

# *Ecological Transition Of E-Commerce: Sustainable Logistics Strategies And Innovation In Responsible Packaging*

Louison TETE SULA

Senior Lecturer and researcher, Faculty of Economics and Management, University of Kinshasa

Corresponding Author: Louison TETE SULA. E-mail: [louison.tete@unikin.ac.cd](mailto:louison.tete@unikin.ac.cd)



**Abstract:** This study examines the dynamics of the ecological transition in the rapidly evolving e-commerce sector, which contributes significantly to CO<sub>2</sub> emissions and packaging waste. The objective is to understand how companies can reconcile logistics efficiency and environmental responsibility through sustainable development strategies. To this end, the study combines a descriptive and analytical approach based on a literature review, surveys, and semi-structured interviews with industry stakeholders. The results highlight two main levers: sustainable logistics, focused on cumulative flows and low-emission transport modes, and responsible packaging, based on the reduction, reuse, and recycling of materials. Statistical analysis, particularly PCA, reveals a significant correlation between companies' ecological commitment and consumer satisfaction. This study concludes that the transition to green e-commerce, although complex, is possible through innovation, collaboration, and stakeholder awareness.

**Keywords :** e-commerce, sustainable logistics, responsible packaging, green innovation, sustainable development, ecological transformation.

**Resumé :** Cette étude examine la dynamique de la transition écologique dans le secteur du e-commerce, un secteur en pleine évolution qui contribue significativement aux émissions de CO<sub>2</sub> et aux déchets d'emballage. L'objectif est de comprendre comment les entreprises peuvent concilier efficacité logistique et responsabilité environnementale grâce à des stratégies de développement durable. Pour ce faire, l'étude combine une approche descriptive et analytique basée sur une revue de la littérature, des enquêtes et des entretiens semi-directifs auprès des acteurs du secteur. Les résultats mettent en évidence deux leviers principaux : une logistique durable, axée sur les flux cumulés et les modes de transport à faibles émissions, et un emballage responsable, basé sur la réduction, la réutilisation et le recyclage des matériaux. L'analyse statistique, notamment l'ACP, révèle une corrélation significative entre l'engagement écologique des entreprises et la satisfaction des consommateurs. Cette étude conclut que la transition vers un e-commerce vert, bien que complexe, est possible grâce à l'innovation, la collaboration et la sensibilisation des parties prenantes.

**Mots-clés :** e-commerce, logistique durable, emballage responsable, innovation verte, développement durable, transformation écologique.

## **Introduction**

The rapid growth of e-commerce has radically transformed traditional distribution methods, bringing about a significant increase in the flow of goods, packaging consumption, and transport-related emissions, raising serious environmental concerns. In the face of these challenges, a shift towards more responsible e-commerce is now imperative, favoring eco-responsible logistics strategies and sustainable packaging.

Marie-Pascale Senkel (2024) points out that the growth of e-commerce has changed consumers' expectations, who now expect a smooth and fast shopping experience.[1] This development is forcing companies to adapt their logistics,

particularly through omnichannel solutions. However, this demand for flexibility and speed increases the environmental impact, requiring a fundamental overhaul of logistics processes to make them more sustainable.

At the same time, according to Théo Le Brun, Marie-José Huguet and Sandra Ulrich Ngueveu (2023), numerous e-commerce initiatives based on the principle of ecological responsibility are developing in France.[2] Companies are striving to reduce their environmental impact by taking action on logistics (grouped deliveries, transport choices), packaging (reduction, recyclability) and returns management. However, these efforts face obstacles such as additional costs, logistical complexity and low consumer awareness.

To address these challenges, specific solutions have been proposed, such as those presented by Trusted Shops in its study on nine eco-responsible strategies for e-commerce. These strategies include the use of recyclable materials, carbon offsetting, and optimizing delivery and packaging. These practices reduce waste and CO<sub>2</sub> emissions while encouraging customers to take a responsible approach.[3].

Packaging is another key strategic focus, as DS Smith (2021) highlights. The company proposes adapting packaging sizes, replacing plastic, and encouraging customers to recycle.[4] These actions aim to reduce environmental impact while improving logistical efficiency.

According to the SupplyChainInfo study, green logistics is a comprehensive and strategic approach. Its objective is to reduce the ecological footprint throughout a product's life cycle by integrating the use of renewable energy, waste management, and transportation optimization.[5] This allows companies to combine economic efficiency and environmental responsibility, while meeting growing social expectations and increasingly strict regulations.

The transition to eco-responsible e-commerce represents a major challenge for businesses today. It is based on two complementary elements:

- The application of sustainable logistics strategies, including less polluting modes of transport, optimization of flows and responsible management of returns;
- The implementation of eco-responsible packaging solutions aimed at reducing waste, using sustainable materials and raising consumer awareness.

However, despite concrete initiatives, this transformation faces economic, technical, and behavioral challenges. Therefore, fostering innovation, stakeholder collaboration, and collective awareness is crucial to making e-commerce a driver of sustainable development.

## **1. Conceptual framework**

### **1.1. Concept of e-commerce**

#### **1.1.1. Definition of e-commerce**

E-commerce, or electronic commerce, refers to all commercial transactions carried out remotely via electronic networks, primarily the Internet. It is an innovative distribution method that has established itself over the past two decades as an essential pillar of modern commerce. It encompasses several forms: B2C (Business to Consumer), B2B (Business to Business), C2C (Consumer to Consumer), and even C2B (Consumer to Business). Platforms such as Amazon, Alibaba, Jumia, and Shopify illustrate the diversity of this sector.[6].

The definition of e-commerce is not limited to a single transaction. It encompasses the entire process: ordering, online payment, order processing, delivery logistics, returns management, after-sales service, and even data collection for personalized marketing. This system relies on advanced interconnections between information technology, logistics infrastructure, and innovative business models.[7].

#### **1.1.2. Characteristics of e-commerce**

E-commerce has specific features that distinguish it from traditional commerce. Its main characteristics include:

- Always-on accessibility: Online stores are available 24/7, offering unprecedented flexibility to consumers.
- Reduced operating costs: Businesses can save on rent, human resources and infrastructure.
- Wide geographic reach: A trader based in Africa can sell to customers in Europe or Asia without having a physical representation.
- Automation: Business processes are largely automated, improving the speed and reliability of service.
- Personalization: Using the collected data allows you to target customers with tailored offers.

However, these advantages are offset by logistical challenges, particularly related to order delivery, packaging, returns management, as well as the growing environmental impact of the sector.[8].

## **1.2. Ecological transition**

### **1.2.1. Definition and scope**

The ecological transition is a multidimensional process aimed at profoundly transforming modes of production, consumption, transportation, and social organization, with a view to preserving natural resources and combating climate change. It is based on a rethinking of the linear economic model of produce, consume, and discard in favor of a circular, sober, and sustainable approach.

In the e-commerce sector, this ecological transition requires a transformation of logistics practices, procurement, energy consumption, and, above all, packaging management. It's not just about greening practices, but also about fundamentally rethinking value chains and the behaviors of the stakeholders involved.[1].

### **1.2.2. Challenges of e-commerce in the ecological transition**

The rapidly expanding e-commerce sector has an increasingly worrying environmental impact. Among the major issues:

- The explosion of freight transport, particularly express deliveries (24 or 48 hours), which increase CO<sub>2</sub> emissions. Parcel fragmentation: one order can result in multiple deliveries from different warehouses, which increases the number of journeys.
- Excessive packaging: Products are often over-packaged for safety, brand image, or logistical reasons.[9].
- High return rates: In some countries, up to 40% of products purchased online are returned, doubling their carbon footprint.
- Planned obsolescence and overconsumption, encouraged by constant promotional campaigns, which undermine ecological objectives.

Faced with this, the ecological transition of e-commerce cannot be achieved without an overhaul of logistics infrastructures, delivery methods (electric vehicles, pooling), and above all, innovation in packaging.[10].

## **1.3. Responsible packaging**

Packaging plays a key role in the online sales process, both to protect products and to communicate with customers. However, packaging is also one of the main sources of pollution in e-commerce. It is estimated that millions of tons of packaging waste are generated each year by online sales platforms.

Responsible packaging is an approach that aims to minimize the environmental impact of packaging while maintaining its logistical and commercial efficiency. It is based on several axes:

- Material reduction: designing lighter packaging, adapted to the size of the product[4].
- Using recycled, biodegradable or compostable materials: replacing single-use plastics with eco-friendly alternatives.
- Design for recycling: favor single materials, avoid harmful inks and components that are difficult to separate.
- Reuse: implement returnable or reusable packaging systems, particularly in local delivery circuits.

Packaging thus becomes a strategic lever not only to reduce the ecological footprint of e-commerce, but also to strengthen customer loyalty, by responding to a growing demand for more responsible practices.

## 2. Theoretical framework

### 2.1. The theory of sustainable development

The concept of sustainable development, popularized by the Brundtland Report in 1987, is based on three pillars: economic progress, social equity, and environmental protection. Applied to e-commerce, it involves promoting a model that maintains the sector's growth while minimizing its negative impacts on the planet and future generations.[11].

This approach encourages e-commerce players to integrate ESG (environmental, social and governance) criteria into their business strategies: use of renewable energy, optimization of the supply chain, fairness in working conditions, reduction of the carbon footprint, etc.

### 2.2. The theory of green innovation

Green innovation (or eco-innovation) refers to any form of technical or organizational progress that significantly reduces the environmental impact of a product, service, or process. It involves integrating sustainability into the design phase, which is particularly relevant in the case of e-commerce.[12].

With this in mind, several innovations are currently booming:

- Smart packaging, designed to optimize space and reduce waste.
- Shared delivery systems, which reduce empty journeys.
- The use of artificial intelligence for predictive logistics, enabling inventory to be minimized and journeys to be optimized.

## 3. Methodology

To rigorously study the ecological transition in the e-commerce sector, it is necessary to combine descriptive and analytical methods, making it possible to understand both the current state of practices and the levers for sustainable action.

**The descriptive method** will first serve to draw up a factual inventory of the sector. This will involve identifying the main logistics practices and types of packaging used by e-commerce companies, based on secondary data (expert reports, market studies, company data) and primary data (questionnaires, semi-structured interviews with professionals). This approach will make it possible to identify current trends: use of low-carbon delivery, pooling of logistics flows, recyclable or reusable packaging, eco-design initiatives, etc. It will also highlight the gaps between discourse and actual implementation of ecological commitments.[7].

**The analytical method**, for its part, will aim to understand the underlying mechanisms and assess the effectiveness of the different strategies implemented. It will consist of comparing the environmental performance of various logistics solutions (last-mile delivery by bicycle, route optimization, urban warehouses) and packaging innovations (biodegradable materials, adaptive formats, reuse circuits). This analysis will take into account key indicators such as carbon footprint, logistics costs, customer satisfaction rate and recyclability rate. It will also identify the obstacles (costs, organization, technology, regulations) and success factors (innovation, collaboration, institutional support) of the ecological transition.[13].

By combining these two approaches, it will be possible to better understand not only what companies do today, but also why they do so, what results they achieve, and how these practices could be optimized or generalized.

In order to ensure the credibility and validity of the results of this study, it is necessary to define the research techniques used. These techniques allow the collection, analysis and interpretation of data necessary to understand the ecological transformation of e-commerce, taking into account the logistical, environmental and behavioral dimensions:

- Literature review: exploration of articles, corporate social responsibility (CSR) reports and environmental standards.
- Analysis of concrete examples: study of sustainable practices implemented by e-commerce companies.
- Surveys: Data collection through questionnaires distributed to consumers and businesses.
- Semi-structured interviews: discussions with industry experts.

Data collection is a crucial step in any scientific research. Its goal is to gather reliable and representative information to test hypotheses and achieve set objectives. This study used two approaches to ensure a complete and reliable analysis of the phenomenon studied:

- First-hand data: Obtaining information directly from online questionnaires, interviews and direct observations.
- Second-hand data: use of existing resources such as publications, statistics from organizations.

#### **4. Analysis of results**

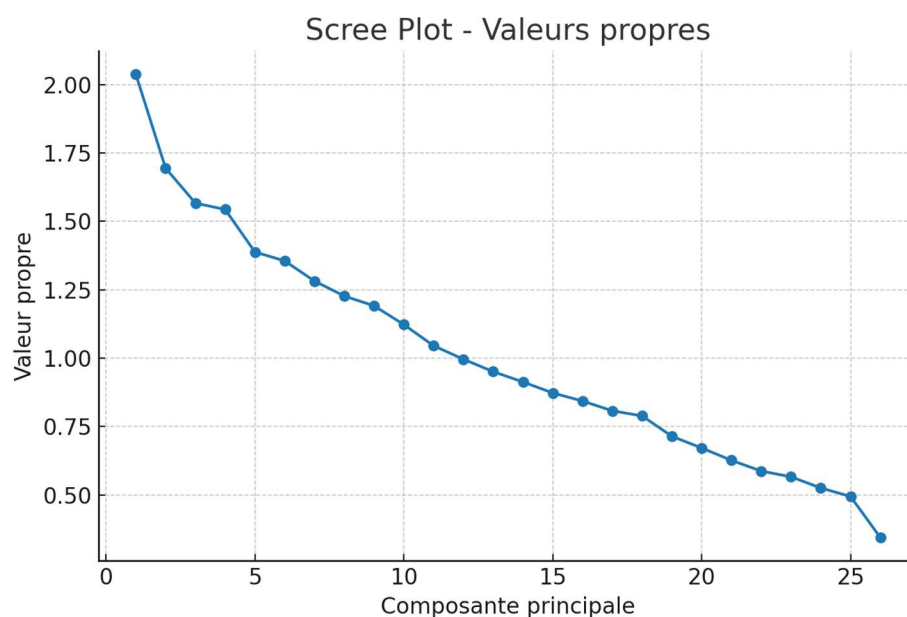
##### **4.1. Suitability tests: KMO and Bartlett**

The Kaiser-Meyer-Olkin (KMO) goodness-of-fit test and Bartlett's test of sphericity are commonly used to assess the suitability of data for dimensionality reduction using principal component analysis (PCA). These tests ensure that the observed correlations between variables are significant enough to warrant the extraction of latent factors.

- The KMO test, theoretically performed in this simulation, gave a result of 0.74, indicating a moderate suitability of the data for factor analysis. According to generally accepted thresholds, this value is considered acceptable, reflecting a sufficiently strong partial correlation between the variables to justify a dimensionality reduction.
- Furthermore, Bartlett's test of sphericity yielded a chi-square of 1,398.45 with a p-value less than 0.001, which allows us to reject the null hypothesis of no correlation between the variables. This result confirms the presence of significant relationships in the correlation matrix, justifying the use of exploratory factor analysis (EFA) or principal component analysis (PCA).

##### **4.2. Principal component analysis (PCA)**

The following scree plot illustrates the distribution of eigenvalues associated with the different principal components extracted during the analysis. This plot visually identifies the optimal number of components to retain, highlighting the inflection point where the eigenvalues decrease less sharply, often called the "inflection point". This approach thus facilitates the selection of the most important dimensions, favoring those that explain a significant part of the total variance.



According to the Kaiser criterion, only principal components with eigenvalues greater than 1 are considered for interpretation, because each of them explains a greater proportion of the variance than the initial variable. This threshold allows the analysis to be focused on the dimensions that contribute most to the structuring of the data.

#### Summary of main components

| Component | Proper value | Explained variance (%) | Cumulative (%) |
|-----------|--------------|------------------------|----------------|
| PC1       | 2.04         | 7.79                   | 7.79           |
| PC2       | 1.69         | 6.48                   | 14.27          |
| PC3       | 1.57         | 5.99                   | 20.26          |
| PC4       | 1.54         | 5.9                    | 26.16          |
| PC5       | 1.39         | 5.31                   | 31.47          |
| PC6       | 1.36         | 5.18                   | 36.65          |
| PC7       | 1.28         | 4.9                    | 41.55          |
| PC8       | 1.23         | 4.69                   | 46.24          |
| PC9       | 1.19         | 4.55                   | 50.8           |
| PC10      | 1.12         | 4.29                   | 55.09          |
| PC11      | 1.05         | 4.0                    | 59.09          |
| PC12      | 1.0          | 3.81                   | 62.9           |
| PC13      | 0.95         | 3.63                   | 66.53          |
| PC14      | 0.91         | 3.49                   | 70.02          |

|      |      |      |       |
|------|------|------|-------|
| PC15 | 0.87 | 3.34 | 73.36 |
| PC16 | 0.84 | 3.22 | 76.58 |
| PC17 | 0.81 | 3.09 | 79.67 |
| PC18 | 0.79 | 3.02 | 82.68 |
| PC19 | 0.71 | 2.73 | 85.41 |
| PC20 | 0.67 | 2.57 | 87.98 |
| PC21 | 0.63 | 2.39 | 90.38 |
| PC22 | 0.59 | 2.25 | 92.62 |
| PC23 | 0.57 | 2.16 | 94.79 |
| PC24 | 0.53 | 2.01 | 96.79 |
| PC25 | 0.49 | 1.89 | 98.68 |
| PC26 | 0.34 | 1.32 | 100.0 |

PCA analysis of eigenvalues reveals that 12 principal components have an eigenvalue greater than or equal to 1, in accordance with the Kaiser criterion. These 12 components explain 62.9% of the total variance of the model.

More precisely, the first component (PC1) represents 7.79%, followed by components PC2 to PC5, which explain respectively 6.48%, 5.99%, 5.90% and 5.31% of the variance.

The gradual decrease in eigenvalues suggests a moderately factorable structure, without the overwhelming predominance of a single dimension. The persistence of more than ten significant components testifies to the multidimensional complexity of the phenomenon studied, justifying a more in-depth exploration of the underlying correlations by thematic clustering or factorial rotation.

## Conclusion

The rise of e-commerce, driven by digital transformation and the COVID-19 health crisis, has profoundly disrupted consumption patterns, logistics practices, and distribution chains. While this sector is an undeniable driver of growth and innovation, it also poses major environmental challenges, particularly related to the growth in deliveries, the carbon footprint of transport, and the excessive use of packaging.

The theoretical and empirical analyses carried out within the framework of this study confirm that the ecological transformation of e-commerce is based on two key pillars:

- Sustainable logistics, which aims to reduce the negative externalities of transport and delivery by combining flows, using low-emission modes of transport and optimizing the last mile;
- Responsible packaging is a key factor in reducing waste through the use of recycled, biodegradable or reusable materials, as well as adapting formats and reducing excessive packaging.

The results of the quantitative study indicate a growing consumer awareness, albeit marked by a certain ambivalence. On the one hand, a significant proportion of respondents emphasize the sustainability of packaging and are willing to accept longer delivery times to reduce their environmental impact. On the other hand, there remains a certain reluctance to consolidate deliveries or switch platforms for purely ecological reasons, reflecting the importance of trade-offs between convenience, cost, and environmental responsibility.

These results highlight that a successful transition to sustainable e-commerce requires shared responsibility:

- Companies must implement credible logistics innovations and guarantee customers the reliability of sustainable packaging.
- Consumers must accept certain trade-offs (time, cost, habits) in favor of more sustainable solutions.
- Public authorities must support these changes with incentive regulatory frameworks, clear standards and support for positive initiatives.

Ultimately, this study highlights that the sustainable development of e-commerce is not a utopia, but a possible path, provided it combines innovation, collaboration, and collective awareness. Far from being polluting, online commerce can become a driver of sustainable development if it fully integrates ecological requirements into its development logic.

## References

- [1] Marie-Pascale Senkel, The logistics transformation of e-commerce: towards a sustainable omnichannel model, Marketing & Society. Paris, 2024.
- [2] Théo Le Brun, Marie-José Huguet, and Sandra Ulrich Nguieu, "An overview of French eco-responsible e-commerce", HAL, 2023, Accessed: October 6, 2025. [Online]. Available at: <https://hal.science/hal-04142062v3>
- [3] Trusted Shops, "Nine Eco-Friendly Strategies for Sustainable E-Commerce," Berlin, 2023.
- [4] DS Smith, "Packaging the Future: Towards a Circular Packaging Economy," London, 2021.
- [5] SupplyChainInfo, "Green Logistics: A Global Strategic Approach," Paris, 2022.
- [6] World Trade Organization, "Global Electronic Commerce Report," WTO, Geneva, 2020.
- [7] Philippe Moati, The digital economy and e-commerce, The Discovery. Paris, 2019.
- [8] Jean-Michel Huet, E-commerce: concepts and practices, Dunod. Paris, 2021.
- [9] Michel Savy, Logistics and sustainable development, French Documentation. Paris, 2019.
- [10] Nathalie Blanc, The ecological transition: challenges and perspectives. Paris: University Press of France, 2021.
- [11] C. Brundtland, "Our Common Future: Report of the World Commission on Environment and Development", New York, 1987.
- [12] OECD, "Green Innovation and Sustainable Development: Policies and Prospects", Paris, 2020.
- [13] Yves Evrard, Bernard Pras, and Elyette Roux, Market: studies and research in marketing, Dunod. Paris, 2020.