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FIGHTING AGAINST COUNTERFEITING, A SOLUTION WITH AI?

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Abstract (100 words maximum)

This thesis explores the role of Artificial Intelligence (AI) in combating counterfeiting across various industries, focusing on its potential as a transformative tool in product authentication and information management. Traditional anti-counterfeiting methods, such as holograms and serial numbers, are increasingly insufficient against sophisticated counterfeiters. By analysing AI's ability to detect counterfeit goods through advanced data analysis, image recognition, and anti-counterfeiting technologies, this study highlights the benefits and challenges of AI adoption. The findings offer insights for businesses, policymakers, and researchers on leveraging AI to ensure product authenticity and enhance supply chain security.

Keywords (minimum of four)

1.Artificial Intelligence (AI)

2. Counterfeiting, fake

3. Anti-Counterfeiting Technology

4. Authentication

5. Genuine product

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1. Introduction

Counterfeiting, a crime that involves the production and the selling of fake goods designed to imitate or mimick genuine products, is estimated to make up 3.3% of global trade. (De Clercq, 2024). The scale of this issue can vary from luxury items to everyday products like pharmaceuticals, sneakers, electronics, music, art or even food. This delinquency causes significant economic losses for legitimate brand / business owners and poses severe health and safety risks to consumers, particularly in the pharmaceutical department (International Chamber of Commerce, 2021). As counterfeiters become increasingly sophisticated, traditional methods of detecting and preventing counterfeiting, such as holograms (a three-dimensional picture made by a complex pattern of light), serial numbers and tamper-evident packaging, have proven to be insufficient by human recognition. These methods, while providing some level of security, are often imitated by counterfeiters who can replicate or manipulate these features with alarming accuracy. This illegal process, which is unfortunately not pursuited as severely as it should, endangers legitimate brand / business owners and demands the businesses to take action; in this case how to best protect their products in potentially using AI as a new tool?

In this context, artificial intelligence (AI) emerges as a new transformative technology that offers powerful tools to analyse datasets, find patterns, and detect anomalies that may indicate counterfeit activity. The futuristic solution of this technology is promising but is still in constant continuous advancements enhancing its capabilities; machine learning and neural networks are examples that can be integrated into information management systems to strengthen the tracking, verification, and authentication of products throughout the supply chain.

This thesis seeks to first explore how counterfeiting is a danger for both the consumer and the brand / business owners, to secondly give examples to demonstrate the existing solutions (traditional methods), and to thirdly show how can AI be effectively used to combat counterfeiting.

Overall, the primary aim of this study is to investigate how AI can improve information management and reinforce the detection of counterfeit products. This thesis will compare and give examples of traditional and non-traditional methods of measures to detect counterfeit, as well as case studies where AI has illustrated to be successfully implemented.

The thesis holds potential to provide valuable insights for businesses, policymakers, and the academic community, as it highlights the dangers of forged products. For the academic world this study shows the techniques found in AI whilst inspecting how it will further develop. For brand / business owners, the study offers practical guidance on integrating AI into their operations to protect their products and brands from counterfeit threats. For policymakers, the study features the regulatory and ethical challenges associated with AI, offering recommendations for future policy development and the security of this new technology.

In a world where accessibility to any type of information is so easy, information management and counterfeit detection are aspects to investigate.

Let’s start from the start.

2. Literature Review

2.1 The Historical of Counterfeiting

The roots of counterfeiting have started as early as 300 BC, where counterfeit coins were a significant problem in the Roman Empire, where these copy versions disrupted economic stability and eroded trust in the monetary system (UNODC, 2024). Over the centuries, the scope of counterfeiting expanded from currency to a wide range of goods, such as dishes, materials, paintings, clothes, food, shoes, items that can go from pharmaceuticals to everyday consumer products.

During the Middle Ages, counterfeiters began focusing more on luxury goods, such as silk, spices, and precious metals. The beginning of the Industrial Revolution in the 18th and 19th centuries further worsened the problem, as mass production techniques made it easier to produce fake goods on a large scale. During this period, the emergence of trademark laws and other legal measures witnessed significant losses as it was challenging, even though the aim was to protect intellectual property (Wadlow, Christopher 2017).

The 20th century introduced new complexities to counterfeiting, especially with the rise of digital technologies and globalization. Counterfeiters adopted advanced printing techniques and digital tools to create highly convincing falsification. The growth of e-commerce platforms has only made the issue more pervasive, as counterfeit goods can now reach consumers worldwide with ease (Gevers, 2023). In addition to physical goods, digital counterfeiting has become another significant concern, particularly in the realms of software piracy and the forgery of digital assets.

Today, counterfeiting affects a wide array of industries, from fashion to computers, pharmaceuticals, footwear, artwork, tobacco or even food. Markets and supply chains are two districts that need to watch out for the sophistication of modern counterfeiters.

Why? Well, the technology is evolving and counterfeiters have become stronger in copying, which has made this a problem more pervasive and challenging to combat than ever before (CBS News, 2024).

2.2 Traditional Anti-Counterfeiting Measures

Traditional anti-counterfeiting measures have long served and still are as the primary defence against the creation of fake goods. For instance, holograms, serial numbers, and tamper-evident packaging have been widely employed across different industries.

Holograms are three-dimensional images embedded into products or packaging. They have been one of the earliest technological solutions to counterfeiting that are commonly used on currency, passports, and high-value items such as electronics and pharmaceuticals. However, as counterfeiters have developed more sophisticated methods, they have managed to produce convincing fake holograms, thus reducing their effectiveness over time (Goodfirms, 2023).

Serial numbers provide a unique identifier for each product or batch, enabling detailed tracking through the supply chain. This method is particularly prevalent in the electronics, automotive, and pharmaceutical industries. Nevertheless, the effectiveness of serial numbers depends heavily on how accurate and accessible the databases can be verified, which means increasing the need for information management and data privacy. Counterfeiters have increasingly replicated or fabricated fake serial numbers, rendering manual verification processes both labour-intensive and prone to error (UNODC, 2024).

Tamper-evident packaging is another traditional method designed to show visible signs of interference, thereby offering an additional layer of security. This approach is widely used in the food, beverage, and pharmaceutical industries to protect consumers from tampered products. Despite its utility, tamper-evident packaging is not reliable, as counterfeiters have developed techniques to copy these protections, often by resealing or mimicking the tamper-evident features convincingly enough to deceive consumers (Gevers, 2023).

While these traditional methods have helped to fight against counterfeiting, their precision is not infallible, meaning that they become less reliable and more dangerous, as they don't always detect a counterfeit. As counterfeiters continue to evolve, the need for more advanced and integrated approaches to ensure product authenticity and consumer safety has grown more urgent (Goodfirms, 2023).

2.3 Technologies VS. Counterfeiting

To overcome the limitations of traditional methods, industries are increasingly adopting emerging technologies such as RFID (Radio-Frequency Identification), blockchain, and machine learning.

RFID technology involves embedding small tags into products, which can be scanned to verify authenticity. Each RFID tag contains a unique identifier that can be matched against a database, enabling real-time tracking and verification throughout the supply chain. This technology has proven particularly effective in industries like fashion and tabacco, where the ability to quickly and accurately track products is critical (Goodfirms, 2023).

Blockchain technology offers a decentralized, immutable ledger that records every transaction associated with a product, from manufacturing to sale. This creates a transparent and tamper-

proof record that can be accessed by all stakeholders, ensuring that each product's history is traceable and verifiable. Blockchain is especially valuable in industries such as luxury goods and pharmaceuticals, where product provenance is crucial for ensuring authenticity (Gevers, 2023).

Machine learning and AI algorithms are increasingly being integrated into anti-counterfeiting strategies. These technologies can analyse large datasets to identify patterns and anomalies that may indicate counterfeit products. For example, AI-powered image recognition can detect subtle differences between genuine and counterfeit goods, while predictive analytics can forecast potential counterfeiting trends, allowing companies to take proactive measures (CBS News, 2023).

The integration of these emerging technologies is transforming the landscape of anti-counterfeiting, offering more robust and potent solutions to a problem that has persisted for centuries. However, the implementation of these technologies also presents new challenges, particularly in terms of data management, security, and scalability (UNODC, 2024).

2.4 AI & Information Management

AI, or Artificial Intelligence, is like a smart computer that can learn, think, and make decisions on its own. It helps machines do things that normally need human intelligence, like recognizing faces, voice recognition, or playing a game. For example, when you ask your phone to play a song, the AI figures out what you want and makes it happen. AI gets better over time because it can learn from the data it sees and experiences.

Information management, on the other hand, is all about organizing and taking care of information so people can find and use it easily. It's like being in charge of a huge library or

database, making sure everything is in the right place, safe, and available when needed. While AI focuses on being smart and solving problems, information management focuses on keeping information neat, organized, and accessible.

AI can be used in information management by recognizing patterns; these patterns have data that are then analysed through various sources, including product images, transaction records, and supply chain data, to detect inconsistencies that may indicate counterfeiting. This process is called pattern recognition. For instance, AI can identify subtle differences in packaging or product design that might be overlooked by human inspectors (Gevers, 2023).

Predictive analytics is another process where AI has proven effective. By analysing historical data, AI can anticipate future counterfeiting trends and help companies develop strategies to prevent counterfeit goods from entering the market. This proactive approach is particularly useful in industries where the risk of counterfeiting is high, such as pharmaceuticals and electronics (CBS News, 2023).

The use of AI in information management represents a significant advancement in anti-counterfeiting efforts. However, it also raises important questions about the security and reliability of these systems considering the increasing sophistication of counterfeiters.

While counterfeiters may try to exploit AI, they face significant barriers-lack of data, expertise, and ethical foundations. Legitimate brand / business owners, however, harness AI to innovate faster, detect fraud earlier, and remain steps ahead. This makes AI an invaluable tool for fighting counterfeiting rather than empowering it.

2.5 Legal and Ethical Considerations

As AI becomes more prevalent in anti-counterfeiting efforts, it is crucial to consider the legal and ethical implications of its use.

Legal frameworks governing the use of AI in anti-counterfeiting vary by region and industry, but they generally focus on data protection, intellectual property rights, and consumer safety. For instance, the General Data Protection Regulation (GDPR) in the European Union imposes strict requirements on the collection, processing, and storage of personal data, which are particularly relevant when AI systems are used to analyse consumer behaviour and transaction data (Goodfirms, 2023).

Ethical issues related to AI include concerns about data privacy, algorithmic bias, and accountability. AI systems rely on large datasets, often containing sensitive information, raising questions about how this data is used and who has access to it. Furthermore, if AI algorithms are trained on biased data, they may produce biased results, potentially leading to unfair outcomes, such as disproportionately targeting products from certain regions or demographics (Gevers, 2023).

Accountability is another critical issue. When AI systems make decisions about which products to flag as counterfeit, it is essential to ensure that these decisions are transparent and that there is a clear process for challenging or reviewing them. This is particularly important in cases where a false positive could result in significant economic or reputational damage (UNODC, 2024).

Addressing these legal and ethical considerations is vital for ensuring that AI is used responsibly and effectively in the fight against counterfeiting.

2.6 Security and Safety

The security and safety of AI systems used in anti-counterfeiting efforts are of paramount importance. Given the high stakes involved, it is essential to ensure that these systems are vigorous, reliable, and resistant to interfering.

Security measures for AI systems include advanced encryption techniques to protect data from unauthorized access, regular software updates to address vulnerabilities, and ongoing security audits to identify and mitigate potential threats. Ensuring the integrity of the data used by AI systems is also critical, as counterfeiters could potentially manipulate this data to evade detection (CBS News, 2023).

Reliability is another key concern. AI systems must be able to function effectively in a wide range of conditions, including different industries and regions. This requires testing and validation of AI algorithms, to ensure that they perform consistently and accurately. Additionally, AI systems must be able to adapt to new threats as counterfeiters develop more sophisticated methods (Goodfirms, 2023).

Ensuring the safeness of AI systems also involves monitoring and evaluation. Continuous monitoring of AI performance allows companies to identify any issues or errors quickly, ensuring that the system remains effective over time. Regular evaluations can also help companies refine their AI systems, making them more resilient to emerging counterfeiting tactics (CBS News, 2024).

While AI offers significant potential for enhancing anti-counterfeiting efforts, it is essential to address the legal, ethical, and security challenges associated with its use. By doing so, companies can ensure that AI systems are not only effective but also safe, fair, and reliable.

3. Methodology

3.1 Research Design

This study follows a qualitative research design, focusing on an in-depth exploration of how AI is already being applied today. By using qualitative methods, the thesis aims to understand the complex dynamics between technology, business, and policy. Through the analysis of case studies, an interview, and secondary data, the study aims to assess the practical effectiveness of AI in various industries affected by counterfeiting. This design allows for a holistic view of AI's impact on counterfeiting, examining not only its technical efficacy but also its implications for brand / business owners and consumers (Goodfirms 2023).

3.2 Data Collection

Data collection in this study was primarily done through case studies and a semi-structured interview with Philippe Chatelain, an expert in product authentication. Case studies were selected from industries most affected by counterfeiting, such as fashion, pharmaceuticals, and electronics. These case studies illustrate how AI has been implemented to prevent counterfeiting, providing concrete examples from companies like Louis Vuitton and Pfizer. Additionally, the interview with Philippe Chatelain offered valuable insights into real-world applications of anti-counterfeiting technologies, as well as the challenges faced during their implementation.

Secondary data was also collected through archival research, using academic papers, industry reports, and legal frameworks governing AI in counterfeiting. These sources provided background on existing technologies, historical perspectives, and emerging trends in the field.

3.3 Data Analysis

The data was analysed using thematic analysis, which allowed for the identification of key patterns and themes in both the case studies and interview responses. Specifically, the effectiveness of AI in detecting counterfeit goods was a central focus. Thematic coding was used to highlight recurring challenges and successful implementations of AI in different industries. Additionally, the case studies were compared to identify common factors that influenced the success or failure of AI integration, such as technological readiness and stakeholder collaboration.

For the interview, responses were categorized based on major themes such as technological advancements, market intelligence, and the practical use of AI in authentication systems. This provided a structured framework for understanding the role of AI in counterfeiting prevention from an industry insider’s perspective.

3.4 Ethical Considerations

Given the nature of the research, several ethical considerations were addressed, particularly around data privacy and security. In the context of AI's application in counterfeiting, privacy concerns are paramount as AI systems often require access to sensitive product and customer data. It was essential to evaluate whether AI tools adhered to data protection regulations, such as the GDPR, to ensure that personal information is not misused.

The research also took care to address potential biases in AI systems, recognizing that algorithmic bias can lead to unfair targeting of certain regions or demographics. Ensuring transparency and accountability in the development and use of AI was a key focus.

Additionally, the interview was conducted following ethical guidelines, with the participant's consent and confidentiality guaranteed.

By addressing these ethical issues, the study ensures that its findings contribute responsibly to the conversation around AI's role in combating counterfeiting.

4. Analysis and Findings

4.1 Case Study Analysis

Counterfeiting remains a critical issue affecting multiple industries globally. In 2024, sectors such as fashion, pharmaceuticals, electronics, and tobacco are particularly vulnerable to counterfeit goods. This section provides an in-depth analysis of how AI has been implemented across these industries, showcasing specific examples that highlight its effectiveness in combating counterfeiting.

Fashion Industry

The fashion industry is among the most severely impacted by counterfeiting, with fake products comprising an estimated 60-70% of all counterfeit goods seized worldwide (Gevers 2023). Luxury brand / businesss, due to their high market value and brand / business prestige, are primary targets for counterfeiters. Louis Vuitton (the most copied luxury brand / business in the world) and Gucci are two prominent examples of companies that have integrated AI into their anti-counterfeiting strategies.

For instance, in 2021, Louis Vuitton has implemented AI-powered image recognition technology to combat counterfeiting products, especially luxury leather goods, such as handbags, wallets and luggage. The brand uses AI to scan and analyse vast databases of product images, enabling the identification of counterfeit items by detecting minute discrepancies in logos, stitching, and patterns. This technology has not only enhanced the accuracy of counterfeit detection but has also accelerated the identification process, allowing the brand / business to respond swiftly to counterfeit threats (Goodfirms 2023). This implementation has resulted in a significant reduction in the circulation of fake Louis Vuitton products, reinforcing the brand / business's market reputation and consumer trust.

Similarly and also in 2021, Gucci has adopted blockchain technology through a partnership with the AURA Blockchain Consortium. This platform records every transaction associated with a product, creating an immutable digital ledger that tracks the item from production to sale. Products vary from luxury handbags, to accessories, and shoes, where high demand of iconic designs are valuable targets of counterfeiters. By scanning a QR code, consumers can access the product's history, verifying its authenticity. This innovative approach has proven highly effective in safeguarding Gucci's luxury products from counterfeiting, while also providing consumers with a reliable tool to ensure the authenticity of their purchases (Gevers 2023).

Pharmaceutical and Cosmetics Industry

Counterfeit pharmaceuticals represent a severe threat to global health, with fake drugs accounting for approximately 10% of all medicines in circulation worldwide (UNODC 2024). The health risks associated with counterfeit drugs, which may contain harmful or incorrect

ingredients, make this an urgent issue. Pfizer and Merck are two pharmaceutical giants that have leveraged AI to protect their supply chains and ensure the authenticity of their products.

In the early 2020s, Pfizer started implementing AI-driven systems to monitor its supply chain for signs of counterfeit drugs. By analysing data from production, distribution, and sales channels, Pfizer's AI algorithms can identify anomalies, such as irregular distribution patterns or discrepancies in chemical compositions. For instance, AI can detect when a batch of drugs does not match the expected chemical profile, indicating the presence of counterfeits. This system has significantly improved Pfizer's ability to detect and intercept counterfeit pharmaceuticals before they reach consumers, thus enhancing patient safety and preserving the company's brand / business integrity (CBS News 2024). Cardiovascular drugs, antibiotics, vaccines, cancer treatment, pain management and erectile disfunction medications are all examples of high-walue and high-demand pharmaceutical products that are targeted by counterfeiters.

From 2019 to 2020, Merck began integrating AI with blockchain technology. Through a blockchain-based system, Merck ensures that every step of the drug manufacturing and distribution process is recorded in a tamper-proof ledger. AI is then used to analyse this data in real-time, detecting any irregularities that might suggest counterfeiting. This combination of AI and blockchain has created a robust framework for tracking and verifying the authenticity of Merck's products, thereby reducing the risk of counterfeit drugs entering the market (Gevers 2023). Cancer treatments, vaccines, diabetes medications and antibiotics are all examples of products Merck focuses on to protect.

Another example that uses AI-driven technologies such as machine learning or image recognition is L'Oréal. This brand / business's AI systems analyse product images to detect

subtle inconsistencies in packaging, logos, and labelling that may indicate a fake. AI-powered algorithms can scan e-commerce platforms and social media to identify unauthorised sellers and counterfeit listings, enabling swift action to protect their brand / business.

Electronics Industry

The electronics industry is particularly susceptible to counterfeiting, with fake electronics comprising approximately 25% of the global market (UNODC 2024). Counterfeit electronics can lead to product malfunctions, safety hazards, and significant financial losses for companies. Samsung and Apple are two leading electronics manufacturers that have adopted AI technologies to combat this issue.

In 2019, Samsung implemented AI-driven supply chain monitoring to detect counterfeit components such as smartphones and tablets, batteries, chargers and microchips. The company uses AI to cross-reference components in its supply chain with a database of authentic parts, flagging any discrepancies for further investigation. For example, Samsung's AI system can detect when a component in the supply chain does not match the expected specifications, indicating a potential counterfeit. This system has proven effective in maintaining the integrity of Samsung's products, ensuring that only genuine components are used in their manufacturing processes (Goodfirms 2023).

Apple also integrated AI into its product verification processes around 2020, particularly in its online retail channels. AI algorithms analyse sales data, customer feedback, and product returns to identify patterns that may indicate counterfeit products such as Airpods, Iphones, Ipads and chargers. For instance, if a particular model of an Apple product has a higher-than-average return rate, the AI system will flag it for further investigation. This approach has helped Apple

to quickly identify and remove counterfeit products from its sales channels, protecting consumers and maintaining the company's reputation for quality (CBS News 2024).

Various other Industries that are impacted by Counterfeits

One of the most alarming industries impacted by counterfeits is the baby food sector. Counterfeit baby food, often packaged to look identical to trusted brand / businesss, can contain harmful or substandard ingredients that pose severe health risks to infants. Fake formulas might lack essential nutrients or, worse, contain toxic substances that could lead to malnutrition, illness, or development issues. In this high-stakes context, AI technology plays a vital role in safeguarding supply chains by quickly identifying and flagging suspicious products. AI-powered image recognition can meticulously scan packaging for subtle discrepancies in logos, colours, or labels that might go unnoticed by the human eye, helping authorities and companies detect counterfeit early. This detection process is crucial, as even a single counterfeit batch reaching shelves could endanger countless infants. By identifying these threats early, AI offers a powerful layer of protection in a sector where the smallest error can have life-altering consequences for vulnerable consumers.

Similarly, counterfeit watches, jewellery, and sportswear are commonly sold under the guise of reputable brand / businesss, posing financial and safety risks to consumers. AI's application in these industries involves analysing micro-level features like the serial numbers of watches or the sticking on luxury sneakers, which helps in detecting fake items that are often indistinguishable to the naked eye. Companies are also increasingly turning to AI to enhance customer trust by incorporating authentication processes at the point of sale, reducing the prevalence of fake goods in the market.

In the field of art, counterfeit versions of high-value painting and designer pieces are often sold at a fraction of the price. AI technologies such as neural networks have been trained to detect minute differences between original works of art and replicas, providing a safeguard for collectors and museums against counterfeiters. These systems are capable of analysing brushstroke patterns, materials, and even pigment compositions, ensuring authenticity in an industry where forgeries can result in significant financial loss.

NFTs (Non-Fungible Tokens) can also play a significant role in enhancing AI-driven systems for detecting counterfeit products. By creating unique digital certificates for each legitimate product (luxury goods, collectible art, music, videos etc..), NFTs allow for a secure, immutable record of authenticity that AI algorithms can verify against. This technology helps track the lifecycle of a product, from production to final sale, reducing the risk of counterfeit goods entering the market.

Tobacco Industry

Counterfeit tobacco products account for approximately 10-12% of the global market, posing significant public health risks due to unregulated production processes (UNODC 2024). Philip Morris International (PMI) and British American Tobacco (BAT) are two companies that have employed AI to detect and prevent the distribution of counterfeit tobacco products.

Philip Morris International has developed an AI-based system that analyses the physical and chemical characteristics of tobacco products to identify counterfeits. For example, PMI's system uses machine learning algorithms to detect anomalies in packaging, labelling, and the chemical composition of tobacco products. When the system identifies a product that deviates from the standard specifications, it is flagged for further inspection. This AI-driven approach

has significantly reduced the circulation of counterfeit cigarettes, ensuring that PMI's products meet safety and quality standards (Gevers 2023).

British American Tobacco (BAT) has implemented AI-powered surveillance systems to monitor online marketplaces for counterfeit tobacco products. These systems can scan websites and online listings, using AI to identify suspicious products based on keywords, pricing patterns, and seller behaviour. When a potential counterfeit is detected, the system automatically alerts BAT's enforcement teams, allowing them to take rapid action. This proactive approach has been instrumental in reducing the availability of counterfeit tobacco products online, protecting both consumers and the company's revenues (Goodfirms 2023).

4.2 Interview Insights

During my research, I've had the privilege to come across Philippe Chatelain a Swiss entrepreneur who has immense experience in product authentication. I found him on LinkedIn, and I contacted him directly through email. Our conversation was very interesting, and I was very happy to gain an inside perspective on how the detection of counterfeit products works and how the authentication process can be managed. Philippe's expertise was developed at Philip Morris (PMI), where he used to analyse the world of counterfeited cigarettes and packages.

In our interview Philippe explained how his approach to fighting counterfeiting was rooted in a multifaceted strategy, involving technological advancements, market intelligence, and collaboration with stakeholders. He emphasized that addressing counterfeiting requires an understanding of its complexity and comprehensive, multi-step approach. For instance,

companies must first understand the scale of the counterfeiting issue by conducting market surveys and investigations to trace the origin of counterfeit goods.

A pivotal aspect of Philippe's efforts was the development and implementation of advanced packaging identification systems to authenticate products. He noted that counterfeit products, often linked to organized crime, are produced and distributed by criminals seeking fast profits with relatively low penalties. This has created an urgent need for reliable and adaptable authentication technologies. Philippe discussed the transition from traditional methods, such as holograms and UV-sensitive packaging, to more sophisticated solutions like smartphone-accessible verification tools, which provide a more user-friendly and robust approach to detecting counterfeit goods.

In terms of AI, Philippe recognized the potential of AI and machine learning, although PMI had not yet fully integrated AI into its anti-counterfeiting efforts during his tenure. He acknowledged AI's capability to handle large datasets, offering insights through image recognition and predictive analytics. In the future, he sees AI playing a critical role in automating investigations, sorting data, and assisting law enforcement with real-time tracking of counterfeit goods. He emphasized that AI could significantly enhance both detection and response times, making it a valuable tool in the fight against counterfeit products.

Phillipe also underscored the importance of blockchain technology in authentication systems. He highlighted its ability to provide a secure and transparent way of tracking goods throughout the supply chain, despite its high energy consumption. This ensures that products are traceable from production to the point of sale, offering another layer of security against counterfeiting.

Philippe Chatelain's insights demonstrate that while AI has yet to be fully leveraged in all industries, it holds a strong potential for the future of anti-counterfeiting efforts. His experience

highlights the need for businesses to integrate advanced technologies strategically and to collaborate effectively with stakeholders to safeguard their products and consumers.

4.3 Discussion of Findings

Existing Research and Academic Perspective

The integration of AI into anti-counterfeiting strategies has been increasingly recognized as a critical area of research within academia. Early studies highlighted the limitations of traditional methods, such as holograms and serial numbers, which have become less effective as counterfeiters employ more sophisticated techniques. In response, scholars have explored the potential of AI to revolutionize the detection and prevention of counterfeit goods.

Recent research has focused on the synergy between AI and other emerging technologies like blockchain and machine learning. For example, academic papers have demonstrated the effectiveness of AI-powered image recognition in identifying counterfeit products in the fashion industry, significantly outpacing traditional detection methods (Goodfirms 2023). The combination of AI with blockchain technology has also been widely studied, with researchers emphasizing the enhanced transparency and traceability it brings to supply chains, particularly in high-risk industries like pharmaceuticals.

Furthermore, academia has begun to address the legal and ethical implications of AI in anti-counterfeiting efforts. Concerns regarding data privacy, algorithmic bias, and the potential for AI systems to disproportionately target certain regions or demographics have been central to these discussions. Researchers have called for comprehensive legal frameworks and guidelines to ensure that AI is used ethically and responsibly in combating counterfeiting (Gevers 2023).

Implications for Businesses and Policymakers

The findings from these case studies have profound implications for both businesses and policymakers. For businesses, the integration of AI into anti-counterfeiting efforts offers numerous benefits, including enhanced detection accuracy, improved supply chain transparency, and increased consumer trust. Companies that effectively deploy AI technologies can gain a competitive edge by protecting their brand / businesss and ensuring the authenticity of their products.

However, the adoption of AI also presents challenges, particularly in terms of data management and security. Businesses must invest in robust data infrastructure to support AI systems and ensure the accuracy and reliability of the data being analysed. Furthermore, companies must address the ethical concerns associated with AI, such as potential biases in algorithmic decision-making and the protection of consumer privacy (UNODC 2024).

For policymakers, the rise of AI in anti-counterfeiting efforts underscores the need for new regulations and standards. Governments must develop legal frameworks that govern the use of AI, particularly in relation to data protection and intellectual property rights. Policymakers should also consider the broader societal impacts of AI, such as the potential for job displacement and the ethical implications of automated decision-making (Goodfirms 2023).

International collaboration is also essential to effectively combat counterfeiting, in the minute of the world. Policymakers must work together to create harmonized regulations and share best practices for the use of AI in anti-counterfeiting efforts. By doing so, they can create a more secure and transparent global marketplace that protects both businesses and consumers from the dangers of counterfeit products.

5. Conclusion

To summarize, counterfeiting is a persistent global problem, affecting numerous industries if not all of them. Traditional anti-counterfeiting methods, while useful, have proven to be insufficient in tackling the increasingly sophisticated counterfeit operations. As shown in this thesis, artificial intelligence (AI) offers powerful and adaptable solution that can significantly enhance efforts to combat counterfeiting by improving product authentication, supply chain transparency, and proactive detection.

AI's ability to process vast amounts of data quickly and accurately is revolutionary. Through AI-powered image recognition and machine learning, companies can identify counterfeit goods with greater precision than traditional methods like holograms or serial numbers. AI systems can detect subtle variations in design, material and productions methods that human inspectors might miss. These systems are also capable of learning from new data, making them more effective at predicting and preventing future counterfeiting attempts.

Furthermore, the integration of blockchain technology with AI enhances traceability and accountability across supply chains. Blockchain ensures that every transaction involving a product is recorded in an unchallengeable archive, which can be cross verified by AI to detect discrepancies or suspicious activities. These layers of security are achievable only through these technologies, where companies can use as a tool to protect the provenance of their product.

However, although these technologies offer many fast and effective changes, there are some concerns about data privacy, algorithmic bias, and the security of AI systems themselves. As counterfeiters become more sophisticated, AI systems must continuously evolve to remain effective. Moreover, brand / business owners must invest in robust data infrastructure and collaborate with regulators to ensure that AI is used ethically and responsibly. Governments are

the main players in this situation; they must implement appropriate legal frameworks that address the complexities of AI, ensuring consumer protection while fostering innovation.

Now of course, there will be in a decline on traditional roles focused on physical authentication, as digital verification reduces the need for manual checks. However, if information biases emerge in AI models by relying on incomplete data this could impact the accuracy and fairness of counterfeit detection across different products and markets. Which is why a follow-up always needs to be made to achieve high precision.

Ultimately, AI represents a critical component in the ongoing fight against counterfeiting. While it is not a standalone solution, AI significantly enhances existing methods, making them more effective, adaptable, and scalable. Its ability to analyse, predict, and respond to counterfeiting threats in real-time offers businesses and governments a proactive approach to protecting consumers and preserving the integrity of legitimate products. The future of AI in this field looks promising, with continued advancements likely to improve both the accuracy and efficiency of anti-counterfeiting measures, offering hope for a safer and more secure global marketplace.

As this thesis has explored, AI is not only a viable solution to counterfeiting but an essential one. Through careful implementation, collaboration, and ongoing technological development AI has the potential to transform how industries protect their products, safeguard consumers, and maintain the integrity of global commerce.

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Compile all sources cited in the thesis, formatted according to the American Economic Review style.

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7. Appendices

INTERVIEW QUESTION PHILIPPE CHATELAIN

Philippe Chatelain is a Swiss entrepreneur and expert in product authentication, with a strong background in technological engineering. He developed his expertise while working at Philip Morris International (PMI), where he led global initiatives to combat counterfeit tobacco products using advanced technologies. Philippe's extensive experience combines innovation, market intelligence, and strategic collaboration to address counterfeiting challenges effectively.

General Background/Introduction

1. Can you provide an overview of your educational background? What did you study?

My study was basically technological engineering. I studied in Switzerland where I did a bachelors and a master's in engineering.

2. Can you provide a brief overview of your professional background? What do you today?

My first job was in a company of big screens for stadiums and time keeping system. I was the developer there. After 2 years I became the manager of a team in this company, where I then escalated to becoming the manager of the company. I stayed 4 years in this company.

After I decided to move to the Tabacco industry. I was interested to follow a company that was in manufacturing. PM offered me a position and I pursued my objective to learn on manufacturing in Neuchâtel, Switzerland. My first position involved working on automatic quality electronics. Then 2 years after, HQ approached me and wanted to offer me a new position that would require to work internationally, for the packaging environment.

Today I am doing a bit of consulting, and I work in trustability technology in giving advantage on sustainability for climate/ CO2 reduction.

3. How did you start working for PM and what was your role in the company?

I was in charge of development of new packaging ID for the product, working worldwide for innovation. Enlarging my knowledge of this product and understanding the complexity behind it. After 3 years of this job, they asked me to participate on a program to fight against counterfeiting. Immediately after I was made head of this program.

When you have an issue, and you know the product is counterfeited. First you need to understand the scale, the complexity, after having put a place a program.

To face counterfeiting, you need to put in place multiple steps:

- *Technology*
- *Intelligence of the market (market survey)/ what is the proportion of the genuine problem we have?*
- *Investigation/ try to understand (like police) from where the product is coming. The origin of the counterfeit*
- *Proof, evidence of the counterfeit products, that people are counterfeiting your product*
- *Collaboration with various stakeholders, training and explaining to them the danger of the counterfeited products . Also communicate strategies, to law enforcement, government, distributors to defeat counterfeiting.*

**Everything is together, you do everything to eliminate the problem. It's a strategy you develop.*

"I asked to pick up empty, consumed packs on the street (empty packs) and study used packs to really have a better understanding of the real market"

4. Could you explain why it was necessary to create an authentication system? What was the reason/need behind it?

Counterfeit are made by criminals. It's proven that counterfeit is mainly done by large organisations, managed by mafia, terrorist, and is made by people who want money quickly no matter what.

It corresponds to 3% of….

People need money. There is drug traffic, arm traffic but the easiest is counterfeit products. Why? Because with counterfeiting you don't get big consequences. It's legitimate products but counterfeited/imitated which in the law, doesn't have big penalties. Criminals use their network to sell their counterfeited products to make money.

Why do people buy it? 1 Some people buy it because they don't know the product is fake. 2 It's better market, less expensive, more attractive, "I know its counterfeited, but I don't care. E.G watches." 3 People think they are buying real authentic products but less expensive.

<u>Development and Implementation</u>

5. Were there already any methods at the time to fight counterfeiting when you first started working there?

It's a learning process, but we were early in finding out and applying technological solutions. Beforehand we were using holograms.

Or for example UV lamps, you can develop products that under UV lamps have an effect. Like a pack of cigarettes, has a part where the colour is brighter or not, with a UV lamp you can tell whether the pack is authentic or not depending on the brightness of the pack.

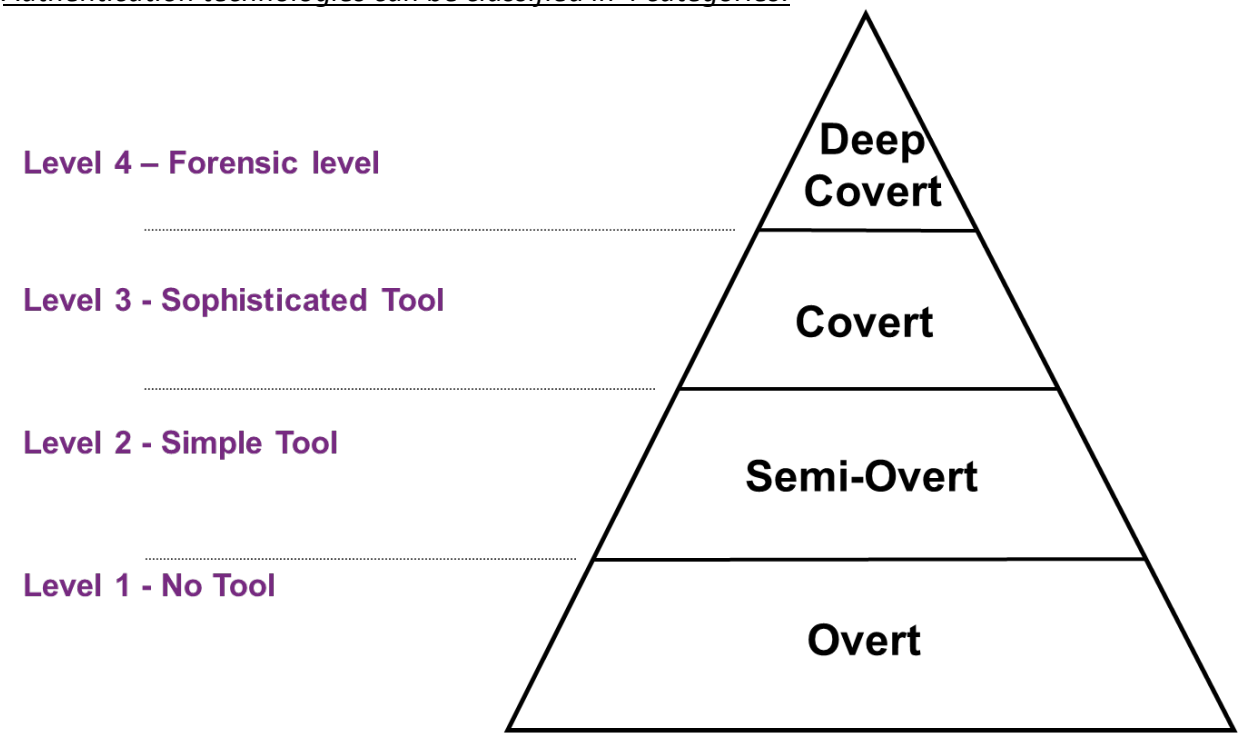
6. What were the main challenges during development and implementation?

I faced many challenges.

> *1st challenge: You need to make sure you have a method/technology to detect. This is very complex. When you develop a technology, this technology cannot be copied. You need to know customers, the stakeholders and what they want, what they use, who they are. You need to find compatibility, a tool (e.g. smartphone) that they can use everyday.*
>
> *2nd challenge: communication internally and externally. Who is behind, who to speak to etc…*
>
> *3th challenge: collaboration (e.g. IP, judges etc..)*
>
> *4th challenge: legal action, people making counterfeit are not very much penalised. The law is not very strong against counterfeit.*

7. What type of authentication technology exists, and which ones do you recommend?

<u>Authentication technologies can be classified in 4 categories:</u>



LEVEL 1
Visual effect, can be detected by necked eyes.
Disadvantage: A mimicking effect can create doubt to stakeholders.

LEVEL 2
A simple and available toll will help to verify, like Smartphone, magnifying glass,..
Should be the most robust solution available for all stakeholders.
LEVEL 3 & 4
Detected by sophisticated devices.
Robust but limiting stakeholders use.

Brand / business owners should define first their strategy prior selecting the appropriate technology, taking into consideration:

- *Who will use it?*
- *Multi-layer approach (several technologies applied)*
- *Applicability on the product (manufacturing, process…)*

Counterfeit Detection

8. Does your invention have any AI detecting system? If yes how? If no is it something you potentially see happen in the future?

At the time no AI was used in PM, not at all.

What is AI? It is a tool that can go through a lot of data, and perform (e.g. books, checking references). For example, translation, vocal or reading etc…

AI is close to machine learning- to make decisions, however it doesn't have feelings, emotions.

Industrially we have exchanged humans to machines, so that humans have easier tasks to do.

Blockchain Integration

9. When speaking about blockchain, could you maybe specify how it plays a role in the authentication system?

Blockchain is a machine that helps to authenticate, it's a system another way of authenticating. Unfortunately, it consumes a lot of energy, but the principle is similar to trackability.

Impact and Results

10. What impact has the system had on reducing counterfeit products?

1 example was a solution implemented in one market (will not mention which one), and it was made a success. 3% of the market was counterfeited and after 6 months of implementation of the process to fight against the counterfeited, there was a decrease of 300x of fake products.

Future Directions

11. When looking at the future, what developments do you see for AI counterfeit detection?

I will give a few ideas:

- *Machine learning is a tool like AI (training a machine to learn) coupled with vision system (e.g. cameras, smartphones)*
- *AI can establish data sorting base on big volume, meaning coupled with unique code per product*
- *AI can help in investigation and can even help the police.*

Best Practices and Recommendations

12. For you what are the main strengths of AI?

In my view, AI is widely used today for the main key following strengths:

- *Data analysis and extraction, predictions and support to automation.*
- *More specifically, to fight counterfeiting, I would say that the key strengths would be in image recognition using machine learning or in investigation activities to help detecting presence of counterfeit products on the supply chain based on data (financial, tracking,…)*

13. Is there any advice you could give to businesses on using technology to combat counterfeiting?

My advice is to use technology

- *Understand the stakeholders, who is using the technology? Who will use it?*
- *Is my technology secure enough?*
- *The complexity of the business: in a company putting a technology to fight counterfeit means having an impact on the product. It's a multi operational*
- *Making sure that it is operational*
- *Anticipate, what to do with the technology if it is compromised.*

Personal Insights

14. Personally, what has been the most rewarding aspect of developing this system?

Many, when you develop a technology and you see it works, that it is a success, it is a satisfaction.

Closing counterfeiters, finding them and stopping them, is rewarding.

Every time I develop a system to fight against counterfeiting, I try to add something else to give it another utility and that is rewarding.