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Impact of additive manufacturing on the Vietnamese transportation industry: An exploratory study

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ABSTRACT

International firms' activities and structures have become highly complex as a result of managing a vast network of entities located around the world. Complex technology such as Additive Manufacturing or generally accepted as 3D printing has received universal interest. Economic growth in Vietnam generates unique infrastructure, logistics services and transportation challenges and opportunities. Logistics are a critically important priority in international trade, foremost in ongoing regional economic expansion. The main objective of this paper is to examine the impact and benefits of advanced technology, affecting logistics services and transportation in Vietnam. This research applied a descriptive survey methodology to gather primary empirical data on the awareness and the willingness to adapt to the technology of organizations focusing on opportunities for the Vietnam market. The results indicated that organizations have a positive attitude towards 3DP impact. The stronger influence was discovered on customization, new customer value proposition, the competitive advantage, and transportation and storage cost reduction. Vietnam is currently one of the most attractive emerging markets in the world. The findings from this research provide timely and valuable new insights into this phenomenon, as a potential mechanism for assisting the revolution of the transportation industry towards improving traffic congestion and pollution.

1. Introduction

Over the past years, the world has been experiencing a rapid growth of new advanced manufacturing technologies such as; 3D printing (3DP), also recognized as Additive Manufacturing (AM), which engenders new opportunities for the transformation of manufacturing processes throughout the supply chain (Despeisse et al., 2017; Steenhuis & Pretorius, 2016). The benefits and sustainable impacts of such technologies remain uncertain and indeterminate; therefore, demand a comprehensive understanding of the information flows and the relationships concerning stakeholders and products in a supply chain (Evans, Bergendahl, Gregory, & Ryan, 2009).

Ever since the mid-1990s, supply chain management has been acknowledged and classified as an important and significant role amongst the practitioners and experts (Akbari, 2013; Akbari & Hopkins, 2016; König & Spinler, 2016), where, the competition today is realized within the supply chains (Christopher, 2016; Schinckus, Akbari, & Clarke, 2019). As a result of the rapid growth of today's supply chain and the importance of effective operations, transportation and logistics had been underscored and given a substantial interest (König & Spinler, 2016; Chopra & Meindl, 2015).

Alongside the significance of advance innovation, the distribution of manufacturing and subsequent flow of goods and materials will be substantially affected by the utilization of technologies such as 3DP (Boon & Wee, 2018; Gebler, Uiterkamp, & Visser, 2014). The 3DP, prized as advanced technology, is described as a process of materials bonding (layers upon layers) to form a three-dimension (3D) objective (Despeisse et al., 2017). In the midst of advantages offered by the technology, "freedom of design" and "mass customization" are posited to be some of the most valued and recognized features of 3DP (Ford & Despeisse, 2016; Rayna & Striukova, 2014, pp. 119–132; Petrick & Simpson, 2013a; Berman, 2012).

Durach, Kurpjuweit, and Wagner (2017), presented their research paper with an inspiration scenario where a visit to the nearest shop to purchase a needed product is no longer necessary in the future; you only need to buy the digital CAD model online

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and print the product at home. However, there has yet to be an answer for the concern "who will be responsible for the warranty procedure"; the production company, printer manufacturer, or the printing materials (ink) firms?

In general, 3D printing is the transformation of the digital world into the physical world, not only software usage. For instance, the technology is already being utilized to build a small village of 50 homes in Latin America (Wang, 2019). Boffey (2018) also reported a similar project in the Dutch city of Eindhoven. Regarding the transportation aspect, an electric car project named LSEV was successfully printed using 3D printing (Ramirez, 2018). Additionally, a Lamborghini was successfully printed by a Colorado physicist named Sterling Backus (Glon, 2019). The technology does not only stop at daily-life usage but is also utilized in highly intricated transportation field such as the aviation industry. Airbus' chief technology officer, Grazia Vittadini, attested that 3D printing enables the manufacturing process of "highly complex parts that were just not achievable by means of standard cutting" (Kottasová, 2018). Furthermore, 3D printing is also employed by the military to "increase the readiness of military vehicles and other units" (Dorsey, 2019). With a potential to change every known aspect of the transportation industry as well as the potential to enable the creation of products that otherwise cannot be produced by the traditional manufacturing process; it can be argued that 3D printing has a direct connection to the transport industry.

In recent decades, the economy of Vietnam has progressed and advanced rapidly, as of today; Vietnam positions itself as one of the fastest developing and one of the most attractive emerging markets in the world (CNBC, 2015). The country entices a huge amount of Foreign Direct Investment (FDI); US$14.5 billion as of December 2015 (CNBC, 2015). Moreover, the CNBC (2015) informed of 6.68 per cent economic growth for Vietnam in 2015 and followed by an average growth of 7.26 per cent for the period of 2002 to 2010 (Clarke, Akbari, & Far, 2017). This rapid growth is also sustained by 9.4 per cent in manufacturing (CNBC, 2015). Unsurprisingly, Ho Chi Ming City (HCMC) in Vietnam is anticipated to be the second fastest-growing economy in Asia by 2021 (Tu, 2017).

The current literature attested that since most studies concerning the implications of 3DP for the logistics industry were conducted in the specific perspectives of companies and not the entire logistics industry. Consequently, the knowledge regarding the impacts of 3DP upon the manufacturing and transport sectors are severely lacking (Holmström, Holweg, Khajavi, & Partanen, 2016; Laplume, Petersen, & Pearce, 2016). For that reason, the main objectives of this paper are to discover, scrutinize and document the potential impact and benefits of advanced technology, such as 3DP, upon the Transportation Industry of Vietnam. While there are some study models which exist in developed countries practising sustainable supply chain, it might not be applicable or suitable for developing countries. Companies from emerging economies, such as Vietnam, encounter challenges attributable to the modest infrastructure, the lack of expertise, and the availability and accessibility of technologies. Evaluating and delving into the impacts and benefits of 3DP in Vietnam, where a lack of particular academic literature exists, therefore, could expound new insights into Additive Manufacturing (AM) as well as sustainable supply chain challenges not limited to Vietnam, but also possibly for emerging markets. To resolve the mentioned issue, the researchers will thereby concentrate on analyzing the status of research in this discipline, future opportunities, and fulfilling the following research question;

RQ1. *With the imminent changes to the supply chain, what is the impact of additive manufacturing (3DP) on the transportation industry in an emerging market*?

Keeping the objective of fulfilling the RQ1 in mind, the researchers will rigorously examine the current literature on 3DP, and Vietnam's economic growth and transportation infrastructure before presenting the results and discussion of this study.

2. Overview of literature

2.1. Additive manufacturing (AM) and 3D printing (3DP)

The idea of AM grasped substantial attention in 2014, where an electric car was printed for the first time in history (Durach et al., 2017). The printing process took about 44 h (Laliberte, 2014). The 3D printing is a process of joining matter, to produce a product layer-by-layer using 3D model data in a computer-aided design file (Dwivedi, Srivastava, & Srivastava, 2017); this "additive" manufacturing is different from the traditional "subtractive" manufacturing technologies (ASTM International, 2012). The 3D printing has a very precise control over the shape or surface of the objects (Fernandez & Coninck, 2019); thus grants the users the ability to construct highly intricate and complex products from a variety of materials namely, plastic, metal, ceramic, sandstone, resin, biomaterial and food substance (Rogers, Baricz, & Pawar, 2016). An author such as Conner (2014), highly values the flexibility of 3DP; stating this as "unparalleled levels of customization", to the fact where each printed component/product can be a new unit, "one of a kind".

Some of the most widely recognized and utilized AM technologies are: digital light processing, stereolithography, fused deposition modelling, laser melting, and selective laser sintering (Oettmeier & Hofmann, 2016). AM is regarded by researchers as a disruptive production technology which initiatives innovation and flexible manufacturing, streamlines supply chain planning (Holmström, Liotta, & Chaudhuri, 2017; Khorram Niaki & Nonino, 2017; Jonsson & Holmström, 2016), diminution of transportation costs and lead time and warehouse space requirement reduction (Sasson & Johnson, 2016). Furthermore, AM also has the potential to engender less wasteful or even a circular economy (Despeisse et al., 2017). 3DP has been principally adopted in industries where customization is compulsory and/or highly favourable namely; "aerospace" and "medicine" (PwC, 2013; Rengier et al., 2010) and in the more recent "wood-furniture sector" of Italy (Murmura & Bravi, 2018).

For over two centuries offshore manufacturing from all over the world has benefitted from economies of scope and scale (Wagner & Walton, 2016). Manufacturing from remote multiple locations based on materials and parts coming from numerous other locations including sourcing, production, storage, and shipping process before final product assembly can be completed (Thomas & Gilber, 2014). This, in turn, increases the costs of storage and transportation as well as extending lead times. To put this in perspective, customers may wait for extended periods of time before receiving their final product (Thomas & Gilber, 2014). However, with 3D printing technology escalating single location production of multiple parts not only shortens lead times but reduces the channels of distribution (Bogers, Hadar, & Bilberg, 2016). Consequently, products can now be manufactured "on-demand and close to the location where the actual demand occurs" which leads a reduction on lead times, lower freight volume and transportation costs (Bogers et al., 2016; Durach et al., 2017; Holmström & Gutowski, 2017; Kunovjanek & Reiner, 2019). Another aspect of using 3D printing is the opportunity to print spare parts for trucks, trains, aircraft and ships on the go without any delay. This can also lead to a significant improvement in flexibility, speed and cost for logistics and transportation. This method has been first used by the aerospace industry when the tools and parts were not available on the spaceships during their journey and it took months and years to deliver them. To illustrate this, Fig. 1 was developed.

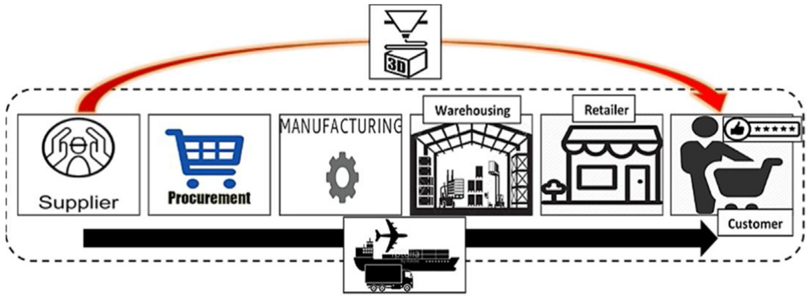

Fig. 1. Impact of 3DP on logistics & supply chain.
Source: Adapted from Akbari (2018), Özceylan, Çetinkaya, Demirel, and Sabirlioğlu (2018).

Notwithstanding it, rising popularity, upon an examination into the contemporary literature attests that many of the current studies concerning 3DP incline to disregard AM effects on the supply chain such as inventory and transportation costs along with reduced risk to supply disruption (Sidoryk & Tirougnanassambandamourty, 2018). Furthermore, 3DP technologies have been posited by Ellinger and Chapman (cited in Durach et al., 2017) to be significant and well-timed as well as having extensive implications for business (Oettmeier & Hofmann, 2016; Steenhuis & Pretorius, 2017), Bogers et al. (2016), Sasson and Johnson (2016) and Holweg (2015) and has cast a shadow on the matter and established that AM would complement today's production process instead of superseding the traditional manufacturing process entirely, at least for the short and medium-term. 3DP will continue to be overshadowed by the traditional manufacturing process in industry sectors where cost is one of the key considerations and customization is rarely demanded or unfavourable (PwC, 2016).

In spite of the fact that 3DP has existed since the 80s, the technology is still in its infancy in both adoption and research (Schniederjans & Yalcin, 2018). It has been scrutinized and rightly pointed out by Weller, Kleer, & Piller (2015) that most of the contemporary academic research in this area is theoretical, limited to predicting/envisaging the influence of this new technology on market structures. Matias and Rao (2015) also concurred with this viewpoint and added that thus far the literature has been mainly theoretical rather than focusing on adoption. The work of Matias and Rao (2015) also explicated that while many studies have pointed out the benefits of 3DP, they all assumed the widespread adoption of the technology for both rapid prototyping and finished goods manufacturing.

3D Printing has advanced from mainly being utilized for prototyping to a formidable contender for traditional volume/variety trade-offs in manufacturing (Bozarth & Handfield, 2008). In light of that, numerous studies had set out to identify the potential impacts of 3D printing upon the logistics and transportation industry. Examining the study of Weller et al. (2015) and Petrick and Simpson (2013b), it can be reasoned that some potential impacts of 3D printing are "greater customization", "new customer value proposition" and "competitive advantage" as the technology allows the manufacturers to engage in situations where production volumes are small while end-user customization requirement is high; as well as enables the production of parts and features that otherwise cannot be manufactured by traditional manufacturing. Researchers such as Khajavi, Partanen, and Holmström (2014); Rehnberg and Ponte (2018) revealed potential impacts such as "spare parts availability" as 3D printing can disrupt the existing spare parts supply chain. Moreover, authors such as Lerch and Gotsch (2015); Vendrell-Herrero, Bustinza, Parry, and Georgantzis (2017) signified potential impact as "eliminating product ranges (user capability to print at home)" as customers can now print the physical version of a chosen product using online data; thus, permitting the "reduction in transportation and storage costs" (McKinnon, 2016). Furthermore, potential impacts such as "better supply chain response times", "greater flexibility and adaptability" and "reduce stock/wastage across supply chain" were observed as 3D printing shortens the product development cycles (Rehnberg & Ponte, 2018) lower energy usage and reduce CO2 emission (Gebler et al., 2014).

Edwards and Hopkins (2018), categorized the current preparation activities for adoption of new technologies such as 3DP into 'Hiring new staff or experts', 'Investing in upskilling current staff by providing in-house training and workshops or Research and Development (R&D)', 'Informal or ad-hoc research and self-education', 'Establishing partnerships with specialist firms', 'Formal research and Investigation', 'Contracting-out development and implementation', 'Negligible investment', and 'No future investment'. Keeping the dimensions in mind, the authors proceeded to review the current situation of Vietnam economy, transportation infrastructure in order to realize the potential impacts of 3DP in the transportation industry in Vietnam.

2.2. Vietnam

2.2.1. Economy and growth

Vietnam is one of the eleven members of the South East Asia Community and is recognized as one of the fastest developing countries in the world (CNBC, 2015). Vietnam is considered as an important market and one of the crucial geopolitical players of the Southeast Asia region (Ngoc Phi Anh & Nguyen, 2013). Historically, Vietnam was one of the poorest nations in the world (Dollar, Glewwe, & Agrawal, 2004); during 1975 to mid-1980, the failure of the Soviet-style central planning economic system in Vietnam (Minh Ngoc, 2008) threaten the economy's stability and thus demanded an economic reform. The Vietnamese government implemented the greatly needed economic reform at the end of 1986 (Minh Ngoc, 2008) under the name "Doi Moi" (Nguyen & Trinh, 2018). The economic reform was proven to be a correct and wise decision made by the Vietnamese government. The "Doi Moi" had drastically changed Vietnam's economy; from severe stagnation in the 1980s to an average GPD per capita annual rate of around 7 per cent (Nguyen, Linh, & Nguyen, 2013) and an economic growth rate of 6.66 per cent (Nguyen & Trinh, 2018). The Vietnam Living Standard Surveys (VHLSS) (cited in Nguyen et al., 2013) also published that the poverty rate had sharply declined during the 1993–2008 period (58 down to 14 per cent). Recognizing the potential advantages of the Foreign Direct Investment (FDI) could provide; the Vietnamese government loosened its investment policy and permitted 100% foreign-owned investments (Osman-Gani, Ahmed, & Ling, 2001).

Consequently, Vietnam has become one of the most attractive emerging markets (Akbari, Clarke, Dang-Pham, & Nkhoma, 2017) in the world; an enticing massive amount of FDI; $14.5 billion as of December 2015 (CNBC, 2015). Furthermore, Vietnam has become

Table 1
Vietnam information.

Logistics Performance Index (LPI) (out of 160 countries)		39	Rank
Vietnam's Infrastructure Quality (out of 144 countries)	Quality of Roads	89	
	Quality of Air Transport Infrastructure	86	
	Quality of Port Infrastructure	77	
	Quality of Railroad Infrastructure	52	
	Overall Quality of Infrastructure	79	
Vietnam expected logistics cost allocation	Transportation	59%	
	Others	41%	

Source: Adapted from Anh (2018), Lotova (2017), and World Bank (2018).

the second-largest coffee producer in the world, one of the top-ten garment exporters and a leading furniture exporter; high-tech products are now being manufactured and developed in the country by multinational organizations such as Samsung, Intel, IBM, Fujitsu, Nokia and Canon (Nguyen & Robinson, 2015). In term of logistics development and investment, the sector has attracted many Third-Party Logistics (3PL) multinational companies such as DHL, Schenker, Kuehne + Nagel, and Gemadept (Tan, Hilmola, & Binh, 2016). Despite the astounding recovery and growth, Tan et al. (2016) posited that high inflation rate and the continuously depreciating currency (Dong) are the two main limitations of Vietnam. However, the work of Nguyen and Trinh (2018) suggested otherwise; stating that the inflation rate is controlled and at an acceptable level.

2.2.2. *Transportation infrastructure in Vietnam*

The US Chamber of Commerce (cited in Assavavipapan & Opasanon, 2016) divided the basic infrastructure of a country into four different domains, comprising energy, water, transportation and broadband. Respectively, each component is fundamental for the national economic prosperity, business competitiveness and welfare (Assavavipapan & Opasanon, 2016). For that reason, a good-quality infrastructure is vital for overall economic growth (World Bank cited in Bbaale, 2018; Ismail & Mahyideen, 2015; Escribano, Guasch, & Pena, 2010).

The preferred mode of transportation for the majority of Vietnamese is the motorcycle (accounts for 95 per cent of total vehicles) (Le & Blum, 2013), and the number of registered motorcycles in 2013 amounted to about 37 million (Ivers et al. and the Ministry of Transport cited in Le & Blum, 2013). Tu (2017) reported that HCMC is projected to be the fastest-growing city in Asia by 2021. The predicted growth is expected to accompany by numerous crippling traffic congestions; as HCMC is notorious for having a history of weak and now outdated, infrastructure (Saigon News, 2018).

The limited, inadequate usable transit space within and around cities, in addition to the increasing demand for road use in areas that lack well-planned urban systems coupled with scant alternative modes of travel (subways, trains, trams, or metro lines) are proposed to be the primary reasons for the traffic bottleneck (Akbari & Hopkins, 2019). The limitation has been reflected in the work of Yean and Das (cited in Dang & Yeo, 2018) which established that Vietnam has suffered from poor quality transportation infrastructure, has led to high logistics expenses and competitiveness reduction in the logistics industry.

Vietnam quality of the infrastructure is currently ranked 89th in quality of roads, 86th in quality of air transport infrastructure, 77th in quality of port infrastructure, 52nd in quality of railroad infrastructure and 79th in the overall quality of infrastructure (Lotova, 2017; Australian Trade & Investment Commission, n.d). Furthermore, Vietnam ranked 39th of 160 countries in term of logistics performance index (LPI) comparing to Singapore at 7th place and Malaysia at the 41st place (World Bank, 2018) (see Table 1).

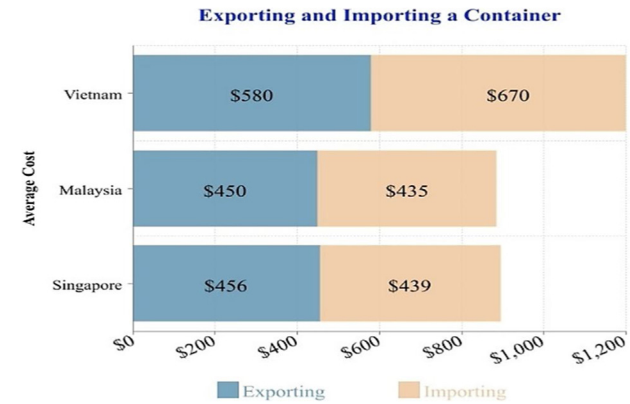

Fig. 2. Vietnam exporting and importing average cost.
Source: adapted from Thu (2012).

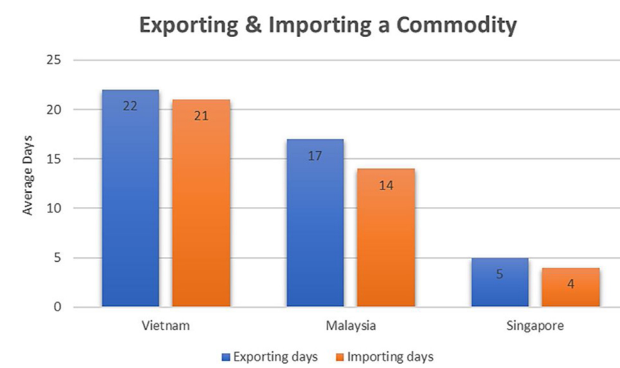

Fig. 3. Vietnam exporting and importing average days.
Source: Adapted from Thu (2012).

Accordingly, Vietnam's average cost for exporting and importing a container was US$580 and US$670, much higher compared to US$456 and US$439 for Singapore, and US$450 and US$435 for Malaysia (Thu, 2012). Additionally, Thu (2012) also reported that average time for exporting and importing a commodity for Vietnam was 22 and 21 days; in contrast to Singapore (5 and 4 days), and Malaysia (17 and 14 days) (see Figs. 2 and 3).

To remain competitive, great investment in infrastructure is desperately needed and highly favoured. Granting large scale infrastructural projects for public service are exceptionally difficult to commence (Narayanaswami, 2017), Thanh and Dapice (2009) attested that the significant infrastructure challenge facing Vietnam is not inadequate levels of investment but rather investment inefficiency. Nonetheless, the Vietnamese government is well aware of the importance of logistics centres in the logistics industry in particular and economic growth in general; as such, a master plan for the development of a nationwide network of logistics centres was approved in 2015 (Pham, MA, & Yeo, 2017).

3. Methodology

The research follows a three-step approach to identify the impact of additive manufacturing, especially 3DP, on the transportation industry in Vietnam. We adopted the following three steps (see Fig. 4).

Step 1. The first step for any research papers was to identify and review the available literature (Akbari, 2018; Denyer & Tranfield, 2009). A literature review considered a methodology to identify and analyze the available articles systematically, to produce a clear picture and identify a gap for future research in a discipline area (Denyer & Tranfield, 2009, chap. 39; Jafari, 2015; Seuring & Müller,

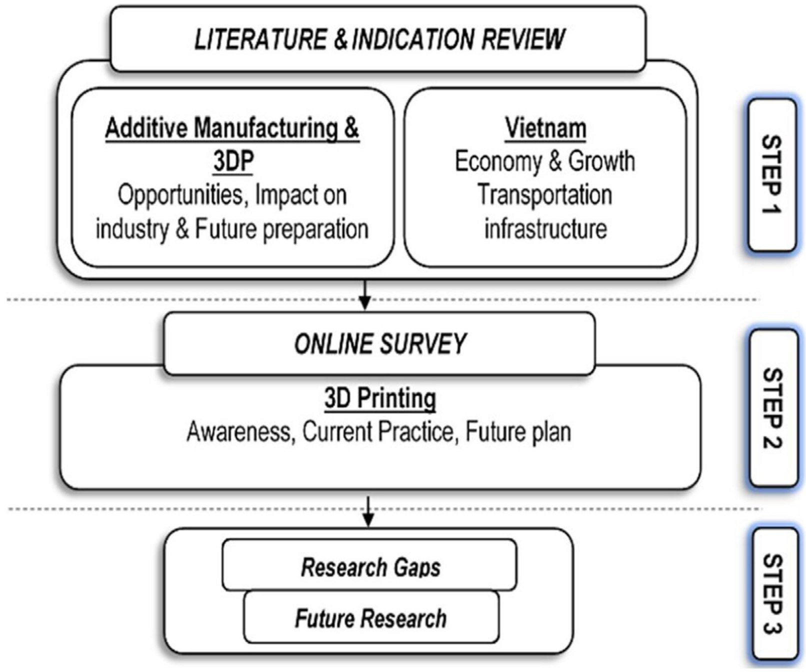

Fig. 4. Research methodology steps.

Source: Adapted from Akbari (2018) and Akbari and Hopkins (2019)

Table 2
Summary of online survey questions.

Demographic information	Gender, age, position, company size
Additive manufacturing/3DP	Current use, impact to the organizations, partners and sector, prediction impact of 3DP in the industry, current preparation, and future investment on 3DP

2008). As a result, an evaluation of the existing literature is incorporated as the initial step in this investigation.

Step 2. In the second step, a descriptive online survey was implemented to collect an instant "snapshot" of the phenomenon explored from a diverse population (Galliers, 1990). The descriptive survey enables the investigators to effectively source the opinions, attitudes, and preferences of participants (McMurray, 2004). In conducting this investigation, an online survey enabled the researchers to associate immediately with senior managers, CEOs, and Directors of 65 transportation companies in Vietnam; one questionnaire from each company. Additionally, due to the fear of leaking out business secret through information sharing, Vietnamese firms usually share information with their strategic partners (Pham, Nguyen, Mcdonald, & Tran-Kieu, 2019; Shieh-Liang, Tran, & Ha, 2016). Thus, severely limiting the data collection process.

A set of 20 questions included in the online survey featured a range of multiple-choice, Likert scale, and open-ended text field questions (see Table 2).

The online survey tool Qualtrics was adopted as the research platform for this investigation, and data were bundled into SPSS for examination and analysis. To recognize any and all relationships that might exist in the collected data, a mixture of analytical techniques including descriptive statistics and linear regression was applied. Furthermore, a Monte Carlo simulation was conducted to generate distributions of feasible values for correlation analysis. Monte Carlo simulations are computational algorithms based on the use of random sampling (Cho & Liu, 2018; Metropolis & Ulam, 1949).

Step 3. In the final step for this investigation, after analyzing and examining all of the data using diverse analytical methods in which two outcomes were identified: (a) research gaps, and (b) future research directions for 3DP and its impact on logistics services and transportation industries in an emerging market.

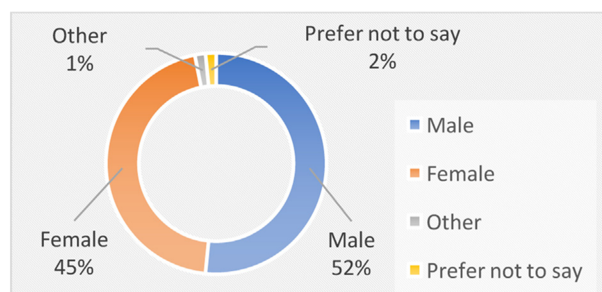

Fig. 5. Proportion of respondents by gender.

Permission was approved as a part of another study and acknowledged by RMIT University (HCMC, Vietnam) to contact the senior managers, CEOs, and Directors of companies in Vietnam. A clear statement was incorporated to clarify that participation was completely voluntary with no request for any personal details, and participants could withdraw from the online survey at any stage. The survey was initially developed in English and then translated into Vietnamese. The participants had the option to choose any of their preferred languages.

4. Results

A sample of 64 survey responses was collected from senior managers, CEOs, and directors in the Transportation and Logistics Industry of Vietnam. Fig. 5 illustrated that the majority of participants are Male (52 per cent) followed by Female (45 per cent), with 1 per cent Other and 1% Prefer not to say. In term of the respondents ages, Fig. 4 demonstrated that a significant portion (84 per cent) of the respondents are 35 years old or younger (see Fig. 6) which have high potential/probability on generating or adapting new idea/3DP solution as the younger adults have been proven to adapt more

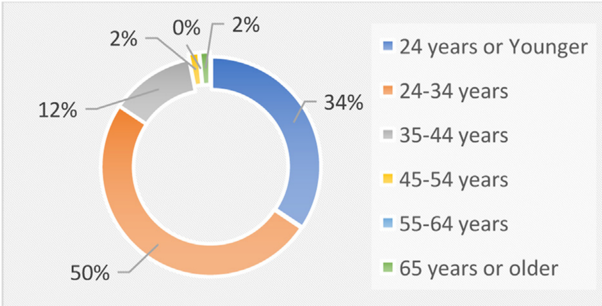

Fig. 6. Proportion of respondents by age.

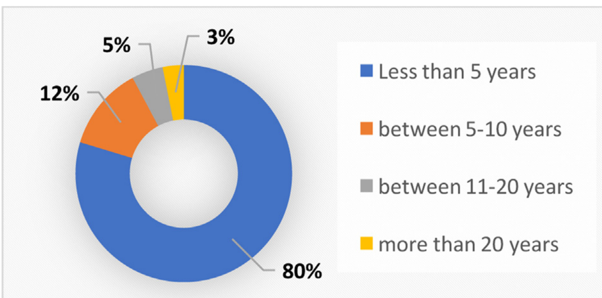

Fig. 7. Experience in supply chain professions.

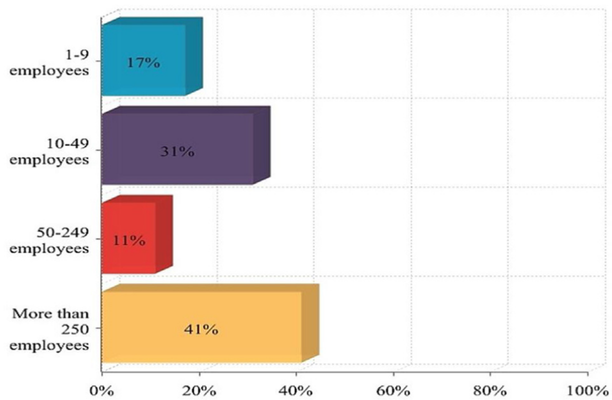

Fig. 8. Company size.

Fig. 9. Usage of 3DP technology.

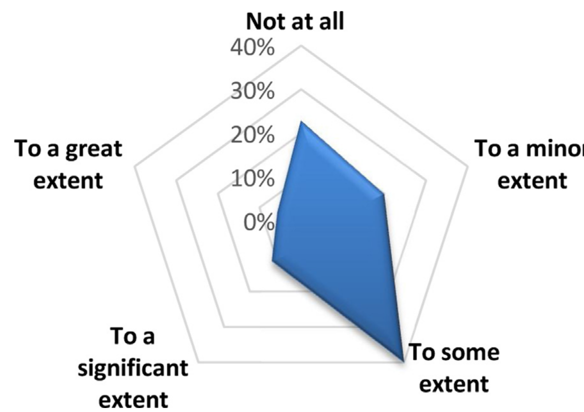

Fig. 10. Organizational impact of 3DP in the next ten years.

quickly to technology comparing to the older adults (Zickuhr and Madden cited in Van Volkom, Stapley, & Amaturo, 2014).

The majority of the respondents have less than five years of experience (80 per cent), followed by 12 per cent between 5–10 years, 5 per cent between 11 and 20 and only 3 per cent possesses more than 20 years of experience (see Fig. 7). These figures suggest that the industry is currently dominated by a large pool of young workforce which are likely to have high motivation and continuously expanding mindset towards their industry despite the lacking experience (Minh, 2016). However, they can accelerate the speed of learning by working in a well-experienced working environment. Despite the majority of the respondents possess little industry's experience, it can be observed that 41 per cent of the respondents are already working for large firms, 31 per cent work in small enterprises, 17 per cent work for micro and 11 per cent work for the medium firm (see Fig. 8).

According to the work of Cuong, Sang, and Anh (2007), the definitions of company size in Vietnam are as follow: micro enterprises (less than ten persons), small enterprises (10–49 persons) and medium-sized enterprises (50–299 persons). This meant a high percentage of the young workforce are currently working for large and medium firms which lead to a higher opportunity to be part of the professional procedure and sophisticated technological facility. Furthermore, large firms could have strong financial status to invest for better production and reduce cost. Therefore, they might have a higher chance to consider adopting new technology to their systems.

Surprisingly, Fig. 9 demonstrated that more than 66 per cent of the participants voted that their organizations currently have no usage for 3DP, 23% voted for the contradictory while 11 per cent do not know whether the technology is being used or not; indicating that more than half of the interviewed firms found no clear usage to their systems or cost-related matters. A similar pattern can be observed even in China, a neighbouring country and a global powerhouse. Players in the supply chain and the general public are reported to be unclear of 3DP abilities and limitations (Ipsos Business Consulting, 2015).

Consequently, the data behaviour in Fig. 10 can be somewhat explained by this phenomenon. Fig. 10 presents the viewpoint of the respondents regarding the impact of 3DP upon their organizations in the next ten years. Nearly half of the respondents (43 per cent) deemed that 3DP will engender minor to no impact while 17 per cent believed that there will be significant to great impact upon the industry. The remaining 40 per cent considered that there will be only some impact caused by 3DP. Nevertheless, due to the lack of awareness and usage of 3DP, it can be attested that the result in Fig. 9 is rather predictive than based on concrete evidence.

It is also worth mentioning that with the growth of technology and media coverage coupled with favourable policies from the Chinese government, 3DP industry of China is expecting to be valued at 9 Billion Yuan in the next few years (Ipsos Business Consulting, 2015). Hence, there is a possibility that the percentage of 3DP usage along with the future standpoint concerning the impact of 3DP

		Current usage of 3DP	Organizational impact for the next 10 years
Current usage of 3DP	Pearson Correlation	1	-.251[a]
	Sig. (2-tailed)		.047
	N	64	64
Organizational impact for the next 10 years	Pearson Correlation	-.251[a]	1
	Sig. (2-tailed)	.047	
	N	63	63

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.245*	.060	.045	.595

a. Correlation is significant at the 0.05 level (2-tailed).

Fig. 11. Relationship between current usage of 3DP and organizational impact for the next 10 years.

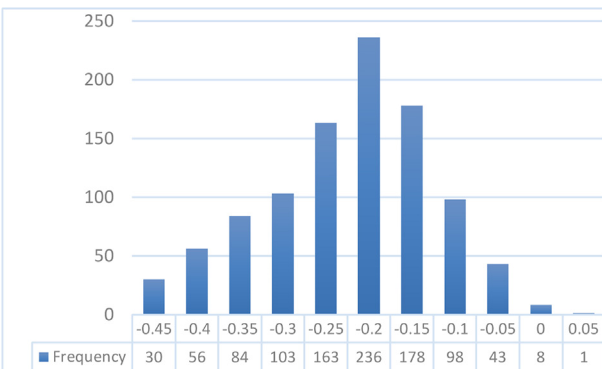

Fig. 12. Random sample distributions by Monte Carlos simulation (N = 1000).

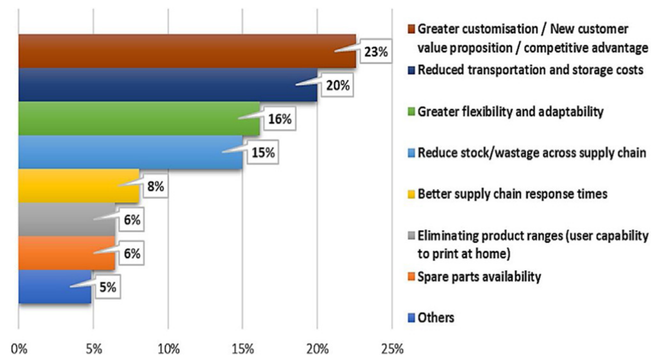

Fig. 13. Impact of 3DP in the industry.

of the Vietnamese firms would change in the near future when subjected to the same or similar conditions.

To examine the relationship between the current usage of 3DP and organizational impact for the next ten years (*where 1* = "*No*" and *2* = "*Yes*"), a standard linear regression was executed, and a negative correlation of -0.251 was identified. This negative correlation demonstrates that the evolving level of current usage of 3DPs and its impact prediction for the next ten years (see Fig. 11).

A Monte Carlo simulation was also performed, for further validation of possible outcome values of the random samples generated for both "current use of 3DP" and "organizational impact for the next ten years" to highlight the robust data pool and remedy the small sample size. This displays the distribution of the correlation coefficient between "current use of 3DP" and "organizational impact for the next ten years" for 1000 replications (see Fig. 12). This distribution indicates a robust negative relationship between the two variables.

Fig. 13 demonstrated the perceived impacts of 3DP in the industry from the interviewees perspective. The majority of the respondents believed in "Greater customization/new customer value proposition/competitive advantage" (23%), "Reduced transportation and storage costs" (20%) followed by "Greater flexibility and adaptability" (16%) and "Reduce stock/wastage across supply chain" (15%). Unexpectedly, most of the respondents did not think that 3DP will enable "Better supply chain responses times" and "Eliminating product ranges" despite believing in the reduction of stock/wastage, various costs and enhanced flexibility and adaptability.

This result is somewhat different from the result of the survey in Australia organized by Edwards and Hopkins (2018). Both respondents from the two surveys agreed that "greater customization", "reduced transportation and storage costs" and "reduce stock/wastage in the supply chain" are the strongest impacts of 3DP upon the industry. However, the Vietnamese firms did not believe in the "Better supply chain responses times" and "Eliminating product ranges" and "Spare part availability" as opposed to the Australian firms.

This is an interesting perspective as the application of AM will impact the manufacturing, parts and component production systems can benefit many industries including medical, aerospace and more. The implication for AM into logistics and supply chain can be significant for both upstream and downstream key players. Progress of material development will make a difference to in the implementation of AM in production and especially logistics where the machinery will transfer to their final location, the design will also transfer electronically, and the movement of materials will be the most significant part of transportation (Silva & Rezende, 2013). This will result in a significant reduction in logistics activities where the end customer's products can be produced in any location, resulting in a cost reduction for both transportation and warehousing. The materials or products will directly move from supplier to the end customer without any need for other supply chain players. This new model will create acute opportunities to develop new products and consumer distribution centres will be repositioned to remote locations. With that being said, the outcome of Fig. 13 engendered an interesting question "why did the interviewees believe in reduced costs and wastage as well as greater customization but disdain in the idea of better supply chain responses time?". For that reason, further examination is highly recommended.

To further the examination, and understand the current state of 3DP in Vietnam, the respondents were inquired about the preparation for the emergence of 3DP. The answers revealed that 19 per cent of the respondents would conduct formal research, 15 per cent

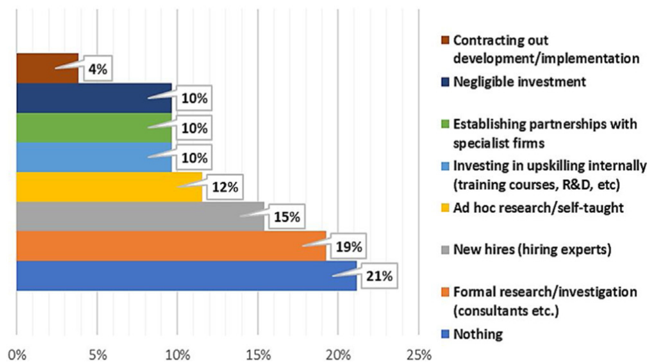

Fig. 14. Preparation for the continued emergence of 3DP.

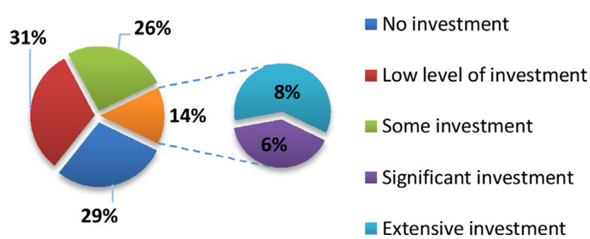

Fig. 15. Prediction for future invest in 3DP in the next ten years.

will hire experts, 12 per cent self-taught/ad hoc research and 10% will co-operate with specialist firms (see Fig. 14). Moreover, only 10 per cent of the firms responded that they would invest in upskilling internally. In another viewpoint, 21 per cent of the respondents will commit no preparation, and 10 per cent will invest negligible resources. The results seem to divide into two factions. On the one hand, firms that prepare for the 3DP emergence seem to head for the direction of outsourcing the preparation to the third parties rather than preparing for the technology themselves. On the other hand, other firms seem to be waiting for the technology to mature before committing resources.

The outcomes in Fig. 15 is foreseeable and expected since the majority of the respondents commit minimal resources or no preparation. As such, it is not unsurprising to see that 60 per cent of the respondents allocate little to no investment followed by 26% of some investment and only 14 per cent administer significant to extensive investment.

5. Discussion

3D printing expressed as a process using digital data for creating physical objects (Rengier et al., 2010). Authors such as Rehnberg and Ponte (2018) forecasted that technology would disrupt the existing supply chain and supplant traditional manufacturing (Rehnberg & Ponte, 2018). Moreover, the implementation of 3DP supports the reduction in transportation and warehousing costs, CO2 emissions, energy usage (Gebler et al., 2014), and perhaps outsourcing the cost of production to the end customer (Rayna & Striukova, 2014, pp. 119–132).

The outcomes from this study established that 66 per cent of the transportation firms do not use 3DP and 23 per cent of the respondents specified that there would be no future impact on the transportation industry. Past research in other countries has identified the least impact of 3DP on the industries. The results align with a recent well-conducted survey in Australia by Edwards and Hopkins (2018).

Despite 59 per cent of the industry practitioners indicating that they have little relevant working experience, 41 per cent of them are working for large transportation firms. Additionally, only a few respondents agree that 3DP has a great impact on the transportation industry while most of the respondents believe that the industry will experience only minor or no impact. While this contradicts much of the past research, the sample age was representing a young generation. Hence, it is significant to pursue further investigation before any generalized conclusion can be drawn.

In the process of examining data by the age of the respondents, it was also discovered that more than 80 per cent of the respondents are younger than 35 years old and have less than five years of relevant experience in the transportation field. For that reason, it can be presumed that the industry is still growing. Furthermore, the highest level of adoption for 3DP was observed in the large size transportation firms, which led to the authors' conclusion that the industry is growing but is still in the early stage of the development. As such, further research and investigation are required.

Many factors are affecting the data representation, such as context, geographical location, culture, economics, and many more. The following studies conducted in the context of other Asian countries offer invaluable insights concerning the observed outcomes. The Indian market is sensitive towards prices of 3DP technology, which in turn intensifies resistant among industrial consumers to opt for 3DP (Venkateswaran, 2015). The Korean market reported the lack of talent pool in the workforce, low-quality 3DP equipment and infrastructure as well as insufficient technology capability (Ng, Karlsson, & Kim, 2017a). The Chinese market is hindered by insufficient technological understanding, awareness, inadequate technology competency as well as a high cost to introduce the technology (Ipsos Business Consulting, 2015). Furthermore, the 3DP adoption in the Asia-Pacific countries is being hampered due to deficient capital investment, combined with the investors' "wait and see" attitude (Ng, Zhu, Law, & Niyomsriskul, 2017b).

Overall, the insights collected from respondents indicated the least practices in 3DP, which was also found the least expected to impact the Vietnamese transportation industry over the next decade. In the context of preliminary actions being taken, no further action along with the formal research or investigation, and new hires were the most common, signifying that most firms are not currently engaging their staff with more in house education and training.

6. Conclusion

In the era of technological disruption, chaotic demand ambiguity, varying consumers' behaviour and external risks such as pollution and climate change which substantially impacts the efficient supply of raw materials and services, 3DP has the potential to transform the entire logistics, transportation industry. With the extensive acceptance of 3DP by businesses, today's transportation is in a transformational phase, and the digital modernization is revolutionizing the landscape of existing business models globally. This study focused on the possibility of making major transformative changes by looking into the impact of additive manufacturing, especially 3DP in the transportation industry in Vietnam. RQ1 set out to establish the current practices and any plan for using or implementing 3DP.

The results of the survey suggested that organizations have a positive attitude towards 3DP impact; however, despite 77 per cent of the practitioners indicating a future impact, only 23 per cent are currently using the technology. 3DP is identified as the least anticipated technology in the transportation industry. It was interesting to note that 11 per cent of participants do not know whether their company is using the technology.

The impact of 3DP was found to be stronger on great customization/new customer value proposition, the competitive advantage and transportation and storage cost reduction. However, the most surprising result from this study was the aversion to the continued emergence of 3DP and future investments in the next ten years. This was a surprising result from this study and required further investigation.

A rise of interest in 3DP has a potential impact on the transportation industry especially in emerging markets, such as Vietnam, disrupting the current practice and impact on traffic congestion and pollution. As rapid technological disruption continues in Vietnam, a transformation like this must seriously take into consideration, as a possible mechanism for improving traffic congestion and pollution.

7. Limitations and Future Research Directions

The collected samples representing some of the age groups and industry categories and it was small, future investigation needed to collect more samples across the different cities and regions to be able to make a more meaningful judgement and consideration.

The researchers intend to conduct a comprehensive structured literature review from the leading journals in the discipline to acknowledge a deep understanding of what trends have occurred in additive manufacturing. The structured literature review which is increasing among researchers as a systematic method for gaining new insights from historical data, and assist the researchers formulating a general statement of the current technological phenomenon.

Future research will magnify the consideration for involving Additive Manufacturing companies and their contribution to the Growth Domestic Product (GDP) Index in developed and emerging countries.

Lastly, the research team also intends to extend the current investigation to other emerging technologies, such as IoT, Blockchain, Big Data, Drones in other emerging markets, so that technological practices in diverse cultures and locations can be evaluated and compared.

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