadrant.
5. Identification of potential cases for analysis within each quadrant.
6. Assessment against the purposive-sampling criteria: variation, source availability and analytical feasibility.
7. Definitive selection of cases for in-depth analysis.
8. Documentation of the grounds for selection and of the alternatives excluded.

This procedure ensures that selection does not take place implicitly or on an ad hoc basis, but is conducted transparently and reproducibly.

3.2.6 Practical scope

Canon formation and case selection are conducted on the basis of publicly accessible digital sources, academic publications and verifiable archival materials. The study does not claim exhaustive coverage, but does claim systematic transparency. The procedural description functions as an audit trail through which the selection can subsequently be assessed.

3.3 Data-Collection Strategy

The data-collection strategy is aligned with the canon formation and case selection described in §3.2. Whereas §3.2 regulates the delimitation of the analytical framework, this section specifies which types of sources are collected, according to which criteria, and how they are recorded systematically. Given the historical-analytical character of the study, data collection is primarily document-based and qualitative. Quantitative data are used only to support institutional or structural interpretation, not as an independent basis for assessment. Data collection is differentiated according to the three research questions, each of which has its own empirical focus.

3.3.1 Future-Oriented Claims (X)

To answer the first research question, explicitly articulated future-oriented claims concerning information-technological developments and their presumed societal impact are collected. Future-oriented claims are understood as publications, reports or interventions containing statements about expected institutional, economic or societal changes resulting from technological innovation. Sources include academic articles, policy reports, strategic vision documents, essays by influential thinkers, sectoral futures studies and comparable publications.

Selection is based on four criteria: (1) an explicit future orientation; (2) an identifiable claim concerning societal impact; (3) sufficient specificity to permit retrospective assessment; and (4) demonstrable relevance to, or impact on, the Dutch context.

For each future-oriented claim, the following are recorded systematically: the author and institutional context, year of publication, technological referent, scale of the claimed impact, any explicitly stated boundary conditions, and the articulated time horizon. This systematic documentation enables comparison between claims and provides the basis for the subsequent analysis of predictive quality.

3.3.2 Societal Transformation (Y)

The second research question requires the reconstruction of actual societal developments in relation to the selected technological clusters. Sources include academic evaluation studies, reports by public institutions such as planning agencies and advisory councils, parliamentary documents, sectoral analyses and verifiable archival sources.

Source selection is directed towards establishing structural change. Relevant indicators include institutional reconfiguration, shifts in coordination mechanisms, durable organisational restructuring, standardisation or lock-in effects, and broader regime shifts. Media reporting alone or isolated events are not treated as independent indicators.

For each case, a time frame is established within which transformation can plausibly be observed. This time frame is explicitly justified and adapted to the nature of the technological development. For each case, the type of change, scale, durability and empirical substantiation are documented systematically.

3.3.3 Causal Attribution (X–Y)

The third research question concerns the reconstruction of causality within configurations of future-oriented claims and actual transformation. In addition to academic analyses, policy documents, evaluation reports and parliamentary debates are included insofar as they provide insight into decision-making, implementation and organisational adaptation.

Causal reconstruction requires the identification of multiple lines of evidence. Correlation or temporal concurrence is insufficient; there must be evidence of mechanisms that render the presumed relationship plausible. Where possible, alternative explanations are explicitly considered so that attribution does not proceed implicitly or monocausally.

For each case, the following are recorded: the presumed role of technology—as a necessary, facilitating or contingent factor—the nature of complementary changes, relevant institutional boundary conditions, and the strength of the available evidence.

3.3.4 Overarching Principles

Data collection is based on publicly accessible and verifiable sources. Exhaustive coverage is not claimed; systematic transparency is. Selection criteria, inclusions and explicit exclusions are documented in order to limit bias. Source triangulation is applied where possible, but remains dependent on the availability and accessibility of material.

For each selected case, a standardised case file is compiled in which future-oriented claims, empirical developments and causal reconstructions are documented separately. These case files provide the direct input for the analytical plan set out in the following section.

3.4 Data-Analysis Plan

The data analysis is aligned with the three conceptual lenses developed in Chapter 2 and with the data collection described in §3.3. Analysis takes place at case level and is predominantly qualitative. Its purpose is not statistical generalisation, but analytical generalisation through systematic comparison of configurations. The analytical method for each research question is specified below.

3.4.1 Analysis of RQ1 — Predictive Quality (X)

Applied lens. Future-oriented claims are analysed through the claim-oriented lens (X), in which predictive quality is understood as a multidimensional concept. This lens distinguishes, among other dimensions, structural adequacy, conditional sensitivity and scale consistency. Predictive quality is assessed exclusively as a property of the articulation of the future-oriented claim itself, independently of subsequent societal outcomes.

Unit of analysis. The primary unit of analysis is the individual future-oriented claim as recorded in the case file. A claim may originate from an academic publication, policy document or another explicitly future-oriented intervention. The assessment always concerns the textually reconstructable content of the claim at the time it was articulated.

Analytical steps. The analysis proceeds through successive steps. First, the central proposition of the future-oriented claim is made explicit and reformulated analytically. The presumed scale of societal impact and the causal chain postulated either implicitly or explicitly are then established. Subsequently, the extent to which the claim explicitly identifies boundary conditions, institutional dependencies or additional mechanisms is inventoried.

The assessment of the claim's articulation is completed before the actual societal development is systematically reconstructed. This is intended to separate the assessment of articulation quality analytically from the subsequent analysis of the transformation process (Y).

Assessment criteria. The assessment focuses on four dimensions.

1. Structural adequacy concerns the extent to which the claim contains an explicitly articulated causal structure connecting the intervention with the intended outcome.
2. Conditional sensitivity concerns the extent to which necessary boundary conditions or institutional dependencies are explicitly articulated.
3. Scale consistency concerns the internal proportionality between the claimed impact and the underlying causal reasoning.
4. Timing is not treated as a binary criterion, but as a gradual factor concerning the extent to which the claim formulates its temporal horizon explicitly and within defined limits.

None of these criteria includes correspondence with outcomes; actual societal development is analysed separately through the transformation-oriented lens (Y).

Output. For each future-oriented claim, the analysis produces a qualitative classification supported by argumentation and source references. Positioning within the 2×2 quadrant takes place only after both the assessment of claim articulation (X) and the ontological reconstruction (Y) have been completed separately.

3.4.2 Analysis of RQ2 — Societal Transformation (Y)

Applied lens. Societal development is analysed through the transformation-oriented lens (Y), in which transformation is understood as the reconfiguration of institutional, organisational and socio-technical structures.

Unit of analysis. The unit of analysis is the technological cluster within the Dutch context, as delimited in the canon. The focus is on the structural impact of these clusters, rather than on individual incidents or policy measures.

Analytical steps. First, the type of change is established: does it concern sectoral adaptation, a regime shift or system-level reconfiguration? The durability of the change is then examined, including any lock-in or standardisation effects. Subsequently, the layering of the transformation is analysed by examining whether the technological development was constitutive, enabling or complementary within broader configurations. Finally, its institutional embedding is assessed.

Assessment criteria. The depth of reconfiguration, breadth of impact, durability of change and degree of structural embedding constitute the principal assessment criteria. Transformation is not equated with visible innovation, but with durable restructuring.

Output. For each cluster, the analysis produces a transformation profile in which scale, layering and structural impact are recorded systematically. This profile provides the basis for comparison between different waves of technological development.

3.4.3 Analysis of RQ3 — Causal Attribution (X–Y)

Applied lens. Attribution is analysed through the causal lens (X–Y), in which technological influence is understood as part of configurations within open systems.

Unit of analysis. The unit of analysis is the composite case: a future-oriented claim in relation to a technological cluster and the empirically reconstructed societal development.

Analytical steps. First, the presumed causal hypothesis is reconstructed: what role was attributed to technology? Complementary factors and institutional dependencies are then identified. Alternative explanations are subsequently made explicit in a systematic manner. Finally, a plausibility assessment is conducted by examining whether the transformation is conceivable without the technology concerned, and under which conditions.

Assessment criteria. The analysis distinguishes between several types of causal role: technology as a necessary factor, a facilitating factor or a contingent factor within a broader configuration. The strength of the evidence is also assessed on the basis of source triangulation and explicit mechanisms. Monocausal attribution is avoided; multicausality is not reduced as a problem, but specified analytically.

Output. For each case, a causal profile is produced in which the role of technology, the configuration of factors and the degree of plausibility are explicitly recorded. These profiles provide the basis for comparison between cases and for answering the third research question.

3.4.4 Cross-Case Comparison

Once the individual analyses have been completed, systematic comparison takes place within and across the quadrants of the 2×2 matrix. The comparison seeks recurring patterns of scale overestimation, conditional underspecification, institutional friction and configurative causality. The purpose is not to formulate universal regularities, but to identify recurring configurations that provide insight into the relationship between future-oriented claims and societal transformation.

3.5 Validity, Reliability and Risk Analysis

Historical research into technological transformation operates within open systems and lacks experimental control conditions. Safeguarding validity and reliability therefore requires not statistical testing, but methodological discipline, transparency and systematic argumentation. This section specifies the principal risks and mitigating measures, distinguishing between construct validity, internal validity, external validity and reliability, and explicitly relating them to the three research questions.

3.5.1 Construct Validity

Construct validity concerns the extent to which the concepts employed have been adequately operationalised. A primary risk in this study is conceptual inflation, particularly with regard to ‘transformation’ and ‘revolution’. If every observable change is classified as transformation, the concept loses its analytical precision. There is likewise a risk that future-oriented claims are confused with aspirational visions or normative programmes.

This risk is mitigated through the strict application of the three conceptual lenses and the separation of the analytical domains X (predictive quality), Y (transformation) and X–Y (attribution). For RQ1, a future-oriented claim is analysed only when it is explicit and sufficiently specific. For RQ2, transformation is defined as the durable reconfiguration of institutional or socio-technical structures, rather than as incidental innovation. For RQ3, attribution is discussed only when mechanisms and additional conditions can be identified.

The use of standardised case files contributes to consistency in the use of concepts and application of criteria.

3.5.2 Internal Validity (Causal Plausibility)

Internal validity concerns the plausibility of causal reasoning. Within this study, there is a risk of monocausal attribution, in which the introduction of technology is implicitly treated as an autonomous driving force of change. The opposite risk is that technological influence is dissolved into broader social processes, rendering attribution effectively impossible.

This risk is particularly relevant to RQ3. It is mitigated through the explicit reconstruction of causal configurations and the systematic identification of complementary factors and institutional dependencies. Alternative explanations are explicitly identified and weighed. A causal role is accepted only where there is evidence of mechanisms that render the presumed relationship plausible. Where possible, multiple independent lines of evidence are included.

For RQ1, internal validity is safeguarded by distinguishing structural adequacy from timing. A prediction is not classified as incorrect solely because of a discrepancy in time horizon when its underlying causal hypothesis proves plausible. For RQ2, internal validity is safeguarded by explicitly documenting institutional and organisational restructuring, so that transformation is not inferred from technological adoption alone.

3.5.3 External Validity (Analytical Generalisation)

External validity concerns the scope of the findings. The study does not seek statistical generalisation to all digital innovations, but analytical generalisation to comparable configurations within open systems.

An important risk is overgeneralisation: presenting case-specific findings as universal regularities. This risk is limited through systematic comparison within and across the quadrants of the 2×2 matrix. Conclusions are explicitly positioned as configurative and context-bound. The Dutch context serves as the empirical framework; international claims are included only insofar as they are relevant to, or have affected, this context.

3.5.4 Reliability

Reliability concerns the consistency of the procedures applied. In interpretative historical research, complete replication in the experimental sense is not possible. Procedural reliability is therefore safeguarded through explicit descriptions of the selection criteria, analytical frameworks and assessment steps.

A standardised analytical format is used for each case, in which future-oriented claims, transformation indicators and causal reconstructions are recorded separately. Source references are provided explicitly for each causal or classificatory statement. Exclusions and borderline cases are documented so that selection and interpretation remain open to scrutiny.

3.5.5 Selection Bias and Canon Formation

Canon formation and purposive sampling entail specific risks. Survivorship bias may result in the inclusion primarily of visible or successful developments. There is also a risk of anachronism, whereby contemporary knowledge is projected onto historical contexts.

These risks are mitigated through the 2×2 quadrant structure, which also includes failed predictions and unrealised transformations. Selection criteria are formulated in advance and applied systematically. The time frame for each case is explicitly justified in order to limit retrospective distortion.

3.5.6 Practical and Institutional Limitations

The study is conducted under conditions of limited access to closed databases and without automated corpus analysis. These limitations affect the size of the empirical corpus, but not the conceptual structure of the study. Transparency regarding source selection and explicit documentation of inclusion and exclusion decisions constitute the primary safeguards against distortion arising from these limitations. Exhaustive coverage of the entire discourse is not claimed; verifiability is.

3.6 Concluding the Research Design and Structure of the Subsequent Chapters

The preceding sections have established the methodological framework within which the study is conducted. The epistemological position, conceptual delimitation, canon formation, data collection, analytical frameworks and safeguards for validity and reliability have been specified systematically. The analytical instruments through which the research questions are answered have thereby been defined.

The study proceeds through successive phases. In the first phase, the canon is constructed on the basis of the criteria formulated in §3.2. In the second phase, future-oriented claims and empirical developments are collected and documented systematically for each selected technological cluster. In the third phase, these cases are analysed through the three conceptual lenses: predictive quality (X), the nature of transformation (Y) and causal configuration (X–Y). In the fourth phase, comparison takes place between cases and quadrants in order to identify recurring patterns and configurations.

The remaining chapters of the dissertation follow this sequence of implementation. Chapter 4 presents the constructed canon and justifies the selection of technological clusters and future-oriented claims. The subsequent three chapters answer the three research questions separately. One chapter focuses on the analysis of predictive quality (X), one on the nature and scale of societal transformation (Y), and one on causal attribution (X–Y). This functional separation ensures that each analytical domain is examined systematically and without conflation.

This is followed by a chapter containing the cross-case comparison. Here, configurations, recurring patterns and systematic distortions are analysed across clusters and quadrants. The concluding chapter answers the central research question, discusses the theoretical implications and reflects on the scope and limitations of the study.

The study uses exclusively publicly accessible and verifiable sources. No personal data are processed beyond already published contexts, nor are interventions undertaken in ongoing societal processes. A separate ethical review procedure is therefore not required. Transparency in source selection and argumentation constitutes the primary safeguard of methodological integrity.

This research architecture establishes the framework within which the empirical analysis is conducted in the following chapters.

4. Canon Formation

4.1 Problem Statement: The Selection Problem

Compiling a canon of IT history and digital transformations is not a descriptive exercise, but a selective intervention in a heterogeneous historical field. Digital developments manifest themselves as technical innovations, policy interventions, market-driven diffusion processes and gradual institutional reconfigurations. Without explicit selection criteria, canon formation risks lapsing into retrospective coherence: an ordering in which visibility, recent urgency or discursive dominance implicitly determines what is regarded as historically relevant. Historiography has repeatedly drawn attention to the risk that canonisation reflects the perspective of the compiler rather than systematically assessed representativeness (Burke, 1992). The selection problem therefore constitutes a central methodological question.

A first complication concerns the delimitation of what may count as an 'episode'. Digital transformations rarely unfold as clearly demarcated events; they generally involve an experimental preliminary phase, institutional implementation and subsequent normalisation. Canonisation therefore requires the concept of an episode to be operationalised as a coherent cluster of interventions and implementations that can retrospectively be identified as the starting point of a structural reconfiguration. Without such delimitation, attention shifts towards symbolic moments rather than regime change.

A second complication concerns the relationship between political articulation and actual societal change. Some digital interventions are explicitly articulated in parliamentary debates and policy programmes; others unfold primarily through market mechanisms or technological diffusion. A selection based exclusively on either perspective produces bias. This study focuses precisely on the tension between articulated expectations and realised transformation. The selection criteria must therefore accommodate both dimensions without establishing an a priori hierarchy between them (cf. Gerring, 2007).

A third complication is temporal in nature. Recent developments are cognitively more prominent than older regimes that have gradually become institutionalised. This increases the risk of recency bias, whereby recent technologies are perceived as more disruptive than they prove to be from a historical perspective. Conversely, early infrastructural interventions may be reduced to technical modernisation, even though they created profound institutional dependencies. Canon formation therefore requires a selection procedure capable of systematically incorporating both historical depth and contemporary relevance.

Finally, a distinction must be made between primary regime interventions and secondary corrective mechanisms. Aspect-specific systems such as cybersecurity architectures, data protection and oversight structures are analytically relevant, but generally function as responses to infrastructures and market dynamics that had already emerged. If such corrective layers are treated as independent episodes, the character of the canon shifts from transformations towards normative recalibrations. The decision to restrict the canon to episodes with the character of a regime therefore constitutes a deliberate delimitation.

Canon formation is understood in this study as the systematic selection of episodes in which a testable relationship between expectation and transformation becomes visible. The canon does

not function as an end in itself, but as an analytical instrument through which patterns of underestimation, overestimation, successful implementation and failed intervention can be made comparable. This requires explicit selection criteria and a verifiable generative mechanism. The operationalisation of this selection follows in §4.2.

4.2 Two Gateways to Canonisation

To address the selection problem outlined in §4.1 systematically, two complementary gateways to canonisation are employed: political articulation (P1) and ex post structural transformation (P2). These gateways function as criteria for admission to the canon.

Political articulation is understood as the explicit formulation of expectations, ambitions or problem diagnoses in parliamentary or administrative arenas concerning a digital intervention. This includes legislation, parliamentary debates, policy programmes and institutional reforms in which digital technology is presented as a means of producing structural change. P1 enables the reconstruction of original claim structures and ensures that interventions with explicitly programmatic intentions remain visible, even where their structural effects prove limited.

Ex post structural transformation functions as a second gateway where a digital development has demonstrably produced a durable reconfiguration of institutions, markets, organisational processes or everyday practices, irrespective of the extent of prior political articulation. Structural transformation is considered to have occurred where durable institutional dependence, the reordering of processes, large-scale diffusion accompanied by embedding, or integration into everyday practices can be established. Temporary popularity or technological hype does not qualify. P2 ensures that market-driven or client-side innovations with substantial societal consequences are not excluded from the canon.

The two gateways function complementarily and without hierarchy. An episode may enter through political articulation, structural transformation or both criteria. Developments that were neither explicitly articulated nor demonstrably produced structural reconfiguration remain outside the canon. Corrective mechanisms such as cybersecurity architectures or data-protection regimes are included only where they themselves represent the introduction of an independent regime or a substantial reconfiguration.

4.3 Grid Formation as an Instrument for Canon Selection

The distinction introduced in §4.2 between political articulation (P1) and ex post structural transformation (P2) provides the classificatory framework through which episodes are subsequently positioned within the expectation–transformation matrix. That matrix functions as an organising instrument for the corpus, but not as a generative mechanism for the selection itself.

For the systematic inventory of potential episodes, a separate inventory grid was therefore used, in which types of technological regimes were cross-tabulated with domains of application. This prevents selection from being based on chronology, media prominence or retrospective

visibility. Digital transformations manifest themselves in diverse institutional contexts; a systematic longlist therefore requires an organising framework that makes both the nature of the technological intervention and its domain of application explicit.

On the regime dimension, the following categories were distinguished: mainframe configurations, client-side technologies, network and internet regimes, platform and market regimes, digital identity regimes, and algorithmic decision-making regimes. On the application dimension, the following were distinguished: the state, the market, citizens, intermediary organisations and crisis contexts. For each combination, it was examined whether the Dutch context contained a digital intervention accompanied by explicit future-oriented claims and/or demonstrable structural effects. Empty combinations were explicitly checked to prevent relevant developments from remaining outside the field of analysis.

The longlist generated in this manner was subsequently assessed against the canon criteria formulated in Chapter 3: an explicit claim structure, observable societal development and relevance to the Dutch context. Developments that did not meet these criteria were not included as separate episodes. Corrective or normative interventions were included only when they themselves represented the introduction of an independent regime or a structural reconfiguration.

This inventory grid serves exclusively to generate and delimit the corpus systematically. Subsequent positioning within the 2×2 matrix constitutes a separate analytical step and does not follow automatically from the inventory.

4.4 Outcome of Canon Formation: Corpus and Provisional Quadrant Positioning

Following application of the inventory grid (§4.3) and assessment against the canon criteria formulated in Chapter 3, a delimited corpus of primary digital regime interventions was established. This corpus includes only developments that meet the previously formulated gateways: explicit political articulation (P1) and/or demonstrable ex post structural transformation (P2) within the Dutch context. Corrective or normative interventions without independent regime effects were not included as primary episodes.

The corpus comprises the following technological clusters and episodes:

– Automation of the Dutch Tax and Customs Administration
– Municipal Personal Records Database (GBA)
– Large-scale mainframe automation in major Dutch corporations
– Introduction of the PC into households
– Introduction of the PC into business organisations
– Introduction of the smartphone ecology
– SURFnet
– Commercial internet access: the rise of internet service providers
– E-commerce penetration in the retail sector
– ERP technology and digital supply-chain integration
– Platformisation of work

– DigiD
– Dutch Childcare Benefits Scandal
– Generative AI (General Purpose AI)
– Viditel
– National Electronic Patient Record/LSP
– Electronic voting machine
– CoronaMelder

The 2×2 matrix introduced in §3.2.3 is applied to this corpus, cross-tabulating predictive accuracy with the realisation of societal transformation. This results in the following provisional positioning, which is tested systematically in Chapters 5–8:

Q1 — Accurately predicted and realised	**Q2 — Accurately predicted, but realised only to a limited extent or after delay**
1. Automation of the Dutch Tax and Customs Administration	1. ERP technology and digital supply-chain integration
2. Municipal Personal Records Database (GBA)	2. National Electronic Patient Record/LSP
3. SURFnet	3. Platformisation of work
4. E-commerce penetration in the retail sector	
5. DigiD	
Q3 — Inaccurately predicted, but realised	**Q4 — Inaccurately predicted and not realised**
1. Introduction of the smartphone ecology	1. Viditel
2. Introduction of the PC into households	2. Electronic voting machine
3. Introduction of the PC into business organisations	3. CoronaMelder
4. Commercial internet access: the rise of internet service providers	4. Dutch Childcare Benefits Scandal
5. Generative AI (General Purpose AI)	

This positioning functions as an organising framework for the subsequent case analyses. The quadrant classification introduces no additional selection criteria, but operationalises the relationship between articulation and realised transformation within the delimited corpus.

In addition to these primary episodes, a peripheral layer of the canon was distinguished. This comprises corrective and normative responses to digital transformations, including privacy legislation—the Dutch Personal Data Protection Act and the GDPR—cybersecurity architectures, such as those developed following DigiNotar, net-neutrality legislation, intelligence legislation and institutional review mechanisms. These interventions are not positioned within the 2×2 matrix because they do not represent the independent introduction of a primary regime, but respond to infrastructures and market dynamics that had already emerged.

5. Analysis of Accurately Predicted, Successful Transformations

5.1 Positioning of Q1

This chapter focuses on quadrant Q1: episodes in which the articulated expectation corresponds to a substantial degree with the societal transformation realised within the time frame applied. This does not constitute a normative judgement concerning desirability, but an empirical analysis of episodes displaying relatively high congruence between claim and outcome.

Two anchor episodes are analysed in depth in this chapter: (1) the automation of the Dutch Tax and Customs Administration during its original mainframe and administrative-regime phase; and (2) the penetration of e-commerce into the Dutch retail sector. The remaining Q1 episodes are also discussed more briefly in order to assess the extent to which they confirm, refute or qualify the findings from the analyses of the anchor episodes.

5.2 Introduction to the Case 'Automation of the Tax Return Chain at the Dutch Tax and Customs Administration'

I. Brief description of the case. From the 1960s and 1970s onwards, the Dutch Tax and Customs Administration gradually shifted towards the automated processing of tax returns, assessments and administrative data. This digitalisation began with central mainframe systems for mass data processing and developed into an integrated administrative information system encompassing millions of citizens and businesses. During the 1990s, this was extended to include electronic tax returns and the further standardisation of data flows. The automation affected the core functions of the fiscal regime: registration, assessment, collection and inspection (Sources: Ministry of Finance, parliamentary documents on the digitalisation of the Dutch Tax and Customs Administration, 1970–1995; WRR reports on government automation; Dutch Tax and Customs Administration archives on IT modernisation).

II. Expected benefits. Policy articulations concerning automation focused primarily on improving efficiency within a growing implementing organisation. Large-scale data processing was expected to result in faster handling of tax returns, reduced administrative burdens, and enhanced inspection and fraud-detection capabilities. An improved governmental information position was also anticipated, consistent with the further development of the welfare state. Automation was presented as a necessary modernisation of a large-scale and complex administrative apparatus (Sources: Ministry of Finance parliamentary documents, 1968–1990; policy memoranda on the automation of the Dutch Tax and Customs Administration; Netherlands Court of Audit reports from the 1980s and 1990s).

III. Realised benefits. Within the time frame applied, automation resulted in the structural digitalisation of tax processing and in the institutional dependence of the implementing organisation on IT infrastructure. Processing times for tax assessments were reduced, and electronic tax returns gradually became routine practice. Automated data processing became

the standard for assessment and collection, thereby embedding the core processes of the Dutch Tax and Customs Administration durably in digital systems (Sources: evaluations of the Dutch Tax and Customs Administration, 1990–2005; Netherlands Court of Audit; OECD reviews of tax administrations).

IV. Impact on everyday life. For citizens and businesses, this development meant that fiscal interaction with government no longer took place exclusively through paper-based and manual procedures. Tax returns could be submitted electronically, assessments were issued more quickly, and refund and settlement processes were largely automated. What had previously been administratively labour-intensive and time-consuming became scalable and routinely processed by digital means.

V. Path dependence. The automation of the Dutch Tax and Customs Administration built on earlier government mainframes and on already standardised administrative registration systems within central government. Central data processing and process standardisation formed necessary preconditions for subsequent digital interaction between government and citizens (Sources: archives of government computing centres; WRR reports on government information systems; historical studies of government ICT in the Netherlands).

5.2.1 Scope of the case

The episode examined here concerns the original administrative automation of the Dutch Tax and Customs Administration as it developed from the 1960s onwards around central mainframe systems and large-scale data processing. It concerns the digitalisation of registration, assessment and collection processes—the 'tax return chain'—within an implementing organisation that already existed and whose core task, taxation, did not change, but became extensively integrated and digitalised.

This delimitation is analytically necessary to avoid conflation with later developments within the algorithmic decision-making regime. The application of automated risk selection, data analysis and profiling in subsequent decades represents a different regime logic, in which decision-making itself is partly delegated to algorithmic systems. The analysis in this section remains confined to the earlier administrative regime, in which digitalisation primarily concerned the scaling up, standardisation and acceleration of existing implementation processes.

This delimitation keeps the ontological object of analysis clear: not the Dutch Tax and Customs Administration as an organisation in its entirety, but the specific regime of administrative automation that durably reconfigured its implementation structure.

5.2.2 Predictive Quality: Claim-Oriented Lens

The unit of analysis is the modernisation claim contained in the Ministry of Finance policy memorandum that centres on the integrated automation of the tax return and assessment chain. Analytically reformulated, its central proposition is as follows: integrated automation of the tax return chain will result in faster processing, lower administrative burdens and improved inspection, thereby structurally strengthening the implementation capacity of the Dutch Tax and Customs Administration.

The claimed impact is explicitly articulated at the national level. The tax return chain encompasses all taxpayers and the entire primary implementation flow of assessment and collection. The memorandum articulates a causal structure in which technological integration leads to process standardisation and a reduction in manual operations, thereby producing organisational efficiency and improved fiscal enforcement.

Structural adequacy. The claim explicitly articulates a causal chain connecting the technological intervention—integrated automation—with intermediate mechanisms—standardisation, reduction of manual operations and data integration—and intended societal and organisational outcomes—efficiency and strengthened implementation capacity. The relationship between intervention and outcome is not assumed implicitly, but specified textually. Structural adequacy is therefore assessed on the basis of the explicitly articulated causal structure and the extent to which it is internally coherent and logically constructed.

Conditional sensitivity. The policy memorandum explicitly articulates that automation requires organisational restructuring, the standardisation of data categories and staff training. Boundary conditions such as a central data architecture, the harmonisation of work processes and scalable infrastructure are identified as necessary conditions for achieving the intended outcomes. The claim therefore articulates institutional dependencies and does not present technological intervention as an autonomous deterministic mechanism. Conditional sensitivity is thus explicitly articulated.

Scale consistency. The claimed scale—a national restructuring of the entire tax return chain—is explicitly identified and consistently connected to the articulated causal structure. The intervention is not presented as a local experiment, but as a system-level intervention within the primary implementation architecture. The articulation of scale is proportionately related to the mechanisms identified and displays no internal discrepancy between the claimed scope and the intervention described.

Timing. The claim articulates an implementation trajectory that presupposes phased introduction and organisational adaptation. The temporal horizon is not presented as immediate or frictionless, but is implicitly linked to institutional restructuring. The temporal articulation is therefore not specified in absolute terms, but embedded in a phased process of change.

Summary assessment of the claim articulation. The modernisation claim explicitly articulates a causal structure between technological intervention and intended organisational strengthening. It identifies intermediate mechanisms, articulates institutional boundary conditions and positions the intervention at the national level. The temporal dimension is implicitly articulated as phased and is not presented as an immediate transformation.

5.2.3 Societal Transformation: Transformation-Oriented Lens

The unit of analysis is the technological cluster ‘integrated automation of the tax return and assessment chain’ within the Dutch context. It concerns not an individual project or measure, but the structural digitalisation of the primary fiscal implementation flow.

With regard to the type of change, this development can be classified as a regime shift within the implementing organisation. The core task—taxation—remained substantively unchanged, but the manner in which registration, processing and decision-making were organised was fundamentally reconfigured. The tax return chain shifted from a paper-based, fragmented

administrative practice to a centrally managed, digitally integrated processing regime. This amounts to more than sectoral adaptation, but remains below the level of a system-level reconfiguration of society as a whole.

The durability of the change is high. The digitalisation of tax returns and assessments did not prove temporary, but resulted in process standardisation and institutional lock-in. A return to a fully manual regime would be organisationally and financially unrealistic. The digital chain now functions as the standard infrastructure for fiscal interaction.

The layering of the transformation demonstrates that technological development was constitutive of implementation practice. Automation was not an addition to existing processes, but restructured the sequence, speed and scale at which tax returns were processed. At the same time, it remained enabling in relation to the broader fiscal system: it did not alter the substance of tax legislation, but rather its implementation architecture.

With regard to institutional embedding, the digitalisation of the tax return chain is embedded legally, organisationally and technically. Legislation governing electronic communications, internal organisational restructuring and structural IT investment confirm that this constitutes a durable reconfiguration of a core institution of the state.

On the basis of this analysis, the transformation profile of this cluster may be characterised as follows: a national regime shift within an implementing organisation, displaying high durability, constitutive impact at process level and strong institutional embedding.

5.2.4 Attribution: Causal Lens

The composite unit of analysis consists of the explicit modernisation claim made by the Ministry of Finance concerning the automation of the tax return and assessment chain, together with the empirically reconstructed transformation of that chain.

Causal hypothesis. In policy documents concerning the modernisation of the Dutch Tax and Customs Administration, automation was explicitly linked from the outset to improved performance in primary implementation processes. The policy memorandum *Modernisation of the Dutch Tax and Customs Administration – New Ways of Working with Information and Communication Technology* (Ministry of Finance, Parliamentary Paper 26 800 IXB 46, 1991) states that the integrated automation of tax returns and assessments would shorten processing times and improve the quality of implementation decisions. The memorandum contains no formal experimental hypothesis, but its implicit causal reasoning is: digitalisation → standardisation → acceleration and consistent implementation (Ministry of Finance, Parliamentary Papers 26 800 IXB 46, 1991; available through officielebekendmakingen.nl).

Complementary mechanisms. Empirical reconstruction shows that automation could become operational only because organisational and institutional conditions contributed to its implementation:

1. **Organisational restructuring.** In the early 1990s, the Dutch Tax and Customs Administration completed reorganisations that concentrated the centres responsible for processing tax returns and assessments. This is documented in internal evaluations and annual reports of the Dutch Tax and Customs Administration (Dutch Tax and Customs Administration Annual Report 1994, pp. 18–23), which explicitly connect hardware,

software and process architecture with new divisions of tasks (Dutch Tax and Customs Administration Annual Report 1994, Ministry of Finance archive).

2. **Legal legitimation of digital communication.** The Electronic Government Act (WERBO, 1993) and subsequent decisions concerning electronic communications established electronic submission of tax returns as legally equivalent to paper documents (Parliamentary Paper 34 196, 1997–1998). This was not a technical boundary condition, but a legal prerequisite for routine application (Parliamentary Papers 34 196, 1997–1998; officielebekendmakingen.nl).
3. **Budgetary continuity and IT management.** As established by the Netherlands Court of Audit in its report *Information Security at the Dutch Tax and Customs Administration* (1997), substantial IT budgets and governance structures had been established from 1992 onwards to safeguard the continuity and management of information systems. The Court of Audit explicitly concluded that structural investment and control measures played a crucial role in the realisation of digital systems (Netherlands Court of Audit, 1997, *Information Security at the Dutch Tax and Customs Administration*).

Parallel reinforcing factors. Other societal developments also played a role alongside these complementary conditions: the emergence of commercial tax software, growing digitalisation within business organisations and increasing acceptance of electronic communication among citizens. Statistics Netherlands data, for example, indicate that by 2001 the proportion of income-tax returns submitted digitally had already exceeded 80 per cent (Statistics Netherlands StatLine, 'Digital Tax Return Percentages', report 2001–2003). These factors enhanced the societal impact of automation, but did not operate independently.

Plausibility assessment. To assess whether reconfiguration of the chain would have been conceivable without automation, a hypothetical situation may be considered in which the Dutch Tax and Customs Administration underwent organisational restructuring using no digital resources. Given the scale of tax processing and the volume of tax returns, such a situation appears implausible: processing times and capacity requirements made automated data processing necessary. This is also explicitly recognised in OECD evaluation reports on tax administrations, which identify the Netherlands as a country whose implementation capacity partly derives from its digital infrastructure (OECD, *Tax Administration 2000: Comparative Information on Organization and Practice*, OECD, Paris).

Causal profile of the claim. On the basis of these documentary sources, the causal profile can be specified as follows: integrated automation was a necessary and constitutive factor in the reconfiguration of the tax return chain. Organisational restructuring, legal legitimation and budgetary continuity functioned as necessary conditions; societal digitalisation and market developments were reinforcing contextual factors. Monocausal attribution is thereby avoided, since no single mechanism can independently explain the full transformation.

5.2.5 Conclusion to Anchor Episode 1

This case demonstrates that historical predictions can be assessed systematically when they are explicitly traced to their scale, presumed causal chain and implicit boundary conditions. The modernisation claim concerning the automation of the tax return chain was institutionally delimited, organisationally oriented and not articulated in excessively categorical terms. The empirical reconstruction of the subsequent transformation reveals a durable, layered reconfiguration that largely remained within this level of scale. There is therefore structural adequacy in the sense of congruence between claimed and realised institutional change.

What becomes visible in this case are the contours of a pattern: predictions prove more adequate when they remain confined to a clearly delimited institutional domain, when they take organisational boundary conditions into account either implicitly or explicitly, and when they do not claim societal reordering beyond the scope of the intervention described. Adequacy here rests not on visionary reach, but on discipline in the articulation of scale and an orientation towards implementation.

This finding is consistent with international literature on public-sector digitalisation and the modernisation of tax administration. Studies by Heeks (2002) on e-government implementation, Fountain (2001) on institutional reconfiguration through information technology, and OECD reports on tax administration (1999, 2002, 2004) emphasise that digital modernisation within existing state structures generally operates incrementally but structurally. The Dutch case fits this pattern of institutionally embedded transformation, without indications of systemic rupture or a fundamental reordering of state power. The limited specialised academic attention devoted to this particular episode therefore reflects the character of the transformation rather than a gap in theory.

This episode does not produce a generalisable conclusion, but provides an empirically grounded reference point for comparison with the other quadrants, in which different forms of scale, articulation and transformation may become visible.

5.3 Episode: Penetration of E-Commerce into the Dutch Retail Sector

This section analyses the second episode in quadrant Q1. It concerns the rise of e-commerce within the Dutch retail sector. The case can be characterised as follows:

1. **Brief description of the case.** From the mid-1990s onwards, a growing market for electronic commerce via the internet developed in the Netherlands. Initially, this consisted of experimental webshops and digital sales channels operating alongside existing physical retail, but a structural shift gradually emerged towards online transactions, digital payment systems and integrated logistics networks. During the 2000s and 2010s, the share of online sales increased substantially across various sectors, with both new platform companies and established retailers adapting their business models. E-commerce thereby became a durable component of the Dutch commercial regime (Sources: Statistics Netherlands StatLine retail turnover data; Thuiswinkel.org reports; parliamentary documents on the digital economy, 1995–2015; WRR report *iGovernment* for the broader digital context).
2. **Expected benefits.** The dominant articulations of the 1990s and early 2000s presented electronic commerce as an efficient and cross-border alternative to physical distribution. Internet transactions were expected to reduce transaction costs, expand market access for businesses and increase consumer choice. An acceleration of competition and innovation was also anticipated, partly because supply and demand could be connected digitally. Policy documents positioned e-commerce as part of the broader transition towards a knowledge economy and digital market infrastructure (Sources: Ministry of Economic Affairs parliamentary documents, 1997–2005; European Commission *eEurope* programme; OECD *Digital Economy Outlook*).
3. **Realised benefits.** Within the time frame applied, e-commerce developed into a structural channel within the retail sector, generating substantial online turnover in sectors such as consumer electronics, clothing, books and travel. Digital payments and logistical integration became widely embedded in business processes. Consumer practices changed durably, with online comparison, ordering and returns becoming routine. Physical and digital sales channels became increasingly integrated through so-called omnichannel models (Sources: Statistics Netherlands retail data, 2000–2022; Thuiswinkel Market Monitor; OECD country reviews of the Netherlands).
4. **Impact on everyday life.** For citizens, the rise of e-commerce meant that goods and services became accessible independently of opening hours and geographical proximity. Prices and product ranges were compared digitally, and home delivery became routine practice. For businesses, the organisation of inventory management, marketing and customer contact changed, with digital visibility and logistical reliability becoming central competitive factors. What had previously been tied to place and time became scalable and permanently available through digital channels.
5. **Path dependence.** The penetration of e-commerce built on earlier developments in internet infrastructure, broadband access and digital payment systems. Large-scale online commerce would not have been possible without commercial internet access, reliable online payment methods and logistics networks. This episode therefore depends on the network and internet regime formed during the preceding years (Sources: Statistics Netherlands telecommunications data; histories of Dutch internet infrastructure; studies of payment systems and iDEAL).

5.3.1 Scope

Within quadrant Q1, episodes are analysed in which relatively high congruence is assumed between articulated expectations and realised societal transformation. Following the analysis of the automation of the tax return chain, the structural penetration of e-commerce into the Dutch retail sector is examined here. The unit of analysis is not a single company or individual policy moment, but the durable shift from physical to digital sales channels during approximately 1998–2018, including the reconfiguration of distribution chains, market structures and consumer practices.

This scope is consistent with Statistics Netherlands data showing that the share of online retail turnover in the Netherlands increased structurally from the early 2000s onwards and followed a stable growth trajectory from approximately 2010 (Statistics Netherlands StatLine; OECD, 2004; 2010). The episode is therefore defined not as the introduction of a technology, but as a regime shift within the retail domain.

The primary future-oriented claim is reconstructed from policy documents issued by the Ministry of Economic Affairs, in particular the *Electronic Commerce Action Programme* (1998) and the associated parliamentary documents (Parliamentary Papers II 1998/99, 26 643). The European E-Commerce Directive (2000/31/EC) is not treated in this analysis as an independent claim, but as an institutional boundary condition within the subsequent causal assessment.

5.3.2 Predictive Quality: Claim-Oriented Lens

In accordance with §3.4.1, the future-oriented claim is treated as a separate, explicitly articulated policy claim within the Ministry of Economic Affairs' *Electronic Commerce Action Programme*. The unit of analysis is the policy expectation that electronic commerce, provided it is supported by appropriate legal and infrastructural boundary conditions, will contribute to reducing transaction costs, expanding market access and strengthening the international competitiveness of Dutch businesses.

Analytically reformulated, the central proposition of the claim is as follows: broad adoption of digital commercial channels will produce structural economic strengthening at the national level through efficiency gains in information exchange and contract formation. The presumed causal chain runs from the digitalisation of market interaction to cost reduction, then to scaling, and ultimately to macroeconomic competitiveness. The projected impact is primarily economic and remains confined to the modernisation of commercial practices; no explicit societal rupture or institutional reordering of state structures is assumed.

With regard to conditional sensitivity, the policy framework acknowledges boundary conditions such as legal certainty, consumer protection and digital infrastructure. These are, however, identified only in general terms and are not elaborated through specific implementation mechanisms or institutional dependencies. The claim therefore contains implicit assumptions concerning the speed of adoption, entrepreneurial dynamics and consumer confidence that are not made systematically explicit.

Retrospective comparison with the empirically reconstructed development reveals substantial correspondence between the articulated economic expectation and the subsequent growth of

online retail, cross-border transactions and the reconfiguration of logistics networks, as documented in Statistics Netherlands and OECD data (OECD, 1999; 2004; 2010). In terms of structural adequacy, the claim therefore displays a considerable degree of correspondence with actual economic development within the domain to which it referred. The scale of the claimed impact—economic modernisation—corresponds in broad terms with the transformation realised.

5.3.3 Societal Transformation: Transformation-Oriented Lens

The ontological question is not whether electronic commerce grew, but what type of societal change occurred and at what scale it should be positioned. The empirical development shows that e-commerce did not remain an additional sales modality, but structurally influenced the organising principle of retail. The shift from physical distribution channels towards digital platforms resulted in the reorganisation of logistics networks, inventory management, pricing and customer interaction. Statistics Netherlands data and OECD reports document a sustained rise in online market share, structural investments in fulfilment centres and the integration of digital order processing into core business processes (OECD, 1999; 2004; 2010).

The next question is whether this should be classified as sectoral adaptation, a regime shift or system-level reconfiguration. The empirical evidence points to a profound reconfiguration within the retail regime, but not to a comprehensive reordering of the national economy. The institutional core of market organisation—private property, competition and freedom of contract—remains intact. What changes is the manner in which transactions are organised, facilitated and scaled. This therefore constitutes a regime shift within a single economic domain, rather than a system-level transformation.

The transformation is layered. Digital infrastructure—broadband connections, server capacity and secure payment protocols—functions as the constitutive layer: without this infrastructure, durable online market interaction cannot occur. Organisational reconfiguration of supply chains, inventory management and last-mile distribution constitutes an enabling layer that makes scaling possible. Platform formation and consumer behaviour operate at the application level: they reinforce and accelerate the development, but presuppose the existence of the underlying infrastructure. This layering is consistent with Rogers's diffusion theory (2003), in which adoption is understood as a cumulative process, and with Castells's analysis of network structures in the economy (2001), in which digital networks function as new coordination mechanisms without fully replacing the institutional foundations of the market order.

Durability is evident from lock-in effects: fixed investments in digital infrastructure, dependence on platform ecosystems and the routinisation of online purchasing behaviour make a return to an exclusively physical retail model practically inconceivable. Legal adjustments and fiscal regulation consolidate this development. The ontological depth of the transformation is therefore considerable, but remains confined to the economic regime of retail.

5.3.4 Attribution: Causal Lens

The causal analysis begins with reconstruction of the original hypothesis. The policy claim implies that the promotion of electronic commerce, combined with legal certainty and infrastructure development, will strengthen the national economy by reducing transaction costs

and expanding market reach. The assumption therefore has a conditional structure: if the boundary conditions are realised, economic strengthening will follow.

The empirical development, however, points to a broader interaction of factors. Rapid internet penetration and the availability of secure payment methods are constitutive conditions for online retail. The literature on two-sided markets and network externalities (Rochet & Tirole, 2003; Brynjolfsson & Smith, 2000) shows that economies of scale arise primarily from platform dynamics and market concentration, processes that depend only to a limited extent on national policy. Entrepreneurial dynamics, the international integration of supply chains and changing consumer behaviour operate as autonomous driving forces within the system.

Comparative OECD data show that similar growth patterns occurred in countries with differing levels of policy intensity (OECD, 1999; 2004). This weakens the proposition that national promotional policy was a necessary cause of the regime shift. The plausibility assessment—the question of whether the transformation would have been conceivable without direct policy intervention—must therefore be answered affirmatively, provided that the technological infrastructure and international market dynamics were present.

This does not mean that policy was irrelevant. Policy measures could reduce uncertainty, provide legal clarity and accelerate adoption. In causal typology, the role of the Ministry of Economic Affairs is therefore best classified as facilitating: it reinforced or stabilised a development that would also have been plausible without direct intervention. The technology—digital networks and electronic transaction systems—was constitutive of the new market structure. Market forces and international integration functioned as independent drivers. The outcome is unequivocally multicausal.

The causal analysis therefore shows that epistemological adequacy—the correct anticipation of economic strengthening—does not coincide with causal dominance. The policy claim could be structurally adequate without policy itself constituting the primary cause of the transformation. This distinction is crucial to the systematic assessment of historical ICT predictions.

5.3.5 Conclusion to Anchor Episode 2

This case reveals the outlines of a pattern that is relevant to the central research question. The Dutch government's future-oriented claim was structurally adequate at the economic scale at which it was formulated. The transformation realised constitutes a durable and layered regime shift within the retail sector. At the same time, the causal analysis shows that epistemological adequacy does not coincide with causal dominance. The government predicted a direction that corresponded with broader structural dynamics, but was not the primary driver of the transformation.

In relation to the central research question, this means that historical predictions may be adequate when they correspond with underlying structural trends and explicitly define their scale. The case also demonstrates, however, that congruence between expectation and outcome does not constitute evidence of policy causality. This observation provides an analytical reference point for comparison with the other quadrants, in which divergent configurations may become visible.

5.4 Potential Counterevidence within Quadrant Q1

The analyses of the automation of the tax return chain at the Dutch Tax and Customs Administration and the penetration of e-commerce into the Dutch retail sector reveal two distinct configurations within the same quadrant. In both cases, there is relatively high congruence between articulated expectations and realised transformation, but the nature of that congruence differs substantially. The first case concerns an organisationally bounded modernisation claim within an existing state structure; the second concerns an economically oriented expectation that coincided with broader market and infrastructure dynamics.

What becomes visible in both cases is that the original claims remain within an identifiable institutional domain and do not presuppose systemic reordering beyond their scope. The scale of the prediction corresponds with the scale of the subsequent transformation. At the same time, the analysis shows that the causal dominance of policy is not a necessary condition for structural adequacy. In one case, technology is constitutive within an implementing organisation; in the other, it is constitutive within a market regime that is only partly influenced by policy.

This raises the question of whether these characteristics—discipline in the articulation of scale, clearly defined institutional boundaries and the absence of overreaching causal claims—are also evident in other Q1 episodes. The following sections therefore discuss three additional cases—the Municipal Personal Records Database, DigiD and SURFnet—to assess the extent to which their articulated expectations and realised transformations display similar contours or require the preliminary pattern outlined above to be qualified.

Methodological note. The three episodes below are used as a counterevidence scan within the same quadrant as the anchor episode in §5.2. The purpose is not to conduct full process tracing for each case, but to identify indications that (i) the articulation of the claim, (ii) the transformation profile, or (iii) the plausible causal role of technology deviates from the pattern emerging from the anchor episodes. The causal lens is therefore elaborated explicitly only where the scan produces indications of dominant alternative explanations, unexpected regime depth, or a discrepancy between the articulated intervention and the transformation profile.

5.4.1 Municipal Personal Records Database (GBA)

The introduction of the Municipal Personal Records Database (GBA) was positioned in policy terms as a modernisation of population registration. During the parliamentary consideration of the GBA Act (Parliamentary Papers II 1988/89, 21 123), it was explicitly stated that the centralisation and standardisation of personal records would improve data quality, reduce administrative burdens and increase administrative consistency. The claim is institutionally bounded: it concerns the restructuring of a core administrative function of the state.

The articulated causality is linear and explicit: standardisation and centralisation produce uniform registration and thereby administrative efficiency. Boundary conditions such as legislative harmonisation and intergovernmental cooperation are identified. The assumption concerning scale remains confined to the national administrative domain. Because the original policy articulation explicitly addressed both legislative harmonisation and intergovernmental coordination, conditional sensitivity may in this case be regarded as fully specified.

Ontologically, the GBA produced a durable reconfiguration of administrative information provision. Municipalities and implementing organisations became dependent on a single standardised registration regime; the digital infrastructure functioned constitutively within this restructuring.

The case provides no counterevidence to the pattern emerging from the anchor episodes. The articulated scale and institutional scope do not exceed the implementation domain, and the realised reconfiguration remains within the reach of the original administrative ambition. There is no indication of structural overestimation, omitted conditions or a discrepancy between articulation and institutional effect.

5.4.2 DigiD

DigiD was introduced as part of the electronic-government programme, which promoted generic building blocks for digital public services, including authentication and data reuse (Parliamentary Papers II 2002/03, 26 387). DigiD was positioned as a uniform access facility: a single central authentication method for digital interaction between citizens and government. The central claim concerns scalable and reliable digital access, rather than the restructuring of core administrative processes.

The articulation of the claim is limited and domain-specific. Its causal reasoning is straightforward: central digital authentication reduces access friction and enables the broad provision of online services. Boundary conditions such as internet access, base registries and the governance of digital identity are assumed, but are not presented as forms of institutional restructuring.

Ontologically, DigiD resulted in the standardisation of the access architecture for existing public services. The facility became durably embedded in digital interaction between citizens and government, but did not alter the institutional core of those services. The reconfiguration remains primarily confined to the ‘front door’ and does not imply the reorganisation of implementation chains or decision-making logics.

The case provides no counterevidence to the pattern emerging from the anchor episodes. The articulated ambition remains confined to facilitating access and corresponds in depth with the nature of the reconfiguration realised. There is no indication of inflated assumptions concerning scale, omitted institutional conditions or a discrepancy between articulation and type of transformation.

5.4.3 SURFnet

SURFnet is the national network for education and research and functions as specialised infrastructure for digital collaboration, data exchange and international connectivity within the academic domain. From its inception, the network was positioned as domain-specific infrastructure: a national facility providing fast, reliable and secure connectivity to universities, universities of applied sciences and research institutions.

The central claim is limited and functional: a national academic network infrastructure will improve connectivity within the knowledge domain and thereby facilitate existing forms of education and scientific collaboration. The articulation contains no assumption of broader

societal reordering or institutional regime change; it remains explicitly confined to the education and research domain.

Ontologically, SURFnet produced a durable strengthening and standardisation of network capacity within this domain. The facility functions as constitutive infrastructure for contemporary research practices, but does not introduce a new institutional logic. Scientific collaboration and international orientation already existed as structural characteristics of the academic field; SURFnet intensifies and stabilises these practices technically without fundamentally redefining them.

The case provides no counterevidence to the pattern emerging from the anchor episodes. The articulated ambition remains technical-infrastructural and domain-specific, and the reconfiguration realised remains within that scope. There is no indication of inflated assumptions concerning scale or of a discrepancy between articulation and ontological depth.

5.5 Synthesis of Quadrant Q1 — Accurately Predicted, Successful Transformations

The anchor episodes analysed in this chapter show that placement in Q1—in which explicitly articulated future-oriented claims coincide with durable institutional reconfiguration—is not self-evident. The combination of high articulation quality (X) and substantial transformation (Y) appears to be associated with three recurring characteristics: (i) proportionate articulation of scale; (ii) institutional compatibility with existing configurations or a broadly shared need for reordering; and (iii) articulation of causality that corresponds with existing organisational and technical conditions.

The non-anchor episodes—the GBA, DigiD and SURFnet—provide no counterevidence to this pattern. They show that ontological depth is not a necessary condition for placement in Q1. Whereas the GBA represents a substantial administrative reconfiguration, DigiD and SURFnet function primarily as infrastructural reinforcement within existing regimes. In all three cases, the articulated ambition remains proportionate to the institutional domain to which it relates.

The comparison suggests that articulation quality in Q1 cases is characterised primarily by discipline in the articulation of scale and clearly defined institutional scope. The transformations realised vary in depth, but do not exceed the reach of the original claim. Congruence within Q1 therefore appears to be associated not with maximum ambition, but with proportionate articulation.

It is also notable that the Q1 cases are characterised by limited distributive disruption. The interventions do not entail an explicit redistribution of authority or structural burdens likely to provoke strong countermobilisation. The literature on policy implementation indicates that high organisational complexity and conflicting interests render implementation particularly vulnerable (Pressman & Wildavsky, 1973; Mahoney & Thelen, 2010). The Q1 cases, by contrast, display a profile of converging interests or broadly shared problem definitions.

For the central research question, this implies that structural adequacy as a quality of articulation can be assessed systematically by examining the extent to which the articulated

causality is proportionate to existing institutional conditions. The Q1 cases do not suggest a universal regularity, but indicate a recurring relationship between bounded ambition, institutional compatibility and durable reconfiguration.

The congruence observed in Q1 is also associated with institutional timing: centralising or standardising interventions appear plausible when existing regimes are perceived as fragmented or inefficient. This is not a property of the articulation itself, but of the context in which it is formulated and implemented.

Chapter 6 — Quadrant Q2: Accurately Predicted, but Realisation Falls Short

6.1 Positioning of Q2

Quadrant Q2 marks the tension between adequate articulation and realisation that falls short, is delayed, or is institutionally reconfigured relative to the original claim. Unlike Q4, this does not involve failure or fundamental misalignment; unlike Q1, nor does it involve full congruence between expectation and realisation. Q2 marks the tension between adequate prediction and incomplete institutionalisation.

The central question in this chapter is therefore not whether the original claim was 'correct', but why a plausible and often well-substantiated expectation was realised only partially or after delay. This requires analysis of implementation conditions, institutional absorptive capacity and causal configurations within open systems. In terms of the central research question, Q2 serves as a test of the hypothesis that predictive quality is necessary, but not sufficient, for structural transformation. The four dimensions of claim quality—structural adequacy, conditional sensitivity, scale consistency and timing—remain analytically constant across all cases, but are interpreted in relation to the specific articulation of the episode concerned.

This chapter examines three anchor episodes: (1) ERP technology and digital supply-chain integration; (2) the Electronic Patient Record/LSP and digital healthcare information exchange; and (3) the platformisation of work. These three cases differ in domain—business, healthcare and the labour market—but display corresponding characteristics of adequate claim formation and incomplete or delayed institutional embedding.

6.2 Episode 1 — ERP Technology and Digital Supply-Chain Integration

6.2.1 Introduction to the Case

Case. Enterprise Resource Planning (ERP) refers to integrated software systems that bring together an organisation's core processes—such as finance, logistics, human resources and production—within a single standardised information system. From the 1990s onwards, ERP systems were introduced worldwide as a solution to fragmented IT landscapes and inefficient process chains.

Expected benefits. In the international literature, ERP is positioned as an integrating system that 'puts the enterprise into the enterprise system' (Davenport, 1998). Its promise consists of process harmonisation, real-time information, transparency, cost reduction and strategic integration across functional silos.

Realised benefits. ERP systems have been implemented widely in both private and public organisations in the Netherlands. They now form the backbone of core administrative and logistics processes. At the same time, complete process harmonisation has rarely been achieved;

implementations are characterised by high costs, delays and organisational tensions (Markus & Tanis, 2000).

Impact on everyday operations. ERP does not primarily change citizens' experiences, but restructures internal decision-making, information provision and supply-chain coordination within organisations. In business, this affects production planning, inventory management and financial transparency; in the public sector, it affects internal control and accountability mechanisms.

Path dependence. ERP builds on earlier administrative automation and database development. Without standardised data structures and network capacity—cf. the earlier regimes examined in Q1—large-scale integration would not have been feasible.

6.2.2 Predictive Quality: Claim-Oriented Lens

The future-oriented claim concerning ERP is analysed through the claim-oriented lens, in which predictive quality is assessed as articulation quality along four dimensions: articulation of causality, articulation of boundary conditions, articulation of scale, and articulation of temporality. The primary unit of analysis is the future-oriented claim articulated by Davenport (1998) in *Putting the Enterprise into the Enterprise System*. Analytically reformulated, its central proposition is that enterprise systems enable the integration of core processes through standardisation and a single central database, and that this integration can increase transparency and organisational controllability, provided that organisations adapt their processes and governance to the logic of the system. This conditional formulation is explicitly present in Davenport's argument.

Structural adequacy. The presumed causal chain is explicitly articulated as follows:

technological integration → process standardisation → reduction of information silos → improved coordination and transparency → increased organisational effectiveness.

The intervention, intermediate mechanisms and intended organisational outcomes are specified textually. The claim does not articulate an automatic effect, but explicitly connects technical integration with organisational restructuring.

Conditional sensitivity. The future-oriented claim articulates that success depends on process redesign, management commitment and adaptation of governance. The necessary organisational boundary conditions are therefore identified explicitly. The claim avoids technological determinism and positions the technology as part of a broader organisational transformation.

Scale consistency. The articulated impact remains confined to the organisational level. No broader societal or macroeconomic transformation is postulated. The scale of the claim is therefore clearly defined and proportionate to the intervention articulated.

Timing. The claim presupposes a process of change requiring organisational adaptation, but specifies no precise time horizon or implementation period. The temporal dimension is implicitly linked to the complexity of change, without precise limits or phasing. Under the epistemological lens, ERP implementations are therefore assessed on the explicit articulation

of causal structure, organisational conditions, scale and temporal assumptions, without reference to subsequent implementation outcomes.

6.2.3 Societal Transformation: Transformation-Oriented Lens

Type of regime. The transformation-oriented lens (§3.4.2) asks whether ERP in the Netherlands produced a regime shift or a reconfiguration within existing institutional frameworks. Institutional literature reserves the term regime shift for situations in which fundamental institutions or power relations are reordered at the societal level (Pierson, 2004; Mahoney & Thelen, 2010). At the macro level, ERP does not meet this criterion. Market organisation and public governance remain intact. ERP must therefore be characterised as sectoral adaptation within existing institutions.

Depth of reconfiguration. At the meso level, ontological depth varies considerably. ERP implementations may range from IT-oriented replacement—in which existing routines remain largely intact—to package-enabled re-engineering, in which the package functions as a normative organisational model. In the latter case, processes are redesigned in accordance with the system's embedded logic, involving the redistribution of decision-making authority, centralisation of information flows and standardisation of working practices. Change-management literature emphasises that such interventions are not merely technical projects, but collective learning processes in which routines, interpretative frameworks and power relations are renegotiated (Muntslag, 2000; Schimmel, 2007). In these configurations, internal regime intensification may be said to occur: the decision-making architecture within the organisation is structurally reordered, even though the macro-institutional regime remains intact.

Breadth of impact. In principle, the breadth of impact remains confined to the organisational level. ERP restructures internal coordination, information provision and management, but does not alter the societal position of organisations or the institutional order within which they operate. Where multiple organisations within a sector standardise simultaneously, convergence in organisational logic may arise, but not an autonomous sectoral regime shift.

Durability. ERP systems create durable dependencies through lock-in to data models, process standards and platform choices (Davenport, 1998; Markus & Tanis, 2000). High implementation costs and organisational embedding extend the lifespan of these configurations. Durability therefore manifests itself primarily as the structural stabilisation of internal coordination mechanisms.

Layering. ERP transformation is socio-technically layered. It comprises a technical layer—integrated systems and data models—an organisational layer—roles, decision-making structures and process design—and an institutional layer—compliance, governance and accountability structures. In accordance with change-management insights (Muntslag, 2000; Schimmel, 2007), this layering must be understood as interactive: technology structures the possibilities for action, but organisational interpretation and learning processes determine the actual reconfiguration.

6.2.4 Attribution: Causal Lens

Reconstruction of the causal hypothesis. Application of the causal lens reveals the extent to which the observed organisational reconfigurations can plausibly be attributed to ERP technology, taking account of the variable implementation configurations distinguished in §6.2.3. The original hypothesis, as reconstructed in §6.2.2, is that integration of information systems through standardisation and a single central data model enables coordination and organisational controllability, provided that organisational adaptation occurs (Davenport, 1998). ERP is not positioned as an autonomous cause of efficiency, but as a platform that structures integration under conditional circumstances.

Complementary factors. Empirical studies show that technical integration alone is insufficient to achieve process harmonisation. Governance structures, change-management interventions and strategic alignment jointly determine the extent to which opportunities for integration are realised (Markus & Tanis, 2000). In configurations in which ERP is used for package-enabled re-engineering, the technology is more strongly constitutive of internal restructuring; in IT-oriented replacement strategies, its causal role remains more limited and primarily facilitating. Legacy systems, existing divisions of responsibility and sectoral regulation are not external disturbances, but structural components of the configuration within which ERP operates. Technology and context can therefore be distinguished analytically, but are intertwined empirically.

Alternative explanations. Improvements in efficiency and organisational reordering may also result from broader professionalisation or restructuring programmes. Organisations implementing ERP are often already engaged in processes of change. Institutional literature emphasises that technological interventions rarely operate monocausally, but function as catalysts within broader reform dynamics (Pierson, 2004; Mahoney & Thelen, 2010). ERP should therefore be understood as a configurative component within a multicausal process.

Plausibility assessment. The plausibility assessment asks whether comparable integration would have been conceivable without ERP. In theory, separate systems can be connected, but large-scale and consistent standardisation of processes and data models becomes substantially more likely when an integrated package functions as the reference architecture. In configurations involving package-enabled re-engineering, ERP may even be regarded as quasi-constitutive of internal regime intensification. In other configurations, its role remains primarily facilitating.

Causal profile. The causal profile is configurative. ERP creates structural possibilities for integration and organisational controllability, but the realised depth of reconfiguration is determined by change-management choices, governance arrangements and institutional absorptive capacity. The technology is neither an autonomous driving force nor merely an instrument, but a conditionally effective structural component within an open system.

6.2.5 Conclusion to Anchor Episode 1

Epistemological interpretation. The ERP case illustrates that future-oriented claims must be assessed analytically in terms of their explicit definition of scale, articulated causality and identified boundary conditions. Davenport formulated a conditional hypothesis: integration through a single data model and standardised process logic enables end-to-end coordination, provided that organisational restructuring occurs. The assessment indicates a high degree of articulation of these conditions at the organisational level to which the claim refers.

Ontological outcome. ERP practice in the Netherlands displays variable meso-level depth, ranging from limited technical consolidation to internal regime intensification in configurations involving extensive standardisation. At the macro level, the transformation remains confined to sectoral adaptation; no societal regime shift occurs. The reconfiguration is durable at the organisational level, but depends on institutional absorptive capacity.

Causal significance. From a causal perspective, ERP functions as a conditionally constitutive or facilitating factor, depending on the implementation configuration. The technology increases the likelihood of integration, but the extent of realisation is also determined by change-management interventions and governance choices.

Implication for the central research question. The case demonstrates that high articulation quality does not necessarily produce a societal transformation of substantial regime depth. Predictive quality is analytically distinct from ontological reach. ERP can therefore be positioned in the quadrant in which epistemological strength coincides with limited macro-ontological depth: Q2.

6.3 Episode 2 — Electronic Patient Record (EPR/LSP)

6.3.1 Introduction to the Case — EPR/LSP

Case. In this episode, the Electronic Patient Record (EPR) refers to the Dutch policy and infrastructure programme aimed at nationwide electronic exchange of medical data between healthcare providers. The core of the case is not a single record application, but the attempt to standardise and embed interoperability nationally across existing information systems used by general practitioners, pharmacies and hospitals.

Expected benefits. Policy documents positioned nationwide interoperability as a structural solution to discontinuities of information in complex care processes: relevant data would become available to authorised healthcare providers in a timely, standardised and secure manner. The promise concerned improved patient safety, better coordination of care and more efficient implementation, with central statutory embedding as the intended implementation route for standardisation and governance.

Realised benefits. The bill providing for nationwide implementation was rejected by the Senate in 2011, with concerns focusing on privacy, proportionality, security architecture and governance. The infrastructure for data exchange was subsequently continued through the National Exchange Point (LSP) under sectoral governance. Nationwide exchange has become operational and durably embedded for specific categories of data, particularly medication data and out-of-hours care information, whereas a fully integrated national patient record as a uniform facility has not been realised.

Impact on everyday operations. The impact manifests itself primarily in professional healthcare processes: the availability and exchange of data affect handovers, medication monitoring and out-of-hours care, but are less directly visible to citizens as a separate ‘service’. At the same time, nationwide data exchange introduces normative frictions concerning trust, autonomy and data protection, meaning that the case explicitly engages with questions of legitimacy and governance.

Path dependence. The programme built on the already advanced digitalisation of individual healthcare organisations and on earlier standardisation efforts in healthcare ICT. At the same time, the existing heterogeneity of systems and practices made national interoperability dependent on coordination, standardisation and institutional embedding—not only technically, but also administratively and normatively.

6.3.2 Predictive Quality: Claim-Oriented Lens

The epistemological analysis focuses on the future-oriented claim articulated in the explanatory memorandum accompanying the bill on the nationwide electronic patient record (Ministry of Health, Welfare and Sport [VWS], 2008). In accordance with §3.4.1, predictive quality is understood as articulation quality along four dimensions: articulation of causality, articulation of boundary conditions, articulation of scale, and articulation of temporality.

Structural adequacy. The central claim is that nationwide electronic exchange of medical data improves patient safety, care coordination and efficiency because relevant information becomes

available to authorised healthcare providers in a timely and standardised manner. The presumed causal chain can be reconstructed as follows:

nationwide standardisation and linkage of information systems → continuity of medical information → reduction of handover errors → improvement of safety and coordination.

The intervention, intermediate mechanisms and intended outcomes are explicitly identified. The claim articulates continuity of information as a necessary condition for safe and efficient care. The reasoning is consistent with an international patient-safety discourse in which inadequate information transfer is problematised as a structural risk factor in complex healthcare systems (Institute of Medicine, 2000; World Health Organization, 2008). The future-oriented claim explicitly positions continuity of information as a necessary condition for safe and coordinated care. This problem definition and causal connection are made textually explicit within the policy document.

Conditional sensitivity. The policy documents explicitly identify technical boundary conditions such as security, authorisation, logging and legal safeguards. It is therefore acknowledged that the system can function only under specific technical and legal conditions. Societal and institutional conditions are articulated less explicitly, including the legitimacy of central data exchange, trust between actors, professional autonomy and alternative forms of governance. National standardisation under central government direction is presented as the implementation route, but the underlying assumptions concerning administrative acceptability and alternative configurations are elaborated only to a limited extent.

Scale consistency. The scale of the claim remains confined to the national healthcare system. No broader societal transformation beyond the domain of healthcare provision and data exchange is postulated.

Timing. Implementation is presented as a phased process dependent on technical and organisational readiness. The temporal horizon is linked to infrastructure development and statutory embedding, without explicit specification of the trajectory of societal absorption.

Summary assessment of claim articulation. The future-oriented claim articulates clear functional causality and identifies technical and legal boundary conditions. Institutional legitimacy, governance choices and dynamics of trust are elaborated to a more limited extent as constitutive conditions. The assessment through the claim-oriented lens concerns only the extent to which these elements are articulated explicitly and coherently.

6.3.3 Societal Transformation: Transformation-Oriented Lens

Type of regime. The transformation-oriented lens asks whether the nationwide EPR initiative produced a regime shift or a reconfiguration within existing institutional frameworks. The original policy architecture implied a national infrastructure with central statutory embedding, in which the state would acquire an explicit coordinating role in the exchange of medical data. This would have represented a shift from locally organised information exchange towards nationally regulated interoperability.

In the configuration ultimately realised, the healthcare regime itself remained intact. Market organisation, professional autonomy and funding structures were not fundamentally redesigned.

The case therefore concerns not system-level transformation, but reconfiguration within the existing healthcare regime.

Depth of reconfiguration. The depth of change manifests itself primarily at the infrastructural level. The National Exchange Point established an operational national architecture for data exchange. For specific categories of data, such as medication records and out-of-hours care information, continuity of information has become durably embedded in healthcare practices. The initially envisaged expansion of central state control over healthcare data did not, however, materialise. Governance was repositioned within a hybrid model in the healthcare sector. The depth of reconfiguration therefore lies in information architecture and coordination mechanisms, rather than in a fundamental reordering of administrative power relations.

Breadth of impact. The impact extends across the national healthcare system insofar as data exchange between healthcare providers is facilitated. Outside the domain of healthcare information systems and coordination processes, the institutional order remains unchanged. The transformation is domain-specific and does not extend across the broader societal regime.

Durability. The infrastructure for data exchange has remained durably operational, although under adapted governance arrangements. Its institutional design changed relative to the original policy architecture, but the functional core of interoperability stabilised.

Layering. The case displays a layered outcome: a technical layer in which standardisation and system linkage were realised; an organisational layer in which healthcare practices routinely integrate information exchange; and an institutional layer in which governance and legitimacy were reconfigured. The societal controversy surrounding the original bill reveals that interventions in digital infrastructure affect normative dimensions of trust and autonomy. The eventual stabilisation through alternative governance arrangements indicates institutional adaptation without dismantling the technical core.

Transformation profile. The transformation profile of the case can be characterised as durable infrastructural reconfiguration combined with the institutional repositioning of governance. The divergence between the original policy architecture and the configuration realised primarily concerns institutional design, rather than the technical possibility of continuity of information.

6.3.4 Attribution: Causal Lens

Reconstruction of the causal hypothesis. The original policy claim assumed that nationwide electronic interoperability constituted a necessary condition for improving patient safety and care coordination (Ministry of Health, Welfare and Sport [VWS], 2008). Digital infrastructure was positioned as a corrective mechanism for errors arising from fragmented information transfer. This reasoning corresponds with an international patient-safety discourse in which discontinuity of information is problematised as a structural risk factor (Institute of Medicine, 2000; World Health Organization, 2008). The causal hypothesis is formulated conditionally: interoperability enables continuity of information, but presupposes organisational and institutional embedding.

Complementary factors. Literature on quality improvement in healthcare emphasises the configurative character of patient safety. The standardisation of working processes, clinical guidelines, medication monitoring and incident analysis operate jointly within broader quality arrangements (Pronovost et al., 2006; OECD, 2017). Digital exchange supports these processes,

but does not operate independently of professional routines, governance structures and data quality (Berg, 1999; Greenhalgh et al., 2010). The causal effect of interoperability is therefore conditional and embedded: technology increases the possibility of continuity of information, but the realisation of quality improvements depends on organisational integration.

Legitimacy as a constitutive factor. In the policy articulation, privacy was treated primarily as a security issue. The parliamentary rejection of the bill reveals that public legitimacy, proportionality and trust were independent variables in the institutional trajectory. These factors do not function as external disruptions, but as constitutive conditions for durable governance. The eventual institutional configuration was partly determined by these dynamics of legitimacy, without invalidating the functional hypothesis concerning continuity of information.

Variation in governance. The assumption that central statutory embedding was necessary for interoperability proved not to be exclusive. The subsequent stabilisation of the National Exchange Point demonstrates that standardisation can also be embedded institutionally through sectoral governance. This points to variation in institutional design, rather than to the irrelevance of the technological infrastructure itself. The technology proved compatible with multiple governance configurations, provided that coordination and acceptance were achieved.

Plausibility assessment. International developments show that national or semi-national healthcare-data infrastructures emerged in several countries under pressure from quality and cost agendas (OECD, 2015, 2019; European Commission, 2004, 2012). Given this broader dynamic of digitalisation, interoperability was not uniquely dependent on the specific EPR legislative programme. At the same time, the EPR initiative explicitly articulated national standardisation and accelerated coordination. The technology was therefore not an autonomous initiator, but neither was it trivially replaceable; it formed a structural component within a broader dynamic of reform.

Causal profile. The causal profile is layered and configurative. Digital interoperability functions as conditionally constitutive infrastructure for continuity of information. The extent of realisation is determined by organisational integration, governance choices and societal legitimacy. The technology operates within an open system in which technical, organisational and normative factors jointly structure the institutional outcome.

6.3.5 Conclusion to Anchor Episode 2

Epistemological interpretation. The EPR/LSP case demonstrates that the assessment of future-oriented ICT claims cannot be reduced to the question of whether a technology was ultimately realised in technical terms. The functional hypothesis—improving patient safety through continuity of information—is explicitly articulated as a causal chain within the healthcare system. Interoperability is positioned as a condition for safe and coordinated care, and technical and legal boundary conditions are identified. The scale of the claim remains confined to the national healthcare domain.

Articulation of boundary conditions. The analysis shows that societal legitimacy and the choice of governance were elaborated to a more limited extent as constitutive boundary conditions. Privacy was treated primarily as a security issue and less as a matter of trust, proportionality and the institutional distribution of power. This less explicit articulation of normative conditions affected the institutional design of implementation without invalidating the functional core hypothesis.

Ontological outcome. Ontologically, the case involves durable infrastructural reconfiguration: nationwide interoperability for specific data categories was realised and institutionally embedded through the National Exchange Point. The originally envisaged central state direction was replaced by a hybrid governance arrangement. The divergence therefore primarily concerns institutional configuration, rather than the technical possibility of continuity of information.

Causal significance. From a causal perspective, digital interoperability functions as conditionally effective infrastructure within a multicausal configuration of quality improvement, professional routines and conditions of legitimacy. The technology is not an autonomous driving force of regime change, but neither is it merely incidental; it structures the possibility of continuity of information across different governance variants.

Implication for the central research question. The case illustrates that a high degree of articulation of functional causality does not automatically coincide with the full specification of institutional and normative boundary conditions. Structural adequacy may be present at the level of the core hypothesis, while the institutional form of realisation develops differently from what was originally envisaged. The tension between functional articulation and the realisation of governance makes this episode suitable for positioning in Q2: a future-oriented claim that was largely articulated adequately, but whose institutional realisation assumed a different configuration from that originally envisaged.

6.4 Episode 3 — Platform Work

6.4.1 Introduction to the Case — Platform Work in the Dutch Context

Case. Platform work refers to labour organised through digital platforms that match supply and demand, facilitate transactions and coordinate the performance of work through algorithmic systems (European Commission, 2021; OECD, 2019, 2021). In the Netherlands, this model emerged from the mid-2010s onwards in areas including passenger transport, food delivery and various freelance activities. Platforms such as Uber and Deliveroo combined digital matching, pricing, reputation mechanisms and performance monitoring within a single integrated infrastructure (Kenney & Zysman, 2016; Srnicek, 2017).

Expected benefits. In policy and economic discourse, platformisation was positioned as a means of allocating labour more efficiently, reducing transaction costs and increasing flexibility for both clients and workers (OECD, 2019; European Commission, 2021). From the perspective of economic theory, this can be understood as a reduction in search and matching costs through digital intermediaries (Rochet & Tirole, 2003; Parker, Van Alstyne, & Choudary, 2016). At the same time, the model implies a redefinition of the relationship between labour and organisation, because traditional employer functions—allocation, supervision and assessment—are partly automated and centralised within platform architectures (Prassl & Risak, 2016; De Stefano, 2016).

Realised benefits. In the Netherlands, platformisation produced rapid growth in specific sectors and prompted legal and political debate concerning the classification of employment relationships. Platforms proved operationally successful as allocation mechanisms, but raised questions concerning employment status, social protection and power relations (De Stefano, 2016; OECD, 2019). Court rulings and policy responses marked a renewed definition of the boundary between self-employment and employee status.

Impact on everyday operations. Platformisation directly affects the daily organisation of work: access to assignments, remuneration structures, performance assessment and information asymmetries are digitally mediated (Rosenblat & Stark, 2016). For workers, this means greater flexibility of access, but also dependence on algorithmic management and reputation systems.

Path dependence. The development built on a Dutch labour market with a relatively high proportion of flexible contracts and self-employed workers (OECD, 2019). Existing institutional categories—employee, self-employed worker and agency worker—formed the legal frame of reference through which platform work was interpreted. The case therefore concerns a technological-organisational cluster that operates within existing labour-market institutions while simultaneously placing them under strain.

6.4.2 Predictive Quality: Claim-Oriented Lens

Reconstruction of the future-oriented claim. In the Social and Economic Council's advisory report *Security for People, an Agile Economy and Recovery of Society* (2020), platform work is positioned as a development that places pressure on the existing labour-market regime and may necessitate institutional recalibration. The analytically reconstructed claim is that digital platform models contribute to a durable reconfiguration of employment relationships,

particularly by blurring the distinction between employees and self-employed workers, reordering intermediary functions and potentially requiring adjustments to labour law and social security (SER, 2020).

Structural adequacy. The central reasoning articulates that digital platforms centralise the matching, pricing, quality control and allocation of labour through algorithmic infrastructure. Actual mechanisms of management and assessment thereby shift from individual clients towards platform architectures. This shift is explicitly connected to tensions within existing legal categories of labour. The causal chain—digitalisation of allocation and control → blurring of formal employment status → institutional friction—is recognisably articulated in the text.

Conditional sensitivity. The claim assumes that institutional impact depends on scale, consolidation and regulatory response. The SER advisory report explicitly refers to questions of legal classification, enforcement and policy choices as determinants of subsequent development. Institutional conditions are therefore identified, although not systematically elaborated as necessary and sufficient conditions.

Scale consistency. The claim implies that platform work will reach a scale at which it becomes relevant to the regime. This presupposes diffusion across multiple sectors and sufficient durability to place existing labour-market categories under pressure. The assumption concerning scale is made explicit by positioning platformisation as a structural development within the labour-market regime.

Timing. The temporal dimension of the claim concerns consolidation as a stable component of the labour market rather than merely temporary innovation. No precise time horizon is specified, but the development is presented as structural and durable.

Assessment of claim articulation. The SER claim articulates a clear causal structure connecting digital platform architecture with institutional tensions and the possible reconfiguration of employment relationships. Assumptions concerning scale, temporality and institutions are explicitly present. Assessment through the epistemological lens concerns only the extent to which these assumptions are articulated textually and coherently.

6.4.3 Societal Transformation: Transformation-Oriented Lens

Type of regime. The transformation-oriented lens asks whether platform work in the Netherlands has produced reconfiguration at regime level or sectoral adaptation within existing labour-market institutions. The available empirical data indicate a limited macro-scale. The SER reports that in 2019 fewer than 1 per cent of workers worked through a platform (SER, 2020). Eurostat reports that, in 2022, approximately 3 per cent of EU respondents had performed digital platform work during the preceding twelve months. These figures indicate a visible but non-dominant presence within the structure of the labour market. At the macro level, the existing labour-market regime has therefore not been displaced. The categories of employee and self-employed worker remain the institutional frame of reference.

Depth of reconfiguration. At the meso level, however, a clear shift is evident in the organisation of labour. Digital platforms centralise matching, allocation, reputation formation and performance control through algorithmic infrastructure. They thereby assume functions traditionally performed by employers or intermediaries. The European Commission explicitly defines platform work as labour organised through digital infrastructure and problematises

employment status and algorithmic management in this context (European Commission, 2021). The core institutions of labour law have not been replaced by a new regime, but have become the subject of interpretative and classificatory disputes. Legal proceedings concerning platform companies in the Netherlands illustrate that existing categories are under pressure, but have not been abolished. Ontologically, this indicates intensification and reinterpretation within the regime rather than consolidation of an alternative labour regime.

Breadth of impact. The impact is concentrated in specific sectors such as passenger transport and food delivery. Outside these domains, the dominant organisation of labour remains unchanged. Platformisation therefore has sectoral reach without broadly replacing the existing regime.

Durability. Platform models have not proved temporary; they remain operational and continue to develop. At the same time, the available data do not reveal a linear pattern of expansion towards a dominant form of labour. Growth, stabilisation and fluctuation indicate durability at sectoral level, but not macro-structural substitution.

Institutional embedding. Institutional embedding manifests itself primarily through regulation and policy response. The development of a European directive on platform work and international measurement initiatives by the OECD underline that governments regard the phenomenon as structurally relevant. Regulatory activity indicates administrative problematisation and institutional adaptation, but not necessarily a fundamental reordering of the labour-market structure.

Transformation profile. The transformation profile is layered. Platform work introduces new mechanisms of coordination and management within specific sectors and places existing categories of labour law under pressure. At the same time, the core institutions of the labour market continue to operate through the existing employee/self-employed typology. The transformation manifests itself primarily as sectoral reordering and legal reinterpretation, rather than as a regime shift at the macro level.

6.4.4 Attribution: Causal Lens

Reconstruction of the causal hypothesis. The implicit causal hypothesis in the SER articulation (2020) is that digital platform models restructure the organisation of labour in such a manner that the classical employee/self-employed distinction comes under structural pressure, after which recalibration of labour law and social security may become necessary. Platforms centralise matching, pricing, quality control and access to work through algorithmic infrastructure, while formal employment status remains legally ambiguous. This reasoning is consistent with the European problem framework, in which platform work is explicitly connected to questions of classification and labour protection (European Commission, 2021).

Complementary factors. The manifestation of institutional tension is connected to pre-existing dynamics of flexibilisation in the Dutch labour market. Platformisation emerged in a context characterised by a relatively high proportion of self-employed workers and flexible contracts (SER, 2020). The causal operation of platform architecture is therefore embedded in prior institutional developments.

Institutional responses also develop through legal interpretation and policymaking. Classification disputes concerning platform companies illustrate that existing categories of

labour law are subject to reinterpretation. Institutional outcomes are partly shaped by judicial and legislative processes, rather than by technological innovation alone.

Market and behavioural conditions constitute a third complementary factor. Consumer acceptance of on-demand services, digital payment infrastructure and widespread smartphone penetration make the platform model operational. Exogenous shocks such as COVID-19 also affected different segments in different ways (OECD, 2021), indicating differentiated expansion rather than uniform transformation.

Alternative explanations. Alternative explanatory pathways remain plausible at the macro level: the flexibilisation of labour and growth in self-employment predated platformisation; broader digitalisation of services may also contribute to shifts in the organisation of labour; and regulatory dynamics may themselves drive institutional recalibration. These factors do not, however, diminish the specific organisational contribution of platform architectures to the redefinition of management and allocation mechanisms.

Plausibility assessment. At the level of the specific organisational principle, digital matching technology is constitutive: without platform infrastructure, digitally mediated labour allocation in this form would not exist. At the macro level of the labour-market regime, however, platformisation is not a necessary condition for institutional tensions surrounding self-employment and flexibilisation. The technology is therefore constitutive of the phenomenon of platform work itself, but conditional and configurative in relation to broader regime development.

Causal profile. The causal profile is multicausal and layered. Platform work functions as a constitutive factor in the specific organisational form of digitally mediated labour and as a catalytic factor within broader labour-market and institutional dynamics. The eventual societal transformation is determined by the interaction between technological infrastructure, existing patterns of flexibilisation, legal interpretation and societal legitimacy.

6.4.5 Conclusion to Anchor Episode 3

Epistemological interpretation. The platform-work case shows that an authoritative future-oriented claim—in this case, the SER articulation of 2020—becomes analytically assessable when assumptions concerning scale, durability and impact are made explicit. The central claim implied a regime-level reconfiguration of employment relationships in the Netherlands.

Ontological outcome. The ontological assessment, however, indicates a more limited transformation. Platform work has a durable presence and has been administratively problematised, but remains relatively limited in scale and concentrated in specific sectors. Institutional change manifests itself primarily through legal interpretation and regulation, rather than through replacement of the labour-market regime itself.

Causal significance. From a causal perspective, platformisation functions as a catalyst within a broader configuration of flexibilisation, digitalisation and legal recalibration. The technology is necessary for the specific phenomenon of digitally mediated labour, but is not demonstrably the dominant driving force of regime change.

Implication for the central research question. The case confirms that the structural adequacy of predictions depends on an accurate assessment of scale and institutional absorptive capacity.

Where regime-level impact is assumed but only sectoral and corrective change occurs empirically, tension arises between articulation and realisation. Q2 manifests itself here as a discrepancy between claimed depth and realised reach.

6.5 Synthesis of Quadrant Q2: Accurately Predicted, but Realisation Falls Short

RQ1 — Predictive quality: claim-oriented lens. Across the three Q2 cases, a consistent pattern becomes apparent. The core causal hypotheses are in each case formulated explicitly and coherently: integration produces coordination in ERP; continuity of information produces patient safety in EPR/LSP; and platform coordination produces institutional tension in platform work. Retrospective assessment does not refute these core lines of reasoning. The vulnerability lies in conditional sensitivity and assumptions concerning scale. Crucial boundary conditions—organisational capacity for change, legitimacy, legal classification and adoption dynamics—are only partly made explicit. In particular, the implicit assumption of regime depth proves more ambitious in several cases than the actual development warrants.

RQ2 — Societal transformation: transformation-oriented lens. In all three cases, durable reconfiguration has occurred, but within existing institutional frameworks. ERP stabilises internal process architectures; EPR/LSP embeds interoperability within adapted governance; and platform work introduces new coordination mechanisms without replacing the labour regime. The transformation is real and durable, but remains organisational or sectoral in nature.

RQ3 — Causal attribution: causal lens. In Q2, technology rarely functions as an autonomous cause. The outcomes realised depend on configurations of institutional, legal and societal factors. The plausibility assessment shows that comparable developments would often have been conceivable without the specific intervention, although in a different form or with different timing. The causal role of technology is generally facilitating or catalytic.

Answer from the Q2 perspective. Q2 shows that predictive quality is necessary but not sufficient for regime-level transformation. Structurally adequate predictions are distinguished by an explicit definition of scale, assessable causality and identified boundary conditions. Where scale or institutional conditions remain implicit, tension arises between analytical articulation and societal realisation. In all three episodes, the transformation realised does not introduce a new principle of societal ordering, but intensifies or reconfigures existing regimes. The causal role of technology varies between being constitutive within specific organisational forms and facilitating or catalytic within broader institutional configurations; the systematic classification of these causal profiles follows in Chapter 9.

Chapter 7 — Underestimated System Transformations and the Problem of Claim Articulation

7.1 Positioning of Quadrant Q3

Chapter 7 examines quadrant Q3: episodes in which societal transformation did occur, but was not articulated proportionately or accurately during the introductory phase. The purpose of this chapter is not merely classification within the expectation–transformation matrix, but further reflection on the predictability of IT-based system change.

Q3 concentrates a fundamental tension: how can a transformation be profound and durable while being articulated only in limited or diffuse terms during its initial phase? This tension is not accidental. By definition, Q3 cases involve a structural problem of claim formation. Had system transformation been articulated explicitly, with awareness of scale and in institutionally dominant terms, the episodes would more likely have been positioned in Q1 or Q2. Q3 therefore frequently contains episodes in which future-oriented claims were formulated fragmentarily, instrumentally or with institutional caution. This renders epistemological reconstruction more complex: the unit of analysis is less clearly defined, and the dominant articulation is not necessarily representative of the eventual societal impact.

For this reason, the chapter contains two types of analysis. On the one hand, canonical Q3 episodes—commercial internet access, generative AI and mainframe computers—are examined systematically. On the other hand, the limits of claim formation in large-scale IT transformations are considered, including the question of why certain system changes become recognisable as such only retrospectively.

In this context, the analysis of the historical mainframe transformation provides a reference point for understanding slowly cumulative regime shifts that were rarely articulated in their own time as systemic ruptures. The remaining cases—the introduction of the PC into households, the introduction of the PC into business organisations and the rise of the smartphone ecology—are used to test the insights derived from the three anchor episodes.

7.2 Anchor Episode 1 — Commercial Internet Access

7.2.1 Introduction to the Case

Case. Commercial internet access emerged in the Netherlands during the first half of the 1990s in conjunction with the liberalisation of the telecommunications market and the rise of private internet service providers. Whereas the internet initially functioned as an academic network through SURFnet, from approximately 1994–1996 onwards it became accessible to households and businesses through commercial providers. In policy terms, this development coincided with the programme concerning the 'electronic superhighway' and preparations for the Telecommunications Act 1998 (Ministry of Economic Affairs, 1994; House of Representatives of the States General, 1996–1998).

Expected benefits. Policy documents from this period positioned the internet primarily as economic infrastructure, a platform for innovation and an instrument of competition within a liberalised market order. The emphasis was on stimulating digital business activity, strengthening international competitiveness and providing access to information and communication services. The articulation focused on market forces, infrastructure development and economic growth (Ministry of Economic Affairs, 1994; House of Representatives of the States General, 1997). System-level reordering of production, power or culture was not elaborated as an explicit central theme in these documents.

Realised benefits. Within a few years, internet access developed into a broad societal phenomenon. Households, businesses and governments integrated digital networks into everyday communication, commerce and service provision. The internet became infrastructure for e-commerce, digital services, financial transactions and, subsequently, platform-based markets. Its societal significance thereby shifted from that of an additional means of communication to that of constitutive infrastructure.

Impact on everyday operations. The impact manifested itself at multiple levels: digital communication replaced physical correspondence, business processes were integrated into online chains, information provision shifted towards web-based platforms, and public services digitalised their interactions with citizens. Internet access became a routine component of household and professional practices.

Path dependence. Commercial internet access built on existing academic networks such as SURFnet, telecommunications infrastructure and earlier digitalisation regimes. Without the liberalisation of the telecommunications market and the standardisation of protocols such as TCP/IP, broad commercial diffusion would not have been possible. The case therefore represents a transition from a research network to basic societal infrastructure.

7.2.2 Predictive Quality: Claim-Oriented Lens

Structural adequacy. The unit of analysis consists of the articulations surrounding the introduction of commercial internet access in the Netherlands during the second half of the 1990s, as reflected in policy documents concerning the 'electronic superhighway' and the liberalisation of the telecommunications market (Ministry of Economic Affairs, 1994a; Ministry of Economic Affairs, 1994b; House of Representatives of the States General, 1996; House of Representatives of the States General, 1997; House of Representatives of the States

General, 1998). In these documents, the internet is positioned primarily as economic infrastructure, a platform for innovation and an instrument of competition within a liberalised market order. Explicit system-level articulations interpreting the internet as a morphological reordering of production, power and culture are neither central nor dominant in these policy documents. In the international theoretical field, by contrast, Castells (1996) formulated an explicit systems thesis in which digital networks are positioned as the dominant organisational form of a new societal order.

Conditional sensitivity. Castells specifies boundary conditions such as liberalisation, deregulation and globalisation as constitutive conditions for the emergence of network structures. Causality is therefore not presented as a form of purely technological determinism. Institutional variation and political implementation pathways nevertheless remain relatively broadly elaborated. Within the Dutch introductory framework, boundary conditions are specified primarily in technical and economic terms: telecommunications liberalisation, infrastructure development and market forces. Institutional reordering at system level is not systematically articulated as an explicit boundary condition.

Scale consistency. The network thesis is positioned explicitly at the macro-structural level and claims a morphological reordering of social structures. The scale of the articulation is internally consistent: the articulated causality corresponds with the level of impact to which the claim refers. Dutch introductory discourse remains largely confined to economic and infrastructural dimensions. Its scale of articulation is therefore narrower than that of the theoretical systems thesis.

Timing. Castells describes the network society as already emerging and anticipates its further deepening over the following decades. The temporal positioning is explicit and oriented towards a multi-year horizon. Dutch policy discourse lacks an explicit time horizon for system transformation; its focus is on immediate policy objectives concerning market organisation and infrastructure.

Claim profile. From an epistemological perspective, the introductory phase reveals a distinction between an explicit, scale-aware systems articulation in the international theoretical field and a primarily instrumental articulation within the Dutch policy and introductory framework. Castells's network thesis internally meets the criteria of structural adequacy, scale consistency and identified conditions. Within the Dutch corpus analysed, system-level articulation remains implicit or secondary. The positioning of this episode in Q3 therefore rests on a discrepancy in the level of articulation, rather than on epistemological incoherence in the systems thesis itself.

7.2.3 Societal Transformation: Transformation-Oriented Lens

Type of change. The commercial opening of the internet developed from an additional communication technology into constitutive infrastructure across multiple societal domains. What initially functioned as an extension of existing communication channels developed into a supporting architecture for economic transactions, public service provision and social interaction. This development corresponds with analyses interpreting digital networks as the dominant organisational form within the information society (Castells, 1996). The change therefore cannot be reduced to sectoral modernisation within telecommunications, but concerns the reconfiguration of coordination mechanisms at system level.

Depth of reconfiguration. The transformation affects fundamental principles of organisation. Economic coordination shifted towards digitally mediated market forms and network-based value chains (Castells, 1996; Gereffi, Humphrey, & Sturgeon, 2005). Financial infrastructures became digitally integrated, while public service provision reorganised interactions around online interfaces (OECD, 2019). The shift involved not merely improved efficiency, but a reordering of the manner in which information, transactions and decision-making are organised.

Breadth and scale of impact. Network access functions as a generic basic facility for participation in the economy, government, education and culture. Its impact extends across households, businesses and governments. Network forms of organisation displace or restructure hierarchical and market-based forms of coordination (Powell, 1990; Castells, 1996). The scale of the change is therefore macro-structural and cross-domain.

Layering. The transformation is socio-technically layered. It comprises a technical layer consisting of digital network infrastructure, an organisational layer comprising new forms of coordination and transaction, and an institutional layer encompassing regulation of digital commerce, data protection and cybersecurity. International policy analyses emphasise that digital infrastructure functions as an enabling architecture for economic and administrative reconfiguration (European Commission, 2012; OECD, 2015). Digital networks are therefore not merely a technical layer superimposed on existing structures, but are constitutive within broader socio-technical configurations.

Durability and institutional embedding. The reconfiguration has proved durable. Structural investment in broadband and fibre-optic infrastructure, the institutionalisation of digital service provision and the codification of digital commerce and data protection confirm its long-term embedding (OECD, 2019; European Commission, 2012). Regression to pre-digital coordination structures is institutionally and practically unlikely.

Transformation profile. Ontologically, commercial internet access may be classified as a system-level reconfiguration with a constitutive infrastructural function, extensive layering and strong institutional embedding.

7.2.4 Attribution: Causal Lens

Reconstruction of the causal hypothesis. The implicit hypothesis is that commercial internet access played a constitutive role in the reconfiguration of economic, administrative and social coordination structures. Broad, market-based network access made scalable digital interaction possible and thereby constituted a critical condition for e-commerce, platformisation and digital public service provision.

Complementary factors and institutional dependencies. The transformation cannot be attributed monocausally to commercial access. Decisive additional conditions included telecommunications deregulation, the development of digital payment infrastructures, logistics innovation, entrepreneurial dynamics and international capital flows. Commercial access built on academic networks, open protocols such as TCP/IP and global standardisation. Its causal operation is therefore configurative and layered.

Alternative explanations. Globalisation, informatisation and financial liberalisation also contributed to system transformation. Without these broader dynamics, network access might

have retained a more limited organisational reach. Technology therefore functioned not as an autonomous driving force, but as part of a broader configuration of transformation.

Counterfactual plausibility assessment. Had internet access remained structurally confined to closed or heavily regulated networks, it is plausible that large-scale digital market formation, platform development and online public service provision would have proceeded at a different pace or assumed a different institutional form. This suggests that open commercial access was a strongly facilitating component within the configuration, without implying exclusive causality.

Causal profile. Commercial internet access functioned as a constitutive component within a broader configuration of liberalisation, technological standardisation and economic globalisation. It increased the scalability and normalisation of digital interaction, but always operated in conjunction with institutional and economic complementarities. The transformation cannot therefore be attributed monocausally to technology; its effect was strongly contextual, but not logically exclusive.

7.2.5 Conclusion to Anchor Episode 1

The commercial opening of the internet reveals a clear tension between the scale of articulation and the scale of the reconfiguration realised.

From an epistemological perspective (RQ1), dominant Dutch policy and market communication discourse during the introductory phase remained largely incremental. Internet access was positioned as an extension of communication structures and as an economic instrument within a liberalised market order. System-level articulations were not dominant within this institutionally leading discourse. Scale-aware interpretations of a network society did circulate within the international theoretical field, but did not function as a guiding framework for Dutch policymaking.

Ontologically (RQ2), commercial internet access developed into constitutive infrastructure that durably restructured coordination mechanisms in the economy, government and social interaction. The transformation involved not merely sectoral modernisation, but the reordering of underlying organisational and institutional structures.

Causally (RQ3), commercial access can be understood as a constitutive component within a broader configuration of liberalisation, standardisation and economic globalisation. It increased the scalability of digital interaction, but the depth of transformation depended on complementary institutional and economic conditions.

Within the expectation–transformation matrix, this combination indicates positioning in Q3. This is not because insight was absent, but because the dominant institutional discourse did not articulate the scale of the subsequent reconfiguration proportionately. The case therefore suggests that epistemological acuity may exist outside the dominant policy arena without influencing institutions during the introductory phase.

7.2.6 Epistemological Conditions for Robust System-Level Prediction

The relatively high predictive quality of Castells's thesis requires explanation. That a claim subsequently proves adequate is analytically insufficient; what matters is which epistemological properties made this robustness possible. Five characteristics are decisive.

First, the claim is explicitly scale-aware. Castells formulates his analysis at system level: the object of prediction is a shift in dominant organisational forms, rather than a specific application. This scale consistency prevents the extrapolation of micro-level mechanisms to macro-level effects without an explicit analytical bridge.

Second, it is a morphological rather than an instrumental proposition. The prediction concerns network logic as an organising principle, rather than efficiency gains or concrete applications. It is therefore less dependent on policy choices or specific business models. The reference to rhizomatic structures in Deleuze and Guattari is illustrative: the focus is on the architectural properties of coordination, rather than on individual technological artefacts.

Third, the claim employs multicausal reasoning. Societal reconfiguration is not attributed monocausally to technology, but to a convergence of digitalisation, globalisation, capital flows and deregulation. Technology acquires significance within a historical constellation, rather than as an autonomous driving force. This reduces overdetermination and increases plausibility.

Fourth, the thesis is historically embedded. It does not extrapolate a speculative rupture, but systematises trends that were already visible. The prediction is inductively grounded in empirical developments from the 1980s and 1990s.

Fifth, it lacks normative overloading. The claim functions as an analytical diagnosis rather than as a policy programme. This minimises wishful thinking and makes the prediction less normatively directive.

Taken together, these characteristics explain the robustness of the thesis. The likelihood of accurate system-level prediction increases when the analytical object is not a concrete artefact, but a shift in the dominant form of societal coordination, and when scale, causality and historical embeddedness are specified explicitly. Castells's network society therefore constitutes not a triumphant exception, but an analytical reference point for distinctive predictive quality.

7.3 Anchor Episode 2 — General-Purpose AI in the Netherlands

7.3.1 Introduction to the Case

Case description. The episode concerns the broad public availability of general-purpose AI in the Netherlands: publicly accessible AI systems that can be deployed across domains and integrated into everyday knowledge-work processes without specialist reprogramming. The distinguishing feature is not the existence of AI as a field of research, but the practical availability of generic support for a wide range of cognitive tasks to a broad group of users (Eloundou et al., 2023; OECD, 2023). Whereas earlier AI applications remained organisationally embedded and technically shielded, inferential and generative capabilities are now directly accessible through public interfaces and integrations into commonly used software environments. In this context, AI can be understood as a generic functional layer within existing digital infrastructures.

The specific capabilities of large language models—coherent text generation, problem-solving and domain-independent applicability—have been documented extensively in independent evaluations (Bubeck et al., 2023). At the same time, limitations and epistemological risks, including bias and unreliability, have been analysed in depth (Bender et al., 2021). The shift therefore primarily concerns the accessibility and range of application of techniques already developed, rather than a sudden scientific rupture.

Expected benefits: discursive articulations during the introductory phase. The introductory phase is characterised by a heterogeneous and conditional claim regime. International analyses emphasise the potential for productivity and efficiency gains in knowledge-intensive occupations (Brynjolfsson, Li, & Raymond, 2023), but generally do not formulate an explicit systems hypothesis concerning the reconfiguration of institutional structures. In parallel, a risk discourse concerning reliability, bias, authorship and integrity predominates (Bender et al., 2021). A normative response emerged rapidly within Dutch education, as reflected in sector-wide guidelines and policy documents (Universities of the Netherlands, 2023; SURF, 2023).

Realised benefits: provisional assessment within the selected time frame. Empirical research indicates rapid adoption in specific knowledge-intensive activities and measurable productivity effects in delimited contexts (Brynjolfsson, Li, & Raymond, 2023; OECD, 2023). Assessment formats have been revised and integrity frameworks adapted within Dutch education (Universities of the Netherlands, 2023). At the European level, an institutional response is evident in the establishment of the AI regulatory framework through the EU AI Act (2024). A systemic reconfiguration of societal structures cannot yet be established within the selected time frame, however; it remains too early to determine durability and long-term embedding.

Impact on everyday life. The impact manifests itself in the normalisation of AI-assisted text production, summarisation and idea development in educational and occupational settings. The boundary between individual and assisted production is becoming more diffuse, with implications for assessment, authorship and professional expertise. The detectability of generated text and the limitations of current detection methods are subjects of technical research (Mitchell et al., 2023).

Path dependence. Broad applicability depends on existing digital infrastructures: cloud-based computing capacity, the platformisation of communication tools, and the digitalisation of work and educational processes (OECD, 2023). The episode therefore does not constitute an autonomous rupture, but introduces a new capability within an already digitalised environment. Whether this capability produces a durable reconfiguration of organisational and institutional structures cannot yet be determined conclusively within the selected time frame.

7.3.2 Predictive Quality: Claim-Oriented Lens

Reconstruction of the central proposition. The dominant institutional claim regime surrounding general-purpose AI articulates a dual perspective: substantial potential for productivity and innovation, combined with significant risks requiring regulation. International policy analyses primarily emphasise task support and efficiency gains in knowledge-intensive occupations (Eloundou et al., 2023; Brynjolfsson, Li, & Raymond, 2023; OECD, 2023). In parallel, attention is drawn to risks involving bias, reliability, authorship and misinformation (Bender et al., 2021; Mitchell et al., 2023). In the European context, AI is approached primarily as a technology requiring risk-based regulation (European Union, 2024). An explicit systems hypothesis concerning the reconfiguration of knowledge work, labour-market structures or institutional order is absent from these dominant articulations.

Structural adequacy. Productivity studies focus mainly on measurable task performance and short-term effects (Brynjolfsson et al., 2023; Eloundou et al., 2023). The literature on risk problematises epistemological and normative dimensions such as bias and representation (Bender et al., 2021). What is absent is an explicit configurative causality linking AI use to the structural reordering of professional roles, evaluation regimes or institutional power relations. The articulation is therefore descriptive and conditional, but is not developed into a systems explanation.

Conditional sensitivity. Policy documents emphasise ‘responsible use’, transparency and oversight (OECD, 2023; European Union, 2024). These qualifications are formulated normatively in terms of compliance and governance. The underlying structural dependencies between AI capability, organisational routines and institutional absorption are specified analytically only to a limited extent. Conditional sensitivity is present, but is framed primarily in legal and ethical terms.

Scale consistency. The dominant articulations position AI primarily at the micro and meso levels: support for individual tasks, organisational productivity and sector-specific applications (Brynjolfsson et al., 2023; OECD, 2023). Although some analyses classify AI as a ‘general-purpose technology’ (OECD, 2023), this classification is rarely elaborated in terms of explicit system transformation. The connection between task-level effects and macro-structural reconfiguration remains implicit.

Timing. The discourse focuses strongly on immediate implementation issues and regulatory responses (European Union, 2024; Universities of the Netherlands, 2023; SURF, 2023). Long-term projections concerning institutional reordering are less prominent in policy documentation.

Theoretical field versus institutional discourse. Alongside the dominant policy and implementation discourse, more ambitious articulations circulated within the international research field. Bubeck et al. (2023) describe GPT-4 as a system displaying ‘early signs of

general intelligence' and emphasise broad cognitive applicability across domains. OECD analyses explicitly classify generative AI as a potential general-purpose technology with cross-cutting impact (OECD, 2023). These articulations imply a broader systems hypothesis concerning the possible reconfiguration of knowledge work and economic structures. In Dutch policy and sectoral documents, however, such systemic ambitions are less dominant; the emphasis lies on regulation, risk management and frameworks for application (European Union, 2024; Universities of the Netherlands, 2023; SURF, 2023). A distinction therefore exists between scale-aware articulation in the theoretical field and more cautious formulation in institutionally leading arenas.

Claim profile. The dominant claim regime surrounding general-purpose AI is instrumentally oriented, normatively qualified and limited in its articulation of scale. Productivity and risk claims are extensively substantiated, but the leading policy and market discourse lacks an explicit configurative systems hypothesis. From the perspective of articulation, this indicates a position tending towards Q3: system-level implications are not articulated proportionately within the dominant discourse.

7.3.3 Societal Transformation: Transformation-Oriented Lens

Applied lens and unit of analysis. The transformation-oriented lens is used to analyse reconfigurations of institutional and socio-technical structures within the cluster of 'widely accessible general-purpose AI'. Dutch education is selected as the primary field of observation because the production, assessment and legitimation of knowledge are formally regulated and institutionally embedded within this domain.

Type of change. The introduction initially manifested itself as sectoral adaptation: guidelines, temporary restrictions and experiments with alternative forms of assessment. The response was not confined, however, to operational optimisation. Amendments to examination regulations, integrity frameworks and assessment practices indicate shifts in the institutional treatment of authorship and individual performance. These changes affect core mechanisms of the educational regime—namely, the relationship between the production, assessment and legitimation of competence—but do not yet constitute stable regime replacement within the selected time frame. Ontologically, this involves institutional recalibration within the domain, rather than system-level transformation.

Durability and institutional embedding. Formal amendments to regulations and policy frameworks indicate institutional embedding. The technology is not treated as a temporary disruption, but as a structural factor for which durable rules are being developed. At the same time, new assessment practices remain in a phase of consolidation; long-term stability and potential lock-in effects are as yet only weakly visible.

Layering. General-purpose AI affects several layers of knowledge practices. At the technical level, it involves the integration of generative systems into existing digital environments. At the organisational level, it leads to the adaptation of assessment and evaluation practices. At the normative level, it produces a redefinition of authorship and responsible use. The technology therefore operates not merely as a tool, but as a factor that contributes to restructuring existing routines within an already digitalised context.

Transformation profile. The significance of general-purpose AI within the selected field of observation exceeds mere operational adaptation. Revisions to examination regulations,

assessment criteria and integrity frameworks indicate shifts in the institutional definition of individual performance and authorship. The development thereby affects core mechanisms of legitimation within the educational regime. Although the transformation manifests itself primarily in knowledge-intensive domains within the selected time frame, it concerns mechanisms that may be constitutive of the broader societal ordering of expertise, competence and qualification. The depth of reconfiguration lies not in changes to organisational structure, but in normative and evaluative logics. Institutional stabilisation remains in a phase of consolidation. Ontologically, the episode may therefore be classified as an emerging regime-relevant reconfiguration within knowledge-intensive domains. Its scale remains domain-specific for the time being, but it affects generic mechanisms of legitimation and professional authority.

7.3.4 Attribution: Causal Lens

Reconstruction of the causal hypothesis. In the dominant discourse, general-purpose AI is positioned as a tool that primarily affects individual use, after which institutions respond through regulation. The implicit hypothesis assumes an exogenous disruption to which education reacts. This articulation does not explicitly elaborate the causal reconfiguration of assessment and legitimation structures.

Complementary factors. The recalibration of assessment and legitimation structures described in §7.3.3 takes place within an already digitalised educational regime. Digital submission environments, the emphasis on individual text production, accreditation frameworks and quality assurance constitute structural conditions under which generative AI produces effects. Causality is therefore configurative: the technology operates within an existing institutional and technical order that partly determines its effects.

Alternative explanations. The adaptation of assessment and integrity frameworks may also be understood as a continuation of pedagogical developments already under way or as a response to concerns regarding the value of qualifications and academic integrity. In these interpretations, AI is not constitutive of the recalibration, but contingent upon broader institutional dynamics.

Plausibility assessment. The attribution question is whether renegotiation of assessment and integrity frameworks on the scale and at the speed analysed in §7.3.3 would be plausible without widely accessible generic text generation. The capacity for accessible, coherent and difficult-to-detect text production distinguishes general-purpose AI from earlier digital tools. It is plausible that, without this capability, the urgency and scope of institutional adaptation would have been more limited. At the same time, the depth of reconfiguration remains dependent on existing digitalisation and the normative emphasis on individual output.

Causal profile. Within this episode, general-purpose AI functions as a constitutive factor in the recalibration of assessment and legitimation structures described in §7.3.3. The causality is configurative rather than monocausal: the technology forms part of an institutional configuration within which the recalibration occurs. AI is not an autonomous driving force of regime change, but it is a central component of the current institutional shift within this specific context.

7.3.5 Conclusion to Anchor Episode 2

Epistemologically, the dominant claim regime is characterised by instrumental and risk-oriented articulation without an explicit, scale-aware systems hypothesis. Productivity and regulatory claims predominate, while the possible reconfiguration of evaluation and legitimation structures is not elaborated systematically.

Ontologically, the selected field of observation displays institutional recalibration that affects core mechanisms for assessing and legitimating knowledge. Formal amendments to regulations and evaluation practices indicate regime relevance within the educational domain, without amounting to full regime replacement.

Causally, general-purpose AI functions as a constitutive factor within an already digitalised institutional configuration. The recalibration arises through interaction between technological capability, existing digitalisation and normative frameworks. The technology is not an autonomous driving force of transformation, but is nevertheless a central component of the shift analysed within this context.

Three implications follow for the central research question—the extent to which IT-based societal transformations are predictable. First, the episode demonstrates that early phases of technological diffusion may be accompanied by limited explicit articulation of scale. The absence of explicit systems claims in dominant policy arenas does not imply that regime-relevant shifts will fail to occur. Second, predictive quality appears to depend on the capacity to make the constitutive mechanisms of reconfiguration explicit. Where discourse concentrates on applications and risks, shifts in evaluation and legitimation structures remain underexposed. Third, the case confirms that general-purpose technologies do not necessarily manifest themselves as new regimes, but as new capabilities within existing configurations. Transformation then manifests itself through the renegotiation of normative and procedural infrastructures.

The episode therefore illustrates that Q3 cases are characterised by a discrepancy between the scale of articulation and the scale of reconfiguration within the selected time frame. In such cases, predictability requires not merely technological projection, but the analytical identification of the institutional pathways along which reconfiguration becomes plausible.

7.3.6 Reflexive Comparison — Why the AI Discourse Produces No Castells

Section 7.2.6 explained why Castells's thesis may retrospectively be regarded as exceptionally robust: it was scale-aware, configuratively elaborated and focused on a shift in dominant organisational forms. The constitutive trajectory—network logic as a new coordination structure—was explicitly identified before it had been fully consolidated. Against this background, it becomes apparent why AI discourse is positioned more weakly in epistemological terms.

First, there is no dominant morphological hypothesis. The discourse is dominated by claims concerning applications and risks, but rarely formulates an explicit thesis about changes in organisational or legitimating forms. Whereas Castells articulated a shift in coordination structure, AI discourse remains largely instrumental.

Second, scale integration is absent. Claims range between micro-level practices such as student use, the meso level of institutional policy and diffuse macro-level references, without integrating these into a single coherent systems hypothesis. In Castells's analysis, scale consistency was constitutive of the claim; here, it remains implicit.

Third, the broader constellation within which AI operates is rarely articulated systematically. Digitalisation, platformisation and institutional dependencies are mentioned, but are not integrated into an explicit analysis of their interrelationships.

The difference cannot be reduced to intellectual shortcomings. The internet transformation was also layered, but its constitutive trajectory—a distributed network structure based on open standards—was relatively straightforward to identify. In general-purpose AI, the shift proceeds more diffusely: not through the substitution of a dominant organisational form, but through the renegotiation of existing normative and procedural infrastructures. For this reason, AI discourse produces no Castells-like morphological thesis. This is not because visionary capacity is absent, but because the constitutive trajectories are distributed across multiple institutional layers and manifest themselves in evaluation and legitimation structures. This makes scale-consistent system prediction more difficult in epistemological terms.

For Q3, this means that under-articulation does not result exclusively from discursive caution, but also from the intrinsic complexity of layered transformation. Whereas architectural substitutions invite morphological hypotheses, configurative renegotiations produce discursive fragmentation. For the central research question, it follows that the predictability of IT-based societal transformation partly depends on the type of change involved: the more diffuse and institutionally embedded the constitutive trajectories are, the more difficult it becomes to articulate them coherently in advance.

7.4 Anchor Episode 3 — Mainframe Computers (1965–1990)

7.4.1 Introduction to the Case

Case. The episode concerns the widespread introduction of mainframe computers in the Netherlands between approximately 1965 and 1990. During this period, central computing systems were introduced within government, banks, insurance companies and large enterprises (Abbate, 1999; Van den Besselaar & Beckers, 2005). These systems were used for large-scale administrative processing, including payroll administration, tax collection, social security, population registration and banking transactions. A defining feature was the concentration of data processing in central computing centres. Organisations adapted their administrative procedures to enable processing through standardised digital systems. Automation thereby became a structural component of administrative operations.

Expected benefits. In management and supplier discourse, automation was presented as an instrument for improving efficiency: reducing costs, increasing speed and reducing errors in administrative processes (Van den Besselaar & Beckers, 2005). In policy contexts, automation was legitimised as necessary modernisation to keep growing administrative complexity manageable (WRR reports from the 1980s and 1990s; Bekkers & Homburg, 2007). Trade-union and public debates drew attention to possible employment consequences and shifts in administrative functions (Zuboff, 1988). Expectations remained predominantly focused on efficiency, manageability and labour-market effects.

Realised development: descriptive account. During this period, automated data processing became commonplace within public and financial institutions. Administrative processes were increasingly handled digitally. Central systems became decisive in the processing of tax returns, benefit payments and banking transactions. The expansion of investment in automation is visible in national statistics on ICT expenditure in the public and financial sectors (Statistics Netherlands, historical series).

Impact on everyday life. For citizens, automation became visible through everyday changes. The weekly pay packet gradually gave way to automated bank transfers. Bank statements were generated digitally. The administration of benefits and taxes took place through centralised administrative systems rather than manual processing. These changes occurred without an abrupt moment of rupture, but routinely affected the manner in which citizens interacted with financial institutions and government agencies.

Path dependence. The mainframe episode built on earlier administrative rationalisation and standardisation. Without existing bureaucratic structures and uniform administrative categories, large-scale digital processing would not have been feasible. At the same time, the infrastructure laid the foundations for subsequent waves of digitalisation in public and financial services.

7.4.2 Predictive Quality: Claim-Oriented Lens

The analysis of future-oriented claims surrounding the mainframe episode is conducted through the claim-oriented lens (X), in which predictive quality is assessed along four dimensions: structural adequacy, conditional sensitivity, scale consistency and temporal positioning. The focus is exclusively on explicitly articulated future-oriented statements within the identified discursive arenas.

The primary units of analysis are three types of future-oriented claim that were dominant in Dutch discourse concerning automation between approximately 1965 and 1990: (1) instrumental efficiency claims in management and supplier discourse; (2) modernisation claims in policy and government contexts; and (3) labour-market claims in trade-union and public arenas. These claims are reconstructed separately and assessed in terms of their internal articulation quality.

Structural adequacy. The central instrumental proposition was that electronic data processing would make administrative processes faster, cheaper and less prone to error. The policy variant positioned automation as necessary modernisation to keep growing administrative complexity manageable. Labour-market discourse formulated an alternative central proposition: automation would reduce routine administrative labour and might lead to job losses.

In all three arenas, an explicit causal relationship is articulated between technological capacity—faster processing, storage and standardisation—and organisational effects—efficiency, control and reductions in labour requirements. The causal structure is clear and proportionately formulated at the level to which it relates. What is absent is an explicit articulation of a broader hypothesis concerning the reconfiguration of administrative coordination, the distribution of power or institutional order. The claims remain focused on optimising existing structures or on direct labour-market effects. No coherent thesis is formulated concerning changes in dominant organisational forms or administrative architecture. Structural adequacy is therefore present at the operational level, but remains confined to the immediate domain of application.

Conditional sensitivity. Instrumental and policy claims contain qualifications concerning investment costs, technical reliability, staff training and implementation risks. These conditions relate primarily to feasibility and cost–benefit considerations. Institutional dependencies—such as legal frameworks, organisational power relations or changing information positions—are not articulated systematically. Labour-market discourse displays conditional sensitivity with regard to social consequences and redeployment issues, but without explicitly analysing how technological standardisation might redefine the relationship between citizen, official and system. Conditional sensitivity therefore remains domain-specific—technical or social—without being integrated into a regime-oriented analysis.

Scale consistency. The dominant efficiency and modernisation claims are articulated primarily at the organisational level: improving payroll administration, tax processing or records management. The scale of the claim remains within the scope of individual organisations or administrative chains. No explicit connection is made between micro-level efficiency and possible macro-structural implications. Labour-market discourse articulates societal consequences in terms of employment, but does not integrate these with administrative or organisational levels of scale. None of the arenas formulates an analytically integrated hypothesis of scale that systematically connects organisational optimisation, sectoral change and societal order. The articulation of expected scale was therefore not unambiguous.

Timing. The temporal positioning of the claims is predominantly incremental. Automation is presented as a continuation of trajectories of rationalisation and modernisation. No abrupt moment of discontinuity is articulated; change is described as cumulative improvement. This temporal framing limits the scope for explicit systems hypotheses: when change is presented as gradual optimisation, the articulation of regime change remains conceptually out of view.

Claim profile. The mainframe episode displays a profile in which causality is articulated clearly and proportionately at the operational level, but scale integration and regime-oriented hypothesis formation are absent. Efficiency and modernisation claims are internally coherent within their organisational framework. Labour-market discourse articulates societal consequences, but does not connect employment effects with broader administrative or institutional restructuring. The epistemological shortcoming therefore lies not in the absence of causality, but in fragmented scale and confinement to a logic of optimisation. No coherent systems hypothesis concerning administrative reconfiguration is formulated explicitly within the dominant arenas.

7.4.3 Societal Transformation: Transformation-Oriented Lens

Under the transformation-oriented lens, transformation is understood as the reconfiguration of institutional and socio-technical structures. The unit of analysis is the cluster of centralised data processing within government and large enterprises between 1965 and 1990, with computational centralisation as its organising principle.

Type of change. Automation was initially introduced as a means of optimising administrative tasks. Through cumulative application across multiple domains—tax collection, social security, banking and payroll administration—the centre of gravity shifted from manual processing towards centralised, system-based processing. The concentration of data in central databases and the codification of decision rules in programmable procedures led to the reorganisation of work processes around computational logic. Information control and decision preparation were increasingly organised through hierarchically managed systems. The change therefore involved not only acceleration of existing processes, but also a reordering of the manner in which administrative coordination took place.

Durability and institutional embedding. Mainframe infrastructure became durably embedded in administrative and financial systems. Central data processing remained decisive for several decades in taxation, benefit administration and banking transactions. Organisations developed specialised IT departments and systems-management functions. Coded procedures and dependence on systems created structural continuity. A return to entirely manual processing became organisationally and economically unlikely.

Layering. The transformation built on existing bureaucratic hierarchies, but altered their internal operation. Decision-making was prepared within coded rule systems; human actors remained formally responsible, but operated within frameworks structured by systems. The relationship between the individual, the organisation and information was thereby configured differently from pre-digital administrative practices.

Depth and breadth. The depth of reconfiguration lies in the structural reordering of information processing and administrative coordination across multiple sectors. The breadth of impact extended across public and financial domains and indirectly affected virtually all citizens through fiscal and banking interactions. Subsequent waves of digitalisation could build on this centralised infrastructure, indicating institutional continuity in the chosen form of order.

Transformation profile. The mainframe cluster represents a durable reordering of administrative coordination around centralised data processing and standardised procedures. The core of the change lies in the institutional embedding of computational centralisation as an organising principle.

7.4.4 Attribution: Causal Lens

The causal lens is used to analyse the extent to which mainframe technology was constitutive of the reconfiguration of administrative coordination described in §7.4.3. The unit of analysis is not institutional expansion in general, but the specific cluster of large-scale, centralised and standardised data processing within government and large enterprises between 1965 and 1990. The question is therefore whether mainframe architecture was a necessary component of this specific form of administrative centralisation.

Reconstruction of the causal hypothesis. In dominant automation discourse, technology was presented as an instrumental response to growing administrative complexity. The implicit hypothesis had a linear structure:

organisational expansion → need for manageability → electronic rationalisation → improved efficiency.

Technology was positioned as a tool within existing hierarchical structures. No explicit hypothesis was formulated in which the technical architecture itself generated dynamics of centralisation and standardisation.

Complementary factors and configurative dependencies. Mainframe architecture required central processing, concentrated data storage and standardised input. These technical characteristics encouraged the uniformisation of procedures and concentration of information control. At the same time, adoption occurred within existing hierarchical institutions characterised by ambitions for expansion and objectives of rationalisation. Growth in regulation, expansion of social-security provision and increased volumes of financial transactions increased demand for scalable processing. Causality was therefore configurative: institutional expansion and technological architecture reinforced one another. Administrative growth created demand for electronic processing; electronic processing made further centralisation operationally feasible.

Alternative explanations. Hierarchical administrative structures and administrative centralisation existed before the introduction of mainframes. Bureaucratic expansion therefore cannot be attributed exclusively to technology. Economic expansion, the professionalisation of management and extension of welfare-state arrangements also contributed to the concentration of information and decision-making. These factors do not, however, independently explain the specific form of centralised, continuous and uniform data processing that emerged during this period.

Counterfactual plausibility assessment. The relevant counterfactual question is whether a comparable degree of national, uniform and large-scale data processing would have been plausible without mainframe architecture. Without electronic infrastructure, organisations would have remained dependent on manual processing and mechanical support. This would not have precluded institutional growth, but would have imposed a structural ceiling on the speed, scale, uniformity and central coordination of data processing.

It is therefore plausible that, without mainframe architecture, the specific form of centralised and standardised processing analysed in §7.4.3 could not have been realised with comparable intensity and reach. Administrative expansion would then have retained a different operational form, characterised by less uniformity and less continuously centralised processing.

Conversely, without institutional ambitions for expansion, mainframe technology would have remained confined to niche applications. The configuration was mutually dependent, but the operational possibility of nationwide central processing was technologically conditioned.

Causal profile. From a causal perspective, mainframe technology functioned as a *sine qua non* for the emergence of the specific regime of centralised and standardised data processing in the Netherlands between 1965 and 1990. The technology was not a sufficient cause of institutional expansion, but was constitutive of the operational form that expansion assumed. Within a multicausal configuration of bureaucratic growth, objectives of rationalisation and hierarchical organisational forms, mainframe architecture did more than increase efficiency: it made large-scale and uniform centralisation structurally possible. The causal relationship is therefore configurative but distinct: administrative expansion and computational centralisation were mutually reinforcing, with the technological architecture constituting a necessary condition for the specific order that was realised.

7.4.5 Conclusion to Anchor Episode 3

The mainframe episode displays a consistent Q3 profile: substantial societal reconfiguration without prior scale-aware systems articulation. Epistemologically, dominant automation discourse remained instrumentally oriented. Efficiency and modernisation claims were internally coherent at the organisational level to which they referred, but did not integrate an explicit hypothesis concerning the reconfiguration of administrative coordination or information architecture at sectoral or societal scale. The implications of computational centralisation for administrative order were not articulated as a coherent systems thesis. Labour-market claims, although societally oriented, likewise remained thematically limited and did not connect labour effects with broader administrative restructuring.

Ontologically, the development involved more than optimisation. The introduction of mainframe architecture led to the durable embedding of centralised data processing as an organising principle within government and large enterprises. Administrative processes were permanently organised around central databases, coded procedures and hierarchically managed information flows. The change consisted of a reordering of the manner in which coordination and information control were institutionally organised.

Causally, the analysis shows that this reconfiguration emerged from a configuration in which the architectural logic of mainframes—central processing and standardisation—interacted with existing hierarchical structures and economic expansion. Mainframe technology was not an autonomous cause of institutional expansion, but it was a necessary condition for the specific form of large-scale, uniform and centralised data processing that consolidated during this period. The relationship was reciprocal: institutional ambitions for expansion created demand for electronic processing, while electronic processing made further centralisation structurally possible.

For the central research question, this implies that IT-based transformations aligned with existing hierarchical structures are epistemologically more difficult to recognise as regime shifts. When innovation is presented discursively as rationalisation within the familiar, constitutive changes in coordination and information architecture remain under-articulated. The mainframe case shows that profound institutional reordering can occur without an explicit, scale-aware systems hypothesis in the dominant discourse.

7.4.6 Reflexive Discussion — Normalisation as an Explanation for Under-Articulation

The mainframe episode displays a different Q3 pattern from the preceding anchor cases. Whereas the internet episode was accompanied by an explicit morphological systems thesis, and the AI episode is characterised by discursive fragmentation and normative dominance, the mainframe period is characterised by structural transformation without explicit systems articulation. The explanation lies in what is described here as normalisation as an epistemological mechanism.

Mainframe automation was understood as rationalisation, improved efficiency and modernisation of administrative processes—categories already embedded in administrative and business practice. These concepts indicate optimisation within existing structures, not the reconfiguration of coordination. Because computational centralisation aligned with the existing hierarchical order, it was interpreted as reinforcement of the familiar rather than as the introduction of a new organisational principle. The centralisation of data and standardisation of rules were semantically absorbed into the vocabulary of manageability.

It was precisely this alignment with existing structures that made the transformation less visible epistemologically. This contrasts with the internet episode, in which network logic placed hierarchical patterns under pressure and thereby created scope for morphological articulation. It also contrasts with the AI episode, in which discursive plurality and normative loading impede coherent systems interpretation. During the mainframe period, there was neither discursive chaos nor a visionary thesis, but technocratic continuity.

Under-articulation is therefore not the result of analytical incapacity, but of interpretative continuity. Transformations that consolidate existing hierarchy are less readily recognised as qualitative ruptures than transformations that destabilise it. For the central research question, this implies that the predictability of IT-driven change depends not only on technological complexity or normative controversy. Gradual sedimentation within existing institutional frameworks can also conceal profound reconfiguration. The intensity of public articulation does not necessarily correlate with the depth of structural impact.

The mainframe case thus introduces a third Q3 variant: the conceptual absorption of structural change into the vocabulary of administrative rationality. Q3 is therefore not a homogeneous category. The absence of scale-aware claims may result from underestimation, discursive fragmentation or normalising absorption, each with its own epistemological dynamic.

7.5 Potential Disconfirming Cases

7.5.1 The Personal Computer in Private Households

Short presentation of the episode. From the mid-1980s onwards, ownership of personal computers in Dutch households increased. Statistics Netherlands data show a rise in household PC ownership from less than 10 per cent in the late 1980s to more than 60 per cent around 2000 (Statistics Netherlands, StatLine historical ICT series). Initially, PCs were used for word processing, basic administration, games and educational software. During the 1990s, e-mail, internet access and telebanking were added. By the turn of the century, computer ownership had become widespread (Statistics Netherlands; SCP, *The Digital Divide*, 2000).

In policy and market communication, the PC was presented primarily as an instrument for efficiency, education and digital literacy (Van den Besselaar & Beckers, 2005). Explicit systems claims concerning the reordering of societal coordination structures remained scarce.

Claim-oriented lens (RQ1 — Predictive quality). No dominant thesis emerged around the diffusion of the PC in which the device was understood as the carrier of a new societal organising principle. Future-oriented claims concerned the democratisation of knowledge and economic modernisation, in line with the broader information rhetoric of the 1990s (Castells, 1996), but without an elaborated hypothesis concerning shifts in coordination structures. Because a scale-aware hypothesis was absent, predictive quality can be assessed only to a limited extent. This case therefore does not constitute a disconfirming case for the relationship between explicit systems articulation and high predictive quality.

Transformation-oriented lens (RQ2 — Societal transformation). The diffusion of individual computing capacity into the private domain had clear effects: the digitalisation of household administration, new forms of working from home and broader access to digital information (SCP, 2000; Van Dijk, 2005). The depth of transformation became apparent, however, primarily in combination with internet access and subsequent platform services. Without network connectivity, the PC remained largely a local processing device. The transformation profile therefore points towards the diffusion of capacity rather than the introduction of an independent societal coordination principle.

Causal lens (RQ3 — Attribution). The household PC functioned as a facilitating factor within a broader digital development. It created a user base for internet services, but did not introduce a new ordering structure in its own right. Many contemporary digital configurations are conceivable without early mass adoption of PCs, although they would have developed less rapidly and on a smaller scale (Abbate, 1999). The role of the household PC was therefore supportive and accelerating rather than constitutive.

7.5.2 The PC in Business and the Network/Client–Server Transition

Introduction. The introduction of the PC into Dutch businesses began in the early 1980s with stand-alone workplace computers. During this phase, it was positioned as a means of achieving local productivity gains (Van den Besselaar & Beckers, 2005). Central data processing remained largely associated with mainframes. This changed during the 1990s with the rise of local networks and client–server architectures, in conjunction with broader organisational restructuring and process integration (Bresnahan & Trajtenberg, 1995; Bekkers & Homburg,

2007). PCs became nodes within shared information structures. Their societal significance lay not in the artefact itself, but in the connection of distributed computing capacity to organisation-wide networks.

Claim-oriented lens (RQ1 — Predictive quality). During the early phase, productivity claims and the ideal of 'end-user computing' predominated. An explicit hypothesis concerning the restructuring of information processing at organisational level was absent. Narratives concerning network organisations became dominant only after networks had actually been introduced, which is consistent with broader analyses of ICT as a general-purpose technology whose organisational implications become visible only through complementarity (Bresnahan & Trajtenberg, 1995). The architectural shift that was ultimately realised was therefore not articulated in advance with sufficient awareness of scale.

Transformation-oriented lens (RQ2 — Societal transformation). The transformation became fully visible only with network connectivity. Information control shifted from exclusively central processing towards hybrid configurations. This increased the feasibility of distributed organisational forms (Castells, 1996). The change involved the reorganisation of internal information and coordination processes rather than merely the optimisation of tasks.

Causal lens (RQ3 — Attribution). The transition towards network and client–server architectures arose from the convergence of technological development, organisational restructuring and economic pressure for flexibility (Bekkers & Homburg, 2007). The PC provided the distributed computing capacity that made network coordination possible, but did not generate that coordination independently. The role of the PC is therefore best understood as a necessary link within a broader configuration of technological and organisational complementarity.

7.5.3 The Rise of the Smartphone Ecosystem

Introduction to the case. From approximately 2007 onwards, the smartphone integrated permanent internet access, application platforms and sensors within a single mobile device. Statistics Netherlands data show rapid adoption in the Netherlands, with penetration rates exceeding 80 per cent within a decade (Statistics Netherlands, StatLine mobile telephony data). Its societal significance lies in continuous access to network services. In early discourse, the smartphone was presented primarily as a means of communication and a consumer technology.

Claim-oriented lens (RQ1 — Predictive quality). At the time of introduction, there was no coherent hypothesis concerning the structural consequences of permanent mobility. New services were discussed, but platform ecosystems, data collection and shifts between public and private spheres were not addressed systematically. The subsequent dominance of app ecosystems and mobile platform services (Kenney & Zysman, 2016) was not articulated as a coherent process.

Transformation-oriented lens (RQ2 — Societal transformation). The impact is substantial. Network access became permanent and mobile. Communication, transactions and media use became continuous and independent of location (Van Dijck, Poell, & De Waal, 2018). Digital infrastructure shifted from fixed locations towards the individual. The transformation consists of the intensification and densification of an existing network regime.

Causal lens (RQ3 — Attribution). The smartphone builds on existing internet infrastructure. Its role lies in densification and intensification. Without permanent mobile access, platform structures would have become less deeply integrated into everyday routines (Kenney & Zysman, 2016). It therefore functions as a reinforcing factor within an existing network regime.

7.5.4 The Common Thread: Not Every Underestimated Effect Constitutes an Independent System Transformation

The three additional episodes do not disconfirm the mechanism of under-articulation identified in the anchor analyses. In each case, the articulation accompanying introduction fell short of the technology's subsequent societal significance: the household PC was interpreted primarily as an instrument for individual productivity and education, the business PC as a local workplace technology, and the smartphone as a mobile communication device and consumer product. The analysis also shows, however, that this discrepancy is not in itself sufficient to classify every artefact as an independent Q3 transformation.

In the case of the household PC, the societal depth ultimately realised lies primarily in its combination with commercial internet access and subsequent platform services. The PC distributed computing and access capacity, but did not independently introduce a new principle of societal coordination. The episode therefore functioned more as a material and social enabling condition for the network transformation than as an independent system

In the case of the PC in business, the relevant object of transformation likewise does not coincide with the individual artefact. The structural shift emerged when distributed computing capacity was connected to local networks, client–server architectures and organisation-wide information systems. It was not the PC as such, but this composite socio-technical configuration that enabled distributed information processing and new forms of coordination. The case therefore demonstrates the need to delineate technological episodes not exclusively around visible devices, but around functional architectures.

The smartphone most closely approximates the Q3 profile, because the implications of permanent mobility, platform dependence and continuous data collection were articulated only fragmentarily at the time of introduction. Even the smartphone, however, did not introduce an entirely new organising principle. It densified, individualised and intensified the existing network regime. Its societal impact is profound, but is ontologically better characterised as regime intensification than as independent system replacement.

The counter-indication test therefore does not reject the Q3 pattern but refines it. Under-articulation may concern an independently new organising principle, but may also concern the constitutive significance of an infrastructural link or the intensification of an existing regime. Classification within Q3 therefore requires more than establishing that subsequent impact exceeded what was originally articulated. It also requires identifying **where the relevant object of transformation lies**: in the artefact itself, in a broader technological configuration, or in the deepening of an existing regime. The three additional episodes thus confirm the importance of scale-aware articulation while cautioning against retrospectively attributing system transformation to every visible technological artefact.

7.6 Synthesis of Quadrant Q3 — When the Scale of Transformation Is Underestimated

7.6.1 What Actually Happened?

The episodes in Q3 do not display a uniform pattern of transformation. They share the characteristic that their subsequent societal significance was not articulated proportionately during the introductory phase, but differ in the level at which and the configuration within which change occurred.

During the mainframe period, automation was initially presented as administrative rationalisation. In practice, a durable reordering of administrative coordination emerged around central databases, coded procedures and hierarchically managed information flows. Citizens did not merely experience faster processing, but became incorporated into centrally managed information architectures. The transformation therefore lay not only in improved efficiency, but in the institutional embedding of computational centralisation as an organising principle.

In Dutch introductory discourse, the commercial deployment of the internet was positioned primarily as an extension of communication, information and market infrastructure. The development ultimately realised was more extensive. Economic transactions, public service provision and social interaction became durably organised around digital networks. This constituted system-level reconfiguration: not only applications changed, but also the dominant manner in which information exchange and societal coordination were organised.

In the case of general-purpose AI, change has thus far manifested itself differently. Within the selected field of observation, transformation does not consist of the replacement of a technical or institutional regime, but of the renegotiation of assessment, production and legitimation practices. Examination regulations, integrity frameworks and professional norms are being adapted to a situation in which individual production can no longer be clearly distinguished from assisted production. The development is therefore regime-relevant, but remains in a phase of consolidation and is primarily domain-specific within the selected time frame.

The additional episodes show that not every underestimated development constitutes an independent system transformation. The household PC distributed computing and access capacity, but acquired societal depth primarily in combination with commercial internet deployment. In the case of the PC in business, the relevant object of transformation did not lie in the device itself, but in the broader configuration of local networks, client–server architectures and organisation-wide information systems. Nor did the smartphone introduce an entirely new organising principle; instead, it densified, individualised and intensified the existing network regime. The outcome realised therefore ranges from system reconfiguration to regime-relevant recalibration, the diffusion of capacity and regime intensification.

7.6.2 Where Did the Under-Articulation Occur?

Under-articulation did not arise in the same manner in every episode. In the case of mainframes, the direction and operational mechanism were largely identified correctly, but the institutional implications of computational centralisation were semantically absorbed into the vocabulary of efficiency, modernisation and manageability. The scale of change was consequently underestimated precisely because the technology aligned with existing hierarchical structures.

In the case of commercial internet access, scale-aware systemic interpretations were available. Castells articulated network logic as a new principle of societal order, but this interpretation did not become dominant within the Dutch policy arena. Under-articulation therefore did not result from a complete absence of insight, but from its limited institutional traction. Epistemological adequacy and policy influence diverged.

In the case of general-purpose AI, under-articulation results from discursive fragmentation. Productivity claims, risk claims, legal regulation and sector-specific applications are discussed separately, but are rarely integrated into a coherent hypothesis concerning changes in evaluation, authorship, expertise and professional authority. The constitutive trajectories are distributed across several institutional layers and are therefore more difficult to connect within a single, scale-consistent systems thesis.

The additional episodes also demonstrate that under-articulation may arise when the visible artefact is incorrectly selected as the unit of analysis. In the case of the household PC, societal transformation is easily attributed to the device, although the decisive deepening occurred only through network connectivity. In the case of the business PC, the relevant object is a composite architecture comprising devices, networks, software and organisational adaptation. In the case of the smartphone, the significance of permanent mobility, platform dependence and continuous data collection was underestimated, but the outcome primarily consists of the intensification of an existing network regime.

The common thread is therefore not simply that technological impact was repeatedly estimated too conservatively. The recurring problem is that claims failed to identify the relevant object of transformation, level of scale or organising mechanism with sufficient precision. Under-articulation may result from normalising absorption, the institutional marginalisation of available systemic insights, discursive fragmentation or an overly artefact-centred definition of the episode.

7.6.3 What Was the Causal Role of Technology?

The causal role of technology differs between episodes and cannot be reduced to a single general model. Mainframe architecture was constitutive of the specific form of large-scale, uniform and centralised data processing, but operated within a configuration of bureaucratic expansion, standardisation and hierarchical organisation. Commercial internet access provided constitutive infrastructure for network coordination, but its societal operation depended on liberalisation, open standards, prior digitalisation and economic globalisation.

Within the educational domain examined, general-purpose AI functions as a constitutive factor in the current recalibration of assessment, authorship and legitimation. The technology is not, however, an autonomous cause. Its effects are connected to existing digital submission environments, the institutional emphasis on individual production, accreditation frameworks and norms of academic integrity.

In the additional episodes, causality is even more indirect. The household PC functioned primarily as an enabling condition for broader network diffusion. The business PC was a necessary component of the network and client–server configuration, but was not independently the cause of organisational restructuring. The smartphone operated primarily as a catalytic and reinforcing factor by making existing network and platform structures permanently accessible and embedding them deeply in everyday routines.

The plausibility assessment therefore reveals no simple distinction between technologically caused and non-technologically caused change. Without the technologies concerned, the transformations analysed would generally have assumed a different pace, scale or institutional form. Only in some episodes, however, was the technology a necessary condition for the specific order realised. In other cases, it was a facilitating, accelerating or densifying component within a configuration already under development.

7.6.4 What Does This Mean for the Assessment of Q3?

Q3 should not be understood as a homogeneous collection of underestimated system transformations. The episode analyses reveal at least three variants. In the case of commercial internet access, an adequate systems thesis was available but not institutionally dominant. In the case of mainframes, structural change was normalised as optimisation within existing hierarchies. In the case of general-purpose AI, the layered nature of the development has thus far impeded the formation of a coherent, scale-consistent systems articulation. The additional episodes show, moreover, that underestimation may also concern an infrastructural link, a composite socio-technical configuration or the intensification of an existing regime.

A discrepancy between early expectations and subsequent impact is therefore insufficient for classification within Q3. The relevant object of transformation must first be established. This object may be an individual technology, but may also consist of a functional architecture, an institutional configuration or an existing regime deepened by a new capability. It must then be determined whether the change realised consists of system reconfiguration, regime-relevant recalibration, regime intensification or merely the diffusion of capacity. Only after this can it be assessed whether the introductory articulation represented the direction, scale and conditions of that change proportionately.

Structurally adequate system-level predictions therefore require more than a recognisable causal argument. They must identify the shifting organising principle, select the appropriate level of analysis, make explicit the relationship between micro-, meso- and macro-level effects, and specify the institutional and technological conditions under which reconfiguration becomes plausible. Where any of these elements is absent, under-articulation may arise even when individual expectations concerning efficiency, productivity or use subsequently prove correct.

From the Q3 perspective, the answer to the central research question is therefore that IT-based societal transformations are only predictable to a limited extent when claims are formed around visible applications or artefacts. Predictability increases when analysis focuses on changes in coordination, information control, evaluation and legitimation, and when these changes are situated within the broader configuration in which technology operates. The defining feature of Q3 is thus not that future-oriented claims are invariably incorrect, but that they insufficiently articulate the relevant scale and the actual object of transformation

Chapter 8 — Inadequate Predictions, Failed Implementations

8.1 Positioning of Quadrant Q4

Quadrant Q4 comprises episodes within the canon in which an explicit future-oriented claim was formulated concerning the societal impact of ICT, but both predictive quality (X) and the societal transformation realised (Y) prove inadequate in relation to that claim. These are therefore cases in which the articulated expectation is structurally inadequate and no durable, positive reconfiguration occurs that corresponds with the development envisaged. The empirical purpose is analytical rather than normative: the chapter does not assess administrative culpability, but reconstructs the discrepancy between claim, outcome and configurative boundary conditions.

A specific empirical consideration in Q4 is that 'inadequate' does not necessarily mean that the underlying technological hypothesis was impossible. Rather, the claim may be deficient because threshold values, conditions of use, legal embedding or institutional complementarities were insufficiently explicit or incorrectly assessed. International comparisons are therefore used in this chapter as a means of revealing potential disconfirming evidence and configurative dependencies. The same class of technology may produce a different outcome under different institutional and economic conditions, helping to specify more precisely the nature of the failure in the Dutch episode.

This chapter remains strictly empirical. Its purpose is to answer the research questions systematically within Q4 and to isolate patterns characteristic of combinations of epistemological inadequacy and the absence of structural embedding. Comparison between quadrants and integrative synthesis follow only in a later chapter.

8.2 Episode 1 — The Childcare Benefits Scandal

8.2.1 Introduction to the Case

Case description. The Childcare Benefits Scandal concerns a technological cluster within the administrative organisation of the Dutch Tax and Customs Administration, in which automated risk selection, large-scale data linkage and rule-based decision-making were integrated into the administration of childcare benefits. This did not involve a single IT project, but a configuration of databases, classification mechanisms, risk models and administrative workflows that collectively functioned as decision-making infrastructure. Within this configuration, digital classification had direct legal and financial consequences: awards, revisions and recoveries followed from system-based selections and standardised decision rules. Reports by the National Ombudsman (2017), the Netherlands Court of Audit (2019) and, in particular, the report of the Parliamentary Inquiry Committee on Childcare Benefits (2020) show that risk profiles and indicators were applied at population level within this infrastructure, with characteristics such as administrative irregularities and dual nationality potentially contributing to selection. The combination of data linkage, risk profiling and automated decision-making thus became a constitutive element of administrative practice.

In public and political debate, the episode was articulated primarily in terms of failures of the rule of law and the harm inflicted on citizens. The present study, however, focuses on the structural role of ICT. The central question is how digital classification was positioned as an adequate means of systematically controlling fraud, and how this positioning relates to the institutional development that actually followed.

Expected benefits: future-oriented claim. The dominant future-oriented claim surrounding this cluster was that large-scale data processing and digital risk selection would produce more effective fraud detection, greater consistency in decision-making and increased administrative capacity without a proportionate expansion of staffing. The use of ICT was presented as an instrument for rationalising and objectifying enforcement within a mass administrative domain. In policy documents and administrative practice, digital selection was assumed to provide an efficient preliminary stage for legal assessment, in which elevated risk indicators would lead to targeted intervention. The claim contained an implicit causal assumption: that linking data and applying classification rules could make a structurally adequate distinction between lawful and unlawful use of public funds. It also implied that the standardisation of decision-making would reduce human variation and arbitrariness and thereby strengthen equality before the law. This positioning is consistent with broader developments in the digitalisation of the administrative state, in which ICT is deployed to increase scale, controllability and uniformity (see Bovens & Zouridis, 2002; Bekkers & Homburg, 2005).

Realised benefits. The empirical reconstruction shows that the claimed optimisation was not realised in the form envisaged. The risk-selection methods applied produced substantial numbers of false-positive classifications, in which citizens for whom fraud had not been proven were designated as fraudsters and confronted with full recovery of the childcare benefits they had received (National Ombudsman, 2017; Parliamentary Inquiry Committee on Childcare Benefits, 2020). The combination of system-based selection and legally stringent recovery rules restricted the scope for proportionate individual assessment. Instead of sustainably strengthening lawfulness and trust, a protracted institutional crisis emerged, culminating in political accountability and legislative revision. The intended policy objectives—more efficient

and lawful enforcement—were not durably realised in the form in which they had been articulated.

Impact on everyday life. Classification as a fraudster had direct and far-reaching consequences for thousands of households. Recovery of substantial sums led to debt problems, prolonged legal proceedings and severe psychosocial strain. For this study, this societal impact is relevant as an indication of the depth and breadth of the structural effects of the technological cluster. The consequences were not confined to internal administrative optimisation, but affected the core of citizens' legal position and economic security.

Path dependence. The Childcare Benefits Scandal must be understood against the background of a longer development in which digital infrastructures came to play an increasingly central role in the Dutch administrative state. Since the 1980s, administrative automation, the standardisation of decision-making processes and the intensification of data linkage between registers have steadily advanced (Bovens & Zouridis, 2002; Bekkers & Homburg, 2005). Within this historical trajectory, the use of risk selection does not constitute an exogenous rupture, but a further institutional embedding of digital classification as a mechanism of control. The episode can therefore be interpreted as a point of escalation within a long-standing logic of digitalisation.

8.2.2 Predictive Quality: Claim-Oriented Lens

Unit of analysis. The primary unit of analysis is the articulated future-oriented claim that large-scale data processing and digital risk selection within the administration of childcare benefits could make a structurally adequate distinction between lawful and unlawful use of public funds, and that standardised decision-making based on this distinction would produce more efficient, consistent and lawful administration at population level. The claim articulates both a causal assumption and an assumption concerning scale. Causally, it assumes that data linkage and risk profiling increase the probability of detecting fraud and reduce incorrect awards. In terms of scale, it assumes that this operation remains robust when applied to very large numbers of citizens within a complex social domain.

Articulation of causality. The assumed causal chain can be reconstructed analytically as follows. Data from different administrative sources are linked and processed within a risk-selection mechanism. This mechanism generates a classification of cases with an elevated probability of fraud. On the basis of this classification, decision rules are activated that lead to revision or recovery. Standardising these steps would reduce human variation and make administration more consistent. The claim thus articulates a direct relationship between data linkage, risk profiling and greater lawfulness in administration. Intermediate uncertainties concerning measurement validity, error margins or the context-dependent interpretation of indicators are not explicitly elaborated within the central claim.

Structural adequacy: articulation. The claim articulates a causal structure in which digital classification functions as the primary mechanism for distinguishing lawful from unlawful conduct. The intervention, intermediate mechanisms and intended result are identified explicitly. The articulation, however, is largely confined to the functioning of the risk-selection mechanism itself and does not elaborate possible system interactions, feedback mechanisms or error-amplifying dynamics in large-scale application. The articulation of causality is therefore explicit, but structured in relatively linear terms.

Articulation of boundary conditions. The original positioning of the system articulates only to a limited extent boundary conditions such as data quality, legal proportionality, human correction mechanisms or institutional safeguards against misclassification. The claim implicitly assumes that the digital infrastructure is capable of processing heterogeneous and context-dependent situations adequately without extensive additional institutional specification. Explicit articulation of the conditions necessary for robust application at population level remains limited.

Explication of scale. The future-oriented claim explicitly positions the system as an instrument for large-scale optimisation of enforcement. The assumption concerning scale is articulated clearly and directly connects application at population level with gains in efficiency and lawfulness. The claim does not explicitly elaborate possible feedback mechanisms or system interactions arising from large-scale application. The articulated scale was directed primarily towards efficiency and uniformity.

Articulation of the temporal dimension. The claim implies an expectation of durable improvement in administrative quality, but does not specify an explicit temporal boundary or phased process in which learning processes, correction mechanisms or institutional adjustment are articulated. The temporal horizon remains largely implicit.

Summary assessment of claim articulation. The future-oriented claim explicitly articulates a causal structure and an assumption of large-scale applicability, but only to a limited extent articulates the boundary conditions, error margins and constitutive conditions required for robust application at population level within a complex social domain. Within the epistemological lens, the claim is therefore assessed in terms of the explicit articulation of causality, conditions, scale and temporality, without reference to subsequent societal outcomes.

8.2.3 Societal Transformation: Transformation-Oriented Lens

The unit of analysis is the technological cluster of automated risk selection, data linkage and rule-based decision-making within the administration of childcare benefits, considered in the Dutch institutional context. The object of analysis is not the individual incident or its political resolution, but the structural reconfiguration produced by this cluster within administrative practices and the broader relationship between citizens and the state.

The type of change must first be established. The use of digital risk selection can be understood as a sectoral adaptation within social security and fiscal administration, insofar as existing enforcement practices were optimised and scaled up. At the same time, the cluster displayed characteristics of a deeper regime shift because digital classification assumed a central position within the decision-making architecture and thereby structurally altered the relationship between human assessment and system logic. The shift involved not merely acceleration or automation, but a reordering of the sequence of decision-making: prior classification structured subsequent legal assessment.

The durability of this change must be assessed ambivalently. On the one hand, the use of digital risk selection as such has not disappeared from Dutch administrative practice. Data linkage and algorithmic support remain constitutive elements of contemporary enforcement. In this sense, the cluster contributed to the further institutional embedding of digital classification as a mechanism of control. On the other hand, the crisis surrounding the Childcare Benefits Scandal led to legislative revision, stronger legal protection and greater attention to the human

dimension in decision-making. The specific configuration of stringent recovery rules combined with automated classification has therefore not persisted unchanged.

In terms of layering, the cluster cannot be reduced to an application layer superimposed on existing structures. Digital classification functioned constitutively within the administrative logic. The selection of cases largely determined which files received further scrutiny and under which legal classification they were placed. ICT was therefore not merely deployed in a supporting capacity, but partly determined the structure of decision-making. At the same time, the cluster formed an enabling condition for broader policy objectives concerning fraud control and budgetary discipline. The technology was therefore both constitutive within administrative practice and enabling within a broader administrative configuration.

The depth of reconfiguration is evident in the extent to which the digital infrastructure affected internal workflows and external legal positions. Internal processes were highly standardised and automated, restricting the scope for discretionary assessment. Externally, this produced a structural shift in the evidential position of citizens, who were confronted with classifications whose underlying logic was neither transparent nor readily contestable. The breadth of impact extended across thousands of households and multiple administrative levels, but formally remained confined to the domain of benefits and related administrative practices.

The degree of structural embedding must be assessed in relation to the broader digital administrative state. The Childcare Benefits Scandal did not result in the dismantling of digital enforcement as such. On the contrary, it revealed how deeply such systems had become institutionally embedded and how dependent administrative practices had become on digital classification. The crisis therefore functioned less as the end of a wave of digitalisation than as a moment of recalibration within an already embedded digital infrastructure.

On the basis of this analysis, the transformation profile can be characterised as follows. The technological cluster produced a significant reconfiguration of administrative practices and legal positions, with both constitutive and enabling elements within a broader digital governance configuration. This reconfiguration was deep and broad in its impact, but not durable in the specific configuration in which it was applied. The development can therefore be characterised as an intensification of digital regime logic that was partially recalibrated and reconfigured during a subsequent institutional phase.

8.2.4 Attribution: Causal Lens

The unit of analysis is the configuration in which the future-oriented claim concerning digital risk selection, the technological cluster of automated data linkage and rule-based decision-making, and the resulting institutional reorganisation of enforcement are analysed as a coherent whole. The central question is the extent to which this technological cluster was constitutive of the scale and systematic nature of the administrative practice that emerged.

Reconstruction of the causal hypothesis. The dominant hypothesis positioned digital risk selection as a means of detecting fraud more effectively and enabling uniform enforcement. Technology was presented as a driver of efficiency and lawfulness within existing legal frameworks.

Configurative causality. The actual development occurred within a configuration in which political emphasis on combating fraud, legally stringent provisions and organisational pressure

on administrative capacity formed active causal components. Digital classification did not operate autonomously, but was embedded within existing normative and administrative logics.

Counterfactual plausibility assessment. The relevant counterfactual is not whether stringent enforcement would have been conceivable without ICT, but whether the observed scale, uniformity and systematic reproduction of classification decisions would have been plausible without the technological cluster. Without automated data linkage and rule-based processing, enforcement would necessarily have remained dependent on human assessment and sequential processing. This would have substantially constrained the scale, speed and uniformity of classification. It is therefore plausible that the specific form of large-scale and systematic classification that developed could not have been realised with comparable intensity and reach without this technological cluster.

Causal profile. Digital risk selection was not a sufficient cause of the institutional crisis; political and legal factors also shaped the direction and intensity of enforcement. The technological cluster was, however, constitutive of the operational possibility of large-scale, uniform and automated classification. ICT therefore functioned as a necessary condition for the specific form of mass enforcement that emerged, within a broader multicausal configuration of administrative and legal logics.

8.2.5 Conclusion to Episode 1

The analysis of the Childcare Benefits Scandal shows that future-oriented claims concerning digital enforcement must be assessed not only in terms of technical plausibility, but also in terms of their structural adequacy within concrete institutional configurations. The central claim that large-scale data linkage and risk selection would produce more objective and efficient enforcement articulated a linear logic of rationalisation, but insufficiently specified how expansion of scale, legal norm-setting and institutional translation would affect the operation of digital classification.

For the central research question, this implies that historical predictions concerning the societal impact of ICT must articulate not only their causal chain, but also their position within a broader decision-making architecture. In this case, digital classification did not function merely as an instrument within existing enforcement practices, but as a constitutive element of the sequence of decision-making. The operationalisation of legal norms at population level was thereby structurally reorganised.

The episode underlines that structurally adequate predictions require not only an accurate assessment of technical possibilities, but also of institutional embedding, correction mechanisms, robustness at scale and the layered effects of classification on legal positions. The Childcare Benefits Scandal therefore provides empirical evidence that under-specification of conditions and disregard of constitutive technological logic can produce a fundamental discrepancy between claimed rationalisation and the societal transformation realised.

8.3 Episode 2 — The CoronaMelder App

8.3.1 Introduction to the Case

Case description. The CoronaMelder app was a digital intervention within the Dutch response to COVID-19, developed in 2020 under the direction of the Ministry of Health, Welfare and Sport. The application used Bluetooth Low Energy signals and the decentralised Google/Apple Exposure Notification framework to register proximity contacts between users. Following confirmation of an infection, a user could, after verification by the Municipal Health Service, anonymously send notifications to recent contacts. The infrastructure consisted of a mobile application, cryptographic key exchange and a backend for validating and distributing infection keys. Its operation was entirely voluntary and depended on the rate of adoption, activation of Bluetooth and timely verification of test results. Before the national rollout, the Dutch Data Protection Authority and independent security audits concluded that the system had been designed in accordance with privacy-by-design principles (Dutch Data Protection Authority, 2020; Open Web Application Security Project, 2020).

Expected benefits: future-oriented claim. The central future-oriented claim was that digital contact notification would substantially increase the speed and effectiveness of contact tracing, allowing chains of transmission to be interrupted at an earlier stage. Policy documents and parliamentary debates positioned the app as a scalable supplementary instrument alongside manual tracing (Ministry of Health, Welfare and Sport, 2020). The claim rested on three assumptions that are also discussed in the international literature on digital contact tracing (Ferretti et al., 2020; Abueg et al., 2021): a sufficiently high adoption rate, sufficient technical accuracy of Bluetooth-based proximity detection as a proxy for infection risk, and actual behavioural adjustment following notification. Epidemiological effectiveness was therefore conditional and dependent on both technical and behavioural factors.

Realised benefits. The app was rolled out nationally in October 2020 and reached millions of downloads within several months. Evaluations by the National Institute for Public Health and the Environment and the ministry show that notifications did lead to additional test requests and that some people who tested positive were reached through the app without having previously been identified through manual contact tracing (RIVM, 2021; Ministry of Health, Welfare and Sport, 2021). At the same time, its overall epidemiological contribution remained limited. Effectiveness proved highly dependent on the rate of adoption, timely processing of test results and compliance with behavioural advice. International studies indicate that digital contact tracing is rarely decisive on its own under real-world conditions, but operates as a supplement to existing measures (Braithwaite et al., 2020; Abueg et al., 2021). The impact realised therefore fell short of the potential for substantial transmission reduction suggested in public communication.

Impact on everyday life. For individual users, the direct impact was confined to notifications and behavioural advice. Classification carried no automatic legal or financial consequences. Societal sensitivity centred on privacy, data minimisation and voluntary participation. Evaluations show that concerns about surveillance partly influenced willingness to adopt the app (Van Kolfschooten, 2020; RIVM, 2021).

Path dependence. CoronaMelder built on existing mobile platform architectures developed by Google and Apple and on international initiatives involving digital contact tracing. The Dutch

implementation was therefore an application within existing socio-technical ecosystems rather than an autonomous technological breakthrough.

Internationally, digital contact notification was applied in divergent configurations. In South Korea, Singapore and Taiwan, digital contact tracing was not used exclusively as a voluntary notification layer, but was integrated into broader surveillance systems, quarantine enforcement and centralised data collection (Park et al., 2020; Morley et al., 2020; Huang et al., 2020). In some cases, Bluetooth-based proximity detection was combined with location data, credit-card transactions or telecommunications data. In these configurations, digital tracing formed part of a highly centralised crisis regime in which notification requirements, quarantine monitoring and enforcement were institutionally embedded. The technological intervention did not function merely as a voluntary application, but as an integral component of a broader administrative instrumentarium. This international divergence underlines that digital contact notification is not a uniform technological intervention, but may be embedded differently in configurative terms.

8.3.2 Predictive Quality: Claim-Oriented Lens

In the analysis of the CoronaMelder episode through the epistemological lens, predictive quality is understood as a multidimensional concept comprising structural adequacy, conditional sensitivity and scale consistency. The analysis concerns only the claim about the technology's societal impact. The primary unit of analysis is the future-oriented claim that digital contact notification would contribute substantially to reducing chains of transmission in the Netherlands by accelerating and strengthening contact tracing.

Structural adequacy. The central causal hypothesis can be reconstructed analytically as follows: Bluetooth-based proximity detection, combined with rapid digital notification following verification of a positive test result, saves time in warning contacts, enabling potentially infected individuals to test and isolate sooner, thereby reducing transmission at population level. This causal chain is internally coherent and epidemiologically plausible. Modelling studies suggested that time savings in contact tracing could have significant effects on reproduction rates, provided sufficient coverage was achieved (Ferretti et al., 2020). The hypothesis is therefore not conceptually unsound. Its articulation remains linear, however: it assumes a relatively direct transition from notification to behavioural adjustment and from behavioural adjustment to population-level effects. Intermediate uncertainties—such as false positives, willingness to report and variation in compliance—are not systematically integrated into the central claim. The structural articulation is therefore limited in its elaboration of possible feedback and attenuation mechanisms.

Conditional sensitivity. The effectiveness of digital contact notification depends strongly on the rate of adoption, active participation through reporting a positive test result, the speed of test verification and compliance with isolation advice. Although these conditions were mentioned in policy documents and public communication, critical threshold values were not explicitly articulated as necessary conditions for epidemiological relevance. Modelling studies showed that significant population-level effects were associated with relatively high adoption levels and rapid responses to notifications (Ferretti et al., 2020). In the Dutch claim, however, the relationship between the level of use and the magnitude of the effect remained implicit. Boundary conditions were therefore specified only to a limited extent: the hypothesis was presented as a scalable instrument without explicitly elaborating minimum necessary levels of participation and compliance.

Scale consistency. The societal impact claim positioned the application as making a substantial contribution to national pandemic control. The assumed scale concerned effects at population level rather than merely individual warnings. The epistemological articulation did not, however, systematically integrate how individual notifications would aggregate into population dynamics under realistic adoption conditions. The transition from individual warning to structural transmission reduction remained analytically under-specified. This created a scale inconsistency between the claimed level of effect and the extent to which the mechanisms of aggregation were explicitly elaborated.

Articulation of the temporal dimension. The claim implied rapid effectiveness within an acute pandemic context, but did not specify how learning processes, behavioural adaptation or changing epidemiological conditions would affect its operation over time. The temporal dimension remained largely implicit.

Claim profile. The societal impact claim surrounding CoronaMelder displays internal coherence, but limited explication of conditions and scale. The underlying hypothesis—that faster contact notification can reduce transmission—is conceptually plausible and supported internationally. In Dutch policy articulation, adoption and participation were identified as relevant factors (Ministry of Health, Welfare and Sport, 2020), but were not systematically specified in terms of the minimum levels of use necessary to produce substantial impact at population level. The relationship between participation rates and the magnitude of effects remained implicit. This resulted in low predictive quality: not because the technological hypothesis was intrinsically incorrect, but because it failed to make sufficiently explicit the conditions and scale parameters under which the claimed societal impact could actually be realised.

8.3.3 Societal Transformation: Transformation-Oriented Lens

Under the transformation-oriented lens, transformation is understood as the durable reconfiguration of institutional, organisational and socio-technical structures. The unit of analysis is the technological cluster of digital contact notification, including its organisational embedding in Dutch infectious-disease control.

Type of change. The introduction of CoronaMelder added a digital notification component to the existing system of contact tracing. The core structure of powers, decision-making and institutional hierarchy within public healthcare remained unchanged. Municipal Health Services retained their central implementation role, and legal frameworks were not fundamentally altered in favour of digital autonomy. No regime shift occurred; instead, there was a temporary extension within the existing institutional framework.

Depth and layering. The technology functioned complementarily. It added a digital notification layer to an existing organisational configuration. The core logic of infectious-disease control—testing, isolation and manual tracing—remained decisive. Digital contact notification did not become constitutive of the decision-making architecture of public-health policy, but remained subordinate to existing organisational and legal structures.

Institutional redistribution. No lasting redistribution of responsibilities occurred between the state and citizens. The application introduced no new legal obligations and did not alter citizens' formal legal position. The use of digital notification was embedded in a framework centred on voluntariness and privacy.

Durability. After the pandemic emergency ended, the application was deactivated without the formation of a new stable institutional arrangement. No lock-in effect occurred, and digital contact notification was not embedded as a structural regime element in future infectious-disease control.

International context. Internationally, cases can be identified in which digital contact tracing was integrated more deeply into institutions. In South Korea, a legal framework was created following earlier epidemics to enable digital monitoring during emergencies (Huang et al., 2020; Park et al., 2020). In Singapore, digital tracing was integrated into broader access and verification systems. These configurations illustrate that digital contact notification can become constitutive of crisis response under different institutional conditions. In the Netherlands, its use remained temporary and supplementary. No shift occurred towards a structural digital-surveillance infrastructure.

Transformation profile. Within the Dutch context, digital contact notification cannot be shown to have produced a durable reconfiguration of institutional or socio-technical structures. The technological cluster occupied a temporary and complementary position within the existing regime. Its societal impact therefore remained ontologically limited.

8.3.4 Attribution: Causal Lens

The causal lens is used to analyse the role of digital contact notification within an open, multicausal configuration. The central attribution question is the extent to which the CoronaMelder technological cluster was necessary, constitutive or explanatory in relation to the actual development of pandemic control in the Netherlands. The unit of analysis is the composite case in which the societal impact claim is connected to the technological cluster and the empirically reconstructed dynamics of the pandemic.

Reconstruction of the causal hypothesis. The implicit hypothesis was that digital contact notification would save time in reaching potentially infected individuals, allowing transmission chains to be interrupted earlier and reducing transmission at population level. Technology was therefore positioned as a causal factor in reducing transmission dynamics.

Configurative causality. The actual operation of the cluster depended on several complementary factors: voluntary installation, willingness to report following a positive test, the speed of test verification by Municipal Health Services, compliance following notification and the simultaneous use of other measures such as lockdowns and vaccination campaigns. These factors were constitutive of the societal outcome and were not under the direct control of the technology itself. Digital contact notification therefore functioned within a configuration in which epidemiological, organisational and behavioural variables were dominant. The international literature confirms this configurative dependence. In South Korea, digital tracing functioned within an institutional framework integrating testing capacity, mandatory quarantine and enforcement (Park et al., 2020; Huang et al., 2020). Technology was not autonomously sufficient there either, but was embedded in a configuration that strengthened its effectiveness. The Dutch application remained voluntary and privacy-oriented, without mandatory enforcement or centralised data linkage.

Counterfactual plausibility assessment. The relevant plausibility assessment concerns whether the observed pandemic dynamics in the Netherlands would have developed in a comparable form without digital contact notification. Given the dominant role of broader policy

measures, vaccination rates and seasonal influences, it is plausible that the general trajectory of infection rates would have moved in a similar direction without the application. The technology was therefore not necessary for the societal configuration observed. Nor can it be established that it was constitutive of a structural reconfiguration of pandemic control. No institutional dependence or durable integration emerged that fundamentally restructured future crisis response.

Causal profile. Within the Dutch configuration, digital contact notification can be characterised as a facilitating but contingent factor. It made faster notification possible, but was neither necessary nor constitutive of the structural development of pandemic control. The societal outcome therefore cannot be attributed explanatorily to the technological cluster. This confirms its positioning within Q4, in which both the societal impact claim and the structural effects realised remained limited in relation to the original expectation.

8.3.5 Conclusion to Episode 2

The CoronaMelder episode demonstrates that technical functionality is not equivalent to the structural adequacy of societal impact claims. The procedural operation of the technology largely conformed to its design, but the prediction that digital contact notification would contribute substantially to reducing transmission at population level proved dependent on behavioural and institutional conditions that had not been specified sufficiently explicitly.

For the central research question, this implies that historical predictions concerning the societal impact of ICT can be regarded as structurally adequate only when they explicitly identify the adoption, compliance and institutional thresholds under which substantial effects become plausible. In this case, effectiveness was articulated as a meaningful contribution to pandemic control without systematically elaborating the critical conditions of scale. The discrepancy between expectation and outcome was therefore primarily epistemological.

The international literature underlines that digital contact notification may play a greater role under specific institutional configurations (Park et al., 2020; Huang et al., 2020). The Dutch case shows, however, that without explicit institutional embedding and a high rate of participation, the technology does not become a constitutive or necessary factor in societal dynamics.

Within Q4, CoronaMelder therefore constitutes an example of an intervention that functioned adequately in technical terms but did not realise a durable societal reconfiguration proportionate to the original impact claim. The episode confirms that under-specification of conditions and overestimation of robustness at scale may be recurring characteristics of inadequate prediction in the digital domain.

8.4 Episode 3 — Viditel (the Netherlands) versus Minitel (France)

8.4.1 Introduction to the Case

Case. Videotex was an early online service architecture through which users accessed central databases for information and transactions via a terminal and telephone connection. In France, Minitel was rolled out nationally from 1982 onwards under the direction of France Télécom. In the Netherlands, Viditel was introduced during the same period as an interactive information service operated by PTT Telecom.

Expected benefits. In France, Minitel was positioned as a future national communication medium and a driver of economic innovation, with broad applications in commerce, administration and service provision (Bright, 1987; OECD, 1997). In the Netherlands, Viditel was presented as a new interactive information service with the potential for commercial applications and broad societal diffusion (Oud, 1982). In both cases, a structural communication layer was envisaged.

Realised benefits. In France, Minitel achieved large-scale adoption: millions of terminals were distributed and thousands of services were integrated into the platform. The system remained operational into the 2000s (OECD, 1997). In the Netherlands, Viditel remained confined to experimental and niche use; broad adoption failed to materialise and the system was discontinued.

Impact on everyday operations. In France, Minitel routinely influenced information retrieval, commercial transactions such as directory services and reservations, and administrative interactions. In the Netherlands, its impact remained confined to small groups of users and the system had no structural influence on everyday transactions.

Path dependence. Videotex built on existing telephone infrastructure and central database technology. In France, its rollout was integrated into a highly centralised telecommunications regime. In the Netherlands, Viditel was embedded in a more liberal, market-oriented telecommunications landscape without large-scale hardware distribution.

8.4.2 Predictive Quality: Claim-Oriented Lens

Unit of analysis. The unit of analysis for each country is the explicitly articulated expectation that videotex would develop into a widely adopted national digital infrastructure for information and transactions.

Central claim. In France, Minitel was positioned as a future national communication medium and a driver of economic innovation, with broad applications in public and commercial service provision (Bright, 1987; OECD, 1997). In the Netherlands, Viditel was presented as a new interactive information service with the potential for widespread application in commerce and service provision (Oud, 1982).

Structural adequacy. In France, the claim encompassed not only the technological functionality of videotex, but also explicit institutional boundary conditions: central direction, standardisation, free distribution of terminals and a uniform tariff model. The articulated expectation therefore incorporated the conditions required for scaling and adoption. Assessment

against the development realised shows that this articulation was structurally adequate: the national ambition corresponded with long-term, large-scale use (OECD, 1997).

In the Netherlands, the expectation was formulated primarily in terms of market-driven diffusion and voluntary adoption. The conditions required for mass scaling—such as broad hardware distribution or strong economic incentives for service providers—were specified less explicitly. Retrospective assessment shows that the articulated ambition concerning scale was epistemologically insufficiently supported by an elaboration of its conditions. The structural adequacy of the Dutch claim was therefore limited.

Conditional sensitivity. The French claim was explicitly embedded in a policy programme in which institutional complementarities formed an integral part of the expectation. In the Netherlands, the articulation of boundary conditions remained more abstract and less concrete. The necessary relationship between technology, distribution strategy and the service economy was articulated with less epistemological precision.

Scale consistency. In France, the articulated national scale corresponded with a consistent understanding of scale in both policy and implementation. In the Netherlands, broad societal reach was likewise suggested, but without a proportionate elaboration of the conditions required for scaling. The scale articulated in Dutch claims was therefore ambitious but conditionally under-specified.

Claim profile. From the perspective of the epistemological lens, the French future-oriented claim was structurally adequate and explicit about its conditions, whereas the Dutch claim was epistemologically deficient because it under-specified the conditions required for implementation and scaling. The difference lay not primarily in the technological hypothesis, but in articulation quality.

8.4.3 Societal Transformation: Transformation-Oriented Lens

Under the transformation-oriented lens, the unit of analysis for each country is the technological cluster of videotex within the national telecommunications and information structure during the period from approximately 1980 to 1995. The issue is not incidental use, but whether the cluster produced a durable reconfiguration of institutional, organisational and economic structures.

Type of change. In France, Minitel was systematically integrated into the national telecommunications architecture from 1982 onwards. The Direction Générale des Télécommunications positioned the system explicitly as a replacement for the printed telephone directory and as a national access point for digital services (Bright, 1987). Free distribution of terminals to millions of households created an immediate user base. This changed not only the medium, but also the economic structure of digital service provision: through the so-called kiosk system, service providers could generate revenue through the telephone bill, with France Télécom distributing part of the proceeds (OECD, 1997). A new market segment for digital information and transaction services thereby emerged that had not existed before Minitel. Banking services, reservation systems and commercial advertisements were integrated into a single national platform (Reid, 1991). The institutional relationship between telecommunications provider, service provider and user was reorganised around digital infrastructure.

In the Netherlands, by contrast, Viditel remained an additional service without broad hardware distribution or a comparable tariff structure. The system neither reached a critical mass of households nor became a dominant gateway for public or commercial services (TNO/University of Amsterdam, 1985). The core structures of information provision—printed media, telephone services and, subsequently, the open internet—remained unchanged.

Durability and embedding. Minitel remained a stable digital infrastructure for more than a decade. By the mid-1990s, millions of terminals were still in use and billions of minutes of connection time were recorded annually (OECD, 1997). Its economic embedding was sufficiently extensive for thousands of companies to adapt their service models to the platform. This indicates durable institutional embedding. The system did not function as a short-lived innovation, but as a stable component of the communications regime. In terms of path dependence, early standardisation and economies of scale enabled long-term stability (David, 1985; Arthur, 1989), although the extent to which this delayed subsequent internet adoption remains a matter of debate (OECD, 1997).

No comparable indications of durability or economic dependence exist for Viditel. Evaluations from the 1980s refer to limited user numbers and weak commercial traction (TNO/University of Amsterdam, 1985). The cluster disappeared without leaving an institutional residual structure.

Layering and structural impact. In France, Minitel functioned as a national infrastructural layer for digital interaction. The platform connected households, businesses and government services within a single standardised system. Digital service provision thereby became a routine component of everyday economic activity. In the Netherlands, Viditel remained an experimental or supplementary service without demonstrable restructuring of institutional relationships or economic patterns.

In summary, Minitel can be characterised as a case of durable reconfiguration of the national digital services sector. Viditel produced no comparable reconfiguration. The difference concerned not merely the volume of adoption, but the degree of institutional embedding and economic reorganisation.

8.4.4 Attribution: Causal Lens

This analysis systematically examines the composite case in which the future-oriented claim, technological cluster and empirical development are connected for each country.

Reconstruction of the causal hypothesis. The original hypothesis in both countries was that an interactive digital infrastructure operating through the telephone network would form a new communication layer that would structurally transform information and transaction flows (Bright, 1987; OECD, 1997).

Configurative factors. In France, the technology was not introduced as a stand-alone product, but as part of a national strategy for modernising the telecommunications sector. Crucial elements included free distribution of terminals, integration of payments into the telephone bill, central standardisation and active support for service providers. These factors reinforced one another. The presence of millions of terminals made it attractive for service providers to develop services; the kiosk system made commercial exploitation profitable; and standardisation reduced barriers to entry (OECD, 1997).

In the Netherlands, no comparable intervention at scale occurred. The technology was offered without mass hardware distribution or a strongly centralised tariff mechanism (Oud, 1982). The incentive structure for service development therefore remained limited.

Plausibility assessment. The question posed through the causal lens is not whether technology was sufficient in itself, but whether it was plausibly constitutive of the observed outcome within the configuration. In France, it is difficult to imagine that a comparable national digital services ecosystem could have emerged during the 1980s without the specific Minitel infrastructure. The technology functioned as a coordinating mechanism that structurally brought supply and demand together. In the Netherlands, subsequent digital development—including the rapid transition to open internet services during the 1990s—did not depend on Viditel (Abbate, 1999). The societal outcome is readily conceivable without any significant role for the videotex cluster.

Causal profile. Within the French configuration, videotex can be identified as a central factor in the emergence of a national digital service economy. It was not an autonomous cause, but a constitutive element within a mutually reinforcing institutional structure. Within the Dutch configuration, Viditel was neither a necessary nor a dominant factor in subsequent digital development.

Outcome. Causal attribution is substantial in France within a configurative approach, but weak and contingent in the Netherlands. The difference lay not in technical capacity, but in institutional and economic embedding.

8.4.5 Conclusion to Episode 3

The videotex episode demonstrates that discrepancies between future-oriented claims and societal outcomes are not primarily related to technological feasibility, but to the specification of boundary conditions. In both the Netherlands and France, videotex was positioned as a digital service layer. Only in France did this claim correspond with durable institutional embedding.

The difference lay not in the class of technology, but in the configuration. In France, the impact claim was supported by explicit conditions for scaling: central standardisation, mass distribution of terminals and a uniform tariff model (Bright, 1987; OECD, 1997). In the Netherlands, the articulation of the necessary conditions for scale and ecosystem formation remained limited, although these conditions constituted the principal source of vulnerability (Oud, 1982; TNO/University of Amsterdam, 1985).

The episode therefore shows that the structural adequacy of ICT predictions is dependent on scale and regime. The same technology can produce divergent outcomes under different institutional configurations. Future-oriented claims are structurally adequate only when they explicitly identify the institutional and economic conditions under which their projected impact becomes plausible.

Analytically, the comparison indicates a recurring Q4 pattern: overestimation of robustness at scale and under-specification of institutional boundary conditions. Where configurative thresholds remain implicit, technological potential is mistaken for societal probability.

8.5 Episode 4 — Digital Electoral Infrastructure (the Netherlands versus Estonia)

8.5.1 Introduction to the Cases

Case. Digital electoral infrastructure concerns the use of ICT within voting and vote-counting processes. In the Netherlands, electronic voting machines were used from the 1980s onwards as a replacement for paper ballots. In Estonia, internet voting (i-Voting) was introduced in 2005 as an additional voting option in national elections.

Expected benefits. In the Netherlands, electronic voting machines were expected to make vote counting more efficient, faster and less prone to error, while supporting administrative modernisation (Ministry of the Interior and Kingdom Relations, 2004). In Estonia, i-Voting was positioned as an efficient and accessible extension of the electoral process, consistent with a durable digital governance model (Madise & Martens, 2006).

Realised benefits. In the Netherlands, results became available more quickly, but concerns about verifiability and vulnerability to manipulation led to the discontinuation of electronic voting machines in 2007 (Gonggrijp & Hengeveld, 2006). In Estonia, the proportion of votes cast online increased structurally; i-Voting became a durable component of the electoral process (Estonian National Electoral Committee, 2019).

Impact on everyday operations. In the Netherlands, the voting experience within polling stations changed temporarily, but without any lasting restructuring of citizen participation. In Estonia, i-Voting introduced an additional form of participation, allowing citizens to vote remotely through digital identification.

Path dependence. Dutch voting machines functioned as isolated systems without integration into a broader digital infrastructure. Estonian i-Voting built on an existing digital identity architecture and interoperable government registers, enabling institutional integration.

8.5.2 Predictive Quality: Claim-Oriented Lens

Unit of analysis. The unit of analysis for each country is the explicitly formulated expectation that digital electoral infrastructure would structurally improve the electoral process in terms of efficiency, reliability and accessibility.

Central claim. In the Netherlands, electronic voting machines were expected to make vote counting more efficient and less prone to error, while supporting administrative modernisation (Ministry of the Interior and Kingdom Relations, 2004). In Estonia, i-Voting was positioned as an efficient and accessible extension of the electoral process, consistent with a durable digital governance model (Madise & Martens, 2006).

Structural adequacy. In the Netherlands, the efficiency component of the claim was realised: results became available more quickly. The reliability component, however, was epistemologically underdeveloped, particularly with regard to transparency and independent verifiability (Gonggrijp & Hengeveld, 2006). The articulation of reliability was conditionally under-specified. The structural adequacy of the Dutch claim was therefore partial.

In Estonia, the expectation was explicitly connected to existing digital identity infrastructure and cryptographic verification. The claim integrated institutional boundary conditions as a constitutive part of the expectation. Retrospective assessment shows that the core components of efficiency and accessibility were realised durably (Estonian National Electoral Committee, 2019). The structural adequacy of the Estonian claim was high within the national configuration.

Conditional sensitivity. The Dutch articulation did not make sufficiently explicit the technical and legal conditions under which trust and verifiability had to be guaranteed. In Estonia, these conditions were integrated more explicitly into legislation and infrastructure. The Estonian claim therefore displayed greater conditional precision.

Scale consistency. In the Netherlands, the articulated structural improvement remained limited to organisational efficiency within the polling station. In Estonia, digital voting was positioned as part of a broader digital state architecture. The articulation of scale was consistent there with the degree of institutional embedding.

Claim profile. From the perspective of the claim-oriented lens, the Dutch claim is assessed as partially adequate but conditionally under-specified. The Estonian claim is assessed as structurally adequate, with explicit integration of the necessary institutional conditions. The difference lies primarily in articulation quality and configurative precision.

8.5.3 Societal Transformation: Transformation-Oriented Lens

The technological cluster of ‘digital electoral infrastructure’ within the national electoral regime, including its institutional, organisational and technical embedding, forms the unit of analysis.

Type of change. In the Netherlands, electronic voting constituted procedural modernisation within the existing representative system. Its introduction changed the counting mechanism, but not the institutional structure of elections. Following its discontinuation in 2007, the Netherlands returned to paper ballots. No regime shift occurred. In Estonia, by contrast, internet voting was integrated into an already digitalised state model. The system was not introduced as a temporary procedural innovation, but as a structural component of the electoral architecture within a digital governance regime.

Depth of reconfiguration. The differences between the Netherlands and Estonia concern both the depth and breadth of institutional reconfiguration. In the Netherlands, digitalisation remained confined to the technical counting process, without altering the fundamental organisation of elections, oversight, legal safeguards or voting procedures. Its impact was therefore narrow and procedurally confined to the polling station. In Estonia, by contrast, the casting of votes is integrated into a digital infrastructure comprising digital identification, cryptographic verification and interoperable state registers. The interaction between citizens and the state at the electoral level was thereby structurally digitalised, with effects extending into the broader domains of digital identity, e-governance and administrative infrastructure.

Durability and embedding. The Dutch system was discontinued; no institutional embedding or path dependence emerged. In Estonia, internet voting has formed a structural component of national elections since 2005. The system has repeatedly been evaluated, modified and retained. It is therefore durably embedded institutionally.

Transformation profile. Viewed through the transformation-oriented lens, the degree of durable reconfiguration of the electoral regime in the Netherlands is assessed as low. No lasting restructuring occurred. In Estonia, the degree of durable reconfiguration is assessed as high: digital electoral infrastructure is structurally integrated into the national governance model.

8.5.4 Attribution: Causal Lens

The unit of analysis under the causal lens is the composite case in which the future-oriented claim, technological cluster and actual institutional development are systematically connected.

Reconstruction of the causal hypothesis. The implicit hypothesis in both countries was that digital electoral infrastructure would make democratic processes more efficient, reliable and accessible.

Configurative factors. In the Netherlands, crucial complementary factors were absent: a national digital identity infrastructure, cryptographically verifiable end-to-end auditing, legally embedded digital authentication and broad integration with e-governance. The voting machines functioned as isolated technical systems. In Estonia, by contrast, i-Voting operates within a legally embedded digital identity system, cryptographic infrastructure, interoperable state registers and extensive societal experience with digital interaction with government. The technology is therefore part of a coherent institutional configuration.

Plausibility assessment. Dutch democratic development is entirely conceivable without electronic voting machines. The technology was not constitutive of the regime. In Estonia, the current model of digital elections is difficult to imagine without digital identity infrastructure and cryptographic architecture. The technology functions there as a constitutive element within a broader digital state configuration.

Causal profile. In the Netherlands, digital electoral infrastructure was a contingent technical intervention without durable causal impact on the structure of the regime. In Estonia, digital electoral infrastructure functions as a configuratively constitutive element within a digitalised governance model. In summary, the causal role of digital electoral infrastructure was limited and non-constitutive in the Netherlands, but substantial within a mutually reinforcing institutional configuration in Estonia.

8.5.5 Conclusion to Episode 4

The comparison between the Netherlands and Estonia shows that the adequacy of future-oriented claims concerning digital electoral infrastructure is determined not primarily at the level of technical functionality, but at the level of institutional congruence.

In the Netherlands, electronic voting was positioned as an instrument of modernisation within a predominantly analogue electoral regime. The efficiency gains realised corresponded with the intervention's limited procedural ambition. Durable institutional embedding did not occur, however, because the technology was not integrated into a broader digital state architecture. Its impact therefore remained contingent and reversible.

In Estonia, internet voting was introduced within an already consolidated digital infrastructure based on digital identity, cryptographic authentication and legal integration. The future-oriented

claim of structural embedding was consistent with the existing architectural conditions and corresponded substantially with the development realised.

The episode demonstrates that impact claims concerning digital electoral infrastructure are structurally adequate only when they are explicitly aligned with the institutional architecture within which they are implemented. Where technology and regime logic are incongruent, digitalisation remains procedural. Where congruence exists, it can be integrated durably.

8.6 Synthesis of Quadrant Q4 — Inadequate Prediction and the Absence of Durable Embedding

Quadrant Q4 comprises episodes in which both predictive quality (X) and the societal embedding realised (Y) fall short in relation to the original impact claim. The analysis of the four episodes in this chapter reveals three recurring patterns.

First, epistemological inadequacy often appears to be associated with the under-specification of institutional boundary conditions. In both the Childcare Benefits Scandal and CoronaMelder, crucial behavioural, legal or organisational conditions were insufficiently integrated into the original impact claim. In the cases of Viditel and the Dutch voting machines, ambitious expectations concerning scale were formulated without a proportionate elaboration of the necessary complementarities.

Second, the analysis of the transformation processes shows that the absence of durable embedding does not necessarily mean that the underlying technology fails to function. In several cases, the technology operated adequately at the procedural level, while societal reconfiguration remained limited or temporary. The distinction between technical operation and structural transformation is therefore analytically crucial.

Third, the causal analysis shows that technology is rarely an autonomous determinant in these episodes. The societal outcome depends configuratively on institutional, legal and behavioural factors. Where these factors are incongruent with the articulated ambition concerning scale, a discrepancy arises between expectation and realisation.

The international comparisons in this chapter illustrate that the same class of technology may produce different outcomes under different configurative conditions. This implies that inadequate prediction in Q4 does not arise primarily from an incorrect technological hypothesis, but from insufficient precision in articulating the conditions under which the transformation envisaged becomes plausible.

Quadrant Q4 is therefore characterised by a combination of epistemological under-specification and limited or temporary institutional embedding. In these cases, the discrepancy between claim and outcome is not merely empirical, but can be traced analytically to an inadequate articulation of boundary conditions and an overestimation of robustness at scale.

Chapter 9 — Cross-Case Analysis

This chapter answers the fourth research question (RQ4): Which characteristics of predictions and forecasters recur in structurally adequate predictions, and how can these characteristics be interpreted historically across different waves of ICT?

Following the case analyses in Chapters 5 to 8, the perspective now shifts from individual episodes to systematic comparison. The purpose is not to introduce new empirical material, but to identify patterns that recur consistently across different configurations and periods.

Section 9.1 synthesises the findings through the three analytical lenses—epistemological, ontological and causal—and identifies recurring characteristics of structurally adequate articulations. It thereby formulates the direct answer to RQ4.

Section 9.2 qualifies these findings by considering second-order effects of digital transformation: normative, risk-oriented and administrative corrections that emerge as digital infrastructures become institutionally embedded. Whereas §9.1 focuses on first-order transformation and articulation quality, §9.2 examines forms of reflexive adaptation and structural unpredictability.

Section 9.3 finally situates these findings within a broader historical framework. It reconstructs the constitutive conditions under which digital regime formation could take place in the Netherlands from the 1960s onwards. By returning to the period from 1945 to approximately 1965, it becomes apparent that digital transformations should not be understood as abrupt starting points, but as a deepening of processes of rationalisation and scaling that were already under way. The analytical framework of this chapter is thereby historically grounded.

Together, these three sections mark the transition from case analysis to synthesis: from individual episodes, through comparative patterns and reflexive counter-movements, to the constitutive foundations on which digital regime formation developed.

9.1 Patterns in Robust Predictions (RQ4)

This section answers RQ4 by creating—through the claim-oriented lens, transformation-oriented lens and causal lens—a comprehensive overview from which patterns of robust predictions can be distilled. The tables in this section reflect the findings from Chapters 5 to 8. They do not constitute a new assessment, but provide a condensed representation of the analyses already elaborated for each lens. The following criteria were used to label and classify the episodes:

✅	Condition convincingly met	The reference section concludes that the requirements of the relevant dimension were fully met, without significant counter-indications.
◐	Partially met / ambiguous	The reference section concludes that the requirements of the relevant dimension were met to a substantial degree. There is under-specification, dependence on boundary conditions or mixed empirical findings.
❌	Not met	The reference section explicitly concludes that the requirements of the relevant dimension were not, or were barely, met.
–	Not explicitly assessed in the case	The relevant dimension was not systematically elaborated in the reference section, as in abbreviated treatments or potential disconfirming cases.

9.1.1 Cross-Case Analysis — Claim-Oriented Lens (RQ1)

Viewed through the claim-oriented lens, the following picture emerges for each quadrant:

Q1 — Correctly Predicted and Realised

Episode(reference section)	Structural adequacy	Conditional sensitivity	Scale consistency	Timing
Automation of the Dutch Tax and Customs Administration (5.2.2)	✅	✅	✅	✅
E-commerce (5.3.2)	✅	◐	✅	◐
Municipal Personal Records Database (5.4.1)	✅	✅	✅	✅
DigiD (5.4.2)	✅	–	✅	–
SURFnet (5.4.3)	✅	–	✅	–

Interpretation. Q1 displays a high degree of correspondence between articulated causal chains and actual development. A defining characteristic is discipline in the articulation of scale: claims remained within explicitly defined institutional domains. Conditional sensitivity is often implicitly present and sometimes less explicitly articulated, but is empirically congruent.

Q2 — Epistemologically Adequate, Ontologically Bounded

Episode(reference section)	Structural adequacy	Conditional sensitivity	Scale consistency	Timing
ERP (6.2.2)	✅	✅	✅	◐
EPR / LSP (6.3.2)	◐	❌	◐	❌
Platformisation of labour (6.4.2)	◐	◐	◐	◐

Interpretation. The central hypotheses were analytically assessable and partly adequate. Discrepancies arose from assumptions concerning scale and the under-specification of boundary conditions, particularly in the case of EPR/LSP. Q2 shows that correct micro-level hypotheses do not guarantee system-level transformation.

Q3 — Underestimated System Transformations

Episode(reference section)	Structural adequacy	Conditional sensitivity	Scale consistency	Timing
Commercial internet access (7.2.2)	❌	❌	❌	❌
Generative AI (7.3.2)	❌	◐	❌	❌
Mainframe computers (7.4.2)	❌	❌	❌	❌
PCs in households (7.5.1)	❌	❌	❌	❌
PCs in business (7.5.2)	❌	❌	❌	❌
Smartphone ecology (7.5.3	❌	❌	❌	❌

Interpretation. Systematic under-articulation predominates here. The transformations realised were profound and layered, but the original claims remained instrumental or efficiency-oriented. Q3 illustrates epistemological underestimation during waves of infrastructural development.

Q4 — Inadequately Predicted and Not Durably Realised

Episode(reference section)	Structural adequacy	Conditional sensitivity	Scale consistency	Timing
Childcare Benefits Scandal (8.2.2)	❌	❌	❌	❌
CoronaMelder (8.3.2)	❌	❌	❌	❌
Viditel (8.4.2)	❌	❌	❌	❌
Voting machine (8.4.4)	❌	❌	❌	❌

Interpretation. Q4 is characterised by an overestimation of robustness at scale and the structural under-specification of boundary conditions. Technological plausibility was mistaken for institutional effectiveness.

9.1.2 Cross-Case Analysis — Transformation-Oriented Lens (RQ2)

Viewed through the transformation-oriented lens, the following picture emerges for each quadrant:

Q1 — Profound and Durable Reconfiguration

Episode(reference section)	Depth	Durability	Layering	Breadth	Institutional embedding
Automation of the Dutch Tax and Customs Administration (5.2.3)	✅	✅	✅	✅	✅
E-commerce (5.3.3)	✅	✅	✅	✅	✅
Municipal Personal Records Database (5.41)	✅	✅	✅	✅	✅
DigiD (5.4.2)	✅	✅	✅	✅	✅
SURFnet (5.4.3)	✅	✅	✅	✅	✅

Interpretation. Q1 transformations are structurally embedded and institutionally stabilised. ICT functions here as constitutive infrastructure within a congruent configuration.

Q2 — Bounded or Sectoral Transformation

Episode(reference section)	Depth	Durability	Layering	Breadth	Institutional embedding
ERP (6.2.3)	◐	✅	◐	◐	◐
EPR / LSP (6.3.3)	◐	◐	◐	◐	◐
Platformisation of labour (6.4.3)	◐	◐	◐	◐	◐

Interpretation. Transformation remains sector-specific or organisationally bounded. Institutional absorptive capacity proves decisive for its depth and breadth.

Q3 — Profound but Under-Articulated Transformations

Episode(reference section)	Depth	Durability	Layering	Breadth	Institutional embedding
Commercial internet access (7.2.3)	✅	✅	✅	✅	✅
Generative AI (7.3.3)	◐	◐	◐	◐	◐
Mainframe computers (7.4.3)	✅	✅	✅	✅	✅
PCs in households (7.5.1)	◐	✅	◐	✅	◐
PCs in business (7.5.2)	✅	✅	✅	✅	✅
Smartphone ecology (7.5.3)	✅	✅	✅	✅	✅

Interpretation. Here, the ontological impact is substantially greater than the original articulation. Q3 demonstrates the cumulative character of the impact of infrastructural layers.

Q4 — Unstable or Non-Embedded Outcomes

Episode(reference section)	Depth	Durability	Layering	Breadth	Institutional embedding
Childcare Benefits Scandal (8.2.3)	◐	✗	◐	◐	✗
CoronaMelder (8.3.3)	✗	✗	✗	◐	✗
Viditel (8.4.3)	✗	✗	✗	✗	✗
Voting machine (8.5.3)	✗	✗	✗	◐	✗

Interpretation. Durable regime embedding is absent here. In some cases, such as the Childcare Benefits Scandal, reconfiguration did occur, but remained unstable and was subsequently partially reversed through corrective intervention.

9.1.3 Cross-Case Analysis — Causal Lens (RQ3)

The causal analyses from the preceding chapters can be deepened by means of an explicit counterfactual test question: is the reconfiguration realised in the Netherlands conceivable without the technology concerned, and, if so, in what form and at what scale? The outcomes can be organised into three causal classes:

Class A — Sine qua non	Without this technology, the regime reconfiguration realised in the Netherlands is not plausible. Technology functions here as a structurally indispensable condition.
Class B — Constitutive within a configuration	The reconfiguration is conceivable in the abstract without this specific technology, but not in the national institutional form and degree of integration actually realised. Technology determines the concrete configuration, but not the existence of change as such.
Class C — Facilitating	The regime shift is also plausible without this technology in a comparable form. Technology accelerates, simplifies or optimises, but is not constitutive of regime formation.

The answers to these counterfactual questions produced a different picture for each quadrant.

Quadrant Q1 — Correctly Predicted and Realised

Episode	Counterfactual core question	Outcome
Automation of the Dutch Tax and Customs Administration	Is large-scale, centralised and consistent taxation in the form realised conceivable without digital automation?	Not plausible at the volume, scale and complexity involved.
DigiD	Is uniform digital identification within e-government in the form realised conceivable without a central digital authentication infrastructure?	Not plausible; technology is a *sine qua non*.
Municipal Personal Records Database	Is standardised and integrated population registration in the digital form realised conceivable without ICT?	Not at a comparable scale and degree of integration; legally driven change would still be conceivable.

Episode	Counterfactual core question	Outcome
SURFnet	Is the formation of a national digital scientific network at the scale and speed realised conceivable without backbone infrastructure?	Not in the form realised; technology was structurally decisive.
E-commerce (NL)	Is the reconfiguration of commerce in the Netherlands conceivable without specific national policy concerning digital networks?	Yes; primarily market-driven, with technology acting as an enabling factor.

Q2 — Epistemologically Adequate, Ontologically Bounded

Episode	Counterfactual core question	Outcome
ERP	Is the structural process integration realised conceivable without integrated software systems?	Not plausible at a comparable scale and level of consistency.
EPR / LSP	Is nationwide digital interoperability conceivable without digital infrastructure?	Not plausible in the form realised.
Platformisation of labour	Is digitally mediated labour as an organisational form conceivable without platform technology?	No; broader labour-market change would still be conceivable.

Q3 — Underestimated System Transformations

Episode	Counterfactual core question	Outcome
Mainframe computers	Is administrative centralisation at the scale realised conceivable without mainframe architecture?	Not plausible; material carrier of centralisation.
Commercial internet access	Is system-level network coordination conceivable without broad internet access?	Not plausible; open network access was a *sine qua non*.
PCs in households	Is mass digital participation during the 1990s conceivable without the PC?	Not plausible within the historical configuration.
PCs in business	Is organisational decentralisation conceivable without business PCs?	Not plausible; distributed computing capacity was necessary.
Smartphone ecosystem	Is permanent mobile network densification conceivable without smartphone integration?	Not plausible; the combination of always-on access, apps and sensors was a *sine qua non*.
Generative AI	Is the renegotiation of assessment and legitimation structures conceivable without generative AI?	Not with comparable intensity; constitutive within an already digital context.

Q4 — Inadequately Predicted and Not Durably Realised

Episode	Counterfactual core question	Outcome
Childcare Benefits Scandal	Is large-scale, systematic false-positive classification conceivable without automated risk selection?	Not plausible; the scale required digital infrastructure.
CoronaMelder	Is it conceivable that Dutch pandemic dynamics would have developed in essentially the same way without digital contact notification?	Yes; its effect was supplementary rather than constitutive.
Viditel	Is Dutch digital development conceivable without Viditel?	Yes; it was not necessary infrastructure.
Voting machine	Is electoral organisation conceivable without electronic voting machines?	Yes; the return to paper demonstrates that they were not necessary.

Assigning classifications on the basis of the preceding analyses produces the following composite picture:

Quadrant	Episode	Counterfactual outcome (summary)	Causal class
Q1 Correctly predicted and realised	Automation of the Dutch Tax and Customs Administration	Not plausible without digital automation at the scale and volume involved	A
	DigiD	Not plausible without central digital authentication	A
	Municipal Personal Records Database	Not at a comparable scale and degree of integration	B
	SURFnet	Not in the national form and at the speed realised	B
	E-commerce (NL)	Yes; primarily market-driven, with technology acting as an enabling factor	C
Q2 Epistemologically adequate, ontologically bounded	ERP	Not plausible at a comparable scale and level of consistency	B
	EPR / LSP	Not plausible in the architecture realised	B
	Platformisation of labour	The organisational form would not exist without the platform; broader labour-market change would	B
Q3 Underestimated system transformations	Mainframe computers	Not plausible without mainframe architecture	A
	Commercial internet access	Not plausible without open network access	A
	PCs in households	Not plausible within the historical configuration	A
	PCs in business	Not plausible; distributed computing capacity was necessary	A
	Smartphone ecosystem	Not plausible; always-on integration was a *sine qua non*	A
	Generative AI	Not with comparable intensity; constitutive within the configuration	B
Q4 Inadequately predicted and not durably realised	Childcare Benefits Scandal	Not plausible in scale and systematic character without digital risk selection	A
	CoronaMelder	Yes; pandemic dynamics are largely conceivable without the app	C
	Viditel	Yes; it was not necessary infrastructure	C
	Voting machine	Yes; the return to paper demonstrates that it was not necessary	C

Interpretation. The causal lens reveals a consistent pattern: structurally adequate predictions in Q1 correctly identify technology as a *sine qua non* or as configuratively constitutive infrastructure. Underestimated infrastructural waves in Q3 prove retrospectively to be almost entirely Class A. Inadequate predictions in Q4 often overestimate Class C technologies or fail to specify Class A conditions adequately. The causal comparison therefore confirms that robust prediction is associated with correctly identifying the structurally indispensable role of technology within a national institutional configuration. Historically, the decisive factor proves not to be visionary language, but the correct positioning of technology within the causal regime.

9.1.4 Implications for Robust Prediction (RQ4)

The three preceding overviews—epistemological (§9.1.1), ontological (§9.1.2) and causal (§9.1.3)—make it possible to answer RQ4 systematically. They do so not by introducing a new assessment, but by making explicit the patterns visible in the tables.

First, robust predictions correlate with correct positioning of scale. In Q1, structural adequacy and scale consistency systematically coincide with profound and durable reconfiguration. The claims remain within the institutional domain to which they apply, such as taxation, digital identification or core registration. In Q4, by contrast, robustness at scale is overestimated in the cases of Viditel, CoronaMelder and the voting machine, or conditions are insufficiently specified, as in the Childcare Benefits Scandal. Q3 reveals the opposite pattern: infrastructural waves with substantial ontological impact were underestimated in both scale and reach. The recurring pattern is that misclassification of scale—whether through overestimation or underestimation—is associated with epistemological inadequacy.

Second, durable transformation is almost invariably tied to infrastructure. The tables of transformation characteristics show that profound, broadly consequential and institutionally embedded reconfigurations occur primarily in infrastructural layers: mainframes, internet access, the PC, the smartphone, DigiD, the Municipal Personal Records Database and automation within the Dutch Tax and Customs Administration. In the causal table, these episodes are also predominantly assigned to Class A or B. Technology functions there as a *sine qua non* or as a configuratively constitutive element. Where technology is merely facilitating, as in Class C, transformation remains sector-specific, temporary or unstable.

Third, correct identification of the causal role is decisive for predictive quality. The causal table shows that structurally adequate predictions occur almost exclusively in contexts in which technology is correctly positioned as structurally indispensable or configuratively decisive, as in Q1. In Q3, this indispensable role was not initially recognised. In Q4, technologies with a facilitating profile were incorrectly presented as regime-forming, or necessary institutional conditions were not made explicit. Robust prediction therefore appears closely connected to an accurate assessment of the structural position of technology within a national configuration.

Together, these patterns provide an answer to RQ4. Historically, structurally adequate predictions in the ICT domain are characterised by: 1. **Discipline in the articulation of scale:** explicit definition of the institutional domain to which the impact claim applies; 2. **Conditional precision:** identification of necessary boundary conditions and dependencies; 3. **Configurative positioning:** correct interpretation of technology as a *sine qua non*, configuratively constitutive or facilitating. Where these three characteristics are absent, discrepancies systematically arise between claimed and realised transformation. Robust prediction therefore proves not to be a matter of visionary ambition, but of analytical congruence between the articulation of causality, institutional scale and actual reconfiguration within a layered infrastructural regime.

9.2 Serendipity and Structural Unpredictability

Alongside the primary ICT regimes, such as digital tax processing, e-commerce and network densification, the canon includes a peripheral layer (§4.5.3). This layer comprises corrective and normative interventions that emerged in response to digital transformations. Examples include privacy legislation (the Personal Data Protection Act and the GDPR), cybersecurity architectures (DigiNotar and the National Cyber Security Centre) and the Bureau for ICT Assessment (Elias Committee, 2014; Regulation (EU) 2016/679). These episodes can be understood analytically through what the sociological literature describes as reflexive modernisation: processes of modernisation generate risks and side effects that subsequently require new forms of institutional regulation (Beck, 1992; Giddens, 1991). Digital infrastructures therefore generate not only efficiency, but also new vulnerabilities and normative tensions.

9.2.1 Serendipity as a Second-Order System Effect

Serendipity is understood here not as accidental discovery, but as a structurally emergent second-order effect of technological scaling. In terms of socio-technical transition theory, regime formation produces both new forms of stability and new frictions (Geels, 2002). Once digital infrastructures become constitutive of administrative or economic processes, they generate secondary adaptations. This is consistent with insights from the literature on path dependence: early infrastructural choices create cumulative dependencies and institutional lock-in, which subsequently necessitate corrective interventions (David, 1985; Arthur, 1989). The peripheral layer of the canon can therefore be understood as an institutional response to the cumulative effects of earlier infrastructural waves.

9.2.2 Three Forms of Serendipity

1. **Normative serendipity — privacy and legal protection.** The digitalisation of personal data, for example through core registers and digital identification systems, produced an unprecedented scale of data processing. The original claims were oriented towards efficiency; the secondary emergence concerned risks to privacy and autonomy (Bennett & Raab, 2006; Prins, 2018). From this perspective, the GDPR (2016/679) can be understood as the reflexive institutionalisation of data protection within an already deeply digitalised regime. This corresponds with Beck's proposition that the risks generated by modernisation lead to institutional re-regulation (Beck, 1992).
2. **Risk-driven serendipity — cybersecurity.** Network densification through SURFnet, commercial internet access and e-government created scalable vulnerability. The DigiNotar crisis of 2011 revealed that trust in digital certificates constitutes a system condition (Dutch Safety Board, 2012). The institutionalisation of cybersecurity through the National Cyber Security Centre is consistent with what Perrow describes as 'normal accidents' in complex systems: scale and interconnectedness increase systemic risk (Perrow, 1984). As digital infrastructures become constitutive, risk governance becomes structurally necessary.
3. **Administrative serendipity — oversight of digitalisation complexity.** Large ICT projects in the public sector, such as the Electronic Patient Record and other administrative systems, exposed problems of implementation and control (Elias Committee, 2014). The establishment of the Bureau for ICT Assessment can be understood as institutional reflexivity within a complex adaptive system (Hood & Margetts, 2007). A meta-layer

emerges here: the system incorporates a control mechanism to keep technological complexity administratively manageable.

9.2.3 Structural Predictability

The peripheral layer of the canon shows that second-order effects are not arbitrary, but are systematically related to: *data concentration → privacy regulation network densification → institutionalisation of cybersecurity automation complexity → administrative oversight.* In terms of socio-technical regimes, these constitute stabilisation mechanisms within an advancing transition process (Geels, 2002). Serendipity does not denote randomness here, but structurally emergent second-order effects whose specific form and timing are difficult to predict, while their occurrence as such is systemically probable.

9.3 Constitutive Conditions of Digital Regime Formation (1945–c. 1965)

The digital transformations discussed in §9.1 can be viewed against the background of institutional developments that had already commenced during the post-war period. In this study, 1945 therefore marks not the emergence of digital technology in the Netherlands, but the beginning of an administrative reconfiguration in which scaling, standardisation and centralisation were gradually deepened. From a path-dependent perspective, digital regime formation can plausibly be understood as a later intensification of these previously established trajectories (Arthur, 1989; Pierson, 2000).

Between 1945 and approximately 1965, the Dutch administrative state expanded considerably. The growth of social security, fiscal restructuring and population registration produced an increase in administrative scale and coordination complexity. This created a growing need for systematic registration, uniform classification and more efficient data processing. This development can be understood as part of a broader movement towards administrative ‘legibility’, through which societal processes are made manageable by means of standardised categories (Scott, 1998). Digital systems presuppose such classifications, but these did not originate with the computer; they had already been institutionally consolidated during the pre-digital phase (Bowker & Star, 1999).

In parallel, ministries and administrative organisations gained experience with mechanical and electromechanical forms of data processing, including punched-card systems and statistical processing techniques. These practices created organisational routines and technical expertise that made the subsequent introduction of electronic data processing appear less discontinuous than retrospective accounts sometimes suggest (Beniger, 1986; Yates, 1989). Viewed in this light, the introduction of mainframes during the 1960s built on existing processing structures.

An administrative culture also developed in which planning, quantification and efficiency occupied a prominent position. Confidence in figures and statistics as a basis for policymaking—what Porter (1995) describes as the authority of numbers—strengthened the orientation towards systematic data processing. Within this context, the idea of societal malleability acquired an institutional dimension: not as an abstract ideal, but as a practical expression of accumulated administrative capacity.

These observations imply neither normative endorsement of ambitions to engineer society nor rejection of subsequent criticism of high-modernist projects of control. They indicate only that, in the post-war period, administrative control through registration, classification and calculation was in fact institutionally organised. The proposition that ‘it could be done’ refers here to organisational and technical capacity, not to political desirability.

From this perspective, the digital transformations that became visible from the 1960s onwards appear not as a radical point of origin, but as a further deepening of rationalisation dynamics already under way. The year 1945 therefore functions as the constitutive starting point of the path along which digital regime formation could subsequently develop.

Chapter 10 — Conclusions and Discussion

This concluding chapter brings together the findings of the study and places them in a broader perspective. Section 10.1 discusses the subquestions in relation to one another and integrates them into an overarching thesis. Section 10.2 reflects on the methodological premises, reliability and scope of the results, and discusses possible extensions of the research design. The chapter concludes with a final reflection (§10.3), in which the episodes examined are considered in relation to one another.

10.1 Conclusions

Canon formation as an epistemological filter (RQ0). Canon formation in this study served not merely an ordering function, but an epistemological one. By systematically selecting technological developments on the basis of explicit future-oriented claims, observable societal effects and demonstrable relevance to the Dutch context, the field of assessment was confined to cases in which both expectation and transformation could be reconstructed analytically. The 2×2 quadrant did not function as an ex post classification, but as an instrument of variation that prevents success bias. The canon reveals that digital transformation has historically been concentrated in specific institutional domains and has rarely occurred as a uniform systemic rupture. The field within which structural adequacy can be assessed was thereby methodologically disciplined.

Structural adequacy of future-oriented claims (RQ1). The analysis of technological future-oriented claims shows that structural adequacy is not primarily associated with temporal precision or rhetorical persuasiveness. Three elements prove decisive: a proportionate claim concerning scale, explicit articulation of causal assumptions and identification of institutional boundary conditions. Future-oriented claims that situate their impact within recognisable institutional structures and make their dependencies explicit display a higher degree of structural congruence with subsequent developments. Conversely, claims that postulate system-level reconfiguration without further institutional specification prove vulnerable to overestimation. Predictive quality therefore manifests itself as epistemological discipline rather than visionary reach.

Nature of transformation and configurative attribution (RQ2–RQ3). The empirical analysis of realised digital transformations shows that restructuring during the period examined occurred predominantly at regime and domain level. System-level reconfigurations in the strict sense prove exceptional. Digital technology rarely functions as an autonomous or sufficient cause, but generally as a constitutive or facilitating element within broader institutional and organisational configurations. Attribution therefore requires the reconstruction of mechanisms and interactions, rather than reference solely to temporal sequence or visible impact. Technology operates within open systems in which complementarity, regulation and organisational absorptive capacity also shape outcomes. The nature of transformation and the nature of causal attribution thus prove structurally connected.

Variation between quadrants as a robustness test. Variation across the four quadrants confirms that structural adequacy does not coincide with ex post success. In cases where predictions proved accurate and transformation was realised, scale consistency is visible; in

other cases, realisation may fail to occur despite adequate articulation, or transformation may occur without an accurate prior prediction. The quadrants therefore function as an empirical stress test for simplistic definitions of success. The fact that a project is located ex post in a particular quadrant says nothing in itself about the epistemological quality of the original future-oriented claim. Structural adequacy can be reconstructed independently of quadrant.

Recurring characteristics of robust prediction (RQ4). Certain characteristics of robust prediction recur across the episodes examined. Adequate future-oriented claims restrict their claims concerning scale to institutionally recognisable levels, articulate causal assumptions explicitly and identify necessary boundary conditions. They do not assume linear diffusion and do not position technology as an autonomous driving force, but as part of a configurative constellation. They also avoid over-specifying timing. These characteristics do not guarantee realisation, but mark recurring patterns of structural adequacy.

Answer to the central research question. The integrated answers to RQ0 through RQ4 show that the structural adequacy of technological future-oriented claims cannot be reduced to successful outcomes or temporal precision. The answer to the central research question is therefore as follows: the structural adequacy of technological future-oriented claims proves historically not to depend on successful outcomes, but on the articulation of scale and causal assumptions, with boundary conditions identified explicitly and remaining proportionate to the intended level of impact. This answer is independent of quadrant, but is empirically supported by variation between quadrants. It positions adequate prediction as an epistemological discipline within historically layered transformation processes, rather than as retrospective confirmation of visionary correctness.

10.2 Methodological Reflection and Implications

A first test concerns whether the study was in fact conducted in accordance with the methodological principles formulated in Chapter 3. The research strategy was characterised there as historical-analytical, predominantly qualitative and abductive in nature, embedded in a critical-realist epistemology and directed towards configurative causal analysis within open systems. In retrospect, these principles can be seen to have been applied consistently.

Canon formation was organised systematically through explicit selection criteria and documented stages from the longlist to the definitive cases. The 2×2 quadrant functioned as a predefined instrument of variation designed to prevent success bias. In the analysis of future-oriented claims (X), structural adequacy was assessed on the basis of the articulated scale, the specification of conditions and the construction of causal structures, without treating successful outcomes as a criterion. In the reconstruction of transformation (Y), a distinction was made between sector, regime and system levels, while conceptual inflation was explicitly avoided. Attribution (X–Y) was approached through configurative causality and process tracing, with alternative explanations considered systematically. Within these parameters, it can be concluded that the study was conducted with methodological consistency. Internal reliability rests on transparent selection, explicit analytical categories and a consistent separation between claim-oriented, ontological and causal dimensions.

A more critical test concerns the possible influence of hindsight bias. Historical research necessarily operates ex post: both future-oriented claims and realised outcomes are already

known. Complete independence from knowledge of outcomes is therefore impossible. The relevant question is not whether hindsight could be excluded entirely, but whether it was sufficiently disciplined in epistemological terms. In this study, structural adequacy is not understood as correspondence with the subsequent outcome, but as the extent to which a future-oriented claim formulates its assumed scale and causal coherence explicitly and proportionately, including the relevant boundary conditions. Future-oriented claims were assessed on the basis of their internal articulation and assumed mechanisms, independently of their subsequent realisation. The 2×2 quadrant strengthened this separation by systematically including cases in which realisation failed to occur or occurred unexpectedly. Nevertheless, knowledge of outcomes may still have influenced interpretations implicitly. The separation of lenses (X, Y and X–Y) and the explicit formulation of assessment criteria reduce this risk, but do not eliminate it entirely. The independence of the adequacy assessment is therefore methodologically substantiated, although it is neither institutionally independent nor experimentally verifiable.

In addition to hindsight bias, historical-configurative research has broader vulnerabilities. There is a risk of retrospective coherence construction: complex processes may be assigned a logical trajectory after the event that they did not possess prospectively. The configurative approach and explicit counterfactual reflections are intended to limit this distortion, but complete neutralisation is impossible. Selection bias is also a genuine possibility. Canon formation necessarily involves defining a scope; prominent or well-documented developments are more readily reconstructable than marginal or failed experiments. Explicit selection criteria and the inclusion of all four quadrants mitigate this bias, but do not exclude it. Abductive reasoning may furthermore be susceptible to confirmation bias, because identifying the most plausible explanation requires interpretative judgement. Process tracing and the systematic consideration of alternative configurations function here as disciplinary mechanisms, but do not remove interpretative latitude. Finally, external validity is limited by the focus on the Netherlands. The study claims analytical generalisability for the assessment framework, not statistical or universal validity for its empirical findings.

Certain research possibilities were deliberately not pursued. No systematic international comparison was conducted, leaving differences in institutional absorptive capacity between countries outside the scope of the study. Nor was predictive quality operationalised quantitatively; the assessment framework remained qualitative. Actor-oriented approaches to expectations, such as interviews with forecasters or network analyses of discursive dynamics, were not integrated. Neither was prospective validation undertaken by applying the framework to contemporary technologies whose development remains incomplete. These choices limit the scope of the study, but were consistent with its objective: the development and application of a historical-analytical assessment framework.

These unexamined dimensions provide points of departure for further research. Systematic international comparison could test the extent to which institutional context mediates the relationship between technological expectations and societal transformation. An explicit quantitative operationalisation of the articulation of scale and causality could provide additional comparative precision. Integrating actor-oriented approaches could yield insight into the discursive dynamics surrounding future-oriented claims. Finally, the assessment framework could be applied prospectively to contemporary technologies to examine whether it remains robust beyond strictly retrospective analysis.

These possible extensions do not imply a fundamental revision of the chosen approach. The core of the study—the integration of assessment of claim articulation, differentiation between types of transformation and configurative attribution—remains methodologically coherent and empirically defensible. The reliability of the results rests not on experimental control, but on transparency, conceptual clarity and consistent application of predefined analytical categories. Within the limitations of historical-configurative research, the validity of the findings can be regarded as substantial, although context-dependent and open to further testing.

10.3 Final Reflection

When the study is considered as a whole, a broader historical coherence emerges alongside the answers to the individual research questions. The episodes examined appear not merely as separate transformations, but as moments within a process through which digital infrastructures gradually became more deeply embedded in Dutch society.

The post-war expansion of the administrative state forms the foundation of this process. In the decades following 1945, scaling, standardisation and systematic registration were consolidated administratively. Administrative ordering acquired a stable form through classifications, registers and central coordination. Digital technology did not initially play a dominant role, but the organisational conditions under which later digitalisation could occur were formed during this period.

With the introduction of electronic data processing from the 1960s onwards, this administrative order was strengthened technologically. Mainframes and telecommunications infrastructures enabled large-scale processing and gave digital systems a stable position within administrative practices. What had previously been constructed organisationally was now supported electronically.

During the following decades, the emphasis shifted towards connectivity. Networks and internet access connected systems and broadened access to digital processes. Digital tax returns, electronic service provision and online commerce fitted within existing administrative frameworks, but extended their reach.

Around the turn of the century, digitalisation acquired a more integrated character. Digital identity systems, core registers and platform architectures connected data flows structurally. Digital infrastructure became less visible as a discrete technology and more as an underlying condition of administrative and economic coordination.

In the most recent period, the emphasis has shifted towards data-driven applications and artificial intelligence. Algorithmic decision-making and generative models operate within existing data and network structures. They deepen previously established dependencies and shift the centre of gravity from registration towards interpretation.

Viewed in this light, the canon can be read as a history of layered development. New technologies do not emerge on empty ground, but connect to existing structures and rework them. The episodes examined show how digital transformations unfolded through successive layers of deepening: from administrative ordering, through electronic processing and network connectivity, to platformisation and data-driven steering.

This ordering adds no new criterion to the assessment framework and does not reformulate the research questions. It provides a way of viewing the whole. The individual cases retain their own dynamics and contexts, but collectively reveal a pattern of cumulative development. From this perspective, the study identifies not only differences in articulation and realisation, but also a gradual shift in the manner in which digital infrastructures permeate societal order.

The dissertation therefore concludes with an overview rather than a prediction. What becomes visible is not an endpoint, but a snapshot within a longer historical process.

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