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The invisible nature of modern slavery in the apparel industry's supply chains

Technological opportunities for detection

Bachelor's thesis in
Operations and Supply Chain Management

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Abstract

Modern slavery is a pervasive conundrum. It is particularly complicated and widespread in the apparel industry due to labour-intensive production that requires human dexterity, relentless upstream cost-cutting pressure, and the industry's global reach.

This thesis contributes to academic research by synthesizing the extant literature to illuminate the potential upsides and risks of technology when it is utilized for detecting modern slavery in the apparel industry's supply chains. The findings reveal that modern slavery remains invisible due to the various barriers that hinder its detection, such as ineffective regulation, conceptual ambiguity, bystander effect, supply chain fragmentation, auditing flaws, and business capabilities to perpetuate the status quo. Industry 4.0 solutions can be employed more effectively to aid detection efforts by tailoring them to the unique circumstances of the supply chain.

However, technology is not an immediate panacea, and the outcome depends on various factors such as the underlying motivation to detect modern slavery. Technology presents unquestionable potential for enhancing detection; however, it can be utilized to both conceal and advance detection.

Keywords: modern slavery, industry 4.0, apparel industry, social sustainability, supply chain due diligence, fast fashion, ultra-fast fashion, bystander effect, auditing

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Tiivistelmä

Moderni orjuus on laajalle levinnyt ongelma. Vaateteollisuudessa ilmiö on erityisen yleinen ja monimutkainen työvoimavaltaisten tuotantoprosessien, toimitusketjujen ylävirtaan kohdistuvien kustannuspaineiden sekä globaalin ulottuvuuden myötä.

Tutkielma edistää akateemista tutkimusta kokoamalla yhteen olemassa olevaa kirjallisuutta, valaisten teknologian mahdollistamia etuja ja riskejä modernin orjuuden havaitsemiseksi vaateteollisuuden toimitusketjuissa. Tulokset osoittavat, että moderni orjuus pysyy usein näkymättömänä havaitsemista vaikeuttavien tekijöiden kautta. Näitä ovat muun muassa tehoton lainsäädäntö, käsitteelliset epäselvyydet, sivustakatsojaefekti, toimitusketjujen pirstaloituneisuus, auditoinnin vajavuudet sekä yritysten kyvykkyydet ylläpitää nykytilannetta. Teollisuus 4.0 -ratkaisuja voidaan hyödyntää tehokkaammin havaitsemisessa sovittamalla niitä toimitusketjujen erityispiirteisiin.

Teknologia ei kuitenkaan ole välitön ratkaisu, vaan sen vaikutukset riippuvat monista tekijöistä kuten taustalla olevasta motivaatiosta havaita modernia orjuutta. Teknologialla on kiistatta valtavaa potentiaalia havaitsemisen tehostamiseksi; sitä voidaan kuitenkin hyödyntää niin modernin orjuuden peittämiseen, että sen tunnistamiseen.

Avainsanat: moderni orjuus, teollisuus 4.0, vaateteollisuus, sosiaalinen kestävyys, toimitusketjujen huolellisuusvelvoite, pikamuoti, ultra-pikamuoti, sivustakatsojaefekti, auditointi

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1.1 Introduction to the topic

Slavery has been haunting humanity ever since the dawn of civilization. Contrary to popular belief, even to this day, we haven't been able to root it out. Slavery is commonly dismissed as a relic of the past, but it's thriving in most corners of business (Quirk 2006). The transatlantic slave trade may have ended at the end of the nineteenth century, but slavery persists all around the world; it just manifests itself differently in many diverse forms.

Contemporary slavery, or modern slavery as it is often called, can be perceived as a multifaceted continuum with varying degrees of coercion and consent (Quirk 2006). Due to this complexity, there isn't a single commonly agreed definition for modern slavery, rather it's used as an umbrella term to represent different forms of human exploitation, such as forced marriage, bonded labour, debt-bondage, child labour, or the removal of one's organs (Voss et al. 2019). The usual manifestations of modern slavery are forced labour, human trafficking, and child labour (Chen et al. 2024). It is estimated that currently 50 million humans are living under modern slavery, and the development is withering towards a hopeless path (ILO 2022). The International Labour Organization estimated that in 2005, there were approximately just over 12 million humans under forced labour (Belser et al. 2005). Today, the number is over double what it was at the start of the millennium; around 27.6 million humans are ensnared in forced labour globally, simultaneously generating 236 billion USD of illegal profits annually (Walk Free 2022; ILO 2024).

Even though it is widely condemned as highly unethical, it remains a viable practice for businesses (Crane 2013). Most countries and governments have passed legislation against modern slavery, but despite this, it keeps steadily rising in all sectors (Chen et al. 2024). Modern slavery is an invisible conundrum, and the way the global supply chains are routinely configured – long and complex with a plethora of different suppliers with poor transparency across the chain – is not helping (Lofti and Walker 2025). Supply chains are a key part of the current modern slavery issue because it is often extremely difficult to identify these common instances of human exploitation (Shilling et al. 2021). Sustainable supply chain management is essential for facilitating decent working conditions, because it does not only shape employment practices, but it also impacts business capabilities and models as a whole (LeBaron 2021).

The garment manufacturing sector in particular is a big modern slavery perpetrator, and according to the Walk Free Organization's 2023 report, the industry has doubled in size in the last 15 years, in part due to the increased consumer demand for fast fashion. Modern slavery encompasses some of the most heinous and vile crimes against humanity. It also causes enormous damage to a company's reputation and bears huge financial risks along with it (Chen et al. 2024). Companies have a responsibility to respect human rights, and thus they must identify and eradicate modern slavery practices from their supply chains (Caspersz et al. 2022).

1.2 The purpose of the study

Technology is increasingly being used for improving the supply chain transparency and helping workers to expose treacherous working conditions (Ford and Nolan 2020). Although it has a lot of potential for combating modern slavery, it's not as clear as how effective it has been. Additionally, it may also be used by the very perpetrators to control the victims. (Chen et al. 2024) The current struggle against modern slavery is extremely wicked and ambiguous in nature; even the identification of victims is far from being straightforward. Furthermore, we have already exhausted the most obvious remedy of legal abolition without real success.

The purpose of this literature review is to analyze the existing research on modern slavery in the apparel industry and assess the possibilities that different industry 4.0 technologies, such as Blockchain, might do to aid detection efforts. The aim is also to contextualize and shed light on the invisible aspect of modern slavery in the apparel industry's supply chains while offering guidance and concrete actions in order to detect modern slavery in these supply chains. Thus, the leading research questions of the thesis are as follows:

RQ1: Why is modern slavery still hiding and what is hindering the detection in today's garment and fashion industry's supply chains?

RQ2: How can industry 4.0 technologies help detect modern slavery in apparel industry's supply chains?

Consequently, for the purpose of this thesis, I am excluding the forms of modern slavery that are not directly tied to supply chains, such as forced marriage, and I will primarily focus on forced labour, child labour, and debt bondage in the apparel industry.

The thesis is structured as follows: Section two centres around conceptualising the hidden element of modern slavery and the challenges associated with detecting it. Section three discusses modern slavery in the apparel industry context. Section four addresses the characteristics of effective detection along with the specific industry 4.0 routes for enhancing detection efforts, as well as the limitations of a technology driven approach. The last section ties the thesis together by synthesizing the extant literature into potential insights, answering research questions, and concludes with pointing direction for future research.

2 The invisibility of modern slavery

2.1 Modern slavery

Modern slavery comprises some of the most extreme forms of labour abuse and exploitation in the global economy (Crane et al. 2022). One of which is forced labour. A common misunderstanding about forced labour is that the victims had to be forced to it, but in reality, often times they freely agreed to work and only afterwards realized the horrific conditions they were tricked into, at which point leaving without repercussions is not an option (Skrivankova 2010). Being a victim of modern slavery does not mean that you are not being paid at all; at times, victims of modern slavery do end up receiving a salary, but the amount is often only nominal. On top of this wage theft, they can be simultaneously denied any benefits and charged an excess amount for essentials such as food, housing, and transportation. Additionally, in many cases, these costs are covered by debt, which in turn makes it more difficult to escape the situation. (Stringer and Michailova 2018) Debt bondage, which is a situation where a victim is forced under debt in order to work – usually with very high interest – is a common way to trap workers (LeBaron 2021). The conditions of the debt are fabricated in a way that the labour does not reduce the original debt. It can even be passed down through generations to the offspring. (Bales 2012) In particular, the risk of modern slavery affects the most vulnerable, as informal actors often employ migrant workers and hold high child labour rates (Chanani et al. 2022).

There is no legal ownership of human beings today; nonetheless, slaveholders still gain control over people and hold all the benefits of ownership just without legal formalities. Modern slavery hides behind various masks using different cunning tactics, but when the lies are peeled away, victims who are denied personal freedoms and controlled by violence for someone else's economic gain remain. (Bales 2012)

2.2 Challenges to unveiling it

2.2.1 Ineffective regulation

During the 1990's it became clear that despite the legal efforts and laws that had been put in place to put an end to modern slavery, labour exploitation was thriving nonetheless (Stringer and Michailova 2018). Certain governments mistakenly believe that existing laws and regulations can effectively address the issue of modern slavery in supply chains (Chen et al. 2024). More recently,

public governance initiatives such as the California Transparency in Supply Chains Act (2010) and the UK Modern Slavery Act (2015) have been established in an effort to increase corporate accountability and transparency, but without much success since they both lack proper enforcement mechanisms (Stringer and Michailova 2018).

Due to the illegality of modern slavery, companies obscure information in their reports. For instance, the use of ambiguous language creates room for varied interpretations, selective disclosure, and strategic silence in turn limit the outsider's access to information. (Stringer and Michailova 2018) Detecting modern slavery may even be more difficult to do than other social issues because it operates invisibly and involves active deceit (New 2015; Stevenson and Cole 2018). Companies also use a variety of different strategies, such as defensive reassurance, transfer of responsibility, and scope-reducing techniques to suppress the effectiveness of due diligence processes. These strategies are aimed at defending the status quo and hiding modern slavery because the company does not benefit from dismantling it from their supply chains, but rather the opposite. (Meehan and Pinnington 2021)

The reporting requirements set for companies are limited and do not demand them to regularly update their efforts to address modern slavery, and thus the impact to transparency is also limited (Voss et al. 2019). The UK Modern Slavery Act (2015) Section 54 mandates companies based in United Kingdom to report on how they are engaged in eradicating modern slavery that concerns their core business operations and their supply chain. Through this, the United Kingdom government is trying to reduce the governance gap and create a ‘‘race to the top’’. However, this notion of transparency legislation rests on the assumption that infringements lead to severe public scrutiny and reputational damage. The concern thus is whether this actually happens in the real world and whether corporate accountability legislation manages to progress the labour standards in a consequential way. (Voss et al. 2019)

2.2.2 Conceptual ambiguity

Countries often try to fit this complex reality in a single definition by defining forced labour too narrowly, for instance forced labour linked to human trafficking, or too broadly, conditions conflicting with human dignity. (Skrivankova 2010) While various legal instruments and jurisdictions have set definitions of their own on forced labour, a lack of guidance on the specific parameters or the normative content blur the line (Allain 2015). In 1930 the International Labour

Organization prohibited forced labour and defined it as ‘’any work or service which is exacted from any person under the menace of any penalty and for which the said person has not offered himself voluntarily’’. (ILO 1930) The menace of penalty relates to the threats that could result in the loss of any rights of privileges, for instance through physical violence, restriction of movement and coercion, and involuntariness to situations where prior consent was given (Guelker 2024). In addition, at the intersection of developing and developed countries, identifying victims becomes highly vague since some activities that are compliant in one place can be ruled illegal in another (Chen et al. 2024).

There is no consensus on the definition of modern slavery, and it is not defined in any international instrument (Voss et al. 2019). Forced labour, on the other hand is defined but the definitions vary and the research does not provide clear boundaries but rather relies on identifying individual indicators of forced labour (Guelker 2024). The absence of clear definitions when dealing with modern slavery and labour abuse makes it difficult to draw lines between extreme exploitation i.e., forced labour, and different types of less severe labour abuse cases (Skrivankova 2010). Due to the plethora of different forms and severities of exploitation that workers are subjected to, the dynamic changing nature of the working conditions and the unique situations and experiences involved, the standard binary classification model – it’s either or with nothing in between – is a drastic simplification that is inadequate to capture the complex phenomena of forced labour (Skrivankova 2010). Through minor, serious and extreme labour violations, working conditions range from decent work to forced labour in a continuum where different levels and combinations of abuse and exploitation occur. Labour exploitation and forced labour are sometimes used interchangeably, which is problematic since the type and severity of exploitation is connected to the effective remediation interventions (Skrivankova 2010). For instance, the remediation for exploitative labour conditions can be found in labour law, whereas forced labour remediation includes both labour and criminal law efforts (Skrivankova 2010).

Therefore, viewing forced labour in a continuum running from mild to severe exploitation is a better way to understand it because the majority of labour carried out – whether voluntary or coerced – is done as a consequence of implicit or explicit threats. (Steinfeld 2009) There are several categories of threats, which create varied degrees of pressure such as economic, physical, psychological, social, and legal threats. The severity of the threats fundamentally affects the end outcome. Drawing the line for forced labour should not be done on the basis of consent, but rather by analyzing the vulnerabilities that can be abused to obtain it. (Steinfeld 2009) The continuum helps to understand the individual reality of a situation and helps in identifying the most suitable way of remediation

(Skrivankova 2010). Hence, without clear boundaries, rules, and understanding of terminology, industries cannot develop the effective solutions it needs to fight modern slavery (Lofti and Walker 2025). Moreover, research has revealed that sometimes workers under these treacherous conditions did not even perceive themselves as slaves (Gold et al. 2015).

2.2.3 Bystander effect

Even though there have been countless number of modern slavery scandals in the media and people are more aware of it than ever before, it still manages to remain hidden. This growing knowledge of the conditions that people are subjected to down the supply chain can lead to the diffusion of responsibility. This phenomenon is known as the bystander effect in psychology literature. (Stevenson 2022)

There are several factors that contribute to the bystander effect, such as the perceived level of emergency; a person is far more likely to intervene in a high emergency situation, and in the context of modern slavery, the perceived level of emergency is highly subjective and linked to prior understanding of modern slavery and its consequences. When it's combined with the hidden nature of the problem, it often leads to the conclusion that no urgent action is needed. Secondly, the surrounding ambiguity of the situation affects the time it takes to respond to it and also how circumstances are interpreted as a whole. To outsiders, it is not clear if workers are paid and how much or whether workers want to stay or be freed from the situation. Thirdly, the sense of responsibility towards the victim and the belief that someone deserves to be helped. This feeling is affected not only by the social and cultural distance between the observer and victim, but also by the potential moral conflict of being complicit in buying products created by modern slavery. (Stevenson 2022) It helps to explain why fashion consumers especially feel that worker exploitation and their welfare are a lesser concern (Stringer et al. 2022). Responsibility also decreases if large companies are perceived to have problems with modern slavery. Lastly, the incentives for assisting the victim are important because criminal activity is involved, and reporting it could potentially put the helper in danger. Furthermore, modern slavery is not a single event, but a continuous silent problem that usually requires indirect intervention towards relevant entities, but at the same time it is difficult to pinpoint the appropriate ones due to the number of authorities and stakeholders involved. (Stevenson 2022)

2.2.4 Victim voices

In order to improve labour conditions, research has identified worker voices as a crucial missing piece in supply chains (Outhwaite and Marting-Ortega 2019). It is acknowledged that worker voices are critically important for understanding the realities of labour conditions (Benstead et al. 2021). Currently, worker voices are not being sufficiently heard but enabling them also is recognized to be highly challenging (Stevenson 2022). Workers can be reluctant to report conditions due to fear of employer retaliation (Chanani et al. 2022). Forced labour obstructs workers' voices due to active repression (Stephens et al. 2025). 'Worker voice' has not been explicitly defined in the field of sustainable supply chain management but is however established in other fields. It can be defined as ''the ways and means through which employees attempt to have a say and potentially influence organizational affairs about issues that affect their work and the interests of managers''. It is also distinguished from employee voice because it's concerned with workers who might not have a direct employment relationship to the lead company. (Stephens et al. 2025)

If the methods to detect and remediate don't involve victim perspectives, their plight remains in the shadow. Therefore, order to detect and address labour exploitation, a more comprehensive approach where workers are included in every step of the way is necessary. (Outhwaite and Marting-Ortega 2019)

2.2.5 Profitable business of slavery

Modern slavery continues to be driven by economic prosperity, just as traditional slavery was. In labour intensive industries, where wages and other labour related costs account for the majority of the total costs, lowering them becomes the most effective strategy for decreasing operation costs and increasing profitability. (Crane et al. 2022) Inherently, modern slavery is an attempt to underprice labour through illegal means (Crane 2013). If it's possible to reduce labour costs lower than the current market rate, then there will always be an incentive for modern slavery usage in order to secure a bigger profit margin (Stringer and Michailova 2018).

By far the most common type of modern slavery in a company's supply chain is forced labour (Chen et al. 2024). Crane (2013) argues that companies using forced labour and slavery have specific 'slavery management capabilities' to do so. There are two types of these capabilities, which encompass different types of activities in order to sustain the hidden practice of modern slavery. First one is *'exploiting and insulating capabilities'* which comprises the access and deployment of

violence, and in the case of modern slavery – compared to traditional – is an essential element because due to the illegality it is difficult to hold onto labour, therefore violence becomes the primary enforcer of exploitative contracts which prevent workers from leaving. '*Debt management'* enables companies to manipulate debt in order to trap vulnerable workers into the cycle of forced labour. '*Accounting opacity'* is the ability to falsify and distort accounting records that are presented to stakeholders such as auditors and investors. '*Labour supply chain management'* is the undercover coordination of workers within a multitiered human trafficking chain that includes various intermediaries. (Crane 2013)

The second type, 'sustaining and shaping capability' comprises of moral legitimization, which means justifying and rationalizing the use of forced labour via storytelling, culture management and other forms of socialization to ensure acceptability. '*Domain maintenance'* relates to the use of illegal practices such as bribery, threats and informal lobbying to achieve the needed goals. (Crane 2013; Chen et al. 2024) This way, the exploitation culprits who abuse victims and so blatantly disregard their human rights enjoy impunity because modern slavery remains concealed (Skrivankova 2010).

2.2.6 Supply chain fragmentation

Outsourcing has become the hallmark in today's realm of business. Globalized modern slavery exists largely due to the business rationale side, but also due to the governance and the structure of complex global supply chains, which enable the precarious conditions in which exploitation occurs (Stringer and Michailova 2018). Research points out that the risk of modern slavery is increased when production and labour recruitment are outsourced (Benstead et al. 2021).
Today, global supply chains are spread throughout a wide geographical area across and within different countries (Tokatli 2008). Meanwhile, companies orchestrating this fragmentation assist in hiding slavery by creating fertile conditions for it to exist in the supply chain either by a deliberate business strategy or due to ignorance (Lofti and Walker 2025). Companies are increasingly outsourcing and subcontracting their activities to suppliers, and the relationships are often operated at an arm's length distance with up to thousands of tier-one suppliers (Stringer and Michailova 2018). Tier-one suppliers may then outsource the more labour-intensive and lower value activities further in order to fulfill the original commission to sub-tier suppliers. The cycle continues and as a result, a shrouded multitiered subcontracting network is formed where unregulated 'shadow factories' with no guarantees and incentives for ensuring decent working conditions exist. Hence,

labour exploitation there is standard practice. (Stringer and Michailova 2018; LeBaron 2014) Suppliers beyond the first-tier are often unknown, as are the sources of their production, because they exist outside of the company's range of influence (Voss et al. 2019).

A vast amount of forced labour is in remote and/or hidden locations in developing as well as in industrialized countries (Crane 2013). LeBaron (2014) highlights that the fragmentation of supply chains is not an automatic or spontaneous phenomenon but a strategy for accumulating profits. By obtaining production elsewhere, companies outsource the workers and by doing so, they strategically offload risks to others in the chain, enabling them to evade and deny liability (Phillips and Mieres 2014).
The connection between resource harvesting i.e., primary activities and the end consumers is well established, and at the same time tracing the chain is extremely difficult or near impossible (Stringer and Michailova 2018). Downward cost pressures and short production lead time have increased demand for low-cost labour (Berg et al. 2020). Therefore, companies' outsourcing practices and consumers' demand for cheaper and faster product delivery plays a significant role in the employment of modern slavery practices because pressure is exerted upstream to the most labour-intensive area of the chain (Kingsley at al. 2026). The primary industries affected have become more uncompetitive due to growing operating costs and smaller profit margins; in order to survive they resort to cutting wages. This 'value trap slavery' makes employing workers legally much harder and puts pressure toward practicing modern slavery. (Crane 2013)

2.2.7 Socioeconomic and cultural factors

Socioeconomic factors like poverty and a low education level within a region give rise to modern slavery. People are more susceptible to deception and coercion since they are out of genuine options to make a living (Chen et al. 2024). Migrant workers are especially vulnerable to modern slavery due to accumulated debts from recruiters who coerce them to remain in the cycle of exploitation (Berg et al. 2020). Sometimes families who are facing financial misfortune are forced to view their own children as commodities (Bales 2012). Thus, in some poor regions' child labour is utilized in order for families to survive (Chen et al. 2024). Contemporary labour relation systems are used to legitimize and hide modern slavery, which exacerbates the situation even more. Fraudulent labour contracts are devised to masquerade modern slavery as a legitimate practice. In reality, the purpose of these contracts is the enslavement of victims. Contract slavery, as it is called, is the quickest growing form of slavery today (Bales 2012).

Social and cultural traditions can disguise modern slavery as culture. Traditional practices and norms can perpetuate exploitation and slavery because, in some cases it is considered acceptable by the locals. (Chen et al. 2024) There are multiple factors that may give rise to an accommodative culture such as traditions, entrenched inequalities, and religious beliefs (Crane 2013). For instance, the religious belief in the inferiority of girls in Thailand makes them particularly vulnerable to modern slavery.

The institutional conditions i.e., the surrounding socioeconomic, geographic, cultural, regulatory, and industry-specific factors all affect the threat of modern slavery's occurrence (Crane 2013). Detection and remediation efforts are embedded into this broader institutional context (Gold et al. 2015). These characteristics and complexities make the detection extremely difficult and even abstract at times.

2.2.8 Auditing flaws

The usual practice for detection are social audits which are not always sufficient for identifying and improving labour conditions. The current business environment encourages a culture of passing audits through dishonesty rather than through improvement. This can lead to mock compliance where suppliers appear to be doing the right things but only for the duration of the investigation (Stevenson and Cole 2018). Similarly, it encourages a variety of fake compliance strategies to fall in line with the codes of conduct such as falsifying documents, holding separate records for auditors and coaching workers for interviews (Benstead et al. 2021). Tambe and Tambay (2020) argue that one of the main reasons that organizations fail to detect modern slavery in the supply chain is due to human-centered due diligence processes, which entail significant weaknesses. There is also growing evidence that standard auditing is ineffective, mostly benefiting the companies and organizations themselves rather than addressing labour exploitation. Companies have their own individual auditing procedures, and the less powerful suppliers in many cases are not involved in the decision making process of how the audits should be conducted and are not able to provide any input. (Benstead et al. 2021) Additionally, misaligned incentives between organizations and suppliers might encourage modern slavery in supply chains (Tambe and Tambay 2020).

The scant success of social auditing on working conditions has demonstrated that gathering data is difficult, costly, and corruptible (Berg et al. 2020). Accomplishing full transparency has a number of challenges, such as effective monitoring which requires active engagement and is costly in a vast

supplier network, unreliability of auditing practices, availability of advanced technological solutions, and the high prevalence of informal actors (Narula 2019). Research suggests that a more specific targeted approach is needed, but complex supply chains and high costs make it impractical (Stevenson and Cole 2018).

3 Apparel industry and modern slavery

It's in the beginning parts during the most labour-intensive stages of production where modern slavery is running rampant, and yet at the same time is most concealed (Stringer and Michailova 2018). Although modern slavery is a significant risk in most sectors of business, fashion, and the garment manufacturing industry is especially vulnerable to it due to the labour-intensive nature of the products (Uddin 2023). In the apparel sector, this stage requires human dexterity or customization which is often carried out by women working from home, informal enterprises or in remote locations. They are often doing tasks such as washing, printing, embroidery or lacework. A large part of the apparel value chains in developing countries is led by multinational enterprises that have numerous brands and labels under. (Narula 2019) Furthermore, due to the wide global reach of the fashion industry, the supply chain is also inherently more complicated and less transparent than in other industries (Annamma 2012). A pivotal development in the demand and growth for the fashion industry's products is the introduction and establishment of global fast-fashion retailers such as H&M, Uniqlo and Zara – to name a few (Stringer et al. 2022). Fast fashion means low-cost clothing that mimics a current luxury fashion trend that is produced in high quantities, and as cheaply as possible. The trends run their course with 'lightning speed' and encourage disposability. (Annamma 2012) The fast fashion sector is especially notorious for the lowered manufacturing costs, increased work intensity and tight schedules. The 'race to the bottom' will only continue as more and more retailers adopt these business strategies. (Stringer et al. 2022; Taplin 2014) Even faster approach i.e., ultra-fast fashion is being pursued by many retailers with shorter lead times where clothes can be brought from design to sale in a matter of days (Camargo et al. 2020). The methods that ultra-fast fashion brands such as Shein, Boohoo, and Asos require to keep their catalogue ceaselessly refreshed have led to the increased utilization of cheap and hazardous materials, reduced product lifespans, and labour exploitation (Sahimaa et al. 2023).

Over the past few decades, the use of sweatshop labour, child labour, and other forms of treacherous working conditions has received increasing coverage and has become a serious challenge for many fashion retailers (Stringer et al. 2022). For instance, the 2013 Rana Plaza tragedy where over 1100 workers died in a building collapse, garnered global attention to the poor working conditions within the garment and fashion industry (Narula 2019). Nevertheless, industry actors keep reporting strong growth and sales figures (Stringer et al. 2022). Research has indicated that there is a silent underlying consensus amongst consumers for the exploitative working conditions in order to ensure the availability of cheap fast fashion clothing. On top of this, it

highlights that consumers are often more interested in their own needs. This is due to the proximal and cultural distance between them, resulting in a lack of connection and a general inability to relate to the dire conditions of the worker. (Stringer et al. 2022)

A large part of the companies operating in the fashion industry have not reported anything or have merely just filed a single statement about addressing and identifying exploitation vulnerabilities in their operations (Voss et al. 2019). Given the fashion and garment manufacturing sectors' lofty profitability worldwide, there is an incentive to avoid investing in strategies to tackle human rights violations (Davies et al. 2025).

Literature offers a variety of different solutions, but many have been critically questioned because the challenge of detecting modern slavery lies in the fact that it operates and hides outside of law, and accomplishing transparency beyond tier-one is extremely challenging (Stevenson and Cole 2018). In line with Gold et al.'s (2015) research, detection and remediation are facilitated by appropriate capabilities that are embedded in the broader institutional context.

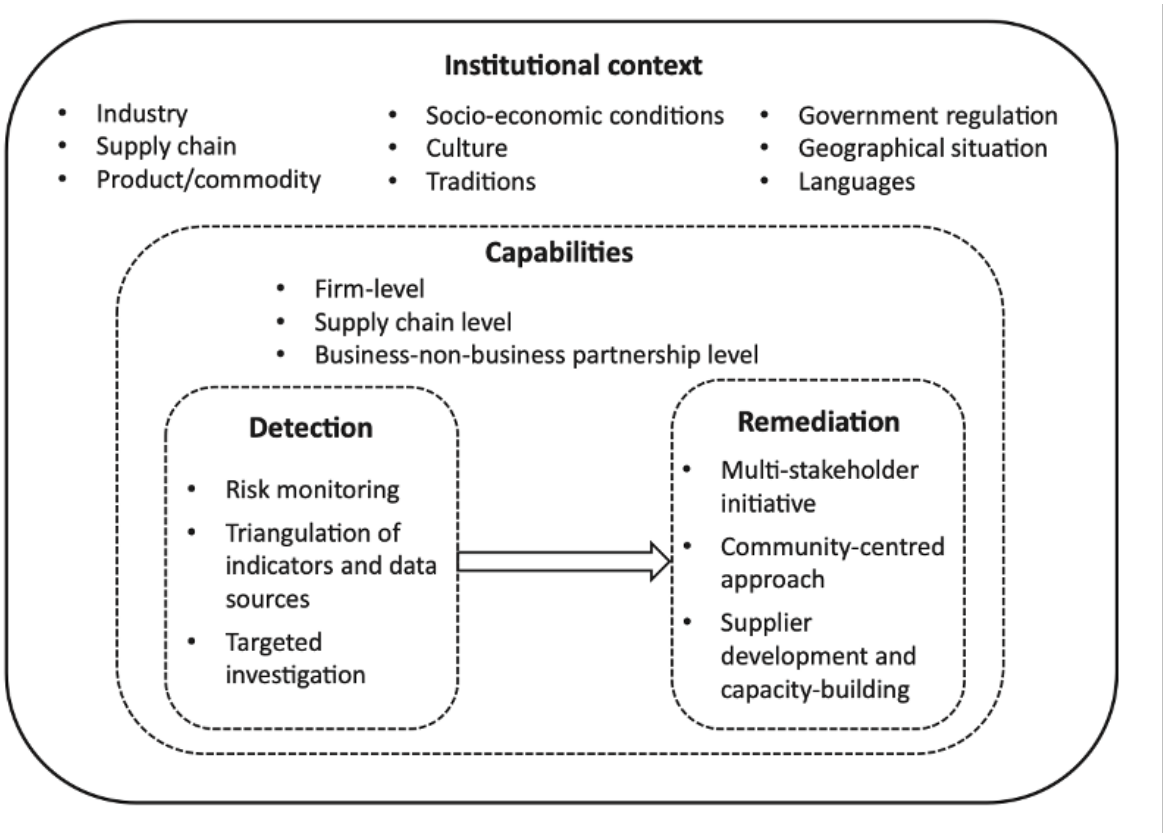

Figure 1. Conceptualising the challenges of slavery to supply chain management (Gold et al. 2015).

4 Enhancing detection with technology

4.1 Effective detection

Human centered due diligence processes are often slower, more expensive, and prone to errors and sabotage. If incentives are misaligned, due diligence processes are less likely to be effective at identifying modern slavery. (Tambe and Tambay 2020) The strong economic incentive for using modern slavery makes perpetrators actively hide it from their operations, making existing indicators of financial, operational, and sustainable supply chain performance challenging to adapt for the detection in a fragmented multi-tiered chain (Gold et al. 2015). Given that the conditions of those who are in the spectrum of modern slavery are under constant change, finding solutions for their plight is situational and highly challenging (Skrivankova 2010). The aforementioned continuum concept is especially valuable in terms of detection and remediation because it can be applied to any situation that deviates from decent work. It emphasizes the multitude of complex circumstances, broadening the scope of interventions. (Skrivankova 2010)

Existing research from other disciplines of science can be used to develop specific social, cultural, and geographical indicators of modern slavery in order to enhance detection (Gold et al. 2015). Additionally, tools specifically designed with human rights terminology and frameworks are more likely to identify adverse human rights abuses that might otherwise stay hidden (Tambe and Tambay 2020). However, the indicators alone are not enough; in practice in order to detect it, different viewpoints and methods, such as the economic data or the evaluation of satellite photos need to be utilized, which will vary depending on the context (Gold et al. 2015). Effective tools and indicators for detecting modern slavery in a supply chain must use a combination of monitoring risk indicators, triangulation of data sources, and targeted investigations (Gold et al. 2015).

4.2 Characteristics of effective detection

4.2.1 Risk monitoring

Traditional monitoring approaches have failed to detect a wide variety of human exploitation and labour violations across supply chains (Outhwaite and Martin-Ortega 2019). Even though it’s not quite clear how to detect modern slavery in parts of the supply chain where it is deliberately hidden, indicators such as low worker protection, a high percentage of poor workers, widespread discrimination against a certain group, social acceptance of worker exploitation, and a high

proportion of low-skilled labour can serve as an early warning for the existence of modern slavery (Gold et al. 2015). To promote supply chain transparency the Chartered Institute of Purchasing and Supply Walk Free Organization presents several risk indicators for the initial monitoring of modern slavery; low capacity of government or law enforcement agencies, high proportion of poor workers, lack of employment opportunities, recruitment of workers by agencies, high proportion of immigrants or ethnic minorities in the workforce, production activities located in less developed or conflict areas and high raw material extraction industries or low-skilled industries (Chen et al. 2024; Walk Free 2014). Indicators give direction to where further testing is required in order to detect in supply chains (Chen et al. 2024). To diversify the risk monitoring process further, companies are now able to use satellite remote sensing to monitor specific forms of modern slavery (Chen et al. 2024; Tambe and Tambay 2020). The detection and assessment of modern slavery in supply chains must also be monitored continuously (Chen et al. 2024). Furthermore, new indicators must be developed so that they account for specific social, cultural, and geographical contexts (Gold et al. 2015). Searcy et al.'s (2025) research on monitoring technologies concluded that identification can be enhanced through leveraging monitoring technologies that are embedded in collaboration. However, four key contingencies facilitate or inhibit the end outcome. They consist of *modern slavery posture*, referring to the level of motivation an actor has to identify modern slavery. *Collaboration scope* relates to the modern slavery identification horizon – whether it's on the micro- or macro-level. *Cross-boundary interactions* is characterized by the collaborations between actors with varying modern slavery postures and different collaboration scopes. Lastly, *contextual embeddedness* relates to tailored approaches that are grounded in collaboration in order to identifying modern slavery. Together or individually, these four contingencies influence the likelihood of detecting modern slavery.

4.2.2 Triangulation

Triangulation is a methodological approach used to understand complex social phenomena and the intricacies of multicultural environments. Triangulation involves using multiple data sources, methods, and perspectives in order to verify the findings which can be used for more nuanced and reliable conclusions. (Meydan and Akkas 2024) The more data sources available, the more opportunities there are for triangulation ensuring better authenticity (Asif et al. 2022). However, in the context of modern slavery detection, triangulation is a resource intensive approach, and in some key sourcing regions may rely on maintaining a local presence and teams of auditors (Stevenson and Cole 2018).

Whistleblowing is an underused practice for gathering information, which is especially important given the difficulties of scaling other practices like auditing in order to maintain visibility throughout the fragmented supply chains (Stevenson 2022). Operationalizing the practice of widespread whistleblowing beyond traditional supply chain actors to anyone with suspicion or the position of a witness, such as victims themselves, customers, suppliers, local community members or anyone from the general public, allows companies to assemble sources of information around the world who are continuously monitoring activities (Stevenson 2022). Worker voice tools also present new opportunities to gather information directly from the workers at scale across countries on their work environment and conditions (Berg et al. 2020).

4.2.3 Targeted investigation

Investigations are carried out in order to gain assurance in the capabilities, performance, and reliability of the supplier. It is also about reassuring investors and stakeholders. (Asif et al. 2022) The most commonly used practice for detecting different forms of modern slavery via investigation are audits against codes of conduct, where working conditions are examined. It is roughly carried out by reviewing documents, financial information, and interviewing individual workers. They can either be conducted prearranged or unannounced in order to expose the actual everyday working conditions. (Benstead et al. 2021; Stevenson and Cole 2018)

In order to avoid the risks of audit fraud or mock compliance, the auditing process needs to be improved upon. Current literature suggests that this can be done by increasing the buyer involvement and shifting from arm's length auditing to supplier development (Benstead et al. 2021). However, multistakeholder supplier development has been questioned in the context of modern slavery (Stevenson and Cole 2018). Sustainable supply chain management practices have little effect when dealing with illegal and actively hidden practices (Gold et al. 2015). The practices that are employed to detect other social issues may not apply to modern slavery, therefore tailored solutions such as targeted audits may be needed (Stevenson and Cole 2018). Research has underscored that targeted audits, which include the investigation of the end-to-end recruitment process and worker interviews and documentation is more likely to identify key indicators of slavery (Benstead et al. 2021).

4.3 Enhancing detection with industry 4.0

Industry 4.0 technologies relate to intelligent processes and products supported by autonomous data collection and analysis in order to enable efficient processes (Asif et al. 2022) It can also be defined in terms of the nine key technologies; cloud, big data analytics, cybersecurity, the internet of things, augmented reality, additive manufacturing, horizontal and vertical system integration, autonomous robots and simulations (Asif et al. 2022). This new industrial revolution has influenced the world of business, including auditing practices. The term 'audit 4.0' has been coined as a framework to promote auditing toward a new generation by utilizing the industry 4.0 technologies, allowing for the continuous collection of data and creation of intelligent modules that can be used for real-time monitoring, auditing, and fraud detection. (Dai et al. 2019) Research suggests that industry 4.0-based auditing can enhance the authenticity, efficacy, and cost-effectiveness. Moreover, they can make auditing more genuine and value-adding. (Asif et al. 2022) When it comes to whistleblowing – aside from overcoming the bystander effect – technology is in a central role of enhancement with the possibility of setting up anonymous hotlines, creating various applications and websites (Stevenson 2018). Digital worker reporting tools present remarkable opportunities for companies to get in touch with hard-to-reach workers for information on their working conditions (Berg et al. 2020). Blockchain utilization can be a powerful tool to combat fraud and deception in the supply chain due to its immutability (Chen et al. 2024). Artificial intelligence can be used to assess the supply chain for violations by monitoring factors such as work hours, irregular employment, and overtime (Chen et al. 2024). The use of biometric data opens a new way to trace risks and detect of modern slavery in the supply chain, although it has not been broadly applied as of yet (Chen et al. 2024).

4.4 Specific avenues for enhanced detection

4.4.1 Blockchain

Blockchain is a decentralized digital ledger technology that records transactions permanently and immutably and enables trustworthy and efficient exchange of information (Cui et al. 2024). When information is added to the Blockchain, it becomes a digital chain with full transparency and immutability (Chen et al. 2024). Low-cost labour-intensive industries like the fashion and garment sector, where reputational risk is a particular concern, Blockchain technology offers a way to increase supply chain transparency (Tambe and Tambay 2020). Workers often don't have any proof

of identity, which in turn exacerbates the situation (Chen et al. 2024). A major benefit of Blockchain is its ability to create unalterable identities for victims who often lack identification documents (Kara 2017; Tambe and Tambay 2020). Blockchain is also useful in preventing illegitimate recruiting since contracts cannot be modified or tampered with afterwards (Chen et al. 2024). It has the potential to prevent individuals from falling into modern slavery and limit coercion that is exercised over workers (Christ and Helliar 2021). Blockchain may also enhance the traceability and accountability of production stages within the global supply chains, enabling companies and consumers to verify it as well (Davies et al. 2025; Shou and Domenech 2022). The wide integration of Blockchain technology holds immense potential with its tamper-proof log of transactions that can be used to trace the flow of materials, goods, and information which increases transparency, traceability as well as accountability throughout the whole supply chain (Saxena et al. 2023).

4.4.2 Digital whistleblowing platforms

Worker reporting tools present new ways to gather information at a large scale directly from the workers themselves about their labour and recruitment conditions across countries and regions simultaneously while increasing efficiency and reducing costs of engagement. (Berg et al. 2020) Worker voice tools are a potential way of detecting the prevalence of child labour in the complex supply chains of the apparel industry (Chanani et al. 2022). It is also emphasized that any worker voice platform should utilize a flexible technology approach that fits the workers' needs and preferences of each context (Chanani et al. 2022).

Technology can also reduce the psychological distance of modern slavery by bringing the events perceptually closer to the decision makers. Moreover, governments can take measures such as establishing hotlines and making investments in technology aimed to identify modern slavery. Non-governmental organizations could focus on providing trusted platforms for data exchange and develop identification capabilities for high prevalence areas of modern slavery. (Searcy et al. 2025)

4.4.3 Technology enhanced audits

The fundamental capabilities of industry 4.0 allow automatic and real-time data collection, cloud-based data storage and sharing, predictive capabilities with data analytics and AI (Asif et al. 2022; Dai et al. 2019). The underlying industry 4.0 technologies can enhance and address the shortcomings of the traditional supplier auditing process by improving authenticity, efficacy, and

cost-effectiveness. Audit efficacy arises from continuous auditing, audit by exception, informed disclosure, and broader scope analyzed information. Continuous auditing is a method where data is being constantly collected and analyzed in real-time. Audit by exception detects risks and abnormalities and makes alerts based on the deviations. Together with continuous auditing, they both rely on the use of sensors, cloud, Blockchain, and other industry 4.0 technologies. Moreover, the highly granular data produced can be customized to serve the requirements of different circumstances. The scope of the audit is vastly broader due to the data collection capability across supply chains from different actors, including the sub-tier suppliers. Furthermore, with these capabilities audit authenticity i.e., the credibility of the investigation, is massively increased via the plethora of different information sources, large data volumes, data veracity, and velocity which allow for more robust triangulation. They enhance transaction tracking capabilities, reduce type-two auditing error occurrence, and reduce conflict of interest between auditor and auditee. (Asif et al. 2022)

Costs can be reduced through cost-efficient supplier monitoring via the automatic and real-time data collection, reducing information asymmetry between actors which minimizes opportunistic behavior. The enhanced transparency in the supply chain where real-time data is available to the auditor and buyer also reduce the supplier monitoring costs. Moreover, the initial setup cost of some of the industry 4.0 technologies, such as Blockchain, data analytics, and AI tools are fairly affordable given that the supplier already has the capability to adopt them. (Asif et al. 2022)

4.4.4 Artificial Intelligence

The mandated statements from companies on combating modern slavery are challenging to surveil effectively, not only due to the difficult and vague language used, but also due to the massive quantities of statements produced (Bora et al. 2025). Project AIMS (Artificial Intelligence against Modern Slavery) utilizes artificial intelligence to analyze modern slavery statements to assess compliance with the UK and Australian Modern Slavery Acts in order to detect specific sectors where reporting is falling short and to share the best practices for modern slavery reporting. Analyzing reports with artificial intelligence enables greater comparisons between companies within and across sectors, countries, and regions. Furthermore, it would reveal changes happening over time and the bad actors could ultimately be held accountable for the exploitation that takes place in their operations. Applying artificial intelligence to analyze modern slavery statements is also much more resource efficient. (Walk Free 2020) Furthermore, since there are jurisdictional differences between countries, it is vital that the tools used for assessment account for them. This problem can be addressed with the construction of annotated datasets which enable cross jurisdictional generalization

assessment. (Bora et al. 2025) Development of artificial intelligence-driven tools for monitoring supply chains can empower companies, auditors, and regulators to detect exploitation more effectively and assess legal exposure. (Rocha et al. 2025).

4.5 Limitations and risks of technology

While technology can facilitate positive outcomes, it can also be used to conceal unethical activities. For instance, victims can be persecuted for whistleblowing, and their voices can be used to actively conceal labour issues (Searcy et al. 2025). Digital technology platforms that collect personal data also pose significant risks to workers. Unauthorized access to personal data could be gained via hacking, confiscation, or unintentional data leaks which could then lead to employer retaliation, personal threats, loss of job, criminal prosecution, or migration officials being informed. (Berg et al. 2020) Data collection could also lead to wider worker surveillance, which can be used to punish unproductive workers, monitor bathroom breaks, or discriminate against workers with conditions impacting their output (Berg et al. 2020). Moreover, the digital tools have evolved in the same economic environment which seek to stabilize and continue the business status quo (Berg et al. 2020). Victims of modern slavery are isolated by technology and face increasing information asymmetries, with many not even aware that they are working as slaves. (Kara 2017; Tambe and Tambay 2020).

While digital tools can enhance supply chain transparency, they are limited by structural challenges such as widespread subcontracting, cost pressures, and companies' general reluctance to adopt technology that could expose labour exploitation. Concerns about cost, accountability, and difficulties of implementing digital solutions contribute to the corporate reluctance of embracing transparency. In this spirit, the fashion industry seems to be especially reluctant to adopt technologies such as Blockchain into their operations, as the bigger actors may be concerned with reputational implications of discovering labour exploitation, while smaller actors may not have the resources to do so. Without an industrywide reform and more consistent oversight, there is a risk that Blockchain might become a superficial solution rather than the revolutionary tool it was supposed to be. (Davies et al. 2025). Furthermore, Blockchain offers potential benefits to increasing transparency and accountability, but it is limited by the supply chains structural challenges, such as cost pressure and large-scale subcontracting practices (Davies et al. 2025). Audit 4.0 also has its limitations as it requires a vast amount of data collection from various sources; therefore, data integrity and authenticity are central issues of achieving benefits (Dai et al. 2019). In addition, the

effectiveness of enhancing audits with industry 4.0 may differ based on the available infrastructure and technological support (Asif et al. 2022).

The collapse of the Rana Plaza factory in Bangladesh is beyond the coverage of industry 4.0 technologies. Aspects like substandard construction and overloading the factory with machinery to the brink of collapse fall outside of the monitoring scope (Asif et al. 2024). Even in the cases where technology is fully utilized, its impact is tied to the quality of data and ethical behavior among all actors (Davies et al. 2025). Many of these technologies are still evolving and largely under exploration in the field of auditing (Dai et al. 2019). Davies et al. (2025) have argued in favor of a more nuanced approach that integrates aspects from multiple fields of study to tackle these issues. Effectively, it requires understanding the management of supply networks together with technological interventions because on their own, they are unlikely to bring consequential changes.

5 Discussion and conclusions

Modern slavery is frequently described as ‘hiding in plain sight’ due to the various barriers that hinder its detection, such as the structure of the global supply chain, inadequate enforcement of laws, lack of a global law, disparities in terminology, limited leverage and power between actors in the supply chain (Lofti and Walker 2025). It is often located far away from public scrutiny, which creates psychological distance between consumers and the victims, as well as supply chain managers (Searcy et al. 2025). A Key characteristic of modern slavery that makes detection grueling is the active deceit involved. Hence, identifying modern slavery requires context bound solutions specifically applicable to the unique circumstances of the supply chain (Searcy et al. 2025).

Economically prosperous companies’ business activities are based on cost minimized mass production, which has led to high levels of subcontracting and outsourcing along the supply chain (LeBaron 2014). The ones who benefit from the status quo the most may not have any interest to dismantle it. Therefore, companies may emphasize the consequences of non-compliance over detecting modern slavery (Stevenson and Cole 2018). Encouraging a shift in consumer attitudes toward more ethical consumption has a crucial role as market demand shapes corporate behavior (Davies et al. 2025).

If victims are unable to get their voices heard, digital whistleblowing may assist companies to reduce exploitation, but only if the company is committed to investing resources in order to make sure data collection is robust, and victims are able to express their concerns (Berg et al. 2020). Additionally, understanding the bystander effect and addressing its causes could encourage broader whistleblowing along the whole supply chain and ultimately lead to enhanced detection. Consequently, the whistleblowing process needs to be as straightforward as possible (Stevenson 2022).

Regulators continue to be focusing on traditional enforcement methods with limited technological adoption, overseeing labour rights. Investments toward educating companies and regulators could help them understand the dynamics of technology better (Davies et al. 2025). Crucially, applying industry 4.0 technology to the social auditing process is still in its early stages of maturity (Asif et al. 2022). Emerging artificial intelligence tools and developments in Blockchain technology can contribute to increased traceability in the supply network, but the success may depend on efforts such as union-led worker organization and robust enforcement mechanisms (Davies et al. 2025).

Technology can either reveal or conceal modern slavery practices. There are several reasons why some actors do not want modern slavery to be detected, such as the profitability of exploiting others, criminal liability, or reputational risks. (Searcy et al. 2025) The difficulty of detecting modern slavery also depends on whether there is a genuine desire to find it and whether it is sought out in reality. Modern slavery posture i.e., the motivation to identify modern slavery, shapes how actors collaborate with others and the type of technologies most likely to get adopted. (Searcy et al. 2025) Technology can be used to advance detection efforts, but it can also be weaponized to perpetuate it. Thus, technology may be the enhancer of detection or the inhibitor, depending on the intentions behind utilizing it. Technology is not a universal cure for modern slavery, but it can aid its identification, given that it is supported by the supply chain actors (Searcy et al. 2025). There is no 'silver bullet' for eradicating modern slavery (Stevenson and Cole 2018). However, research can play a vital role in speeding up the widescale adoption and full utilization of industry 4.0 to push detection forward (Dai et al. 2019).

To conclude, the following table summarizes the thesis by responding to the research questions, along with presenting specific industry 4.0 derived applications to address each challenge that inhibits detection, as well as highlighting the effects on detection.

Table 1. How industry 4.0 technology can be used to detect modern slavery

Recognized challenges for detecting modern slavery	*Specific application of industry 4.0 to address challenges*	*Outcome*
Ineffective regulation	Analyzing modern slavery statements with AI	Enforcing supply chain transparency laws / Legal exposure
Conceptual ambiuguity	Cross-jurisdictional generalization evaluation with AI	Enforcing supply chain transparency laws / Legal exposure
Bystander effect	Digital whistleblowing for anyone	More witnesses are able to report and draw attention to exploitation
Victim voices not heard	Digital whistleblowing for victims	Understanding the shrouded working conditions directly from the victims' first-hand experiences
Socioeconomic & cultural challenges	Enhancing risk monitoring with industry 4.0 capabilities	More accurate direction for further investigation
Supply chain fragmentation	Information from different stages of production within the supply chain added to Blockchain	Transparency is enhanced via the companies and consumers ability to verify immutable information
Business capabilities	Adding employment contracts, documents and records in Blockchain	Information cannot be manipulated retroactively
Auditing flaws	Enchancing auditing processes with industry 4.0 capabilities	Increased auditing efficacy and authenthicity

Modern slavery is distinctly difficult to research (Lofti and Walker 2025). Notwithstanding, there are countless avenues that future research could take. The first suggestion is to focus on how technology could be utilized by the general public more effectively. Secondly, technology brings a variety of concerns for the worker; for instance, artificial intelligence-based surveillance systems can be used to punish workers for slacking, hence future research could focus on the legal gaps inadequate to address these issues. Finally, the use of biometric data and its application for modern slavery detection in the apparel sectors supply chains is deeply underexplored.

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Appendices

Appendix 1: Utilization of artificial intelligence tools

Generative artificial intelligence was used for supporting tasks before, during, and after the writing process. The utilization of specific tools is described below in more detail. I assure that the tools were used appropriately and disclosed in accordance with the university's policy. I take full responsibility for all the content presented.

1. **Tool: Google Gemini 3**
    a. Stage of use: Before writing to narrow down the research scope.
    b. Purpose of use: I wanted to research the 'invisibility' of modern slavery in the apparel industry. I utilized Google's generative AI tool Gemini to give me potential research avenues based on these interests.
        i. Example prompt (14.2): ''Can you suggest directions for my research? I want to combine the persistence of modern slavery with the apparel industry's supply chains.''
    c. Verification: It suggested several paths for research, such as ''*the structural risk factors and technological capabilities for managing risks''*. I used the suggestions only for direction, and no text from the tool was used in the thesis.
2. **Tool: ScopusAI**
    a. Stage of use: Both before and during the research and writing process.
    b. Purpose of use: I used the tool to find additional potential studies for the purpose of my thesis.
        i. Example prompt: ''What are the methods for detecting modern slavery in supply chains?''
    c. Verification: It suggested multiple studies, some of which I ended up studying further and utilizing for my research.

3. **Tool: Grammarly**

    a. Stage of use: After the writing process

    b. Purpose of use: Correcting potential grammar mistakes

    c. Verification: The tool mainly suggested adding commas to places where I had accidentally left them out and also gave me ideas for rephrasing some of the sentences. I evaluated the feedback to the best of my abilities and corrected everything manually in case the correction it gave was appropriate.