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An introduction to the field of abundant economic thought

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ABSTRACT

The problems facing the 21st century world, and the new technologies that have emerged to meet them, are harbingers of a new industrial revolution—Industry 4.0 (I4.0). The resulting information-based economy is challenging traditional economic thought, as evidenced by the appearance of “Abundance” as an economic philosophy. Abundant economic thought is relatively undeveloped.

Here, authors help define the field of Abundance based on the possibilities of the new information-based economy and the technological harbingers of I 4.0. Ten basic tenants of Technological Innovation Management (TIM) are presented as a basis for abundant economic thought. It is further shown that the Abundance perspective can elevate the Bottom Billion and nurture a sustainable and vibrant and growing middle class. Finally, we show one industry group that is operationalizing abundant economics.

1. Introduction

Abundance refers to the hypothesis that technological innovations that are fundamental to the Industry 4.0 are transforming society by generating information as a basis for economic turnover. This information-based economy is helping not only people at the Bottom of the Pyramid, or the Bottom Billion, but is also helping to establish a vibrant, sustainable and growing worldwide middle class (Pralhalad, 2012; Mahto et al., 2017). Geissinger et al. (2018) states that this “sharing economy can be regarded as a discontinuous innovation that creates increased abundance throughout society.” They define the abundant sharing economy as “ICT-enabled platforms for exchanges of goods and services drawing on non-market logics” and provide evidence from 165 sharing economy actors.

The perspective presented by Geissinger et al. (2018) differs little from the economic dimension of Abundance as put forth by Diamandis and Kotler (Diamandis and Kotler, 2012). Further it is of the same genre as the work initially brought forth by Rawls in “A Theory of Justice” (Rawls, 1973). Rawls states that all social primary goods—liberty and opportunity, income and wealth, and the bases of self-respect—are to be distributed equally unless an unequal distribution of any or all of these goods is to the advantage of the least favored (Rawls, 1973, 2009). Thus, the economic interpretation of Abundance, as embodied in the Peace Engineering and Innovation movement, is an economy where the transfer of technological innovation and information are treated as non-diminishable goods for both sender and receiver (Diamandis and Kotler, 2012). Here, we introduce the importance of technology, technological innovation, their management, and the resultant discontinuous innovations they drive, as critical for establishing a more inclusive economic future for the world.

Technology, technological innovation, and their management, challenge and oppose the concepts of the equilibrium economy (Keynes, 2018 [1936]) and of classical political economics developed by Adam Smith (Smith, 1937), Ricardo (Samuelson, 1959), and others.

Abundance Economics can be seen as an expansion of the Austrian school of economics and its emphasis on innovation as put forth by Schumpeter (Schumpeter, 1934, 1942) and later by many others including Kirchhoff (Kirchhoff et al., 2013). The later contrasted Schumpeterian creative destruction and the role of the technology entrepreneur against the Neo-Marshallian equilibrium.

Many of the authors in the field of Abundant economic thought have found evidence of a middle class in the U.S. that is reduced in number and has diminishing financial means, by utilizing data in the public domain (Kochhar, 2018). Further, they find that the middle class has also receded in both North America and Europe. The percent of adult Americans living in middle income household was 52% in 2016, down from 61% in 1971. Moreover, the American household middle class is not graduating to higher income brackets. American adults living in upper income incomes rose from 14% to 19% but Adults living in lower income households grew from 25% to 29%. Further, from 1971 to 2011, the share of adults in the middle class dropped ten points from 61% to 51% (Current Populations Survey Annual Social and Economic Supplements, 2011; U.S. Census Bureau, 2012; Kochhar, 2018). Abundance is a solution to this sociological trend, as it proposes discontinuous innovation as an agent of transformational societal change (Groen and Walsh 2013a).

We now show how some of the basic principles from the field of Management of Technology (MoT) overlap with abundant economic thoughts. We call these basic tenants the “MoT Heuristics on Technological Innovation.” Many authors writing in the field of Abundance discuss the potential economic rise of the poorest of the world population, namely the Bottom Billion (Collier 2007), and how this population segment can be a source of breakthrough innovation (Pralhalad 2012). Finally, we provide a glimpse into one industry group that is operationalizing abundant economics in an I 4.0 world.

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2. Literature review

Technological innovation is creative and pluralistic or multiplicative in nature, i.e., synergistic (Groen and Walsh 2013b). Abundance takes technological innovation one step further. Abundance not only suggests synergy, but also proposes that information transfer does not diminish the knowledge resident in either the sender or receiver in the transaction, thus creating a larger base for idea generation and innovation potential for both parties. Here we demonstrate how authors focusing on Abundance have tried to extend ten of the basic heuristics or tenets of MoT literature.

2.1. MoT heuristics on technological innovation

Abundance finds foundation in the MoT literature. For example, the Schumpeterian economic view concerning creative destruction (Schumpeter, 1934, 1942) is based on technological innovation “floating all economic boats (regional economies)” to a new and higher level. Further, the technological innovation literature includes improvements through knowledge transfer where knowledge is shared for the betterment of all (Gassmann et al., 2010). Other multiplicative benefits in economic thought are based on technology management practices such as road mapping disruptive 21st century innovation (and portfolio management) for synergistic effect for technological innovation (Linton and Walsh, 2004b, Walsh, 2001). Here we select a set of MoT innovation or technological innovation (TI) heuristics that demonstrate a foundation in the technological innovation literature for an Abundance-like concept.

2.1.1. MoT heuristic 1: technology is a multiplier for GDP

Solow won a Nobel Prize by showing that technology and its management was the factor that increased each country's output differentially and in every case at a rate faster than just the combination of Labor and Capital (Solow, 1956). This multiplicative knowledge transfer often is brokered by social entrepreneurs not only across countries and regions, but also between urban and rural settings. Here the notion of Abundance points at the role of technological innovation as a motor of the envisaged awakening of the rural (Richter et al., 2019). In “Here there be Dragons, a pre-roadmap construct for IoT service product infrastructure” (Islam et al., 2018a), the authors view Abundance thought as a keystone in the method that the IoT will act as a harbinger for I 4.0.

In the journey towards a more abundant world through addressing technology gaps with entrepreneurship, entrepreneurial stress induced by overwhelming uncertainty is a threat that calls for immediate attention when it comes to the design of a suitable support structure (Rauch et al., 2018; Kibler et al., 2019). Further, the authors of “External complexities in discontinuous innovation-based R&D projects: Analysis of inter-firm collaborative partnerships that lead to abundance” (Islam et al., 2018a, 2018b) extend the value of policy and management of technology by comparing how nanotechnology was developed in differing European countries. Their analysis of the external complexities that influence the key dimensions of collaborative partnerships in discontinuous innovation-based nanotechnology R&D projects across Europe depicts an Abundance-based collaboration model. Their examination uses both secondary and primary data to initially examine nanotechnology companies and then merge them with a survey of 97 top executives and senior administrators of nanotechnology R&D projects across 12 European countries. They show that this network facilitates highly valuable and long-term interfirm relationships, producing optimal partnership size with an effective organizational structure which leads to Abundance through patents and new product development.

Authors Grinin, Grinin, and Korotayev (Grinin et al., 2019) further this with research on dynamic technology progress. The authors quantitatively analyze the long-term dynamics of technological

progress from 40,000 BCE and projecting through the 22nd century. They provide a simple hyperbolic equation model to define the rapid technology progress being made toward singularity in the early 21st century. Their method measures the worldwide technology dynamic growth with an accuracy of $R^2 = 0.99$.

2.1.2. MoT heuristic 2: technology change is biggest change and opportunity agent in today's economy

Change is the single largest opportunity agent in business (Christiansen and Raynor, 2013). Technology is the biggest change agent in the world in the past, present and future (Smith, 1937). The disruptive technology of additive manufacturing is changing the way physical products are produced (Maresch and Gartner, 2018). These changes cause economic development at a non-linear rate that is more than neoclassical economic thought based on the value of capital and labor alone. Further, exceptionally aligned entrepreneurs (Walsh et al., 1996) who promote technological change have captured significant wealth and job creation.

Abundance researchers (Sydow and Müller-Seitz, 2018) further develop the concept by exploring how open innovation (Chesbrough, 2003) is conducted at the network level. They examine the open network that development of the International Technology Roadmap for Semiconductors (ITRS), focusing on the technological discontinuity affecting a single industry through this collaborative even when the technology disruption is unknown. They highlight the attempts by the ITRS network to overcome technology uncertainty and share the information to all participating firms through a process they named the “stretching practice.” This effort contributes to the knowledge on firm sharing information for each firm's advantage through roadmapping and open innovation techniques.

2.1.3. MoT heuristic 3: the sequence of process and product innovation is dependent on type and intensity of the technology in product and service production technology

The process and product innovation sequence are different in each of the generic technology product paradigms. Management practice must be radically different in these differing paradigms in order to be effective. First researchers showed that, in fabrication and assembly-based products product innovation, preceded process innovation (Abernathy and Utterback, 1978). Next, MoT researchers showed that service process innovation preceded service product innovation (Barras, 1986). MoT researchers then found that, in materials and computer science, product and process innovation occurred simultaneously. Now the Abundance perspective suggests that in an information economy product and process innovation are not only simultaneous but synergistically non-diminishing between actors (Diamandis and Kotler, 2012). Others have shown that specialization of management practice only increases with innovation intensity and patents (Coccia, 2005). This has profound implications on the management of businesses in the 21st century abundant world.

The authors of “Digital Disruption beyond Uber and Airbnb – tracking the tail of the sharing economy” (Geissinger et al., 2018) extend the use of information sharing for mutual benefit in the service technology sector. They show that both that information developed by a deep understanding of their competencies are affected by the sharing economy. They draw on data from the Swedish media landscape. They systematically assess ways in which actors in traditional media as well as users in social media perceive that different sectors of the economy are gaining traction in an abundant or “sharing economy.”

2.1.4. MoT heuristic 4: technology and strategy are interrelated

Technology and Innovation are affected by, and affect strategy at, the firm, country policy and cluster levels (Ansoff and Stewart, 1967; Friar and Horwich, 1985; Hamel, 1990; Eggers et al., 2018). Established strategies such as global sourcing of innovation have made knowledge transfer happen on a global scale with positive long-term effects for the

home and host regions (Rosenbusch et al., 2019). Other authors have shown how patent intensity affects, and is affected by, strategy (Choi et al., 2007; Maresch et al., 2016). Indeed, all of these researchers show that technology based economic development is not a zero-sum game, and lay the foundation for Abundant economic thought. At the same time, generic and practically most influential strategic recommendations such as Porter's (Porter, 1980, 1996) dichotomy of cost-leadership versus diversification (Gartner and Fink, 2018) need to be revisited and extended in view of technological transformation in the digital era. In times where technologies such as additive manufacturing enable the automated delivery of individualized market offers, firms, clusters and regions will be especially successful if they manage to overcome this dichotomy in their strategy. Instead of their firm strategies "getting stuck in the middle" (Porter, 1980) novel technologies will provide them with the means to better serve more customers at better prices.

2.1.5. *MoT heuristic 5: managers are uncomfortable with the strategic importance of technology and innovation*

Many managers, with the exception of technological entrepreneurs, are uncomfortable with both Technology and Innovation as a critically important strategic factor (Burgelman et al., 2008; Henderson, 2006). Researchers have shown that disruptive technology-based change is difficult for many successful organizations where anything other than incremental innovation is often seen as a threat (Tushman and O'Reilly, 1996). The reluctance of managers to acknowledge the strategic value of technology inhibits managing through technological transitions and accepting the foundational importance that technology has in the genesis of firm strategy and success (Bitindo and Frohman, 1981; Danneels, 2004). A new type economy with managers who promote technological change is a positive change. Currently entire enterprises are built on innovations based on sharing economy (Geissinger et al., 2018).

Other researchers have shown the effects of technology-based networking competencies to overcome these managerial hesitations. These networks often lead to system integration on the basis of innovative technology (Middel et al., 2012), and nurture the ability to work together as a manager with content specialist for example in the medical sector (Koelewijn et al., 2012). The more informed and better integrated in a wholistic strategy of society and economy these actions are, the more technological transitions can contribute to a more abundant reality. Providing an information bases on which to build such a joint vision of the future, the gap between research and practice needs to be closed (Kieser et al., 2015). This again paves the way toward and abundant economic vision.

The authors exploring abundance in "To network or not to network – Is that really the question? The impact of networking intensity and strategic orientations on innovation success" (Eggers et al., 2018) further the literature on the managerial barriers within a firm toward technology innovation. They focus on when to use networks to assist firms to become successful innovators through information sharing (Abundance). The enhance the literature by focusing on one of the worlds engines of wealth and job Small and Medium Enterprises (SMEs). They add to the abundant economic thought by providing a discussion concerning the circumstances under which networking activities enable SME. They find that both high- and low-intensity networking firms can use different combinations of underlying strategic orientations and resource-leveraging capabilities to enable innovation success.

2.1.6. *MoT heuristic 6: technology change effects both service and physical products*

The service sector for many years did not benefit as expected from technology development (Diamandis and Kotler, 2012). Yet technical change affects all service product and physical product-based businesses (Morone and Berg, 1993; Rosenbloom, 1978). Today over 70% of most economies GDP comes from the service sector (Berg and

Einspruch, 2009). Finally, for the first time a service technology (IoT) is a harbinger for a Schumpeterian wave (I4.0) (Liu et al., 2011; Thoben et al., 2017; Schmidhuber et al., 2018). Technologies in service sector are by nature multiplicative and now not only form a foundation for the abundance argument but for the current Schumpeterian wave I4.0. This is a fundamental building block of the pluralistic abundance economic view.

The authors of "Disruptive Technologies and Abundance in the Service Sector-toward a refined Technology Acceptance Model" (Schmidhuber et al., 2018). They further the Abundance debate by depicting that information sharing disruptive technologies-based firms are in the service sector. Indeed, this is based on the IoT the first service technology to be a harbinger as a Schumpeterian wave (I 4.0). They focus on the mobile payment phenomena which provides every mobile device customer the opportunity to conduct commercial transactions without cash or cards. They depict the Asian market as lead user groups and European market as a fast follower. They state that the "Mobile payment" phenomena is a recent example of the puzzle of abundance. They depict the potential of the phenomenon describing it as a situation in which the potential of a new disruptive technology is not tapped by the masses even though it offers substantial benefits to them.

2.1.7. *MoT heuristic 7: core competence and learning curves progress us toward abundance*

Technology learning curves are one of the most important physical and service product strategic tools (Foster 1985, 1988, 1993; Linton et al., 2000). Learning curves are firm specific and linked directly through the absorptive capacity argument to core competency view of the firm (Prahalad 2012, Prahalad and Hamel 1990). As a firm build bundles of competencies and capabilities it becomes more differentiable and can learn faster than its competitors along these differentiable pathways. In order for a firm to have a core competence that competence must be scalable. Again, we see a foundation of abundant thought since this learning during any firm transaction is pluralistic and inherent to the firms involved. The importance of managing core competences as well as their technical development is increasing important. The term "dynamic capabilities" furthers the concept at is foundational for maintaining the scalability of the core competences (Teece, 2014, Teece and Leih, 2016). These concepts provide some substance to the Abundance perspective of information and innovation sharing and where change is relentless and requires constant unlearning and transformation to sense and seize the opportunities.

Learning provide an avenue to connect to other tools like road-mapping. Firm, Industry and regional roadmapping is about shared learning at the firm, the community and the industry (Linton and Walsh, 2004b, Linton and Walsh, 2013). Using learning curves to predict technological advance is extremely important to a firm (Lafond et al., 2018). Learning can also be negative as in the case of learning by hackers (Gary et al., 2019).

The authors of "Here there be dragons, a pre-roadmap construct for IoT service Infrastructure" (Islam et al., 2018b) focus on the use of roadmapping. The authors further the use of learning curves as the backbone of an IoT roadmap that would make it a platform in an abundant economy. They discuss how the IoT can be used to address the major challenges facing the 21st century world through disruptive technology-based solutions. They focus on one of the most promising exponential technology set to address world challenges is the Internet of Things (IoT) based Trillion Sensor System (TSS) to provide abundance and a platform for the resurgence a world based middle class. They provide a model for the development of a robust IoT based TSS infrastructure would create an addition to world GDP equal to that of the U.S. and along with it wealth and job creation that would help raise the economic status of the "Bottom Billion" and provide a worldwide wage platform for a middle class.

2.1.8. MoT heuristic 8: a technology's strategic impact is determined by its relative disruptive nature

The potential strategic impact of a technology is determined by its continuum from sustaining to potentially disruptive (Bower and Christensen, 1995). If a technology can form the basis of a product which creatively destroys the core product of an industry or provides a product base that forms a new industry then it is radically strategically important. Cluster theory advocates all push for advanced technology based economic development (Walsh, 2001). Further many cluster theories promote entrepreneurial based disruptive technology commercialization (Cordero et al., 2009; Kirchoff and Walsh, 2000). The IoT is currently changing many industries due to its disruptive nature and harbinger for I 4.0 (Carayannis et al., 2018)

The authors of "Make Disruptive technology change happen- the case of additive" (Maresch and Gartner, 2018) further the traditional MoT literature on the strategic impact of disruptive rather than incremental technologies, and on multiplicative economic development by focusing on potentially disruptive technologies. The authors' exemplar is Additive Manufacturing (AM). They show that even though firms are choosing a disruptive technology path they often struggle. AM, for example, has not yet established itself on a large scale in many fields of application. They show that the choice to use AM often rely on a multi-perspective technology foresight process. They support this through an empirical study that provides an explanation of the link between the challenges and opportunities offered by AM.

2.1.9. MoT Heuristic 9: A firm's innovation process is linked to its historical choice of disruptive or sustaining technologies

Individual firms have a preferred innovation pathway which is linked to the disruptive or sustaining nature of the technology they use to develop products (Marquis, 1972). The firm's penchant for market pull versus technology push innovation strategies can be mapped. The result of those innovation strategies, namely the firm's product's diffusion curve, will reflect the firm's strategic innovation choices. The basic diffusion patterns will all be s-shaped (Marinakos, 2012), but Abundance-based innovation will diffuse at faster rates – reflecting the exponential development of the technology (Diamandis and Kotler, 2012).

The authors of "Abundance—A new window on how disruptive innovation occurs" (Mahto et al., 2017) focus on the distributive innovation phenomena and how it can be used for social change. They further the MoT literature by trying to get firms that may not have historically choose to embrace a disruptive technology to consider it and other firms more comfortable with disruptive innovation to excel. They state that "disruptive innovation can benefit from a coherent theoretical framework." Further they provide one that explains origins of disruptive innovation and the role of scarcity/abundance in that process from a market perspective. Specifically, the authors address the need to understand how radical or disruptive innovations occur to create a more abundant world and what market conditions motivates innovators, especially in communities enduring poverty and scarcity of resources such as the "Bottom Billion" to reverse the status of the shrinking middle class.

2.1.10. MoT Heuristic 10: R&D's mission is to reinvent the corporation

Managing R&D is a task designed often to continuously reinvent the firm and initiate new enterprises (Mechlin and Berg, 1980). R&D accomplishes this by intensifying competencies, creating new ones and further developing old ones. In the entrepreneurial and small business world R&D is often synonymous with the founder's backgrounds (Walsh et al., 1996). Abundant entrepreneurs often have technological competencies but also managerial capabilities (Linton and Walsh, 2004b). One tool a firm often uses its Ambidexterity—ability to be efficient and thrive in the current situation while proactively seizing the potential of uncertain potential of upcoming technologies (Tushman and O'Reilly 1996; Gibson and Birkinshaw, 2004). Another is the entrepreneurial

mindset – the capacity to recognize the opportunity to bet on and willingly mobilize the resources to seize it are at the core of navigating the abundant spaces (Shepherd et al., 2010). Further, R&D managers often try to fulfill the corporate mission by making a difference (Diamandis and Kotler, 2012) using Abundant thought by being transformational for their communities by meeting 21st Century Grand Challenges.

The authors of "Collaborative open foresight—A new approach for inspiring discontinuous and sustainability-oriented innovations" (Wiener et al., 2018) focus on how disruptive changes present risk and opportunities for companies. They show how corporate R&D and innovation strategists are opening their disruptive efforts at the early stage by performing collaborative open foresight efforts in the hope of transforming their firms into a more competitive position. They depict these firms sharing information for mutual "Abundant" benefit. They use case studies that demonstrate that established companies often fail to recognize the potential of disruptive changes and how this process speeds innovation not only in the established firm but other firm collaborators as well. This sharing of information and skills provide

One question remaining relates to the efficacy of the Abundance. Its ability to rise the "Bottom Billion" to economic stability and provide a basis for a vibrant worldwide middle class. Here we provide a glimpse into that possibility through a short exemplar of how a sensor and Sensor systems network operationalize Abundant economic thought.

3. Methods

We demonstrate and test abundance economics as a foundation for a sustainable worldwide middle class by using a modified case study approach (Yin 2017, 1981; Eisenhardt, 1989). We embrace the case study of Trillion Sensors and Trillion Sensors systems initiative as a case study. We considered it as an exemplar through the use of secondary data – allowing other parties to consider the application independently of access to proprietary data or inside information. In the case, we follow up after the analysis with secondary data was complete to better assess the accuracy of our findings. These firms and individuals that comprises the Trillion Sensors and Trillion Sensor System initiative gathered data by holding international conferences in the United States, Europe and elsewhere from 2013 through 2018. We utilized the Trillion Sensor and Trillion Sensor Systems initiative series of conferences to gather data from more than 1000 people working in firms and academic institutions located in Asia, North America, South America, Europe, Australasia and Africa. The organization utilized the "Abundance" perspective and seeks to operationalize it through the ubiquitous applications of sensors and their systemization to meet some of the 21st century world global challenges.

4. Results

4.1. A micro and nano technology-based network abundance based operational aims

One information sharing network – Trillion sensor and Trillion Sensor Systems initiative which is a series of conferences to gather data from more than 1000 people working in firms and academic institutions located in Asia, North America, South America, Europe, Australasia and Africa. They utilized "Abundance" perspective and information sharing to try to move the sensor market from approximately 25 billion sensors worldwide market (Cisco, 2016) to between 1 and 10 trillion. They believe that the ubiquitous applications of sensors and their systemization to meet some of the 21st century world global challenges.

The T Sensor and T Sensor System initiative was born of Hewlett Packard's vision of the Central Nervous System of the Earth. In 2010, they predicted a need for over a trillion sensors to develop for the central Nervous system of the earth and focused on areas such as structural health systems, Smart Highway systems, wildlife tracking

and many others but did not approach many other multibillion sensor markets. Many predicted a more limited sensor marketplace than the T Sensor initiative envisioned. ABI predicted that 40.9 billion sensor market per year by 2020 (Drubin, 2014). BI (BI, 2016), IDC–Norton (IDC, 2016), Juniper (Juniper, 2016) and Gartner (Gartner, 2017) followed with sensor production prediction of 34, 28.1, 38.5 and 20.797 billion sensor market by 2020. In 2013 the founder of the Trillion Sensor effort predicted a trillion-sensor market by 2030. In 2017 some at the Trillion Sensor conference were predicting a 10,000 billion sensor market by 2030.

Historically the sensor market has been much smaller but the growth has been substantial. The sensor market was only 0.5 billion sensors in 2003, grew to 12.5 billion devices in 2010, and was approximately 25 billion sensors by 2015 (Cisco, 2016). The growth of nano- and micro-sensor and sensors systems is thought to arise from the radical decrease in the cost of making sensors and sensor systems. The cost boundaries derived by this group were \$1 per sensors and \$15 per systems. This Pricing was attained through the embrace of techniques like Systems on a Package (SoP), IoT access, additive manufacturing (Gartner et al., 2015), plastic MEMS and nano devices, and many others (Roach and Walsh, 2016). Below we further the economic discussion through Abundant thought. The resultant world would either be a 1 trillion sensor market world, a 10 trillion sensor market world or a 100 trillion sensor market world.

4.2. The sensors network aims are progressing: what trillions of sensors means to the “Bottom billion,” the world middle class and wide GDP

The T Sensor groups stated that a trillion-sensor worldwide market would be feasible if the sensor cost would decrease to \$ 1 per sensor and the systemization costs would lower to \$15. In order to reach the \$1 cost per sensor and \$15 cost for systemization an aggressive learning curve effort and all economies of scale would have to be reached. A single complete Tsensor system then could be produced for \$16 dollars. We provide in Table 1 the implications to the World GDP for the production of 1 trillion sensor per year, 10 trillion sensor per year and finally 100 trillion sensor per year. In Table 2 we provide the current World GDP and the single largest county GDP. The potential GDP contribution from the production of 1 trillion sensors would contribute nearly the contribution of the largest country's GDP and the production of 10 to 100 trillion sensors per year would greatly eclipse world GDP.

The sensor and sensor system community are still working toward those costing levels and succeeding in many cases. ABI and other market projection groups predicted that 40.9 billion sensor market per year by 2020 (Drubin, 2014). But what happens if this singular effort based on abundant thought succeeds. Does it make a worldwide impact for the “Bottom Billion” or a foundation for a worldwide middle class? If this singular effort is successful at the trillion-sensor system level it would have an \$16 trillion dollar effect on approximately \$84 Trillion World GDP. This is comparable to the US contribution of approximately \$20.494 trillion (World GDP, 2019). The sensor market would create approximately 36,326,979 million new high paying middle jobs based on current Sensor market revenue to employee data (US Department of Labor, 2019).

These predictions are impossible under traditional economic thought. GDP compound annual growth rate since 1900 has never greater than the 17.8% posted in 1986 (IMF, 2019) from any estimation service (IMF, OCED, World Bank, or UN). Currently world GDP is approximately 5.9% (IMF World GDP April, 2019). Still, if these new abundant economic rules hold and sensor production grows, what would happen to world job

Table 1
Contribution to GDP.

Market size	1 trillion Sensor market	10 trillion Sensor market	100 trillion Sensor market
Contribution to GDP	\$16 trillion	\$160 trillion	\$1600 trillion

Table 2
Current GDP from world's Largest Economy and world GDP.

Economy	World's Largest US 2018	World GDP (2018)
GDP	\$20.494 trillion	\$84.484 trillion (IMF 2019)

growth? What would it mean to a new world middle class?

The average small business generates about \$100,000 in revenue per employee. Larger companies generate closer to \$200,000. Fortune 500 companies average \$300,000 per employee (Small Business Matters, 2017). More specifically, IoT industry is a combination of information technology and manufacturing. The United States Census Bureau (2012) economic census of 2012 shows \$372,893 in revenue per employee for NAICS code 51 (Information) and \$507,994 for NAICS codes 31–33 (Manufacturing). The average revenue per employee for these two industry per-employee revenues is \$440,444.

In Table 3, we provide the sales of 1, 10, and 1000 trillion sensor markets. We then divide the market value by revenue per employee to derive the projected number of new employees created by these three futurist world visions. As you can see, the lower futurist value of 1 trillion sensors creates more than 36 million new jobs. A ten trillion sensor world create more than 363 million new jobs. And a 100 trillion sensor world create more than 3.6 billion new jobs, assuming constant productivity at our aggressive economies of scale basis. Where this last number is probably unreachable, no one country could provide a workforce of even 36 million new employees.

These numbers assume our aggressive learning scenario and do not take into account supply chain employee requirements nor capitalization of equipment necessary to produce and systemize sensors which would create even more jobs. Further, here we do not even include the well known job multiplier discussion. This results in a conservative employment need but one which is tied to the current income distributions of the industry. Will these new employees be recompensed at middle class rates? The annual mean wage for NAICS code 51 (Information) in 2018 was \$76,990, and the annual mean wage for NAICS codes 31–33 (Manufacturing) in 2018 was \$53,020 (United States Department of Labor 2019). The average of these two is \$65,005. According to the U.S. Census Bureau, the 2017 median household income was \$61,372. The Pew Research Center (Kochhar 2018) defines the middle class as comprising those earning between two-thirds and double the median household income. This means that the middle class comprises people making between \$40,500 and \$122,000 without Purchasing Power Parity (PPP). The United Nations' International Labor Organization reports that in 2011 the world's average salary is just less than half the average salary in the U.S. (Alexander 2012). Therefore, we estimate that the PPP contribution will be one-half of the U.S. amounts as we cannot predict which countries will provide the new employees.

The final question is, what would be the annual contribution of these jobs to the economy? We multiply the projected number of new employees by the average salary (Table 4). The projected contributions to the annual economy vary between more than \$2.6 trillion to more than \$236 trillion, or \$1.18 Trillion to more than \$118 trillion from a PPP point of view.

5. Discussion and conclusion

Abundant economic thought seeks to rewrite economic rules. Due to globalization, political action, loss of union power, and many other factors, the middle class has lost ground even in the once bastions of the middle class – the United States of America and Europe. The glimpse into the sensor-based case study presented above is just one initiative focusing on abundant economic thought. If these and other Abundance based initiatives were to prevail, then they would greatly advance the development of a new and vibrant middle class (Committee on Prospering in the Global Economy of the 21st Century 2007).

Table 3

Projected numbers of new jobs created by the three trillion sensor world visions.

Market size	1 trillion Sensor market	10 trillion Sensor market	100 trillion Sensor market
Contribution to GDP	\$16 Trillion	\$160 trillion	\$1600 trillion
Revenue per employee	\$440,444	\$440,444	\$440,444
Number of new employees	36,326,979	363,269,791	3632,697,914

Table 4

Projected contribution of the new jobs to the economy.

Market size	1 trillion sensor market	10 trillion sensor market	100 trillion sensor market
Number of new employees	36,326,979	363,269,791	3632,697,914
Annual contribution to the economy (all US employees)	\$2361,435,269,895	\$23,614,352,763,955	\$236,143,526,899,570
Annual contribution to the economy (PPP estimate)	\$1180,717,634,948	\$11,807,176,381,978	\$118,071,763,449,785

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