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Rural E-Commerce Warehousing Innovation in China: A Digital, Platform, Collaborative and Green Framework

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Abstract

Rural e-commerce in China depends on warehouses that can consolidate dispersed orders, handle perishable products and coordinate several logistics providers. This study examines how these functions are organised at county level through a documentary multiple-case study with abductive interpretation. The nine-document corpus comprises six national policy or statistical sources and four county case reports from Hebei, Guangxi and Guizhou; one document serves both national and case roles. The analysis compares facilities, digital systems, asset sharing, governance, environmental practices and reported operating outcomes. It distinguishes four configurations: a shared county warehouse-distribution centre, an origin cold-chain warehouse, a cloud-warehouse node serving several firms and a common-distribution platform with integrated data. A Digitalisation-Platformisation-Collaboration-Greening (DPCG) framework connects these configurations to five proposed mechanisms: lower transaction costs, economies of density, coordination of resources through data, joint governance and reduced product loss. Their usefulness depends on local conditions. Shared facilities need sufficient throughput, digital systems need compatible data standards, and participating organisations need workable rules for allocating costs and benefits. Cold-chain investment also depends on processing capacity and access to markets. The framework offers a basis for comparing county warehousing choices and specifying conditions for further investigation. The cases are drawn from published documentary accounts, including administrative and media reporting; their outcomes were not independently verified, and the analysis does not establish causal effects.

Keywords

Collaborative Logistics; Digitalisation; Rural E-commerce; Sustainable Warehousing; Warehousing Platform.

1. Introduction

Digital technologies reduce the costs of searching for products, matching buyers and sellers, and tracking transactions (Goldfarb & Tucker, 2019). The scale of online commerce in China makes the logistics behind these transactions consequential. National online retail sales reached RMB 15.97 trillion in 2025. Physical goods accounted for RMB 13.09 trillion, or 26.1% of total retail sales. Rural online retail sales were RMB 3.00 trillion, while online retail sales of agricultural products were RMB 783.31 billion, increasing by 6.7% and 9.9%, respectively (National Bureau of Statistics of China [NBS], 2026; National Data Administration, 2026).

The benefits of this expansion vary across households and places. Couture et al. (2021) found limited evidence of average producer-income gains from a rural e-commerce programme, with consumer gains concentrated among a minority of younger, wealthier households in more remote markets. Studies of county development and rural revitalisation also report spatial variation and nonlinear relationships (Deng et al., 2024; Qin et al., 2023). These findings

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motivate attention to the conditions under which online transactions become useful local economic activity. They do not, by themselves, identify warehousing as the cause of uneven outcomes.

Warehouses provide a practical point of entry into this question. Consolidation, pre-cooling, grading, inventory control, sorting and dispatch connect dispersed producers to outbound markets and support the delivery of consumer goods into villages. These activities involve decisions about which goods to combine, how long to store them, who can use available capacity and who bears losses. Their organisation therefore matters alongside the physical capacity of a facility.

County operators face several connected difficulties. Seasonal agricultural output and low parcel volumes can leave facilities underused for much of the year. Separate courier networks may duplicate routes and premises, while incompatible order and inventory systems obstruct coordination. Perishability adds time and temperature constraints. Outbound farm shipments also differ from inbound consumer parcels in their timing, handling needs and preparation for sale. Under these conditions, the returns to equipment or buildings depend partly on how organisations share information, facilities and responsibilities.

The literature reviewed below approaches these issues through different units of analysis: households and counties in rural e-commerce research, routes in logistics models, and facilities in warehousing studies. This paper brings them together at the level of a county warehousing-distribution configuration, defined as a combination of technology, shared assets, governance arrangements and environmental practices. It addresses three questions:

RQ1: Which structural constraints limit reliable and sustainable rural e-commerce warehousing?

RQ2: How are digital, platform, collaborative and green practices combined in the county configurations described by the selected cases?

RQ3: Which mechanisms and boundary conditions could explain the documented arrangements and reported outcomes, and what might they imply for rural development?

Four county cases from Hebei, Guangxi and Guizhou inform a DPCG framework. Drawing on transaction cost economics, resource management, dynamic capabilities and network governance, the framework links specific operating arrangements to proposed mechanisms and their limits. The contribution is an account of how warehousing resources and decision rules fit together, followed by design questions for public agencies and operators. The analysis is exploratory: it develops explanations to examine further, without estimating the effects of these arrangements on county development.

2. Literature Review

2.1. Digital Economy, Rural E-commerce and Complementary Logistics

Lower information costs can expand trading opportunities, but the effects of digital access depend on what users can do with it (Goldfarb & Tucker, 2019). Aker and Ksoll (2016), for example, found that a mobile-phone intervention increased crop diversification without improving farm-gate prices. The distinction between changed behaviour and improved returns is relevant to rural e-commerce. In China, Deng et al. (2024) report nonlinear and spatial differences in the relationship between the digital economy and rural revitalisation in Guangdong. Du et al. (2022) examine regional differences using indices of coordinated development, while Qin et al. (2023) evaluate rural e-commerce and county development. These studies address different outcomes and levels of analysis.

Couture et al. (2021) provide a further reason to distinguish access from outcomes. Their evaluation found consumer benefits concentrated in a subset of households and little evidence

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of average producer-income growth. This supports a closer examination of complementary services, but it does not test the warehousing mechanisms proposed here. Aggregation, quality control and fulfilment are plausible parts of that inquiry because they determine how farm output is prepared, stored and dispatched to fulfil online orders.

Research on rural logistics helps specify operational choices. Hong et al. (2025) examine a two-echelon, two-way network and report reductions in distance and distribution cost relative to the comparison design. Such results depend on the model and operating conditions considered. Wang et al. (2024) analyse strategic interactions in collaborative innovation along the rural e-commerce chain under digital empowerment. Together, these studies direct attention to network structure and incentives. The present study extends that discussion to the combination of facilities, shared services, data access and decision rights within county warehousing arrangements.

2.2. E-commerce Warehousing and Logistics 4.0

E-commerce warehouses handle small orders, varied assortments, short delivery commitments and fluctuating demand. Research consequently examines picking systems, inventory visibility, automation and fulfilment networks (Boysen et al., 2019). Omnichannel warehouse design also depends on product assortment, service commitments and integration across channels (Kembro et al., 2018). Logistics 4.0 research connects these operational choices to sensing, cloud computing and analytics that support coordination and adaptation (Winkelhaus & Grosse, 2020).

Applying these ideas to rural counties requires attention to throughput, skills, connectivity and investment capacity. Where order volumes cannot justify extensive automation, barcode records, a shared warehouse management system or coordinated dispatch may address the immediate constraint. A useful starting question is which information is missing from daily decisions and which organisations need to exchange it. This shifts assessment towards the operational contribution of a technology and the conditions needed to maintain it.

2.3. Platformisation, Collaboration and Network Governance

Transaction cost economics links organisational choices to uncertainty, asset specificity and the costs of monitoring exchange (Williamson, 1979, 1985). A shared county hub may reduce some of these costs by pooling facilities and standardising services. Here, platformisation means organising warehousing resources for use by multiple participants. It includes shared centres, cloud-warehouse services and common data systems; it does not require ownership by a large digital platform.

Pooling resources introduces decisions about access, service quality and payment. Cao and Zhang (2011) associate supply-chain collaboration with joint advantage through information sharing, coordinated decisions and complementary resources. Powell (1990) explains the role of network arrangements in coordinating interdependent organisations, while Provan and Kenis (2008) identify conditions affecting the suitability of different governance modes, including trust, network size, shared goals and coordination needs. These issues are relevant when local authorities, couriers, postal and transport operators, cooperatives, processors and farmers participate in one county network. Each may contribute different assets and face different commercial risks.

The capability literature adds a question about how those resources are used. Sirmon et al. (2007) connect value creation to structuring and combining resources. Dynamic capabilities concern an organisation's capacity to renew its activities and resource base as conditions change (Teece et al., 1997); digital transformation can require corresponding changes in processes and relationships (Warner & Wäger, 2019). Applied here, these perspectives draw attention to the coordination of storage space, cold rooms, vehicles, inventories and orders. The

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presence of each resource is insufficient evidence that the network can use them together effectively.

2.4. Greening, Cold Chains and Sustainable Rural Value

Environmental performance involves several operating decisions. Inventory policy, equipment and facility utilisation affect warehouse-related emissions (Fichtinger et al., 2015). Freight pooling can change transport emissions by consolidating loads and reducing overlapping movements (Pan et al., 2013). For perishable products, time and temperature control influence deterioration and loss throughout the cold chain (Mercier et al., 2017). These studies identify specific processes through which warehousing choices may affect resource use.

The relevant trade-offs need to be considered together. Refrigeration may reduce spoilage while consuming additional energy; shared capacity may improve utilisation while requiring extra handling or transport. This study therefore uses greening to cover loss prevention, capacity utilisation, energy use and packaging. The documentary cases can identify relevant practices and reported outcomes, but without comparable measurements they cannot establish a net environmental improvement.

2.5. Research Gap and Integrated Analytical Lens

Across the reviewed literature, the unresolved issue for this study is how these operating and organisational choices interact at county level. A facility-based analysis can miss the rules governing shared use; a network model can leave inventory and cold-chain handling implicit; county-level economic outcomes provide limited detail about either. Examining warehousing-distribution configurations connects these perspectives while retaining the local conditions that shape their feasibility.

The DPCG framework uses four dimensions to organise that comparison. Digitalisation concerns information available for operating decisions. Platformisation concerns access to shared assets and services. Collaboration concerns responsibilities, incentives and the allocation of costs and benefits. Greening concerns product loss and environmental resource use. Transaction cost economics, resource management, dynamic capabilities and network governance help interpret the relationships among these dimensions. Their proposed complementarity remains an analytical explanation to be assessed against the cases and tested with stronger operational evidence.

3. Materials and Methods

3.1. Research Design and Unit of Analysis

This study compares four county cases using documentary evidence. It follows an abductive approach: concepts from transaction cost economics, resource management, dynamic capabilities and network governance guide the reading of the documents, while differences between the cases help refine the proposed explanations. Case comparison is useful for developing such explanations when operating data are incomplete, provided that the scope of the evidence is explicit (Eisenhardt, 1989; Eisenhardt & Graebner, 2007; Yin, 2018). The resulting propositions are intended for subsequent testing.

The unit of analysis is the county warehousing and distribution configuration. It includes the facilities used to collect, store, handle and dispatch goods, together with their information systems and operating arrangements. This boundary allows the comparison to follow activities across a warehouse, village stations and transport services. It also captures decisions shared by several organisations, such as the allocation of capacity or responsibility for delivery failures.

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3.2. Documentary Corpus and Case Selection

The corpus contains nine documents published or made available between January 2021 and June 2026. Six provide national statistics or policy context, and four describe county cases. The State Post Bureau's 2023 response to a legislative recommendation serves both purposes, so the total comprises nine distinct documents. Table 1 identifies each source and its use.

The materials include official statistics, policy documents, an administrative response, and case accounts published or reproduced by government and local media websites. These sources have different evidential roles. National statistics establish market scale; policy documents describe priorities and intended arrangements; case reports describe particular facilities and activities. Publication on an official website does not make a case account an independent evaluation. Some reports reproduce media coverage and give limited information about how performance indicators were calculated.

Table 1. Documentary corpus and analytical use

Source group	Documents	Material examined	Analytical use
National statistics	NBS (2026); National Data Administration (2026)	National online retail, rural online retail and agricultural-product sales.	Establishes market context; does not measure warehouse performance.
Rural logistics policy	General Office of the State Council (2021); Ministry of Commerce et al. (2024); State Post Bureau (2023)	County-township-village networks, common distribution, shared facilities and service objectives.	Identifies policy priorities and coordination requirements.
Cold-chain policy	National Development and Reform Commission (2022)	Origin handling, pre-cooling, temperature control, traceability and network integration.	Identifies proposed capabilities; policy objectives are not observed outcomes.
She County, Hebei	State Post Bureau (2023), administrative response	Joint courier company, shared operations, reported costs, delivery volume and village stations.	Examines shared assets and operating arrangements.
Fuchuan, Guangxi	State Post Bureau (2025), China Post Express News report	Distribution nodes, cold storage, processing capacity, fleets and reported delivery indicators.	Examines an origin cold-chain configuration and its evidential limits.
Sinan, Guizhou	Su and Wu (2023), Tongren media report	Resident enterprises, daily orders and courier partnerships at a cloud-warehouse node.	Examines shared fulfilment; technical and cost information is limited.
Pingquan, Hebei	Langfang Municipal People's Government (2025), Hebei Daily report	Distribution nodes, common information system and reported operational coordination.	Examines data integration across a local network.

Nine distinct documents comprise six national sources and four case accounts: State Post Bureau (2023) serves both purposes. Case reports are documentary accounts, not independent audits.

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The four cases were selected to cover different uses of county warehousing. Each concerns a county or county-level city, includes activities beyond parcel collection, and describes organisational or technical features relevant to the framework. She County in Hebei concerns shared courier operations; Fuchuan Yao Autonomous County in Guangxi links origin handling to cold-chain services; Sinan County in Guizhou provides a warehouse service for local firms; and Pingquan City in Hebei connects a distribution network through a common information system. Their geographical and commodity differences support comparison, but the selection does not represent the distribution of warehousing practices across rural China.

3.3. Coding and Comparison

The comparison uses six categories: physical facilities and routes; digital systems and data; shared assets and services; governance; environmental or loss-reduction practices; and reported operating outcomes. For each case, the analysis distinguishes the arrangement described in the source, the outcomes reported there, and the mechanism inferred from theory. This distinction matters where a document reports both new infrastructure and county growth without establishing a causal link between them.

The cases are then compared for evidence consistent with five mechanisms: lower transaction costs, economies of density, coordination of resources through data, governance across participating organisations, and reduced product loss. A mechanism can be relevant without being directly measured. For example, shared sorting in She County is consistent with spreading fixed costs across a larger flow of parcels, but the source does not separate that effect from changes in demand or other operating conditions. Similarly, Sinan's merchant and order counts establish the scale of a shared service at the reporting date, rather than a before-and-after efficiency gain.

Missing information is carried into the interpretation. The analysis does not reconstruct baselines, calculate unreported effects, or treat capacity as actual utilisation. Percentage changes retain the comparison stated by the source where available. Where the source does not specify the measurement period or denominator, that limitation is noted. The cross-case tables therefore provide a structured comparison of documentary evidence, not a common dataset of independently observed performance.

3.4. Credibility and Scope

The main safeguard is traceability between a claim and the document that supports it. Statistical claims are attributed to the issuing agency, and case outcomes are identified as reported figures. National policies help interpret the local arrangements but do not independently corroborate their performance. Explanations involving industrial structure, public investment and local demand remain relevant because the available material cannot isolate their effects.

The study uses publicly available documents and involves no interviews, experiments or participant recruitment. It does not analyse individual-level personal data. The main methodological limitation is the uneven detail and possible positive selection of the published case accounts. The framework should be assessed as an interpretation of these accounts, with its causal claims reserved for future research.

4. Results and Discussion

4.1. Structural Constraints in Rural Warehousing

Read together, the policy documents, case accounts and literature identify six recurring constraints (Table 2). National policies emphasise shared delivery networks, rural e-commerce services and origin cold-chain capacity (General Office of the State Council, 2021; Ministry of

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Commerce et al., 2024; National Development and Reform Commission, 2022). Facility fragmentation is closely related to low throughput. When several carriers maintain separate premises and routes in the same county, each must cover its fixed costs from a small parcel flow. Agricultural seasonality adds another difficulty: capacity needed during a harvest peak may remain lightly used for much of the year. Aggregating flows can help, but only where their timing and handling requirements are compatible.

Information fragmentation creates a different problem. A carrier may know where its own parcels are while lacking the inventory, vehicle or station data needed to coordinate with another operator. A common facility can therefore remain operationally divided even after firms move into the same building. The policy emphasis on shared distribution needs to be accompanied by practical decisions about identifiers, data access and scheduling responsibility.

For agricultural goods, the weakness often lies before long-distance transport. Collection, grading, pre-cooling and packing must be completed within a product's handling window. A cold room has limited value if produce arrives too late or if suitable onward transport is unavailable. These links also complicate investment: the organisation paying for origin facilities may not receive all the gains from improved product quality.

Finally, counties differ in terrain, industrial concentration, fiscal resources and operating skills. These differences limit the transfer of a configuration from one location to another. A shared parcel centre and a seasonal fruit hub face different demands even when both are described as rural e-commerce warehouses. The design responses in Table 2 should therefore be read as options to investigate against local operating conditions.

Table 2. Structural constraints and proposed design responses

Constraint	Operational problem	Underlying mechanism	Proposed response
Fragmented assets	Separate premises, sorting operations and routes serve overlapping areas.	Fixed costs are divided across operators with limited throughput.	Pool compatible flows and consolidate selected facilities through a shared operator.
Thin and seasonal demand	Parcel volumes are low or fluctuate sharply around harvest and sales peaks.	Idle capacity raises unit costs; peak capacity may be underused for much of the year.	Verify combined demand, use flexible capacity and stage investment.
Data silos	Orders, inventory, vehicles and stations cannot be viewed consistently across firms.	Incompatible records and unclear access rights obstruct joint decisions.	Agree identifiers, interfaces, access rules and responsibility for data quality.
Weak origin handling	Delayed pre-cooling, inconsistent grading and temperature breaks expose produce to loss.	Specialised facilities are expensive and may be disconnected from transport or sales.	Link cold storage to collection, processing, temperature monitoring and market demand.
Collective-action problems	Partners seek common services but disagree over contributions or returns.	Investment costs, operating risks and benefits fall on different actors.	Specify service obligations, cost allocation, data rights and dispute resolution.
Local variation	A model copied from another county may attract insufficient use.	Terrain, commodities, skills, fiscal capacity and demand differ.	Select functions using local evidence and test utilisation before expansion.

The responses are analytical design proposals. Their effectiveness was not estimated from the four cases.

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4.2. County Configurations

4.2.1. She County Shared Warehousing and Distribution

The State Post Bureau (2023) describes five courier firms establishing a joint distribution company in She County. The firms shared warehousing, sorting, transport and delivery. The account reports that unit delivery cost fell from RMB 1.15 to below RMB 1 per parcel, daily delivery volume increased by 150% year on year, and 308 service stations provided broad village coverage. The volume comparison is explicitly year on year; it is not an estimate of the effect of the joint company.

This arrangement brings asset sharing and joint operation into the same organisation. It offers a plausible route to higher utilisation because parcels from several carriers can pass through common facilities and routes. However, the report does not provide a cost decomposition or a comparison county. The practical question is whether partners consistently transfer sufficient volume to the common operation. Retaining parallel facilities while sending only occasional overflow to the shared centre would weaken the expected savings.

4.2.2. Fuchuan Origin Handling and Cold-chain Services

The Fuchuan account describes a network comprising one county distribution centre, 12 township transfer stations and 117 village service stations. It reports a 20% reduction in village delivery cost and a 30% improvement in delivery efficiency, without providing enough detail to reproduce either calculation (State Post Bureau, 2025).

The county's agricultural e-commerce park occupies approximately 18.7 hectares and contains more than 150,000 cubic metres of intelligent cold storage. The account also identifies three fruit-processing lines and four cold-chain fleets, and reports an agricultural-product handling capacity of 500 tonnes per day for the park. This is a capacity figure, not evidence that the park or its fleets handled that volume each day. For 2024, the source reports 2.6196 million express items. The same account states that annual county e-commerce sales exceeded RMB 1 billion, without separately specifying the sales year.

Fuchuan is relevant because it places cold storage alongside processing, transport and access to sales channels. These connections make it possible to examine loss prevention as part of the origin-handling process. The account does not measure food-loss reductions, energy use or the separate contribution of cold storage to sales. It supports the identification of an integrated configuration, while leaving its environmental and income effects open to further study.

4.2.3. Sinan Cloud Warehousing for Local Firms

Su and Wu (2023), reporting for the Tongren Integrated Media Center, quote the node's operator as saying that Sinan's Qianhuo Cloud Warehouse served 28 agricultural-product and processing enterprises and handled more than 800 orders a day. Partnerships with couriers, including ZTO and YTO, connected the warehouse to delivery services.

The case illustrates how local firms can use a common storage and fulfilment service. Pooling their orders may help support capabilities that a small merchant could struggle to maintain alone. The reported merchant and order counts establish participation and activity, but the source gives no comparable pre-entry fulfilment costs or inventory measures. It also provides little detail about the node's digital systems. Any claim of improved efficiency therefore remains an inference. Continued operation would depend on merchant retention, reliable product records and fees that cover the service's costs.

4.2.4. Pingquan Coordination through a Common Information System

The Pingquan account reports two county warehousing and distribution centres, 28 township-level centres or service stations, and 238 village stations. It describes a common-distribution information system that tracks operations and matches people, vehicles, goods, stations and routes (Langfang Municipal People's Government, 2025).

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Here, the relevant configuration links data to an existing network of physical nodes. The reported system provides a basis for coordinating work across those nodes, although the source does not quantify a separate effect on cost or service reliability. Its usefulness depends on whether participating organisations enter consistent data and act on shared decisions. The availability of a dashboard alone does not establish that vehicle allocation, dispatch or exception handling has changed.

Table 3. Comparison of four county warehousing configurations

Case and configuration	Documented features and reported indicators	Analytical emphasis	Interpretation and evidential boundary
She County Shared distribution centre	Five courier firms formed a joint company. Reported delivery cost fell from RMB 1.15 to below RMB 1 per parcel; average daily deliveries increased 150% year on year. The network had 308 service stations.	Platformisation and collaboration	Consistent with pooling assets and compatible flows. The source does not isolate the arrangement's causal effect or describe detailed cost-sharing rules.
Fuchuan Origin cold-chain system	One county centre, 12 township stations and 117 village stations. Reported delivery cost fell 20% and efficiency rose 30%. The park had over 150,000 m3 of cold storage and reported handling capacity of 500 tonnes/day.	Greening, digitalisation and collaboration	Connects storage, processing and transport. Capacity is not measured utilisation. Baselines, food-loss rates, energy use and net emissions benefits are unavailable.
Sinan Cloud-warehouse node	The operator reported 28 resident enterprises, more than 800 daily orders and partnerships with ZTO and YTO.	Platformisation; limited evidence on digitalisation	Documents shared fulfilment and demand aggregation. No before-and-after cost comparison or detailed description of digital interfaces is provided.
Pingquan Data-integrated distribution	Two county centres, 28 township-level centres or related service nodes, and 238 village stations; a shared information system supports tracking and coordination.	Digitalisation and collaboration	Documents a network and information system. Efficiency claims are unquantified; data rights, scheduling authority and operator accountability require further investigation.

Figures are attributed to the sources listed in Table 1 and were not independently audited. DPCG emphases are interpretations, not measured scores or mutually exclusive categories.

4.3. The DPCG Framework

The literature-derived DPCG dimensions provide a common basis for interpreting the four cases: digitalisation, platformisation, collaboration and greening. Each identifies a practical design question. Digitalisation concerns which information is available and how it informs operations. Platformisation concerns access to shared assets and services. Collaboration concerns who makes decisions and bears costs. Greening concerns product loss, energy, transport and packaging. Figure 1 places these questions within a common warehousing and distribution system.

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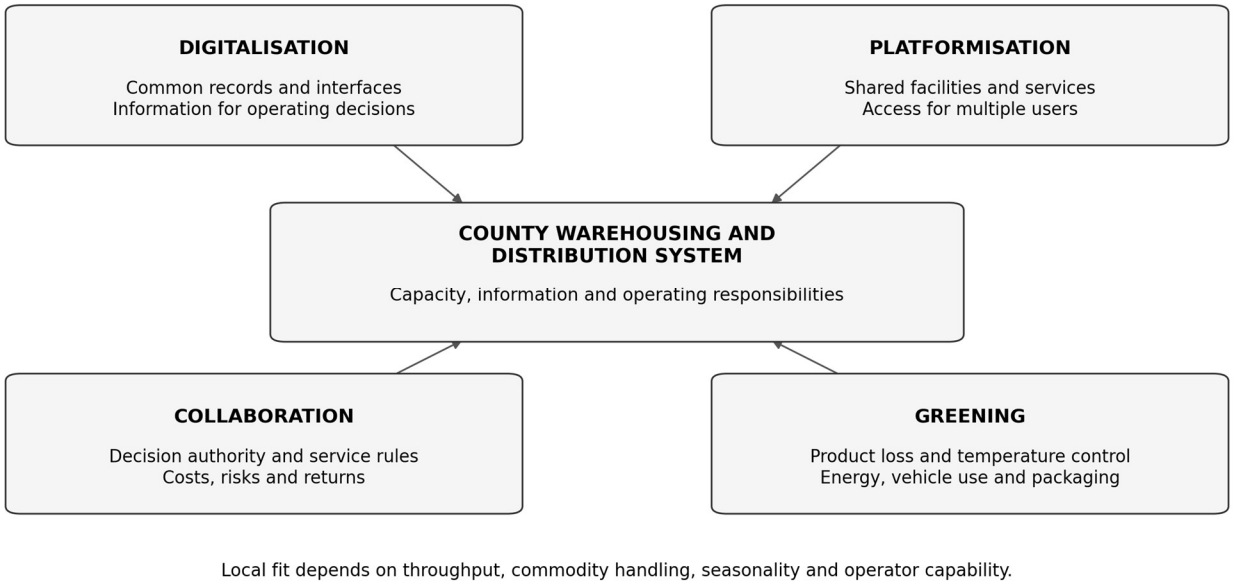


Figure 1. The DPCG framework for interpreting county warehousing and distribution.

Digitalisation should begin with the information required for a specific task. A shared warehouse management system (WMS), common product identifiers and mobile scanning may be sufficient for inventory reconciliation and dispatch. Temperature sensors address a different need in perishable-product handling. More advanced forecasting or automation becomes useful when data quality, transaction volume and maintenance capability support it. Across organisations, the basic requirement is that records describe the same goods, locations and events in compatible ways.

Platformisation refers to providing warehousing functions as services available to several users. Storage, grading, packing, order fulfilment and cross-docking can be offered separately or as a package. The operator may be a business, cooperative or public service organisation. What matters for this framework is how users gain access, how the service is priced and whether it consolidates activity. Opening a shared centre while leaving all existing capacity in place can increase the county's total fixed costs.

Collaboration concerns the arrangements that keep shared services working. Participating carriers, producers and public agencies need to know who controls daily operations, how capacity is allocated at peaks, and who pays when service fails. Data access and commercial confidentiality also require agreement. County government can help coordinate public-service objectives, land and infrastructure, while a named operator needs sufficient authority to manage routine work and resolve exceptions.

Greening covers operational choices whose environmental consequences can be measured. For agricultural products, timely collection, pre-cooling and temperature control can protect quality. Shared vehicle movements may improve load factors; cold-store management affects energy demand; and packaging choices affect material use and recovery. These benefits should not be assumed from equipment installation. None of the four case accounts supplies an independently measured life-cycle carbon assessment, and the Fuchuan account does not quantify food-loss savings. In this study, greening is a design dimension whose outcomes still require measurement.

The dimensions are interdependent. A shared facility needs committed users; digital records need an operator able to act on them; and cold-chain capacity needs a product flow that justifies its operation. Their relative importance varies with the county's circumstances. Different

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ownership arrangements may provide similar functions, so the framework does not prescribe a single organisational form. The following propositions express relationships for later testing.

Proposition 1. Digitalisation is more likely to improve rural warehousing performance when organisations use interoperable data and shared routines to make operating decisions.

Proposition 2. Shared warehousing is more likely to achieve economies of density when compatible flows are consolidated and underused parallel capacity is retired or repurposed.

Proposition 3. Collaboration is more likely to persist when participants have explicit, enforceable arrangements for costs, risks, data access and the distribution of returns.

Proposition 4. Investments intended to reduce product loss are more likely to generate economic and environmental benefits when temperature control is connected to origin handling, sales and sustained facility utilisation.

4.4. Mechanisms Linking Configuration and Performance

Five mechanisms help explain why these arrangements may matter. Figure 2 sets out the proposed pathways. The arrows represent analytical propositions; their size and direction have not been estimated from the case data.

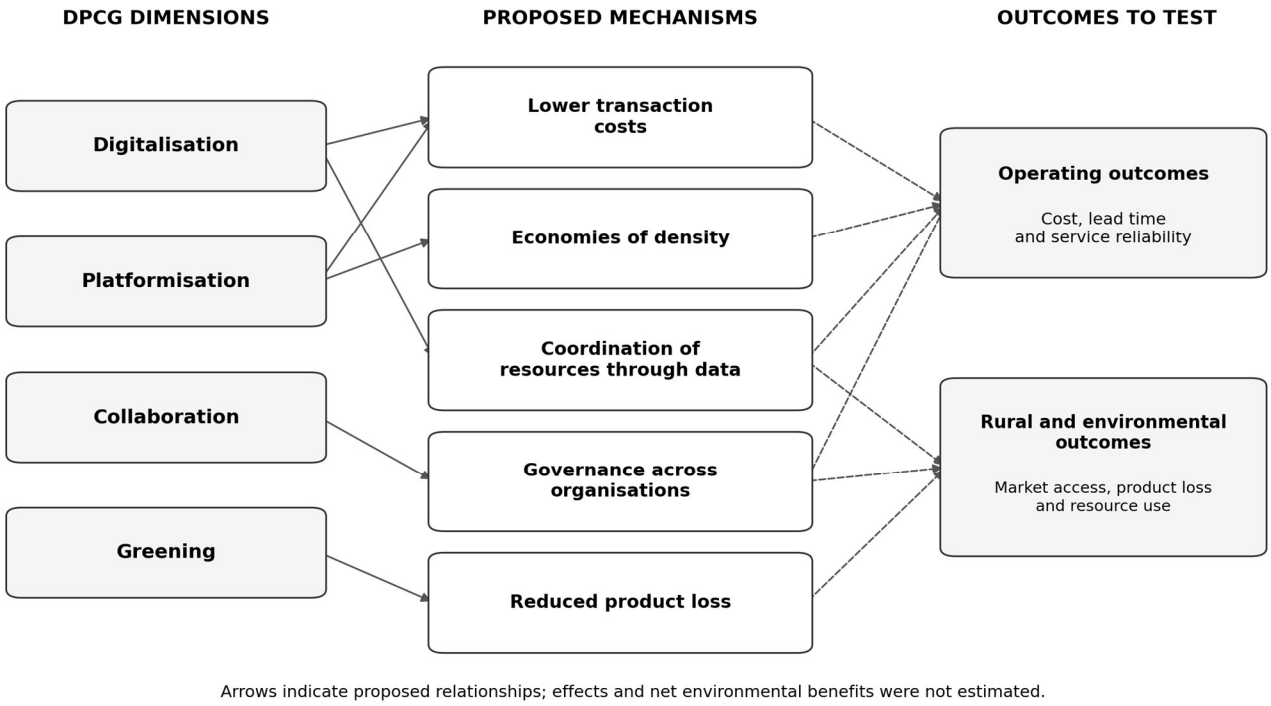


Figure 2. Proposed pathways linking DPCG dimensions, mechanisms and outcomes. Arrows do not represent estimated causal effects.

Lower transaction costs arise when a common service reduces repeated coordination between dispersed shippers and carriers. Standard service rules can simplify booking and settlement, while reliable tracking can make responsibility for delays or damaged goods easier to establish. She County's joint company is consistent with this explanation because it places several delivery activities within one operating arrangement. Whether its coordination savings exceed the cost of managing the joint company requires further evidence (Williamson, 1979, 1985).

Economies of density arise when compatible parcels or products move through the same facilities and routes within a useful time window. Annual volume alone is insufficient to establish viability; the timing, handling requirements and operating schedule of the combined flows also matter. Complementary seasonal products may help use facilities across the year.

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She County reports a lower unit delivery cost, and Sinan reports orders aggregated from multiple firms. These observations motivate the mechanism, but do not identify a common minimum throughput or show how much of the reported performance is due to consolidation.

Coordination through data connects available resources to current demand. Pingquan's information system illustrates the information needed to allocate people, vehicles and routes across a network. Similar coordination in a cold chain could use harvest, order and temperature records to plan collection and dispatch. Resource management theory explains why the value of those records depends on how assets are combined and deployed (Sirmon et al., 2007). Data quality and decision authority remain necessary operating conditions.

Governance across organisations can support the continuity of joint services. Carriers contribute networks and operating knowledge, producers contribute supply and local knowledge, and public agencies may support remote-area coverage or common infrastructure. These interests do not automatically coincide. Rules on service levels, charges and access can help maintain participation, while unresolved disputes or unequal control of information can undermine it (Cao & Zhang, 2011; Provan & Kenis, 2008). The cases show organisational arrangements, but provide limited evidence about the negotiation and enforcement of their contracts.

Product-loss reduction is especially relevant to origin warehousing. Pre-cooling, grading and temperature-controlled storage can extend the time available for sale and distribution, subject to the product and handling conditions (Mercier et al., 2017). Fuchuan connects cold storage, processing and transport within the same county system. A net environmental benefit would still depend on the amount of loss avoided, energy demand, refrigerant impacts and transport changes. Without those measurements, the framework identifies a pathway to investigate rather than an established emissions reduction.

Proposition 5. Configurations that fit local commodity flows and align data, shared capacity and operating responsibilities are more likely to sustain performance gains than interventions addressing a single component in isolation.

4.5. Local Conditions and Implementation Tests

Configuration choice depends on order density, perishability, seasonality, terrain, existing industry and operator capability. A county may need a shared parcel centre alongside a separate origin cold-chain hub, with common information services connecting them. Table 4 translates the case comparison into questions for investment and operation. The suggested indicators are prospective management measures; they are not additional outcomes observed in the four cases.

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Table 4. Evidence and operating measures for configuration decisions

Configuration	Evidence needed before investment	Measures to monitor	Warning signs and response
Shared distribution centre	Combined parcel and tonnage profiles across seasons; partner volume commitments; inventory of existing facilities and routes; an agreed operating and cost-allocation arrangement.	Cost per parcel or tonne; route distance per order; vehicle load factor; share of traffic using the centre; delivery reliability.	Partners retain duplicate operations or use the centre only at peaks. Revisit volume commitments, asset consolidation, service terms and the operator's cost base before adding capacity.
Origin cold-chain warehouse	Commodity characteristics and harvest calendar; expected buyers and volumes; pre-cooling requirements; storage-utilisation estimates; energy and transport costs; an off-season operating plan.	Harvest-to-pre-cooling time; temperature excursions; product losses; storage utilisation; realised quality grades and prices; energy per tonne handled.	Low utilisation, temperature breaks or energy costs outpace benefits. Adjust capacity, aggregate suitable products and repair handling routines before expansion.
Cloud-warehouse node	Merchant participation and retention prospects; product and order profiles; common product records; agreed inventory responsibilities; transparent storage and fulfilment charges.	Active merchants; orders per labour hour; inventory accuracy; order-cycle time; fulfilment cost; merchant retention and service complaints.	Merchant departures or inventory discrepancies persist. Simplify onboarding, correct product records and review service bundles, responsibilities and pricing.
Data-integrated distribution platform	A named network operator; compatible identifiers and interfaces; data-access agreements; scheduling and exception rules; staff capacity to act on information.	Data completeness; scan compliance; exception-resolution time; vehicle and station utilisation; scheduling changes and service reliability.	Dashboards are used without changes in operations. Clarify decision authority, connect information to dispatch routines and address missing or unreliable records.

These are proposed decision tests and monitoring measures, not thresholds estimated by this study. Local operators need baselines and consistent definitions before evaluating changes.

4.6. Theoretical Contributions

The analysis gives county warehousing a clearer organisational boundary. Following goods through collection, handling, storage and dispatch reveals decisions that cannot be understood by studying the warehouse building alone. It also connects facility research to rural logistics research, where the emphasis often falls on routes and terminal access. The county configuration is a useful intermediate unit because it brings physical capacity and coordination decisions into the same analysis.

The framework also specifies how the theoretical explanations relate. Transaction cost economics helps explain the incentive to consolidate activities. Resource management and dynamic capabilities help explain how organisations combine and adjust assets as demand changes. Network governance addresses the arrangements needed when those assets belong to different actors (Sirmon et al., 2007; Teece et al., 1997; Warner & Wäger, 2019; Provan & Kenis, 2008). These perspectives guide interpretation; the documentary comparison does not test their relative explanatory power.

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A further contribution is to make the conditions of technology use explicit. In a low-volume county, common identifiers and agreed dispatch procedures may deserve priority over automation. The relevant choice depends on the task, available skills and recurring costs. The same reasoning applies to sustainability: installing cold storage and reducing net environmental burdens are separate achievements. By including utilisation and loss measurement in the framework, the analysis offers specific questions for evaluating that relationship.

4.7. Policy and Management Implications

County planning should start with existing flows and assets. A useful assessment would map parcel volumes, agricultural production calendars, warehouses, delivery routes and gaps in origin handling. It should also identify which operators would commit volume to a shared service. Public support can then be linked to specified outcomes such as remote-area coverage, reliable collection or open access to common facilities. Operating income and any continuing public compensation need to be considered alongside construction costs.

Operators can reduce investment uncertainty by introducing changes in stages. Initial work might connect order records, standardise scanning or consolidate a small group of routes. Measurements of cost, service reliability and capacity use can guide subsequent expansion. Agreements between participants should identify the operator's responsibilities, service charges, access to data and procedures for losses or delays. Commercially sensitive information needs to be handled in a way that allows competing firms to use the shared service.

Cooperatives, processors and producers have a role in defining collection schedules, grades and packaging requirements. Where improved handling supports a higher selling price, contracts should specify how returns are distributed and who bears spoilage or rejection costs. The present cases do not show whether producers obtained a larger share of value, so that outcome needs to be assessed directly.

Environmental monitoring should accompany cost monitoring. Relevant measures include time to pre-cooling, temperature excursions, food-loss rates, energy per tonne handled, vehicle load factors and packaging recovery. They can reveal trade-offs that facility counts miss. For example, a cold store may reduce product losses while consuming more electricity, and route consolidation may alter both distance and the number of vehicle movements. Assessing those changes together is necessary before claiming a net benefit.

4.8. Limitations and Future Research

The evidence has several limits. Officially hosted case reports may favour successful initiatives and omit difficulties. The four purposively selected cases provide useful contrasts but cannot establish how common each configuration is. Their numerical indicators use different units, reporting periods and unspecified baselines, which prevents a comparable estimate of performance. Information on subsidies, operating profitability, contracts and producer income is also limited.

The documentary snapshots cannot establish whether services remain viable after demand changes or public support ends. They contain no independently verified carbon assessments and insufficient data to estimate food-loss or energy effects. Accordingly, the five propositions should be treated as hypotheses arising from the comparison.

Future studies could collect operating records before and after service changes and compare similar counties with different arrangements. Interviews with operators, merchants, producers and public agencies would help examine decisions and benefit allocation that published reports leave unclear. Particular priorities are to estimate the throughput needed to sustain each configuration, measure year-round cold-chain utilisation, and assess food loss alongside energy

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and transport impacts. Such work would provide a basis for testing the framework's proposed mechanisms.

5. Conclusion

The four cases describe different responses to the difficulty of organising rural warehousing. She County brings courier operations into a shared company; Fuchuan connects origin handling and cold-chain services; Sinan pools fulfilment activity for local firms; and Pingquan coordinates a distribution network through shared information. Their common feature is the relationship between physical capacity and the arrangements for using it.

The DPCG framework organises this relationship around digitalisation, platformisation, collaboration and greening. It proposes that these dimensions can influence performance through coordination costs, economies of density, resource use, governance and product-loss prevention. The documentary evidence supports this interpretation of the configurations, but does not establish the causal effect of the framework or a net environmental benefit.

For a county considering investment, the first task is to identify the operating constraint and the flows available to support a service. Capacity, data arrangements and decision responsibilities can then be designed together, with expansion tied to evidence of use. Evaluation should include operating costs and service quality as well as losses, energy demand and the distribution of benefits to producers. These measures would make the contribution of warehousing to rural e-commerce more directly testable.

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