

## **A Systematic Literature Review of Industry 4.0: Bridging between the Information Asymmetry and Corporate Governance**

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**Abstract.** With the growing literature on information asymmetry and industry 4.0 (IR4.0), a systematic review of the application of IR4 on mitigating information asymmetry is inevitable. Most of the existing literature focuses on management and computer science, and limited study links the analysis directly to the impact of technology on mitigating information asymmetry in corporate governance. Therefore, this study aims to fill in the literature gaps by refining and identify the linkage between adoption IR4.0 or enabling technologies of IR4.0 (Blockchain, Cyber-Physical System (CPS), Internet of Things (IoT), and Cloud Computing) related to mitigating information asymmetry. Firstly, the systematic review found 521 research articles from Scopus and Web of Science database and analysed nine articles based on inclusion and exclusion criteria. The review analysis found that blockchain technology plays a vital contribution in representing the enabling technologies of IR4.0. Most of the review analysis discussed blockchain technology on mitigating information asymmetry in corporate governance. Only one review article discussed widely with enabling technologies of IR4.0 on mitigating information asymmetry. However, the management field report was discussed too widely with theory and concepts related to computer science literature. Therefore, this study will focus on the discussion of blockchain technology on mitigating information asymmetry. The findings conclude that the enabling technologies of IR4.0 will mitigate information asymmetry in the corporate governance in the form of enabling open information transactions, decentralised governance, representing faithfulness of financial reporting, promote smart contracts, and enhance market competitiveness and social welfare. Finally, this study emphasised a framework based on the systematic literature review with suggested that IR4.0 will be a new mechanism to mitigate information asymmetry in the corporate governance, which will directly influence the intention of the corporate governance players to mitigate information asymmetry.

**Keywords:** Information Asymmetry; Industry 4.0; Blockchain, Corporate Governance

## 1 Introduction

This study examines the impact of the adoption industry 4.0 on mitigating information asymmetry in corporate governance. This article also tries to identify the linkage between the adoption industry 4.0 and the effects on mitigating information asymmetry. Based on our knowledge, this issue had not been addressed yet in the systematic literature review. Since 20<sup>th</sup> century, information asymmetry remains an unresolvable problem in corporate governance. Major prior studies determined that an individual tends to be involved in information asymmetry for the sake of their benefits or relies on the organisation's objective (e.g., Connelly et al. 2011; Hagedoorn 2006; Zaheer & Soda, 2009). For instance, management manipulating accruals, constructing transactions, and disclosing false information to mislead information users (Healy & Palepu, 2001; Lie 2005). The issue of information asymmetry brings negative consequences to corporate governance, such as impacts on decision making and business growth. Hence, organisations have to find solutions to mitigate information asymmetry. The organisation had mitigating information by adopt a rewarding system, monitoring system, and etc. However, information asymmetry still being unresolvable. Therefore, there are necessities to adopt disruptive technology to improve the resolutions of mitigating information asymmetry. By adopting industry 4.0, this will impact on the traditional methods of industrial production, corporate governance, and business regulations. Therefore, it will further improve corporate performance and leads to the organisation into the new edge.

The terms of industry 4.0 or the fourth industrial revolution are based on integrating the systems through big data, the emergence of analytics and business-intelligence capabilities, generating new forms of human-machine interaction, and improvements in the transferring digital instructions to the physical world. Thus, bring a new value chain and management level across the products' life cycle (Baur & Wee, 2015; Kagermann, 2013). Many prior studies examined that adopting industry 4.0 will decentralise corporate governance, and the disclosed information would be high transparency, traceable, and tamperproof (e.g., Yu, Lin & Tang, 2019). However, a question of whether the adoption industry 4.0 will mitigating the problem of information asymmetry is unclear.

Notwithstanding its benefits, when we look into the literature of information asymmetry and industry 4.0 itself, there are limited study links the management literature and computer science literature. From the perspective of management literature, prior studies have focused on studying the antecedent conditions that will lead information asymmetry, the motivation, resolutions on mitigating information asymmetry, and the impacts of information asymmetry towards the organisations. However, the literature of adoption disruptive technology on mitigating information asymmetry is limited in the management literature. On the other hand, from the viewpoint of industry 4.0 literature, most of the prior studies mainly focus on introducing, technology applied, research and development (R&D), opportunities and challenges on IR4 (e.g. Zhou, Liu & Zhou 2015; Ghobakhloo 2018; Moktadir, Ali, Sarpong & Shaikh 2018). While most of the existing literature focuses on computer science, limited study links the analysis directly to technology's impact on mitigating information asymmetry in corporate governance. Therefore, a systematic literature review on adoption industry 4.0 related to mitigating information asymmetry are necessary. The discussion in the

article can improve our understanding of the linkage between industry 4.0 on mitigating information asymmetry in corporate governance.

The remainder of the article is structured as follows. Section 2 presents the literature review of information asymmetry and industry 4.0. Section 3 discussed the methodology. Section 4 discussed the linkage between the adoption industry 4.0 on mitigating information asymmetry. Section 5 concludes.

## 2 Literature Review

### *Information Asymmetry*

Information asymmetry defined as a condition wherein imbalance information within two parties in a relationship (Akerlof 1970). Information asymmetry exists in all exchange relationship, including commerce relationship (Hambrick & Manson 1984). Previous studies had explored information asymmetry in various ways with different theories. Bacharach (1989) examined that information asymmetry plays a mechanism role in Bacharach's theoretical models, which will impact the flow of independent to dependent variables. Stiglitz (2002) depicted information asymmetry is a condition wherein different party gain different information towards a thing.

Moreover, Connelly et al. (2011) further explained that information asymmetry is a type of private information, which information-rich actors tend to involve in self-interest activity. Therefore, prior studies examined that information asymmetry is a mechanism that can be arbitrary use by actors to pursue self-interest. Despite the dynamic research on information asymmetry theory, extensive research studies towards information asymmetry are sufficient to prove that information asymmetry is a severe problem in corporate governance. For instance, Healy and Palepu (2001) reported that capital markets and organisations encountering losses consequences corporate disclosure related to information asymmetry. Bergh et al. (2018) justified that information asymmetry made a severe risk to the organisation.

Information asymmetry became a severe problem in corporate governance. Therefore, numerous researchers have identified various resolutions on solving information asymmetry. According to Bergh et al. (2018), the answers of organisations' information asymmetry can be classified into two: (i) reduce information asymmetry and (ii) increase information asymmetry for the sake of self-benefits. Eisenhardt (1989) and Jensen (1983) explained that outcome-based incentives could reduce information asymmetry. Mejia and Balkin (1992) supported it by explaining that monitoring systems are considered a costly and challenging system, which some agent has high autonomy, independence, and highly specialised information. However, Abrahamson and Park (1994) argued that agent would be unable to deceive their principle, which will directly reduce information asymmetry problem by monitoring the agent's behaviour. Moreover, some authors argue that information asymmetry can be reduced by using incentives to gather and disclose information (e.g., Madhok & Tallman 1998; Heeley, Matusik, & Jain 2007). However, Bovivie et al. (2016) argue that information asymmetry should be exploiting by engaging in information concealment behaviours. The above argument shows that solution for information asymmetry remained unclear and need further investigation. The answer could be adopting a new technology

mechanism to reduce information asymmetry while minimising unanticipated cost and risk. This study aims to understand better new technology mechanism adoption on solving information asymmetry in research and literature.

#### *Industry 4.0 and Its Enabling Technologies*

The concept of industry 4.0 (IR4.0) manifested at Germany Hanover Fair in 2011 then officially declare as Germany National Strategy in 2013. IR4.0 is also called an industrial revolution, smart manufacturing, industrial internet, and smart product. Prior studies Kagermann et al. (2013) claimed that the world started to engage in research and funding programs towards IR4.0 to take the pioneering role in the manufacturing industries. Although there is still no unanimously adopted the definition of IR4.0, Baur and Wee (2015) describe IR4.0 or the fourth-stage of industrialisation as "the next phase in the digitisation of the manufacturing sector, driven by four disruptions: the astonishing rise in data volumes, computational power, and connectivity, especially new low-power wide-area networks, the emergence of analytics and business-intelligence capabilities; new forms of human-machine interaction such as touch interfaces and augmented-reality systems; and improvements in transferring digital instructions to the physical world, such as advanced robotic and 3-D printing." Moreover, Zhou, Liu and Zhou (2015) depicted that the integrations of IR4.0, horizontal integration, vertical integration, and end-to-end integration, will bring interconnection with man to man to machine, machine to machine or service to service. Therefore, IR4.0 will influence on traditional methods of industrial production and corporate governance business regulations.

There are numerous methods to apply technologies for the implementation of IR4.0. These technologies included the cyber-physical system (CPS), Internet of Things (IoT), cloud computing, blockchain, and other related technologies (Xu, Xu & Li 2018; Gobakhloo 2018). Xu et al. (2018) explored that IR4 mainly dependent on the use of CPS, IoT and cloud computing. Moreover, Viyasitavat et al. (2018) explained that blockchain is one of the core applied technologies in IR4.0. Therefore, although there are various applied technologies in IR4.0, this study will only examine selected core technologies particularly significant of IR4.0, CPS, IoT, cloud computing and blockchain. However, there are no means meant to be exhaustive for the enabling technologies' coverage in this section. In the context of IR4.0, IoT usually referred to Industrial Internet of Things (IIoT) (Wang, Wan, Zhang, Li & Zhang 2016). However, the function is akin to IoT, enabling physical objects to communicate with each other and further share information and coordinate decisions (Ashton 2009; Xu, He & Li 2014). CPS further defined as a collection of transformative technologies that enables connection of the operations of physical assets and computational capabilities (e.g., Varghese & Tandur 2014; Lee, Bagheri & Kao 2015; Mladineo, Veza & Gjeldum 2017).

Moreover, the implementation of cloud computing allows all data store in a private and public cloud server. Viryasitavat et al. (2018) further explained that blockchain provides a solution which can build trust, reduce costs, and accelerate transactions in business process management (BPM) framework for service composition in IR4.0. Prior studies show an in-depth explanation of what enabling technologies of IR4.0. However, there is a need to further improve in literature how these enabling technolo-

gies in IR4.0 can solve corporate governance, such as information asymmetry. Therefore, this study aims to understand better how these enabling technologies solve information asymmetry in research and literature.

### 3 Methodology

All studies with information asymmetry and where applied technology of industry 4.0 was identified via two world-renowned indexed electronic databases: Web of Science (WoS) and Scopus, using the following search strings: ("information asymmetry") AND ("industry 4.0" OR "industrial revolution" OR "smart manufacturing" OR "industrial internet" OR "smart product") OR ("cyber-physical system" OR "CPS\*" OR "internet of things" OR "IoT\*" OR "cloud computing" OR "blockchain"). A research article was considered eligible for inclusion if: (1) it is on Finance area; (2) technology of industry 4.0 is applied to study the information asymmetry issue; (3) it is a peer-reviewed article. Article types of paper were only limited to Journal types written in English. Initial searches were conducted in August 2019 and then updated in September 2019 to ensure that all 1990 to September 2019 papers were included.

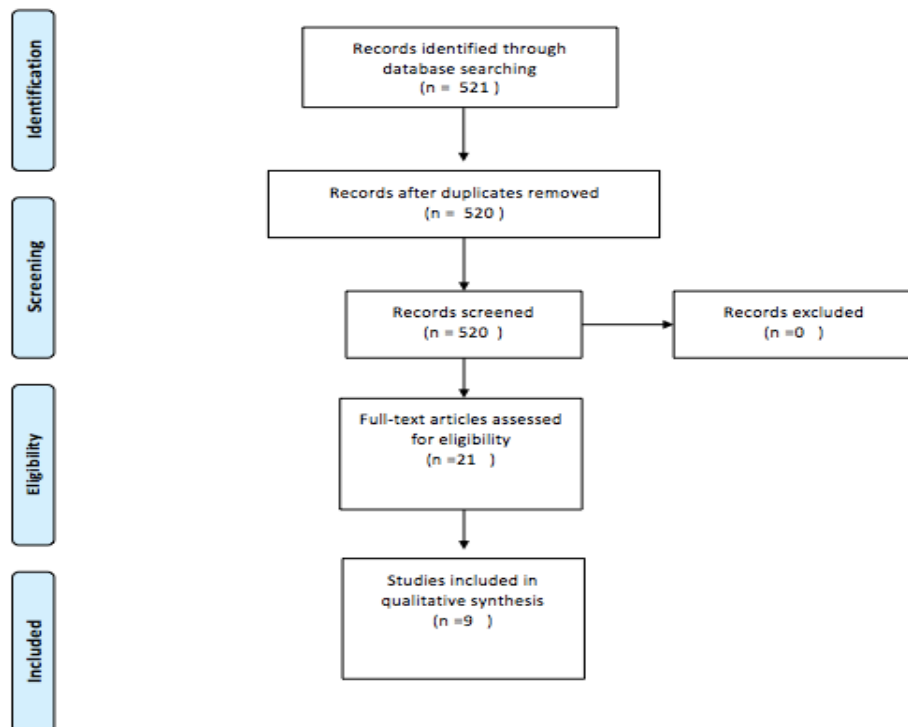


Fig. 1. Retrieval Process.

In phase 1, a total of 521 peer-reviewed research articles were retrieved at this stage. Restricting the search to WoS and SCOPUS means our review is not exhaustive and provides only a sample of the literature on information asymmetry in the finance area and its applied in IR4.0. In phase 2, we scanned titles and abstracts to selected articles with clear relevance to information asymmetry issues and implied use of industry 4.0 technique. Twenty-two papers were retained and went through full-text review, of which, nine articles fulfilled the inclusion criteria. Seven articles were retrieved from Web of Science and two journal articles from SCOPUS, of which, no papers were common to the two databases as shown by Figure 1.

#### **4 The Linkage Between Industry 4.0 on Mitigating Information Asymmetry**

From the systematic literature review, most of the articles discussed the blockchain technology – one of the enabling technologies in IR4.0. This section explains the integration of blockchain to mitigate information asymmetry in corporate governance.

##### **1. Open Information Transactions**

Blockchain potentially mitigates the traditional information transaction asymmetries. The prior studies emphasised that blockchain systems play a significant role in accounting and supply chain transaction. The transaction information of accounting and supply chain would be visible to all blockchain participants kept in public ledgers or consortium-based quasi-public ledgers. In general, the peer-to-peer public blockchain system is fully decentralised. Anyone has the authority to access and amend the transactions to ensure the availability of information is authentic. Therefore, all transaction information would be publicly exposed and solve the information transaction asymmetries using the peer-to-peer public blockchain systems. On the other hand, from New Institutional Economics (NIE), blockchain technology enables anyone to share information fully transparently without the need for the centralised clearing-house. Hence, except than accounting and supply chain systems, some organisations apply blockchain in their governance aid system to reduce information asymmetry and increase effectiveness (O'Leary 2017; O'Leary 2018; Reinsberg 2018).

##### **2. Decentralised Governance**

Blockchain and smart contracts can disintermediate traditional organisational governance structures. Conventional corporate governance systems tend to be centralisation and hierarchy, with different hierarchical top-down command and rule-setting decision-making degrees. The agent tends to be involved in self-benefits activities by using their authority with ignorance the order from principle. Alternatively, the blockchain system introduces decentralised and spontaneous coordination with resolving the problem of traditional centralised governance, known as the principle-agent dilemma (information asymmetry). In a simple form, blockchain enables a database system in which decentralised agents or institutions can record information and main-

tain it. For instance, the Schelling points (kind of blockchain solution) allow people to converge on a mutually consistent decision framework, in the absence of direct communication and centralised coordination. Moreover, blockchain technology enhances a responsible and accurate record keeper, reducing the problem of manipulation and tampering. Hence, blockchain and smart contracts might exterminate information asymmetry by introducing new ways of coordinating activities. The activities such as task allocation, coordination, and supervision of a group of people who share common economic interests are geographically distributed, without the necessity of a centrally managed organisation (Shermin 2017; O'Leary 2017; Cong & He 2018; Eling & Lehmann 2017).

### 3. Representational Faithfulness of Financial Reporting

Stakeholders find it challenging to establish whether financial reporting information does represent what it purports to because of information asymmetry and agency problems. In theory, insiders used to mislead outside capital providers about the entity's financial positions and operating performance to obtain more capital or out of personal interests of insiders. Thus, the emergence and development of financial accounting and independent auditing to solving information asymmetry. However, it cannot wholly solve due to conflicting interests between insiders and outsiders, the denseness of accounting and auditing, and nonindependence of the auditing, financial accounting, and external auditing. Blockchain technology creates a new Accounting Information System (AIS), which can address the information asymmetry and agency problems inherent in financial reporting and audit. These systems will enhance the representational faithfulness of financial reporting. The blockchain records and validates the information in a decentralised way. The entire process does not require any authority intermediaries, and the blockchain technology guarantees the information to be transparent, secure, tamperproof, and reliable. As a result, the application of blockchain technology in financial accounting can make the firm's accounting process transparent, improve the quality of external reporting information, and effectively reduce the information asymmetry between firms and outside investors. In the short run, the blockchain technology could be used as a platform for firms to voluntarily disclose information, which is high-quality signalling that enables firms to solve the trust problem with investors. In the long run, the application will impact financial accounting, effectively reducing the errors in disclosure, increasing the quality of accounting information, and mitigating information asymmetry. In sum, this concept will reduce the agency problems and costs inherent in financial reporting and audit and enhance the financial reporting system's credibility and transparency (McCallig, Robb & Rohde 2019; Yu, Lin & Tang 2019).

### 4. Smart Contracts

The problem of incomplete contracts is one of the challenges of governance as they cannot specify all contingencies such as information asymmetry and agency slack. Blockchain technology enables smart contract with some codes that run on top of a blockchain (Diedrich, 2016; Swan, 2015; Szabo, 1994). In theory, smart contracts can bind parties effectively to mitigate uncertainty in relational contracting. In smart contracts, the parties will lose their stake resources if they did not behave compliant with not follow through on its promise to provides an incentive or information. Moreover,

the smart contracts will evaluate and verify whether a party complies with the terms and regulations. Once the smart contract has been set up, the modifications will be recorded on the blockchain with traceable. Hence, blockchain, notably smart contracts, mainly provide a mechanism for bringing trusted data which can reduce uncertainty around contract enforcement, while also decreasing information asymmetry by providing an impeachable record of transactions (Reinsberg 2018; Yu, Lin & Tang 2019).

#### 5. Enhance Market Competitiveness and Social Welfare

Blockchain enables a decentralised record-keeper to decrease manipulation and misreport with allowing better and efficient information aggregation. This information distribution process changes the information environment and the economic behaviours of blockchain participants. The blockchain technologies will mitigate information asymmetry as a barrier to entering the market and greater the competition while enhancing the welfare and consumer surplus. In the traditional world, market players are not able to observe about their competitive business activities. In contrast, blockchain enables the market players to infer the aggregate business condition by serving as record-keepers (a system in the blockchain) and detecting deviations in any collusion equilibrium because the information is open and transparent. The market players (blockchain node) can observe all trade information in the exchange and all incoming exchange transactions. With this information, the market player can exploit the information asymmetry between what they can see and other market players, then enhance market competitiveness. However, even though the blockchain can mitigate information asymmetry barrier and encouraging entry for market players, it can also lead to greater collusive behaviour (Cong & He 2018; Freund & Stanko 2018).

#### 6. Discussions

As mentioned, the issue of information asymmetry is a common but impactedness problem in corporate governance. This problem plays a significant problem in both shareholder and stakeholder perspective. Information asymmetry commonly related to an individual tends to involve information asymmetry for the sake of own benefits or to realise organisation's goals (e.g., Connelly et al. 2011; Hagedoorn 2006; Zaheer & Soda 2009). The loopholes in management had created various opportunities for corporate governance player involve in information asymmetry. Thus, the corporate governance players tend to lack intention on mitigating information asymmetry due to their benefits. Hence, information asymmetry is still unresolvable and has negative consequences even though prior studies try to minimise information asymmetry. However, earlier studies argue that there are necessities to adopt technology in this technology era, thereby improving mitigating information asymmetry. Therefore, this study filled in the research gaps and answer whether adoption IR4.0 will be mitigating the problem of information asymmetry. This study concludes and suggests that IR4.0 will be a new mechanism to alleviate information asymmetry in corporate governance. The adoption of IR4.0 will increase corporate governance players' intention to mitigate information asymmetry by enabling open information transaction, decentralised governance, representing faithfulness of financial reporting, and promoting smart contracts. Hence, without the necessity of a centrally managed organisation, the corporate governance players have no opportunity to involve in information asymmetry



activity for the sake of self-benefits or the organisation. On the other hand, blockchain technology's role enables the corporate transaction to be transparent, improves information quality, and effectively reduces information asymmetry between insider and outsider. Therefore, we suggest that the adoption of IR4.0 in corporate governance will boost the intention of solving asymmetry and mitigate information asymmetry. The framework below shows that the adoption of IR4.0 will mitigate information asymmetry and increase their intention of solving information asymmetry.

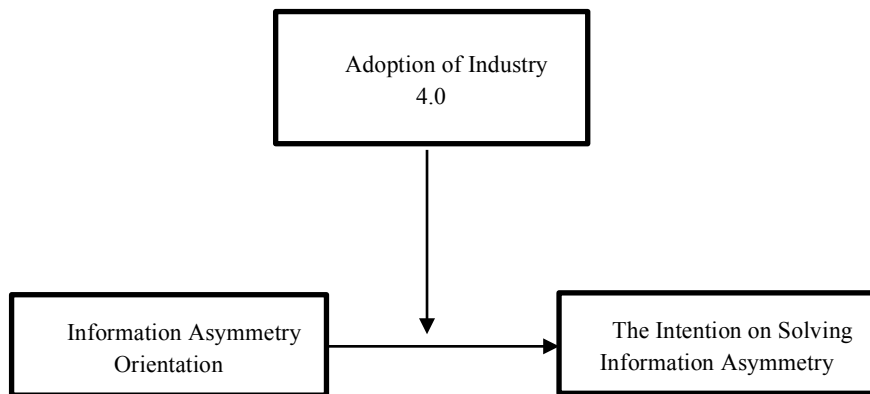


Fig. 2. Proposed Framework.

## 5 Conclusion

This study applied a systematic literature review to present the influences of IR4.0 in corporate governance and provided a set of empirical features related to resolutions of information asymmetry in corporate governance. Most of the prior studies focus on IR4.0 in the area of computer science. There are limited study links that analyze directly the impact of technology on solving information asymmetry in corporate governance. However, some of the previous studies have emphasized how the influences of enabling technologies in corporate governance do not entirely focus on information asymmetry issues. Hence, prior studies have rarely addressed qualitative and systematic preferences. Notably, the literature does not have a systematic study-related integration of IR4.0 on mitigating information asymmetry in corporate governance. Therefore, this study integrated all related articles to address those dilemmas from prior studies.

The findings conclude that the enabling technologies of IR4.0 will mitigate information asymmetry in corporate governance in the form of enabling open information

transactions, decentralised governance, representing faithfulness of financial reporting, promote smart contracts, and enhance market competitiveness and social welfare. The enabling technologies of IR4.0 will decentralise governance. Hence, this decentralised and spontaneous coordination will resolve the problem of information asymmetry. Also, IR4.0 enables open information transactions that anyone can share, access, and amend information in a fully transparent manner without centralised clearinghouse, meanwhile providing a representational faithfulness of financial reporting. Moreover, the decentralised record-keeper encouraging entry for market players, meanwhile improve social welfare. Smart contracts, known as one of the enabling technologies of IR4.0, provide a mechanism for bringing trusted data which can reduce uncertainty around contract enforcement. Specifically, this study emphasised a framework based on a systematic literature review. The framework suggested that IR4.0 will be a new mechanism to mitigate information asymmetry in corporate governance. It will directly influence the intention of corporate governance players to mitigate information asymmetry.

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