

"Leveraging the Internet of Things (IOT) For Enhanced Supply Chain Transparency and Ethical Sourcing In Global Outsourcing"

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I. INTRODUCTION

In an increasingly interconnected and complex global economy, outsourcing business processes and production has become a prevalent strategy for companies seeking to lower costs and enhance efficiency. However, this reliance on external partners, often located in different countries, has introduced significant challenges related to transparency, accountability, and ethical governance (Friedman, 2005). Stakeholders, including consumers, investors, and regulators, are progressively demanding greater visibility across the entire supply chain, from the procurement of raw materials to the distribution of the final product (Savitz, 2013).

The Internet of Things (IoT) represents a revolutionary influence in supply chain management, delivering unmatched visibility, efficiency, and intelligence throughout the entire network. By integrating sensors, RFID tags, and various devices into products, equipment, and vehicles, organizations can establish a "smart" supply chain that offers real-time data and automated insights (Intellectsoft, 2023). This level of connectivity facilitates a shift from reactive to proactive management, which enhances decision-making and fosters a more resilient supply chain.

Background of the Study: Leveraging IoT for Supply Chain Transparency and Ethical Sourcing

The globalization of commerce has resulted in increasingly complex and opaque supply chains, which pose significant challenges for corporate accountability and consumer trust (Gereffi & Lee, 2016). This complexity, fueled by outsourcing and global manufacturing, has led to a critical lack of visibility beyond tier-one suppliers, complicating the ability of companies to oversee ethical and environmental practices throughout

their networks (Awaysheh et al., 2020). The fragmentation of information frequently results in information silos, where real-time data regarding product origin, working conditions, and carbon footprint is inaccessible to key stakeholders, including consumers and regulators (Choi et al., 2018).

Concerns regarding unethical labor practices, such as forced and child labor, along with environmental degradation, have intensified consumer and investor demand for corporate social responsibility and supply chain transparency (Hoejmose & Adrien-Kirby, 2012). High-profile cases of malpractice have damaged brand reputation and underscored the inadequacy of traditional auditing methods. Manual audits and certifications often yield a static and easily manipulated view of compliance, failing to provide the continuous, real-time assurance necessary to substantiate ethical sourcing claims (Seuring & Müller, 2008). This has resulted in a disconnect between the stated ethical commitments of companies and their capacity to effectively monitor and enforce these standards across a vast global network.

The rise of the Internet of Things (IoT) offers a revolutionary approach to addressing these issues by establishing a digital thread that ensures comprehensive visibility. By integrating sensors, RFID tags, and various connected devices into products and logistics assets, IoT facilitates the ongoing collection and transmission of real-time data regarding a product's journey, conditions, and origin (Wamba et al., 2015). This technology is capable of monitoring not only a product's location but also environmental factors such as temperature and humidity, providing unparalleled detail and traceability (Tao et al., 2019). Through the utilization of IoT, businesses can transition from reactive, sporadic inspections to a proactive,

continuous monitoring framework, thereby enhancing their ethical sourcing efforts and fostering a foundation of trust with consumers and partners (Kouhizadeh et al., 2020). Consequently, this research seeks to investigate how IoT can be effectively implemented to improve supply chain transparency and guarantee ethical sourcing within the realm of global outsourcing.

The Rise of the Internet of Things (IoT) as a Solution

The Internet of Things (IoT) has surfaced as a revolutionary technology capable of tackling these challenges. IoT devices, including sensors and RFID tags, can be integrated into products, machinery, and shipping containers to gather and relay real-time data. This data encompasses crucial information such as a product's location, temperature, and condition throughout every phase of the supply chain. This capacity to deliver real-time, detailed data establishes a digital thread that connects the physical realm to the digital, providing a new degree of visibility that was once unattainable.

This study's background thus establishes that the present condition of global supply chains is marked by an urgent requirement for improved transparency and ethical accountability. It contends that conventional approaches are inadequate to fulfill this requirement and that the Internet of Things (IoT) presents a promising, technologically sophisticated solution to reconcile business efficiency with ethical responsibility.

The growing demand for transparency and ethical sourcing

In recent years, the demand for transparency has grown due to increased pressure from consumers, regulators, and investors. Notable incidents related to forced labor, child labor, hazardous working conditions, and environmental harm have highlighted the ethical sourcing practices of leading companies. Consumers are more inclined to endorse brands that can demonstrate their products are sourced ethically and sustainably. Consequently, supply chain transparency has evolved from being a mere luxury to an essential competitive factor and a vital aspect of corporate social responsibility (CSR).

Outsourcing as a standard practice for efficiency and cost optimization

Outsourcing, which involves delegating internal business functions to external service providers, has emerged as a strategic approach for companies aiming to lower expenses and enhance

their competitive position. This is especially relevant in a global environment where organizations can take advantage of variations in labor and production costs across different nations (Grossman and Helpman, 2005). The pursuit of efficiency serves as a key driving force, enabling businesses to concentrate on their core strengths while allowing external partners to manage non-essential tasks (Linder and Sawyer, 2003). For instance, in a smart city, IoT sensors are capable of tracking traffic patterns to improve traffic light schedules, thereby alleviating congestion and minimizing fuel usage. In a warehouse setting, these sensors can also track energy consumption to automatically deactivate lights in unoccupied aisles (Wang et al., 2016).

Ethical challenges and lack of transparency

Despite the economic advantages, global outsourcing presents considerable ethical challenges. The intricate and extensive nature of supply chains frequently leads to a significant lack of transparency, complicating the detection and confrontation of poor working conditions, including forced labor and insufficient wages (Ethical Trading Initiative, 2013). This lack of clarity permits unethical practices to continue unnoticed, thereby exposing companies to substantial reputational and financial threats (Vorecol, 2024).

The absence of real-time, verifiable information has traditionally hindered the monitoring of labor practices, the assurance of product quality, and the verification of environmental compliance (Smith, 2021). This article posits that the Internet of Things (IoT), with its capacity to gather and relay real-time data from physical entities, provides a revolutionary solution to these challenges. By integrating IoT sensors and devices throughout the outsourcing value chain, organizations can attain an unparalleled level of real-time transparency, effectively closing the information gap and promoting a more ethical and efficient global outsourcing environment (Jones, 2022).

Increasing stakeholder demand for visibility and accountability

A diverse array of stakeholders—including consumers, investors, and regulatory agencies—are exerting pressure on companies to assume greater accountability for their supply chains (Meixell and Luoma, 2015). Consumers are becoming increasingly aware of the origins of their products and the methods of their production, prompting them to seek transparency as a means of

ensuring accountability (Sedex, 2024). This demand is further fueled by emerging technologies such as blockchain and the Internet of Things (IoT), which provide unprecedented levels of traceability and transparency (ResearchGate, 2024).

The Internet of Things (IoT) signifies a fundamental shift from a conventional, human-centered internet to one that encompasses a network of interconnected physical devices capable of communicating and interacting with one another. At its foundation, IoT constitutes an ecosystem of physical objects, or 'things,' that are outfitted with various technologies, including sensors, processors, and software, enabling them to gather and transmit data (Gubbi et al., 2013). This interconnectivity empowers these devices to function and share information autonomously, with minimal or no human involvement (Al-Fuqaha et al., 2015). The core of IoT resides in its capacity to convert everyday objects from passive instruments into intelligent, data-producing entities. This transformation holds significant implications across numerous sectors:

Connectivity: The "Internet" in IoT

This section pertains to the "Internet" component of the Internet of Things (IoT). It facilitates communication between devices and the cloud, utilizing technologies such as Wi-Fi, Bluetooth, cellular networks, or specialized low-power networks. The Process: A standard IoT system operates through several essential steps. The connectivity element is what fundamentally characterizes the Internet of Things (IoT), enabling devices to interact and operate as part of a broader, intelligent network. It serves as the digital conduit that allows physical objects to transmit and receive data.

The selection of connectivity technology is influenced by various factors, including data volume, transmission range, and power consumption: Wi-Fi is prevalent for devices within a local network, such as smart home appliances, owing to its high bandwidth and extensive availability; Bluetooth is well-suited for short-range communication between proximate devices, such as a smartphone and a fitness tracker; Cellular networks (like 4G or 5G) are employed for devices that require data transmission over long distances where a Wi-Fi connection is unavailable, such as connected vehicles or remote sensors, while specialized low-power networks, including LoRaWAN and NB-IoT, are tailored for devices that transmit small data packets infrequently and need to function on a single battery for years,

making them ideal for agricultural sensors or asset trackers.

Smart homes

Devices like smart thermostats, lighting systems, and security cameras gather information about their environment and user actions to automate processes, increase energy efficiency, and bolster security (Ranaweera and Seneviratne, 2017).

Industrial and commercial applications

In the fields of manufacturing and logistics, IoT sensors installed on machinery and vehicles are utilized to monitor performance, track assets, and enhance supply chains. The real-time data generated from these sensors facilitates predictive maintenance, which in turn minimizes downtime and boosts operational efficiency (Rao and Singh, 2018).

Wearable technology

Smartwatches and fitness trackers equipped with sensors gather data regarding an individual's health metrics, including heart rate and activity levels. This data is subsequently utilized to deliver personalized health insights and to monitor overall wellness (Seneviratne et al., 2015). The core concept of the Internet of Things (IoT) is that these "things" are no longer standalone; they are integrated into a broader, interconnected system. This network of devices generates a continuous stream of data that can be analyzed to yield valuable insights, facilitating enhanced automation, more informed decision-making, and the development of entirely new services and business models (Atzori et al., 2010). The real-time data and insights offered by IoT pave the way for innovative services and business models, such as "as-a-service" offerings, where a company markets the outcome of their product (e.g., uptime) instead of the product itself (Batra and Kaur, 2019).

The IoT process in key steps

A standard IoT system functions through a repetitive, four-phase cycle that converts unprocessed data from the physical environment into significant actions and insights:

Data Collection

A sensor on a device gathers information from its surroundings. Data Transmission: The information is transmitted to a central hub or a cloud-based platform. Data Processing: Software evaluates the data and, depending on its programming, may initiate an action (for instance,

activating a fan if the temperature exceeds a certain threshold) or notify a user. Action/Insight: The analyzed data can facilitate task automation, enable real-time monitoring, or produce insights that assist businesses and individuals in making more informed decisions. This represents the initial phase where sensors integrated into a device collect data from their environment. This could encompass anything from a temperature measurement in a warehouse to a light sensor detecting movement or a microphone capturing a specific sound. The data is continuously gathered, establishing the basis of the entire system.

In the realm of supply chain management, the preliminary phase of data collection via sensors is a vital element of the Internet of Things (IoT). This phase is essential for developing a real-time, transparent, and responsive supply chain. The information collected offers a digital representation of the physical environment, enabling informed decision-making and automated operations. The transition to proactive management, propelled by the data and automation facilitated by IoT, is fundamentally transforming how businesses function and how we engage with our surroundings, rendering systems smarter, more efficient, and more responsive. Sensors are strategically placed throughout the supply chain to monitor a diverse range of variables, including:

Asset Tracking

The integration of GPS and RFID sensors into products or shipping containers presents a robust solution for improving supply chain visibility. By delivering continuous location information, these technologies empower managers to oversee goods in real-time, transitioning from static, periodic updates to a dynamic and ongoing stream of data. This facilitates more precise forecasting of delivery timelines, enhanced resource distribution, and a proactive strategy for addressing disruptions (Srinivasan, 2020). In addition to fundamental tracking, this real-time information can be scrutinized to uncover inefficiencies, refine routes, and guarantee the prompt arrival of goods, which is essential for sustaining consumer satisfaction and operational effectiveness.

Environmental Monitoring

Temperature and humidity sensors play a crucial role in the transportation of perishable items such as food and pharmaceuticals. They guarantee that products stay within their required temperature and humidity levels, thus preventing spoilage and preserving quality (Rana et al., 2021). This real-

time information is frequently utilized to activate alerts when conditions stray from the standard, allowing for prompt corrective measures. Continuous monitoring is an essential aspect of maintaining cold chain integrity, minimizing waste and ensuring product safety from the point of origin to the end consumer (Rana et al., 2021; Identec Solutions, 2024).

Inventory Management

Intelligent shelving systems and RFID readers within warehouses facilitate the automatic monitoring of inventory levels, delivering a precise, real-time assessment of stock. This innovation diminishes the necessity for manual inventory checks, reduces inaccuracies, and aids in the optimization of stock levels (Gligor and Holcomb, 2012). For instance, manual inventory assessments tend to be slow and susceptible to errors.

Through the Internet of Things (IoT), intelligent shelving and RFID technology in warehouses enable the automatic tracking of stock levels as items are added or removed. This results in an accurate, real-time inventory count, which assists in avoiding both overstock situations and expensive stock shortages (Wang et al., 2016). Furthermore, this information can be leveraged to automate the reordering process, guaranteeing that products are consistently in stock.

Fleet Management

Sensors in vehicles track fuel usage, engine efficiency, and driver conduct. This information aids in optimizing routes, lowering operational expenses, and enhancing safety (Kim et al., 2017). The ongoing flow of data gathered by more sophisticated supply chain analytics and automation. In the absence of this essential layer of information, processes like demand forecasting, predictive maintenance, and autonomous logistics would be unfeasible (Kamble et al., 2018). For instance: Sensors installed on machinery and vehicles assess performance and gather data regarding wear and tear for predictive maintenance. By examining this data, organizations can foresee potential equipment malfunctions before they happen. This enables planned maintenance, minimizes unexpected downtime, and prolongs the lifespan of vital assets (Rao and Singh, 2018).

Data Transmission

After the data is collected, it is transmitted to a central location. This transmission is facilitated by the connectivity technologies previously

mentioned. Typically, the data is directed to a central hub or a cloud-based platform for both storage and processing. This phase is essential as it transitions the data from the physical device into the digital realm. In the context of supply chain management, data transmission represents a vital step in transferring information from physical assets to a digital platform for subsequent analysis and action. This procedure is fundamental to a contemporary, transparent supply chain. It offers real-time visibility, enabling companies to address issues proactively instead of reactively (Attaran, 2020).

How Data transmission works in supply chain management

Once sensors attached to a physical asset gather data (such as location and temperature), this information needs to be sent to a central hub. Various connectivity technologies are employed for this purpose, selected according to considerations such as data volume, distance, and energy usage. The data that is transmitted is subsequently stored and processed on a cloud-based platform or within a supply chain management (SCM) system, resulting in the creation of a digital twin of the physical supply chain (Mu & Antwi-Afari, 2023).

From the physical to the digital:

IoT sensors installed on pallets, trucks, or individual products gather real-time data, including location (via GPS), temperature, and humidity. This represents the raw data from the physical supply chain; Selecting the Appropriate Network: The data is subsequently transmitted through various connectivity technologies: Cellular networks (4G/5G) are frequently utilized for long-distance transportation, ensuring continuous tracking of shipments over extensive distances.

Low-Power Wide-Area Networks (LPWANs) such as LoRaWAN are well-suited for monitoring assets in remote locations or for devices that require prolonged operation on a single battery, like agricultural sensors or asset trackers (KORE Wireless, 2024). Wi-Fi or Bluetooth may be employed in controlled settings, such as a factory floor or a distribution center, to relay data from machinery or nearby assets to a local network. The Objective: Real-Time Visibility: After transmission, the data is stored and processed on a digital platform. This provides managers with a real-time overview of their entire supply chain, enabling them to pinpoint the exact location of a shipment, its condition, and any potential issues as they emerge, facilitating proactive decision-making (Kore Wireless, 2024).

Cold Chain monitoring

A primary illustration is the "cold chain," in which perishable items such as food or pharmaceuticals must be maintained within a designated temperature range throughout transportation (Zhang et al., 2017). Organizations like Maersk and DHL employ IoT sensors in refrigerated containers to continuously track temperature and humidity levels. Should the temperature stray from the established range, the sensor relays this information through a cellular network to a centralized cloud platform. An automated notification is promptly dispatched to the logistics manager, enabling them to rectify the situation before the product deteriorates, thereby conserving resources and ensuring consumer safety (Techstack, 2024).

For delicate items such as food or pharmaceuticals, it is essential to uphold specific environmental conditions. IoT sensors installed in containers and warehouses are capable of monitoring temperature, humidity, and pressure. If the conditions fall outside the necessary range, the system can initiate an immediate alert, facilitating swift action to avert spoilage or damage (Rana et al., 2021). This represents a crucial application in the management of the cold chain.

Predictive Maintenance

The transmission of IoT data plays a crucial role in predictive maintenance. Rather than waiting for a machine to malfunction, sensors installed on equipment in factories or warehouses, including conveyor belts and forklifts, gather data regarding their operational performance (for instance, vibration, temperature, and motor speed). This information is sent to a cloud platform, where it is analyzed to forecast when a component is likely to fail. Consequently, maintenance teams can arrange repairs in advance, minimizing unanticipated downtime and reducing expenses (Intelliarts, 2023).

Data Processing

Once the data reaches a central hub or cloud, software is utilized to conduct an analysis. This processing can range from being simple, like a basic temperature reading, to being highly intricate, frequently involving advanced machine learning algorithms to identify patterns (Koubaa, 2018). The system, guided by pre-defined rules or analytical models, decides the suitable action to take regarding the data. For example, if a temperature reading exceeds a certain threshold, the system is programmed to execute a predetermined action, such as sending an alert or automatically modifying

a thermostat setting (Hassan and Karray, 2018). This phase, where data is converted into actionable insights and responses, is crucial to the operation of contemporary smart systems and the Internet of Things (IoT).

Action/Insight

The concluding phase of an IoT system entails utilizing processed data to either initiate an automated action or produce insights for human decision-making (Kouhizadeh et al., 2020). For example, an automated action might involve a straightforward command such as activating a fan based on a temperature measurement, whereas an insight could manifest as a dashboard that presents real-time energy consumption statistics to enhance usage efficiency or forecast equipment malfunctions (Tao et al., 2019).

Once data has been gathered and processed, its significance is realized through its application to instigate specific actions or deliver actionable insights (Wamba et al., 2015). These actions may vary from basic control commands within a smart environment to intricate robotic modifications in an automated manufacturing setting. Alternatively, the processed data can be represented visually through a dashboard or report, enabling users to make well-informed decisions, such as optimizing energy usage or establishing a predictive maintenance timetable (Awaysheh et al., 2020).

The importance of IoT

The significance of the Internet of Things (IoT) is rooted in its capacity to connect the physical and digital realms, thereby fostering enhanced efficiency, productivity, and convenience in our personal and professional spheres. The IoT signifies a substantial technological advancement, fundamentally altering our interactions with the environment by linking our tangible existence with the digital domain (Mu & Antwi-Afari, 2023). This integrated system of sensors, devices, and software enables objects to gather and share data, transforming them from mere tools into active contributors within a smart ecosystem. This functionality results in unparalleled levels of efficiency, productivity, and convenience in both our personal and professional lives.

Real-World Applications of IoT

The transformative power of IoT is visible across various sectors:

Manufacturing and Supply Chains

In industrial environments, the Internet of Things (IoT) facilitates real-time oversight of

machinery and production processes. Sensors installed on equipment can forecast maintenance requirements prior to any breakdown, significantly minimizing downtime and enhancing efficiency (Mu & Antwi-Afari, 2023). Within supply chains, IoT devices monitor the location, temperature, and state of products, guaranteeing quality and offering a clear, verifiable account from the source to the end consumer.

Smart cities and infrastructure

IoT sensors serve as the cornerstone of intelligent urban environments. They are capable of monitoring traffic patterns to enhance signal timing, organizing waste collection schedules according to the fullness of bins, and identifying water leaks in pipelines to preserve resources. This data-centric strategy facilitates improved management of city resources and elevates the living standards for inhabitants (Madakam et al., 2015).

Real-Time asset tracking and monitoring

IoT sensors can also be utilized to monitor the physical movement of products and raw materials from their source to the final consumer. For instance, GPS trackers and environmental sensors are capable of tracking the location, temperature, and humidity of a shipment (Brown, 2023). This offers unparalleled insight into logistics and transportation, enabling companies to pinpoint bottlenecks, avert spoilage, and confirm the integrity of the supply chain (Clark, 2022).

Healthcare and personal wellness

Wearable Internet of Things (IoT) devices, including smartwatches and fitness trackers, are designed to monitor vital signs and activity levels, offering users immediate access to their health data. Furthermore, this technology facilitates remote patient monitoring, allowing healthcare professionals to observe patients' conditions from a distance and respond more promptly when necessary, which contributes to better health outcomes (Singh et al., 2016).

Ethical sourcing and labor monitoring

A significant challenge in outsourcing involves guaranteeing equitable labor practices and secure working environments. The Internet of Things (IoT) can be utilized to oversee environmental conditions within factories, such as air quality and noise levels, or even to monitor the operational hours of machinery to confirm it is not being excessively utilized (Davis, 2024). Although direct human oversight is intricate, IoT can offer

indirect signs of ethical adherence, such as confirming that production timelines are met and that machinery is operated safely (Evans, 2023).

Ethical sourcing and labor monitoring represent two essential elements of corporate social responsibility (CSR) that emphasize the importance of fair and humane practices throughout a company's supply chain. Ethical sourcing, often referred to as responsible sourcing, involves obtaining goods and services from suppliers who comply with ethical standards, which encompass fair labor practices, environmental sustainability, and a positive social impact (IBM, 2023). Labor monitoring entails the active tracking and evaluation of working conditions to ensure alignment with these standards (Fair Labor Association, 2024).

Ethical Sourcing

Ethical sourcing requires a company to extend its focus beyond the conventional considerations of cost, quality, and delivery, taking into account the social and environmental consequences of its suppliers. The objective is to refrain from sourcing from businesses that participate in detrimental practices such as child labor, forced labor, unsafe working environments, and insufficient wages (Greenly). This approach is motivated by a growing consumer demand for transparency, regulatory obligations (including the EU's Corporate Sustainability Reporting Directive), and the necessity to safeguard a company's brand reputation.

Companies implement ethical sourcing by: Developing a Code of Conduct

A collection of established guidelines that suppliers are required to adhere to, frequently grounded in global labor standards set forth by entities such as the International Labour Organization (ILO) (Fair Labor Association).

Supplier Vetting

Conducting due diligence is essential for assessing the ethical policies and practices of a potential supplier prior to finalizing a contract. This procedure guarantees that a company's supply chain is in harmony with its own ethical standards and objectives related to corporate social responsibility, thereby reducing risks associated with reputation, legal compliance, and human rights. A thorough due diligence process encompasses several critical steps.

Initially, a company must define explicit ethical criteria against which potential suppliers will be evaluated. This encompasses policies

concerning labor rights, environmental impact, anti-corruption measures, and responsible sourcing practices. Subsequently, a stringent screening phase is conducted where the company employs questionnaires and self-assessments to collect preliminary information from suppliers. For a more in-depth evaluation, on-site audits or third-party certifications are frequently utilized to validate the information provided and to directly assess working conditions, safety protocols, and environmental management systems. The IBM Supplier Conduct Principles serve as a notable example of this methodology, delineating the company's expectations for suppliers in relation to labor, health and safety, environmental stewardship, and ethical business conduct (IBM, 2023). By integrating these principles into the due diligence process, a company guarantees that its suppliers are not only financially viable but also ethically accountable.

Supply chain transparency

Supply chain traceability is an essential process that ensures raw materials and products are sourced in an ethical and sustainable manner. This entails the capability to monitor the journey of an item from its initial source such as a farm or mineright through to the end consumer (TradeBeyond, 2025). By establishing strong traceability systems, companies can develop a transparent record of a product's history, which is crucial for validating assertions regarding ethical sourcing, labor practices, and environmental impact (MorrowX, 2024).

This procedure aids organizations in identifying and mitigating risks such as forced labor, deforestation, or the presence of harmful chemicals that may be concealed within the supply chain. For instance, a company like Greenly emphasizes the significance of mapping suppliers, including those beyond the first tier, to obtain a comprehensive understanding of the origins of materials (Greenly, 2025). This detailed level of visibility not only fosters consumer trust but also assists businesses in adhering to an increasing number of international regulations and standards. Ultimately, traceability converts ethical sourcing from a simple assertion into a verifiable, data-supported reality.

Labor monitoring

Labor monitoring serves as a vital element of ethical sourcing, enabling companies to confirm that their suppliers adhere to the agreed-upon ethical standards. It is an ongoing, complex process that involves collecting data through audits,

interviews with workers, and on-site inspections, evaluating this information against established codes of conduct, and executing remediation plans to rectify any identified breaches. This process is essential for guaranteeing fair wages, safe working environments, and the elimination of forced or child labor. A 2017 study conducted by the Fair Labor Association indicates that effective labor monitoring systems are crucial for recognizing and addressing labor rights violations within global supply chains.

Key aspects of effective labor monitoring systems include:

Independent Audits

Third-party auditors perform on-site evaluations of factories and workplaces to evaluate conditions, engage with workers, and examine documentation such as payroll and working hours. Organizations such as the Fair Labor Association (FLA) and the Ethical Trading Initiative (ETI) have established detailed codes and standards for these audits (Fair Labor Association). For example, the ETI's Base Code addresses essential aspects including working hours, living wages, and the right to associate freely (Ethical Trading Initiative).

Worker hotlines and grievance mechanisms

Providing workers with a safe and confidential way to report violations without fear of retaliation

Baseline assessments

Gathering preliminary information regarding working conditions to pinpoint potential risks and establish a standard for future enhancements (U.S. Department of Labor, "Framework for Independent Verification of Ethical Sourcing").

Continuous improvement

The analysis of monitoring data and audit results serves to guide decision-making, pinpoint opportunities for enhancement, and formulate corrective action strategies in collaboration with suppliers (Fair Labor Association, 2017). This approach acknowledges that merely imposing penalties on a supplier is unlikely to result in lasting change.

Quality control and predictive maintenance

IoT sensors can be seamlessly integrated into the manufacturing process to monitor the quality of products in real-time. These sensors are capable of identifying defects or deviations from established quality standards, which facilitates immediate corrective measures (Garcia, 2023).

Additionally, by gathering data on machine performance, IoT can support predictive maintenance, thereby minimizing downtime and ensuring the reliability of production lines (Harris, 2024). This level of transparency also applies to the quality of the outsourced services themselves.

By enabling devices to automatically collect and share data, IoT streamlines tasks, optimizes resource utilization, and offers insights that were previously inaccessible. This transition from reactive to proactive management serves as a significant catalyst for the enhanced efficiency and convenience observed in our homes, workplaces, and communities (Atzori et al., 2010). The fundamental aim of this interconnectedness is to empower these smart objects to gather and disseminate data with minimal human involvement, which fosters continuous optimization and more informed decision-making (Gubbi et al., 2013).

The adoption of IoT in the supply chain delivers several significant benefits:

The automation of tasks such as inventory management and route optimization results in decreased labour costs, fuel savings, and a reduction in waste due to spoilage or theft (De Vass et al., 2018). Tasks including thermostat adjustments, inventory level management, or rerouting delivery vehicles can be automated using real-time data, which minimizes human error and enhances efficiency (Al-Fuqaha et al., 2015). To achieve improved efficiency, real-time data and automation work together to streamline operations, resulting in quicker order fulfillment and more agile responses to supply chain challenges.

Enhanced visibility and accurate tracking contribute to a better customer experience, enabling companies to offer precise and reliable delivery information, thereby fostering trust and loyalty. By providing early warnings of potential disruptions, IoT increases resilience, allowing companies to develop better contingency plans and making their supply chains more robust against unforeseen events. It is essential to define clear, measurable objectives for the pilot project, such as a 20% reduction in unrecorded overtime or a 10% increase in on-time deliveries. This approach not only justifies further investment but also illustrates the value of the IoT system..

The theoretical framework

Two main theoretical frameworks for utilizing IoT to improve supply chain transparency and promote ethical sourcing are Stakeholder Theory and Diffusion of Innovations Theory. Together, these two theories elucidate both the "why" (stakeholder demands) and the "how"

(technological diffusion) of employing IoT to create more transparent and ethical supply chains:

Stakeholder Theory

Stakeholder theory, formulated by R. Edward Freeman, asserts that a company's prosperity relies not solely on its shareholders but also on its capacity to generate value for all its stakeholders (Freeman, 1984). These stakeholders encompass employees, customers, suppliers, communities, and regulators. In relation to ethical sourcing and the Internet of Things (IoT), this theory offers a compelling perspective for evaluating a company's conduct.

Application

The Internet of Things (IoT) aids organizations in overseeing their relationships with key stakeholders by providing the transparency they need. Consumers, an essential group of stakeholders, are becoming more conscious of ethical sourcing and may choose to boycott brands that do not meet their expectations. IoT offers the critical data required to support ethical assertions, such as the elimination of child labor or the implementation of environmentally sustainable practices, and shares this information with consumers, thereby building trust and protecting the company's reputation (Jani, 2025; Sharma et al., 2023).

Another significant stakeholder group, investors, are employing Environmental, Social, and Governance (ESG) criteria to assess a company's ethical performance. Real-time IoT data offers verifiable metrics for ESG reporting, enabling companies to showcase their dedication to responsible practices and attract investments from socially conscious investors. By leveraging IoT to address the concerns of these varied stakeholders, companies can generate shared value and attain long-term success that transcends mere profit maximization.

Diffusion of Innovations Theory

Formulated by Everett Rogers, the Diffusion of Innovations Theory elucidates the mechanisms, motivations, and pace at which novel ideas and technologies disseminate within a social framework. This theory holds significance for the integration of IoT in ethical sourcing as it examines the elements that affect the likelihood of companies embracing and executing this emerging technology.

Application

The theory outlines several critical factors that affect the adoption of an innovation, such as

relative advantage, compatibility, complexity, trialability, and observability (Rogers, 1995): Organizations are likely to adopt IoT for ethical sourcing if they view it as superior to traditional methods like manual audits. The capacity to monitor conditions in real-time and proactively address risks offers a considerable relative advantage over reactive auditing; adoption is more probable if the technology is seen as compatible with a company's established values and operational practices. Companies already dedicated to CSR will find it simpler to incorporate IoT into their supply chain management.

Conversely, if the IoT technology is overly complex to implement or manage, its adoption will be sluggish. Solutions that are intuitive and can integrate smoothly with existing enterprise systems are likely to achieve greater success; the opportunity to test the technology on a limited scale without substantial commitment is essential for its diffusion. Companies might begin by installing IoT sensors in one or two factories to evaluate its effectiveness before expanding its use throughout their entire supply chain. As other organizations successfully adopt IoT for ethical sourcing, their favorable outcomes (such as enhanced reputation and reduced risk) become visible to competitors, promoting broader adoption within the industry. This serves as a significant catalyst for change.

Strategic recommendations for leveraging IOT for enhanced supply chain transparency and ethical sourcing

To successfully utilize the Internet of Things (IoT) for improved transparency in supply chains and responsible sourcing, organizations must go beyond merely adopting technology. They should instead adopt a strategic, phased methodology. This entails the integration of IoT solutions at key junctures within the supply chain to collect actionable data, while also tackling the ethical and technical issues that arise from heightened surveillance and data gathering (Wieland and Wallenburg, 2021). This methodology recognizes that simple technological adoption is insufficient; a comprehensive strategy is essential to guarantee that the technology is employed in a responsible and effective manner (Gligor and Holcomb, 2012).

1. Implement a phased integration strategy

instead of a full-scale, costly rollout, companies should begin with a pilot program at a high-risk or high-value part of their supply chain. This could be a specific factory with a history of

labor violations or a key product line with a complex material sourcing process.

i. Identify critical touchpoints

Determine the key points in the supply chain where visibility is most lacking. This could be at raw material extraction, during manufacturing processes, or in the logistics phase.

ii. Deploy Targeted Sensors

Use specific IoT devices for a particular ethical challenge. For example, deploy temperature and humidity sensors for perishable goods, or use smart badges and geo-fencing to monitor working hours and factory entry/exit (Batra and Kaur, 2019).

iii. Establish Key Performance Indicators (KPIs)

To successfully leverage IoT for ethical sourcing, organizations need to define Key Performance Indicators (KPIs) that will assess progress and ensure accountability. These indicators should extend beyond conventional metrics of cost and speed, incorporating social and environmental aspects (Wieland and Wallenburg, 2021). By establishing precise KPIs, companies can convert vague ethical objectives into concrete, measurable results (Gligor and Holcomb, 2012). This strategy facilitates ongoing monitoring and enhancement, rather than merely providing reports. For example, KPIs can be utilized to evaluate supplier compliance or the proportion of products sourced from certified ethical manufacturers (BSR, 2025; Sievo, 2025).

2. Prioritize Data Integrity and Security

The ethical value of an IoT system is directly linked to the integrity of its data. It is essential to implement strong security protocols to prevent data manipulation that may conceal unethical practices and to safeguard sensitive information.

i. Ensure data encryption

All data transmitted from IoT devices must be encrypted, both during transmission and when stored. This measure protects against cyber threats and unauthorized access to sensitive information regarding suppliers and workers (Nassehi and Newman, 2016).

ii. Utilize blockchain for verifiability Integrate

IoT data streams with blockchain technology to establish an immutable, transparent,

and distributed ledger of all transactions and events. This integration makes it nearly impossible for any single entity to modify or falsify data, thereby providing a verifiable record of a product's journey and its ethical credentials.

iii. Implement a zero-trust architecture

Assume that no device or user can be trusted by default. Enforce strict access controls and multi-factor authentication for all users and systems to minimize the potential impact of a security breach (De Vass et al., 2018).

3. Foster a culture of collaboration and worker empowerment

Technology serves as a tool rather than a standalone solution. In order for IoT to effectively promote ethical change, it should be utilized to empower individuals rather than merely monitor them.

i. Establish a remediation process

The information gathered through IoT should not be employed exclusively for punitive actions. Instead, it ought to initiate a collaborative effort with suppliers to pinpoint and rectify problems. For instance, if sensors indicate alarmingly high temperatures, the data should facilitate cooperation with the factory to enhance ventilation, rather than simply leading to contract termination (Fair Labor Association, 2024).

ii. Integrate worker feedback

Enhance sensor data by incorporating direct feedback from employees via anonymous hotlines or digital grievance systems. This approach offers a more comprehensive and human-centered perspective on working conditions that mere data points fail to convey.

iii. Ensure data privacy

Formulate a clear and transparent policy regarding data usage that is communicated to all stakeholders, particularly workers. This policy must outline what data is being collected, the reasons for its collection, and how it will be utilized to safeguard their privacy and foster trust.

II. CONCLUSION

The incorporation of IoT into outsourcing operations signifies a fundamental change, evolving from a mere transactional relationship to one founded on data-driven trust and mutual visibility. By facilitating real-time monitoring of assets, environmental conditions, and production processes, IoT technology converts the abstract

notion of transparency into a concrete reality. This not only enables companies to uphold quality standards and reduce risks but also empowers them to confidently showcase their dedication to ethical sourcing and sustainable practices. Although challenges such as data security, implementation costs, and interoperability persist, the long-term advantages of enhanced brand reputation, improved operational efficiency, and increased stakeholder confidence significantly outweigh these initial obstacles. As IoT technologies become increasingly accessible and advanced, they are sure to become an essential resource for businesses maneuvering through the complexities of the global market, paving the way for a more accountable, ethical, and transparent future in outsourcing.

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