The Singular Economy: End of the Digital/Physical Divide

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Abstract

The divide between the "digital" economy and the traditional "physical" economy is outdated. In fact, we are in a transition to a singular economy. This paper classifies economic objects (including actors) as either physical or virtual and argues that due to emerging technologies, these objects are interacting with each other in both physical and increasingly digital spheres in tandem. This paper recognizes the elemental difference between atoms and bytes but argues that physical and digital economic activities are becoming inseparably intertwined. Furthermore, arbitrarily dividing the economy into two categories — one "physical" and the other "digital" — distorts the overall view of the actual execution of economic activity. A wide range of innovations emerging concurrently is fueling the transition to a singular economy. Often referred to as the elements of the Fourth Industrial Revolution (4IR), four emerging technological areas are reviewed here: distributed ledger technology, artificial intelligence/machine learning/data sciences, biometrics and remote sensor technologies, and access infrastructure (universal internet access/electricity/cloud computing). The financial services sector is presented as a case study for the potential impact of these 4IR technologies and the blurring physical/digital line. To reach the potential of these innovations and a truly singular economy, it requires the concurrent development of social, organizational, and regulatory innovations, though they lag in terms of technological progress thus far.

Keywords
digital economy, physical economy, singular economy, internet of things, blockchain, artificial intelligence, fourth industrial revolution

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1. INTRODUCTION

The digital economy is dead. More specifically, the clear divide between the "digital" economy and the traditional "physical" economy is outdated. Due to converging technologies and changes in society that are part of the Fourth Industrial Revolution (4IR) (Schwab, 2016), a fully "singular economy" is emerging. During the Second Industrial Revolution (electricity), one tracked electrified companies or industries; however, we no longer speak of a separate "electrified economy" from the rest of the economy. Electrical power is a ubiquitous input for the economy as a whole. This paper argues the same transition for digitalization has been going on for decades. The blending of digital and physical social interaction has already occurred to a significant degree (Crabtree and Rodden, 2008; Arthur, 2017). Conversations with a friend or colleague flow between the physical and digital worlds uninterrupted, both elements of a singular interpersonal relationship. The same is now coming true for the economy.

Shopping and money management have made significant inroads into the digital world during the adoption of the Internet, but additional areas of economic activity have been slower to emerge in robust digital forms, due to a variety of factors including the heightened sensitivity related to financial matters; the challenge of proxying physical objects into the digital world and understanding the fundamental distinction between physical and virtual objects; the greater need for trust, privacy, and finality in transactions; oligarchical established incumbents; and strict national-based regulation. New technologies and new generations are taking us over these hurdles with increasing speed, and as a result, the economy is converging into a unified mix.

It will not, however, just be the technologies that get us there, but the reaction, use, misuse, experimentation, and eventual adoption will craft the singular economy. It will also be the innovations in organizational structures, business models, regulation, and perspectives on trust that will make it a reality. This paper argues that none of the technologies discussed herein alone could achieve a singular economic landscape. It is their convergence, interdependence, combinatorial, and exponential nature which is building the bridge to the singular economy from many sides. If each is successful in achieving some of its stated potential, the resulting singular economic structure will define our global economic future.

This paper sets out important terms (Section 2) and provides an overview of some of the key converging technologies which herald this singular economy (Section 3). Section 4 presents a select literature review related to trust and technology diffusion. Section 5 identifies an intrinsic/alias distinction through which to view economic objects and proposes the transition from a bifurcated to a singular economy. Section 6 presents the case study of "fintech" – or financial technologies – as a critical gateway to the singular economy. Section 7 provides a discussion of key challenges and Section 8 concludes.

2. KEY TERMS

2.1. Digital Economy: Sector or Economic landscape

The concept of the "digital economy" does not have a universal or generally accepted definition. Within the range of definitions, there is a useful differentiation between the limited concept of the "digital sector" of the economy (largely Information Communication Technology (ICT) goods and services, online platforms) and the broader concept of digitalization throughout the modern economy (International Monetary Fund [IMF], 2018, p.1). This paper begins with the latter definition in mind and makes the argument that efforts to split up the digitalized sphere of economic activity from the physical (in terms of products, processes, services, and relationships) is increasingly problematic and attempts to do so distort the overview of the underlying blending reality. Economic statistical agencies are increasingly challenged to define where the boundaries are (see Section 5.2 for a more detailed discussion on measurement).

2.2. Virtual vs. Physical vs. Digital

Combined with the concept of a blended digital/physical economic system is the conceptual understanding of the system's elements. This paper makes the distinction between an inherently virtual object and a physical one. Inherently physical objects occupy particular space and/or time. One can ask, "Where are they? When?" and be given a specific answer. For example, "The ball is on the table now." Virtual objects for this paper include mental objects (ideas and concepts that exist within a mind) as well as any other object which is non-spatiotemporal to include abstract objects.[1] Such things would include the terms of a contractual agreement, the notes of Beethoven's Ninth Symphony, and your state's approval of your right to drive a car. One cannot ask the same "Where is it? When?" questions about such objects. One can ask about digital or physical occurrences of them —

[1] There exists a robust philosophical discussion around the definition of abstract objects (see the SEF primer (https://plato.stanford.edu/entries/abstract-objects/) on abstract objects for a good overview), whether they do or do not exist, and if so, how they are classified. This paper does not comment on this discussion and includes such objects, if they do exist, in the virtual categorization.

such as a particular performance of Beethoven's symphony — however, the answer does not apply to the symphony itself.

The use of the word "virtual" in this sense embodies the "non-physical" element of its common definition. Virtual can also be used to connote something within a computer system, though this paper excludes this element of the definition. To make the distinction between independent existence (physical or virtual) and existence within a computer system, this paper will refer to "digital" objects to mean the version of either a virtual or a physical object which has been translated into the 0s and 1s of a computer system. This paper will argue that the limited spatiotemporal constraints for digital objects mean that virtual objects may be able to be embodied more fully in their digital versions than physical objects. However, digital versions will still be proxies of the underlying inherent object.

2.3. The Fourth Industrial Revolution (4IR)

A 2018 Atlantic Council report summed up the current state of change:

> The convergence of our physical and digital worlds is disrupting everything, resulting in profound implications for governments, the private sector, societies, and individuals around the globe. Emerging technologies of the Fourth Industrial Revolution—artificial intelligence (AI) and machine learning (ML), biotechnology and gene editing, the Internet of Things (IoT) and big data—can no longer be thought of as distant possibilities but are instead a part of today's reality (Turekian et al., 2018, p.1).

The 4IR leverages the three previous industrial revolutions, namely the first (the steam engine/mechanization ~1760-1820), the second (electricity ~1870), and the third (digital/electronics ~1969). The World Economic Forum highlighted a key difference in that "when compared with previous industrial revolutions, the Fourth is evolving at an exponential rather than a linear pace" (Schwab, 2016, para.3). While the actual technologies referenced as part of the 4IR are not set in stone, they generally include those mentioned above as well as robotics, blockchain/distributed ledger technology, nanotechnology, and 3D printing. These technologies will be referred to throughout this paper collectively as the 4IR technologies.

3. KEY TECHNOLOGIES

There is a wide range of concurrently emerging technological innovations that are fueling the transition to a singular economy. It is essential to include a range of technologies, for as noted above, none of them will have the full transformative power to enable a singular economy on their own. It is their convergence, interdependence, combinatorial, and exponential nature that should be kept in mind. Four areas and their subcomponents are included in this review: distributed ledger technology, artificial intelligence/machine learning/data sciences, biometrics and remote sensor technologies, and access infrastructure (universal internet access/electricity/cloud computing). They have been chosen due to their potential impact on core economic and relational elements. However, this list is not exhaustive and could easily include other innovations, such as those mentioned in Section 2.3.

3.1. Distributed Ledger Technology

First came the blockchain, then came the broader concept of distributed ledger technology. Blockchain technology can be traced back to a 2008 white paper entitled "Bitcoin: A Peer-to-Peer Electronic Cash System," by one or many persons calling themselves Satoshi Nakamoto.[2] The white paper proposed "a peer-to-peer distributed timestamp server to generate computational proof of the chronological order of transactions" (Nakamoto, 2008, p. 1) with the goal to create a payment/currency system that used cryptography and a distributed network to allow "any two willing parties to transact directly with each other without the need for a trusted third party" (Nakamoto, 2008, p. 1). The system is built on existing technologies, such as private key cryptography and the Internet, while combining them in such a way to take into account human nature. For example, the protocol incentivizes the network participants (called nodes/miners) to maintain the integrity of the chain (of blocks of transaction data) through providing a reward (in new bitcoins) to a miner for each new validated block of transactions that is added to the chain and confirmed through consensus of the majority of the nodes. It also improves security not only through cryptography, but also due to the fact that every node reviews, validates, and maintains a full copy of the blockchain, which means there is no single point of failure or target to attack.[3] Furthermore, the constantly updated and shared chain allows for "digital scarcity," meaning creating something in the digital world that can be authenticated as an original and traded as such. Scarcity is critical for many sectors, e.g., financial services such as representing stocks, bonds, property, or other physical assets in a digital form.

Since the launch of the first blockchain (the system supporting bitcoin described above), the blockchain concept has been expanded to the broader idea of distributed ledger technology (DLT). In a simplified form, a DLT is a decentralized system where network participants can contribute information that is validated, time-stamped, and added sequentially and irrevocably to the shared ledger (or record of information) through some process of consensus by the participants. In contrast to the bitcoin blockchain, new distributed ledgers can be public or closed/permissioned (meaning only specific nodes will be allowed) and can modify any of the elements of the general structure, such as how validation of a new block is achieved. Experimentation with this new technology is gaining steam in a variety of sectors to include the financial services, supply chain management, and healthcare industries. Deloitte estimated that 27,000 new DLT projects had been initiated in 2016 alone (Trujillo, Fromhart, & Srinivas, 2017).

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[2] The actual identity of the founder(s) of bitcoin/the blockchain remains unknown.

[3] More detailed information on the technical workings of bitcoin and blockchain abound on the Internet. Some good overviews include: https://www.coindesk.com/information/what-is-bitcoin/ or https://bitcoin.org/en/faq

3.1.1 Smart Contracts

DLT is also making possible the concept of a "smart contract" which can be thought of as an autonomous electronic contract that operates on a blockchain or DLT. As explained in a Forbes.com article:

> The principal aim of the smart contract is a tamper-proof, unambiguous, computable contractual relationship whose payout (or other outcome) automatically occurs after some prespecified event and that once started cannot be stopped, even by injunction. The concept of an automated contract is not new... What is new and interesting with smart contracts is the attempt to generalize the concept for a wider class of contracts and to use a newer set of technologies, such as decentralized blockchains and oracles, to strictly enforce the contracts (Juetten, 2017, para. 3).

DLT and its subcomponents are included in this paper due to their potential to change ideas of trust between parties to a transaction, contractual processes, and the implementation of digital scarcity.

3.2. Artificial Intelligence/Machine Learning/Data Sciences

Artificial intelligence (AI) is hard to define, and the lines between it, machine learning, and data sciences are often blurred. In broad terms, AI generally refers to technologies that allow computers to simulate cognitive processes, such as elements of human thinking. Often considered a subset of AI, machine learning enables computers to act and learn without being explicitly programmed, to include finding patterns or relationships in massive amounts of data and using this information to improve their performance automatically (Chessen, 2016, p. 6-7).

The concept of artificial intelligence has been around since the 1950s (the term was coined by Dartmouth math professor, John McCarthy, in 1955). Despite this, Brynjolfsson and McAfee (2017) stress:

> Although it is already in use in thousands of companies around the world, most big opportunities have not yet been tapped. The effects of AI will be magnified in the coming decade, as manufacturing, retailing, transportation, finance, healthcare, law, advertising, insurance, entertainment, education, and virtually every other industry transform their core processes and business models to take advantage of machine learning (para.5).

AI and its related areas such as machine learning and data sciences are included in this paper due to their potential to make sense of the increasing volumes of data (e.g., self-driving car control systems), combinatorial power with other technologies (e.g., biometric sensors), and function as core elements enabling "interaction" technologies between the physical and digital worlds (e.g., natural language processing).

3.3. Biometrics and Remote Sensor Technology

Until science fiction comes to pass, physical objects will always be, in their pure form, outside the digital world. This begs the question: for a singular economy, how can physical objects operate in the digital world? Enter biometrics and remote sensor technology. Biometrics, often paired with AI, help approximate humans in a digital environment. For non-human physical objects, there is the Internet of Things (IoT) and the underlying remote sensing and communication technologies. While the target is different (human vs. non-human), both sets of technologies are essential for "proxying" physical objects into the digital world.

"The need to authenticate ourselves to machines is ever increasing in today's networked society and is necessary to close the gap between man and machine to secure our transactions and networks" (Jain, Bolle, & Pankanti, 2006, p. vii). At its core, the problem of resolving a person's identity has two elements: identification and authentication. Identification is the first step (answering who am I?) and the second is confirming a claimed identity (Am I who I say I am?) (Jain et al., 2006, p. 2). Biometric techniques attempt to achieve the first step by identifying a person's physical characteristics, either physiological traits (e.g., fingerprints or hand geometry) or behavioral characteristics (e.g., voice or signature) (Jain et al., 2006, p. 4). This information is then stored and referenced to determine the second step, authentication.

For other physical objects (though the separation is not entirely distinct), there is the emerging Internet of Things (IoT). Miorandi, Sicari, De Pellegrini, and Chlamtac (2012) describe:

> The term "Internet-of-Things" is used as an umbrella keyword for covering various aspects related to the extension of the Internet and the Web into the physical realm, by means of the widespread deployment of spatially distributed devices with embedded identification, sensing, and/or actuation capabilities. Internet-of-Things envisions a future in which digital and physical entities can be linked, by means of appropriate information and communication technologies, to enable a whole new class of applications and services" (abstract).

This will mean objects such as cars, refrigerators, and telephone poles can connect and interact with each other, humans, and broader systems. We will be able to summon a driverless car, and it will be able to take itself to the repair shop. A refrigerator will be able to order food - even comparison shop with coupons- and adjust when it runs to save energy. Telephone poles could report weather information or the status of their conditions to drop the cost of monitoring and improve service.

Biometric and sensor technologies are included in this paper as they are a foundational channel of interaction between the physical and digital spheres.

3.4. Access Infrastructure (Internet Access, Electricity, and Cloud Computing)

For the digital sphere of the singular economy to function, the participants in the economy — both human and otherwise, such as the IoT — must have access to the Internet, computing resources, and electricity to power their connection in whatever form it takes. This may sound basic in comparison to the futuristic technologies mentioned above. However, "recognizing the growing importance of access to the Internet as foundational to global socioeconomic development, the international community has begun to focus more attention on the issue through both new strategic initiatives and ambitious targets such as that of the UN Sustainable Development Goals (SDGs) to achieve universal access by 2020" (Schmida et al, 2017, p. 6).

The Internet is essentially the ground, computing resources the food, and electrical power the air/water of the digital world. It is important to keep these in mind because a failure to expand access to these elements will mean the exclusion of millions of economic participants from the singular economy, reducing benefits and increasing overall costs. These infrastructure elements are included in this paper to highlight that 4IR technologies largely rely on these for their existence or at least to reach their immersive potential.

4. RELEVANT LITERATURE

Understanding the economy as a singular economy, rather than a distinct digital economy and a physical economy, more accurately reflects the current status quo for many (though not all as noted in the universal access point above) and the future for all. To understand the obstacles and opportunities of this blending process, it is necessary to look to a range of disciplines including economics, sociology, and philosophy. The two literature reviews below are especially relevant for the holistic approach to analyzing the transition to a singular economy.

4.1. Trust

Economic activity requires multiple parties, be they buyers and sellers, intermediaries, producers, designers, and the like. To work together, the individuals (or machines) must have a structure to transact or work together in some way. For human economic activity, a fundamental component of this activity is trust or at least cooperation. They are different but related concepts, but both are relevant for the discussion here.

There is a rich body of interdisciplinary literature which looks at the complex concept of trust. Niklas Luhmann (1979/2017) proposed that "trust, in the broadest sense of confidence in one's expectations, is a basic fact of social life. In many situations, of course, a person can choose in certain respects whether or not to bestow trust. But a complete absence of trust would prevent him or her from even getting up in the morning" (p. 4). Generally speaking, trust comes into play in situations where the risk of a negative outcome is greater than the advantage to be gained yet with the expectation of a positive outcome. If the gain is greater than the loss and the expectation is positive, then no trust is needed as the decision to act is the result of rational evaluation. This is different from gambling which has a negative mathematical expectation — meaning a gain greater than the loss, but an expectation of a negative outcome.

For digital systems, who or what you trust in or agree to cooperate with is varied and is changing. "Cooperation can take place in the absence of trust. When individuals or groups reach a point at which their mutual self-interest in trade outweighs their mutual dislike, they can cooperate. But this point is better characterized as tolerance than trust" (Norton, 1996, p. 352). Research has shown that a sense of being a member of a group increases the likelihood of cooperating (McAdams, 1995). For some digital networks, the idea of social capital or reputation within a group promotes trust, termed interpersonal trust (Resnick, Zeckhauser, Swanson, and Lockwood, 2006). In others, the platform/intermediary has become a trusted brand (e.g., Amazon) and may provide guarantees, escrows, or insurance for the transaction (like credit card chargebacks), which is considered institutional trust (Patnasingam, Gefen, & Pavlou, 2005). With the introduction of DLT/blockchain and smart contracts, proponents argue that the technology would enable the digitalization of trust by replacing trusted intermediaries and central authorities with algorithmically-based trust among a decentralized, distributed network of peers (Jarvenpaa & Teigland, 2017, p. 5813) and individuals could rely on the system to validate, store, and enforce contractual clauses (Reijers, O'Brolcháin, and Haynes, 2016, p. 137) which is considered process-based trust.

4.2. Technology Diffusion

The 4IR technologies have the potential to enable new products, processes, and economic relationships, but whether they will reach this potential remains unclear. The rate and path of diffusion of these technologies will significantly influence the answer. Taken together, "Can they be considered general purpose technologies (GPT), such as the steam engine or the computer?" Commentators are making the argument that they should be (see, e.g., Brynjolfsson and McAfee, 2017 regarding AI). Whether GPT or not, they are increasingly infrastructure technologies and when/if they continue on their diffusion path, they may embody the elements of the basic GPT definition: "(1) is widely used, (2) is capable of ongoing technical improvement, and (3) enables innovation in application sectors (AS)" (Bresnahan, 2010, p. 764). However, there are key questions about the first point of a GPT (or at least infrastructure technologies), and that is that it is widely used. As addressed in Section 3, the access infrastructure (internet access, electricity, and cloud computing) is, to varying degrees, widely used. Therefore, the question is likely to surround the diffusion of the other technologies.

For these technologies, the national and global diffusion of use is much more instructive than focusing more traditionally on the production of the technologies, as was the case with diffusion of the Internet, computers, and mobile phones (Stoneman and Battisti, 2010). Small and large companies — incumbents and new entrants — are experimenting widely with 4IR technologies. Similarly, there are both supply and demand forces at work. For example, with biometrics, the demand for greater protection of personal data and the reduction of fraud is of paramount interest to both sides. Cryptocurrencies (such as bitcoin), which are enabled by DLT, could be seen as a supply-side innovation (being provided to the market), but others argue that there is a demand pull now, as opposed to previous iterations, in part due to individuals' loss of trust in the traditional banking sector after the 2007-8 financial crisis.

An interesting element of 4IR technologies is that they are not local in nature. They are being adopted by companies with global presences (e.g., JPMorgan, Alphabet/Google, Alibaba, and Boeing) and by smaller companies targeting a global audience. As a result, this paper argues that sector delineation is more relevant than national markets for 4IR technology diffusion. However, due to the heavily regulated nature of many critical sectors, such as financial services and healthcare, adopters of the innovations will have to incorporate local regulatory modifications.

Numerous theories exist about the diffusion path for new innovations, including epidemic or evolutionary models. Epidemic and later modified models (see, e.g., Mansfield, 1968, and Rose and Joskow, 1990) focus on contact between a current adopter who may influence or "infect" others. Evolutionary economics theories are varied, but focus more on a learning and progression model that shares characteristics with biological evolution, such as response to the external environment, learning, random variation, and the adaptation/grow/winnowing or the death of ideas (see, e.g., Dosi, 1991 and Nelson, 1995). How technologies diffuse is likely to combine economic as well as political aspects and interests. For example, the creation and ongoing discussion of the DLT, especially in its most public form as the bitcoin blockchain, is largely influenced by libertarian and anti-central government ideas. Some have argued that "being a transformative technology, the blockchain's political implications are significant because the applications that the technology affords can reconfigure economic, legal, institutional, monetary and ultimately broader socio-political relationships" (Reijers, O'Brolcháin, and Haynes, 2016, p. 147).

Furthermore, "the diffusion of innovation will frequently be subject to network and lock-in effects. In network situations, the ability of one adopter to benefit from a new product depends on what others have adopted" (Greenhalgh, 2010, p. 184). 4IR technologies are strongly influenced by network effects. They rely almost entirely on the basis of the existence of the Internet, collective digital platforms, and communications and electricity infrastructure without which they cannot function. They also, as aforementioned, strongly rely on each other for success and/or the means of diffusion/adoption.

5. THE SINGULAR ECONOMY

The term "singular economy" as used in this paper is intended to refer to an economic system as a whole which contains both physical and digital spheres and the division of the spheres into separate categories distorts the overall view of the actual execution of economic activity. It is important to note that this paper argues for the existence of both spheres — physical and digital — and does not foresee a migration to a wholly digital economy overall or in any particular sector or industry. It argues that an integrated hybrid model will be the resulting state after our current period of transition. Furthermore, it argues that all objects (physical and virtual) will be able to engage in either the physical or the digital worlds via their intrinsic forms or a proxy alias. While the Internet of Things and cyberphysical convergence/second economy theories about "real-world components interacting with cyberspace via sensing, computing and communication elements" (Conti et al., 2012, abstract) is a part, it is more than that. It is the true intertwining of the two economic spheres in a way that has heretofore not been possible, with important implications for the representation of and interaction with virtual objects in particular.

5.1. Intrinsic/Alias Distinction

Looking toward the singular economy, it is useful to identify an "intrinsic/alias" distinction to clarify that any actor, good, service, process, or element (collectively referred to herein as "objects") of economic activity has an "intrinsic" nature and a "proxy" alias. This is useful for this discussion, as the concept of the physical or digital economy confuses the sphere in which the object interacts with its inherent nature. Previously this was not a problem, because there was essentially only the physical world in which to interact.[4] To allow their existence to extend into their non-native sphere, the objects must gain an alias or proxy. For millennia, we have figured out how to proxy virtual objects into the physical world, such as musical instruments to play a composition, written contracts to formalize an agreement, or pressing metal to serve as money. However, due to 4IR technologies, objects can increasingly gain a robust proxy into the digital sphere as well. Examples include your digital persona within your bank's applications or the digital proxy of your car's location in your navigation app.

Intrinsic Nature

Whether something is "intrinsically physical" or "intrinsically virtual" depends on the specific characteristics of the object and includes how it comes into/goes out of existence. As discussed in Section 2, inherently physical objects occupy particular space and/or time. Virtual objects, for this paper, include mental objects (ideas and concepts that exist within a mind) as well as any other object which is non-spatiotemporal - to include abstract objects. An additional important consideration is how such objects come into and go out of existence. For example, a person, a car, or a house is intrinsically physical. These objects have to follow the laws of physics and can only fully go out of existence by destroying their actual physical forms.

Compare that to the right of ownership of the house or car. Possessing a car or house is an intrinsically physical state, but what about owning it? The right of ownership is a social concept and is intrinsically virtual. It is, at its core, an agreement between you and the seller, often with an entity like a government representing broader society which approves and tracks the agreement. In this case, to "destroy" your right, the participants in the agreement can decide it no longer exists, such as nationalization of private property by governments. This is an especially important criterion for many economic virtual objects based on agreement, due to the contractual/transaction-based nature of a significant portion of economic activity. Furthermore, depending on your philosophical position, abstract objects (a subset of virtual for this discussion) such as Beethoven's Ninth Symphony or the design of a microchip, can never be destroyed.

[4] It is recognized that some economies and societies operate/d to an extent in a social/mental environment, with little physical codification of economic transactions (i.e., without written contracts, deeds, or even a handshake). A full discussion of this variant is outside the bounds of this paper.

Proxy Alias

As the singular economy reaches its full potential, it will not — nor can it by definition — change the intrinsic nature of economic objects. Those are what they are. What is changing are the digital proxy aliases, potentially for all objects. This will have a fundamental impact on how economic activity occurs.

In the example above, a person can be proxied into the virtual digital realm through a number of means, such as biometrics, a password, or other virtual digital representation. The person can then interact in that world, though has more limitations on overall transformations in that world than a digital proxy of an intrinsically virtual object. For example, a person cannot be copied, sent instantaneously across the world, or shared with many people all at once in their full form. Cars are increasingly being digitally proxied by remote sensor technology and are expected to achieve similar levels of engagement in the digital world as the sensors, underlying software, and the communication networks improve. On the flip side, societies have traditionally relied on physical proxies for numerous intrinsically virtual economic objects. They have created them out of necessity and convenience to manage concepts in the historically physical dominant economy. From the example above, the ownership right has been physically proxied by way of a paper title deed with ink signatures of the buyer and seller and raised imprint stamps from the government.

However, in some cases, societies and individuals have misevaluated an object's intrinsic nature. A current debate is money. Many might believe that money equals cash (physical bills and coins or metals like gold) and therefore money is intrinsically physical. However, this paper argues that money is intrinsically virtual (especially due to the final criteria that if a controlling participant – for example, a government – decides their currency no longer exists as a representation of their government, it doesn't and/or society refuses to accept it for money-based functions, it does not exist as money). Cash is money's physical alias.

Why is this important? This distinction would suggest that as a universal digital world is emerging and as the economy becomes fully blended, you will see objects that are intrinsically virtual possibly losing their traditional physical aliases to a certain degree - think books, music, and money, but also contracts, stocks, bonds, and other social, governmental (e.g., patents), interpersonal (e.g., employee contracts), or intercorporate agreements. This is a key distinction between the definition of physical and virtual objects for this paper and concepts like "tangible" or "intangible" assets — where objects like cash, stocks, and bonds are considered tangible — a legacy from their physical proxies. Of importance to note is that virtual objects share the (largely) non-spatiotemporal state of a digital world hinting that their digital proxies may be able to be closer to their intrinsic forms. In addition, the 4IR technologies create the potential for intrinsically physical objects to gain much more robust proxies into the digital world via such innovations as biometrics, natural speech processing, virtual and augmented reality, geotagging of physical assets, and smart home devices. The result is a simultaneous "existence" and ability to engage in both spheres concurrently.

5.2. The Transition from Digital/Physical to Singular

Expanding on the introduction of a "digital economy" in Section 2, the term is commonly traced to the 1996 book, The Digital Economy: Promise and Peril in the Age of Networked Intelligence, by Don Tapscott. The Oxford Dictionary defines a digital economy as "an economy which functions primarily by means of digital technology, especially electronic transactions made using the Internet." It is also referred to as the Internet economy or the Web economy. When the term was coined, the implementation of digital technologies largely focused on "digital transactions, which automate and substitute physical resources for digital. Digital substitution creates virtual copies of the real world, creating e-channels, e-stores and other e-surrogates for physical processes" (McDonald and Rowsell-Jones, 2012, p. 10). This allowed for some sense of differentiation but maintained the traditional economic landscape. However, integration of innovative technologies has expanded beyond automation and substitution. Physical and digital systems now augment and accompany each other in a dynamic way (McDonald and Rowsell-Jones, 2012). A straightforward example of this is "the navigation apps we use every day, which overlay digital maps with information about the physical world to create an augmented view far richer and more useful than either the physical or digital view alone." (Edwards, 2017, para.3).

Commentators are increasingly remarking on this definitional challenge. In its February 2018 Measuring the Digital Economy report, the International Monetary Fund (IMF) commented that "the lack of a generally agreed definition of the "digital economy" or "digital sector" and the lack of industry and product classification for Internet platforms and associated services are hurdles to measuring the digital economy" (p. 1).

Expanding on the idea of the digital economy, W. Brian Arthur (2011) proposed the idea of a "second economy" where:

> processes in the physical economy are being entered into the digital economy, where they are "speaking to" other processes in the digital economy, in a constant conversation among multiple servers and multiple semi-intelligent nodes that are updating things, querying things, checking things off, readjusting things, and eventually connecting back with processes and humans in the physical economy. So we can say that another economy—a second economy—of all of these digitized business processes conversing, executing, and triggering further actions is silently forming alongside the physical economy" (p. 3).

While this approach begins to include the idea of object communication and the proxies between the physical and digital worlds, it still presents the economies as distinct. It also assumes that the digital economy is largely autonomous, which need not be taken as a given.

While it might have made sense in the early days of internet/computing adoption to recognize digitization as a new and separate phenomenon, this distinction is no longer clearly determinable. Numerous commentators are recognizing this shift. For example:

> It's getting harder and harder to separate the digital economy from the rest of our economy

> which can only be a positive, because it means technology is being embraced everywhere from healthcare to education, from agriculture to the delivery of government services (Deloitte, 2015).
> We've gotten used to emphasizing the divide between digital and physical, but it's quickly disappearing: when digital data about the physical world is comprehensive, real-time and freely available, the physical and digital augment each other (Edwards, 2017, para.3).

The "separation" challenge is clearly visible in attempts to measure a distinct physical and digital economy now and in the future. The Organization for Economic Cooperation and Development (OECD) (2014, 206, 2017), the U.S. Bureau of Economic Analysis (BEA) (Strassner, 2016 and Barefoot et al., 2018), and other commentators (e.g., Bukht and Heeks, 2017; Ahmad and Schreyer, 2016) present serious issues about continuing to accurately measure a distinct digital economy and the blurring of boundaries with the traditional physical economy. In 2014, the OECD already recognized that "as ICTs and the Internet become basic infrastructure for business and society, it will be increasingly difficult to measure the digital economy as distinct from the overall economy" (OECD, 2014, p. 19). Two years later, the OECD commented that digitalization and disintermediation "raise more profound questions about the scope of the accounting framework. Models like UberPop and Cashierless tills are dependent on greater participation (labour input) on the part of the consumer, but the consumer's activity remains outside of the GDP production boundary" (OECD, 2016, p. 33).

By 2017, the OECD expanded its measurement schema from the "digital" economy to the "digitalized" economy. Though still trying to maintain separate digital and physical economies, the OECD commented on the "the need to see the digital economy within the core accounts (the absence of which has to some extent fueled the mismeasurement hypothesis)" (p. 2). The report continues by discussing the 'non-trivial' task of trying to define digital and non-digital goods (p. 8) and the blurring of the lines between digital goods and services (p. 3).

> U.S. BEA grapples with the increasing difficulty of maintaining a digital/physical split throughout its 2018 working paper (Barefoot et al., 2018). Citing challenges such as:
> -"BEA did not include structures and IoT infrastructure in the initial estimates because of the difficulty in determining the proper allocation of these categories into digital and nondigital components…" (p. 9).
> -"it is unclear what value from P2P or "platform-enabled" transactions BEA should attribute to the digital economy..."(p. 9).
> -"The rapid advancement of digital technology poses other challenges as well. The digital economy is evolving faster than ...classification standards, methodologies, and source data... This challenge may compound as technology continues to advance…" (p. 17).

What seems clear is that innovation is outstripping the terms and measurement approaches related to a separate "digital economy." In the end, what we recognized as the rise of a separate economic model — the digital economy — is actually a transition phase to a blended reality.

5.3. Industry Examples

It is important to note that this paper does not argue nor believe there is evidence to support the migration to wholly digital industries or an economy. The data to date suggests that industries will have varying levels of integrated hybridization and are likely to retain some elements of both spheres. Each industry is incorporating or experimenting with 4IR technologies in different ways, and even though different industries may have similar hybrid aspects, we continue to classify them, this paper would argue increasingly arbitrarily, into different economies (physical vs. digital).

For example, compare purchasing a physical good from Amazon and purchasing a home/real estate in the U.S. today. Most commentators and statistical agencies would consider Amazon purchases part of the 1990's concept of the "digital economy" as they are "digitally transacted." A consumer reviews information, pictures, and then purchases the item with a non- cash transaction online/via mobile technology. The consumer may or may not have seen the item in person in a store, in another's home, or in another environment. The enormous physical infrastructure behind Amazon and its third-party sellers has been considered "complementary infrastructure" to the main digital function of marketing and transaction (Reeves, Ueda, and Chittaro, 2017). Of Amazon's $173.7 billion 2017 operating costs, however, only $32.6 billion is related to technology, content, and marketing (Amazon, 2018), making the "complementary" (largely inherently physical) infrastructure roughly 81% of overall costs.

What about home buying in the U.S.? In a 2017 report, the National Association of Realtors found that 95% of buyers used online websites for information, 72% used mobile or tablet websites, and 36% viewed online videos of properties. Only 50% went to actual open houses before purchasing. Interestingly, 99% of Millennials (born 1980-1998) searched on online websites compared to 89% of Older Boomers (born 1946-1954) and 77% of the Silent Generation (born 1925-1945) (p. 7). While there is a difference between generations, the usage of a digital selection channel is still a significant majority for all buyers. For real estate agencies (commercial and residential), 82% use electronic forms and 78% use electronic signatures (p.18). Email is the preferred form of communication between agents and clients at 94% (p. 16). In terms of the transaction, funds for the purchase are wired electronically in almost all cases, and algorithms determine buyers' credit score/loan eligibility. As a result, U.S. home buyers are increasingly selecting, transacting, and paying for real estate in the digital sphere. However, real estate is not considered part of the digital economy definition. Why? Because the item purchased is larger? More expensive? There are more people involved in the process? What happens when the book from Amazon is purchased in one of their new physical stores?

The above example demonstrates increased digitalization in the transaction process. Similar hybridization trends are appearing in products/production, for example in manufacturing, PwC research found that:

> a significant portion of new sales growth for industrial equipment manufacturers in the immediate future will come from connected equipment with sensors, actuators, and analyti-

> cal insights that can exchange critical data with other machines and computer networks in real time via the cloud… 72% of manufacturing companies surveyed by PwC said they are dramatically increasing their level of digitization and expect to be able to be ranked as digitally advanced by 2020, compared with just 33% today. These companies are committing US$907 billion per year — about five percent of revenues — toward greater connectivity and smarter factories (Mueller et al., n.d., para. 3).

These examples, from manufacturing, retail, and real estate, three of the largest industries of the U.S. and global economies are being replicated in various forms throughout the modern economic landscape. A fourth industry, financial services, will be explored in more detail in Section 6.

6. FINTECH: A CASE STUDY

Technical capability or innovation itself does not a revolution make. It is the design, implementation, and adoption of the 4IR technologies that will determine if we achieve a fully singular economy. To analyze how the theories on trust and diffusion/adoption mentioned from Section 3, in combination with proposed intrinsic/alias distinction relate to the 4IR technologies, this paper will look at the financial sector as a case study.

Finance can be thought of as "a 'derivative' of social and political needs, engineered by economic theories and computational and data driven technologies" (Tapiero, 2013, p. 1). "It is a conjuration of economic, legal, and increasingly information-based technologies, but put simply, a means to meet certain ends" (Chiu, 2016, p. 58). In line with the intrinsic/alias distinction presented in Section 5.1, it is important to differentiate between goods — financial or otherwise (like a house) — and a financial service — mortgage on a house or the title. Financial services are largely the process to acquire or transfer a financial good, not the good itself (Asmundson/IMF, n.d., para. 2). Therefore, the largely intrinsically virtual nature of the financial services sector makes it a prime area for adoption of the 4IR technologies and potential disruption to its market structure, products, and processes. A particular challenge to keep in mind with this sector is its overall importance to governments, which results in significant formal oversight and attempts to license, regulate, and supervise it (Asmundson/IMF, n.d.).

6.1. Role of the Financial Sector and Potential for Adoption/Disruption

The IMF states that "the financial sector covers five broad functions: (i) make and receive payments, including across borders; (ii) save to be able to consume or invest later; (iii) borrow to be able to consume or invest now; (iv) manage risks to income, savings, and transactions; and (v) receive advice on all the above" (He et al., 2017, p. 11). As noted above, most of these services at their core are intrinsically virtual, namely involve an agreement, right, or concept, and while they may transact in physical goods, the financial sector does not design, produce, store, or otherwise create/distribute the intrinsically physical underlying objects. It is the layer above which funds them, as-signs and transfers ownership rights, hedges risks, and other such intrinsically virtual activities. Some elements of financial transaction processes have already migrated to a digital form, though the digitization to date has often been to mimic the traditional physical alias forms of money, seals, written signatures, bills, certificates, and the use of double- entry bookkeeping (Bauerle, n.d.). As a result, financial processes and products are ripe to be reimagined, if traditional physical alias thinking and approaches can be overcome.

The economic actors in financial transactions, however, are most often intrinsically physical individuals, whether private or within organizations. People, as noted in Section 4.1, need trust or at least a willingness to cooperate to transact. This has to be true in the singular economy as well.

6.2. As Tech Merges with Fin

The inroads of technology into the financial services sector are broadly referred to as "fintech." "FinTech covers digital innovations and technology-enabled business model innovations in the financial sector. Such innovations can disrupt existing industry structures and blur industry boundaries, facilitate strategic disintermediation, revolutionize how existing firms create and deliver products and services, provide new gateways for entrepreneurship, democratize access to financial services, but also create significant privacy, regulatory and law enforcement challenges" (Philippon, 2016, p. 2).

Discussions about the impact of technology on the financial services sector abound. An initial conversation centers on the potential for fintech to "dis-intermediate" the sector. "At its heart, the financial sector intermediates. It channels money from savers to borrowers, and it matches people who want to lower risk with those willing to take on that risk" (Asmundson/IMF, n.d., para. 4). It is also a market that depends on trust between participants.

According to Nissan (as cited in Chiu, 2016, p. 83), "Disintermediation often refers to innovations that allow the bypassing of existing middlemen so that the entities at the end of the supply and demand chain (i.e., savers/investors and borrowers/fundraisers) could meet directly." French and Leyshon (2004) describe financial intermediaries as being either a) "Type 1 intermediation serves to reduce information and/or transaction cost"(p. 267); b) "Type 2 intermediaries create liquidity in the financial services market through the transformation of the maturity and risk profiles of savers and borrowers" (p. 268); and c) Type 3 intermediation provides "a more efficient application of the traditional solutions to the traditional problems of retail monetary networks" (p. 283).

Enter 4IR technologies. For example, DLT, by providing a forum for the supply and demand sides of capital to meet and transact directly (individuals or organizations) and have their agreements be executed and confirmed securely on the platform, will introduce transactions which remove the current settlement, clearing, and centralized custodial system participants (Chiu, 2016, p. 86).

Removing an intermediary is not just replacing their function. Trust in the intermediary is often a reason for their existence, due to asymmetries in information about the product, process, or counterparty. For financial technologies to intermediate – either between consumers, peer-to-peer, or on the "back-end" in the business-to-business market, such as between banks – the systems will need to be deemed "trustworthy." Some commentators refer to the bitcoin blockchain as a "trustless" system. What is intended is that participants do not have to trust another human. Proponents argue that that interpersonal trust has been replaced with process trust in the blockchain protocol. It is this change in the trust paradigm combined with the functional substitutive capabilities of the technology which show potential for disintermediating many organizations in the financial services sector. This shift in terms of the intrinsic/alias distinction would be to shift the virtual object "trust" from personal or its physical alias often as a stamp/contract/deed and the like to a digital form in terms of the system or software structure.

However, in true disintermediation, risk and effort are shifted to the investor/consumer. For some market participants, this may be viable, but for many it is not. For example, to transact directly with an insurance company and cut out the broker, they will use new Type 1 informational intermediaries (e.g., online search sites). All of the information may be out there to make an independent decision, however, the time, effort, and cost to review this as an individual is either uneconomical or unappealing. Therefore, for some transaction elements, fintech is likely to lead (and already has in some areas) to re-intermediation (French and Leyshon, 2004). A further example is the exchanges surrounding bitcoin and other such currencies. While the "purpose" of the bitcoin system was to create a peer-to-peer payment system, many bitcoin holders have their holdings in an intermediary exchange, such as Coinbase or Bitstamp.

Given the importance to national governments and the overall size of the financial services sector[5], fintech is a high-profile sector. The sector is actively being attacked by both startups and incumbents looking to leverage 4IR technologies. However, for the supply-side, the environment appears to be following an evolutionary adoption path. Banking institutions are investing heavily in AI, testing a wide variety of applications and use cases to see what works.Tech firms, such as Apple with its iPhone X, have pushed biometric systems out to a huge installed base and these protocols are being incorporated into financial services applications, an example of the network /lock-in effect of the large existing population of iPhone users. Recognizing the importance of network effects for DLT adoption especially, financial services incumbents have developed R&D consortia such as hyperledger (https://www.hyperledger.org/) and R3 (https://www.r3.com/) to define use cases and try to identify future benefits collectively.

The adoption by end consumers may be more akin to the epidemic diffusion model mentioned in Section 4.2, as individuals hear about others who are investing in cryptocurrencies, or using new authentication protocols. In addition, the "infrastructure" element of these technologies likely means consumers are using them or are working with companies using them already, perhaps with-

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5 Precise estimates for the financial services sector are unavailable, but many estimates range from $11 – 15 trillion

out explicit awareness. For example, the current narrow AI uses in banking include chatbots in customer service, antifraud and risk processes, and credit underwriting (Joyce, 2018). These front- and back-end technologies are driving adoption of digital banking services, which is already strong in many developed countries. Physical cash is now used for less than a third (27.4%) of transactions in the U.S. (Greene and Stavins, 2018, p. 12), a percentage that is actually much higher than in many other countries. In addition, 62% percent of Americans in 2017 used a mobile banking app, up from 48% in 2015 with a generational breakdown of 75% of millennials, 66% of Gen Xers, 47% of baby boomers, and 40% of seniors." (Bank of America, 2017, para.7).

Large organizations, investors, and startups alike seem to have a "fear of missing out" (FOMO) mentality, with many comparing the 4IR technologies with the Internet revolution in the 1990s.[6] The actualization of this fear will depend on the overall adoption of the technologies in conjunction with each other, as well as the possibility of individuals truly migrating from trusting the traditional transaction systems (banking branches, intermediaries, documents, and other forms of intrinsically physical "assurance") to a fully digital environment. In turn, this would create a more fully hybrid digital/physical sector. If this threshold is passed in the financial services sector, then the economy is on the path to a truly singular future.

7. CHALLENGES

Many of the 4IR technologies are just making their way into the early stages of experimentation. Use cases are still being defined, and many have not yet produced additional value, increased productivity, or replaced existing technologies. For this, the accompanying organizational structures and business models also need to innovate (Brynjolfsson and McAfee, 2017) as does regulation. As a result, benefits and productivity gains are likely to lag the technology breakthroughs (OECD, 2016, p. 8). Organizations (public and private) in this hybrid economy need to recognize that their strategies and workforces must simultaneously work in both spheres in an integrated fashion. This will include new concepts of employment and the role of humans vs. non–humans in the workplace, an area for which there is already a robust debate. Furthermore, we as individuals, our communities and our societies are also innovating to adopt and adapt to unlock the potential of this future economic structure.

For regulation, there will be many new challenges. How do you regulate something that is autonomous? What if there is no individual or corporation "in charge"? In the case of the financial services sector, supervisory agencies regulate intrinsically virtual products and services. As those objects lose their physical aliases for more closely formed digital ones, the regulators will have to shift as well and will need increased technical skills to supervise the digital realm directly. This

[6] This is a popular refrain at technology conferences and in business and technology media, for a sampling, see e.g., https://hbr.org/2017/02/a-brief-history-of-blockchain, http://www.pepperlaw.com/publications/blockchain-technology-preparing-for-disruption-like-its-the-1990s-2016-03-14/, and https://www.fastcompany.com/3044375/the-future-of-the-internet-of-things-is- like-the-internet-of-the-1990s

may include regulators having their own digital aliases and seeing "dashboards" of compliance information on systems and markets in real time. Laws and legislation related to intrinsically virtual products and services may be able to be coded directly into their digital proxies. This could be in the software itself, such as in a "compliant" smart contract — a smart contract that includes what is now the "boilerplate" compliance clauses from the physical alias documents of a transaction. This compliance code could be required for systems to be licensed or otherwise approved by regulators, standards bodies, or supervisory organizations. Similarly, legislators and agencies that are responsible for the promulgation of implementing rules for new legislation will have to understand how the principles or goals can be incorporated into a blended physical/digital environment.

Furthermore, definitions, academic models, and statistical analysis related to the economy are increasingly challenged by the emerging singular economy. Statistical agencies not only need to search for new approaches to track what is happening now, but they need to be suitably flexible to adapt as the 4IR technologies really hit their stride. The U.S. BEA has suggested one approach that "in the future, it may be possible for BEA to develop a new input category for digital inputs to production under the current KLEMS (K-capital, L-labor, E-energy, M-materials, and S-purchased services) production framework" (Barefoot et al., 2018, p. 18). Other such approaches that recognize the embedded nature of digital elements throughout the economy would likely compliment the current transition to a singular economy.

8. CONCLUSION

Recognizing the singular economy will change the way we perceive the economy. Separate terms, indicators, strategies, policies, and measurement frameworks were useful in the transition from a traditional physical to a singular economy (via the digital economy), but policymakers, economists, researchers, and economic actors now need to address the economy as a single system to fully understand the emerging reality. Addressing separate digital and physical economies or disaggregating indicators between these economic spheres is increasingly arbitrary and misleading.

Different geographic regions and socioeconomic strata are at different levels of the transition, but the end state will be a singular economy, with the objects in their intrinsic forms and the ever-increasing "proxy" alias options for the interaction in the physical as well as the digital worlds. The physical/digital divide is no longer a restriction. In the future, the human and machine divide may also become less relevant, perhaps prompting a "third-dimension" to the singular economy. The innovations embodied in the 4IR technologies are a key element, but the transition is not entirely dependent on them. They are critical to make certain interactions and transactions possible, but they are likely to be eclipsed themselves by other more advanced technologies in the future; quantum computing, for example, is expected and will likely solidify or accelerate this trend.

Beyond the technology are the social, organizational, and regulatory innovations which accompany these technologies, to include the transfer of trust to new entities and processes, new forms of interpersonal agreements and employment, and disintermediated economic relationships. If these new technologies can get us to this level of economic engagement in the digital world, then many things are possible. We have been wading into a hybrid economic engagement over the past 30 years with e-commerce as the first wave and the sharing economy as the second. Will we go all in? Signs point to yes.

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