“Computational entrepreneurship: from economic complexities to interdisciplinary research”

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COMPUTATIONAL ENTREPRENEURSHIP: FROM ECONOMIC COMPLEXITIES TO INTERDISCIPLINARY RESEARCH

Abstract

The development of technology is unbelievably rapid. From limited local networks to high speed Internet, from crude computing machines to powerful semi-conductors, the world had changed drastically compared to just a few decades ago. In the constantly renewing process of adapting to such an unnaturally high-entropy setting, innovations as well as entirely new concepts, were often born. In the business world, one such phenomenon was the creation of a new type of entrepreneurship. This paper proposes a new academic discipline of computational entrepreneurship, which centers on: (i) an exponentially growing (and less expensive) computing power, to the extent that almost everybody in a modern society can own and use that; (ii) omnipresent high-speed Internet connectivity, wired or wireless, representing our modern day's economic connectomics; (iii) growing concern of exploiting "serendipity" for a strategic commercial advantage; and (iv) growing capabilities of lay people in performing calculations for their informed decisions in taking fast-moving entrepreneurial opportunities. Computational entrepreneurship has slowly become a new mode of operation for business ventures and will likely bring the academic discipline of entrepreneurship back to mainstream economics.

Keywords computing power, high-speed connectivity, entrepreneurship, economic calculations, connectomics

JEL Classification D11, D87, L26

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INTRODUCTION

Our earnest academic discussion will begin with the following fictional story, which serves as an introduction to subsequent conceptual developments.

Today was not a good day for Liz Woo, a sociologist specialized in applied business, as her laptop decided to break down. She had bought this laptop from an online store run by the home startup chain Bambix, believing in supporting the local digital economy.

A series of automated phone calls and circular online customer inquiries had led Liz nowhere to fixing her laptop, wasting her some precious time with its incessant questions for her laptop's ID number, purchase receipt and warranty card. The lack of online solution prompted Bambix's automated system to direct Liz to a store closest to her place, which she was happy to comply as she preferred human contact over some unknown machine.

At the store, Liz was sorely disappointed again when she was walked through a series of automated steps, from filing in the laptop's biomet-

rics to the receipt ID and payment confirmation. No staff was seen in sight. Surrounding Liz were computers speaking in their monotonous robotic cadence, politely but oblivious to her growing frustrations.

Only when she demanded to talk to a manager did she finally see a tall, attractive young man, likely in his twenties and new to the startup business. With his curly blond hair, stylish purple scarf and a mega-watt smile, he immediately won Liz over. The young man introduced himself and apologized profusely for the troubles she was going through to get her laptop fixed.

The sociologist in Liz was delighted – successful startups must allow humans to talk to humans. A five-minute conversation not only resolved Liz's problem but also inspired her to write up a case study on human interaction in a digital world. The young man happily agreed with her inquiry and promised to provide her with related information and customer feedback, proudly declaring he remembered every feedback.

Liz was over the moon.

As he walked her out of the store, Liz asked for his business card, upon which was his detailed contact information. His name was printed in bold sans-serif typeface in the center. It reads: RD_6fc1363ca0c277e2.

Welcome to the world of computational entrepreneurship!

1. THEORETICAL DISCUSSIONS

1.1. Unnatural high-entropy settings

In the increasingly connected world, the future job prospects for Ph.D. students are highly uncertain. Statistics have shown that only 3-4% of the PhDs students can find a tenured academic position. However, in a recent survey of 5,700 Ph.D. students worldwide, nature finds that graduate programs do not seem to prepare the junior scientists for their future jobs. About 30% of the respondents stated they did have useful conservations about careers with their supervisors, and the same percentage finds their supervisors' advice on non-academic careers (Editorial, 2017). It is reasonable to assume that most of them are not learning any useful entrepreneurial skills.

Meanwhile, in the world of startups, things seem to be refreshing with the arrival of a new form of digital economy. The new economy has been referred to by many names: "the platform economy", "the gig economy", "the sharing economy", "the peer-to-peer economy", etc. (Bodie, 2017). Whichever name it goes by, the new phenomenon is characterized by four elements: real-time data, mobile payments, on-demand delivery, and flexible pricing; these elements enable the success of Uber, which in turn inspires a blooming of copycat startups – the Uberization of everything (Freeman, 2015). The exponentially growing number of startups has been efficiently exploiting cloud-based big data technologies. Phenomenal startups such as Uber, Amazon, Traveloka, and Airbnb all utilize a computational model to save cost, shorten decision-making time, diversify and improve products and services. Customer experience with these businesses has been markedly improved with greater perceived ease of use and usefulness (i.e., people find their mobile apps useful and effortless to use) (Nugroho, Bakar, & Ali, 2017).

Not only startup with clear business intention, social media like Facebook with more than two billion users, is increasingly used as an online marketplace where product brands' pages constantly refresh and make updates using countless of detail calculations. Since the online customers have easy access to massive information and choices at the same time, businesses on this social networking site have no choice but to lead the innovation race. The pressure to perpetually create new content, be sensitive to information to detect even the slimmest opportunities has made a lot of online stores die down from the market. However, the same driving force also enables us to witness utmost creativity and productivity. This results in a spiral effect when the digital economic activities leave behind a stupendous amount of data, which, with the aid of artificial intelligence analysis

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tools, provides businesses with valuable real-time customer insights. In fact, this source of data not only helps inform customer centered management strategies, but also monitors customer behavior in their desired way.

The reaction toward this new economy has varied greatly. At the one end of the spectrum, people worry this technology-driven economic shift will only exacerbate income inequality, at the other end, there is a beaming optimism about a post-capitalist world (McAfee & Brynjolfsson, 2017).

It is uncertain how the shift will unfold, what is clear is that the business world has never witnessed such disruptive change of this volume and velocity before. This level of disruption, which is powered by an unprecedented level of inexpensive advanced computation and network, suggests it is time to revise our understanding of how business startups work. We need a new model of entrepreneurship.

1.2. Traditional vs. computational entrepreneurship

Entrepreneurship as an academic discipline started with the Austrian school of economics whose founders were Menger, Wieser, and Schumpeter (Campagnolo & Vivel, 2014). It is interesting that while most other economics schools developed mathematical models, the theory of entrepreneurship and innovation of Joseph Schumpeter has never followed this direction (Pacher, 2014). Many researchers in this school of thought even distanced their works from statistical analyses. The Austrian school of economics is famous for their methodological opposition to classical economics, which utilized mathematics (Yeager, 1997). In consequence, although the theory of entrepreneurship has become increasingly important, entrepreneurship has always been considered an upstart, even an outsider of the mainstream economic theories.

Conventional entrepreneurship possesses three main characteristics: risk-taking, small-scale, and self-employment. The development of small and medium enterprises in Vietnam during 1990 (Vuong & Tran, 2009) or the booming of large-scales start-ups programs (Vuong, 2016) could illustrate these characteristics. In these periods, many start-ups operate according to the family business model at small or medium scale (Pham, Bell, & Newton, 2018). The traditional taxi business is also a type of entrepreneurship with a kind of "linear business development": the drivers usually start off working for a taxi company, then gradually move toward using their cars to make more profit. In education, the lecturers or professors also start their businesses by offering tutorials to their classes; some offer their expertise in the form of consulting (Bercovitz & Feldman, 2008). All these traditional start-ups require risk-taking, substantial efforts and some luck to achieve a certain level of success.

However, perhaps the Austrian economists did not envision how modern computing power and connectivity would have influenced entrepreneurship. The following examples illustrate this point clearly. A group of scholars and scientists who are originally teaching at universities, rather than starting their business the traditional ways as mentioned above, became famous in social media with their unrelenting attitude in addressing controversial topics; people refer to them as the Intellectual Dark Web (Weiss, 2018). They all started as a kind of intellectual YouTube stars, then created their channels, making profits from either direct viewers-sponsorship, advertisements, books, or speaking engagements. In any event, it is clear the digital platforms play a key role in their success. Another example is the family of Ryan ToysReview, which according to Forbes, earned USD 22 million in 2018 with about 17 million subscriptions for their attractive children video channels (Robehmed & Berg, 2018). All these stories of successful start-ups point to three outstanding features: the increasingly networked world, the increasing number of small and super small businesses, and the lowering computational cost.

These features signal the need to studies a new field: "Computational Entrepreneurship". This phrase is mentioned briefly in Dark Deleuze of Andrew Culp. However, the concept has not been developed fully (Culp, 2016). The author assesses this concept from the viewpoint of a traditional start-up, perhaps, that is why further development is limited.

It is crucial, however, to note that computational entrepreneurship differs from e-entrepreneurship in nature. The latter refers to the foundation and operation of businesses solely on the basis of technological innovations in telecommunication, information

technology, media technology, and entertainment. It utilizes the advancements of the commercial electronic networks where information is available to the public, and the connection is not limited to a community but the whole world (Kollmann, 2006).

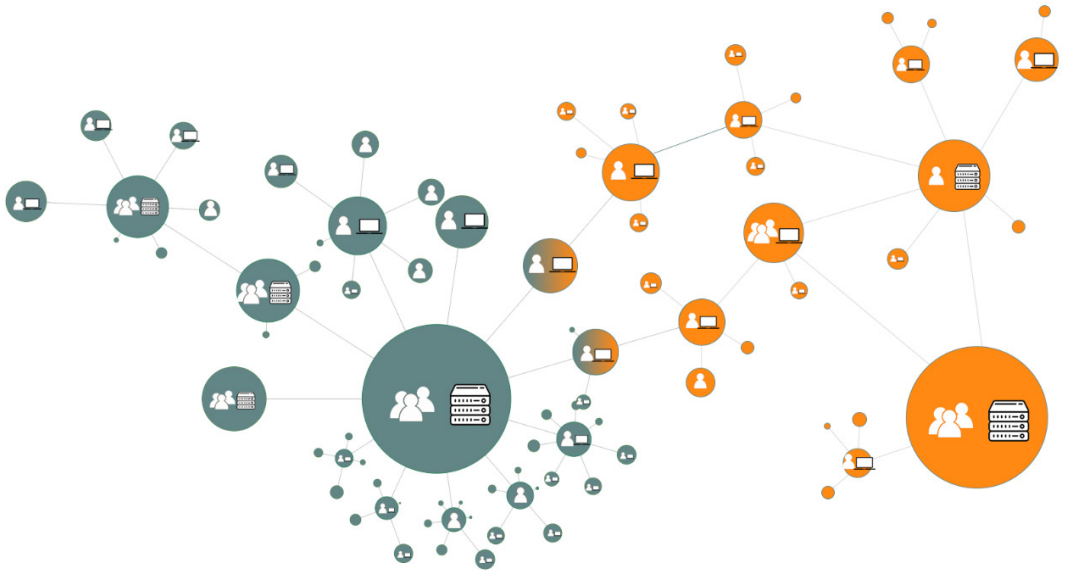
Computational entrepreneurship, on the other hand, is the establishment and management of companies with the power of connection, computation, and data analysis tools. The accessibility to mass connection and cheap computational power allows the entrepreneurs to venture with detailed calculations. In traditional entrepreneurship, the entrepreneur often starts with little information and a nothing-to-lose attitude. For instance, the rise of Vietnamese small and medium enterprises after 1986 was a result of the devastating socio-economic situation. Therefore, only by taking the risk that Vietnamese people could improve their lives. However, such an all-in attitude has been replaced by the detailed calculation based on the massive amount of information, connection and the power of computation. Data pile up speedily every day due to the ability to leverage information, leading to a typical feature of computational entrepreneurship: the use of big data and artificial intelligence technologies. To enhance customer interaction and satisfaction, for example, a lot of startups have had to develop news coverage function in their apps, which offers hourly updates on everything happening in the world. Users' footprint data are also resourceful to inform and facilitate business decisions. This is how computational entrepreneurship is not only limited to tech-based products and services, but also includes the manufacturing and trading of physical commodities.

With its unique characteristics and principles, computational entrepreneurship deserves extensive research including the construction of the model and its emerging significance regarding academic, scientific and social aspects.

2. DISCUSSIONS

2.1. Computational entrepreneurship: a modus operandi

Scientists have tried to study and comprehend the complexity of the human mind for years. However, even a map of a simple 302-neuron nervous system of C. elegans roundworm shows a complex neurons connection (White, Southgate, Thomson, & Brenner, 1986). The map illustrates the system called connectome – "the totality of connections between neurons in a nervous system" (Seung, 2012). Inspired by the idea of connectome, the author would like to propose a model of the massive connectivity of computational entrepreneurship as shown in Figure 1.



Note: The circle node represents an entrepreneur or entrepreneurs and their computational powers. Nodes connect with each other to create a massive connectivity.

Figure 1. The massive connectivity of computational entrepreneurship

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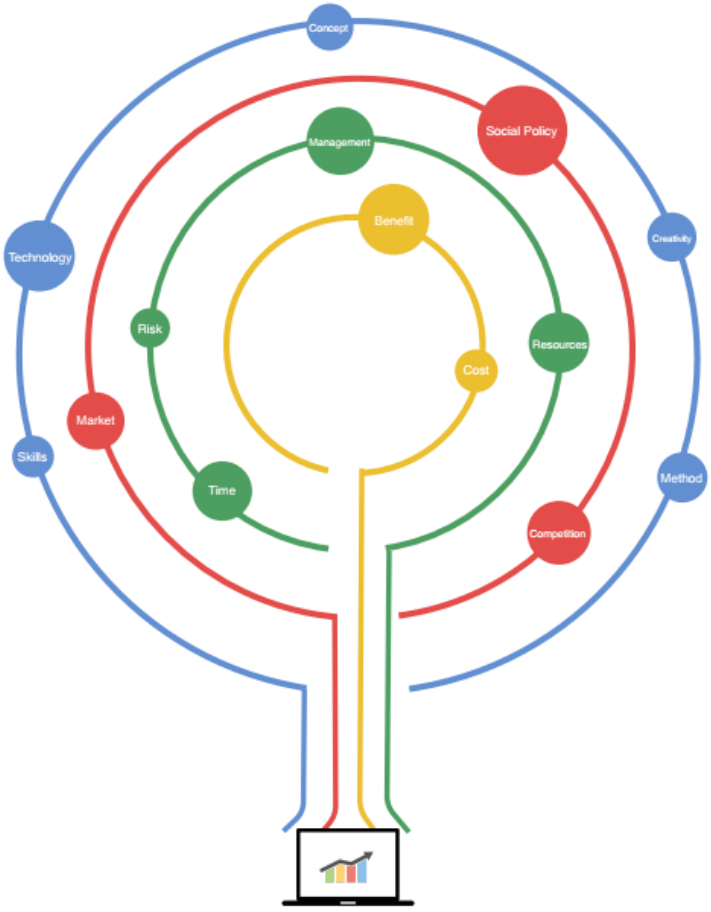

Note: Complex calculations that a computational entrepreneur has to consider with the help of computational power.

Figure 2. The calculation of an entrepreneur in computational entrepreneurship

In the model, each node of the network represents an entrepreneur or entrepreneurs with their own computational power and calculations. The massive connectivity is a collection of small webs of entrepreneurs' interaction and connection. In each small web, entrepreneurs connect with each other, and also with some bigger entrepreneurs who control the systems of the web. The relationship among entrepreneurs is hierarchical because of computational power. There are investors fund startups who create the system (Uber, Facebook), while individuals are exploiting the system for their business venturing (Uber drivers, Facebook users).

Figure 2 represents the complexity of calculation that an entrepreneur has to do in computational entrepreneurship. Various factors are taken into consideration with the help of computing power. In traditional entrepreneurship, information and data are not readily available, and the calculation highly depends on the business acumen of the entrepreneur. Computational entrepreneurship allows the accessibility to more information and data, and consequently, leading to a more complex calculation. For instance, research has shown that entrepreneurs tend to prolong their ventures if the possibility of the first success is uncertain, while if the success chance is high, entrepreneurs are more likely to proceed with the plan (Q. Vuong, Do, & T.-T. Vuong, 2016). Connectivity and computational power help reducing the uncertainty by the thorough analysis of data and information.

Computational entrepreneurship allows everyone to access the cheap and powerful computational power, the vast amount of information, and the highly connected world. The accessibility has elevated the complexity of calculations that an entre-

preneur has to make to an utmost detail to navigate in the massive chaotic network.

To illustrate these models and understand their implications, we need only to look at the obvious examples of Uber and YouTube. These computational platforms enable a multi-level ecosystem of entrepreneurs. For example, Uber founders are not the only entrepreneurs, but thousands of drivers as well. Here computational entrepreneurship forces entrepreneurs of all levels to calculate to make the most profit. While Uber must make thousands of calculations simultaneously to arrange bookings to make a profit, the drivers must also make detailed calculations to make the most profit, e.g. which hours of a day pay the most, whether to go a short distance many times or a long distance fewer times, which booking to receive, which to cancel.

As millions of people enjoy watching others play videos and post comments, YouTube enables many young adults to start-up as a professional game streamer. For example, a famous one called PewDiePie on Twitch can serve 75 million followers on YouTube by uploading videos daily. PewDiePie used to hire a team for creating contents, but after a while, he decided to fire everyone in order to be more himself (PewDiePie, 2017): "I thought I had to be more professional. But I think, in reality, the more I try to be a professional, the more I sort of lost touch and just the direct connection with what's so good about YouTube". This is how computational entrepreneurship takes the concept of self-employment to another level: it has created a one-person army.

As for the ideas of an ecosystem of newborn start-ups, a successful YouTube star can attract the sponsorship of other entrepreneurs, such as food producers, e-legal service, fitness equipment producers in the case of Joe Rogan who is a member of the Intellectual Dark Web (Weiss, 2018). As the success of YouTube stars can be attributed to the fact that their personalities are attractive to certain niches of viewers, the sponsors, by choosing the right person to fund, can advertise to a massive number of customers who have a high probability of enjoying their products. Traditionally, this kind of effective marketing is impossible. Advanced algorithms and low-cost computing power arguably enable all of these.

2.2. An emerging academic discipline

Here, we propose that besides inheriting the basic characteristics of traditional entrepreneurship, "computational entrepreneurship" has the following new elements, which create a substantial change in the behaviors, as well as the ability to mitigate risks of entrepreneurs.

First, computational entrepreneurship utilizes low-cost extensive computing power, user-friendly algorithms, high connectivity, and the use of technologies across platforms. The development of computational power follows Moore's Law closely: computer power will double every two years. However, experts are predicting Moore's Law will meet economic and physical limitations soon, especially in the era of mobile computing (Waldrop, 2016). This leads to the second characteristic.

Second, computational entrepreneurship takes place on a very large scale, which is supported by the high speed of the Internet, as well as the development of social media. These platforms enable the ability to connect at the same time billions of consumers. Moreover, Internet and cloud computing also help entrepreneurs to cut cost and focus more on different aspects of their ventures (Frankenfield, 2018). The cheap computing power and high-speed connection lead us to the third and final characteristic.

Third, the differential calculation for cost-benefit analysis is performed to the utmost details, even down to the level of payment method (such as cash) that has very low value, but in a very large scale. There are millions of these calculations done at the same time thanks to the inexpensive computing cost. This implies the possibility of not only peer-to-peer, but also hierarchical or multi-level start-ups, indeed, an ecosystem of newborn start-ups. In the past, Walmart and FedEx have successfully embraced the idea of small benefit, but on a large scale. Now, Amazon and Elon Musk have enhanced and expanded the model to an even larger scale through technology.

In such an open but competitive environment, speed is everything: speed of calculation, speed of thinking, speed of failing. There is a constant pressure to keep up the stream of contents. The

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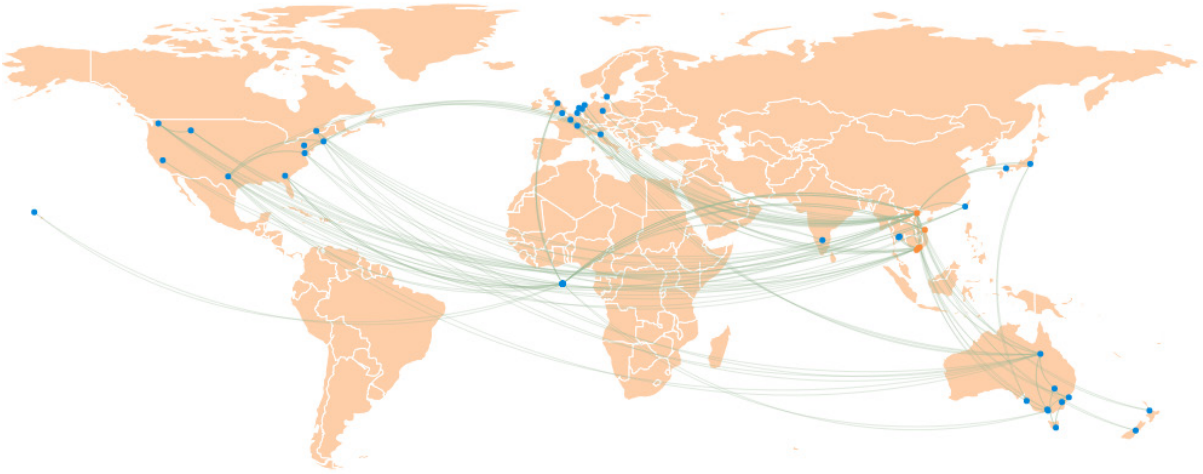
survivor is not the most hardworking, or the most creative, but a combination of both. Vuong and Napier (2014) suggest three types of creativity: aha moment, serendipity and 3D creativity. Aha moment and serendipity creativity require a spark of genius to come up with a brilliant solution or a special insight to spot the hidden information. 3D creativity, on the other hand, is a combination of discipline, expertise, and knowledge about other areas. Aided by the advantages of computational entrepreneurship, 3D creativity entrepreneurs are capable of surviving and thriving in the fast pace world of computational entrepreneurship. Moreover, they are also able to take advantage of the concept of "serendipity", defined as "the ability to recognize and evaluate unexpected information and generate unintended value from it" (Vuong & Napier, 2014). Therefore, computational entrepreneurship has become the mode of operation for the heavily technology-driven world.

In a developing country like Vietnam, the society has been enthusiastic for technology and startup in recent years. For instance, roughly 3,000 Vietnamese startups are seeking investment, and in 2017, 92 startups received US$ 291 million from investors (Ngoc, 2018). At the same time, technology is expected to change Vietnamese agriculture, finance, and banking, or Hanoi urban (VNA, 2018a, 2018b, 2018c). However, the number of academic research on entrepreneurship and technology is still limited. During 2008–2018 (Figure 3), Vietnamese scholars and international collaborators have published around 100 scientific research on entrepreneurship in Vietnam, but only three papers discuss technological issues (Hoang & Swierczek, 2008; Le, Vu, & Nghiem, 2018; Le, Rowe, Truex, & Huynh, 2012). The more common topics are management (Luu, 2017; Pham et al., 2018), cultural impacts (Vuong, 2016; Vuong & Tran, 2009), or gender issues (Le & Raven, 2015; Nguyen, Frederick, & Nguyen, 2014; Poon, Thai, & Naybor, 2012). The focus on traditional topics in Vietnamese entrepreneurship research is due to insufficient data on technology and startup, but shortly, the interests in this topic and its implications are foreseeable, as the systems can be further improved and become even more advanced computational platforms.

Here, it is likely that the entrepreneurs will still be individuals, they will keep creating an ecosystem themselves through the real-time data generated in their economic activities, such as price information, transaction time, the total value of a transaction, the demand-supply equilibrium.

2.3. Scientific and societal implications

The rise of computational entrepreneurship might be disruptive and subversive for the modern mainstream economic theory championed by



Note: A world map of entrepreneurship research collaborations between Vietnamese and international scientists from 2008 to 2018. The link represents connections between Vietnam's research centers: Hanoi, Da Nang, Ho Chi Minh, and international scholars.

Figure 3. Map of Vietnamese and international collaborations in entrepreneurship research, 2008–2018

Keynes and Hicks. The corresponding mathematical models of Arrow and Samuelson are static and based on the assumptions of a closed economy with two goods. Arguably, these models might not be adequate for studying or navigating the chaotic and uncertain business environment that we live in today, especially with the rise of a new type of entrepreneurship as demonstrated above. It is necessary to craft new models starting with the basic assumption of an extremely open economy in an integrated, well-connected world and with many goods.

In the realm of academia, academics are perhaps witnessing revolutionary transitions resulting from the power of big data technologies. Traditionally, they are often thought to be analogous to the Schumpeterian entrepreneurs who are willing to take a risk and bear the uncertain outcomes of their activities. These activities, even though initially are to serve their benefit, eventually end up raising general productivity and quality of life. The academically stimulating environment where innovation is key and exploitation of resources and opportunities must be optimal also signal an entrepreneurship-enabling setting where everyone competes to be the most creative (Shane, 2003). However, traditional academic entrepreneurship is mostly limited by its top-down system, which hinders the businesses' flexibility and freedom to develop (Labaree, 2018).

Meanwhile, computational entrepreneurship has steered everything through a transitional period. Publons is an academic startup typical of this type, which began by applying advanced algorithms to connect and process a huge amount of data contributed by peer reviews of thousands of researchers. Particularly, after the integration with Clarivate Analytics and upgrading of the database, Publons has been empowered to serve a wide variety of searching demands of scientists including counting and filtering citations. This model of connecting and storing information constantly could be seen in several startups over the past decades such as Google whose founder was also an academic. The application of computational models has offered businesses of this type more freedom and better capabilities to diversify and specialize, which is essential to their competitiveness. This means that it is reasonable to expect large transition in the field of academic entrepreneurship when vast employment of artificial intelligence calculations helps lower the computational cost.

The rise of computational entrepreneurship has caught not only the academic world by surprise, but also governments and smaller-scale social organizations. As the transformation of the economy gradually took place, powered by the new entrepreneurship, a proper understanding of computational entrepreneurship would be necessary for these bodies to navigate the unusually high-entropy world better. Ignorance of the opportunities that new entrepreneurship could open up could lead to unnecessarily extreme reactions, such as the global protests against Uber in 2015 (Arthur, 2015). The clash between the new and the traditional has always been inevitable, and the business world is no exception. However, how much is lost in the process of transition depends on the actors' capacity to create new knowledge. This applies to both public and private economic actors: to limit casualties, policy-makers must consider the new phenomenon in startups, whereas companies should make sure to update their business strategies constantly and accordingly.

Doing business in a world where computational entrepreneurship is gaining more and more presence meant operating in an environment filled with vast amounts of moving information and intense competition. New information piled up and spread to a large number of people in a matter of seconds. For individuals aspiring to do business, such a situation could open a potential window of opportunity; however, the latter was narrow and quick to close.

An example of this would be the YouTuber community. The success of large channels (millions of subscribers) such as PewDiePie, Markiplier or Cryotic had elevated these gamers into public figures and extended the content creation trend outside of the gaming community. As there are minimal limitations on what kind of content one may create, a vlogging channel of one's daily life or a channel producing videos that consist of readings of text messages could still rise to popularity, as long as the creator had a strategy to attain it. This gave rise to a wave of medium-sized channels (hundreds of thousands of subscribers), as well as the formation of theme-based sub-communities such as the horror/true crime fans, movie crit-

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ics, fitness influencers, voice over artists, political commentators, etc. Here, the opportunity aspect of computational entrepreneurship could be seen: even subjects that at a glance seemed rather obscure could turn into a niche market, and any individual can aspire to make ad revenue out of it.

However, the flip side of the coin is the fierce competition: because anyone can do it, creators would not be able to make it to monetization without some feature to differentiate themselves from other creators in the same niche market. As such, to seize the opportunity, entrepreneurs in this era had to make many observations and devise computation-based strategies to grow. These strategies are similar to those in traditional entrepreneurship and could range from very conscious and well-planned innovative approaches (Vuong & Napier, 2014) to more spontaneous and intuitive conducts (Napier & Vuong, 2013). The difference is that they would be much more instantaneous due to the rapidity of the Internet, and largely based on analytics data provided by the platform. While these strategies are predicted by the model above, it is important to note that this type of one-person entrepreneurship depended on two layers of policies: those of their platform (private) and those of the government (public). The additional layer of private-based policies meant additional strategic interactions to be taken into consideration by those who aspire to be computational entrepreneurs.

Among all recent technological achievements, perhaps artificial intelligence (AI) deserves a special mention. AI as a concept and technology had made its way into many fields, including medicine (Hamet & Tremblay, 2017), philosophy (Sloman, 1971) and, quite often, economics (Dirican, 2015; Wright & Schultz, 2018). AI in business has gathered particular attention in the extant literature, yet it is usually larger firms and the use of automation that were discussed. Little has been said about the entrepreneurial firms utilizing AI technologies, such as BenchSci, a machine learning-based search engine on antibody-related data in medical journal articles (https://www.benchsci.com/), or UNSILO of Aarhus, a firm specialized in providing AI technologies that had worked with ScholarOne to bring AI into the academic peer-revision process (Heaven, 2018). If AI could be considered more impactful on society and the economy than the Industrial and digital revolutions combined (Makridakis, 2017), then it would not be far-fetched to believe that AI and machine learning-based small firms – or even micro-firms – such as these computational entrepreneurs would one day become the driving force in economies. Nevertheless, this outlook is mitigated by the fact that successful tech startups were often sought out and bought by large giants (Techworld Staff, 2018). While this is largely private matters that depended on individual entrepreneurs, institutional actors should also keep in mind that computational entrepreneurs, albeit often small, are still a thriving group of economic actors that is still evolving, so long as AI technology and the philosophy of science and data keep developing.

A more concrete issue that should be of concerns to policy makers when it came to machine learning and data-based economic activities is ethics, as computational entrepreneurship largely relies on data mining and the computation and analysis of said data. A notable case would Netflix's use of advanced algorithms to track individual preferences of content, personal device, screening time, etc. Data are then used to make decisions on film investment and to improve content to keep its subscribers stay (Simon, 2014). Netflix is still able to maintain its boundaries, while other companies may not. The year 2018 had witnessed many privacy scandals related to tech companies, such as the case of Google analyzing search data to generate relevant marketing content to viewers or Facebook private user information being spoiled to big companies targeted advertisements (Dance, LaForgia, & Confessore, 2018).

In a world more networked than ever, with the sharing economy becoming more and more present in general economic activities (Hamari, Sjöklint, & Ukkonen, 2016), it was no wonder that concerns over privacy had seen an outbreak in the past years. Perhaps as a response, governing institutions around the world had taken actions: an illustrative example would be the EU General Data Protection Regulation, one of the strictest data protection law in the world (Council of the European Union & European Parliament, 2016) The challenge here is to strike a balance between protecting user privacy and leaving corporates a

sufficient marge de manoeuvre. More precisely, big tech companies have transformed from mere service providers into platforms for computational entrepreneurship with many small businesses growing on top of theirs, as seen in the example of YouTube above, but also the case of Uber or Facebook. Policy-making bodies need to take this into account to manage the ethical aspect more efficiently without thwarting the growth of a new entrepreneurial ecosystem. This includes not demonizing corporations who are providing platforms for the new form of entrepreneurship in the public eye. This could only be done by seriously considering computational entrepreneurship as an academic discipline on its own and ensuring that its meaning is well communicated to the public to avoid unfounded distrust (Vuong, 2018).

The first seeds of critical thinking were sowed when Socrates walked around Athens and debated with the citizens. Gradually, the reasoning process demanded evidence, whether to confirm a pre-existing theory or to construct a yet-to-be theory. It was then that science was born. The scientific method solidified itself by empirical statistics. In the beginning, statistics was used as an adjective that came before a field, such as "statistical mathematics" (Aitken, 1942). As empirical science branched out into more specific fields, the word "statistics" alone had become too general. Among other terminologies that had been used, "computational" was an option. First used in chemistry, physics and biology (Clark, 1985; Krogh, Brown, Mian, Sjölander, & Haussler, 1994; Potter, 1973), the term then entered social sciences with computational economics (Amman, Tesfatsion, Kendrick, Judd, & Rust, 1996) or computational folkloristics (Vuong et al., 2018). Today, fields qualified as "computational" most often handle huge volumes of complex data and supplement theoretical studies. The complexity of data and algorithms does not exclude entrepreneurship. Computational entrepreneurship has been gradually growing as a phenomenon and would only further develop into a long-standing category on its own. The current movement of the world's economy, with its revolving around start-ups and the rise of "computational entrepreneurship," will bring entrepreneurship back to the mainstream of economics and expand the territory of economics studies. It would be reasonable to expect an academic discipline dedicated to this form of entrepreneurship.

AFTERTHOUGHT AS A CONCLUSION

Humanity has always been surprising itself by its curious and inventive nature. Technology has developed to the point where the most groundbreaking discoveries, inventions, and theories from the past – constitutional laws, antibiotics, and electricity, to name a few examples – is today taken for granted as mundane reality. Machine learning and AI technology seem to be no exception to this, especially when they are often integrated into both personal life and economic and academic activities through other technological applications. It is then perhaps reasonable to envision a world where computational entrepreneurship and micro firms, even one-person firms such as in the case of YouTubers, have become so successful that its widespread existence becomes another stylized fact.

As Tversky once said, "He who sees the past as surprise-free is bound to have a future full of surprises", the similar logic could lead to if you take the part for granted, then you might really be surprised by how many of the outlandish things you doubt today will become the reality of tomorrow. Can we think of a more radical computational entrepreneurship system where the majority of entrepreneurs are robots of all type?

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