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**SGX-ESS Essay Competition-“What is the future construct of price formation in the ‘Computing Fog’”**

### **Executive Summary**

For centuries, centralised markets where traders assemble to conduct exchanges under a central body have been the norm. These exchanges provided convenience and security where all information and transactions flowed through. In capital markets, concentrating market details allowed price discovery mechanisms and appropriate valuation to function by maintaining up-to-date knowledge of market conditions.

Yet, in the wake of new innovations, markets now veer towards a common trend; decentralisation. Utilising tokenization and distributed information, decentralised markets offer greater transparency, accessibility and liquidity in trade. Along with cloud computing, decentralised markets are able to capitalize on monitoring technology to gain greater information for asset valuation.

Ultimately, the realistic implications of this revolution are still unclear. This essay will seek to evaluate how and why this shift towards decentralisation fundamentally changes price formation mechanisms in markets.

Therefore, to understand how price formation and discovery function change it is crucial to understand its roots in centralised markets. Subsequently, this essay will compare how the factors affecting these functions change in a fully interconnected market. Now absent the restrictions on information flow, it is gearing up into an ideally efficient market.

Furthermore, I propose the key success factors governments must focus on advancing the cause of decentralisation while desisting its misuse. Supporting new decentralised markets with intrinsic socially beneficial mechanisms will ensure its transparency is not exploited. Furthermore, to prevent information flow from being corrupted, government investment into automated monitoring will allow it to keep up in this evolving landscape. Finally, trans-national relations must be enhanced to avoid a decentralised market being impeded by geo-political disputes.

The path to decentralisation will be difficult. But once the enhancements of price formation are fully realised, an insightful government will not regret pushing its nation towards the path of information sharing and equal opportunity.

(Words: 296)

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## **1.0 Introduction: Rise of the Computing Fog**

The world is barreling towards a new era of technological innovation. Gone are the days where digital expertise was concentrated in the offices of corporations in the Silicon Valley. Now, access to and knowledge of the internet has normalized with almost 60% of the world population having some form of wireless connection to the World Wide Web as of May 2020<sup>1</sup>.

For markets, the Computing Fog describes the optimal digital spectre where mobile connectivity can flourish. By shifting asset movement between distributed organisations onto the digital spectrum; they can become more versatile, conducting transactions with greater efficiency and convenience<sup>2</sup>.

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<sup>1</sup>World Internet Users Statistics and 2020 World Population Stats. (n.d.). Retrieved July 14, 2020, from <https://www.internetworldstats.com/stats.htm>

<sup>2</sup>Interested in Becoming a Member? (n.d.). Retrieved July 14, 2020, from <https://m360.sim.edu.sg/article/Pages/Breakthroughs-in-IOT-Paving-the-Way-in-Singapore.aspx>

In the past, business transactions were restricted to and dictated by centralised institutions<sup>3</sup>. Now, developments in blockchain technology<sup>4</sup>, peer to peer networking<sup>5</sup>, the outbreak of cryptocurrency<sup>6</sup> and the IOT(Internet of Things)<sup>7</sup> forgo these restrictions, revolutionising markets with much success (Figure 1).



**(Figure 1: Illustration of SMEs adoption of digital technologies into their businesses)<sup>8</sup>**

Digitisation in markets are conducted with the common goal of decentralisation. The potential for SMEs, that make up 99% of enterprises in Singapore<sup>9</sup>, is vast in this new

<sup>3</sup> The capitalization of markets by large centralised exchanges has resulted in an equity gap forming between “blue-chip” companies and SMEs, inhibiting their capital growth and innovation further widening the disparity. Klagge, B., & Martin, R. (2005). Decentralized versus centralized financial systems: Is there a case for local capital markets? *Journal of Economic Geography*, 5(4), 387-421. doi:10.1093/jeg/lbh071

<sup>4</sup> Developments in Blockchain technology enable organisations to monitor all transaction histories and reduce information gaps or inefficiencies through employing a harmonized ledger. Blockchain also aid in creating a more robust ownership of assets for all parties involved in transaction(Singapore Blockchain Ecosystem - An Industry Report)

<sup>5</sup> Ibid

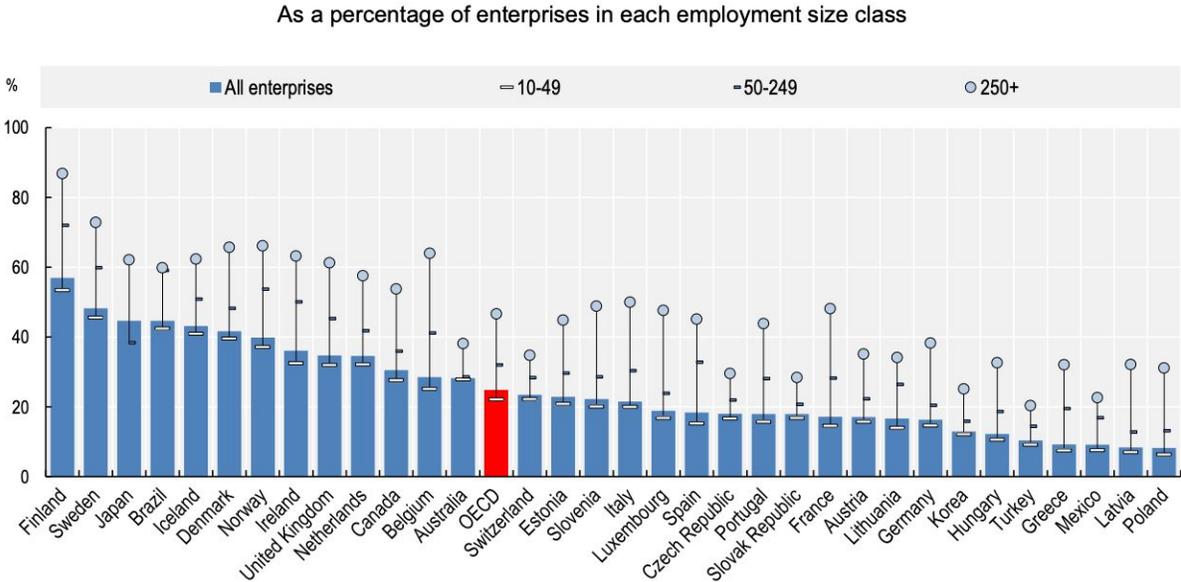
<sup>6</sup> Under the Payment Services Act (PS Act) 2019 the MAS(Monetary Authority of Singapore) has acknowledged the impact cryptocurrencies have upon the economy and seeks to regulate their effects.

<sup>7</sup> The Internet of Things (IoT) is defined as a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies (International Telecommunication Union, 2015).

<sup>8</sup>Singapore SMEs who embrace digital transformation expect to see average revenue gains of 26%: ASME-Microsoft study. (2018, October 23). Retrieved July 14, 2020, from <https://news.microsoft.com/en-sg/2018/10/23/singapore-smes-who-embrace-digital-transformation-expect-to-see-average-revenue-gains-of-26-asme-microsoft-study/>

<sup>9</sup>SMEs vs MNCs: Benefits of working in a Singaporean SME. (n.d.). Retrieved July 14, 2020, from <https://sbr.com.sg/hr-education/commentary/smes-vs-mncls-benefits-working-in-singaporean-sme>

market. Increasing productivity for local business will present opportunities to overcome traditional barriers to entry, promote flexibility and allow them to compete against or collaborate on equal footing with the MNCs that dominate industry.<sup>10</sup>



Notes: Cloud computing refers to ICT services used over the Internet as a set of computing resources to access software, computing power, storage capacity and so on.

**(Figure 2: Enterprises integrating the cloud computing, 2016)<sup>11</sup>**

Therefore, the Computing Fog will create fairer, more interconnected marketplaces absent centralised intermediaries<sup>12</sup>. Fog computing technology is being increasingly

<sup>10</sup> SMEs are a key pillar of Singapore's economy constituting 99% of all its enterprises and employing about 65% of its workforce yet account for 48% of its GDP showing the majority power concentrated with several large Multinationals. *ibid*

<sup>11</sup> OECD, ICT access and use database; Eurostat, Information Society Statistics and national sources, July 2020

<sup>12</sup> Intermediaries can influence the terms of trade in their favour rather than that of other parties for it is tasked by to be impartial. Concentrated intermediaries can control liquidity and establish monopolies on trade, in the process extracting unfair advantages from the parties involved.

Luke, M., Antsy, G., Taylor, W., & Sirak, A. (n.d.). Blockchains in Power Markets: Decentralized Disruption or Incremental Innovation? [Web log post]. Retrieved July 15, 2020, from [https://www.nera.com/content/dam/nera/publications/2019/PUB\\_Blockchains\\_and\\_Power\\_Markets\\_0219.pdf](https://www.nera.com/content/dam/nera/publications/2019/PUB_Blockchains_and_Power_Markets_0219.pdf)

adopted (Figure 2) and will open information flow throughout the market placing<sup>13</sup>. In a decentralised market, business works for the many and not for the few.

More accessibility begets greater progress as has been recognised by G20 efforts to expand these opportunities for all<sup>14</sup>. Digitisation and decentralisation are very likely to be the next step for markets worldwide.<sup>15</sup> However, in a world with parties primarily operating in their own self-interests, the feasibility of a fully distributed transparent market is still debatable.

To best comprehend the effects decentralisation can have on market mechanisms, one must understand how they operated in the past. This essay first examines the behaviour of centralised marketplaces to elaborate how price formation will evolve correspondingly with the decentralisation revolution.

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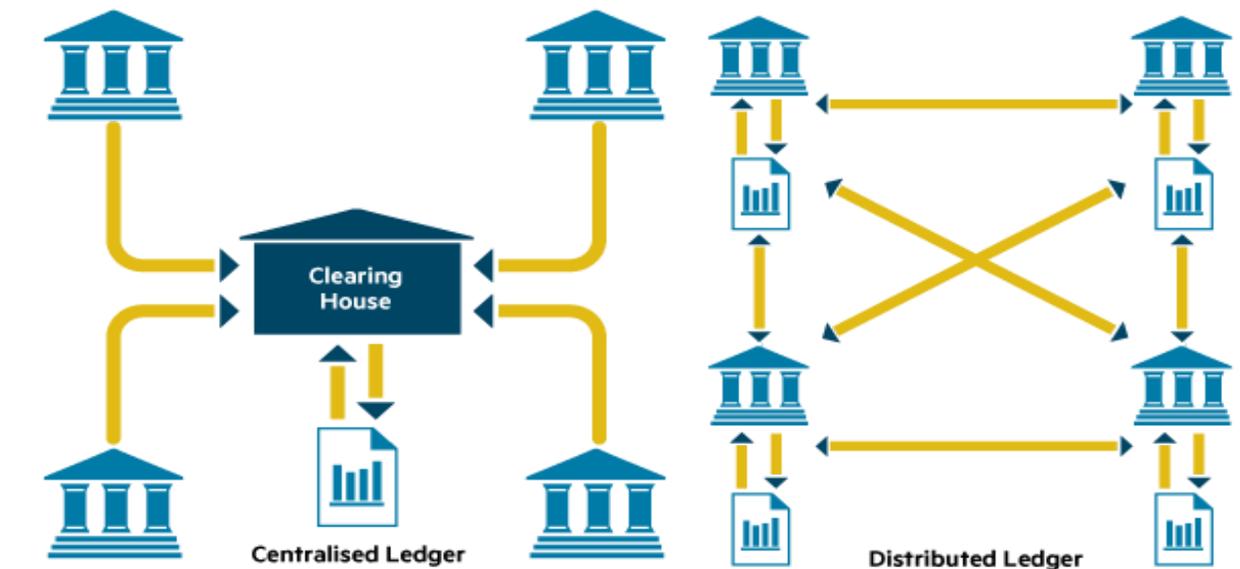
<sup>13</sup>Through cloud services, the Internet also provides SMEs with access to a wide range of technologies and applications, including big data analytics, helping firms to solve problems at a much lower cost *KEY ISSUES FOR DIGITAL TRANSFORMATION IN THE G20*. (2017, January 12). Retrieved July 15, 2020, from <http://www.oecd.org/G20/key-issues-for-digital-transformation-in-the-G20.pdf>

<sup>14</sup> Ibid

<sup>15</sup>Singapore, already with a rich foundation of digital infrastructure and an educated workforce to enrich digitalisation as the next big break-through, set to add as much as \$10 billion to their economy by 2021A *World in Transformation*. (n.d.). Retrieved July 14, 2020, from <https://sponsored.bloomberg.com/news/sponsors/features/imda/singapore-advancing-the-regions-digital-superhighway/?adv=17532>

## 2.0 Tenure of Centralised Markets

Centralised markets arose out of a need for trust and control in transactions. Imperfect information and lack of trust in the effective exchange of goods and services naturally limit confidence. Thus, centralised intermediaries like banks, exchanges and other financial institutions took the burden of these problems, providing a trusted third party to facilitate trade or make payment<sup>16</sup> (Figure 3).



<sup>16</sup> The NYSE accounts for over 30% of all trading conducted globally, a highly centralised institution for economic activity. Together with NASDAQ, they account for over half of all financial transactions worldwide in a concentrated majority. In contrast to today's networks, distributed ledgers eliminate the need for central authorities to certify ownership and clear transactions. They can be open, verifying anonymous actors in the network, or they can be closed and generate a majority of the network to be already identified. The best known existing use for the distributed ledger is the VeriCurrency. (n.d.). Retrieved July 14, 2020, from [https://markets.cboe.com/us/equities/market\\_share/](https://markets.cboe.com/us/equities/market_share/)  
Graphic source: Santander InnoVentures, Oliver Wyman & Anthemis Partners  
 Furthermore, the "Big four" accounting firms are already indicative of an intense concentration of power. Charged with the incompatible responsibilities of both impartially auditing and simultaneously seeking higher profitability for their clients.

Oh, B. (2019, October 29). Singapore's Big Four: Some Facts About Each Accounting Firm. Retrieved July 14, 2020, from <https://corpsexperiences.net/guides/accounting-firms-in-singapore/accounting-firm/>

**(Figure 3: Left: Transaction flow in a centralised market, Right: Transaction flow in a fully decentralised market<sup>17</sup>)**

## **2.1 Price Discovery Mechanism in Centralised Markets**

Price discovery occurs when buyers and sellers agree on a price at which they are willing to trade. In centralised markets, where transactions are highly concentrated, this process can be executed swiftly with all pertinent information and sentiments made clear to every party<sup>18</sup>.

In markets familiar to price volatility like commodities<sup>19</sup>, forward trading on centralised exchanges helps mitigate risk<sup>20</sup>. With centralised markets being structured for steady flow of market information, they facilitate the forces of demand and supply in price discovery mechanisms. These mechanisms operate in futures markets faster<sup>21</sup>, quickly reflect incoming information into prices.

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<sup>17</sup> The Fintech 2.0 Paper: Rebooting financial services [Web log post]. (n.d.). Retrieved July 15, 2020, from <https://santanderinnovations.com/wp-content/uploads/2015/06/The-Fintech-2-0-Paper.pdf>

<sup>18</sup>Biais, B. (1993). Price Formation and Equilibrium Liquidity in Fragmented and Centralized Markets. *The Journal of Finance*, 48(1), 157-185. doi:10.1111/j.1540-6261.1993.tb04705.x

<sup>19</sup> Commodity markets are prone to disruptions and shocks due to fluctuations in economic activity and interruptions in distribution which can cause sudden downturns in the market. Cinquegrana, Piero. "The Need for Transparency in Commodity and Commodity Derivatives Markets. ECMI Research Report No. 3, 15 December 2008." (2008).

<sup>20</sup> Centralised futures markets are less susceptible to shocks and thus present the most efficient market conditions for trade Franken, Jason R.V. & Pennings, Joost M.E., 2005. "Changing Agricultural Marketing Channel Structures: Interdependencies & Risk Preferences," 2005 Annual meeting, July 24-27, Providence, RI 19414, American Agricultural Economics Association (New Name 2008: Agricultural and Applied Economics Association).

<sup>21</sup> Futures markets have been attributed to higher liquidity compared to the cash market for the commodity, as they facilitate the more versatile functioning of price discovery in the market. Inoue, Hiroataka. "The Effects of Open Market Operations on the Price Discovery Process in the Japanese Government Securities Market: An Empirical Study." (1999).

A study conducted by The International Organization of Securities Commissions highlighted how quality and availability of information is the cornerstone for the functioning of credible price discovery<sup>22</sup>. As noted by the United Kingdom's Economics Ministry that "greater transparency across all parts of the commodity market....play a role in helping all sides gain a better understanding of trends in supply and demand"<sup>23</sup>.

Centralised futures exchanges, like the London Metal Exchange, convey confident information on market trends and aid in price stabilisation (Margaret E. Slade and Henry Thille, 2005). Symmetric information has thus been a key factor in how price discovery operates effectively in a market.

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<sup>22</sup> Publicly posted cash market data and transactions regarding public prices, storage reports, inventory statistics and other market details on commodities reduce market uncertainty and allow parties to understand the fundamental driving forces in the market. Stronger data collection and dissemination are essential to achieve a practical method of price discovery.

Task Force on Commodity Futures Markets [Web log post]. (2009, March). Retrieved July 15, 2020, from [https://www.cftc.gov/sites/default/files/idc/groups/public/@swaps/documents/file/plstudy\\_22\\_iosco.pdf](https://www.cftc.gov/sites/default/files/idc/groups/public/@swaps/documents/file/plstudy_22_iosco.pdf)

<sup>23</sup> Global Commodities: a long term vision for stable, secure and sustainable global markets (June 2008) at p. 64.

## 2.2 Price Formation in Centralised Markets

Price formation is an analytical process conducted to determine the intrinsic value of an asset or a company. It determines the present (or future) value of a good or service after a valuation analysis<sup>24</sup> or an evaluation of comparable goods<sup>25</sup>.

As a model-driven approach to determine accurate value, share prices on centralised stock exchanges are typically derived through price formation. In the context of launching a fresh IPO or the acquisition of companies by other firms, price formation plays a key role in the appropriate valuation of any enterprise.

In conjunction with price discovery, price formation consists of deliberate decisions made by company management with private information along with information gained from independent market forces. A study by Deloitte Review identified effective price formation as “The ability to manage information flow, make rapid pricing decisions, escalate pricing exceptions and control market execution of pricing<sup>26</sup>”.

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<sup>24</sup>Valuation analysis of assets comes through the examination of several factors such as the market value of the asset, evaluation of forward earnings(such as EPS), enterprise value (market value of equity plus book value of debt). Gleason, C. A., & Lee, C. M. (2003). Analyst Forecast Revisions and Market Price Discovery. *The Accounting Review*, 78(1), 193-225. doi:10.2308/accr.2003.78.1.193

<sup>25</sup>Model for a comparative analysis with similar companies was achieved so that the intrinsic value can be calculated using relative assets in the market.

Bhojraj, S., & Lee, C. M. (2002). Who Is My Peer? A Valuation-Based Approach to the Selection of Comparable Firms. *Journal of Accounting Research*, 40(2), 407-439. doi:10.1111/1475-679x.00054

<sup>26</sup>Meehan, J., Davenport, C., & Kahlon, S. (2012, February). The price of pricing effectiveness: Is the view worth the climb? [Web log review]. Retrieved July 15, 2020, from [https://www2.deloitte.com/content/dam/Deloitte/ie/Documents/Strategy/Price\\_of\\_Pricing\\_Effectiveness\\_Jul12.deloitte\\_global.pdf](https://www2.deloitte.com/content/dam/Deloitte/ie/Documents/Strategy/Price_of_Pricing_Effectiveness_Jul12.deloitte_global.pdf)

In the trading of securities, arbitrary changes in the liquidity of its underlying asset can cause changes in volatility of prices even between the opening of the market versus at its close.<sup>27</sup>

Empirical study of stocks on the centralised New York Stock Exchange revealed that the formation of prices, even throughout the day, varied as new information was incorporated into more accurate valuation. Thus, the lower price variance at the close of trading can be accredited to the efficient flow of information on this centralised exchange.

The benefit of trading on centralised exchanges has proven to be greater access to unbiased estimates of value. Concise evaluation of information form accurate prices, thus placing centralisation at the forefront of market efficiency.

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<sup>27</sup> This study concluded that even the overnight interruption of trading along with corresponding sudden information shocks can result in stark changes in the price formation process. Gerety, M. S., & Mulherin, J. H. (1994). Price Formation on Stock Exchanges: The Evolution of Trading within the Day. *Review of Financial Studies*, 7(3), 609-629. doi:10.1093/rfs/7.3.609

## 2.3 Limitations of Centralised Markets

While efficient markets work for the common good, centralised market structure also concentrates information into dense, albeit more convenient, systems that create a single point of failure.

Commodity trading suffers from this as derivative prices potentially divorce from real-time asset valuation due to information discrepancies between professionals and less knowledgeable actors. Information asymmetry lies in the intermediation of these transactions where accurate valuation is lost<sup>28</sup>. Absent accurate market information of the trade, price discovery is unable to operate efficiently.

Consequently, with less accountability, opaque actions of controlling financial institutions have proven detrimental to global economies. The most glaring example being the 2008 Financial Crisis. This crisis exposed the limitations of centralised markets and incited a new movement, the age of decentralised markets<sup>29</sup>.

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<sup>28</sup> The inaccuracies of projections in futures spot market prices stems from a failure to convey all relevant information thus it does not prove to be an unbiased estimator of the value of a given commodity.

Perrakis, S., & Khoury, N. (1998). Asymmetric information in commodity futures markets: Theory and empirical evidence. *Journal of Futures Markets*, 18(7), 803-825.  
doi:10.1002/(sici)1096-9934(199810)18:73.0.co;2-#

<sup>29</sup>In August 2009 following the Great Recession, the Economist Intelligence Unit declared support of decentralization over centralization: "Companies have to deal with dramatically more uncertainty, complexity and ambiguity in the current recession. Success does not come from centralization. True exibility arises when those who are closest to customers are empowered to respond to constant shifts in demand, preferences and attitudes."

### 3.0 Advance of Decentralisation

The decentralisation of markets through the elimination of a centralised exchange and intermediaries is not a novel concept<sup>30</sup>. In finance, corporate bond trading occurs in fragmented over-the-counter(OTC) markets similar to commodities like agriculture and metals<sup>31</sup>.

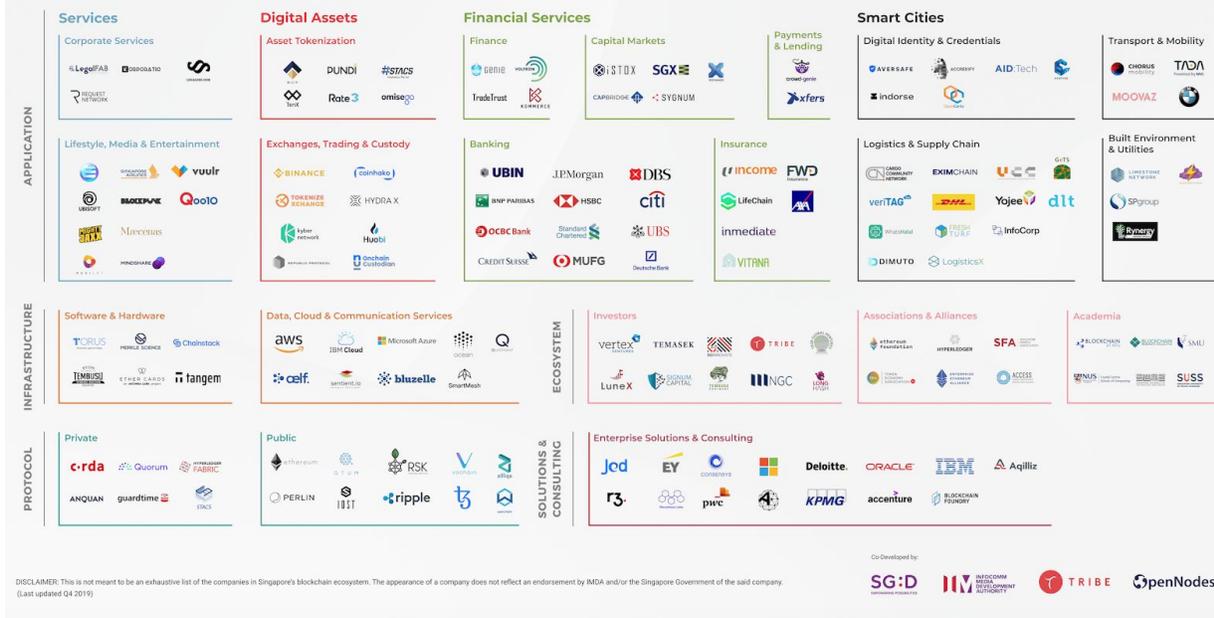
However, expedited by technological leaps in peer-to peer transactions, distributed ledger technology, edge computing and decentralised currency, these markets are on a fast track of digitization(Figure 4).

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<sup>30</sup> Decentralised markets oversee the removal of middlemen in common exchanges increasing transparency too often shadowed by intermediaries.

<sup>31</sup> Agricultural cash markets as well as that of livestock are traded on decentralised OTC markets using bilateral contracts to facilitate trade. This is the same for the exchange of non-ferrous metals mainly through decentralised markets while referencing quoted prices on the LME. Cinquegrana, Piero. "The Need for Transparency in Commodity and Commodity Derivatives Markets. ECMI Research Report No. 3, 15 December 2008." (2008).

# SINGAPORE BLOCKCHAIN LANDSCAPE 2019

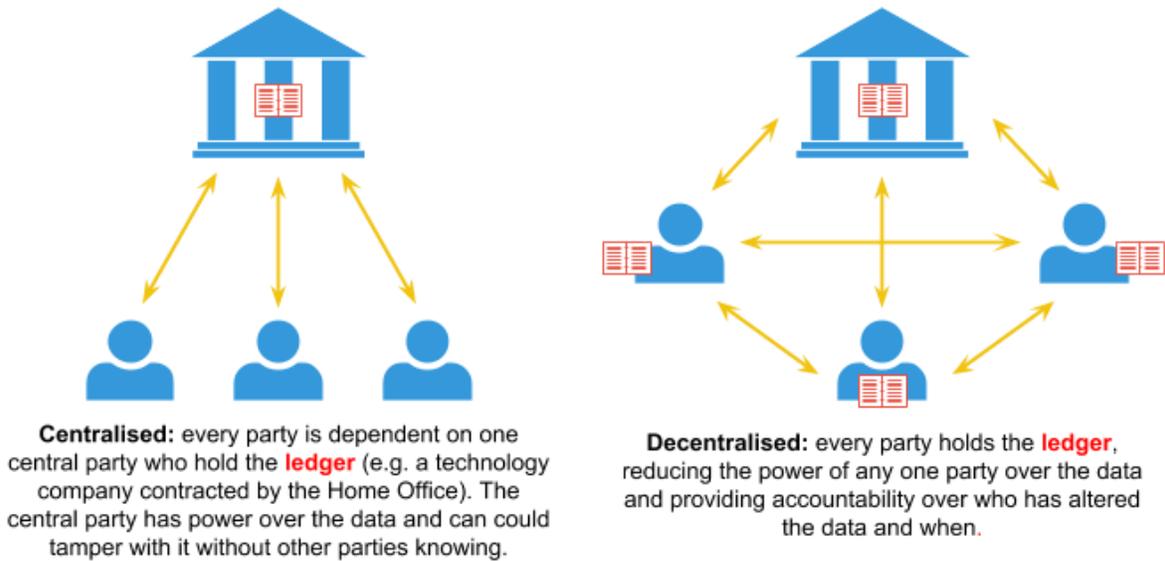


(Figure 4: Companies integrating Blockchain technologies into their business)<sup>32</sup>

In today’s context, decentralisation occurs through the implementation of blockchain technology, which has revolutionised financial markets.<sup>33</sup> Focusing on capital markets where information revelations are theoretically reflected onto prices, distributed ledger technology has been steadily revamping this network (Figure 5).

<sup>32</sup>Singapore Blockchain Ecosystem. (n.d.). Retrieved July 14, 2020, from <https://www.imda.gov.sg/programme-listing/Blockchain-Innovation/Singapore-Blockchain-Landscape-Map>

<sup>33</sup> The Monetary Authority of Singapore actively encourages experimentation by partnering with private industry in experimenting with cross-border payments using blockchain and distributed ledger technology.



**(Figure 5: Infographic of how decentralised ledger system changes the ownership of information in a market<sup>34</sup>)**

Technological advances in tokenization and efficient distribution of information have created efficiency gains through greater liquidity<sup>35</sup> and transparency, placing decentralisation ahead of the curve.

<sup>34</sup> West, P. (2018, February 19). Is distributed ledger technology the answer? Retrieved August 02, 2020, from <https://openinnovation.blog.gov.uk/2018/02/19/is-distributed-ledger-technology-the-answer/>

<sup>35</sup> Tokenization in traditionally illiquid markets such as housing and commodities allow smoother transactions, less the volatility common to these markets

### 3.0.1 Tokenization

Tokenization resolves the illiquidity of commodities<sup>36</sup>, energy assets or real estate by giving them a digital representation of their unique value<sup>37</sup>. This digital securitization of assets increases the versatility of trading by removing intermediaries such as clearing houses or FX and facilitates the decentralisation of financial exchanges. It is already being recognised as the future of economies<sup>38</sup> and is being pursued by Singapore<sup>39</sup> (Figure 5).

STRENGTHS	WEAKNESSES
<ol style="list-style-type: none"><li>1. Pro-business environment</li><li>2. Internationally trusted legal system and IP framework</li><li>3. Political stability</li><li>4. Technologically savvy consumers</li><li>5. Pro-open source environment, which has contributed to driving innovation in Singapore, e.g. in blockchain</li></ol>	<ol style="list-style-type: none"><li>1. Small domestic market</li><li>2. Small population size constrains the volume of data available for AI model development</li></ol>
OPPORTUNITIES	THREATS
<ol style="list-style-type: none"><li>1. AI research – Singapore universities amongst the top in ranking in citation impact<sup>1</sup></li><li>2. Shift of AI from discovery phase to implementation phase<sup>2</sup> – Opportunities for Singapore to reap economic benefits of AI through driving adoption</li><li>3. Recognised as one of the top blockchain hubs<sup>3</sup> globally, creating opportunities for thought leadership</li><li>4. Neighbouring countries in ASEAN with large populations present tech providers in Singapore with ripe opportunities for technology adoption</li></ol>	<ol style="list-style-type: none"><li>1. Need for Singapore to constantly keep abreast, due to dynamic and fast-moving pace of technological advancements globally and in neighbouring countries</li><li>2. Relatively more urgent need, compared to neighbouring countries in ASEAN, to address job displacement from technologies including AI and robotics<sup>4</sup></li></ol>

NOTE: 1) 'NTU Ranks Top 3 Globally in Citation Impact of AI Research', NTU, May 2017; 2) 'What China can Teach the US about Artificial Intelligence', New York Times, Sep 2018; 3) '5 Reasons why Singapore is a Famous Hub for Blockchain and Crypto Conferences', CoinStaker, Sep 2018; 4) A 2018 study conducted by Cisco and Oxford Economics indicated that within Southeast Asia, Singapore will be worst-hit by job displacement arising from technologies – Nearly 21% of full-time workers could be impacted

<sup>36</sup> Transition away from physical assets and focusing on improved transaction processing through the use of digital tokens make it easier to exchange assets on the market, process revenue streams, liquidate assets and record transactions on a common ledger.

Don, B. (2019, March). Real Estate Use Cases for Blockchain Technology [Web log review]. Retrieved July 15, 2020, from <https://entethalliance.org/wp-content/uploads/2019/05/EEA-Real-Estate-SIG-Use-Cases-May-2019.pdf>

<sup>37</sup> The World Economic Forum postulates that by 2025 10% of world GDP would be stored on blockchain technology.

Deep Shift Technology Tipping Points and Societal Impact [Web log post]. (2015, September). Retrieved July 15, 2020, from

[http://www3.weforum.org/docs/WEF\\_GAC15\\_Technological\\_Tipping\\_Points\\_report\\_2015.pdf](http://www3.weforum.org/docs/WEF_GAC15_Technological_Tipping_Points_report_2015.pdf)

<sup>38</sup> The United Arab Emirates has an initiative in place to shift all economic activity in government services onto blockchain by 2020.

Dubai Blockchain Strategy. (n.d.). Retrieved July 14, 2020, from <https://www.smartdubai.ae/initiatives/blockchain>

<sup>39</sup> The Monetary Authority of Singapore has acknowledged the application of blockchain towards a more dynamic financial sector as a payment and transaction platform to revitalize industries and ensure their competitiveness in the global economy.

**(Figure 5: Pros and Cons of Singapore’s increasing adoption of Blockchain and smart technology)<sup>40</sup>**

Managed by smart contracts<sup>41</sup> that allow the disintermediation of transactions, trades are conducted in the nascent market of digital securities primarily in the form of ‘security tokens’<sup>42</sup>. Similar to how futures markets allow traders to hedge price risks, tokenization is a form of asset-backed derivative. However, in decentralised markets it is impossible for the value of the securitized token to exceed that of the asset itself reducing bifurcation problems existing today in derivatives traded on centralised markets<sup>43</sup>.

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<sup>40</sup>Singapore’s pro-business and educated workforce has the potential to successfully integrate blockchain into its business ecosystem, placing it at the forefront of innovation in the world. Executive Summary for Artificial Intelligence and Data and Blockchain [Web log post]. (n.d.). Retrieved July 15, 2020, from <https://www.imda.gov.sg/-/media/Imda/Files/Industry-Development/Infrastructure/Technology/Technology-Roadmap/WG4-Executive-Summary-for-Artificial-Intelligence-and-Data-and-Blockchain.pdf>

<sup>41</sup> Smart contracts automate the transaction process by authenticating parties, transferring funds or ownership instantaneously upon the fulfillment of all pre-arranged terms and recording the transaction on the blockchain.

What are smart contracts on blockchain? (2020, February 26). Retrieved July 14, 2020, from <https://www.ibm.com/blogs/blockchain/2018/07/what-are-smart-contracts-on-blockchain/>

<sup>42</sup>Security tokens derive its value from an external and tangible asset and offers to the token holders a wide range of rights (entitlement to a share of profits, ownership or equity in a legal entity, and so on). Don, B. (2019, March). Real Estate Use Cases for Blockchain Technology [Web log review]. Retrieved July 15, 2020, from

<https://entethalliance.org/wp-content/uploads/2019/05/EEA-Real-Estate-SIG-Use-Cases-May-2019.pdf>

<sup>43</sup>Valuation of a digitised asset comes most easily from the valuation of its under-lying asset. Any appreciation in price of the asset will be reflected in that of its derivative on the digital spectrum.

Tokenization and valuation methodology. (n.d.). Retrieved July 14, 2020, from <https://www.equisafe.io/blog-posts/use-cases-for-tokenization-and-valuation-methodology>

### 3.0.2 Distributed Ledger Technology

The automation of transactions enhances the sharing of information on the blockchain. Distributed ledger technology creates an immutable record of the asset and fund flow with its cryptographic consensus model subverting the single point of failure in centralised exchanges<sup>44</sup>.

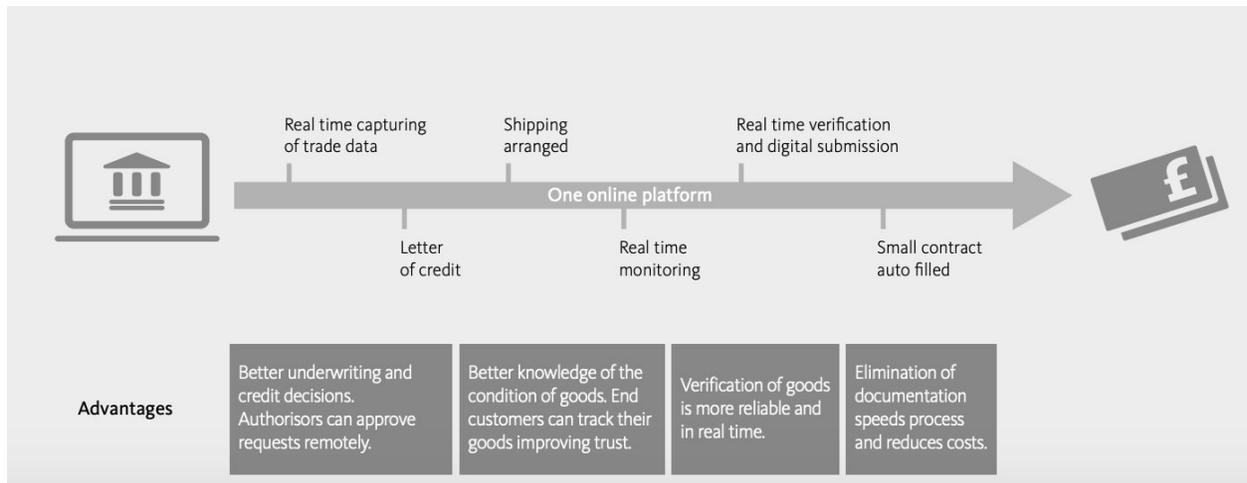
Even now, regulators of centralised exchanges recognise that the theoretical benefit of concentrating information has lapsed in realistic accountability.<sup>45</sup> Thus, combining decentralisation with the superior data collection in the IoT(Internet of Things) allows information to be universal and instantly accessible<sup>46</sup> (Figure 6).

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<sup>44</sup>The Tokenization of Assets and Potential Implications for Financial Markets [Web log post]. (2020, March). Retrieved July 15, 2020, from <https://www.oecd.org/finance/The-Tokenisation-of-Assets-and-Potential-Implications-for-Financial-Markets.pdf>

<sup>45</sup> In 2008, the US Securities and Exchange Commission revised its energy supply company data distribution regulations, mandating greater information transparency for investors to prevent information asymmetry from arising due to intense centralisation (n.d.). Retrieved July 15, 2020, from <http://www.sec.gov/news/press/2008/2008-304.htm>.

<sup>46</sup>The IoT establishes a robust network of data collection from every digital device involved in the trading process. By capitalizing on the complete and real-time knowledge regarding the good in any transaction, all parties will be on equal ground and symmetric information can be achieved. What is the Internet of Things, and how does it work? (2017, September 19). Retrieved July 14, 2020, from <https://www.ibm.com/blogs/internet-of-things/what-is-the-iot/>



**(Figure 6: Infographic of the IoT facilitated trade flow process)<sup>47</sup>**

Increasing accessibility to information yields transparency between traders dealing directly on the blockchain<sup>48</sup>. Additionally, disintermediation through tokenization removes sources of friction in exchanges streaming them with consistent liquidity<sup>49</sup>. As information distribution and valuation through tokenization reform the factors affecting price formation and discovery, their mechanisms have come to evolve in these new markets.

<sup>47</sup>The Fintech 2.0 Paper: Rebooting financial services [Web log post]. (n.d.). Retrieved July 15, 2020, from <https://santanderinnovations.com/wp-content/uploads/2015/06/The-Fintech-2-0-Paper.pdf>

<sup>48</sup>Digitisation of assets on a peer to peer network will allow trading directly on a decentralised platform. Deep Shift Technology Tipping Points and Societal Impact [Web log post]. (2015, September). Retrieved July 15, 2020, from [http://www3.weforum.org/docs/WEF\\_GAC15\\_Technological\\_Tipping\\_Points\\_report\\_2015.pdf](http://www3.weforum.org/docs/WEF_GAC15_Technological_Tipping_Points_report_2015.pdf)

<sup>49</sup>Housing assets will become much more liquid, being made easier to trade on the market (being in a more versatile form i.e token). It would also in theory limit the need for high cost/high-friction intermediaries involved in transactions as the trade could be done directly. Owning interests in real estate (via real estate tokens) rather than actual physical properties will give sellers and investors greater flexibility in using its capital. Don, B. (2019, March). Real Estate Use Cases for Blockchain Technology [Web log review]. Retrieved July 15, 2020, from <https://entethalliance.org/wp-content/uploads/2019/05/EEA-Real-Estate-SIG-Use-Cases-May-2019.pdf>

### 3.1 Transparency

A truly decentralised market will see information and capital flowing liberally between parties in deals executed automatically with smart contracts. Smoother trade finance yields efficiency gains by removing search frictions that cause deadweight loss<sup>50</sup>, perpetuating quality information<sup>51</sup> and limiting control of centralised exchanges on information to extract economic gain<sup>52</sup>.

Decentralised exchanges will blend together asset valuation and efficient information collection through real time monitoring to phase out inefficiencies as seen in Figure 7.

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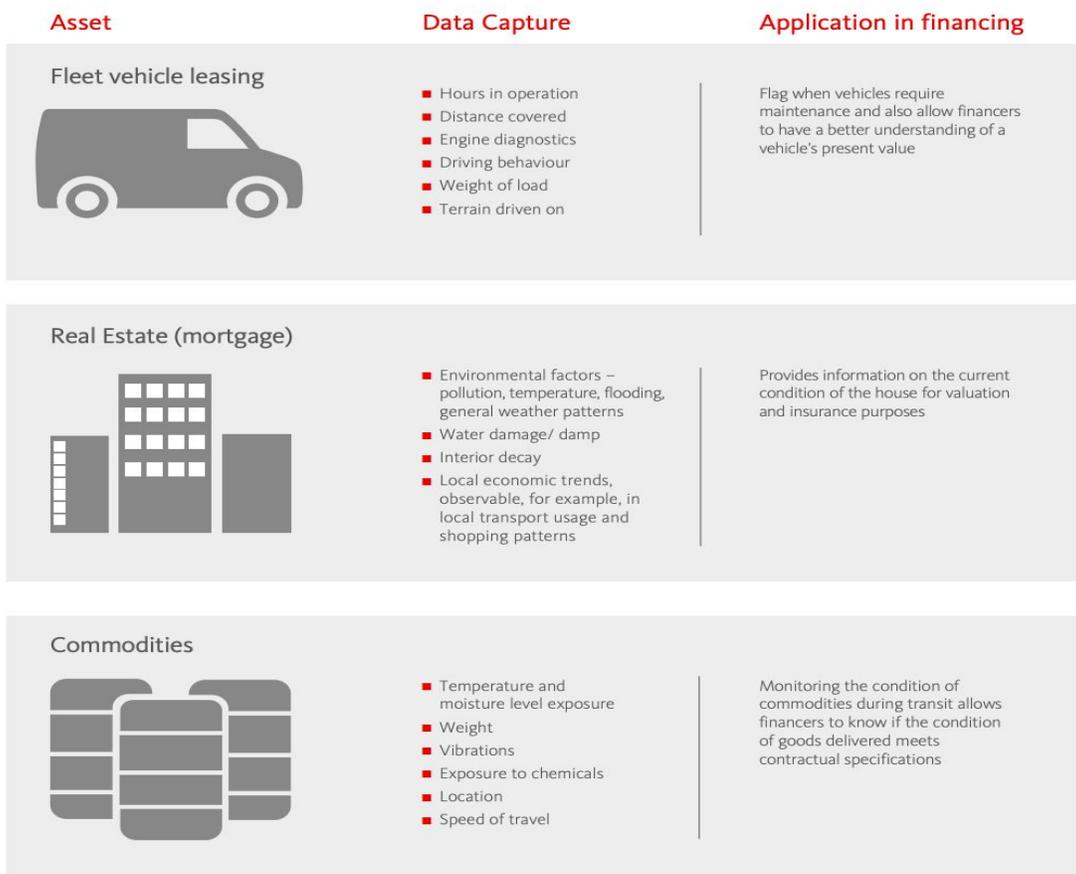
<sup>50</sup> Nyarko, Y., & Pellegrina, H. (2019, March). From bilateral trade to centralised markets A search model for commodity exchanges in Africa [Web log post]. Retrieved July 15, 2020, from <https://www.theigc.org/wp-content/uploads/2019/04/Nyarko-and-Pellegrina-2019-Working-paper.pdf>

<sup>51</sup> Increased data monitoring could help to rationalize supply chains and ensure that the right quantity and type of goods and services are in the right place at the right time.

Deep Shift Technology Tipping Points and Societal Impact [Web log post]. (2015, September). Retrieved July 15, 2020, from

[http://www3.weforum.org/docs/WEF\\_GAC15\\_Technological\\_Tipping\\_Points\\_report\\_2015.pdf](http://www3.weforum.org/docs/WEF_GAC15_Technological_Tipping_Points_report_2015.pdf)

<sup>52</sup>Information and data has become the new currency, one which big businesses and even governments increasingly attempt to control and harness in order to extract economic gain. *ibid*



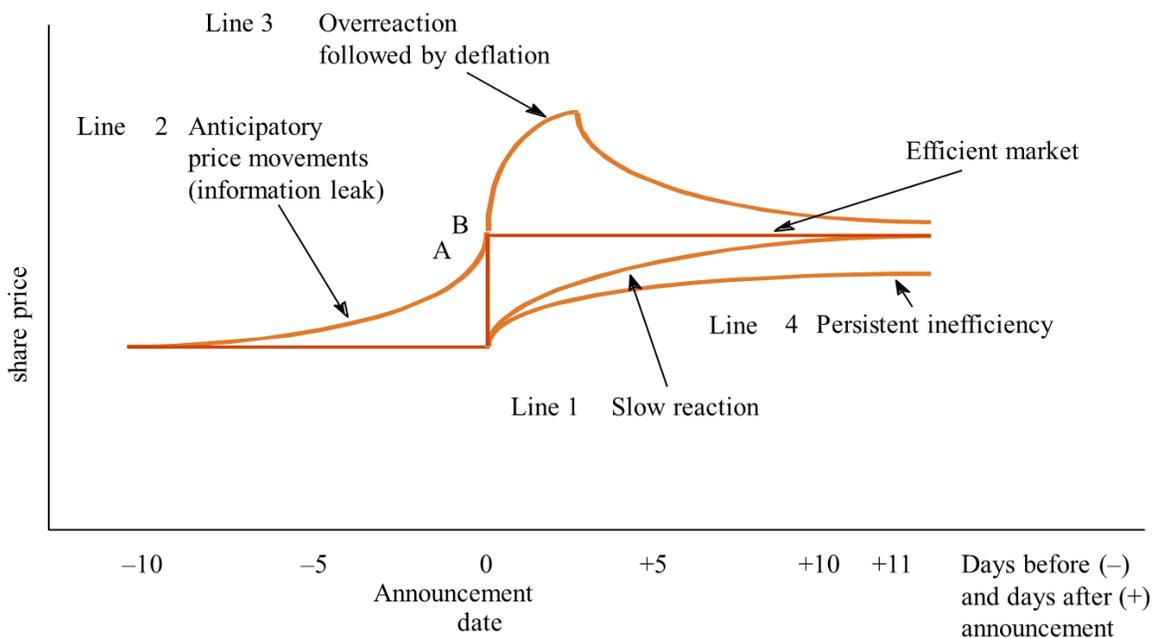
**(Figure 7: Illustration of the applications monitoring technology can have in accurate price formation for collateral financing)<sup>53</sup>**

Price formation metrics will grow past the need for a concentrated body to be trusted. Now value can be derived from information obtained by reliable technology integrated into the market<sup>54</sup>.

<sup>53</sup> Monitoring technology will have the capability to track specific data about assets to derive their most accurate valuation will all prevalent information at hand  
 Deep Shift Technology Tipping Points and Societal Impact [Web log post]. (2015, September). Retrieved July 15, 2020, from [http://www3.weforum.org/docs/WEF\\_GAC15\\_Technological\\_Tipping\\_Points\\_report\\_2015.pdf](http://www3.weforum.org/docs/WEF_GAC15_Technological_Tipping_Points_report_2015.pdf)

<sup>54</sup> Increasing the affordability and openness of these markets reduce barriers to entry and allow access to markets unimpeded by third party influence.

Integration of fundamental, real-time information into stock prices is the basis of the Efficient Market Hypothesis. Absolute awareness of all information in capital markets would eliminate the rift between the intrinsic value and market value of any asset, allowing them to adjust correspondingly to new information<sup>55</sup>.



**(Figure 8: Graphical representation of how an efficient market behaviour differs from typical speculation in capital markets)<sup>56</sup>**

In Figure 8, Line 1 details how a market with fully integrated information would change upon the announcement of new, valuable information regarding the asset. The vertical

<sup>55</sup>Degutis, A., & Novickytė, L. (2014). The Efficient Market Hypothesis: A Critical Review Of Literature And Methodology. *Ekonomika*, 93(2), 7-23. doi:10.15388/ekon.2014.2.3549

<sup>56</sup> Efficient Market Hypothesis. (n.d.). Retrieved July 14, 2020, from <http://seadnafinnegan.blogspot.com/2014/10/efficient-market-hypothesis.html>

increase in price as its value has changed renders it impossible for traders to earn a higher return than the market return due to speculative price movements<sup>57</sup>.

Therefore, symmetric information between parties - on account of the complete distribution of information- renders line 2 and 3 improbable in an efficient market. Only through the axiomatic analysis of markets, using all information available, will trades operate efficiently.

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<sup>57</sup>Brealey, R. A., Myers, S. C., & Allen, F. (2008). Brealey, Myers, and Allen on Valuation, Capital Structure, and Agency Issues\*. *Journal of Applied Corporate Finance*, 20(4), 49-57. doi:10.1111/j.1745-6622.2008.00203.x

### 3.2 Globalization and Greater Connectedness

Decentralisation, by means of tokenization and greater distribution of information, precipitates seamless cross-border transactions. Globalisation plays a fundamental role in the evolution of the networks of price formation: it expands markets, changing their compositions and increasing connectedness.



(Figure 9: Imports and Exports growth in Singapore)<sup>58</sup>

The liquidity offered by tokenization will globalise financial flows, offering a potentially broader pool of funds available<sup>59</sup>(Figure 9). This increasing interconnectedness of

<sup>58</sup> "STATISTICS SINGAPORE - Infographic - Singapore's International Trade." Accessed June 13, 2020. [https://www.singstat.gov.sg/modules/infographics/-/media/Files/visualising\\_data/infographics/trade\\_and\\_investment/singapore-international-trade](https://www.singstat.gov.sg/modules/infographics/-/media/Files/visualising_data/infographics/trade_and_investment/singapore-international-trade).

<sup>59</sup> This would benefit SMEs in particular who traditionally have more difficulty in finding funding (vis a vis larger ventures and MNCs) in the early days of their start-ups and will thus cause permutations in the composition of market players.

markets enables investors and capital seekers to have greater access to one another, without the inhibitions of geographical borders<sup>60</sup>.

The connectivity that digital platforms offer alters the economics of cross-border interactions, reducing barriers to entry for these considerably smaller entities<sup>61</sup>. As a result, markets today will reap the gains of both heightened capital and information flow.

Elevated levels of data flow will mitigate information asymmetry, facilitating not only the movement of capital, goods and services, but also help market participants in their assessment of potential transactions. The distribution of information tends to have an effect of equalizing the positions of market participants.

The proliferation of decentralisation will make information asymmetry a thing of the past. Knowledge is power; only when that power is given equally can markets truly work for everyone's benefit.

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<sup>60</sup> SMEs are said to be born global while individuals themselves become direct participants in global peer-to-peer transactions when decentralisation occurs.

<sup>61</sup> Markets expand due to the increased number of participants. Aside from the traditional big market players - multinational corporations - small and medium sized enterprises (SMEs) and individuals are also brought into the fold.

## **4.0 Rule-setting and Regulation for a Well-governed Decentralised Market**

In the age of technology, governments must differentiate the positive innovations with potentially adverse ones. They must accept that the inherent decentralised nature of these markets makes control and regulation over it fundamentally challenging.

Thus, governments would be ill-advised to impose rigid control over markets, similar to how centralised exchanges worked under federal management<sup>62</sup>. Instead, managing prominent decentralised markets becomes a matter of providing legislation support. Platforms that take into account public welfare in terms of security, accessibility and privacy, while restricting actions of ill-intent on parallel platforms, must be carefully identified and spearheaded.

Three key characteristics of decentralised markets must be examined and regulated through governmental intervention for all to succeed. They come in form of:

- 1. Potential for Cyberattacks (External Threats)**
- 2. Setting Standards (Internal Threats)**
- 3. Cooperation: Managing Cross-Border Jurisdiction**

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<sup>62</sup>Federal Securities Laws. (2017, May 04). Retrieved July 14, 2020, from <https://www.sec.gov/page/federal-securities-laws?auHash=B8gdTzu6DrpJNvsGIS1-JY1LnXDZQqS-JgJAgasXimg>

## 4.1 Potential for Cyberattacks (External Threats)

Ubiquitous mobile connectivity implies universal access. For most this provides productive benefit. Yet, those harbouring malicious intent can potentially exploit the same opportunity gifted by digitising the market.

Fortunately, sensitive blockchain markets are safe from the same cyber attacks that can cripple centralised exchanges due to its distributed nature<sup>63</sup>. The consensus protocol of blockchain maintains the unbiased nature of the market and secures the legitimacy of transactions on the blockchain<sup>64</sup>. While data stored on the blockchain is inherently resistant to unauthorised changes (Through its Proof of Stake mechanism(Figure 10)) and enables parties to have fully traceable control over their data, this poses privacy issues that require oversight.

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<sup>63</sup> To amend the transactions recorded on the blockchain supposedly for self gain it would require the creation of a separate chain of transaction records simultaneously with the legitimate one. Lest the acquisition of a 51% majority control of all nodes within the blockchain, the processing power required to maintain an altered transaction history that is to be recorded on all nodes in the blockchain would be an impossibility. Furthermore if a party manages to gain a majority control of the blockchain and unilaterally conduct illegal transactions all other nodes would instinctively sell off stake in the chain causing the value of its tokens to plummet and thus making the attempted value gain by the majority party counter-intuitive.

<sup>64</sup> As a decentralized platform, blockchain supports peer to peer communication. So, in a comprehensive network each node has a complete copy of all the historic information available and just through achieving consensus of the majority will more data be added to the chain of previous information. To establish a new transaction two parties will enter into a smart contract that will pre-set terms and conditions regarding payment, delivery and other assurances that will validate the transaction. Furthermore to be established on the blockchain a majority of the nodes will authenticate the trade and protect the block from any sort of fraud transaction. Remya Stephen and Aneena Alex 2018 IOP Conf. Ser.: Mater. Sci. Eng. **396** 012030



**(Figure 10: Illustration of Proof of Stake mechanism: A method to ensure fraudulent transactions cannot be conducted in the blockchain<sup>65</sup>)**

<sup>65</sup> Proof-of-stake is the amount of coins that are held. Intuitively, nodes which pour significant resources into the system are less likely to cheat. In order to successfully complete an attack on the blockchain, an attacker has to control more than 50 percent of the resources of the entire network (known as a 51% attack). With proof-of-stake, if an attacker tries to monopolize coins the network participants will detect it, and the value of the coins held will be significantly reduced. This works as a deterrence against attacks.

Bitstamp. (2018, October 26). FOLLOW THE LINE: Proof of Stake #crypto basics #blockchain pic.twitter.com/KTfCZwTtKv. Retrieved July 14, 2020, from <https://twitter.com/bitstamp/status/1055838298801926146>

In order to encourage secure transactions on the blockchain, government subsidy or tax exemption for preferable blockchain networks to operate on public networks are one method. The chains that utilise mechanisms<sup>66</sup> which retain appropriate security measures to deter attacks while ensuring that private user information remains confidential must be fostered.

Therefore, the technical nature of certain blockchains will encompass suitable security standards to be enforced. It will be the responsibility of the governing body to ascertain the appropriate platform to trust verified market transactions be conducted on.

Additionally, since decentralised networks inherently cross borders, trans-national privacy protection measures must be implemented in digital economies under all jurisdictions<sup>67</sup>.

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<sup>66</sup> A study by Dongqi Fu and Liri Fang (2016) examined the model for “Decentralised privacy” by the MIT Media Lab creating 4 protocols to solve the problem with data ownership. Protocol one implements a new mechanism where identity consists of single signing key pairs for the two parties involved as well as a symmetric key used to encrypt or decrypt the data, so that the data is protected from all other participants in the system. Protocol two verifies whether the originator has the appropriate permissions of operations. Protocol three and Protocol four are both about access and control to the data in question. Fu, D., & Fang, L. (2016). Blockchain-based trusted computing in social networks. *2016 2nd IEEE International Conference on Computer and Communications (ICCC)*. doi:10.1109/compcomm.2016.7924656

<sup>67</sup> The OECD Recommendation of the Council concerning Guidelines governing the Protection of Privacy and Transborder Flows of Personal Data (amended in 2013) recognises the value of globally interoperable privacy frameworks that ensure effective protection of privacy and support the free flow of personal information around the world. There exist a range of approaches to interoperability among privacy frameworks.

## 4.2 Setting Standards (Internal Threats)

In a revolutionary, interconnected world, information is fully accessible and integrated into all levels of industry; yet markets are susceptible to failures if automation is not given the appropriate standards to enforce. Therefore, it would be up to government regulation to ensure valuation occurs using quality information rather than from employing generic standards that are open to misinterpretation or abuse.

Typically, the employment of technological standards and solutions to share information are common at an industry level. Thus, government incentivisation for national industries to engage in global standardisation efforts in terms of practises and specifications would be key<sup>68</sup>.

In the fast-paced world of IoT generated data and information, it would be beneficial for regulators to invest in machine learning such as artificial intelligence to interpret data. Data gained from new innovations in technologies have valuable insight into trends and quality assurance allowing governing bodies to adjust regulatory policies accordingly.

While decentralised platforms are symbols of free exchange and opportunity, preserving the ethics of such platforms are critical. Therefore, by employing their own technologies

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<sup>68</sup> Legal regulations must be updated regularly as technology develops, new technologies have to receive proper management immediately and gaps in the regulations should be mitigated. Innovative methods proposed by a technology law professional to revise legislation regarding new advances, will curb any potential technologies from superseding the law through loopholes in its framework.

to scan and filter out potentially illegal activity on markets, decentralised platforms preserve the crucial anonymity of the blockchain and its distributed nature while insuring trust into the platform's reputation.

### **4.3 Cooperation: Managing Cross-Border Jurisdiction**

Governments looking to regulate decentralised markets will need to find the line between advocating internet openness, enabling access to the full spectrum of information available, and maintaining a degree of national security in the digital age. Security concerns arising from influence by foreign powers on the market are justified yet governments should seek to pursue trans-national cooperation between regulatory agencies rather than isolationism when dealing with external threats.

In today's data-intensive environment, cooperation and coordination between cross border regulatory authorities must work together. By enforcing certain standards of privacy protection they can safeguard confidential information to sustain the legitimacy of the platform.

Additionally, because market regulators will be limited by their jurisdiction, futures market regulators must be prepared to share such intelligence with their regulatory counterparts, both domestic and foreign.

Since globalisation of the market is such a key factor in decentralisation, information flow across the market, regardless of its geo-political affiliation, is important for any efficient market operating at a global scale. As such, healthy relations between nations invested into the market would be a cornerstone of effectively governing a decentralised market.

## **5.0 Conclusion: Path to Decentralisation**

By all accounts decentralised markets are in their infancy. No specific framework exists to guide markets down this bold new avenue and existing infrastructure is not wavering in maintaining the status quo of centralisation. Certainly, it is easier to accept the way we have always conducted business to be the only one. To find a better way takes effort.

Realistically, the path towards a fully decentralised market brings forth security concerns, privacy issues, high costs of implementation and requires a leap of faith by governments to invest in them. But for those marginalized by the intense concentration of power prevalent in markets today, decentralisation is an equalizer.

Transparency and liquidity pushes market power into the hands of those who trade on it. Blockchain technology will transform valuation mechanisms into a precise, efficient and fair evaluation of value in the market. It will expand their networks, improve international cooperation and promote the free exchange of information across borders.

Decentralisation is the answer to a fully efficient market and this digital age will see it come to fruition.

(2967 Words excluding reference, footnotes, tables, appendices and charts)

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