Ca' Foscari
University
of Venice

Master's Degree Programme

in Innovation &
Marketing

Final Thesis

TECHNOLOGICAL INNOVATION AS A STRATEGIC RESPONSE TO COUNTERFEITING IN THE LUXURY FASHION INDUSTRY

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Academic Year
2025 / 2026

INDEX

INTRODUCTION

The rapid growth of counterfeiting in the Luxury Fashion Industry represents a major economic and strategic challenge, threatening brand equity, eroding consumer trust and generating significant financial losses across global markets. Valued at around $500 billion a year globally, counterfeiting generates more than 60% of the value from fashion and luxury goods (McKinsey, 2022). Given the scale, the rapid growth and the increasing impact of luxury counterfeits, it appears necessary to analyse and understand the causes and effects of such growth from a multidisciplinary point of view. Moreover, while existing literature extensively examines counterfeiting from an economic and behavioural point of view, limited attention has been paid to proper solutions for luxury fashion manufacturers, other than the use of Direct Authentication and the reliance on product-level countermeasures.

In this context, the primary objective of research is to examine how technological innovation can be leveraged to mitigate, address and prevent the phenomenon of counterfeiting in the Luxury Fashion Industry, with a focus on Fashion and Leather Goods (i.e., apparel, accessories and footwear). Furthermore, by emphasizing on IIoT, Blockchain and AI, the thesis will analyse the role, benefits and limitations of technological innovation in enhancing product authentication and supply-chain traceability.

The rationale underlying the objectives of research is primarily linked to the necessity to develop a comprehensive model that integrates both existing theoretical frameworks and industrial investigations with empirical evidence concerning how technological innovation can be implemented to respond both proactively and reactively to Luxury-Fashion counterfeiting.

The content of the thesis is subdivided into 3 distinct chapters, each with their separate objectives and their research designs and methodologies.

Chapter 1 will start by presenting a systematic literature review on the phenomenon of counterfeiting. The final goal of this review will be to obtain a preliminary and multidisciplinary framework on the phenomenon, enabling to assess the legislative, operational and economic effects in the Luxury Fashion Industry. The analysis of academic literature, the EU legislative framework on IPRs and scientific papers on technological innovation will be essential to create a conceptual frameworks for subsequent chapters and to identify the solutions currently available to Luxury Fashion Brands.

Chapter 2 will then investigate on how innovation can be used as a countermeasure to prevent, address and mitigate the effects of Luxury-Fashion counterfeits. Through the analysis of secondary sources of data and industry reports on technological innovation, the chapter will investigate on the most feasible and scalable technologies currently available to Luxury Brands to preserve brand equity, guarantee product authenticity and foster supply-chain traceability. More specifically, the chapter will focus on the analysis of IIoT, Blockchain and AI, allowing the comparison of different technologies and to identify optimal combinations of technological and operational innovations.

Ultimately, starting from the theoretical framework provided in Chapter 1 and the qualitative investigation performed in Chapter 2, Chapter 3 will undertake a multiple - case empirical investigation to illustrate how technological innovation can be implemented in industrial settings as a countermeasure against counterfeiting. Specifically, the chapter will examine how IIoT systems, Blockchain and Artificial Intelligence have been implemented by Luxury Brands, Consortiums of Luxury Brands and technology providers targeting both primary and secondary markets, as a both proactive and reactive response to counterfeiting in the Luxury Fashion Industry.

Given the lack of multi-disciplinary studies on this subject, the adoption of multiple research methodologies and the analysis of different sources of data will enable to create a more comprehensive evaluation of the phenomenon and to evaluate the key benefits and limitations of the identified technologies. Moreover, it will enable to analyse the scalability potential of such technological solutions for other luxury brands and across globally-dispersed fashion supply chains.

Overall, the creation of a comprehensive model that integrates both a theoretical and empirical evidence confirms that technological innovation represents a strategically feasible and documented solution to counteract both proactively and reactively Luxury-Fashion counterfeiting. The implementation of technologies such as IIoT, Blockchain and AI have been proven to benefit fashion manufacturers and both primary and secondary markets by supporting regulation compliance, by providing proof of authenticity, proof of origin, supply-chain traceability and fingerprinting. Moreover, the conducted research furtherly demonstrates that the implementation of how technology adoption can be leveraged to foster collaborative governance through cross-company cooperation and open innovation, facilitating common anti-counterfeiting objectives while maintaining individual brand identities and competitive advantages.

1. UNDERSTANDING COUNTERFEIT: A SYSTEMATIC LITERATURE REVIEW

This thesis aims at understanding the phenomenon of counterfeit within the Luxury Fashion Industry with a specific focus on Fashion and Leather Goods. The primary objective of the research is to examine how different tools, innovations and new digital technologies can be leveraged and integrated to battle the phenomenon of counterfeit, enabling an effective authentication and traceability system for fashion supply chains.
Counterfeit can be defined as the intentional practice of manufacturing and distributing unauthorised replicas of genuine products. Grossman and Shapiro (1988) identified two main types of transactions involved in the market for counterfeit goods:

1) **DECEPTIVE COUNTERFEITING** is defined as the case in which consumers unknowingly purchase counterfeited items. Deceptive counterfeit has been predominantly observed in the automotive and electronic industries and in the pharmaceutical and medical industries.
2) **NON-DECEPTIVE COUNTERFEITING** is defined as the case in which buyers knowingly and deliberately purchase counterfeited items. Non-deceptive counterfeit is especially common in the Luxury Fashion Industry, as consumers are fully aware of purchasing an unauthorised replica through unauthorised channels.

As reiterated in the following paragraphs, most of the available scientific research on the subject of counterfeit focuses on non-deceptive counterfeit, investigating on the psychological and social determinants that motivate deliberate counterfeit purchases. However, as the final aim of this thesis is to explore current and future solutions to mitigate the effects of counterfeit and to enable effective traceability for fashion manufacturers, the thesis will focus on the phenomenon without making a distinction between deceptive and non-deceptive counterfeit (Nia, Lynne Zaichkowsky, 2000).
The final goal of the systematic literature review performed in this chapter is to obtain a preliminary and multidisciplinary framework on the phenomenon of counterfeiting, enabling to assess the legislative, operational and economic effects in the Luxury Fashion Industry. Analysing academic literature on the phenomenon, EU legislative framework on IPRs and scientific papers on technological innovation, the developed framework will be essential for the identification of the solutions currently available to Luxury Fashion Brands.

The systematic literature review will consider the European Union as a geographical scope, excluding all articles and case studies outside this area of interest. The geographical scope of the thesis aims at giving a bounded and more precise image of the phenomenon of counterfeit, as the majority of the Luxury and Premium maisons in the Fashion Industry originate in Europe, with a higher concentration in Italy and France.

The chapter will start by defining the research methodology through which the review is performed, and by describing the selection process of the articles that represent the groundwork of the thesis. The chapter will then supply the EU juridical framework and by providing a general business analysis of the phenomenon of counterfeit. Subsequently, the systematic literature review will analyse the determinants of counterfeit consumption, the impact of counterfeit consumption on Brand Equity and the effects of information asymmetries and market uncertainty on Luxury Markets.

Eventually, the information obtained through the systematic literature review, the conclusions drawn and the highlighted gaps in research will comprise the groundwork of analysis performed in the Chapter 2.

1.1. Methodology employed in the systematic literature review

The literature review reported in this chapter adopts a "Systematic Quantitative Approach". This approach, developed by Pickering and Byrne (2014), consists in a 15-step method to undertake a systematic quantitative literature review.

The Systematic Quantitative Approach provides a methodology to select and survey the papers to be included within the review, making each step explicit and reproducible (Pickering & Byrne, 2014). The concept behind this methodology is that by making the process explicit and reproducible, the outcomes of the research should provide the same results if performed by others.

The Systematic Quantitative Approach enables to identify the fields covered by the existing research, its boundaries and its gaps, highlighting the available opportunities for future developments. Eventually, it provides a more comprehensive view of the phenomenon analysed than traditional narrative reviews, becoming particularly suitable for trans-disciplinary research (Pickering & Byrne, 2014).

The 15 steps undertaken to perform the systematic quantitative literature review can grouped within broader stages represented as follows.

- *Steps 1-4* consist in defining the overall subject of the research (Step 1), formulate the research question to be addressed (Step 2), identifying the keywords mostly appropriate to the research question (Step 3) and select the appropriate scientific databases from which collecting the data (Step 4).

For this specific review multiple searches were conducted, at different dates and with different combinations of keywords. As previously mention, the ultimate aim of the review is to investigate on the phenomenon from a legislative, economic and managerial point of view, on its effects within the Fashion industry and on which are the currently available tool and technologies to mitigate its effects.

As previously mentioned, the review performed within the present chapter analyses the European Union as a geographical scope, excluding all articles and case studies outside this geographical scope.

The keywords identified were, therefore, "Counterfeit", "Luxury" and "Fashion". The foremost research databases adopted for the review of scientific literature, journals and books are *SCOPUS* and *EUR-Lex*. The review was conducted in the period from November 2025 to January 2026.

- *Steps 5-9* consists in the assessment of outcome of the first 4 steps of the review, by reading each article's title and abstract to verify its relevance with the selected topic for inclusion in the research (Step 5). Once non-eligible articles have been removed, the following step consist in structuring a database in which all citation of reviewed articles will be stored (Step 6), and insert the 10% of eligible articles (Step 7) to test the validity of the database (Step 8). Macro-categories and sub-categories are to be identified concurrently with once the articles have been analysed (Bolt et al., 2022). Once the validity and the structure of the database have been tested, the bulk of selected papers can be entered (Step 9).

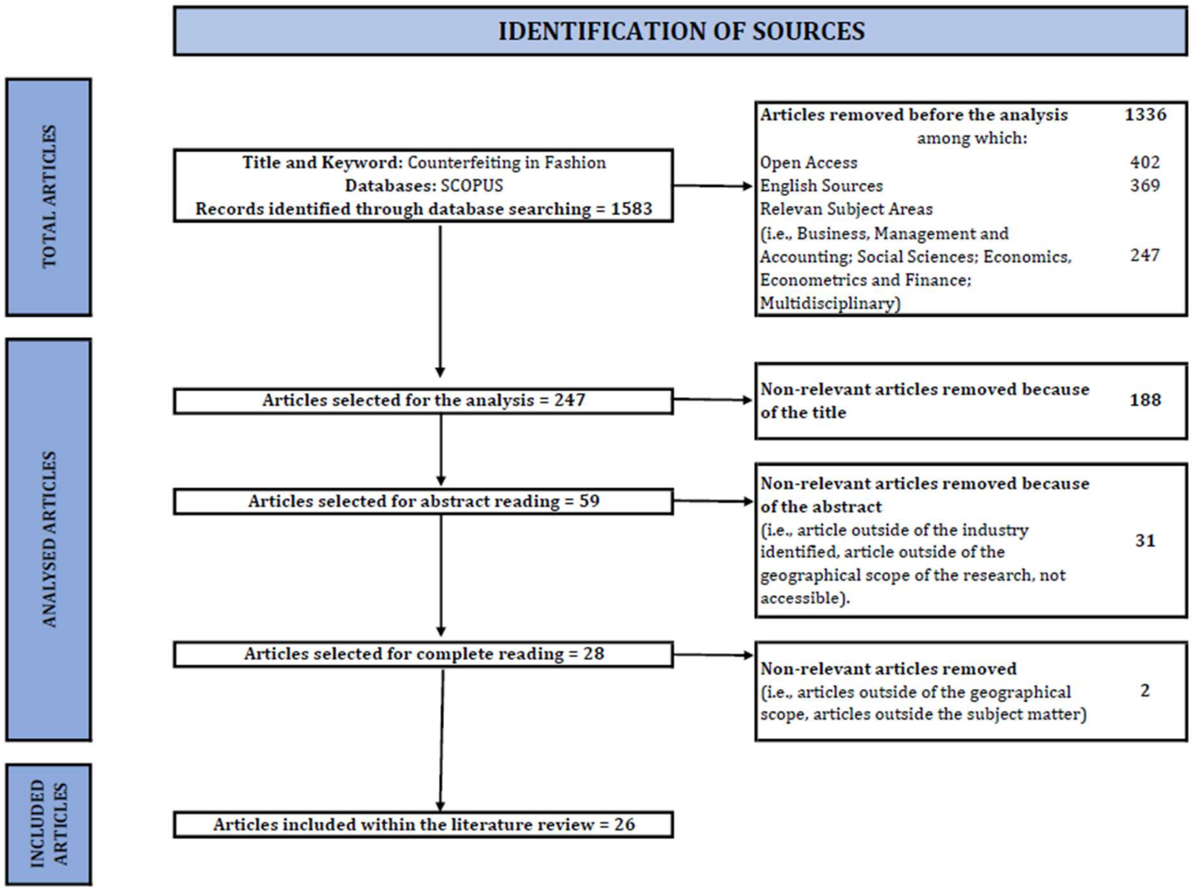

Table 1: Article selection process SCOPUS

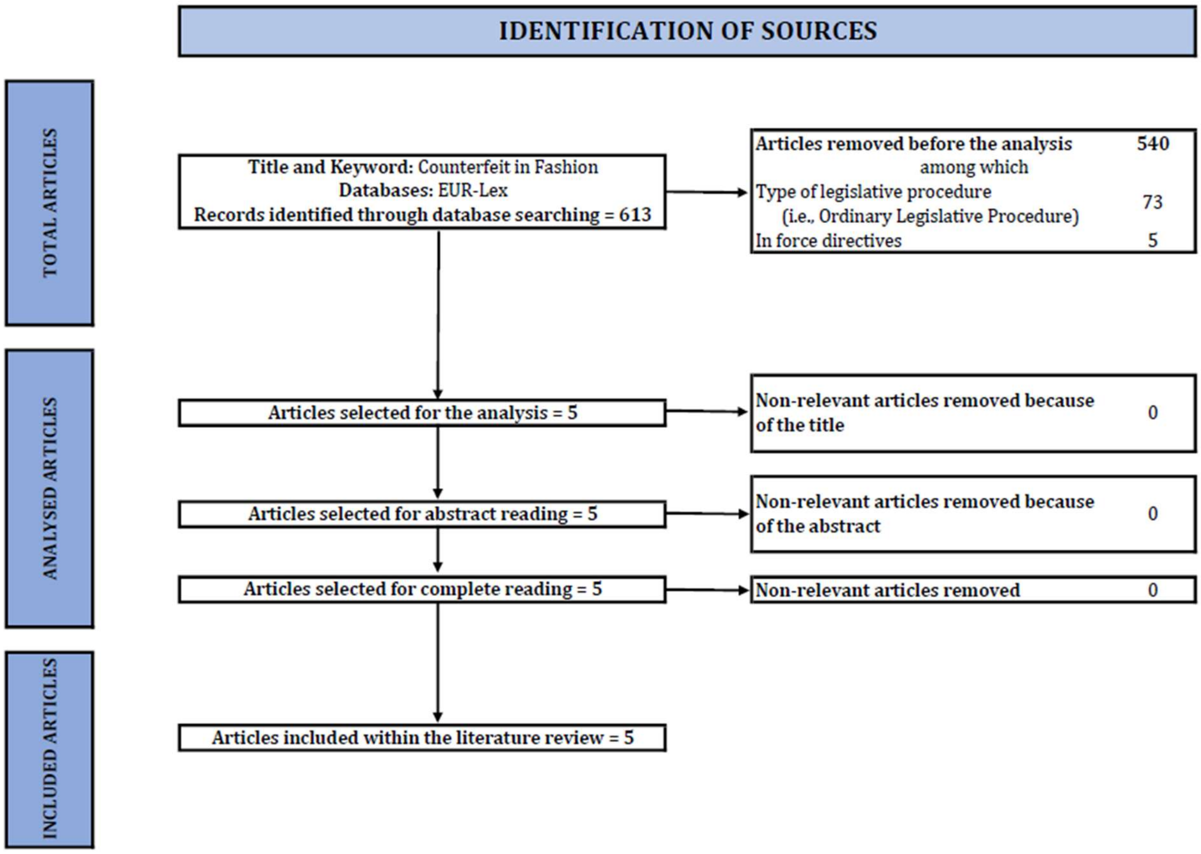

Table 2: Article selection process EUR-Lex

By applying the process described, at the end of the selection process a total of 32 articles were selected from the systematic literature review. More specifically, a total of 26 articles were selected from the database *SCOPUS (Table 1)* and a total of 6 articles were selected from *EUR-Lex (Table 2)*.

- *Steps 10-15* consist in developing a summary table of the selected eligible articles for the literature review (Step 10), defining the methods of analysis (Step 11) and evaluating the key results and conclusions of the review (Step 12-15). This specific stage of the review serves to identify common findings among sources and to suggest possible areas for future research (Bolt et al., 2022).

The summary table "*Table 3*" reports the articles selected for the systematic literature review. For each of the selected articles, the table shows the number, author, title and publication date, source, editor and reference. These elements are used to allow a more direct recall to the literature throughout the review.

N° Art	Author	Title	Year	Source	Editor	Reference	Database	Macro-Theme
1	Agrawal, T. K., & Pal, R.	Traceability in textile and clothing supply chains: Classifying implementation factors and information sets via Delphi study	2019	*Sustainability*	ELSEVIER	(Agrawal & Pal, 2019)	SCOPUS	Supply Chain Management
2	Akerlof, G. A.	The market for "lemons": Quality uncertainty and the market mechanism.	1978	Journal of Economics	JSTOR	(Akerlof et al., 1978)	**SCOPUS**	**Consumer Behaviour**
3	Appel, G., Libai, B., & Muller, E.	On the monetary impact of fashion design piracy	2018	*International Journal of Research in Marketing*	ELSEVIER	(Appel, Libai, Muller, 2018)	SCOPUS	Brand Management
4	Assaf-Zakharov, K.	Non-traditional trademark protection as (non-traditional) means of cultural control	2018	*The Protection of Non-Traditional Trademarks: Critical Perspectives*	Oxford	(Assaf-Zakharov, 2018)	SCOPUS	Brand Management
5	Badhwar, A., Islam, S., & Tan, C. S. L.	Exploring the potential of blockchain technology within the fashion and textile supply chain with a focus on traceability, transparency, and product authenticity: A systematic review.	2023	*Frontiers in Blockchain*	Frontiers	(Badhwar, Islam, Tan, 2023)	SCOPUS	Supply Chain Management
6	Bian, X., & Moutinho, L.	The role of brand image, product involvement, and knowledge in explaining consumer purchase behaviour of counterfeits: Direct and indirect effects	2011	*European Journal of Marketing*	Emerald Publishing	(Bian, Moutinho, 2011)	SCOPUS	Consumer Behaviour
7	Ching, K., Forti, E., Katsampes, S., & Mammous, K.	Style and quality: Aesthetic innovation strategy under weak appropriability	2024	*Research Policy*	ELSEVIER	(Ching, Forti, Katsampes, Mammous, 2024).	SCOPUS	Brand Management
8	Chrimes, C., & Heim, H.	The Fashion Product Passport: In Search of the "Killer App"	2023	*Fashion and Environmental Sustainability*		(Chrimes, Heim, 2023)	SCOPUS	Supply Chain Management
9	Fiza, A., Shahzad, I., Muhammad, H., Rehman, H. U., & Sajjad, B. (	Impact of consumer Attitude towards purchase intention of the counterfeit products: a multigroup analysis between the user and non-user	2021	*Industria Textila*		(Fiza et al., 2021)	SCOPUS	Consumer Behaviour
10	Hayes, A. S., & Pellandini-Simányi, L.	The upside of uncertainty: how counterfeit risk in secondary markets influences primary luxury sales	2025	*Journal of Business Research*	ELSEVIER	(Hayes, Pellandini-Simányi, 2025)	SCOPUS	Supply Chain Management
11	Jankowska, M., Pawełczyk, M., & Szpyt, K.	Intellectual property considerations in the internationalisation of e-commerce platforms for Poland-based brands	2019	*Digital Internationalisation of Firms*	ELSEVIER	(Jankowska, Pawełczyk, Szpyt, 2019)	SCOPUS	Supply Chain Management
12	Jiang, J., & Chen, J.	Managing the product-counterfeiting problem with a blockchain-supported e-commerce platform	2021	*Sustainability*	ELSEVIER	(Jiang, Chen, 2021)	SCOPUS	Innovation Management
13	Keller, K.L.	Managing the growth trade-off: Challenges and opportunities in luxury branding.	2017	Book: Advances in Luxury Management		(Keller, 2017)	**SCOPUS**	**Brand Management**
14	Klöckner, M., Schmidt, C. G., Fink, A., Flückiger, L., & Wagner, S. M.	Exploring the physical–digital interface in blockchain applications: Insights from the luxury watch industry	2023	*Transportation Research Part E: Logistics and Transportation Review*	ELSEVIER	(Klöckner et al., 2023)	SCOPUS	Innovation Management
15	Lee, H., & Yeon, C.	Blockchain-based traceability for anti-counterfeit in cross-border e-commerce transactions	2021	*Sustainability*	ELSEVIER	(Lee, Yeon, 2021)	SCOPUS	Innovation Management
16	Montecchi, M., Plangger, K., & Etter, M.	It's real, trust me! Establishing supply chain provenance using blockchain	2019	*Business Horizons*	ELSEVIER	(Montecchi, Plangger, Etter, 2019)	SCOPUS	Innovation Management
17	Muposhi, A., & Dhurup, M.	Stemming the sportswear counterfeit tide: Emerging market evidence of rational and normative drivers	2020	*Acta Commercii*		(Muposhi, Dhurup, 2020)	SCOPUS	Consumer Behaviour
18	Nia, A., & Lynne Zaichkowsky, J.	Do counterfeits devalue the ownership of luxury brands?	2000	Journal of product & brand management	Emerald Publishing	(Nia, Lynne Zaichkowsky, 2000)	**SCOPUS**	**Brand Management**
19	Niu, B., Mu, Z., Cao, B., & Gao, J.	Should multinational firms implement blockchain to provide quality verification?	2021	*Transportation Research Part E: Logistics and Transportation Review*	ELSEVIER	(Niu, Mu, Cao, Gao, 2021)	SCOPUS	Innovation Management
20	Purwanto, P., Margiati, L., Kuswandi, K. U. S. W. A. N. D. I., & Prasetyo, B.	Consumer motives for purchasing counterfeit luxury products: behind the status signaling behavior using brand prominence	2019	*Business: Theory and Practice*	ECONSTOR	(Purwanto ET AL., 2019)	SCOPUS	Consumer Behaviour
21	Reinhardt, N., Reinhard, M. A., & Bittner-Fäthke, G.	The correlation between honesty-humility and attitude toward counterfeit luxury	2023	*Italian Journal of Marketing*	Springer	(Reinhardt, Reinhard, Bittner-Fäthke, 2023)	SCOPUS	Consumer Behaviour
22	Sovtić, D., Trpkov, A., Radenković, M., Popović, S., & Labus, A.	Examining Readiness to Buy Fashion Products Authenticated with Blockchain	2025	*Journal of Theoretical and Applied Electronic Commerce Research*	ELSEVIER	(Sovtić et al., 2025)	SCOPUS	Innovation Management
23	Varela, M., Lopes, P., & Mendes, R.	Luxury brand consumption and counterfeiting: A case study of the Portuguese market	2021	*Innovative Marketing*	Business Perspectives	(Varela, Lopes, Mendes, 2021)	SCOPUS	Brand Management
24	Wee, C. H., Ta, S. J., & Cheok, K. H.	Non-price determinants of intention to purchase counterfeit goods: an exploratory study	1995	International Marketing Review	Emerald Publishing	(Wee, Ta, Cheok, 1995)	SCOPUS	Consumer Behaviour
25	Wu, H., Wang, S., Pu, C., Ma, J., & Zeng, Y.	Enhancing counterfeit RFID tag classification through distance based cognitive risk control	2025	*Scientific Reports*		(Wu, Wang, Pu, Ma, Zeng, 2025)	SCOPUS	Innovation Management
26	Xu, J., & Sutunyarak, C.	Factors that influence consumers' inclination to acquire counterfeit luxury goods	2024	*Journal of Infrastructure, Policy and Development*	EnPress	(Xu, Sutunyarak, 2024)	SCOPUS	Consumer Behaviour

27	EU Parliament and Council of the EU	EU Regulation 608/2013: Customs enforcement of intellectual property rights and repealing Council Regulation (EC) No 1383/2003	2013	*EUR-Lex*		EU Regulation 608/2013	EUR-Lex	EU Law
28	European Commission, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs	EU Directive 2004/48 EC: Intellectual Property Rights Enforcement Directive (IPRED)	2004	*EUR-Lex*		EU Directive 2004/48 EC	EUR-Lex	EU Law
29	EU Parliament and Council of the EU	Directive 98/71/EC on the legal protection of design	1998	*EUR-Lex*		EU Directive 98/71/EC	EUR-Lex	EU Law
30	EU Parliament and Council of the EU	EU Regulation 2022/2065: Single market for digital services - Digital service act	2022	*EUR-Lex*		EU Regulation 2022/2065	EUR-Lex	EU Law
31	EU Parliament and Council of the EU	EU Directive 2024/1760: Corporate Sustainability Due Diligence	2024	*EUR-Lex*		(EU Directive 2024/1760)	EUR-Lex	EU Law
32	EU Intellectual Property Office (EUIPO)	Economic impact of counterfeiting in the clothing, cosmetics and toys sectors in the EU	2024	EU Intellectual Propeerty Office (EUIPO)		EUIPO. DOI: 10.2814/053613	EUR-Lex	EU Law

Table 3: Table of selected articles (merged table SCOPUS and EUR-Lex).

Considering the selected literature, it is possible to identify 5 main macro-themes (*Table 4*). Coherently with the purpose of the thesis, the macro-themes identified with the biggest influence on the review appear to be EU Law and Intellectual Property Rights protection (19% of articles), Consumption Behaviour (25%) focusing of individuals' attitude towards counterfeits and buying motivations and Brand Management (19%), focusing on market positioning and luxury protection strategies. Other macro-themes identified concern Supply Chain Management (16% of articles), focusing on ethical sourcing and product traceability, and Innovation Management (22%), with a particular focus on digital authentication systems and anti-counterfeiting technologies.

MACRO-THEMES	RESULTS	% RESULTS
EU Law and IPRs	6	19%
Consumer Behaviour & Counterfeiting	8	25%
Luxury Brand Management & Marketing Strategies	6	19%
Supply Chain Management & Sustainability	5	16%
Innovation Management & Traceability Technologies	7	22%
TOTAL	**32**	**100%**

Table 4: Macro-themes from the selected bibliography

Considering the year of publishing of each article, it is possible to estimate the frequency of publishing of the selected literature (*Table 5*). It can be observed of the frequency of publishing significantly increased from 2010 onwards, incorporating articles on supply chain transparency and technological innovation. The recent growth can be associated to scandals concerning apparel manufacturing in lesser-developed countries and to the increasing EU regulatory pressure concerning sustainability requirements and supply chain traceability.

YEAR	RESULTS	% RESULTS
1970-1979	1	3%
1980-1989	0	0%
1990-1999	2	6%
2000-2009	2	6%
2010-2019	9	28%
2020 - 2025	18	56%
TOTAL	**32**	**100%**

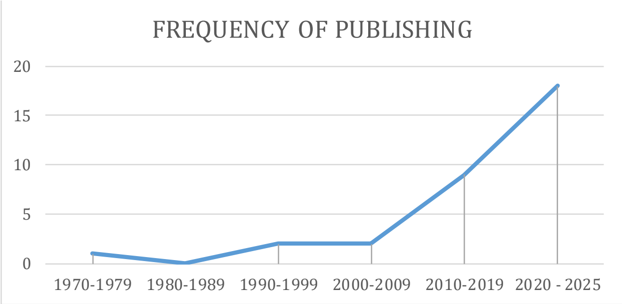

Table 5: Frequency of Publishing of Selected Articles

With respect to the research methods implemented in the articles included in the literature review (*Table 6*), the 44% of such articles follow a quantitative method such as behavioural analysis and other empirical researches. Each of these studies analyses input data through multiple linear regression techniques, aiming at identifying the most significant variables from the surveys. The 22% of the articles concern qualitative studies and case studies, while another 5% of the articles concern systematic reviews, concentrating hence on frameworks already available in the literature, reviewing processing them to adapt them to the topic discussed in the article. The remaining 6% of articles provided concern legal sources coming from EU legislators.

METHOD	RESULTS	% RESULTS
Quantitative Studies	14	44%
Qualitative Studies	7	22%
Systematic Reviews	5	16%
Legal Sources	6	19%
TOTAL	**32**	**100%**

Table 6: Research Methods of Selected Articles

The 75% of the articles selected for the literature review can be defined as "peer-reviewed", hence defined as scientific publications validated by peer experts in the field of research. Only 6% of selected articles concern reports and book chapters, hence not subject to proactive evaluations from peer experts. Eventually, the remaining 19% concern legal sources, as provided by EU Regulations and Directives (*Table 7*).

SOURCE TYPE	RESULTS	% RESULTS
Peer-reviewed journal articles	24	75%
Reports & Book Chapters	2	6%
EU Regulations & Directives	6	19%
TOTAL	**32**	**100%**

Table 7: Source Type of Selected Articles

Consistently with the type of sources highlighted by "*Table 7*", 75% of authors are academic researchers, 6% are industry researchers and the remaining 19% are institutional policy authors (*Table 8*).

AUTHOR QUALIFICATION	RESULTS	% RESULTS
Academic researches	24	75%
Industry researches	2	6%
Institutional policy authors	6	19%
TOTAL	**32**	**100%**

Table 8: Author Qualification of Selected Articles

The key implications of the research can be summarised in 5 points, coherently divided as the macro-themes identified in "*Table 4"*:

1) From a legislative point of view, the selected literature highlight that strong IP enforcement laws and an international coordination are necessary to contrast the growth of counterfeit markets.
2) Consumer Behaviour studies emphasize the key determinants of counterfeit consumption behaviour, trying to understand the possible strategies to undermine the presence of counterfeited version of original luxury products.
3) Studies on Luxury Brand Management show the importance of investing in Brand Equity Strategies, aiming at enhancing financial and consumer-based value through product authentication.
4) Studies in the field of Supply Chain Management (SCM) address on ethical sourcing and product traceability as the solutions to the lack of transparency in fashion supply chains and to the issue of product authentication.
5) Eventually, the literature on Innovation Management developed in recent years highlights how Technology Adoption can be integrated to IP enforcement laws and

brand equity strategies to achieve digital authentication systems and to mitigate the effect of counterfeiting.

The outcomes of the systematic literature review emphasize the importance of considering the phenomenon of counterfeit with a transdisciplinary perspective, as the integration of different subjects of analysis allows to gain further insight on the phenomenon and at exploring possible solutions to mitigate its effects.

1.2. Juridical perspective and EU Legal norms on counterfeit

Between 2018 and 2021, the *European Intellectual Property Rights Office (EUIPO)* conducted an assessment of the economic impact of counterfeiting in sales and employment in the clothing, cosmetic and toy sectors in the EU. Considering the scope of the Fashion Industry, this study has estimated a loss of €11.944 million in sales, equivalent to the 5,2% of total sales in the EU. It has also been proven that the loss in sales led a drastic consequence on the level of employment in the fashion sector, with a reduction in the industry's workforce of 160.352 people, with Germany and Italy the most affected countries (EUIPO. DOI: 10.2814/053613).

Given the magnitude of the estimated economic impact of counterfeiting in the Fashion Industry in the EU context it is necessary to provide a legal framework to the phenomenon of counterfeiting and to single out the appropriate definitions as provided by EU jurisprudence. The juridical perspective is provided by the analysis of several in-force EU legal norms sourced by *EUR-Lex*, the official online gateway to EU law and EU documents, selected as explained in the previous paragraph.

The in-force norms selected to provide a legal perspective to the phenomenon of counterfeit are the following:

- *EU Regulation 608/2013*: Customs enforcement of intellectual property rights and repealing Council Regulation (EC) No 1383/2003. This regulation is mostly relevant for settling procedures for preventing physical counterfeit from entering the EU market;
- *EU Directive 2004/48 EC*: Intellectual Property Rights Enforcement Directive (IPRED);
- *EU Directive 98/71/EC:* Legal protection of designs. The directive establishes the legal framework for the protection of industrial designs as an IPRs;
- *EU Regulation 2022/2065: Single market for digital services - Digital service act.* Given the increase in sales of counterfeit goods via online marketplaces, the norm also known as the E-commerce Directive is extremely relevant by establishing a traceability mechanism, allowing transparency in transactions and preventing counterfeit goods from entering the EU market.

By analysing the EU norms previously listed, it is possible to extract the definitions necessary for the proper representation of the EU legal framework on the subject of counterfeit:

- An **Intellectual Property Right (IPR)**, the core concept related to the phenomenon of counterfeit, can be defined as follows:
  - A *trademark*;
  - A *design*;
  - A *copyright* or any related right as provided for by National or Union law;
  - […];
  - A trade name protected by an exclusive IPR by National or Union law (EU Regulation 608/2013, Art. 2).
- A **Trademark** can be defined as a sign, phrase or symbol that denotes a product or service and legally differentiates it from all others of its kind (source: Investopedia). In EU jurisprudence it regarded to as "a trademark registered in a Member State […], or registered under international arrangements which has effect in a Member State or in the Union" (EU Regulation 608/2013, Art. 2).
- A **Design** can be defined as:
  - "The appearance of the whole or a part of a product resulting from features, in particular the lines, contours, colours, shape, texture and/or materials of the product itself and/or its decorations […]" (EU Regulation 2024/2822, Art. 3);
  - "A design registered in a Member State […], or registered under international arrangements which has effect in a Member State or in the Union" (EU Regulation 608/2013, Art. 2).
- **Copyright** can be described as the range of rights granted to authors and performers, producers and broadcasters ensuring the protection of both economic rights (e.g., authorizing or prohibiting the distribution of copies) and moral rights (i.e., the rights to claim authorship) (source: EU copyright - EUR-Lex).
- **Counterfeit goods** can be defined as:
  - "Goods which are the subject of an act infringing a trademark in the Member State where they are found and bear without authorisation a sign which is identical to the trade mark validly registered in respect of the same type of goods, or which cannot be distinguished in its essential aspects from such a trademark" (EU Regulation 608/2013, Art. 2);
  - "Any packaging, label, […], warranty document or other similar item, even if presented separately, which is the subject of an act infringing a trademark or a geographical indication, which includes a sign, name or term which is identical to

> a validly registered trade mark or protected geographical indication, or which cannot be distinguished in its essential aspects from such a trademark or geographical indication, […]" (EU Regulation 608/2013, Art. 2).

On account of the definitions provided by EU jurisprudence and on account of the analysis performed on the selected legal framework, it can be said that EU norms collectively establish a comprehensive legal system aimed at protecting IPRs, trademarks and designs across both the physical and digital dimensions within the EU market.

EU Regulation 608/2013 plays a central role on the empowerment of national customs authorities to intervene whenever there are reasonable indications of infringement of an IPR, enabling the enforcement at national level of EU norms on the protection of trademarks, designs, copyrights and IPRs (Art. 2). According to the regulation, customs authorities are obliged to suspend the release or detain suspected good and to notify the rightsholder, so that proceeding to determine the suspected infringement may begin (Art. 17). The scope of the regulation is represented by goods released for free circulation, import or export, excluding all goods released for free circulation under the end-user regime and goods of a non-commercial nature stored within private entities' luggage while travelling (Art.1).

EU Directive 2004/48/EC (IPRED) harmonises civil enforcement mechanisms within the EU, ensuring that rightsholders have access to effective procedures and remedies against IPR infringement.

EU Directive 98/71/EC further strengthens the framework by establishing the legal foundation for the registration and exclusivity of industrial designs within the EU. The directive clarifies that a design is protected only in the case it is *new* and has *individual character*, meaning that no identical design has been made available to the public before the date of registration, except in the case of immaterial designs (Art. 4). Through registration, rightsholders gain exclusive rights, enabling them to prevent the manufacture, sale or importation of goods incorporating a protected design.

Finally, considering the digital dimension, **EU Regulation 2022/2065** establishes clear obligations for intermediary service providers established or located in the EU, including e-commerce platforms, aiming at developing an online environment respectful of fundamental rights, at fostering innovation and at setting clear responsibilities for such intermediaries (Art. 1 and 2). The Regulation, also knowns as the *Ecommerce Regulation*, furtherly contributes to the protection of IPRs through the establishment of a standardised process to flag illegal online content (Art. 16) to collect data about online traders, aiming at the safeguard of consumers and of IPRs. Eventually, the Regulation provides that Member States should designate a *Digital Service Coordinator* (DSC) as a competent authority to supervise all relevant providers of intermediary services (Art. 49 and 50) and to write annual reports on their activities (Art. 55).

Preventing the circulation of counterfeit goods is a shared objective of EU Member States. The EU framework sets the norms regulating the proper provisions and penalties in the case of infringement of an IPR, a trademark, a copyright or a protected design.

EU Regulation 608/2013 provides that the good suspected to be counterfeited, violating a trademark, a design or an IPR, may be destroyed under customs control, without there any need to determine whether an actual IPR has been violated. Once the holder of the good has been notified, the destruction of the good proceed when at least one of the following conditions is fulfilled:

- The holder of the good has confirmed the violation of an IPR within 10 working days from notification;
- The holder of the good has agreed to the destruction of the good within 10 working days from notification;
- The holder of the good has not notified their opposition to the custom authorities within 10 working days from notification (Art. 23).

The regulation also provides that samples may be taken by custom authorities before destruction of the goods to be used for educational purposes.

Eventually, **EU Regulation 608/2013** enables customs authorities to request the holder of the good, person or entity entitled to the good a reimbursement of the costs incurred for detention, storage and eventually destruction of the good (Art. 29). Nonetheless, the regulation also grants Member States the possibility to lay down provisions establishing penalties that should be effective, proportionate and dissuasive (Art. 30).

1.3. Determinants of Counterfeit Consumption in Luxury Markets

Studies on Consumption Behaviour constitute the 25% of the overall literature selected for the review. The prevalence of this topic in the literature reflects a growing interest in academic research in investigating the factors that drive individuals towards the consumption of counterfeit products.

An initial review of the literature suggests that price alone cannot be considered as a consistent or sufficient driver of demand for counterfeit consumption. Although lower prices are often cited as a primary advantage of counterfeit goods, price is not a strategic variable that manufacturers can adjust to compete with counterfeit alternatives (Wee, Ta, Cheok, 1995). Contextually, the Veblen Curve shows how luxury brands can exploit premium price strategies to make their offer more desirable, to enhance their intangible value and hence their brand equity (*Figure 1*).

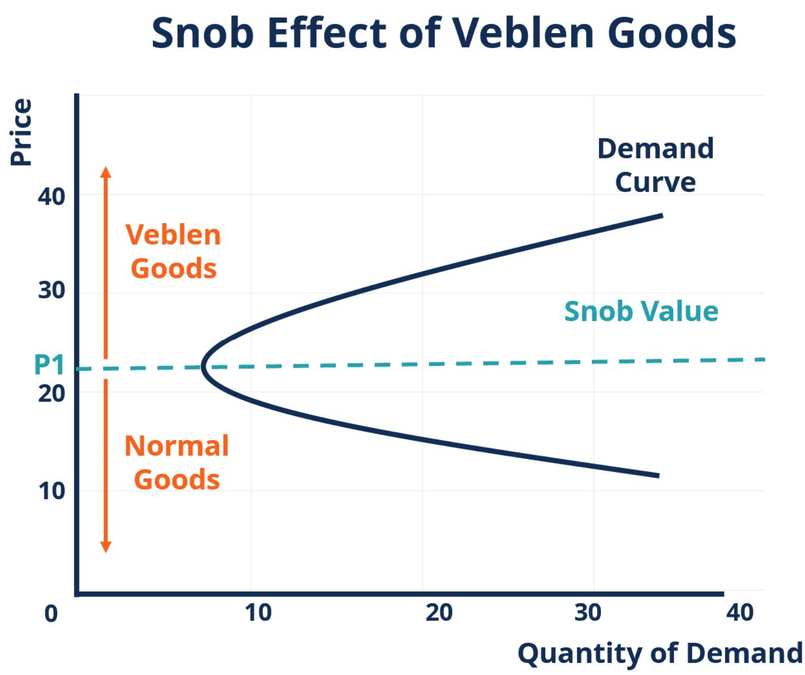

Figure 1: Veblen Curve (source: Veblen Goods - Definition, Differences, Examples)

A growing body of research has shifted its focus towards non-price determinants of counterfeit consumption, which appear to be more significant to influence consumers' purchasing decisions. Studies by Wee, Ta & Cheok (1995), Fiza et al. (2021) and by Xu & Sutunyarak (2024) highlight a range factors shaping consumers' willingness to purchase counterfeited products. The determinants that were identified can be clustered into four main branches:

- **Psychological Determinants:**
  - Attitude: consumers' overall evaluation of the product or brand;
  - Brand Status: as consumption patterns symbolize users' social class position, people tend to purchase products identifiable with their current class position or with the class above them (Mellott, 1983);
  - Materialism: the importance a customer attaches to possessions. It has been proven that the more materialistic a consumer is, the more they are likely to purchase counterfeit goods (Belk, 1985);
  - Novelty Seeking: consumers are more likely to purchase counterfeit products that are low cost, satisfying their need for experimentation when the product is at the early stages of the product life cycle;
  - Risk Perception: how individuals perceive, understand and judge risk and how risk influences consumption. Studies prove that poor quality, financial loss and social rejection lead to negative attitudes towards counterfeit goods.
- **Product-related determinants**, especially important for Fashion-related products**:**
  - Perceived Value: consumer's evaluation of a product is the direct consequence of the product's functionality, the emotional benefits, social recognition and economic benefits led by it. The affordability of counterfeited solutions plays a major role in this phenomenon, as consumers' limited financial resources represents an obstacle in the social status and personal identity they want to express (Xu, Sutunyarak, 2024);
  - Perceived Fashion Content: an individual is more likely to engage in counterfeit purchases when the good is more fashionable than functional, hence, when the perceived fashion content of the product is high.
- **Demographic determinants**: age, education, income. The presence of demographic indicators such as high levels of education or high income are proven to have negative effects on counterfeit consumption (Wee, Ta & Cheok, 1995).
- **Social determinants:**
  - Subjective Norm: the social pressure an individual perceives when performing or not performing a certain behaviour, influencing their actions and behaviours;
  - Perceived Behavioural Control: individual's perception of their ability to engage in a certain behaviour. Although it is not a socially desirable behaviour to adopt, it has been proven that individuals that in the past have purchased fashion

counterfeits are more likely to develop purchasing habits that might be difficult to depress, leading them to develop a rather positive attitude towards counterfeit (Fiza et al., 2021).

The analysis of counterfeit consumption determinants allows to conclude that consumers' willingness to purchase counterfeits is positively related to brand attitude and value perception. Luxury consumption functions as a materialistic signalling mechanism, by means of which individuals communicate social status, identity and group of affiliation, regardless of product authenticity (Purwanto et al., 2019). On the other hand, consumers' willingness to purchase counterfeits is negatively related to product involvement and product knowledge (Bian, Moutinho, 2011), meaning that the more consumers are involved in the purchasing decision and the more the knowledge they possess on the product, the less likely they are to engage in counterfeit purchases.

Although it has been studied that consumers with higher levels of product knowledge are less likely to engage in counterfeit consumption, in those cases in which counterfeited products do not significantly differ from their authentic versions in terms of acceptable performance and functionality, consumers are likely to prefer counterfeited products in any case (Bian, Moutinho, 2011).

Other important determinants of consumption behaviour that can be identified are Honesty and Humility. In Consumption Behaviour studies, Honesty and Humility, often defined as the tendency to be fair in dealings with others, has been proven to play a central role in the development of Attitudes and in shaping consumption behaviour. The Honesty-Humility behavioural tendency can be decomposed in subcategories of behaviour, namely Sincerity (i.e., the tendency to be genuine in interpersonal relations) and Fairness (i.e., the tendency to avoid fraud and corruption) theoretically representing Honesty, and Greed-Avoidance (i.e., the tendency to be uninterested in high status symbols and wealth) and Modesty (i.e., the tendency to be unassuming) theoretically represent Humility (Reinhardt, Reinhard, Bittner-Fäthke, 2023). Theoretical evidence suggests that the presence of low levels of Honesty and Humility play a stronger role in the development of a positive attitude towards counterfeit consumption. Specifically, people with low levels of Greed-Avoidance, Sincerity and Modesty show a higher interest in shaping a fictional self-image and in manipulating others into thinking they have a higher social ranking. Because the negative effects of counterfeiting outweigh the positive effects for companies of the original products whose luxury brands suffer (Loken & Amaral, 2010), it is important to further develop the current state of research in this field (Reinhardt, Reinhard, Bittner-Fäthke, 2023).

Considering the possible strategic solutions to address the increasing presence of counterfeit alternatives in the market, brand could leverage consumers' perceived risk to shift the demand towards original product versions. Furthermore, to leverage moderate levels of uncertainty to shift demand towards consumption of original product versions, as explained in the following paragraphs, brand could emphasize the safety and dependability of their products and educate consumers about the hazards linked to counterfeit goods to decrease their inclination to buy them (Xu, Sutunyarak, 2024).

1.4. Luxury Branding and Value Drivers

Luxury or Status is defined as the characteristics of a certain category of goods and services whose mere use or display adds prestige to the owner, beyond functional utility (Grossman & Shapiro, 1988). Brand image represents the primary competitive advantage for luxury brands. It allows the creation of an intangible value signalling social success and class superiority, going hence beyond product functionality (Keller, 2017).

A study conducted by Bushman (1993) analyses how luxury or status goods can be exploited as symbolic instruments to express and reinforce self-image, status or social identity. Results suggest that, unlike with mass-market goods, the label or image associated with luxury products or brands is frequently valued more than the product itself (Nia, Lynne Zaichkowsky, 2000).

K.L. Keller, in the book "Managing the growth trade-off: Challenges and opportunities in luxury branding" (2017) provides a list of ten characteristics through which Luxury Brands can be commonly identified:

1. Luxury brands must always maintain a premium image, responding to high levels of consumer involvement;
2. Luxury brands must create an intangible brand association and an aspirational image;
3. All aspects of marketing must be aligned to ensure a consistent branding across different platforms and channels;
4. Brand elements, aside brand name, are intangible assets and important drivers of brand equity;
5. Secondary associations can be important drivers of brand equity;
6. Luxury brands must carefully select and control distribution via a selective channel strategy;
7. As previously mentioned, luxury brands may employ a premium pricing strategy to enhance the sense of exclusivity and the product value.
8. Luxury brands must carefully manage brand architecture;
9. Competition must be broadly defined, as luxury brands can compete with brands operating in other sectors or product categories;
10. Luxury brands must legally protect all trademarks and aggressively combat counterfeits (Keller, 2017).

The concept of Luxury is linked to individuals' subjective perception of prestige, creativity, craftsmanship and innovation. Despite the multiplicity of definitions associated with luxury, the literature converges of four key dimensions that feature the competitive advantage of luxury products:

- Quality, which reflects superior craftsmanship and perceived excellence, reinforcing a sense of superiority and elitism;
- Scarcity, consisting in both physical rarity (i.e., shortage of resources) and virtual rarity (i.e., purposeful shortage created by communication), enhancing exclusivity and desirability of luxury goods;
- Premium Price, which serves as a monetary tool for signalling status and exclusivity;
- Superfluity, reflecting the non-essential nature of luxury goods, not consumed to satisfy basic of primary needs (Varela, Lopes, Mendes, 2021).

Among these dimensions, product scarcity and perceived rarity are well-established demand drivers in luxury markets, as they reinforce the exclusivity and symbolic value of branded products. Nonetheless, such scarcity can result in demand spill-overs, redirecting consumer demand towards lower-quality and more accessible substitutes to respond to the desired aesthetic or social-related benefits (Ching, Forti, Katsampes, Mammous, 2024). At the same time, the proliferation of counterfeited products introduces a paradox. While counterfeits benefit from demand spill-overs, the large-scale diffusion of counterfeit goods erodes the perception of perceived rarity, weakening the exclusivity associated with original products. As a result, counterfeiting diminishes the core value proposition of luxury brands, generating long-term negative effects on brand equity and market positioning (Varela, Lopes, Mendes, 2021).
The rise of counterfeit consumption is closely associated with the concept of "fake-chic", which describes the pursuit of a sophisticated or luxurious appearance through the use of affordable or counterfeited versions of branded luxury goods (Purwanto et al., 2019). Existing literature highlights a growth in counterfeit consumption, regardless of consumers' financial capacity to afford original luxury goods. Such behaviour is primarily driven by the desire to access the symbolic and social value associated with luxury goods, rather than purely economic constraints. Specifically, the aspiration to own and display branded luxury items often outweighs both the ability and willingness to pay the premium price required to access authentic products.

An empirical qualitative study conducted performed by Varela, Lopes and Mendes (2021) on the Portuguese market identifies three key determinants influencing counterfeit consumption, namely Product Category, Brand and Channel of Distribution. Findings indicate that accessories represent the most frequently counterfeited category (31%), followed by clothes (25%), watches (22%), footwear (12%) and perfumes (10%). In terms of Brands, findings indicate that the most frequently counterfeited brands are Louis Vuitton (26%), Ray-Ban (22%), Nike (15%), followed by Michael Kors (10%), Chanel (6%), Prada (6%), Burberry (6%), and others (3%). Eventually, the analysis on channels of distribution show that the channels of acquisition appear to be street vendors (28%) followed by E-commerce (26%) (Varela, Lopes, Mendes, 2021).

Despite the ethical, legal and reputational concerns associated with counterfeit consumption, consumers continue to engage in "Fake-chic" consumption. This persistence can be explained by inability of less-informed individuals to distinguish between authentic and counterfeit goods. As a result, the perceived social benefits of social signalling may outweigh the risks and moral considerations associated with counterfeit consumption (Purwanto et al., 2019).

1.4.1. The impact of Counterfeit on Luxury Brand Equity

Existing literature highlights how information asymmetries between brand and consumers contribute to the proliferation of counterfeit goods in luxury markets. Consumers' limited ability to accurately assess product attributes and distinguish between original and counterfeited product increases market uncertainty, facilitating the diffusion of counterfeit alternatives. Within this context, the growing presence of "fake-chic" solutions has influenced significant academic interest in examining the implication of such phenomenon on Brand Equity in the Luxury Fashion Industry.

Brand Equity can be defined as the intangible value associated with a Brand, which extends beyond the functional and physical attributes of the product itself. This value is embedded in consumers' brand perception, and represents a key strategic asset for firms operating in luxury markets. Brand Equity is typically conceptualised from two complementary perspectives, namely Financial-Based Brand Equity and Consumer-Based Brand Equity.

Financial-Based Brand Equity refers to the value generated by a Brand in terms of market performance and economic outcomes. This dimension can be assessed through different methodological approaches:

- The **Cost-based approach** focuses on the historical or replacement cost associated with building the brand;
- The **Market-based approach** evaluates brand value based on consumers' willingness to pay, stock market performance and share evaluation;
- The **Income-based approach** estimates Brand Equity through prospect earnings, including premium profits, royalties and excess returns attributable to the brand.

Consumer-Based Brand Equity focuses on the cognitive and psychological value that a brand generates in the minds of consumers. It encompasses key dimensions such as Brand Awareness (i.e., the extent to which consumers are familiar with a brand, its image and its qualities), Brand Attitude (i.e., the evaluation and attitude consumers hold towards a specific brand, measuring the extent to which they like/dislike the brand), and Brand Reputation. Altogether, Consumer-Based Brand Equity shapes consumers preferences, purchasing intentions and long-term brand loyalty.

A central components of the Consumer-Based approach is Brand Image (i.e., how the brand wants to be perceived by competitors and consumers), which directly influences

Brand Perception (i.e., how consumers perceive the brand). This relationship is particularly important in the Luxury Fashion industry as value creation highly relies on symbolic attributes and aesthetic differentiation (Bian, Moutinho, 2011).

An empirical research conducted by Nia & Zaichkowsky (2000) investigates how the presence of counterfeit product solutions affect these dimensions of Brand Equity. The research is built on earlier research by Dubois & Duquesne (1993), comparing consumer perception of original and counterfeited luxury goods across eight image-related dimensions, including quality, status symbol, price, durability, exclusivity, rarity, fun and prestige (Dubois & Duquesne, 1993). Findings indicate that authentic luxury products consistently outperform counterfeit goods across all dimensions, confirming the superior perceived value of original items. Despite the recognized inferiority of counterfeit goods, consumers may still derive satisfaction from their consumption. Nia & Zaichkowsky's empirical research suggests that the existence and diffusion of counterfeiting do not necessarily lead to a substantial erosion of Brand Equity, particularly from a Consumer-Based perspective (Nia, Lynne Zaichkowsky, 2000).

A study by Appel, Libai & Muller (2018) examine the dual impact that fashion design piracy has on the value of authentic product versions. Findings show that the existence of an acceleration effect through which the introduction of exact replicas shortly after the launch of on authentic design can increase its visibility and market diffusion. On the other hand, this positive effect is counterbalanced by the risk of overexposure which, particularly in the fashion industry, may erode perception of exclusivity and uniqueness. As a result, overexposure can reduce both the perceived and economic value of the original product, and hence, its Consumer-Based and Financial-Based Brand Equity.

While the direct impact of counterfeiting on Brand Equity may be limited, counterfeit raises significant ethical, legal and reputational concerns. In some cases, counterfeiting may lead to long-term risks such as brand dilution and loss of consumer trust. Furthermore, the widespread availability of counterfeit can challenge the exclusivity that features Luxury Brands 'positioning. To contrast the negative effects of counterfeiting, luxury brands must adopt a proactive approach for brand positioning and value preservation, emphasizing on both the tangible and intangible value of authentic products. At the same time, addressing counterfeiting through legal enforcement of IPRs and strategic innovation remains essential to safeguard Brand Equity the increasingly uncertain luxury market environment.

1.5. Information Asymmetry and Market Uncertainty in Luxury Markets

The proliferation of “exact copies” or “super fakes” – counterfeited products indistinguishable from authentic products – raises concerns about the integrity of market dynamics and about the growth in information asymmetries. The objective of “exact copies” is to emulate the appearance of existing successful products, strategically capitalizing on established demand (Ching, Forti, Katsampes, Mammous, 2024).

George A. Akerlof in “The Market for Lemons” (1970) provides an economic explanation of the cost associated with dishonest market behaviour. The model explains how asymmetric information between buyers and sellers and the reduction of average quality of goods can lead to market failure. Akerlof’s theory models the instance in which products of varying quality levels are offered at the same market price. When both high-quality and low-quality products are marketed at identical prices, consumers with limited experience lack sufficient knowledge to accurately distinguish higher- and lower-quality versions of the same product. As product quality can be often only assessed after a prolonged period of experience (Akerlof et al., 1978), consumers tend to assume general quality when making purchasing decisions. Consequently, the information asymmetry raises perceived market uncertainty, resulting in a decline in trust, willingness to buy and potentially in adverse-selection effects.

The rapid expansion of digital platforms has revolutionized the way both brands and counterfeiters reach audiences, increasing the impact information asymmetries (Hayes, Pellandini-Simányi, 2025) and increasingly exposing consumers to product uncertainty in both primary and secondary markets. In this context, the “Cross-Market Effect” proposed by Hayes & Pellandini-Simányi (2025) examines the relationship between authentication uncertainty in secondary markets with primary-market preferences. The model distinguishes contemporary luxury markets through two distinct distribution channels:

- <u>Primary markets,</u> which operate under authorised direct control and monitoring of original brands and authorised retailers, allowing to guarantee product authentication against counterfeits.
- <u>Secondary markets</u>, which include commercial resellers and C2C exchanges – typical in markets for second-hand luxury products – where brand oversight is limited and product authenticity can be uncertain.

Within this framework, the model identifies three threshold levels of uncertainty, reflecting the heterogeneity of consumers' risk perception, value orientation and purchasing priorities (Hayes, Pellandini-Simányi, 2025):

- **PRICE ADVANTAGE**: low levels of uncertainty are usually typically associated with non-deceptive counterfeits. Although consumers are able to distinguish products with varying quality levels, the price advantage of counterfeits outweighs the perceived risk, leading consumers to favour secondary markets.
- **AUTHENTICITY GUARANTEE**: Moderate levels of uncertainty pose consumers in front of an argument: purchasing from secondary markets at lower price but at higher risk and purchasing in primary markets at higher price but with guaranteed authenticity. Empirical evidence suggests that, even for price sensitive consumers, moderate levels of uncertainty may shift demand towards primary markets.
- The proliferation of "exact copies" generates extremely high levels of authentication uncertainty, posing consumers in front of a crossroad:
  - **MARKET EXIT**: when products of varying quality levels are offered at the same market price, the authenticity uncertainty and may erode trust, resulting in consumers with low experience to exit the market entirely.
  - **RISK ACCEPTANCE**: in the case of a price advantage of secondary markets, the risk of unknowingly purchasing a fake becomes an acceptable trade-off for certain consumers, shifting the market towards a secondary-market preference.

Comparing the 2 models, the major cost of dishonesty in Akerlof's models is represented by individuals willing to purchase goods of inferior quality and with higher levels of uncertainty, leading legitimate businesses out of the market. On the other hand, the Cross-Market Effect Model suggests that, rather than pursuing zero tolerance to counterfeits, brands should balance uncertainty reduction, strategically aligning demand with a level of uncertainty such that it allows a shift towards primary markets.

In the case of non-deceptive counterfeiting, the primary competitive advantage of counterfeit products is the significantly lower price compared their authentic versions. This price advantage can significantly reduce the revenues of authentic brands, consequently cannibalizing brands' ability to innovate – particularly for those brands whose competitive strategy highly relies on aesthetics and design differentiation.

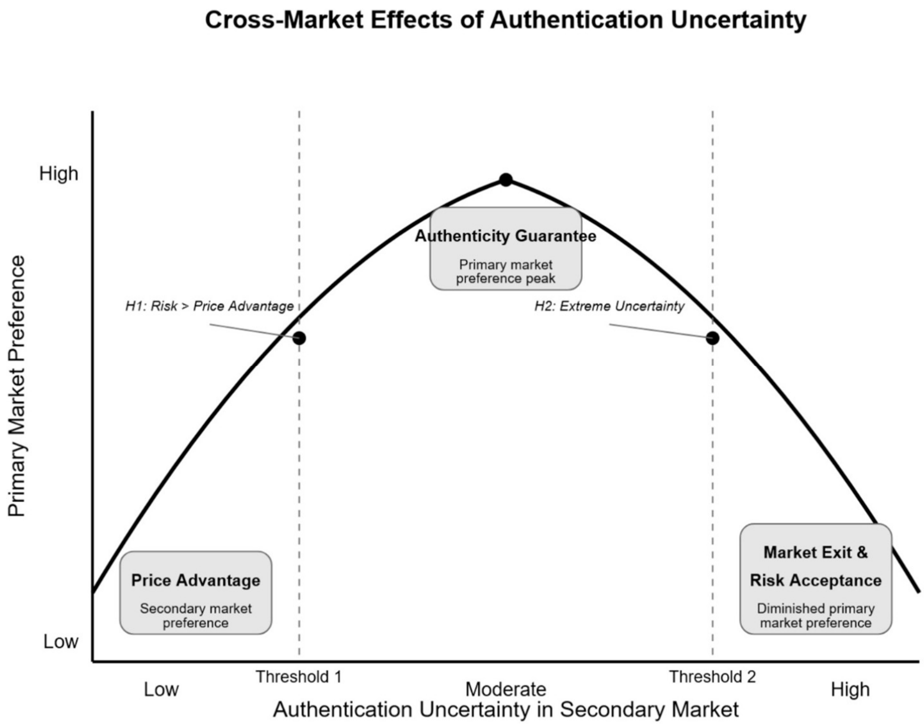

Figure 2: The Cross-Market Effect of authentication Uncertainty (source: Hayes, Pellandini-Simányi, 2025)

Conversely, when the price gap between original and counterfeited products is relatively small, as in the case of deceptive counterfeiting, consumers are more likely to choose genuine products. This phenomenon highlights how guaranteed product authenticity can shift demand towards primary markets. "Certified pre-owned" programs (Miller and Brannon, 2022) exemplify how brands can strategically participate in secondary markets, such as pre-owned luxury markets, while maintaining authentication control (Hayes, Pellandini-Simányi, 2025).

The increasing levels of authentication uncertainty highlight the central role of information asymmetry in contemporary luxury markets. As counterfeit products become more sophisticated and distribution channels more fragmented, traditional methods for quality signalling are no longer sufficient to guarantee product authenticity. Scientific literature shows the increasing importance of integrating IP enforcement policies with supply chain traceability and innovation management.

1.5.1. Innovation as a solution to Market Uncertainty

The rise of e-commerce platforms, has transformed the global retail market for both primary and secondary markets, granting brands the access to global scale audiences (Jankowska, Pawełczyk, Szpyt, 2019). Internationalization, however, opens brands to numerous risks and challenges concerning the protection of labels, trademarks and other assets subject to IPRs. In this context, Innovation has emerged as a critical mechanism for addressing counterfeit-related challenges.

In markets with relatively stable technologies and product categories, radical innovation is not always seen as a feasible solution to gain a competitive advantage, as it may require significant capital investments and long periods of developments. Incremental innovation, on the other hand, is often a more feasible solution, particularly in markets where aesthetic innovation is a crucial determinant for the success of new products.

In the case of the Fashion Industry, characterized by stable technologies and product categories, empirical studies focused on the use of aesthetic innovation as a tool to contrast counterfeiting (Ching, Forti, Katsampes, Mammous, 2024). Aesthetic innovation encompasses two factors:

- **New Style**: a recognizable pattern of aesthetic choices such as colours or patterns (Godart, 2018),
- **Quality Attribute innovation**: higher quality of raw materials and of the overall product.

To innovate a fashion product, therefore, aesthetic innovation may be used by fashion brands to release new style variants of existing products, higher quality versions or products with both new style and higher quality.

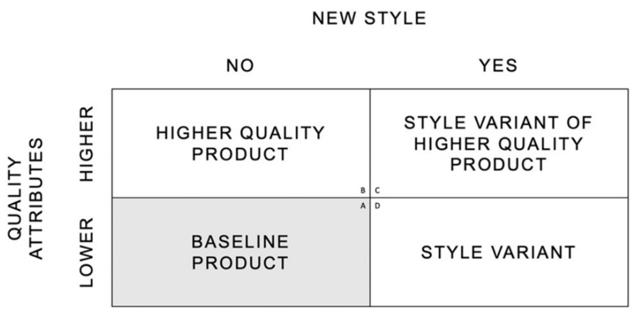

Figure 3: Dimensions of Aesthetic Product Innovation and Types of New Products (source: Ching, Forti, Katsampes, Mammous, 2024)

As new style variants of existing products do not require significant capital investments due to stable technologies, such variations are more likely to face counterfeit that the baseline product. Although studies suggest that innovating through quality enhancements may reduce counterfeiting, the effects of such innovation are only temporary and they might not be consistent overtime due to higher development costs. On the other hand, products that combine new style variants with quality enhancements are 20% more likely to be counterfeited and are more likely to attract price competition, relative to style variants of lower quality products (Ching, Forti, Katsampes, Mammous, 2024).

It can be inferred, eventually, that aesthetic innovation should not be a stand-alone tool to prevent counterfeiting. If implemented, brands should consider also how value is perceived and captured by consumers and not just how it is created, especially when counterfeit undermine exclusivity and profit margins.

As in the case of exact copies, where counterfeit products become more sophisticated and distribution channels more fragmented, traditional methods for quality signalling are no longer sufficient to guarantee product authenticity. Considering the increasing importance of integrating IP enforcement policies, supply-chain traceability, technological innovation and digital innovation become hence key tools to contrast counterfeit and preserve the integrity of the luxury fashion industry.

Term firstly coined for the food industry, traceability can be defined as "the ability to trace the history, application, location and distribution of products, parts and material, to ensure the reliability of sustainability claims in areas of human rights, labour, the environment and anti-corruption" (ISO 9001, 2015). Traceability enables the transparent collection of both qualitative and quantitative data to monitor the economic, environmental and social impact associated with product manufacturing and consumption (Agrawal & Pal, 2019).

The implementation of an effective traceability system requires the disclosure of product-related information, including data on product origin of raw materials and composition, and process-related information, concerning the nature of manufacturing activities and production stages. Additional required data concerns quality attributes – including audit and test reports, quality certification, disposal information and other type of traceability information – and information on the social and environmental impact of business operations (Agrawal & Pal, 2019).

In the context of technological and digital innovation, emerging technologies such as Internet of Things (IoT), Blockchain and Artificial Intelligence (AI) are reshaping the landscape of IPRs protection (Jankowska, Pawełczyk, Szpyt, 2019). The integration of such technologies might enable the creation of a more robust system for product authentication and for the enforcements of IPR. More recently, Artificial Intelligence (AI) technologies have further expanded the range of available anti-counterfeiting tools. Machine Learning Algorithms (i.e., AI capable of autonomously identifying patterns and anomalies within large datasets) can support the detection of IP infringements by analysing visual data associated with the product. In addition, Natural Language Processing (NLP) techniques can monitor and process user-generated content across digital platforms, detecting subtle indicators of counterfeit distribution or IPR violation (Jankowska, Pawełczyk, Szpyt, 2019).

The adoption of traceability systems and advanced technological solutions offer significant benefits for firms operating in luxury markets. By increasing transparency and enabling reliable product authentication, such solutions contribute to reducing information asymmetry between firms and consumers, strengthening hence trust and improving the effectiveness of IP enforcement policies. The implementation of such systems nonetheless entails substantial costs, including high technological investments, infrastructure integration challenges, the need for coordination across complex global supply chains and potential negative spill-overs. Consequently, firms must balance the benefits of such anti-counterfeiting capabilities with the operational and financial costs associated with the adoption of such traceability technologies.

1.6. Conclusions

The articles selected for the systematic literature review examine the phenomenon of counterfeit with a multidisciplinary approach that involves regulatory systems, consumer behaviour, strategic management and technological innovation. Counterfeiting is addressed not only as an illegal practice but also as a socio-economic phenomenon.

Among the key themes discussed throughout the literature review, the first one concerns the juridical framework governing counterfeiting. EU legislation emphasizes the importance of protecting IPRs, trademarks and copyrights as primary regulatory focus to contrast the market for counterfeit goods, specifically focusing on the production and distribution phases of the value chain. Particular attention is also paid to the phenomenon of digitalization, with a series of regulatory initiatives that focus on the role of counterfeit in online marketplaces and e-commerce platforms. Such regulations aim at ensuring trade traceability and transparency of the supply chain. The juridical framework shows the importance of integrating the efforts legislators and businesses to prevent and to contrast the effects of counterfeit.

From an economic point of view, information asymmetry, psychological and social determinants emerge as consistent drivers for the proliferation of counterfeit. Statistics from EUIPO estimates a loss in sales equivalent to the 5,2% of total sales in the EU and a reduction in employment in the fashion sector of 160.352 people (EUIPO. DOI: 10.2814/053613). Nonetheless, research also estimates that the availability of counterfeited product alternatives does not significantly reduce brand equity from a financial or consumer basis (Nia, Lynne Zaichkowsky, 2000).

A third part of the literature review focuses on counterfeit consumption behaviour and the factors that drive luxury-fashion branding strategies. The literature makes a main distinction between non-deceptive and deceptive counterfeit, distinguishing when counterfeit consumption is intentional or not (Nia, Lynne Zaichkowsky, 2000). Considering the selected literature, most of the empirical studies focus on non-deceptive counterfeit, investigating on the psychological and social determinants that motivate deliberate counterfeit purchases. Findings show that luxury goods serve strong symbolic functions related to identity construction, social signalling and prestige communication. In fact, considering luxury markets, consumers show high levels of involvement and low levels of price sensitivity.

Eventually, a detailed analysis on the effects of information asymmetries and market uncertainty on market dynamics, shows the necessity to analyse counterfeit as a broader phenomenon, taking into consideration both deceptive and non-deceptive counterfeiting and both primary and secondary markets. Literature converges on the conclusion that while risk management is a necessary condition to develop strategic countermeasures, no single anti-counterfeiting technique is sufficient. The lack of transparency encountered especially in the Fashion Industry proves that the EU legal systems cannot be a standalone countermeasure to the phenomenon. To mitigate the effect of counterfeit brands are required to integrate innovation with operational and marketing strategies and to establish effective traceability systems for fashion supply chains.
The reviewed literature reveals areas of research that remain unexplored. Despite IoT and Blockchain technologies being widely explored in the context of technological innovation, literature lacks evidence of the real-case application of such systems, their related costs and the actual outcomes, and risk analysis of how such instruments can negatively affect businesses with supply-chain traceability, supplier resistance, governance requirements and potential negative spill-overs. Eventually, an additional gap is represented by governance strategies for secondary markets, which present limited evidence on how to manage authentication, how such markets can implement the innovation practices previously mentioned and how such channels could be integrated into the brand's strategy.

MACRO-THEMES	HINTS FOR FUTURE RESEARCH
EU Law and IPRs	How do regulatory frameworks impact the challenges associated with technology acceptance?
Consumer Behaviour & Counterfeiting	Which are the possible cross-cultural differences in value and risk perception for counterfeit luxury goods? Is it possible to implement predicive models to forecast and uncerstand consumers' willingness to buy counterfeit goods?
Luxury Brand Management & Marketing Strategies	Which are the effects of brand image of both authentic and counterfeit luxury goods on users' status?
Supply Chain Management & Sustainability	How can firms facilitate supply chain collaboration to address the challenges of rapid technological innovation? How should brands incentivize partners to enter and update their operational systems to allow supply chain traceability? How authentication uncertainty affects luxury brands with different price dynamics and availability constraints?
Innovation Management & Traceability Technologies	Which is the best possible combination of technologies to ensure data security and data consistency? How can firms facilitate the technology acceptance of specific linkage approaches for supply chain traceability? Which are the effects of technological innovation for supply chain actors in fashion supply chains? How should inter-organisational data management and governance processes be designed in a blockchain network? Which are the requirements for a more extensive use of traceability technologies in fashion supply chains?

Table 9: Hints for future research for each macro-theme in the selected literature

Although significant progress has been made in understanding the causes and consequences of counterfeit in the Fashion Industry, evidence shows that future research should concentrate on developing integrated and interdisciplinary frameworks to adapt technological and digital innovation to business and real-case scenarios, with possible beneficial results on counterfeit-mitigation strategies.

From a regulatory perspective, existing literature lacks empirical research on how evolving regulatory frameworks influence brands acceptance of emerging technologies. This highlights the need to bridge legal analysis with studies on technology adoption and market behaviour.

With regard to consumption behaviour, limited attention has been paid to the possibility to adopt more advanced and data-driven approaches to forecast consumers' willingness to purchase counterfeit goods. On the other hand, with regard to brand management, insufficient research has been conducted on the comparative effects of authentic and counterfeit brand images on consumers' status and identity.

Concerning supply-chain management, literature lacks a comprehensive study addressing cross-company collaboration in fashion supply chains. More specifically, future research is needed to understand how brands should encourage supply-chain partners to adopt traceability systems and to align with brands business models.

Finally, in the field of innovation management, existing studies present significant gaps regarding the optimal conditions for integrating innovative technologies in fashion supply chains. More specifically, research lack empirical data on the governance and the cross-company operations necessary for a widespread adoption of such technologies.

Among the identified gaps in research, the following chapters will address the questions drawn in supply-chain management and innovation management. More specifically, they will employ secondary sources of data and industry reports to investigate on the possible governance stimuli for cross-company collaboration across fashion supply chains and the optimal arrangement of innovations for product authentication and traceability. Eventually, a series of empirical studies will be employed to observe the real-case application in Luxury Brands of innovation technologies as countermeasures against counterfeit.

2. INNOVATION AS A COUNTERMEASURE AGAINST COUNTERFEIT

As discussed in Chapter 1, despite the growing body of literature addressing the causes and consequences of counterfeiting in the Luxury Fashion Industry, significant gaps remain in the development of a trans-disciplinary and integrated framework highlighting the possible business applications of technological innovation. Although existing literature widely conceptualizes on technologies such as Blockchain and IoT, research gaps highlight the lack of a universally acceptable system to counteract the phenomenon of counterfeiting. Moreover, research gaps emphasize the need to explore the possible combination of technological solutions to respond to brands' necessities, focusing on their effects on operative models and their benefits in counterfeit-mitigation strategies.

Starting from the research gaps highlighted in the systematic literature review, Chapter 2 will present an explorative research on the role that technological innovation plays in ensuring effective product traceability and authentication. To respond to need for a more integrated framework, the analysis performed will adopt a qualitative secondary data-analysis approach, drawing on a range on industry reports, academic studies and empirical industry evidence. Concerning supply-chain management, the analysis of technological innovations will address the need for cross-company collaboration across fashion value chains. Finally, concerning innovation management, Chapter 2 will analyse which are the potentially optimal arrangement of innovations for product authentication and traceability conditions as countermeasures against Luxury-Fashion counterfeiting.

The chapter will outline the research methodology adopted for the qualitative secondary data-analysis performed, including the criteria for the selection of industry reports, articles and empirical industry studies. The analysis will then focus on the existing product-level protection measures, before shifting its focus to the existing technological-innovation solutions. The analysis will emphasize on Industrial Internet of Things (IIoT), Blockchain systems, and Artificial Intelligence (AI). Finally, the qualitative analysis will draw its conclusions by evaluating the benefits and strategic implications associated with technology adoption, emphasizing on the scalability potential of innovation across the fashion value chain. At the same time, the conclusions drawn will assess the costs, operational challenges and limitations that may hinder their effective implementation in real-case scenarios.

The findings derived from this integrative and exploratory analysis will serve as the foundation for the multiple-case empirical study performed in Chapter 3.

2.1. Research Design and Methodology

The second chapter of this thesis introduces a section independent from Chapter 1, shifting from a systematic literature review to a more empirical and exploratory approach. Starting from the theoretical framework provided in Chapter 1, Chapter 2 adopts a Secondary Data-Analysis Approach to perform a qualitative investigation on innovation as a countermeasure against counterfeiting in the Luxury Fashion Industry. As the possible operational and industrial implications of technological innovation are often not-fully captured by academic papers, mainly due to the rapid evolution of innovative systems, the methodology adopted reflects the necessity to overcome this gap in research from an exploratory point of view. The research aims therefore at examining the existing technological and operational solutions, but also at analysing industry reports to study the costs and benefits related to such innovations. Moreover, the integration of academic articles with industry and company documentation allows a more comprehensive evaluation of both the potential and practical applicability and scalability of innovation as an anti-counterfeiting strategy.

For the Secondary Data-Analysis Approach, multiple searches were conducted focusing on articles and reports directly relevant to anti-counterfeiting strategies in the Fashion and Luxury industries, and with a particular attention to data on traceability and authentication technologies. The main keywords identified were "Technological Innovation", "Luxury Counterfeit", "IoT, "Blockchain" and "AI". The review was conducted in the period from March to April 2026.

The main databases identified are McKinsey & Company, Deloitte and PWC. In addition to these research databases, additional sources of data were identified by means of ChatGPT in order to further integrate the bibliographic groundwork of the chapter. According to academic guidelines set by Ca' Foscari University of Venice, the use of AI software such as ChatGPT is allowed for educational purposes only, expect correct mention and execution of its use. By using the following prompt: *"Which are the most relevant sources of data in the case of technological innovation as a countermeasure against Luxury-Fashion Counterfeiting? Make a list of 15-20 records with evidence on the key benefits, limitation and scalability potential of IoT, Blockchain and AI systems",* the use of ChatGPT led to the identification of 10 articles, used to support the bibliographic framework of this secondary data review. All the sources identified through AI were independently verified and assessed for accuracy and reliability.

With respect to the source type included in Secondary Data-Analysis Review, the 44% of the selected records are represented by Articles and 23% by Industry Reports from sources such as BoF, McKinsey & Company, Deloitte and PWC. Each of these sources analyses the use of the identified technologies and examines their benefits, costs and limitations, considering their application in the Luxury Fashion Industry.

Considering the selected secondary sources of data, it is possible to identify 5 main macro-themes. Coherently with the purpose of this section, the macro-themes identified with the biggest influence on the analysis appear to be Strategic Implications of Innovation (50% of selected records) and Technological Innovation (33%), followed by Physical-Level Protection Measures (10%), EU Law (3%) and Economic Trends (3%).

By estimating the frequency of publishing of the selected records, it can be observed an increase in publishing from 2020 onwards. The growth can be possibly associated with the larger number of publications of articles and industry reports on the use Blockchain and AI technologies.

The outcomes of this secondary data-analysis review emphasize the importance of adopting a transdisciplinary approach, integrating academic and scientific findings with tangible and effective applications of the findings identified. Moreover, they enable to provide a feasibility and scalability overview of each technology, allowing to compare the benefits, opportunities, costs and risks associated with their integration and implementation.

Despite the advantage of providing insight on the economic and operational consequences of innovation adoption, the methodology adopted presents certain limitations. Secondary data might be subject to biases that may emphasize successful traits and undermining the associated risks and costs. Nonetheless, secondary data-analysis remains an appropriate approach given the dynamic and rapidly evolving nature of technological and digital innovation. It also provides a solid foundation for the empirical investigation developed in Chapter 3.

2.2. Product-Level Protection Measures

The intrinsic physical characteristics of Luxury Fashion Goods represent the primary defence mechanism against counterfeiting and represent a fundamental criterion through which consumers distinguish authentic goods from counterfeit replicas. Luxury clothes, leather goods and accessories are the result of the highly specialised craftsmanship, incorporating artisanal techniques, premium materials and rigorous quality control implemented by luxury maisons.

Nonetheless, the increasing sophistication of counterfeit replicas, the emergence of fake-chic and super-fake goods, and the increasing popularity of second-hand markets have significantly reduced consumers' ability to identify product authenticity based solely on visual cues. Such conditions reinforced the importance of maintaining rigorous and strictly high standards of craftsmanship and product quality.

Among the most relevant Product-Level protection measures, material quality, stitching quality, logos and serial numbers represent the most important physical identifiers of product authenticity.

Material quality plays a central role in luxury product authentication. Luxury brands source premium raw materials, with strict criteria focusing on composition, texture and durability. Fabrics like silk, cashmere or extra-fine wool with a refined and smooth texture and a light weight are often substituted in counterfeit replicas by cheaper materials, often synthetic and with a much shorter durability. Similarly, in leather goods, authentic products are often crafted from full-grain or top-grain leather, which softens and develops a distinctive patina overtime. Counterfeit replicas, on the other hand, often employ bonded or synthetic leather, often presenting machine-stamped patterns and which deteriorates more rapidly.

Stitching represents another critical indicator of product authenticity. Luxury items are characterised by precise, uniform and tightly executed stitching, with consistent tension and with carefully selected colour-matching threads. In case of hand-stitching, usually employed for handbags or haute-couture pieces, stitching might present slight irregularities that reflect artisanal production. Additionally, stress-points are typically reinforced though double or triple stitching. Conversely, counterfeit products often exhibit either poorly executed stitching or excessively uniform machine-produced seams.

Hardware elements, especially for accessories, also serve as key authentication markers. Metal components are generally manufactured from high quality material, such as stainless steel or gold-plated metals, characterised by their weight, durability, and by the finely-engraved logos on each hardware component. Counterfeit accessories, on the other hand, present lower-quality and lightweight materials, with imprecise or poorly executed engravings.

Branding elements, such as logos, patterns and designs, provide another striking identifier of product authenticity. Authentic products display consistent alignment and proportionality of patterns, while logos present high-quality typography and consistent spacing. Minor irregularities in symmetry or positioning and misalignment often indicate counterfeit production.

Figure 4: Original Louis Vuitton Baseball Cap (source: [LOUIS VUITTON](#))

Figure 5: Counterfeit Louis Vuitton Baseball Cap (source: Reddit)

Attention to details is also reflected in internal components and internal linings, presenting high-quality structure, fabrics and hardware, consistently with external components, patterns, designs and stitching. Similarly, packaging constitutes an integral part of the luxury experience and reflects the same standards of quality as the product itself.

Finally, serial numbers, authenticity cards and security labels represent additional layers of product-level protection. Many luxury brands assign products with unique serial numbers linked to internal databases, enabling product traceability and facilitating verification processes. Authenticity Cards and holographic labels, often incorporating sophisticated security features, further support the identification of genuine products by allowing both consumers and retailers to assess their legitimacy.

The tangible product features examined are at the basis of Direct Authentication, a form of product validation that requires the exploration of a products' physical properties (e.g., density and weight), chemical properties (e.g., composition) and visual properties. Although it is widely used in product validation in the Luxury Industry, the proliferation of super-fakes makes Direct Authentication not a scalable solution to counterfeiting, mainly due to consumers' lack of technical knowledge, the long waiting lists and the high costs related to expert product validation. Nonetheless, Direct Authentication and products' physical features represent the foundation for the implementation of "phygital" systems, allowing to establish a connection between the physical product and the brand's digital interface. As will be discussed in the following sections, such connections are enhanced through the adoption of enabling technologies, such as IIoT, which allow the collection, transmission of large amounts of data in real time and at low prices.

Overall, while product-level protection measures remain fundamental components in anti-counterfeiting strategies, the increasing sophistication of counterfeit replicas highlight the need to explore complementary technological solutions.

2.3. Technological Anti-Counterfeiting Solutions

The market for counterfeit goods has an estimated annual market value of approximately $500 billion, with more than 60% of its value coming from counterfeit fashion and luxury goods (McKinsey & Company, 2022). The threat of counterfeit proliferation has led luxury brands to rethink their operational structures, fostering the development of new business and operating models grounded in technological and digital innovation. Moreover, the rapid expansion of luxury resale markets, with a growth rate 11 times faster than the overall apparel retail sector (The Future of Fashion Resale, BoF, 2021), furtherly reinforces the need for reliable authentication mechanisms and product traceability systems (McKinsey & Company, 2022).

As traditional protection methods are often complex and economically demanding when implemented on a large scale, technological innovation emerges as a key countermeasure against counterfeiting. According to McKinsey & Company, based on a study performed by Crunchbase, investments in fashion-related technologies reached $16,2 billion in 2021. In the same year, fashion companies invested between 1,6% and 1,8% of their revenue in technology on average. As fashion technology advancements are expected to accelerate across the entire value chain, from internal processes to consumer experiences, investments in their integration are expected to increase up to 3% – 3,5% by 2030 (McKinsey & Company, 2022).

The search for effective and scalable technological solutions against counterfeiting has become increasingly urgent after the publication of EU Regulation 2024/1781. Commonly known as the Ecodesign for Sustainable Products Regulation (ESPR), the legislation introduces the mandatory implementation of Digital Product Passports (DPPs) within the EU, establishing their mandatory adoption in the textile industry from February 2027. Digital Product Passports (DPPs) are comprehensive, structured digital records integrating and preserving information about a products' lifecycle. Their upstream application aims at storing and sharing product information across the entire value chain, enhancing transparency and traceability, while their downstream application aims at directly engaging with the final consumers, enhancing the brand's storytelling and overall enhancing consumers' trust (Deloitte, 2023).

An empirical study by BoF & McKinsey suggests that technological and digital innovation has an impact that goes far beyond the reduction operational costs. The instance is supported by a survey that aims at analysing and ranking the most impactful strategic uses of different types of innovations, allowing compliance with ESPR in luxury fashion brands (*Figure 6*) (McKinsey & Company, 2022). Results highlight "traceability of product materials and supply chains" (37% of responses) and "protection against counterfeits" (26% of responses) as the most impactful ones, followed by "Transparency of product lifecycles" (18%) and "connection to digital experiences" (13%) (McKinsey & Company, 2022).

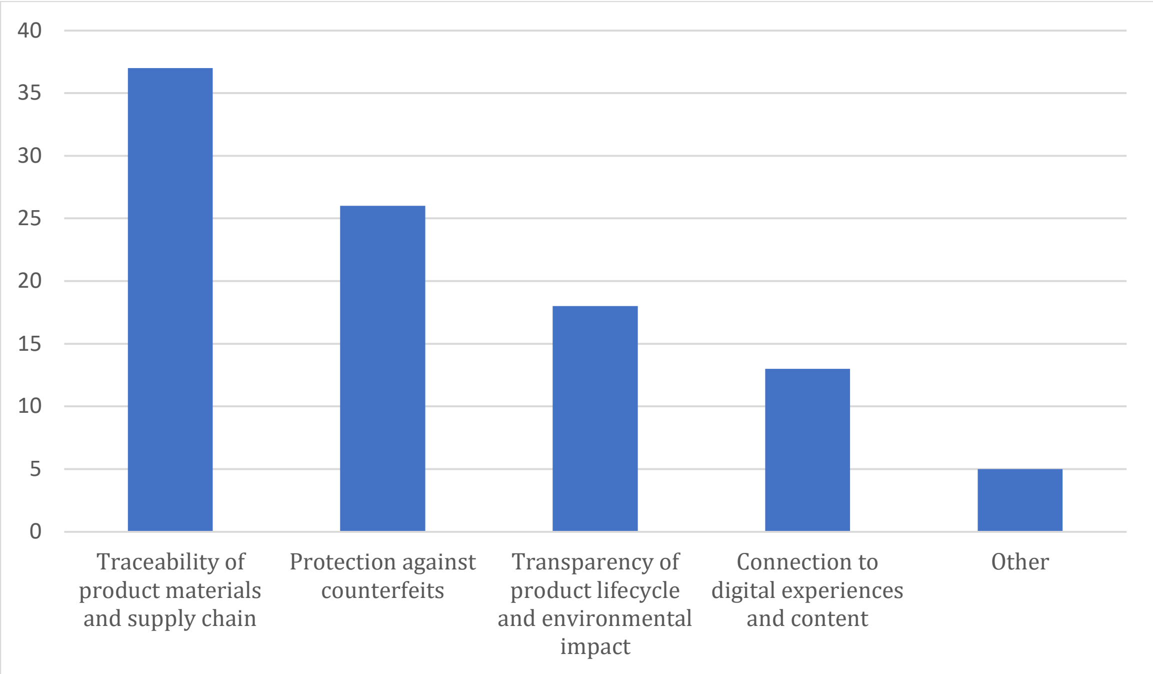

Figure 6: The most impactful use cases for Digital Product Passports (source: The State of Fashion 2022, McKinsey & Company)

Compliance with ESPR significantly increases the importance of searching technological solutions capable of supporting traceability, authentication and transparency across fashion value chains. Moreover, the adoption of technological innovation introduces a critical issue concerning the implementation of "phygital" systems, which refer to the integration of physical product components with digital interfaces. The connection among these two dimensions is typically achieved through Cyber-Physical Systems (CPS), combining tangible product components (e.g., sensors, tags, transmitters, etc.) with virtual elements. However, while such systems enable a more precise traceability and monitoring, they also expose brands to issues related to data accuracy and data security. Another solution to the phygital paradigm is the development of Cyber-Physical Production Systems (CPPS) and Digital Threads, which allow a continuous integration and sharing of data across supply-chain actors, enhancing operational efficiency, control and coordination (Bagnoli et al., 2022). The integration of these technological innovations enables luxury brands to either to optimize existing processes or to develop new operational paradigms. Among these innovative business models, Smart-Factory Models are directly derived by phygital operations. Smart-Factory Models emphasize B2B operational excellence, leveraging on technologies to efficiently produce cyber-physical goods and to undergo a phygital transformation. Smart-Factory Models, enabling inter-company exchange of information, foster the creation of global value chain networks, constituting an integrated collaborative environment. Such connections provide companies with a dramatic increase in transparency, benefitting both the economic and social spheres of the business model (Bagnoli et al., 2022).

Among the available technologies, shareholders and investors focus their resources on those technologies that allow more agile, engaging and sustainable commerce, whether consumers are buying from primary or secondary markets, new or second-hand goods. A CPS can be achieved by brands through the implementation of IoT technologies, whereas the development of CPPS is possible through the implementation of Blockchain or AI-enabled systems, supporting the collection, transmission and secure storage of large volume of data across geographically-dispersed supply chains. As it will be discussed in the following paragraphs, these technologies contribute to reducing information asymmetries and the consequent market uncertainty in product distribution, enhancing traceability, enabling real-time monitoring and ensuring the integrity of product-related information.

2.3.1. Industrial Internet of Things

Industrial Internet of Things (IIoT) integrates Information and Communication Technologies (ICT) within manufacturing systems, connecting and integrating digital settings with physical objects. This level of integration is made possible through the use of sensors, software and other technologies embedded in physical tools, enabling different devices to communicate and to exchange information through a centralised digital ecosystem. Among the IIoT technologies that are scalable and applicable to the Fashion Industry, QR codes, RFID and NFC systems emerge as the most effective and widely adopted solutions for product traceability and authentication (Kenton, 2025).

A Quick Response (QR) code is a two-dimensional barcode that encodes information in a squared pixel grid. It enables a rapid to digital content about the product scanned through remote scanning devices (e.g., mobile phones). Thanks to the high data storage capacity, QR codes enable brands to support product authentication and supply-chain management by bridging physical and digital environment (Hayes, 2025).

Figure 7: Label with embedded QR code and RFID tag (source: Vestiaire Collective)

In the context of counterfeiting, by assigning each product with a unique digital identity, QR codes allow real-time verification of a product's origin, serial number and production data, allowing brands to improve their product authentication, traceability and transparency strategies. Moreover, QR codes support the implementation of DPPs, integrating the information linked by blockchain technologies throughout fashion supply chains. The use of QR codes plays a particularly relevant role in the expansion of secondary markets and in the growth of second-hand luxury markets, reducing product uncertainty and ambiguity (Supercode, 2026).

Radio Frequency Identification (RFID) is an advanced automatic identification technology that enables the detection and recognition of objects through electronically stored data, without requiring direct physical contact or manual intervention (Wu, Wang, Pu, Ma, Zeng, 2025). RFID technologies operate through:

- RFID Tag: the microchip attached to the product, which stores and transmits data via an antenna (i.e., transponder) either passively (i.e., powered by the RFID reader) or actively (i.e., powered by an internal battery).
- RFID Reader: the interrogator that activates the RFID tag through radio waves, allowing data transmission.
- A software system that processes the data collected by the RFID reader (Wu, Wang, Pu, Ma, Zeng, 2025).

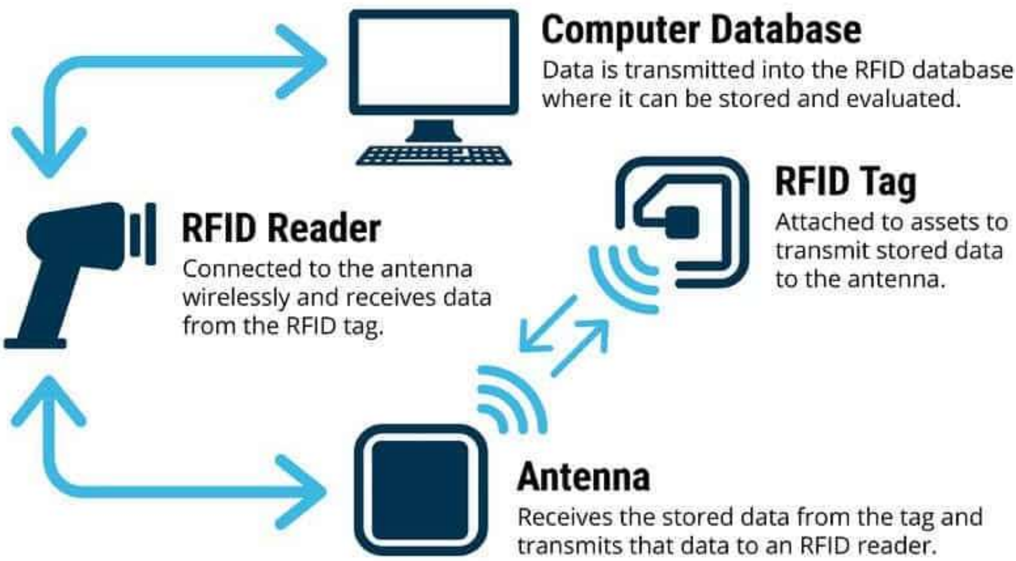

Figure 8: RFID system configuration (source: What is RFID? - Ohmify)

RFID are increasingly adopted in logistics and retail operations, where they support product traceability and identification through physical-layer signals analysis and wireless communication. Moreover, as more than 80% of the global population is expected to have access to 5G (i.e., fifth generation mobile network) by 2030, IoT devices are expected to develop faster connectivity and data transfer (McKinsey & Company, 2022).

Near-Field Communication (NFC) technologies represent a subset of High-Frequency (HF) RFID, enabling short-range communication between devices within a phygital system. Similarly to RFID, NFC systems are composed of three main components:

- NFC Tag: the microchip embedded to the physical product;
- NFC Reader: the reader/writer that scans the NFC tag and allows NFC devices to access data through radio waves;
- An NFC software system that processes the data collected by the NFC reader (Khartit, 2026).

Although the similar configuration to RFID systems, NFC facilitates inter-device communication over significantly shorter distances, typically within few centimetres.
Within the framework of IIoT solutions against luxury counterfeiting, RFID and NFC systems play complementary roles. RFID systems, characterised by one-way communication and longer reading ranges, are particularly effective in supply chain management and logistics, enabling bulk scanning, real-time inventory tracking and enhancing operative transparency. Conversely, NFC technologies, characterised by two-way communication and shorter reading ranges, are more suitable for product-level authentication and consumer-oriented validation systems. Also, the encryption of data guaranteed by NFC readers enables to enhance data security, making NFC particularly suitable in integrating DPPs.
IIoT benefits luxury brands by improving cross-company communication, by improving coordination and by improving product monitoring and control. Among the available hardware IIoT technologies, RFID currently appears to be one of the most viable technological solution to enable automatic product authentication and to enhance product security. In particular, by leveraging the intrinsic characteristics of individual tags, RFID systems can support anti-counterfeiting strategies by providing unique and difficult-to-replicate identifiers for each product (Wu, Wang, Pu, Ma, Zeng, 2025). Furthermore, the compatibility of RFID systems with AI-based technologies further strengthens their role in large scale monitoring, control systems and in automation of authentication processes (WirelessLinks, 2025).
Despite its advantages, RFID systems present certain limitation. From a purely technical point of view, the degradation of radio signals may compromise the system's performance and affect data reliability. Conversely, from a business point of view, the adoption of RFID systems exposes brands to the risk of unauthorized access to datasets and of potential

confidential-data disclosure. To increase data protection and system reliability, industry experts have developed a range of encryption technologies and security protocols (Wu, Wang, Pu, Ma, Zeng, 2025). Nonetheless, reports from McKinsey & Company prove that only 10% of senior fashion executives have invested in this type of technology when seeking to address supply chain visibility and traceability (McKinsey & Company, 2022).

The integration of IoT, QR codes and RFID systems with other technologies represents an optimal configuration of technological innovations for the advancement of anti-counterfeiting strategies within the Luxury Fashion Industry. By enabling secure data-exchange, these technologies contribute to reducing information asymmetries and strengthening consumer trust. Nonetheless, their effectiveness ultimately depends from the reliability of input data and from a coordinated implementation across the entire supply chain.

2.3.2. Blockchain

The increasing speed and complexity within the Fashion Industry has led brands to rely extensively on outsourcing, resulting in the progressive loss of direct control over supply-chain activities. At the same time, the increasing globalization and fragmentation of the Fashion Supply Chain have significantly constrained brands' ability to communicate useful and verifiable information about their products. Ensuring a transparent and traceable network of information has become a critical challenge for luxury brands and fashion supply chains. To address these issues, blockchain technologies emerged as a solution to collect, store, secure and communicate product-related information (Montecchi, Plangger, Etter, 2019).

Blockchain can be defined as a decentralised and distributed public digital database for recording data and information. The system allows multiple stakeholders to collect and store data into individual blocks, organised in a chain shape. The information in each block is stored in an encrypted form, ensuring irreversible data-entry and preventing the value of such encrypted data to be altered once recorded. The immutability of records facilitates a significant reduction in the risk of fraud and counterfeit product substitution. This also enhances the overall transparency and reliability of supply-chain information. Furthermore, the decentralised nature of blockchain facilitates collaborative governance, allowing stakeholders involved in the digital transaction to access and validate share information without reliance on a centralised authority (Badhwar, Islam, Tan, 2023).

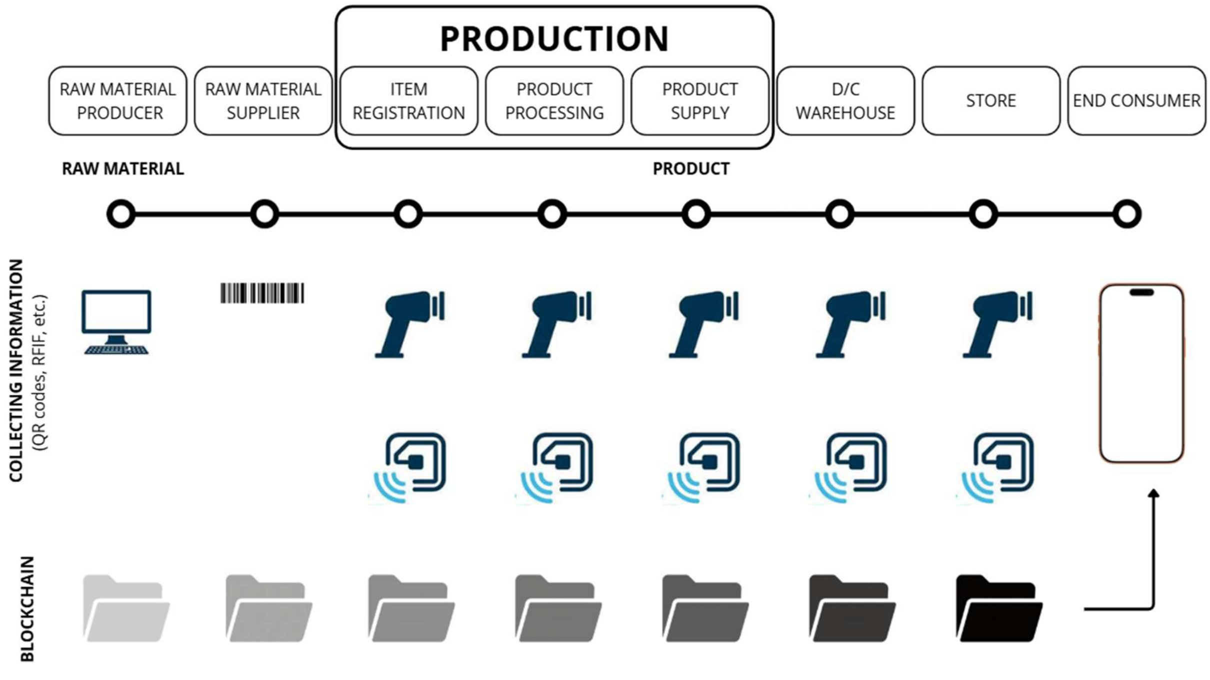

Figure 9: Blockchain configuration for Supply-Chain Traceability (source: Lee, Yeon, 2021).

The adoption of Blockchain technologies is mostly effective in business contexts characterised by large-scale production and high manufacturing costs, price-sensitive consumers and risk-averse retailers. Additionally, their effectiveness increases when the operational efficiency of traditional supply chain actors exceeds that of alternative digital platforms, particularly in cases where counterfeit producers face higher production costs within blockchain-enabled environments (Jiang, Chen, 2021).

The strategic relevance of blockchain technologies is furtherly reinforced by the increasing sophistication of counterfeit products and the rapid expansion of secondary markets. Empirical evidence shows a shift in luxury consumption of 66% of consumers, across different generations, towards online platforms, with 13% purchasing only online and 53% in both online and in-store (PWC, 2026). In this context increasingly impacted by information asymmetries between brands and consumers, the implementation of blockchain technologies emerges as key strategy to support product authentication and traceability and to facilitate the creation of DPPs. Moreover, considering the increasing importance of e-commerce distribution platforms, blockchain also supports consumers in directly managing the digital ownership of purchased products (Klöckner et al., 2023). Overall, the traceability allowed by blockchain contributes to develop more sustainable business models, aligning brands' operations with ESG requirements and sustainability standards (Badhwar, Islam, Tan, 2023).

Despite the benefits supported by the implementation of blockchain technologies, several limitations prevent the widespread adoption of such systems. A critical issue concerns the phygital interface and the lack of a universally reliable method to link the physical product to their digital records in each block of the system (Klöckner et al., 2023). To address this limitation, brands increasingly rely on "digital twins", which create a synchronized digital representation of a physical asset and enable continuous product monitoring throughout the products' lifecycle (Klöckner et al., 2023). Additionally, reducing the number of interaction points between physical and digital systems may help to minimize the inconsistencies in the transcription and communication of data (Klöckner et al., 2023).

Another significant limitation is related to the potential trade-off between supply-chain transparency and the proliferation of confidential information. While blockchain enhances the visibility across supply-chain operations, overexposure may increase the risk for disclosure of trade secrets, intellectual property and supply chain details that sustain the brand's image and competitive advantage, thus make brands more vulnerable to competitors (Montecchi, Plangger, Etter, 2019).

To mitigate the identified economic, scalability and data security challenges of technological innovation is the adoption of permissioned enterprise blockchain technologies, systems requiring Proof-of-Authority (PoA) protocols to send and validate transactions (Yiu, 2021). Such systems ensure greater control, governance and compatibility with existing supply chain processes, making it more suitable and scalable for supply-chain actors. Another solution is represented by smart contracts, self-executing contracts among supply-chain actors, directly written into lines of code. As smart contracts are automatically executed, they allow to forego the costs of intermediation, enabling the adoption of blockchain technologies in a more efficient and cost-effective way. Furthermore, as smart contracts are transparent and directly encoded, they allow to reduce the risks related to the terms of the contract (Gupta, 2023).

2.3.3. Artificial Intelligence

Artificial Intelligence (AI) has emerged as a central driver of digital transformation across different industries, including the Luxury Fashion Industry. Among the available definitions proposed by literature, McKinsey & Company define AI as a machine-based system capable of performing cognitive functions typically associated with human intelligence, such as perceiving, reasoning, learning and problem solving (McKinsey & Company, 2022). AI systems emerge as key technological countermeasures against counterfeiting, demonstrating substantial improvements in product authentication compared to traditional models. Moreover, beyond authentication, the adoption of AI-enabled technologies has demonstrated significant potential across multiple domains, including supply-chain optimization, demand forecasting, risk management and overall, in reinforcing brands' strategic value (Zhang, Cheng, 2023).

Unlike other technological tools, such as IIoT systems requiring product-embedded infrastructures, AI systems are non-invasive tools that do not need any product-embedded components. As AI systems mainly operate through external analysis, they enable product classification and the detection of product anomalies (Sharma et al., 2017). Such a configuration requires fewer investments in physical infrastructures, enables a better scalability, and facilitates its implementation across different product categories.

Among the AI-enabled technologies currently available to fashion manufacturers, Computer-Vision and Image-Recognition systems emerge as powerful techniques for product authentication. These systems rely on advanced feature extraction techniques that analyse both macro-design elements and micro-level details, enabling the identification of subtle inconsistencies that might indicate counterfeit production (Zhang, Cheng, 2023). Complementing such systems, Machine Learning algorithms enable to leverage supervised data (i.e., pre-labelled data used to learn the relationship between input and output and to predict new outcomes) and unsupervised data (i.e., non-labelled data used to learn the properties of the structure of the datasets). Machine Learning Algorithms are capable of learning and improving from experience without being explicitly programmed. While supervised learning enables the classification of products based on known patterns, unsupervised learning facilitates anomaly detection by identifying deviations from expected data structures (Zhang, Cheng, 2023).

Finally, building on these two approaches, Data-Fusion or Multi-Modal AI systems represent a further advancement. These systems integrate multiple authentication signals, including visual, spectral, physical and supply-chain data, to create a comprehensive authentication profile. By combining different data sources, Multi-Modal AI systems enable to enhance counterfeit-detection capabilities, increasing the accuracy of authentication up to 17,3%, while reducing false positives by up to 62% (Zhang, Cheng, 2023).

A Study by Zhang & Cheng (2023) explores and exemplifies the use of a Multi-Modal AI technique to enable product authentication across globally-dispersed supply chains in the Luxury Fashion Industry. The innermost layer of the Multi-Modal AI system focuses on material authentication, using spectral analysis to assess material composition (i.e., chemical properties). A second layer focuses on manufacturing verification, based on the analysis of macro-level and micro-level production features (i.e., physical and visual properties). The third layer incorporates a digital authentication system, relying on embedded digital authentication elements, such as RFID tags or NFCs. The fourth layer focuses on supply-chain verification, through blockchain-based mechanisms to ensure product traceability. Finally, the outermost layer consists in a consumer-oriented authentication AI system, typically enabled through mobile scanning interfaces. Each layer is annotated with data on authentication strength, error rate and computational requirements (Zhang, Cheng, 2023). Furthermore, the gradient colour transition highlights the higher vulnerability of outer layers compared to inner ones (*Figure 10*).

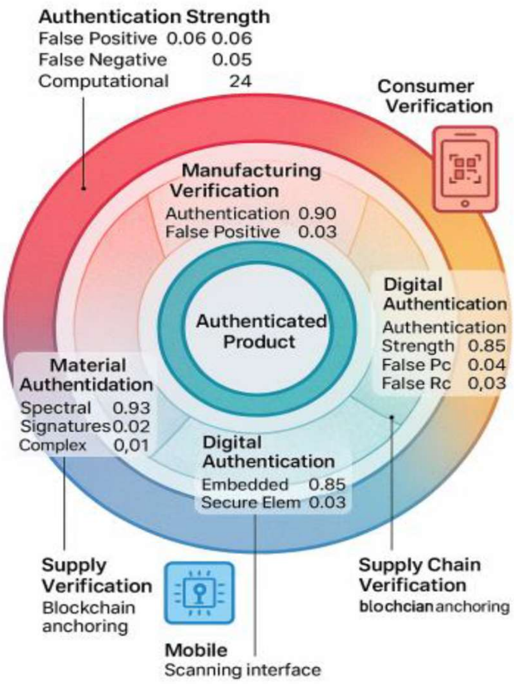

Figure 10: Multi-Modal AI system for luxury-goods authentication (source: Zhang, Cheng, 2023)

Empirical evidence on the implementation of Multi-Modal AI systems, integrating with Blockchain, IoT and RFID technologies, indicates a 76% decrease in counterfeit incidents over an 18-months period, with authentication accuracy exceeding 99,7% across different product categories (Zhang, Cheng, 2023). Moreover, additional empirical evidence on the adoption of AI systems in the Luxury Fashion Industry suggest that brands that integrated such AI in their business models are expected to achieve up to a 118% cumulative increase in cashflow by 2030, whereas, brands failing to implement such systems may experience a decline up to 23% within the same timeframe (McKinsey & Company, 2022). These projections position AI technologies no only as strategic and innovative tools, but also as determinants for long-term competitiveness in luxury industries.

Despite the advantages and the versatility of AI-enabled technologies, they also present several limitations. Data security and data privacy concerns represent a significant challenge, particularly in relation to sharing and handling sensitive information across supply-chain actors. Additionally, the implementation of AI systems often requires substantial financial investments, with uncertain returns on investments (ROI) in industries characterised by high levels of counterfeit activity (Zhang, Cheng, 2023). Furthermore, the increasing diffusion of AI technologies has contributed to the emergence of AI-enabled counterfeiting techniques, intensifying the competitive pressure. A study by MarqVision (2026) indicates that 78% of brands lose at least 5% of their annual revenues due to counterfeiting, while at least 82% are expected to increase financial investments in brand-protection technologies within the end of 2026, highlighting both the risk and strategic necessity of AI adoption (MarqVision, 2026).

2.4. Benefits and Strategic Implications

Technological innovation has emerged as a central driver of strategic countermeasures against counterfeiting in the Luxury Fashion Industry. Its relevance is primarily linked to its capacity to enhance operational efficiency, to strengthen product authentication and to enable scalable solutions across increasingly complex and geographically-dispersed supply chains. Recent industry evidence by Deloitte (2026) highlights the strategic importance of financial investments oriented towards technological innovation and brand equity enhancement. Digital acceleration represents the top investment priority for 20,5% of luxury brands' executives. A stronger focus on digital acceleration is given by Japan (33,3%), followed by the UK (30%) and France (24%). In contrast, while the financial investments are mainly focuses of brand & market expansion (26,2%), human capital (11,4%) and ESG compliance (10,2%), supply-chain modernization and cross-company digital integration are prioritised by only the 3,3% of executives. Similarly, only the 4,8% of executives highlight the need to increase investments in brand protection, in IPRs safeguard and in counterfeiting mitigation strategies (Deloitte, 2026).

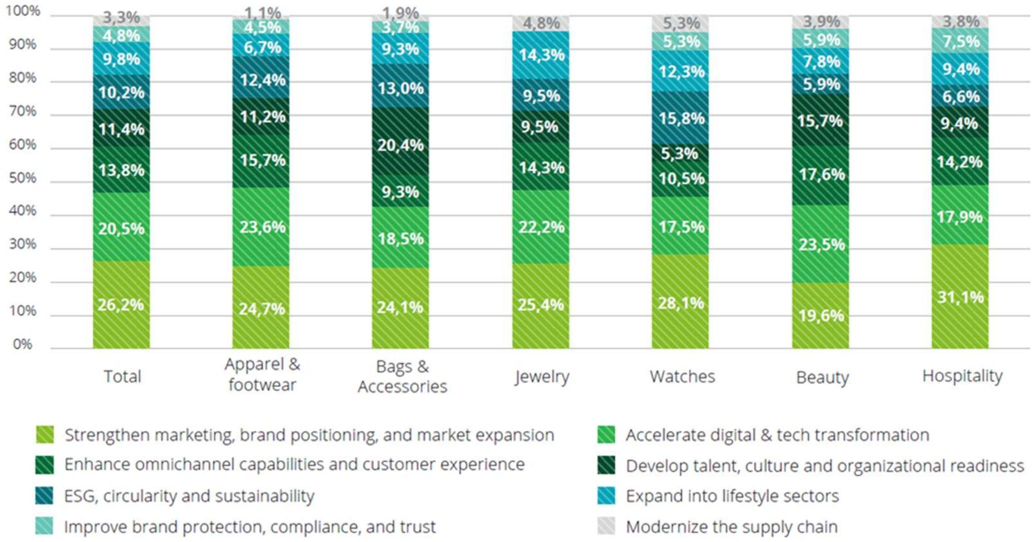

Figure 11: Major expected financial investments by category (source: Deloitte Global Powers of Luxury 2026)

Luxury brands are increasingly required to adopt innovative systems to ensure product traceability and to validate product authenticity. Empirical evidence indicates that traceability and product authenticity represent the most valued functionalities of DPPs, citied by 70% of consumers at the point of purchase and 67% in resale markets (BCG, 2025). Rather than functioning as isolated tools, the analysed technologies must operate within integrated ecosystems that combine product-level, digital and organisational measures. In this context, as highlighted throughout paragraph 2.3, CPS enable the connection between physical products and digital infrastructures through the adoption of IIoT technologies, while CPPS leverage Blockchain and AI systems to support the collection, transmission and secure storage of big data across geographically-dispersed supply chains. When analysed individually, each of the technologies identified contributes to a different extent to brands digital acceleration, allowing counterfeit mitigation through product authentication and supply-chain traceability. Each technology, hence, generates distinct benefits for brands integrating them in their strategic solution.

	DIRECT AUTHENTICATION	IIoT	BLOCKCHAIN	AI
OPERATING PRINCIPLES	*Product validation that requires the exploration of a products' physical, chemical and visual properties.*	*Systems connecting and integrating physical objects with digital settings*	*A decentralised and distributed public digital database for recording encrypted data*	*A machine-based system capable of performing cognitive functions typically associated with human intelligence*
BENEFITS	Product features are visible to naked eye	IIoT technologies are consumer firendly and facilitate product authentication	As records are encrypted and immutable, data is more secure and reliable	Non-invasive technology (i.e., it does not require embedded components)
	High consumer involvement	Enables real-time supply-chain traceability while enhancing data security	The decentralised nature of blockchain facilitates collaborative governance	It enables product clasfficiation, detection od anomalies and product authentication
		High compatibility of IIoT technologies with blockchain and AI-based systems	Facilitates the dreation of DDPs	Scalable acrsoss multiple domains and product categories
		Low possibility of replication thanks to encrypted data	Blockchain can be easily integrated with IIoT and AI	It enables authentication accuracy exceeding 99,7% across different product categories
		RFID and NFC readers are capable of detecting clones		Brands implementing AI in their business models are expected to achieve up to a 118% cumulative increase in cashflow by 2030
		Passive RFID are inexpensive		

Table 10: Benefits of examined technologies

While product rarity and intrinsic physical product features remain fundamental in shaping the luxury consumer experience, these elements alone are no longer sufficient to effectively address the growing sophistication of counterfeits. Nonetheless, despite its limited scalability, Direct Authentication remains highly relevant due to the inherent quality, craftsmanship and artistry of physical product features. Furthermore, Direct Authentication represents the foundation for the implementation of CPS, allowing to establish a connection between the physical product and the brand's digital interface.

IIoT, primarily contributing to the development of CPS, enables real-time supply-chain traceability while, at the same time, enhancing data security and reducing information asymmetries between entities involved. It is a user-friendly solution to facilitate product authentication. IIoT tools such as RFIDs or NFCs reduce the likelihood of product/data replication and support the detection of counterfeit items. Additionally, their compatibility with blockchain and AI-based systems, alongside with the low cost of Passive RFID and NFC tags (i.e., respectively 0,05€ to 0,15€ for RFID tags and 0,20€ to 0,40€ for NFC tags) makes IIoT a scalable solution, allowing its implementation across supply-chain operations.

Blockchain technologies, thanks to their encrypted, decentralised and immutable structure, enhance data reliability, integrity and transparency while distributing, at the same time, collaborative governance among value-chain actors. Such decentralised disruptive ecosystems are likely developed based on open-source protocols, which guarantee the development of collaborative governance among value-chain actors (Yiu, 2021). Additionally, Blockchain supports the adoption of DDPs and can be easily integrated with different combinations of technologies, such as IIoT and AI. Blockchain-based digital assets are projected to account for 10% of overall luxury goods by 2030, amounting to $50 billion revenue opportunities, of which $10-20 billion coming from new technologies developed to address emerging consumers' needs (Stanley & Deloitte, 2023). The integration of multiple technologies and the exploitation of the synergies developed in phygital ecosystems, facilitates both counterfeit prevention and counterfeit detection. Counterfeit prevention can be obtained by two-factor authentication, implemented through IIoT systems, verified blockchain nodes and DPPs, increasing the synergy in the Cyber-Physical System. On the other hand, counterfeit detection is based by means of authentication and product traceability, possible again by means of IIoT systems, verified blockchain nodes and DPPs, registered throughout the whole value chain by firms involved (Ting, Tsang, 2013). As previously mention, strategic anti-counterfeiting measures are increasingly focused on counterfeit-prevention, rather than on making adjustments and mitigating its effects. This phenomenon proves how technological innovation has shifted brands strategies from reactive detection models to proactive and data-driven modes, possible through CPSs and collaborative governance.

Among the analysed technologies, the focus of financial investments mainly extends AI technologies. AI and Machine-Learning systems, being non-invasive technologies and not requiring product-embedded devices, are scalable anti-counterfeiting solutions applicable across multiple domains and product categories. They enable effective product classification, detection of anomalies and product authentication, with levels of accuracy

approaching 99,7%. Additionally, the integration of AI systems into Smart-Factory business models are associated with substantial economic benefits, including projected increases in cashflow and long-term ROI. The focus on AI-enabled systems is mainly consequent to the versatility of such systems, contributing at improving brands' operational efficiency by 15,7%, at reducing operational and distribution costs and at fostering automate product authentication. Among the applications for AI adoption, executives highlight its potential in product innovation (21,3%), marketing (21,3%), customer engagement (21,1%) but also supply-chain, demand and inventory intelligence (20,6%). Eventually, despite the proved benefits and scalability potential of AI-enabled systems, Deloitte estimates shows that only 11,9% of luxury brands have started to implement AI in their organizations (Deloitte, 2026).
As seen in the previous chapter, scientific literature views the lack of a universally scalable solution to prevent and detect luxury-fashion counterfeiting as one of the main limitation of current anti-counterfeiting strategies. Nonetheless, from the exploratory research performed on the technological solutions currently available, it is possible to assume that, thanks to the increasing versatility of such technologies, the lack of a universal technological language can, in fact, benefit brands in some ways, by allowing them to freely select the most suitable and scalable combination of technologies (e.g., IIoT and Blockchain, IIoT and AI, Direct Authentication and AI, etc.). Financial investments on technological innovation and overall decision making can, therefore, be influenced by brands' market positioning and their level of exposure to counterfeiting.
From a financial point of view, while the cost of authentication technologies has historically represented a barrier to their widespread adoption, recent technological innovations have contributed to a significant reduction in cost. For instance, the price of RFID tags has declined by approximately 80% over the past decade, improving the economic feasibility of widespread adoption throughout fashion supply chains (McKinsey & Company, 2022). Ultimately, it is important to highlight that successful scalability and effectiveness of technological innovations depends not only on the cost reduction, but also on the establishment of common standards among contractors, cross-company collaboration and interoperability among supply-chain actors. In this perspective, technological innovation is essential to establish a strategic infrastructure capable of facilitating an effective exchange of data among stakeholders (McKinsey & Company, 2022).

2.5. Costs and Limitations

While innovation provides significant opportunities and solutions to mitigate the adverse effects of Luxury-Fashion counterfeiting, the implementation of different strategic countermeasures entails economic, operational and structural limitations. These limitations appear particularly critical due to the complexity and the geographical dispersion of supply chains, the high manufacturing costs, the presence of risk-averse value chain actors and of price-sensitive consumers. For this reason a comprehensive evaluation of the available technological solutions to counterfeiting requires an assessment of the constraints of each individual technology, focusing on their scalability potential, cost-efficiency and practical applicability (*Table 11*).

	DIRECT AUTHENTICATION	IIoT	BLOCKCHAIN	AI
OPERATING PRINCIPLES	*Product validation that requires the exploration of a products' physical, chemical and visual properties.*	*Systems connecting and integrating physical objects with digital settings*	*A decentralised and distributed public digital database for recording encrypted data*	*A machine-based system capable of performing cognitive functions typically associated with human intelligence*
LIMITATIONS	Lack of consumers' technical knowledge	Overtime degradation of stored data due to the lack of power supply	The lack of a universably reliable phygital system limits blockchain scalability	Data privacy and Security
	Complexity of products' structures	Average lifespan of 3 to 5 years due to the lack of power supply	Overexposure may lead to the disclosure of sensible data, making brands more vulnerable to competitors	Social Acceptance and Ethical Considerations
	Requires professional validation, which is costly and time-consuming	Their effectiveness depends on the reliability of input data		Mainly consumer-oriented, rather than business or supply-chain oriented
		Active RFID tags are very expensive		Brands failing to implement AI systems may experience a decline in cashflow up to 23% by 2030
				AI systems often requires substantial financial investments, with uncertain returns on investments (ROI)

Table 11: Limitations of examined technologies

The growth in precision and sophistication of super-fake replicas makes Direct Authentication an ineffective and limited strategy, mainly due to consumer's lack of technical knowledge on product features and the consequent presence of information asymmetries between fashion manufacturers and end consumers. Moreover, as Direct Authentication often requires professional validation, this traditional solution appears to have a low cost-efficiency ratio and a low scalability potential.

IIoT technologies, including RFIDs and NFCs, are subject to both technical and economic constraints. Due to the lack of power supply in passive RFID and NFC tags, such technologies are subject to data degradation and usually have a useful life spanning from

3 to 5 years. As RFID and NFC tags require passive systems for data storing, their effectiveness highly relies on the reliability of input data. Moreover, while tags might appear as inexpensive investments for supply-chain traceability and product authentication, their adoption also requires substantial investments in IIoT readers and software.

Among the available IoT systems, the use of decentralised NFCs, used especially in blockchain, has been proven to increase computation time by 34,08%/36,14%, with respect to their centralised counterparts. Nonetheless, although the implementation of a decentralised system may raise some concerns about their scalability across value chains, the incremental computation time is a reasonable cost compared to the benefits in data integrity and data security in individual blockchain nodes (Yiu, 2021).

Similarly, Blockchain technologies, while enhancing supply-chain transparency and fostering collaborative governance, face significant challenges concerning the phygital interface. The absence of a universally accepted phygital system may limit the scalability of the technology and, at the same time, compromise the accuracy and reliability of records. Additionally, the high level of transparency associated with blockchain systems can lead to brands overexposure, leading to the potential disclosure of sensitive data and consequently increasing brands' vulnerability to competitors.

Finally, although it appears to be a highly scalable and effective solution to counteract counterfeiting, AI presents critical limitations related to data privacy, data security and other ethical considerations. The implementation of AI-enabled systems also requires substantial investments with potentially uncertain ROI, especially complex and uncertain market dynamics as in the Fashion Industry.

Although the lack of a universal technological solution can be assumed as an opportunity for brands to adopt technologies more suitable for their market positioning, financial availability and level of exposure to counterfeiting, this lack also limits the strategic scalability and inter-operability of such technologies, preventing the creation of a common digital ecosystem or communication language through which operations are carried out.

The increasing digitalization of operative and business models has exposed fashion brands to higher risks associated with cyber-security and improper data handling. In particular, the growing relevance of digital assets, such as DPPs, has intensified the need for robust protection mechanisms to safeguard sensitive data and data integrity.

Moreover, competition among tech companies to provide a solution to this traceability problem has led to a phenomenon called tech-washing, the practice of placing a current buzzword on pseudo-tech solutions (Chrimes, Heim, 2023).
Ultimately, existing industry reports and empirical contributions highlight a consistent limited availability of comprehensive and systematic evidence regarding the effectiveness of technological innovation in counteracting counterfeiting within the Luxury Fashion Industry. This gap in literature can be primarily attributed to two interrelated factors. Firstly, the introduction of key regulatory frameworks, namely Directive (EU) 2024/1760 and Regulation (EU) 2024/1781 have only recently started to shape innovation and technology adoption, with a consequence limited availability of data on technological effectiveness. Secondly, the high levels of confidentiality that characterize both luxury brands and their relative supply-chain networks significantly constraint data accessibility, as firms are often reluctant to disclose sensitive information regarding their operational and technological infrastructures.
In response to these emerging risks, fashion brands are required to strengthen their operational resilience by allocating greater resources to cybersecurity infrastructures (McKinsey & Company, 2022) while, at the same time, adopting an integrated, hybrid approach to combine multiple technologies in a unified framework. One key solution consists in the development of standardised protocols and inter-operability frameworks, facilitating collaborative governance, facilitating seamless exchange of information between value-chain actors and reducing inconsistencies in CPS. A solution to the issue of product reliability and security may be the use of two-factor authentication, incorporating watermarks in RFID or NFC validation systems. Such two-factor authentication mechanisms require users to match the information embedded in the tag with that captured from the watermark on the product label (Ting, Tsang, 2013). Similarly, the implementation of advanced encryption techniques can help to establish secure data architectures and reduce the cyber-security risk associated with blockchain nodes and AI data handling systems.

2.6. Conclusions

The second chapter of this thesis adopted a Secondary Data-Analysis Approach to investigate on innovation as a countermeasure against counterfeiting in the Luxury Fashion Industry. As, previously mentioned, as the operational and industrial implications of technological innovation are often not-fully captured by academic papers, the research aimed therefore at examining the existing technological and operational solutions, and at analysing industry reports to study the costs and benefits related to such innovations and to build a comprehensive evaluation of the applicability and scalability potential of innovation as a countermeasure against counterfeiting. The analysis performed started from a preliminary review of the existing product-level protection measures from Direct Authentication. The focus then shifted towards technological and digital measures, emphasizing on Industrial Internet of Things (IIoT), Blockchain systems, and Artificial Intelligence (AI).

The initial overview of the intrinsic physical characteristics of Luxury Fashion Goods highlights how the exploration of a products' physical properties (e.g., density and weight), chemical properties (e.g., composition) and visual properties is at the basis of Direct Authentication. The research highlighted the difficulty of brands in identifying and differentiating original luxury items from counterfeits, mainly due to the increasing sophistication of counterfeit replicas, the emergence of fake-chic and super-fake goods, and the increasing popularity of second-hand markets enhancing the information asymmetries between consumers and brands. Although such conditions make Direct Authentication not a scalable solution to Luxury-Fashion counterfeiting, products' physical features represent the foundation for the implementation of "phygital" systems, allowing to establish a connection between the physical product and the brand's digital interface.

As traditional protection methods are often complex and economically demanding, technological innovation emerges as a key countermeasure against counterfeiting (McKinsey & Company, 2022). Moreover, the search for effective and scalable technological solutions against counterfeiting has become increasingly urgent after the publication of EU Regulation 2024/1781 (ESPR), introducing the mandatory implementation of DPPs within the EU and establishing their mandatory adoption in the textile industry from February 2027.

Among the most scalable and applicable technologies for the Fashion Industry, IIoT, and more specifically RFID and NFC, emerges as the most effective and widely adopted solutions for product traceability and authentication (Kenton, 2025). While RFID systems, characterised by one-way communication and longer reading ranges, are particularly effective in supply chain management and logistics, NFC technologies, characterised by two-way communication and shorter reading ranges, are more suitable for product-level authentication and consumer-oriented validation systems. In the context of luxury counterfeiting, IIoT benefits brands by improving inter-operability and cross-company communication. Moreover, the low cost of passive tags and the compatibility with other technologies make RFID scalable across different levels along the value chain.

By analysing the structure and use of Blockchain technologies, research suggests that the adoption of Blockchain technologies is mostly effective in business contexts characterised by large-scale production and high manufacturing costs, price-sensitive consumers and risk-averse retailers (Jiang, Chen, 2021). As such systems are highly compatible with other CPS and technologies, Blockchain supports the implementation of DPPs. Moreover, blockchain-based digital assets are projected to account for 10% of overall luxury goods by 2030, amounting to $50 billion revenue opportunities, of which $10-20 billion coming from new technologies developed to address emerging consumers' needs (Stanley & Deloitte, 2023).

Ultimately, AI systems emerge as key technological countermeasures against counterfeiting, demonstrating substantial improvements in product authentication, potentially across other multiple domains, including supply-chain optimization, demand forecasting, risk management and overall, in reinforcing brands' strategic value (Zhang, Cheng, 2023). The focus on AI-enabled systems is mainly consequent to the versatility and the non-invasive nature of such systems, contributing at improving brands' operational efficiency by 15,7%, at reducing operational and distribution costs and at fostering automate product authentication (Deloitte, 2026). Despite the advantages and the versatility of AI-enabled technologies, they also present several limitations concerning data security and data privacy. Additionally, the implementation of AI systems often requires substantial financial investments, with uncertain returns on investments (ROI) in industries characterised by high levels of counterfeit activity (Zhang, Cheng, 2023).

The analysis performed highlights how no single technology currently offers a universally applicable solution to the problem of counterfeiting. Nonetheless, his limitation can also be interpreted as the strategic opportunity to adopt tailored combinations of technologies aligned to brands exposure to counterfeiting risks.

From a scalability perspective, the economic accessibility of certain technologies (e.g., passive RFID and NFC tags) is not a sufficient factor to ensure widespread technological adoption. As a matter of fact, successful technological also requires the establishment of common standards and inter-operability frameworks, allowing to establish better communication networks between brands and their supply-chain actors. Ultimately, the increasing digitalization of operational and business models require brands to pay greater attention to data security and data governance infrastructures, mitigating cyber-security risks through two-factor authentication mechanisms and adopting advance encryption systems.

In conclusion, the findings of this chapter suggest that technological innovation is reshaping anti-counterfeiting strategies in Luxury Fashion, driving brands towards proactive, data-driven and prevention-oriented models, supporting the development of more resilient, scalable and long-term business models.

3. EMPIRICAL ANALYSIS ON INNOVATION AS A COUNTERMEASURE

The conclusions derived from the systematic literature review conducted in Chapter 1 highlight that, despite the substantial body of literature dedicated to examining the causes and consequences of counterfeiting within the Luxury Fashion Industry, existing literature on the phenomenon lacks a comprehensive and transdisciplinary framework capable of systematically analysing the adoption of technological innovation as a strategic solution to counterfeiting. These research gaps have been partially addressed through the exploratory qualitative analysis performed in Chapter 2, drawn on industry reports and secondary data to investigate how technological solutions can be implemented as tools for counterfeit prevention and mitigation. Nonetheless, as the possible operational and industrial implications of technological innovation are often not-fully captured by academic papers, mainly due to the rapid evolution of innovative systems, the implementation of an empirical approach, combined with the exploratory investigation performed in the previous chapter, becomes essential to bridge the existing gap between conceptual analysis and practical application.

Starting from the theoretical framework provided in Chapter 1 and the qualitative investigation performed in Chapter 2, Chapter 3 undertakes an empirical investigation to illustrate how technological innovation can be implemented in operational and industrial settings as a countermeasure against counterfeiting.

Specifically, the chapter will examine how IIoT systems, Blockchain and Artificial Intelligence have been implemented within both primary and secondary markets as both a proactive and reactive response to counterfeiting in the Luxury Fashion Industry. Each section will begin with a concise introduction to the case analysed, followed by a detailed description and examination of the technological solution implemented. Each case study will then discuss and evaluate the main benefits and limitations linked to the adoption of such technologies, paying particular attention to their financial and operational feasibility and their strategic impact. Finally, each section will assess the scalability potential of these solutions, considering their applicability across fashion supply chains and their scalability to other luxury brands.

After this empirical technological assessment, the chapter will end by synthesizing the key empirical findings and by linking such findings to the theoretical and exploratory insight obtained in the previous chapters.

3.1. Empirical settings and sources of data

As previously mentioned, existing academic and industry literature often fails to fully capture the operational implications and scalability potential of emerging technological innovations. This limitation is largely attributable to the rapid evolution of innovative systems, accelerating technology obsolescence. The adoption of an empirical research methodology appears therefore essential to bridge the gap between established theoretical frameworks and the practical implementation of the technologies analysed. In this context, the theoretical framework developed in Chapter 1, together with the qualitative investigation performed in Chapter 2, provides the conceptual foundation for the empirical analysis undertaken in this chapter.

Chapter 3 adopts a Multiple-Case-Study research methodology, aiming at illustrating the findings of the previous chapters and at examining how technological innovations are applied within real-case and industrial settings as countermeasures against counterfeiting.

The rationale underlying the adoption of this methodological approach is primarily linked to the necessity to develop a comprehensive analysis that integrates both existing academic literature on anti-counterfeiting technologies in luxury fashion and empirical evidence concerning the practical implementation of such technologies by firms operating within the Luxury Fashion Industry. While the theoretical framework provides an overview of the main technological solutions currently available to luxury brands, the integration of empirical case studies enables a more detailed understanding of the opportunities and threats connected to technology implementation. In particular, it provides insight on technology functioning, the financial investments required for their adoption, their scalability potential and the related strategic implications.

Focusing on IIoT systems, Blockchain and AI as the main subject of analysis, the chapter will analyse one representative case study for each technological domain. The main objective behind this empirical configuration is to examine the selected technologies under different perspectives, including their accessibility, scalability, and costs related to technology adoption. By allowing a comparison among technologies and case studies, the empirical analysis also allows to investigate on how different technologies may align with the strategic needs of different brands, providing therefore practical guidance to luxury fashion brands for technology selection. Ultimately, the empirical analysis enables to analyse how IIoT, Blockchain and AI can affect, either positively or negatively, both primary and secondary market, supporting both proactive and reactive anti-counterfeiting strategies within the Luxury Fashion Industry.

To support the Multiple-Case-Study Approach, multiple searches were conducted focusing on articles, brand and industry reports on the adoption of a representative case of IIoT systems, Blockchain and Artificial Intelligence. For each technological domain, a specific case study has been identified:

- *Moncler Group* for IIoT, RFID and NFC systems;
- *Aura Blockchain Consortium* for Blockchain technologies;
- *Entrupy* for Artificial Intelligence.

The selection of such case studies was guided by a set of specific criteria aimed at ensuring both analytical relevance and research consistency. Such criteria include:

- Relevance to the technology: as previously mentioned, considering the industry analysis on IIoT, Blockchain and AI conducted in Chapter 2, one representative case study was selected for each technological domain. This configuration enables to further examine such technological frameworks, their operational characteristics, strategic applications and associated limitations;
- Relevance to the industry: given the primary objective of identifying the most suitable technologies against luxury fashion counterfeiting, with a specific with a focus on Fashion and Leather Goods, the selected case studies comprehend Luxury Brands, Consortiums of Luxury Brands and technological frameworks targeting both primary and secondary markets. This diversification allows to further analysed the potential technology scalability to different operational contexts;
- Data Availability: as one of the highlighted research limitations concern limited data availability and high confidentiality related to anti-counterfeiting strategies, one of the main case-selection criteria concerned the availability of sufficiently documented and accessible data on such cases. Considering both bibliography, a total of 36 references were identified:
  - Moncler Group: 12 references including articles, reports and web sources;
  - Aura Blockchain Consortium: 13 references including articles, reports and web sources;
  - Entrupy: 11 references including articles, reports and web sources.

- Potential integration with complementary technologies: particularly relevant considering the increasing convergence of anti-counterfeiting technological architectures, each selected case study was identified considering their potential interoperability with other technological frameworks.

The empirical investigation was conducted in the period from April to May 2026.
To support the empirical analysis, the primary databases employed for the analysis of each representative case study is represented by the official corporate website of the brand or technology analysed. The identified sources of data include company financial statements and non-financial reports, statistics and other data in support of technology implementation. Additional research databases include Google and industry reports produced by major consulting firms, including McKinsey & Company and Deloitte.

3.2. IIoT: the case of Moncler Group

The Moncler Group is an Italian multinational holding group specialised in luxury outwear and apparel. Operating at the crossroad between technical performance and fashion design, the Moncler group and its brands are differentiated for their deep commitment to product innovation, advanced material search and the consistent objective of mediating functional excellence with aspirational luxury. As of today, the group counts two maisons, Moncler and Stone Island, both positioned within the luxury casualwear segment.

Figure 12: Logo of the Moncler Group (source: monclergroup.com)

Moncler was founded in 1952 in Monestier-de-Clermont, France, initially established as a manufacturer of sleeping bags and mountaineering equipment for alpine expeditions. Over the years, Moncler gradually specialised in the production of high-performance down jackets (i.e., lightweight and highly insulating coats made from waterproof technical fabrics and filled by duck under-feathers). The brand's first significant turning point is represented by the expansion of the 1980s, when the iconic Moncler down jacket became emblematic in the emerging urban subculture known as "i paninari". This subcultural movement, originated in Milan and gradually spread across other major Italian cities, was characterised by a strong orientation towards consumerism, branded fashion and the adoption of globalised logos and symbols as markers of personal identity. Within this context, the Moncler down jacket, appreciated for its distinctive shiny and colourful fabrics, eventually became Moncler's signature product and primary source of brand recognition worldwide.

The brand's transition towards a luxury positioning was accelerated by the acquisition of the brand by Italian entrepreneur Remo Ruffini in 2003. Since the acquisition, Moncler underwent a comprehensive repositioning strategy, shifting from a primarily technical and sportswear-oriented identity towards a more a more exclusive and fashion-oriented one, embodying the brand's slogan "born in the mountains, lives in the city". This repositioning involved the implementation of a selective distribution strategy and the development of high-end and haute couture collections presented during international fashion weeks.

Figure 13: Logo of Moncler (source: monclergroup.com)

Stone Island was founded in 1982 by Italian designer Massimo Osti in the Emilia Romagna region of Italy. The idea behind the creation of Stone Island was the creation of a laboratory for textile experimentation, material innovation and manipulation. Inspired by the worn texture and looks of military uniforms, the practice of garment dying pioneered by Osti has been central to Stone Island's technical innovation. The key innovation has been represented by the exploration of new techniques to simulate natural material aging, creating fake worn and vintage looks, obtained primarily by processing fabrics and finished clothing with acids, enzymes and dyes. Another emblematic brand identifier is represented by the compass rose badge introduced in 1983, functioning as a removable parch sewn to the left sleeve.

Stone Island was officially acquired by the Moncler Group in 2021, representing a significant step in the group's long-term strategy of building a portfolio of luxury brands with strong community-driven identities. The acquisition has driven a significant international expansion that allowed the brand to enter a luxury positioning.

Figure 14: Logo of Stone Island (source: monclergroup.com)

From a financial point of view, the group reported a total annual gross revenue reaching €3,13 billion in 2025, with a registered increase of 1% with respect to 2024. Considering the single brands within the group, Moncler registered revenues for €2,72 billion, while Stone Island registered revenues for €411,2 million (source: Moncler – Annual Financial Report 2025).

By making an in-depth analysis of the Moncler group and its brands, their history and heritage, their mission, vision and core values, it is possible to identify some common patterns that bring them together:

- <u>Material and product innovation:</u> as already mentioned, the preservation of brand heritage and brand identity is not in conflict with continuous design renewal and material experimentation, prioritizing artistic expression and vision.
- <u>Connection to strong subcultural communities</u>: the connection to loyal subcultural communities is grounded non only in aesthetic appreciation, but also in genuine appreciation of craftsmanship and technical differentiation.
- <u>Growing responsibility</u>: both brands highlight necessity of considering social and environmental consideration and sustainability compliance in shaping decision making, operation and processes across organization. All these factors appear essential determinants of long-term success and in the creation of shared value.

3.2.1. Analysis of the technology implemented

Operating in more than 70 countries around the world, the Moncler Group has progressively integrated sustainability, traceability and anti-counterfeiting measures into its corporate governance framework. In particular, the Group's Corporate Risk Management department is responsible for implementing policies aimed at ensuring compliance with national and international regulations concerning ESG due diligence, product traceability and DPPs. Moreover, to strengthen IPR protection and to prevent and mitigate the risks associated with luxury counterfeiting, the IPR and Brand Protection department collaborate with customs authorities, suppliers, certifying bodies and other service providers to ensure a secure and reliable authentication and end-to-end traceability (source: Moncler - Consolidated non-financial statement 2020). In this context, considering the growing sophistication of counterfeit products, the Moncler Group has encouraged its brands to adopt increasingly advanced technological solutions. Such authentication-traceability systems, based of IoT, DPPs, Blockchain and AI, reflect hence the phygital transformation within the luxury-fashion sector.

A particularly advanced authentication-traceability infrastructure has been introduced by **Moncler** starting from the Spring/Summer 2016 collection, when the brand implemented a system combining RFID, NFC and QR code technologies. As today, all Moncler products feature a RFID-based system that assigns each garment with a unique alphanumeric code, associated with both a QR code and an embedded NFC tag. The encryption method through which these identifiers are generated makes them non-predictable and extremely difficult to replicate using traditional encoding systems. Moreover, through the official Moncler authentication platform, this phygital system allows consumers to verify the authenticity of such labels and to obtain an authenticity certificate for the product.

The integration of RFID, NFC and QR codes into a single IoT ecosystem significantly enhanced Moncler's ability to monitor supply-chain traceability and post-sale traceability:

- RFIDs enabled wireless identification and inventory tracking throughout logistics and distribution operations;
- NFCs facilitated CRM and a greater consumer engagement through the enhanced sophistication of digital twins and DPPs;
- QR codes enabled a more direct and immediate access to digital product verification platforms and product information.

Moreover, this increasingly integrated IoT systems has enabled Moncler to implement a more precise monitoring of changes of ownership, allowing consumers to easily retrieve authenticity certificates also in in second-hand and other secondary markets (source: NFC anti-counterfeiting - Moko).

The activation of these anti-counterfeiting protocols is accelerated before commercialization, during final qualitative inspections of final products. During this final examination stage, aimed at guaranteeing quality assurance, labelling and functionality of each garment, the complex anti-counterfeiting protocol is verified and the final authentication system for consumers, enabled through the IoT systems previously mentioned, is activated.

A similar, yet distinct, authentication-traceability infrastructure has been implemented by **Stone Island**, which has introduced a more structured system starting from the Spring/Summer 2014 collection. Stone Island's approach to digital product authentication is articulated through a long-term partnership with Certilogo ®, an Italian platform for product authentication the fashion and luxury sector.

Figure 15: Logo of Certilogo ® (source: certilogo.com)

The technical architecture of Certilogo ® is governed by "Secure by Design™", a security framework that directly manages interconnected industrial processes. Ensuring secure product authentication and ID certification, the technological framework also enables to proactively intercept, recognise and manage cloned and fake product IDs on counterfeited and illicit products. It also enables brands to recover stolen sales lost to counterfeiters. The "Secure by Design™" system relies on digital product identifiers, represented by a unique 12-digit CLG (Certilogo ®) code and a corresponding QR code, embedded into garment labels during the manufacturing process. These identifiers work as phygital systems bounding the tangible product to their digital identity record, allowing consumers to verify product authentication-traceability by scanning the label on the official Certilogo ® platform, both before and after point of purchase (source: certilogo.com).

A particularly significant feature within Certilogo ®'s authentication-traceability system concerns its Fraud Detection System, based on AI for verifying product authenticity and to detect and manage counterfeit or illicit products. The convergence of IoT systems with the real-time data collected through AI-enabled systems provide a better strategy to respond to the challenges of luxury counterfeiting, enabling the platform to detect anomalous usage patterns and adapting its authentication responses accordingly. Overall, this systems enables to enrich CRM strategies through increasing engagement, trusted traceability and through end-to-end product-lifecycle monitoring.

3.2.2. Benefits & Limitations

The adoption of the IoT-enabled authentication-traceability system by Moncler generates benefits that extend beyond the primary objective of contrasting counterfeiting. From a supply-chain perspective, the integration of embedded RFID tags enables continuous product traceability from product manufacturing and logistics, to product distribution and after-sale monitoring. The linkage between the RFID tags and the authentication infrastructure reduces information asymmetries between production and consumption and enables Moncler to monitor both the geographic and commercial circulation of its products overtime, including circulation in secondary markets and resale markets.

Moncler’s authentication systems and NFC and QR-code technologies extend beyond supply-chain optimization, supporting also other strategic objectives related to direct consumer engagement. By registering the purchased product on Moncler’s official authentication platform, consumers voluntarily disclose information about their identity and purchasing context. The information generated through user registration represents useful data that the brand can leverage for CRM purposes, to enhance consumer engagement and to establish phygital systems for a persistent direct relationship with the end user.

According to annual non-financial consolidated statements of the Moncler Group, the enforcement of Moncler’s authentication-traceability system has had measurable results in terms of operational effectiveness, counterfeit prevention and mitigation. Moncler’s 2020 non-financial report highlights that constant online monitoring and the implemented anti-counterfeiting strategies allowed the brand to intercept more than 82.600 online auctions for counterfeit products, to close nearly 425 websites, 17.00 pages and remove more than 45.000 social-media posts reporting on counterfeit products (source: Moncler - Consolidated non-financial statement 2020). By 2023, Moncler was able to intercept more than 94.000 auctions for counterfeit product, to close nearly 500 websites, 39.000 pages and 127.000 social-media posts reporting on counterfeit products (source: Moncler - Consolidated non-financial statement 2023). The evolution of this trend highlights the effectives of the implemented framework, and how the incremental integration of different technologies such as IoT, Blockchain and AI, increasingly generating benefits than extend also beyond the primary anti-counterfeiting functions.

Considering the anti-counterfeiting measures adopted by Stone Island, the implementation of Certilogo ®’s “Secure by Design™” framework has been a key to brand protection, enabling the brand to track and trace authentic products and any patterns in counterfeiting arising in the market. The continuous stream of authentication data generated through consumer interactions creates a network of information that enables Stone Island to calibrate its enforcement priorities depending on the geographical concentration of counterfeit activity and on the emergence of more sophisticated counterfeiting techniques.

Certilogo ® also provides significant advantages from a CRM perspective. Through consumer engagement with the authentication platform, Stone Island is able to strengthen direct communication with consumers, drive traffic towards official brand channels and improve after-sales service delivery. In this context, Certilogo ® operates as a relational ecosystems through which Stone Island reinforces trust, transparency and long-term consumer loyalty.

Another critical advantage of Certilogo ® concerns the technological independence of the system, addressing the primary vulnerabilities of other IoT systems. Moreover, the ability to detect clones, rather than simply providing label scanning as proof of authenticity, substantially raises both physical and technological barriers for counterfeiters.

According to annual non-financial consolidated statements of the Moncler Group, the enforcement of Stone Island's authentication-traceability system has had measurable results in terms of operational effectiveness, counterfeit prevention and mitigation. Similarly to Moncler, starting from the Fall/Winter 2020 collection, Stone Island has used Certilogo ® to offer consumers authentication services for all Stone Island and Stone Island Shadow Project product (excluding footwear and some type of accessories), providing secure smart labels for over 25 million products. Combined with the constant monitoring of e-commerce platforms, Stone Island was able to intercept more than 45.000 auctions for counterfeit product, to close nearly 190 websites, 18.000 pages and 86.000 social-media posts reporting on counterfeit products since 2014 (source: Moncler - Consolidated non-financial statement 2023).

Despite the effectiveness and the benefits registered by Moncler, the IoT framework implemented presents several structural limitations, related to the hardware and material infrastructures inherent to its adoption. As highlighted by literature, a key limitation of IoT systems is the technological obsolescence of embedded tags and the consequent overtime degradation of stored data. Jointly with the high dependency on input data precision, these infrastructural limitations represent a risk to brand security and to counterfeit adaptation. Deceptive counterfeit manufacturers can easily implement NFC replicas linking directly to sophisticated clone websites, overcoming official verification processes. As the clonability of physical markers represent a primary vulnerability of phygital systems, although RFID systems and intelligent labels are aimed at ensuring secure product authenticity and traceability, Moncler is not yet immune from the persistent threat of sophisticated replication.

Considering the partnership between Certilogo ® and Stone Island, the implementation of the “Secure by Design™” framework also presents measurable limitations. Similarly to Moncler, the risk of duplication represents a consistent limit of IoT-enables systems, highlighting how such systems cannot be implemented as a self-sufficient countermeasure to prevent and mitigate luxury counterfeiting. Furthermore, as the system’s effectiveness depends on active consumer participation in the authentication and validation process, consumers who do not activate Certilogo ®’s ID receive no authentication benefits. This activation gap is particularly relevant in secondary markets, where products frequently circulate without direct engagement from original purchasers.

3.2.3. Scalability Potential

The IoT-based systems implemented by both Moncler and Stone Island represent overall a scalable technological solution that can be potentially extended across the luxury fashion industry and the broader fashion supply chain.

From a technical point of view, the RFID-NFC infrastructures adopted by Moncler and the "Secure by Design™" by Certilogo ® are based on standardised and interoperable technologies, capable of furtherly integrating other technologies and of integrating existing manufacturing, logistics, supply chain and CRM systems. The modular architecture of such IoT infrastructure enables their implementation across brands operating at different scales and with different positionings, overcoming the structural complexity of globalised fashion supply chains.

Considering the specific case of Certilogo ®, empirical evidence demonstrates the scalability potential of Certilogo ®'s framework through useful empirical evidence on its commercial adoption trajectory. Since its foundation in 2006, Certilogo ® has collaborated with over 80 fashion and luxury brands, generating secure digital identities for over 570 million products worldwide. Through its product digitalization and its authentication services, the platform is able to enhance trust, strengthen engagement and support phygital transactions. This also demonstrates how IoT can facilitate industrial scalability without requiring brands to invest in proprietary authentication assets and infrastructures internally.

Despite the scalability potential, as highlighted by literature, one key scalability limitation of the authentication-traceability framework implemented by the Moncler Group is related to the hardware-centric authentication model based on NFC and RFID components. From a financial point of view, as the implementation of IoT for product authentication and traceability requires considerable investments, the scalability of such IoT systems is closely linked to the relationship between implementation cost and product value. As the adoption of IoT systems entails investments in both hardware and software integration, a technological transaction becomes more economically viable for brands whose average selling price is greater than the average unitary cost of authentication. Moreover, empirical evidence shows that whenever such hardware and software systems are not implemented by the brand first hand or in primary markets, its implementation is secondary and second-hand markets becomes inappropriate, if not unfeasible (source: Certilogo ®).

Ultimately, this empirical analysis suggests that the effectiveness of IoT-based anti-counterfeiting systems do not primarily depend on the specific physical technologies employed, but rather on the digital security infrastructure within which such technologies operate, ensuring data encryption, fraud detection and resistance to cloning and data manipulation.

3.3. Blockchain: the case of AURA Blockchain Consortium

The Aura Blockchain Consortium is a non-profit association of luxury brands investing in technologies aimed at advancing the worldwide adoption of blockchain solutions for the Luxury Industry. Its aim is to improve the lifecycle of luxury goods, including buying, owning, selling, reselling and recycling, resulting in overall greater product utility via the enhancement of product transparency and traceability.

Figure 16: Logo of the Aura Blockchain Consortium (source: Aura Consortium)

The Aura Consortium is a collaborative initiative that seeks to create a balance between competition and collaboration among its members. Although each brand presents its unique values, craftsmanship and creativity processes, the Aura Consortium promotes the creation of shared decision-making processes, aimed at generating value for all stakeholders through trust, sustainability, authenticity and innovation. Moreover, being a non-profit organization, any revenue generated by the Aura Blockchain Consortium is reinvested into the consortium to support its mission and operations, benefitting all associate members.

The Aura Blockchain Consortium was founded in April 2021 from the joined venture between LVMH, Prada Group and Richemont, represented by Cartier. Later in October 2021 the OTB group joined the Aura Blockchain Consortium as a founding member.

LVMH (Louis Vuitton – Moet Hennessy) is a French multinational holding group that specializes in luxury goods. Founded in 1987, LVMH holds 75 maisons across 6 different business sectors, including Fashion & Leather Goods, Wines & Spirits, Perfumes & Cosmetics, Watches & Jewellery, Selective Retailing, and Other Activities. Considering the business sector of Fashion & Leather Goods, LVMH counts 14 maisons with a total annual gross revenue reaching €37,77 billion in 2025, with a registered decline of 8% compared to 2024 (source: LVMH). Considering the business sector of Fashion & Leather Goods, the LVMH associate members of Aura Blockchain Consortium are Louis Vuitton, Christian Dior and Givenchy. Other brands from other business sectors are also associate members in the Aura consortium, namely Bulgari and Hublot from the Watches & Jewellery business sectors, and Hennessy from the Wines and Spirits business sector.

Figure 17: Logo of the LVMH group (source: LVMH.com)

The **PRADA GROUP** is a leading player in the luxury industry, known for combining tradition, innovation and engagement with the dynamic cultural evolution of the society. Founded in 2003 as a structured multinational holding group, the PRADA GROUP owns several prestigious brands across 3 main business areas, including Fashion & Leather Goods, Sports – Competitive Sailing, and Food & Beverage. Namely, the brands held by the group are Prada, Miu Miu, Versace, Luna Rossa, Church's, Car Shoe and Marchesi 1824. The Prada Group reported total net revenues of €5,72 billion, with a registered increase of 9% compared to 2024 (source: PRADA GROUP). Considering the brands owned by the PRADA GROUP and considering the business sector of Fashion & Leather Goods, only Prada and Miu Miu are official associate members of the Aura Blockchain Consortium.

Figure 18: Logo of the PRADA group (source: pradagroup.com)

RICHEMONT is the one of the world's leading luxury multinational holding groups, particularly renowned for its dominance in the market for Luxury Watches & Jewellery. Founded in 1988 by the South-African entrepreneur Johann Rupert as a spin-off from the Rembrandt Group, RICHEMONT consolidated in the market for Luxury Watches & Jewellery, disinvesting from other sectors like tobacco. Richemont operates a portfolio of 24 maisons, subdivided across several business sectors, including Jewellery, Specialist Watchmakers, Fashion & Leather Goods and Selective Retailing. In 2025, the group registered total sales for €21,4 bullion, with a registered increase of 8% compared to 2024 (source: Richemont). Richemont, under representation of Cartier (i.e., operating in the sector of Luxury Jewellery), is one of the founding members of the Aura Blockchain

Consortium. However, to this day, Cartier remains the only associate Maison to the Aura Consortium.

Figure 19: Logo of the RICHEMONT group (source: richemont.com)

The **OTB Group**, acronym for “Only the Brave”, is an Italian multinational luxury group, known for its unconventional approach to Fashion and its strong emphasis on creativity and innovation. Founded in 2002 by the Italian entrepreneur Renzo Rosso, founder of Diesel ® (1978), the OTB Group owns 8 brands subdivided between the Fashion & Leather Goods and the Product, Licensing & Distribution business sectors. In 2025, the OTB Group registered €1,7 billion in gross sales, with a registered decline of 4,8 % compared to 2024 (source: OTB). Although it joined the Aura Blockchain Consortium only in October 2021, 6 months after its foundation, the OTB Group is part of the founding committee of the Aura Consortium. Among its maisons, only 3 brands are official associate members of the Aura Blockchain Consortium, namely Maison Margiela, Marni and Jil Sander.

Figure 20: Logo of the OTB group (source: OTB.net)

By making an in-depth analysis of the founding members of the Aura Blockchain Consortium, their history and heritage, their mission, vision and core value, it is possible to identify some common patterns that bring them together:

- Heritage, Authenticity and Innovation: the core values of each founding member highlight the necessity to maintain and preserve the historic heritage of the maisons and their savoir-faire. Nonetheless, the preservation of traditional expertise and craftsmanship does not come in contrast with experimentation of new materials, new technologies and new business models that are aligned with the brand’s DNA.
- Creativity: as already mentioned, the preservation of brand heritage and savoir-faire is not in conflict with continuous design renewal and experimentation, prioritizing artistic expression and vision.

- Quality and craftsmanship: being a pillar of luxury manufacturing and marketing, founding brands present a strong focus on product excellence and knowhow, aiming at sustaining and protecting brand authenticity and brand image.
- Entrepreneurial spirit: particular attention is paid to the empowerment of individual maisons within these multinational holding groups. A common value is the necessity to establish decentralised structures, establishing agile brand governance and Open Innovation while guaranteeing the preservation of the identity of each individual brand.

3.3.1. Analysis of the technology implemented

The Aura Blockchain system consists in a multi-nodal blockchain system, secured and verified by ConsenSys technology (i.e., a decentralised blockchain production studio, founded in 2014) and Microsoft. It enables direct-to-consumer access to product traceability history and roof of authenticity through secure and non-reproducible data.

The Aura Blockchain Consortium provides a range of technological solutions designed to address diverse operational needs and business models within the Luxury Industry. In particular, the Aura Consortium offers brands the opportunity to experience both public blockchain (i.e., an open, decentralised, non-restrictive and distributed database, requiring a consensus algorithm for verifying transactions) and private blockchain (i.e., a closed, restricted and permissioned system in which each node has a different level of accessibility and authority in verifying transactions, enhancing privacy and control). This hybrid approach enables to create a space where brands can develop trust with their customers and engage them in new experiences (source: Solutions - Aura Blockchain Consortium).

Among its core offerings, the Aura Consortium focuses primarily on two technological applications: the development of DPPs and the creation of a system for Digital Collectibles. The **Aura DPP** frameworks provides brands a comprehensive solution to comply with EU Regulation 2024/1781 (ESPR), introducing the mandatory implementation of DPPs within the EU. At the same time, the system offers a flexible solution for brands, allowing them to tailor the technology to their ecosystem, for instance by implementing either public or private blockchain systems. The Aura DPPs enable multiple functionalities, including product authentication via Aura Certification, supply chain traceability and enhanced transparency across the entire product lifecycle (i.e., from material sourcing to waste and end-of-life management). Additionally, Aura DPPs facilitate the creation of products' digital twins, which are at the basis for Digital Collectibles. Such digital assets enable functionalities such as proof-of-ownership, warranty management and insurance, transfer of ownership and resale processes. Overall, the functions of Aura DPPs facilitates customer engagement and the creation of brand communities. In the context of DPPs, the Aura Consortium provides *Aura SaaS* (Software as a Service), a user-friendly traceability platform integrating a private blockchain infrastructure. This solution is tailored to aide brands in their day-to-day operations, including supply-chain management, customer service, manufacturing processes, logistics and sustainability practices.

AURA SAAS

Figure 21: Logo of Aura SaaS (source: Aura Consortium)

In addition to DPPs, the Aura Consortium has introduced an innovative solution in the domain of consumer engagement and loyalty management, through the implementation of NFTs (Non-Fungible Tokens) and SBTs (Soul-Bound Tokens). These technology facilitate the creation of **Digital Collectibles** which, as already mentioned, enhances the value of physical products by generating a digital twin. Such digital assets help brands to enhance perceived value and strengthen the relationship between brands and consumers. The introduction of this form of phygital system into loyalty programs can symbolize a diverse array of benefits, including after-sales services, repair privileges, ownership certifications, loyalty rewards and many others. For instance, NFT-based membership can grant consumers early access to new product launches, invitations to exclusive events and many other personalised experiences. In the context of Digital Collectibles, the Aura Consortium offers Aura MTM (Multi Token Minter), a solution that enables brands to collect tokens on public blockchains, distributing them to any digital wallet. Acting as a bridge between Web2 and Web3 environments, MTM allows to create NFTs and SBTs and customised smart contracts (source: Solutions - Aura Blockchain Consortium).

AURA MTM

Figure 22: Logo of Aura MTM (source: Aura Consortium)

3.3.2. Benefits & Limitations

Affiliation to the Aura Blockchain Consortium offers Luxury Brands the possibility to access advanced infrastructures aimed at product authenticity, supply-chain visibility and customer engagement. Considering the wide range of blockchain solutions offered by the Aura Blockchain Consortium, the core functions of its blockchain infrastructures can be summarized into 3 key dimensions:

- **Transparency**, referring to the ability of Aura Blockchain, secured and verified by ConsenSys technology and Microsoft, to share verifiable and immutable data enhancing product authenticity;
- **Traceability**, referring to its ability to monitor and record the complete lifecycle of a product;
- **Tradability**, referring to the integration of NFT-based systems in aiding transfer of ownership and resale processes of digital assets (source: Blockchain in Retail Fashion and Luxury | ConsenSys).

Considering the highlighted functionalities of Aura Blockchain's solutions, affiliation to the Aura Consortium entails significant opportunities and benefits for luxury brands, which can be summarised into 7 key points:

- **Luxury Authentication:** Although counterfeit remains a persistent challenge, a strategic response lies in enabling an accessible product authentication. In practice, Aura's authentication systems involve the integration different tools, including QR codes, RFID, NFC, Artificial Intelligence and other technologies in support of authentication processes. Upon purchase, consumers can scan the product's identifier to access a secure digital record of the product, through which it is possible to verify the ownership of the product and to get detailed information of the product lifecycle. By providing stakeholders with the tools to verify product authenticity, Aura Blockchain reduces perceived value of counterfeit goods and diminishes the attractiveness of the luxury industry as a target for counterfeiting.
- **Supply chain transparency:** Despite recent progress in supply chain transparency, significant limitations remain. As highlighted by the Fashion Transparency Index 2022, the 250 largest fashion brands and retailers achieved an average transparency score of only 24% (source: Fashion Transparency Index). In this context, Aura Blockchain offers a scalable and integrated solution to enhance transparency and traceability. The offered Distributed Ledger Technology (DLT) allows participants to

independently validate transactions, creating a comprehensive blockchain report of the product's lifecycle, with data on material sourcing, manufacturing processes, maintenance history and environmental impact.

- **Transfer of ownership and resale:** According to an analysis conducted by Bain & Company, the second-hand luxury market gas reached a market value of €33 billion in 2021, representing an increase of 65% compared to 2017. In contrast, sales in primary markets experienced a growth of only 12% during the same period. Given the expected sales growth of Luxury-Fashion goods in second-hand markets, the Aura Consortium plays a critical role in reinforcing trust and verifiability across both primary and secondary markets. Aura Blockchain systems can ensure that product traded within secondary markets are associated with comprehensive digital records, including data on maintenance and repair history, ownership history and provenance. Such solutions significantly enhance traceability even after purchase and strengthen the value and credibility of pre-owned Luxury-Fashion goods (source: Aura Blockchain Consortium)
- **Personal relationship:** The implementation of Aura Blockchain can significantly enhance consumer relationships by enabling new channels of engagement, strengthening customer loyalty and facilitating the development brand-centric communities. From a CRM (i.e., Customer Relationship Management) perspective, one key strategic application of Aura Blockchain consists in the integration of NFTs into loyalty programmes: NFTs can be leveraged to establish token-based rewards systems or to create early product-trial programmes, enabling brands to foster a deeper engagement while supporting co-creation and innovation processes (source: Aura Blockchain Consortium).
- **Accessible and secure platform:** As highlighted by both industry reports and academic literature, a key boundary of blockchain adoption is the risk of unintentional data exposure to competitors and counterfeiters. Such concerns regarding data security often discourages brands from fully implementing such solutions. In this context, Aura Blockchain offers an accessible and user-friendly approach to data protection through an advanced encryption system. This system, combines with decentralised data-validation processes, ensures enhanced control over data access and integrity. As a result, Aura Blockchain provides a highly secure infrastructure through which data is immutably secured:

- **Open Innovation:** The Aura Blockchain Consortium is a collaborative initiative that seeks to create a balance between competition and collaboration among associate members. Although each brand presents its unique values, craftsmanship and creativity, the Aura Consortium encourages associate brands to collaboratively develop innovative responses to shared risks and challenges, establishing common standards and fostering collaborative governance frameworks.
- **Common standards:** The unprecedented collaboration among these groups and the development of an advanced technological innovation helped to raise the industry standards in sustainability practices and product sourcing. Moreover, Aura Blockchain can be leveraged to help brands to comply with emerging EU normative Corporate Sustainability Due Diligence (EU Directive 2024/1760) and ESG rating (EU Regulation 2024/3005).

Although affiliation to the Aura Consortium presents significant opportunities for luxury brands, affiliation also entails a series of structural challenges and limitations that might affect the extent to which Luxury Brands can fully leverage it as a countermeasure against counterfeiting. Such limitations are subordinated to operational, financial and strategic trade-offs, reflecting the challenges related to implementation costs, data governance and the potential constraints of collaborative frameworks.

From a financial point of view, although the Aura Blockchain does not impose a fixed membership fee, affiliation and participation to the Aura Consortium requires significant financial investments in blockchain integration, the integration of related IIoT systems and the adaptation of Operational and Business Models to the collaborative governance of the consortium.

From ad operational point of view, a second important limitation is represented by the dependency on ecosystem adoption and network effects. As with most blockchain-enabled systems, the effectiveness of Aura's infrastructures is contingent to the scale of adoption and the number of affiliated participants across value chains. As a consequence, uneven adoption might reduce the overall effectiveness of this technology.

In addition to the scalability limitations, another challenge is represented by Aura's collaborative governance and strategic alignment. While the Aura Consortium fosters the establishment of commonly shared standards and protocols, the coexistence of competing brands within the same framework might lead to potential tension in decision-making processes. Divergent strategic interests might limit the effectiveness of technology adoption. At the same time, shared standards and protocols might constraint brand differentiation, potentially diluting distinctive brand identity, essential in luxury positioning.

Ultimately, a critical limitation concerns data governance and information sensitivity. Despite the employment of encryption and DLT systems, the perceived risk of data leakage can prevent supply-chain participants from fully engaging in the consortium's shared goals.

3.3.3. Scalability Potential

From an operational perspective, the integration of Aura Blockchain as a DLT enables the replacement of traditional outdated traceability systems with infrastructures that allow the simultaneous access, validation, record of data. The transaction towards this networking and collaborative infrastructure can lead to measurable performance improvements for all supply chain actors, including the potential increase in trade volumes up to 15% (source: Blockchain in Retail Fashion and Luxury | ConsenSys). Such results make Aura Blockchain a feasible and scalable solutions for all luxury brands willing to invest in technological infrastructures for counterfeit prevention, ESG compliance and overall ethical production and consumption.

As Millennials and Gen Z account for approximately 85% of global luxury sales, Luxury Brands are increasingly allocating financial resources to address the sector's slowdown, partially driven by the loss of aspirational consumers. In this context, the operational and financial benefits of Aura Blockchain become a strategic solution to enhance product utility and to increase the demand for product transparency, sustainability and authenticity. As a consequence, Aura's infrastructures contribute to reinforcing brand credibility and trust.

In financial terms, the integration of Aura Blockchain can also contribute to substantial cost reductions by improving data management processes, optimizing supply chain coordination and reducing risks associated with counterfeiting and grey markets (source: Blockchain in Retail Fashion and Luxury | ConsenSys).

From a financial point of view, there is no standardised membership fee for joining the Aura Blockchain Consortium. Entry conditions are negotiated case-by-case, making it a highly flexible and scalable solution for brands withing the Luxury Fashion Industry. Furthermore, being a non-profit organization, any revenues generated by the Aura Blockchain Consortium are reinvested into the consortium to support technological development, operational activities and at maximizing the benefits for all associate members.

Despite lacking a fixing membership, participation to the Aura Blockchain Consortium entails economic commitment, primarily associated to the implementation of blockchain-based solutions. Such commitments include licensing fees for technological services such as Software-as-a-Service (SaaS) platforms and other operational expenditure (Bagnoli et al., 2022).

From a strategic perspective, the adoption of Aura Blockchain's infrastructures can support the transaction towards outcome-oriented Servitization Models. Such Business Models undertake a consumer-centric approach, where the value is increasingly derived from services and digital infrastructures rather than sole physical products. These Servitization Models, which are an evolution of Phygital systems, can eventually lead to product dematerialization, through the creation of digital twins, and to product democratization, facilitating a broader access to Luxury Goods for aspirational consumers (Bagnoli et al., 2022).

3.4. AI: the case of ENTRUPY

As highlighted by both academic literature and industrial reports, the implementation of AI-enabled systems for Luxury-Fashion authentication appears to be primarily consumer-oriented, rather than directly integrated into operational or supply chain processes. Consequently, although AI adoption is associated with substantial economic benefits, including projected increases in cashflow and long-term ROI, its implementation by fashion manufacturers remains limited compared to other solutions such as IoT or Blockchain. Nonetheless, it is essential to examine how technological innovation can be implemented within secondary and resale markets, rather than exclusively in primary distribution channels. Analysing the role of AI-driven authentication can indirectly generate strategic benefits for luxury brands by reducing information asymmetries, enhancing consumer trust and limiting brand-equity erosion consequent to Luxury-Fashion counterfeits.

Entrupy is a New-York-based technology company that provides an AI-based Machine Learning Algorithm for product authentication and traceability within the Luxury Fashion Industry. Founded in 2012 by Vidyuth Srinvasan and Ashlesh Sharma, Entrupy operates as a provider of product authentication and fingerprinting services for a wide range of stakeholders, including resellers, retailers, online marketplaces, brand manufacturers and luxury consumers.

The technology developed by Entrupy emerged from a four-year extensive research conducted in collaboration with New York University, with the objective of addressing the persistent a globally extensive issue of product counterfeiting. More specifically, the innovative technology introduced by Entrupy emerged as a response to the lack of a scalable, objective and affordable alternatives to Direct Authentication methods in the Luxury Fashion Market.

entrupy

Figure 23: Logo of Entrupy (source: entrupy.com)

Commercially launched in 2016, Entrupy leverages an advances image recognition technology, analysing multiple high-resolution and highly-magnified photographs of the product. Such images are cross-referenced against an extensive database of data on both authentic and counterfeit items, allowing to identify and deliver product authentication with a level of accuracy approaching 99,86% (source: Entrupy).

Entrupy's technological framework integrates complementary functionalities of authentication and fingerprinting into a comprehensive model aimed primarily at secondary markets. The framework starts with product authentication, providing additional quality assurance before the product enters the market. In doing so, product authentication enables to accelerate resale transactions, increase consumer trust and enhance operational reliability. Product authentication is then integrated by product fingerprinting, creating a continuous chain of verification throughout the product lifecycle. By assigning a digital identity to each item, the system enables a continuous traceability across transaction stages, reducing the vulnerabilities related to post-sale counterfeit substitution and fraudulent returns.

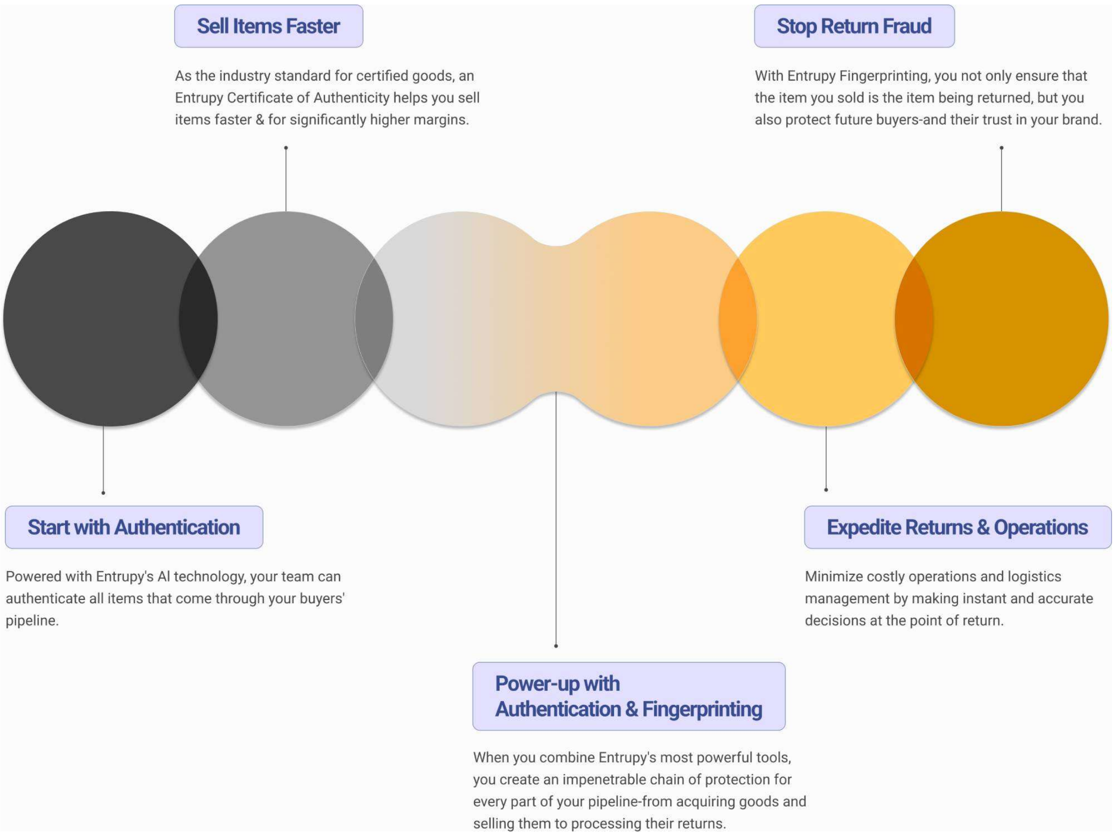

Figure 24: Entrupy's security enforcement strategy (source: entrupy.com)

The authentication-traceability framework implemented through Entrupy demonstrates how AI-driven technologies can support not only counterfeit mitigation, but also broader operational optimization and lifecycle management for all Luxury Fashion Products. Another significant advantage is represented by the scalability of the technology across multiple product categories, including handbags and accessories, sneakers and footwear, watches and, since 2025, apparel. Such versatility also enhances the scalability of the technology across different segments and levels of product positioning.

Considering the Luxury segment, in 2025 Entrupy registered over $3,7 billion worth of products submitted for authentication, identifying a total authenticated value of $3,34 billion (91,9% of total submissions) while detecting $294 million worth of unidentified or counterfeited goods (8,1% of total submissions). These results reflect a marginal improvement of 0,3% compared to 2024, although the absolute volume of counterfeits detected continued to rise il line with the platform's growth (source: Entrupy | State of Fake Report – 2025 & 2026).

Conversely, the Apparel category, introduced only in 2025, recorded the highest counterfeit penetration rate of any category Entrupy has ever tracked since the publication of its first report in 2019. The system was able to authenticate only 65,15% of scanned items, leaving the remaining 34,85% of items as unidentified or counterfeited. Such data demonstrates a more consistent pattern for counterfeiting in the apparel sector, making it the riskiest category by a significant margin (source: Entrupy | State of Fake Report – 2026).

Considering the wide range of product categories and segments covered by Entropy's authentication system, these statists indicate a growing trend in product authenticity among verified products, suggesting hence a progressive improvement in authentication performance and operational efficiency.

3.4.1. Analysis of the technology implemented

As counterfeiting is increasingly more sophisticated, Entrupy's objective is to offer a science-based approach, powered by Machine Learning Algorithms that are constantly self-improved and adapted to the ever-changing conditions of the luxury and apparel market.

As previously mentioned, Entrupy's technological framework integrates complementary functionalities of authentication and fingerprinting into a comprehensive model, aimed primarily at secondary markets.

Entropy's Authentication system consists in an AI Machine Learning technology that objectively assesses a product's authenticity by analysing multiple high-resolution and highly-magnified photographs of the product examined. The system encompasses different product categories:

- Luxury Authentication, covering over 20 top luxury brands, consists in the validation of mainly handbags, watches and all sorts of luxury accessories;
- Sneaker Authentication, encompassing all kinds of luxury and premium footwear, from sneakers, to heels and formal shoes;
- Apparel Authentication, introduced in 2025.

The Authentication process starts by scanning a magnified photograph of the product under examination by using the Entrupy scanning device or the Entrupy mobile app. Once the product is scanned, the Machine Learning algorithm processes the pictures comparing them against millions of records to provide accurate authentication. Statistics show that 95% of all registered authentications take under 1 minute to verify (source: Entrupy | State of Fake Report – 2026).

The algorithm classifies an item as "unidentified" whenever the AI system detects enough inconsistencies in product materials and structure that it is not possible to classify the product as authentic, leading hence to the identification of a counterfeited item (source: Entrupy | State of Fake Report – 2025).

Entrupy's AI technology delivers product authentication with a level of accuracy approaching 99,86%, with each new datapoint registered contributing at continuously improving and adapting the algorithm to the ever-changing world of luxury goods and to the increasing sophistication of counterfeit items. To overcome the 0,14% error rate and to protect users from the minimum probability of misidentifying a counterfeit product as authentic, since 2025 Entrupy has introduced a 100% financial guarantee. This solution serves as a warranty for every authentication submission, aiming at protecting users from related financial losses and therefore aiming at reflecting the high accuracy standard set by the service provider (source: Entrupy | State of Fake Report – 2026).

Inside Entrupy's Authentication System, a lew layer of examination accuracy is represented by Market Edge, an additional analytical feature designed to facilitate and support product pricing, product evaluation and product comparison for luxury resale markets. The analytical framework encompasses 3 layers:

- <u>Market Value</u>: focusing on the economic value of the product, the system enables to access real-time and 30-days minimum/maximum prices to support both users and resellers in determining the most appropriate price for buying and selling.
- <u>Market Grade</u>: focusing on the physical conditions of the product, the system provides users with a detailed report of the product examined, allowing also to justify product pricing.
- <u>Market Match</u>: by comparing the product under examination with similar alternatives, the system enables to identify and cross-reference the item considered, enabling to compare it across top marketplaces (source: entrupy.com).

Figure 25: Logo of Entrupy's Market-Edge system (source: entrupy.com)

The second service provided Entrupy's authentication-traceability framework is the Entrupy Fingerprinting technology, aiming at creating an intangible traceability system to product origin verification and fraud prevention. The technology encompasses:

- <u>Return Fraud Detection</u>: primarily indicated to resale-market consumers, the system aims at providing additional quality assurance at the point of sale, confirming that the item purchased matches the registered inventory. By providing instant confirmation of the product's identity, the system ensures that the product return ensuring that the product return has not been fraudulently substituted with a counterfeited one.
- <u>Supply-Chain Protection</u>: similarly to Blockchain technologies, the system creates a network for registering product transaction and verifying every block or touchpoint within the supply-chain and resale market.

3.4.2. Benefits & Limitations

A systematic advantage of Entrupy's AI system for luxury and apparel authentication and traceability concerns its non-invasive architecture. In contrast to IoT technologies, Entrupy's system does not require any physical modification or additional embedded component to the product under examination. Authentication and Fingerprinting are instead performed using highly-magnified images and Machine Learning algorithms trained to detected inconsistencies in product's physical features. This architecture eliminates the vulnerabilities related to IoT systems, such as tag clonability, and extends its scalability potential to products manufactured prior the introduction of embedded authentication infrastructures, including vintage items. Additionally, the system's architecture support authentication and traceability across multiple product categories, including handbags and accessories, sneakers and footwear, watches and, since 2025, apparel.

From an operational perspective, Entrupy reduces the costs, inconsistencies and personal biases related to Human Direct Authentication. While Direct Authentication presents a 15% error rate, Entrupy's 99,86% accuracy rate allows a reduction of both the costs and the error rate associated with counterfeit detection, while sustaining an examination scale not sustainable by human efforts (source: fashionunited.uk).

Moreover, Entrupy's Authentication Certificate and the analytical feature of Market Edge support operational decision-making by providing retailers and resellers with objective reports, allowing to analyse market benchmarks, to support pricing and enhance trust.

Another significant operational benefit is represented by Entrupy's Fingerprinting system and its application in Supply-Chain Protection and Return Fraud Detection. Its main objective is to safeguard the supply chain from the intrusion of fraudulent items at any stage of the product lifecycle, extending its benefits also to primary distribution channels.

From a financial point of view, one of the major benefits related to the adoption of Entrupy is its pricing architecture, making the technology accessible to a wide range of business sizes and authentication needs. For Luxury Authentication, monthly subscription starts from a minimum of 139$ per month with 5 authentications available, up to 1049$ per month with 50 authentications available. Subscription to Entrupy's Fingerprinting system requires an incremental subscription fee from 15$ up to 60$ per month, depending on the plan selected. Similarly, subscriptions to the Apparel Authentication system start from a minimum of 100$ per month with 5 authentications available, up to 800$ per month with

50 authentications available. For both Luxury and Apparel Authentication, Entrupy also offers flexible tariffs based on authentication volume. Such plans provide open APIs (Application Programming Interfaces) for integration with store systems and detailed monthly usage reports. Additionally, as the scanning infrastructures remain property of Entrupy throughout the subscription period, the system removes all capital expenditures related to hardware procurement (source: Entrupy.com).

Ultimately, by analysing Entrupy's Authentication and Fingerprinting systems, it can be inferred that the adoption of such AI and Machine Learning technologies in secondary markets generates a set of indirect strategic benefits also for primary markets. By reducing information asymmetries between buyers and sellers, Entrupy's system strengthens consumer trust and contributes to limiting the erosion of brand equity for Luxury Brands. The technology's institutional recognition by leading actors in the luxury sector provides a further support to its operational credibility. In 2019, Entrupy was selected by LVMH to participate in "La Maison des Start-ups", an acceleration programme focused on product authentication. Entrupy's participation to the programme signals additional institutional validation of the AI technology, reflecting the alignment between Entrupy's authentication capabilities and the strategic brand-protection priorities set by major luxury maisons (source: entrupy.com).

Although Entrupy provides significant advantages for its users, the Authentication system provides structural limitations that must be evaluated against its strategic and operational benefits. The main limitation of Entrupy's Authentication system is represented its hardware dependency. Although Entrupy's proprietary scanning devices benefits users by removing capital expenditures related to equipment procurement, hardware dependency might prevent smaller resellers and individual users from implementing the authentication system without a prior investment in the scanning infrastructure.

A second structural limitation concerns the limited secondary-market targeting strategy implemented by the technology. As Entrupy's Authentication and Fingerprinting systems are primarily designed to prevent counterfeits from entering secondary and resale markets, the technology has limited applicability to the upstream issues of counterfeit production and the penetration of counterfeit goods into primary distribution channels. As a consequence, the technology appears to be a more suitable solution for mitigation strategies, rather than counterfeit prevention strategies.

3.4.3. Scalability Potential

Entrupy's AI Authentication system presents a scalability potential that is structurally different from the IoT and Blockchain technological frameworks examined in the previous paragraphs. Rather than depending on physical modification or additional embedded component, as in IoT systems, Authentication and Fingerprinting are performed through Machine Learning algorithms trained to detected inconsistencies in product's physical features. The absence of additional physical markers and the minimal hardware required have significant implications for the technology's scalability, making product scanning possible for multiple product categories and for items manufactured before the existence of any digital authentication infrastructure. This approach shows the importance played by product-level markers and the intrinsic physical characteristics of Luxury Fashion Goods, compared to IoT and embedded holograms or tags which can be subject to replication (source. Forbes.com).

As already mention, product authentication is possible by scanning a magnified photograph of the product under examination. As every new datapoint registered contributes at continuously improving and adapting the Machine Learning algorithm, each product scan contributes at improving the model's accuracy for all users simultaneously. The increasing database creates a self-reinforcing mechanism, where every product scan generates greater accuracy, leading then to further adoptions of the system.

From a financial point of view, the subscription-based pricing strategy adopted by Entrupy removes all financial barriers to technology adoption, usually characterizing proprietary or in-house authentication infrastructures. Instead, the variety of subscription plans makes Entrupy's services more versatile and scalable, enabling businesses of any size to access the AI system at variable cost depending to their authentication volumes.

From a geographical point of view, the scalability and international applicability of Entrupy's authentication and fingerprinting framework are further demonstrated by its global operational reach. According to Entrupy's State of Fake Report 2025, the platform currently operates in more than 90 countries worldwide, highlighting also the growing international demand for AI-driven authentication within both primary and secondary markets.

Despite the scalability potential assessed for Entrupy's authentication systems, as already mentioned, a structural limitation to Entrupy's adoption concerns the limited secondary-market targeting strategy implemented by the technology. As Entrupy's systems have proved limited upstream applicability and limited applicability to primary markets, the technology appears to be a more suitable solution for mitigation strategies, rather than counterfeit prevention strategies.

3.5. Linking Empirical Evidence

The experimental investigation conducted through the multiple-case-study approach adopted had the objective of collecting empirical evidence on technological innovation for counterfeit prevention and mitigation. Specifically, the methodology adopted aimed at identifying recurring patterns and the complementary relationship across the cases and technologies analysed. By means of a cross-case analysis, the study establishes a connection between empirical findings and the theoretical framework developed in the previous chapters, thereby contributing to bridging the existing gaps in both academic research and industrial evidence concerning anti-counterfeiting technologies.

	MONCLER GROUP	AURA BLOCKCHAIN CONSORTIUM	ENTRUPY
Technology Type	RFID tags NFC tags QR codes	Distributed Ledger Technology (DLT) SaaS traceability platform	Machine learning algorithms Fingerprinintg cloud platform
Required Infrastructure	Embedded hardware tags Tag readers Cloud authentication platforms Colud database	Decentralised Blockchain networks IoT hardware SPM softwares Cloud database	Microscopic scanning devices Machine Learning algoritms for authentication and fingerprinting Cloud database
Target Market	Primary Markets (via production and distribution) Secondary markets (via ownership tracking)	Primary markets (via production traceability and DPPs) Secondary Markets (via ownership transfer and MTM)	Secondary markets (via product authentication, fingerprinting and fraud detection)
Key Benefits	Authentication hardware embedded from manufacturing CRM enrichment	Immutable product identity record DPP development Secure transfer of owvership and MTM ESG due diligence complicance	Non-invasive technological architecture 99,86% authentication accuracy Self-inproving Machine Learning Secondary market governance
Key Limitations	Tag clonability and vulnerability to replication Hardware obsolescence Consumer activation gap	Dependency on input-data accuracy Uneven technology adoption Implementatio costs Data Sensitivity concerns Tensions in collaborative governance	Hardware dependency (scanning devices) Limited orientation towards secondary markets
Scalability Potential	High scalability potential for the luxury segment	High scalability potential via SaaS models and case-by-case membership terms Network effects amplifying adoption span and enhancing accuracy	Very high scalability potential via wide range prices Self-reinforcing mechanisms via widespread adoption and input data enhancing accuracy
Required Investments	High adoption costs via hardware components and maintenance	No fixed membership fee, case-by-case membership terms Significant IT integration and governance investments	Subscription-based pricing with a wide range of membership terms

Table 12: Comparative analysis of the examined case studies

The comparative analysis of the selected case studies reveals several recurring patterns across the different technological architectures examined. The first and most consistent pattern concerns the multidimensional nature of the value generated through technology adoption. Across all the cases analysed, the primary objective of product authentication and counterfeit deterrence was integrated by a broader range of secondary benefits encompassing supply-chain management, CRM and ESG due diligence compliance. This convergence highlights the necessity for brands to adopt comprehensive strategic infrastructures capable not only of addressing luxury counterfeiting effectively, but also of generating additional operational benefits.

A second recurring pattern concerns the progressive integration of phygital systems. Across all the cases analysed, a significant degree of interconnection between the physical product and its digital interface emerged. Within this context, the effectiveness of anti-counterfeiting systems relies increasingly on digital infrastructures and software capabilities for data collection, data storage, analysis and machine learning algorithms. Furthermore, the growing digitalization of operational and business models requires brands to invest further resources advanced encryption systems and secure authentication protocols to mitigate the risks related to data governance and cybersecurity.

The third common pattern concerns the role of network effects and data compounding in determining the long-term effectiveness and scalability of technological frameworks. Across all three case studies, it is possible to identify a self-reinforcing mechanism, whereby widespread adoption of a given technology amplifies its overall effectiveness, encouraging as a consequence further diffusion and adoption of the system itself. This process strengthens the technological ecosystem and increases the strategic value by the anti-counterfeiting infrastructure overtime.

Consistently with the common advantages identified through this comparative analysis, this study also highlights a set of structural limitations shared across the analysed technologies. The first limitation concerns the increasing sophistication of counterfeit products and super-fake replicas, continuously evolving in response to technological advancements and new strategic countermeasures. This ongoing race between authentication technologies and counterfeit adaptation, as in the case of IoT and tag duplication, accelerates technological obsolescence and reduces the effective lifespan of embedded product components.

Ultimately, although technology adoption has proven to operate as a self-reinforcing mechanism, a second limitation concerns the uneven participation of supply-chain actors and end-users in the adoption process. This limitation appears consistent within the theoretical framework and industry overview, highlighting how the effectiveness of anti-counterfeiting systems also depends on widespread engagement.

The analysis of the three selected case studies allows the integration of empirical findings with the outcomes of both the theoretical framework and of the industry overview developed in the previous chapters. As one of the main registered gaps in research concerns the absence of real-case data on technology implementation and the related operational benefits and costs, the multiple-case-study approach adopted within this chapter aims at directly bridging this gap, providing empirical documentation of how IIoT, Blockchain and AI can perform in actual industrial settings. Additional gaps in literature concern the absence of effective governance systems for managing product authentication within secondary markets, as well as the limited exploration of how open innovation practices and cross-company collaboration may contribute to mitigate the risks associated with luxury fashion counterfeiting. The selected case studies, therefore, provide not only technological insight, but also operational and strategic evidence on how cross-company collaboration is required to develop scalable and effective anti-counterfeit infrastructures.

The empirical analysis of the Moncler Group, the Aura Blockchain Consortium and Entrupy demonstrates that no single technology currently represents a comprehensive solution capable of addressing all the risks and vulnerabilities associated with luxury counterfeiting. Conversely, each technological framework contributes to address specific risks and challenges:

- *IIoT*, as highlighted by the analysis of the Moncler Group, appears to be mostly effective in reducing information asymmetries within primary markets, enabling product traceability and authentication through embedded tags and connected devices. Although IoT enables the establishment of phygital frameworks, empirical evidence reveals structural vulnerability related to tag replication and cloning. Moreover, its effectiveness appears primarily bounded within primary markets, with limited applicability within secondary and resale markets.
- *Blockchain*, as highlighted by the analysis of the Aura Blockchain Consortium, addresses the issues related to supply-chain traceability. By enabling immutable, decentralised and verifiable records throughout the entire product lifecycle, blockchain facilitates supply-chain transparency, ESG due diligence and strengthens product authentication. Nonetheless, in absence of widespread technology adoption, the reliability and completeness of records may be compromised.

- *AI*, as highlighted by the analysis of Entrupy, appears to be mostly effective within secondary markets, providing accessible and scalable luxury authentication and fingerprinting for a vast variety of product categories. Although it remains one of the most accessible and scalable solutions, empirical evidence shows that, at the moment, the system is primarily adopted by third-party marketplaces and resellers, benefiting brand manufacturers only indirectly.

A further recurring element emerging from all the analysed cases and technological frameworks concerns the collaborative structures involving multiple stakeholders. Such collaboration may take different forms, including compliance with technological standards and infrastructures, as in the case of the Aura Blockchain Consortium, or data-sharing to enhance authentication accuracy, as in the case of Entrupy. Such findings suggest that the effectiveness of technological innovation increasingly depends not only on technology sophistication, but also of the capacity of companies and brands to participate to anti-counterfeiting strategies with an interconnected approach.

Overall, the comparative analysis of IIoT, Blockchain and AI demonstrates that the most effective anti-counterfeit architecture is not based on the isolated adoption of a single technology, but on the combination of different complementary technologies. Such an integrated technological architecture must implement specific technological frameworks, whereby every technology addresses the specific structural vulnerabilities related to other systems.

- At *manufacturing level*, IIoT provides the most effective solution to establish a fundamental link between the physical product, its digital interface and the DPP.
- At *supply-chain level*, Blockchain provides the greatest benefits by allowing verified, immutable and decentralised product traceability across all supply-chain nodes. Blockchain infrastructures also play a crucial role in improving supply-chain transparency and in supporting ESG due diligence compliance.
- At *distribution level*, AI-based authentication provides the highest level of accuracy and precision compared to other systems. Particularly effective for authentication and fingerprinting, AI also contributes to the enhancement of CRM processes by improving consumer trust, authentication accessibility and consumer engagement.

3.6. Conclusions

The empirical analysis conducted in Chapter 3 examines three real-case implementations of technological innovation as strategic countermeasures against counterfeiting in the Luxury Fashion industry. Each case is representative of one of the technological domains identified within Chapter 2, namely IIoT, Blockchain and AI. More specifically, the case of the Moncler Group has illustrated how IIoT systems has been implemented as a phygital framework for product authentication, the Aura Blockchain Consortium has illustrated how Blockchain technologies can been integrated into operational workflows as a cross-company DLT (Distributed Ledger Technology) for supply-chain traceability and DPPs, and the case of Entrupy has exemplified how AI-powered Machine Learning can be leveraged as non-invasive authentication systems for secondary and resale markets.

Drawing on the collected empirical documentation, empirical evidence has enabled a structured comparative assessment of the three technological frameworks and their respective contribution to the proactive and reactive anti-counterfeiting objectives, identified in the previous paragraph.

Through the systematic literature review conducted in Chapter 1 it was possible to identify five key macro-themes structuring the existing body of research on Luxury-Fashion counterfeiting, as reported on "*Table 4*". The empirical analysis of Chapter 3 has significantly contributed to integrate those macro themes, confirming the relevance of a comprehensive research that encompasses both a theoretical framework and empirical evidence on the theme.

With respect to "*EU Law and IPRs*", the three case studies demonstrate how technological innovation increasingly operates as an instrument of regulatory compliance, rather that exclusively responding to individual brand strategies. The convergence between investments in anti-counterfeiting technologies and EU regulatory compliance helps to respond to the absence of empirical research on how regulatory frameworks influence technology adoption and technological innovation, helping therefore at bridging an existing gap in research.

With respect to "*Brand Management*", although existing research estimates that the availability of counterfeited product alternatives does not significantly reduce brand equity (Nia, Lynne Zaichkowsky, 2000), empirical evidence on IIoT, Blockchain and AI demonstrates that technological innovation can be leveraged to preserve brand equity by providing proof of authenticity at point of purchase in both primary and secondary

markets and providing proof of origin and complete supply chain traceability, reducing overall information asymmetries between brands and consumers.
With respect to "*Supply-Chain Management*" and "*Innovation Management*", the most prone macro-themes to future research, the empirical evidence collected throughout Chapter 3 provides the most substantial contribution. The analysed cases address the gap concerning cross-company collaboration within fashion supply-chains, demonstrating the feasibility in establishing cooperation systems for supply-chain traceability and open innovation, while maintaining distinct brand identities and competitive advantages. The three case studies also provide evidence on the benefits related to the integration of authentication protocols within manufacturing activities and within secondary distribution channels.
Although the empirical exploration led to significant contributions to research on anti-counterfeiting technologies for Luxury Fashion, such contributions does not resolve all the research questions identified through the systematic literature review, as depicted in "*Table 9*". Concerning the questions on "*Consumption Behaviour*", the identified macro-theme fell outside the scope of the empirical research, remaining hence unanswered and available for future research on Luxury-Fashion counterfeiting. Concerning "*Brand Management*", empirical evidence does not resole the question on brand perception, focusing on how authentic and counterfeit brand image affect users' status, remaining again available for future research on this theme. Eventually, from the perspective of "*Supply-Chain Management*", an underlying cross-company collaboration model remains still a subject going through continuous evolvement. For this reason, further developments on collaborative governance remain open to future adaptations or innovations.
Overall, empirical evidence confirms that technological innovation represents a strategically viable and operationally documented response to counterfeiting. Although empirical evidence disproves the existence of an ultimate technological solution against Luxury-Fashion counterfeiting, continuous innovations demonstrate the ever-evolving nature of technological frameworks and the existence of diverse technological solutions and architectures suitable for different levels of financial resources available, different levels of exposure to counterfeiting and different and different strategic objectives.

CONCLUSIONS

The primary objective set within the present thesis was to explore how technological innovation can be leveraged as a strategic instrument to prevent, address and mitigate the phenomenon of counterfeiting in the Luxury Fashion Industry, with a focus on Fashion and Leather Goods (i.e., apparel, accessories and footwear). By integrating three different research methodologies, namely a systematic literature review, an exploratory analysis of secondary data and a multiple-case-study empirical investigation, it was possible to develop a comprehensive and transdisciplinary framework for analysing the phenomenon of counterfeiting under a legislative, operational, supply-chain and technological point of view.

From a theoretical perspective, the research conducted enabled to extend the understanding of the phenomenon of Luxury-Fashion counterfeiting as a multi-dimensional phenomenon encompassing different disciplines and subjects. More specifically, starting from the systematic literature review, it was possible to identify 5 key macro-themes, each capturing different aspects and consequences of counterfeiting, namely "*EU Law and IPRs*", "*Consumption Behaviour*", "*Brand Management*", "*Supply-Chain Management*" and "*Innovation Management*". The subsequent qualitative analysis of Chapter 2 and the empirical investigation of Chapter 3 helped to prove that such macro-themes are not independent strategic variables, but rather the structural components of a single integrated anti-counterfeiting architecture.

The empirical analysis conducted in Chapter 3 enabled to substantially integrate the conceptual framework developed throughout Chapter 1 & 2, focusing on IIoT, Blockchain and AI. Empirical evidence demonstrated that an effective anti-counterfeiting strategy should rely on a technological architecture that requires widespread adoption among brands and supply-chain participants. Eventually, research demonstrated that no single technology constitutes the ultimate solution to Luxury-Fashion counterfeiting. Rather, a robust anti-counterfeiting architecture should include a layered combination of technological frameworks, including IIoT systems for authentication at manufacturing level, Blockchain technologies for product traceability at supply-chain level and AI systems for authentication, fingerprinting and CRM at distribution level.

Beyond the theoretical contribution of this thesis, the research generates practical implications relevant to Luxury-Fashion practitioners. Empirical evidence demonstrates that investments in technological adoption benefit brands beyond the primary objective of counterfeit deterrence. Each of the analysed technologies demonstrates benefits that encompass transparency of manufacturing and distribution operations, CRM by improving consumer trust, authentication accessibility and consumer engagement, brand equity reinforcement and regulatory compliance through ESG due diligence and DPPs. Empirical evidence shows therefore an increasing trend of technological innovation towards proactively addressing the risks associated to counterfeiting.

The most significant limitations of the performed research concern the high dependency on secondary sources of data across all the second and third chapters. While the systematic literature review draws on peer-reviewed academic literature and EU-Law sources, the qualitative analysis of Chapter 2 relies primarily on industry and corporate reports, which can result on biased outcomes by undermining the risks and costs related to technology adoption. Similarly, Chapter 3 largely relies on brands' own annual financial and non-financial statements, press articles and content obtained through the official communication channels of the identified case studies. In this case, the absence of audited and third-party documentation of technology adoption and performance does not enable a precise and objective analysis of the related costs, opportunities and threats.

Finally, while the adoption of a multiple-case-study approach enables a rich contextual analysis, the focus on multiple technologies and multiple brands does not allow statistic generalization. Although case studies were selected following specific criteria, including relevance to the topic and technological domain and data availability, they may not be representative of a broader population of Luxury Brands and technology providers.

By analysing the gaps in research identified in Chapter 1, the outcomes of the qualitative exploration of Chapter 2 and the empirical investigation conducted in Chapter 3, it is possible to identify several questions that remain open for future investigation. Firstly, from a "Consumption Behaviour" perspective, research does not address how consumers' willing to purchase counterfeit goods is affected by the increasingly widespread adoption of authentication technologies both in primary and secondary markets. Secondly, from a "Brand Management" perspective, it might be crucial for further research analysing the indirect effects of secondary-market authentication and fingerprinting for brand equity protection. Eventually, from a "Supply-Chain Management" perspective, it might be important to analyse the governance conditions under which supply-chain participants can be encouraged to adopt traceability systems compatible with EU and brand standards, particularly for globally dispersed supply chains operating across multiple jurisdictions.

DECLARATION OF USE OF AI TOOLS

The undersigned TREVISAN DAVID, matriculation number 889365, enrolled at Ca' Foscari University of Venice in the Master's Degree Programme in "Innovation & Marketing", author of the final degree thesis "TECHNOLOGICAL INNOVATION AS A STRATEGIC RESPONSE TO COUNTERFEITING IN THE LUXURY FASHION INDUSTRY", supervisor CABIGIOSU ANNA, aware of the sanctions provided for by Art. 76 of the Consolidated Law, D.P.R. 28/12/2000 n. 455, and of the forfeiture of benefits provided for by Art. 75 of the same Consolidated Law, in the event of false statement, under his personal responsibility pursuant to Articles 46 and 47 of D.P.R. 28/12/2000 n. 445,

DECLARES

to have used AI technologies to support various aspects of the research and writing of his final thesis, in particular "CHAT GPT-5". The tool has been employed, starting the author's research and from the qualitative analysis performed in Chapter 2, for the identification of secondary sources of data to further integrate the empirical research conducted.

THE AUTHOR FURTHER DECLARES THAT

all materials generated by the AI tool has been carefully verified, reviewed and reworked by the author, who assumes full responsibility for the quality, accuracy and scientific integrity of the work.

BIBLIOGRAPHY

CHAPTER 1

- Pickering, C., & Byrne, J. (2014). The benefits of publishing systematic quantitative literature reviews for PhD candidates and other early-career researchers. *Higher Education Research & Development*, *33*(3), 534-548.
- Bolt, E. E. T., Winterton, J., & Cafferkey, K. (2022). A century of labour turnover research: A systematic literature review. *International Journal of Management Reviews*, *24*(4), 555-576.
- European Union Intellectual Property Office. (2024). *Economic impact of counterfeiting in the clothing, cosmetics and toys sectors in the EU*. EUIPO. DOI: 10.2814/053613.
- Regulation (EU) No 608/2013 of the European Parliament and of the Council of 12th June 2013 concerning customs enforcement of intellectual property rights and repealing Council Regulation (EC) No 1383/2003.
- Directive 2004/48/EC of the European Parliament and of the Council of 29th April 2004, also known as the Intellectual Property Rights Enforcement Directive (IPRED).
- Directive 98/71/EC of the European Parliament and of the Council of 13th October 1998 on the legal protection of design.
- Regulation (EU) 2022/2065 of the European Parliament and of the Council of 19th October 2022 on a Single Market for Digital Services and amending Directive 2000/31/EC (Digital Services Act) (Text with EEA relevance).
- Agrawal, T. K., & Pal, R. (2019). Traceability in textile and clothing supply chains: Classifying implementation factors and information sets via Delphi study. Sustainability, 11(6), 1698.
- Appel, G., Libai, B., & Muller, E. (2018). On the monetary impact of fashion design piracy. International Journal of Research in Marketing, 35(4), 591-610.
- Assaf-Zakharov, K. (2018). Non-traditional trademark protection as (non-traditional) means of cultural control. teoksessa Calboli, Irene–Senfleben, Martin, The Protection of Non-Traditional Trademarks: Critical Perspectives, Oxford, 362-381.
- Badhwar, A., Islam, S., & Tan, C. S. L. (2023). Exploring the potential of blockchain technology within the fashion and textile supply chain with a focus on traceability,

transparency, and product authenticity: A systematic review. Frontiers in Blockchain, 6, 1044723.

- Bian, X., & Moutinho, L. (2011). The role of brand image, product involvement, and knowledge in explaining consumer purchase behaviour of counterfeits: Direct and indirect effects. European journal of marketing, 45(1/2), 191-216.
- Ching, K., Forti, E., Katsampes, S., & Mammous, K. (2024). Style and quality: Aesthetic innovation strategy under weak appropriability. Research Policy, 53(3), 104947.
- Chrimes, C., & Heim, H. (2023). 13 The Fashion Product Passport: In Search of the "Killer App". Fashion and Environmental Sustainability, 149.
- Fiza, A., Shahzad, I., Muhammad, H., Rehman, H. U., & Sajjad, B. (2021). Impact of consumer Attitude towards purchase intention of the counterfeit products: a multigroup analysis between the user and non-user. Industria Textila, 72(6), 606-612.
- Hayes, A. S., & Pellandini-Simányi, L. (2025). The upside of uncertainty: how counterfeit risk in secondary markets influences primary luxury sales. Journal of Business Research, 201, 115698.
- Jankowska, M., Pawełczyk, M., & Szpyt, K. (2025). Intellectual property considerations in the internationalisation of e-commerce platforms for Poland-based brands. Digital Internationalisation of Firms, 262.
- Jiang, J., & Chen, J. (2021). Managing the product-counterfeiting problem with a blockchain-supported e-commerce platform. Sustainability, 13(11), 6016.
- Keller, K. L. (2017). Managing the growth tradeoff: Challenges and opportunities in luxury branding. Advances in luxury brand management, 179-198.
- Klöckner, M., Schmidt, C. G., Fink, A., Flückiger, L., & Wagner, S. M. (2023). Exploring the physical–digital interface in blockchain applications: Insights from the luxury watch industry. Transportation Research Part E: Logistics and Transportation Review, 179, 103300.
- Lee, H., & Yeon, C. (2021). Blockchain-based traceability for anti-counterfeit in cross-border e-commerce transactions. Sustainability, 13(19), 11057.
- Montecchi, M., Plangger, K., & Etter, M. (2019). It's real, trust me! Establishing supply chain provenance using blockchain. Business Horizons, 62(3), 283-293.
- Muposhi, A., & Dhurup, M. (2020). Stemming the sportswear counterfeit tide: Emerging market evidence of rational and normative drivers. Acta Commercii, 20(1), 1-10.

- Nia, A., & Lynne Zaichkowsky, J. (2000). Do counterfeits devalue the ownership of luxury brands? *Journal of product & brand management*, *9*(7), 485-497.
- Niu, B., Mu, Z., Cao, B., & Gao, J. (2021). Should multinational firms implement blockchain to provide quality verification? Transportation Research Part E: Logistics and Transportation Review, 145, 102121.
- Purwanto, P., Margiati, L., Kuswandi, K. U. S. W. A. N. D. I., & Prasetyo, B. (2019). Consumer motives for purchasing counterfeit luxury products: behind the status signalling behaviour using brand prominence. Business: Theory and Practice, 20, 208-215.
- Reinhardt, N., Reinhard, M. A., & Bittner-Fäthke, G. (2023). The correlation between honesty-humility and attitude toward counterfeit luxury. Italian Journal of Marketing, 2023(4), 503-519.
- Sovtić, D., Trpkov, A., Radenković, M., Popović, S., & Labus, A. (2025). Examining Readiness to Buy Fashion Products Authenticated with Blockchain. Journal of Theoretical and Applied Electronic Commerce Research, 20(2), 119.
- Varela, M., Lopes, P., & Mendes, R. (2021). Luxury brand consumption and counterfeiting: A case study of the Portuguese market. Innovative Marketing, 17(3), 45.
- Wee, C. H., Ta, S. J., & Cheok, K. H. (1995). Non-price determinants of intention to purchase counterfeit goods: an exploratory study. International Marketing Review, 12(6), 19-46.
- Wu, H., Wang, S., Pu, C., Ma, J., & Zeng, Y. (2025). Enhancing counterfeit RFID tag classification through distance based cognitive risk control. Scientific Reports, 15(1), 4150.
- Xu, J., & Sutunyarak, C. (2024). Factors that influence consumers' inclination to acquire counterfeit luxury goods. Journal of Infrastructure, Policy and Development, 8(7).

CHAPTER 2

- Regulation (EU) 2024/1781 of the European Parliament and of the Council of 13th June 2024 establishing a framework for the setting of eco-design requirements for sustainable products, amending Directive (EU) 2020/1828 and Regulation (EU) 2023/1542 and repealing Directive 2009/125/EC (Text with EEA relevance).

- Bagnoli, C., Albarelli, A., Biazzo, S., Biotto, G., Marseglia, G. R., Massaro, M., ... & Troiano, L. (2022). Industry 4.0 and the emergent business models. In Digital business models for industry 4.0: how innovation and technology shape the future of companies (pp. 119-210). Cham: Springer International Publishing.
- Deloitte (2022) Global Powers of Luxury Goods 2022
- Deloitte (2026) Global Powers of Luxury Goods 2026
- Dou, J. (2024). The application and challenges of artificial intelligence in the fashion and luxury industry. Applied and Computational Engineering, 42(1), 90-96.
- Garcia-Cotte, H., Mellouli, D., Rehman, A., Wang, L., & Stork, D. G. (2024). Deep neural network-based detection of counterfeit products from smartphone images. arXiv preprint arXiv:2410.05969.
- Gupta, S. (2023). An Ethereum-based Product Identification System for Anti-counterfeits. arXiv preprint arXiv:2308.04006.
- Italian Ministry of Economic Development (2016), Leather Good Counterfeiting: Consumer Guidelines. ConfConsumatori
- McKinsey & Company (2022), The State of Fashion 2022. McKinsey & Company
- McKinsey & Company (2022), The State of Fashion Technology. McKinsey & Company
- McKinsey & Company (2026), The State of Fashion 2026. McKinsey & Company
- OECD & EUIPO (2025), Mapping global trade in fakes 2025: Global trends and enforcement challenges. OECD & EUIPO
- Sharma, A., Srinivasan, V., Kanchan, V., & Subramanian, L. (2017, August). The fake vs real goods problem: microscopy and machine learning to the rescue. In Proceedings of the 23rd ACM international conference on knowledge discovery and data mining (pp. 2011-2019).
- Ting, S. L., & Tsang, A. H. (2013). A two-factor authentication system using radio frequency identification and watermarking technology. Computers in industry, 64(3), 268-279.
- Yiu, N. C. (2021). An empirical analysis of implementing enterprise blockchain protocols in supply chain anti-counterfeiting and traceability. arXiv preprint arXiv:2102.02601.
- Zhang, D., & Cheng, C. (2023). AI-enabled Product Authentication and Traceability in Global Supply Chains. Journal of Advanced Computing Systems, 3(6), 12-26.

CHAPTER 3

IIoT: the case of the Moncler group

- Moncler – Annual Financial Report 2025
- Moncler - Consolidated non-financial statement 2020
- Moncler - Consolidated non-financial statement 2023
- Moncler and the Battle Against Counterfeiting, 2016

AI: the case of ENTRUPY

- Entrupy | State of the Fake Report – 2026
- Entrupy | State of the Fake Report – 2025

SITOGRAPHY

CHAPTER 1

- What Is a Trademark? – Investopedia
- EU copyright - EUR-Lex
- Veblen Goods - Definition, Differences, Examples

CHAPTER 2

- Linee guida uso responsabile IA ricerca
- Denim Cap S00 - Accessories | LOUIS VUITTON
- Internet of Things (IoT): Definition, Benefits, and Functionality
- Vestiaire Collective
- Quick Response (QR) Code: What They Are, How They Work, and Types
- QR Codes for Luxury Brands (2026) | Supercode
- What is RFID? - Ohmify
- 2026 Anti-Counterfeiting Priorities for Tech Manufacturers - AGMA Global
- How Luxury Brands Can Counter the Rise of Superfakes | BCG
- Embracing Digital Product Passport as a regulatory requirement | Deloitte Global
- RFID vs NFC - What's The Difference?
- How To Spot Fake Designer Bags Using Stitching Logos and Materials
- Decoding Luxury: How to Authenticate Designer Goods and Avoid Counterfeits. | LUXESTYLE JUNKIE
- Brands Face Growing 'AI Tax' as Counterfeit Activity and Impersonations Threaten Revenue | Morningstar
- Near Field Communication (NFC): A Comprehensive Guide
- Fashion Retail Outlook 2026 | Strategy&
- Trends-Luxury-Fashion-2025.pdf
- The State of Fashion: Luxury | BoF

CHAPTER 3

IIoT: the case of the Moncler group

- Moncler Group | Moncler e Stone Island
- Il piumino Moncler: il capo iconico dei Paninari | Outpump

- Stone Island: Verify Product Authenticity
- Certilogo | Secured by Design™
- Case Study – Stone Island | Certilogo
- Reimagining Customer Connections Through Digital Product Passports | BoF
- NFC anti-counterfeiting - Moncler - Moko
- Certilogo ® | About Us

Blockchain: the case of AURA Blockchain Consortium

- AURA Blockchain Consortium: blockchain for luxury goods
- LVMH, Prada Group and Cartier come together to form the Aura Blockchain Consortium supporting the first global blockchain dedicated to the luxury industry | Prada Group
- About us – ConsenSys
- INSIDE LVMH, discover the world of LVMH
- LVMH closes 2025 with revenue at 80.8 billion (-5%) and operating margin at 22% - Il Sole 24 ORE
- Investor Relations: gli Highlights del Gruppo Prada | Prada Group
- Results, reports & presentations | Richemont
- OTB presents its 2025 full-year results – OTB Group
- Fashion Transparency Index: Fashion Revolution
- Sustainability within the Luxury Industry: LVMH & Aura Blockchain Case Studies | by Afina Suleimanova | Medium
- Blockchain in Retail Fashion and Luxury | Real World Blockchain Use Cases
- Blockchain in Supply Chain Management | Real World Blockchain Use Cases
- Aura Blockchain Consortium | Department of Economic and Social Affairs

AI: the case of ENTRUPY

- Luxury Authentication - Entrupy
- Apparel Authentication - Entrupy
- Return Fraud Detection - Entrupy
- Pricing - Entrupy
- Technological tools to combat counterfeiting | Managing Intellectual Property
- Interview With Vidyuth Srinivasan - CEO & Co-founder of Entrupy

- [Entrupy Battles Counterfeiting as Luxury 'Dupes' Become Ubiquitous]
- [Behind Entrupy, official AI authenticator for luxury handbags on TikTok Shop]
- [Entrupy Selected to Participate in LVMH Accelerator Initiative - Entrupy]