Supplementary Information 1.
Case registry, coding protocol, calculations and source verification

S1. Literature-to-construct mapping

Table S1. Literature positioning and the claim-level evidence gap

Literature stream	Representative sources	Position retained	Limit identified	How the present study departs
Digital transformation and BPM	Vial 2019; Verhoef et al. 2021; vom Brocke et al. 2014; Iden et al. 2025	Digital value depends on organizational processes, ownership, measurement and capability	Transformation and maturity do not establish whether a specific consequential claim can be independently reconstructed	Shifts the unit of analysis from digitalization of the organization to defensibility of a material event-to-claim chain
Provenance, data governance and auditability	Abraham et al. 2019; Appelbaum 2016; Moreau et al. 2015; Pan et al. 2023; Pasquier et al. 2018	Origin, lineage, decision rights and inspectable histories are necessary for accountable use of process data	Lineage or governance at data-environment level may still omit claim-specific responsibility, source validity or transformation logic	Treats these mechanisms as constitutive but non-substitutable components of claim-level EVC
Process mining and event-log evidence	Jans et al. 2013; van der Aalst 2016; Janiesch et al. 2020; Chiu et al. 2026; Mugwira et al. 2026	Event logs enable process reconstruction and can extend audit evidence	Analytical value presupposes that relevant events, identities, timestamps and transformations were captured with adequate evidentiary meaning	Moves upstream from analysis of event logs to governance conditions under which event data can function as defensible evidence
Blockchain, IoT and traceability	Casino et al. 2019; Rejeb et al. 2019; Saberi et al. 2019; Chen et al. 2024; Charfi et al. 2026	Shared histories, sensing and integrity mechanisms can strengthen traceability and record protection	Tamper resistance or connectivity can preserve an incorrect input and therefore cannot by itself establish claim truth	Separates integrity of the recorded history from source validity, reconstruction and claim-level admissibility
Assurance and outcome verifiability	Simnett et al. 2009; Christensen et al. 2021; Dai and Vasarhelyi 2017; Oh 2026; Zengin-Karaibrahimoglu et al. 2026	Credibility depends on corroborable evidence; downstream verifiability and assurance affect stakeholder confidence	The upstream organizational formation of reconstructable process evidence remains under-specified	Defines EVC as the upstream process capability that determines whether corroborable evidence exists before assurance or stakeholder evaluation begins
Information economics	Akerlof 1970; Spence 1973	Information asymmetry creates search, screening and signaling problems	Does not specify which process-evidence architecture changes verification effort for a material business claim	Links completeness of an event-to-claim evidence chain to search, reconciliation and challenge effort

S2. Source hierarchy and coding rules

Table S2. Documentary source classes

Class	Definition	Permitted use	Restriction
A	Audited, regulated or formal corporate report / operational filing	Numerical outcomes; formal controls; governance and traceability disclosure	May still aggregate away event-level evidence

Class	Definition	Permitted use	Restriction
B	First-party corporate pages, interviews or company implementation descriptions	Process context; management explanation; documented organizational mechanism	Not treated as independent confirmation of performance effect
C	Technology-provider implementation case	Technical architecture; intended functionality; process scope	Not treated as independent evidence of realized business impact

Table S3. Coding states used in the 12-case screen

Code	Decision rule
O – Observed	The source explicitly documents the field at the selected process or claim level.
P – Partial	A related mechanism is documented, but claim-level linkage, granularity, actor history or transformation detail is incomplete.
N – Not established	Available public evidence does not support the field; this is not interpreted as absence of internal capability.
A – Alternative cause	The source explicitly identifies a non-digital mechanism that overrides digital attribution for the selected KPI.
NA – Not applicable	The field is not evaluated for the selected digital-causal claim because an alternative mechanism already blocks attribution.

S3. Twelve-case documentary corpus

Table S4. Full case corpus, source class and analytical role

Case	Group	Process context	Source class	Primary documentary basis	Analytical role
Astarta	Ukraine core	Livestock management	A+B	Annual/operational reports; AgriChain Cattle	Mechanism-rich case; incomplete claim reconstruction
Moloko Vitchyzny	Ukraine core	Farm modernization / livestock	B	Company pages and modernization materials	Bundled digital and physical modernization
Ovostar / YASENSVIT	Ukraine core	Egg flow + SCADA water control	A+C	Ovostar operational reports; SV Altera implementation case	Bounded digital-control mechanism + aggregate outcome context
KSG Agro	Ukraine core	Pig productivity	B	Company-hosted technologist interview	Negative attribution case
MHP	Ukraine core	Integrated governance / traceability	A	Integrated report 2024	Disclosure-rich / aggregated evidence
Arla Foods	External replication	Dairy chain	A	Annual financial and sustainability report 2024	Replication in mature dairy reporting context
Danish Crown	External replication	Meat / livestock chain	A	Annual report 2023/2024	Replication of control/responsibility fields

Case	Group	Process context	Source class	Primary documentary basis	Analytical role
Royal Agrifirm	External replication	Feed / agri-production	A	Annual report 2024	Feed-chain replication
ForFarmers	External replication	Feed / farming solutions	A	Annual report 2024	Information/process-control replication
Fonterra	External replication	Dairy chain	A	FY24 sustainability reporting data	Structured dairy-reporting replication
JBS	External replication	Meat chain	A	Sustainability report 2024	Large-chain traceability/governance replication
Adecoagro	External replication	Farming / dairy	A	Integrated report 2024	Combined farming/dairy replication

S4. Full 12-case evidence matrix

Table S5. Documentary evidence states across the 12-case corpus

Case	Mechanism	Traceability / control	Process KPI	Responsibility / auditability
Astarta	O	O	O	P
Moloko Vitchyzny	O	P	O	P
Ovostar/YASENSVIT	O	O	O	P
KSG Agro	A	NA	O	N
MHP	O	O	O	O
Arla Foods	O	O	O	O
Danish Crown	P	O	O	O
Royal Agrifirm	O	P	O	P
ForFarmers	O	O	O	O
Fonterra	O	O	O	O
JBS	P	O	O	O
Adecoagro	O	O	O	O
Observed n/N	9/12	9/12	12/12	7/12
Observed %	75.0	75.0	100.0	58.3

Note: O = observed; P = partial; N = not established; A = alternative cause; NA = not applicable. Main-text strict percentages count O only.

S5. Reproducible calculations

Table S6. Input values and arithmetic used in the Results section

Case	Metric	Baseline	Comparison	Calculation	Result	Source
Astarta	Milk production	115 kt (2023)	126 kt (2025)	(126−115)/115×100	+9.6%	Astarta Holding PLC 2026
Astarta	Average herd	26k (2023)	29k (2025)	(29−26)/26×100	+11.5%	Astarta Holding PLC 2026
Astarta	Unit milk yield	25.8 kg/day (2023)	27.5 kg/day (2025)	(27.5−25.8)/25.8×100	+6.6%	Astarta Holding PLC 2026
Ovostar	Eggs produced H1	732m (2023)	706m (2024)	(706−732)/732×100	−3.6%	Ovostar 2024a, 2024b
Ovostar	Eggs processed H1	213m (2023)	274m (2024)	(274−213)/213×100	+28.6%	Ovostar 2024a, 2024b
Ovostar	Processing share H1	213/732 = 29.1%	274/706 = 38.8%	38.8−29.1	+9.7 pp	Ovostar 2024a, 2024b
YASENSVIT	SCADA coverage	20 poultry houses	20 poultry houses	Documented scope	Hourly plan/actual control	SV Altera 2019
KSG Agro	Average daily gain	476 g/day	515 g/day	(515−476)/476×100	+8.19%	KSG Agro n.d.

Note: percentage changes are arithmetic reproductions of cited source values and are not causal digital-effect estimates.

S6. Claim-level evidence records

Table S7. Claim, supported evidence, missing link and admissible inference

Case	Material claim	Supported observation	Strongest evidence properties	First missing / competing link	Admissible inference	Primary sources
Astarta	Milk output/yield improvement is a digital effect	Digital livestock-management system + reproducible outcome series	Traceability; process context; partial provenance	Actor-level task history; corrections; transformation lineage	Digital mechanism supported; causal performance effect not independently reconstructable	Astarta Holding PLC 2026; AgriChain 2025
YASENSVIT	SCADA improves water-control response	Hourly plan/actual control across 20 poultry houses	Traceability; bounded control history	Alarm acknowledgement; response timestamps; actor attribution	Control architecture supported; response effectiveness not publicly auditable	SV Altera 2019
MHP	Public governance metrics are claim-level verifiable	Metrics, controls, audit context and traceability disclosed	Responsibility; traceability; audit context	Single event-to-claim lineage; versioned transformation rules	High transparency; claim-level reconstructability not established	MHP SE 2025
KSG Agro	Positive productivity difference is a digital effect	515 vs 476 g/day; source identifies genetics	Observable KPI + explicit causal explanation	Competing mechanism: genetics	Digital attribution rejected	KSG Agro n.d.

S7. Regulatory source verification

Table S8. EU legal instruments used to delimit the regulatory context

Instrument	Official identifier	Issuing institution	Year	Role in article	Scope note
Corporate Sustainability Reporting Directive (CSRD)	Directive (EU) 2022/2464	European Parliament and Council	2022	Sustainability-reporting context	Amended, including by Directive (EU) 2026/470
CSRD simplification amendment	Directive (EU) 2026/470	European Parliament and Council	2026	Current reporting context	Amends corporate sustainability-reporting and due-diligence requirements
European Sustainability Reporting Standards (ESRS)	Commission Delegated Regulation (EU) 2023/2772	European Commission	2023	Reporting-standard context	Delegated act; not an act of Parliament and Council
Revised ESRS	Commission Delegated Regulation (EU) 2026/1563	European Commission	2026	Updated ESRS context	Amends Delegated Regulation (EU) 2023/2772
NIS2	Directive (EU) 2022/2555	European Parliament and Council	2022	Cyber-resilience boundary	Cybersecurity context; not a generic evidence-verification mandate
European Digital Identity Framework	Regulation (EU) 2024/1183	European Parliament and Council	2024	Identity / attribution context	Amends Regulation (EU) No 910/2014
AI Act	Regulation (EU) 2024/1689	European Parliament and Council	2024	AI accountability context	Risk-based AI obligations; not a generic TrustTech mandate
Ecodesign for Sustainable Products Regulation (ESPR)	Regulation (EU) 2024/1781	European Parliament and Council	2024	Digital Product Passport boundary	Food and feed are excluded from ESPR scope
General Food Law	Regulation (EC) No 178/2002	European Parliament and Council	2002	Agri-food traceability basis	Article 18 establishes traceability requirements
Official Controls Regulation	Regulation (EU) 2017/625	European Parliament and Council	2017	Agri-food control/audit context	Sector-specific official controls

Note: official identifiers and issuing institutions are reproduced to avoid ambiguity in the legal context. The instruments delimit context; they are not treated as one unified technology mandate.

S8. Derived trend calculations for Figure 4

Table S9. Astarta values, normalized indices and five-year compound growth

Indicator	2020	2024	2025	Index 2020	Index 2024	Index 2025	2020–2025 change	CAGR
Average herd	22	28	29	100.0	127.3	131.8	31.8%	5.7%
Daily milk yield	21.4	26.3	27.5	100.0	122.9	128.5	28.5%	5.1%
Milk production	93	119	126	100.0	128.0	135.5	35.5%	6.3%

Source: authors' calculations from Astarta Holding PLC (2021, 2025, 2026). Index = value / 2020 value × 100; CAGR = (2025/2020)^(1/5) − 1.

S9. Result-to-source traceability matrix

Table S10. Result-to-source traceability matrix

Main-text result	Location	Derivation / value	Supplement	Primary basis	Inference boundary
Corpus structure and source-class composition	Table 1; Fig. 2	12-case registry; source class A/B/C	S3–S4	Case registry and eligibility records	Analytical-replication design; not statistical representativeness
Strict evidence observability: 75.0%, 75.0%, 100.0%, 58.3%	Table 3; Fig. 3	Counts of O codes across four Stage-1 fields	S4	Full 12-case coding matrix	Public-document observability only
Relaxed O+P sensitivity: 91.7%, 91.7%, 100.0%, 91.7%	Table 4; Fig. 3	Reclassification of P as observable	S2, S4	Coding rules and full matrix	Sensitivity bound, not preferred estimate
Astarta 2020–2025 livestock trends	Table 5; Fig. 4	22→29k herd; 21.4→27.5 kg/day; 93→126 kt	S5, S8	Astarta 2021, 2025, 2026	Observed segment dynamics; causal digital effect not isolated
Ovostar H1 processing shift	Table 5; Fig. 5	29.1%→38.8%; +9.7 pp	S5	Ovostar 2024a, 2024b	Product-flow shift; digital cause not established
YASENSVIT control architecture	Table 5; Fig. 5	20 houses; hourly plan/actual SCADA	S5–S6	SV Altera 2019	Architecture established; response-effect evidence unavailable
KSG productivity difference	Table 5; Fig. 5	476→515 g/day; +8.19%	S5–S6	KSG Agro n.d.	Digital attribution rejected because genetics is documented cause
Claim-level inference limits	Table 6	First missing or competing evidence link by deep case	S6	Case-specific evidence records	Maximum defensible inference; not a maturity score
EU regulatory scope statements	Discussion 5.3	Official identifiers and issuing institutions	S7	Official EU legal acts	Regulatory context; no generic TrustTech mandate

Source: authors' traceability table based on the source register, coding matrix and calculations reported in Sections S2–S8.