# The path of the adoption of digital technology to SMEs' business performance: evidence from China

Fen Lyu

# UNIVERSITE PARIS I PANTHÉON SORBONNE
## Ecole de Management Panthéon - Sorbonne
## UFR 06

Laboratoire de rattachement : PRISM

THÈSE
Pour l'obtention du titre de Docteur en Sciences de Gestion
Présentée et soutenue publiquement
le 8 décembre 2020 par

**Fen LYU**

## Titre de la thèse
# The Path of the Adoption of Digital Technology to SMEs' Business Performance: Evidence from China

**Sous la direction de Mme Catherine de LA ROBERTIE**
Professeure, Université Paris 1 - Panthéon Sorbonne

**Rapporteurs**
Mme Sylvie FAUCHEUX, professeure, Conservatoire national des arts et metiers, Paris, France
M. Yuming ZHU, professeur, Northwestern Polytechnical University, Xi'an, China

**Suffragant**
M. Kevin W. LI, professeur, University of Windsor, Ontario, Canada

UNIVERSITE PARIS I PANTHÉON SORBONNE
Ecole de Management Panthéon - Sorbonne
UFR 06
Laboratoire de rattachement : PRISM

THÈSE
Pour l'obtention du titre de Docteur en Sciences de Gestion
Présentée et soutenue publiquement
le 8 décembre 2020 par

**Fen LYU**

# Titre de la thèse
# The Path of the Adoption of Digital Technology to SMEs' Business Performance: Evidence from China

**Sous la direction de Mme Catherine de LA ROBERTIE**
Professeure, Université Paris 1 - Panthéon Sorbonne

**Rapporteurs**
Mme Sylvie FAUCHEUX, professeure, Conservatoire national des arts et metiers, Paris, France
M. Yuming ZHU, professeur, Northwestern Polytechnical University, Xi'an, China

**Suffragant**
M. Kevin W. LI, professeur, University of Windsor, Ontario, Canada

## Résumé

D’impressionnantes améliorations dans le domaine de la technologie numérique, comme le big data, la réalité virtuelle, l’enregistrement dans le cloud et l’intelligence artificielle ont continuellement et durablement pénétré plusieurs champs, qui ont redessiné le paysage de l’innovation en accélérant la croissance d’internet, la computation data orientée, l’aide en ligne portée par des plateformes et l’industrie de l’intelligence. La prolifération des technologies numériques accélère l’intégration avec l’économie réele, conduisant les technologies numériques à prendre de l’ampleur en tout. Tremplins pour l’emploi, les petites et moyennes entreprises (PMEs) sont l’unité de base, pour les développements économiques et les activités innovantes. Elles sont les parties les plus larges et les plus dynamiques sur le marché économique, et donc l’innovation digitale est l’enjeu de la survie et la croissance des PMEs chinoises. De ce fait, une compréhension claire d’à la fois les processus par lesquels les PMEs développent l’innovation digitale mais aussi les revenus qui découlent de l’innovation digitale en termes de part de marché et taux de profit sont importants.

La démonstration de cette thèse se base sur l’utilisation d’un cadre théorique conceptuel, la chaîne de valeur d’innovation digitales (CVID), et montre comment l’approche CVID permet de comprendre le processus de transformation digitale des PMEs. La valeur de la CVID est exprimée en montrant les interrelations clefs dans le processus de l’innovation digitale, en partant de l’adoption des technologies numériques (ATN) à travers l’innovation digitale vers la performance commerciale en ce qui concerne la part de marché et le niveau de profit.

Cette thèse a démontré de manière empirique que l’adoption des technologies numérique peut avoir un impact positif sur à la fois les réseaux commercials et personnels des PMEs. De plus, les résultats indiquaient que les réseaux hétérogènes, comprenant à la fois les réseaux commercials et personnels, rendus abordables par l’adoption des technologies numériques, permettent aux PMEs de constamment administrer des activités d’innovation digitale. Cette thèse étend la revue de littérature existante concernant la chaine de valeur de l’innovation en illustrant empiriquement l’importance des technologies numériques en regard des activités d’innovation digitale, en particulier pour les produits d’innovation digitale, le numérique dans le contexte du support en ligne, et l’innovation dans le cadre du business model, qui a une influence indirecte sur la performance de PMEs.

Un avantage clef de l’approche CVID est alors sa capacité à mettre l’accent sur les rôles des différents facteurs dans différentes chaines du noyau de la performance commerciale, et de montrer leur impact direct et indirect. Cette recherche apporte une contribution dans le domaine de l'innovation numérique visant à catégoriser les dimensions de l'innovation numérique en suggérant que l'innovation numérique implique l'innovation de produits numériques, l'innovation de service numérique et l'innovation de modèle d'entreprise selon la relecture des études précédentes sur l'innovation. Cela s'étend aux connaissances existantes sur la chaîne de valeur de l'innovation en illustrant empiriquement l'importance de la technologie numérique par rapport aux activités d'innovation numérique, en particulier pour l'innovation des produits numériques, l'innovation des services numériques et l'innovation de modèle d'entreprise. Cette recherche correspond également à la nécessité de fluidifier l'innovation numérique d'aujourd'hui, facilitant ainsi la diversité et la flexibilité de DIVC dans un environnement dynamique et sans limites.

## Summary

Impressive developments in digital technology such as big data, virtual reality, cloud computing and artificial intelligence have been continually and thoroughly penetrating various fields, which have reshaped innovation landscape by accelerating growth of internet of everything, data-driven computation, platform support and intelligence industry. The mushrooming of digital technology is accelerating the integration with the real economy, driving the digital innovation to expand with full extent. Small and medium enterprises (SMEs) are the basic units to promote employment, economic development and innovative activities. They are the largest and most dynamic parts in the market economy and thus digital innovation is central to the survival and growth of Chinese SMEs. Therefore, a clear understanding both of processes by which SMEs develop digital innovation and the benefits which flow from digital innovation in terms of market share and profit level is important. This thesis demonstrates the use of a conceptual framework, the digital innovation value chain (DIVC), and shows how the DIVC approach helps to understand the process in digital innovation for SMEs. The value of the DIVC is expressed in showing the key interrelationships in the process of digital innovation from adoption of digital technology (ADT) through digital innovation to business performance in terms of the market share and profit level.

This research empirically showed that the ADT can have a positive influence on both business networks and personal networks for SMEs. Furthermore, the results indicated that heterogeneous networks including business networks and personal networks afforded by ADT

allows SMEs to continuously deal with digital innovation activities. We extend existing knowledge about innovation value chain by empirically illustrating the importance of digital technology with respect to digital innovation activities, in particular for digital products innovation, digital service innovation and business model innovation , which has indirect influence on SMEs' business performance.

A key benefit of the DIVC approach is therefore its ability to emphasize the roles of different factors at various chain of the digital source-digital innovation-SMEs' business performance nexus, and to show their indirect and direct impact. This research provides a contribution in the area of digital innovation aimed at categorizing dimensions of digital innovation by suggesting that digital innovation involve digital products innovation, digital service innovation and business model innovation according to review on previous studies of innovation. It extends existing knowledge about innovation value chain by empirically illustrating the importance of digital technology with respect to digital innovation activities, in particular for digital products innovation, digital service innovation and business model innovation. This research also corresponds with the need to make today's digital innovation more fluid, thereby facilitating the diversity and flexibility of DIVC with regard to dynamic and boundless environment.

## Mots-clés

Chaîne de valeur de l'innovation numérique –Performance des PMEs

Adoption de la technologie numérique –Réseaux hétérogènes

## Keywords

Digital innovation value chain –SMEs' business performance

Adoption of digital technology –Heterogeneous networks

## Acknowledgements

I would like to thank my supervisor, Prof. Catherine de La Robertie, who offered me many precious opportunities for discussion and constant support during my PhD. It was a great honor for me to benefit from her exceptional experience, profound knowledge and useful comments. Owing to her, I have a chance to get into the academic world and I am always encouraged to continue as a researcher. Moreover, she acted as a role model to me not only academically but aslo in life. The most important thing I learned from her is her independence and also her spirit of persistence in developing her career, which have always encouraged me to extend the boundaries of my own life.

I gratefully acknowledge the help of Prof. Sylvie FAUCHEUX, for she accepted to become the rapporteur of my thesis and offered me valuable suggestions. From June, she has spent much time reading through the draft and provided me with inspiring advice. Without her patient instruction, insightful criticism and expert guidance, the completion of this thesis would not have been possible. I would also like to express my gratitude to the second rapporteur of my thesis, Prof. Yuming ZHU, because he devoted his valuable time to help my research and to show me what a high academic standard can be. A similary gratitude belongs to the member of the jury, Prof. Kevin W. LI. He spent a considerable portion of his time to reading my thesis and making suggestions for further revisions. His willingness to give me his time so generously has been much appreciated.

During my PhD studies, thanks to the Chinese Scholarship Council (CSC), I had the chance to come to Paris 1 to discover a different culture and discuss with great fellow students from PRISM, which was a source of inspiration. I would therefore like to give my thanks to my colleagues in Paris 1, with a special word to Prof. Negassi, Prof. Sattin, Abida, Hongfeng, Fengmei, Khaoula, Amine, Ghalia, Robin, Mehdi, Ahmed, Muhammad, Ibitihel for providing me such a friendly work atmosphere and their generous help.

I also had the chance to attend the courses and meet with different researchers and professors from ESCP who helped me to build my academic foundation.

Last but not least, I would like to thank my friend, Tim, who comes from the UK and has always been kind and patient in helping me to revise my editing. I also would like to thank my friends in Paris, without whose support I would not have come this far and my family for their unconditional love and encouragement, especially my daughter , who was always by my side to trust me, without whom none of this would have been possible.

## List of abbreviations

*CVID: Chaîne de valeur d'innovation digitales*

*PMEs: Petites et moyennes entreprises*

*ATN: Adoption des technologies numériques*

*DIVC: Digital innovation value chain*

*SMEs: Small and medium enterprises*

*IVC: Innovation value chain*

*DT: Digital technology*

*ADT: Adoption of digital technology*

*BN: Business networks*

*PN: Personal networks*

*DPI: Digital products innovation*

*DSI: Digital service innovation*

*BMI:Business model innovation*

*MS :Market share*

*PL: Profit level*

*EFA: Exploratory factor analysis*

*CFA: Confirmatory factor analysis*

*SEM: Structual equation method*

$x^2$: *Chi square*

*df: Degree of freedom*

*GFI: Goodness of fit index*

*AGFI: Adjusted goodness of fit index*

*NFI: Normed fit index*

*CFI: Comparative fit index*

*RMSEA: Root mean square error of approximation*

*SRMR: Standardized root mean square*

*Std.Dev: Standard deviation*

*AVE: Average variance extracted*

*CR: Composite reliability*

*C.R.: Critical ratio*

## Table of Contents

# Introduction in French

Durant les dernières décennies, le monde a traversé une révolution technologique et une transformation industrielle. D'impressionnantes améliorations dans le domaine de la technologie numérique, comme le big data, la réalité virtuelle, l'enregistrement dans le cloud et l'intelligence artificielle ont continuellement et durablement pénétré plusieurs champs, qui ont redessiné le paysage de l'innovation en accélérant la croissance d'internet, la computation data orientée, l'aide en ligne portée par des plateformes et l'industrie de l'intelligence. Du fait du développement de la technologie connectée, telle que l'omniprésence informatique, la converge digitale, les architectures tournées vers le service, l'enregistrement dans le cloud et l'open source, les frontières du temps, distance et fonctions au sens traditionnel du terme se sont chevauchées. (Yoo et al., 2010 ; Merali et al., 2012 ; Bharadwaj et al., 2013 ; Koch et Windsperger, 2017). Les technologies numériques ont pour un temps joué un rôle complémentaire dans la promotion de l'efficacité et la productive au travail, alors que du fait de l'arrivée d'objets intelligents, qui ont fait prendre à la technologie numérique une place plus centrale, et donc les technologies numériques ont rapidement pris le statut de propulseur d'innovations fondamentales.

*« Il se trouve que, la technologie numérique évoluant si rapidement, chaque industrie s'en trouve bouleversée. »*

Ce sont les propos de George Westermam, ingénieur de recherche au centre du Digital Business du MIT, et il est aussi l'un des investigateurs propulsant le Centre de Transformation Digitale. Le questionnaire proposé par Fitzgerald et al. (2014) montre que les cadres savent que la technologie digitale importe réellement. 78% des répondants affirment que la transformation numérique va devenir un enjeu majeur pour leurs entreprises dans les deux prochaines années. Moins de 5% des répondants ont exprimé que la transformation numérique ne deviendra jamais un enjeu majeur pour leurs entreprises. En même temps, 81% des cadres ont déclaré que leurs entreprises essaient déjà d'atteindre la transformation digitale. De présentes études menées par Capgemini Consulting and MIT's Center for Digital Business ont découvert que les entreprises qui investissaient dans les technologies numériques faisaient plus de profit que leurs homologues. Les personnes interrogées dans le questionnaire susmentionné pendent que l'incapacité à faire aboutir efficacement la transformation digitale portera préjudice à la capacité concurrentielle de leurs entreprises. (Fitzgerald et al.,2014).

Les nouvelles fonctionnalités des technologies numériques dans plusieurs secteurs d'activité causent de rapides changements dans le paysage de l'innovation.

Lori Beer, vice-président exécutif de la technologie de l'information et affaires spécialisées, à WellPoint, une des licences Blue Cross/Blue Shield les plus larges de la nation a déclaré que

*« Actuellement, nos produits et services sont en fait des clients nous encourageant, fournissant des possibilités pour les employeurs, de l'information, de la donnée, tout comme dans un scénario type de service financier. La technologie a toujours importé au commerce, alors qu'elle devient beaucoup plus stratégique, notamment dans ce domaine, lorsque l'on voit l'émergence de la technologie numérique. On voit une transformation dans comment les clients interagissent avec la technologie numérique. »*

La croissance des technologies numériques, les acteurs connectés, croisent toutes les facettes des industries et la société change la manière les manières de procéder en termes d'innovation, quel que soit leurs secteurs d'activités. Les technologies numériques envahissent nos vies à l'heure actuelle, il est absolument nécessaire de se mettre à jour, et de devenir porteur d'un changement stratégique pour bon nombre d'entreprises. Selon l'enquête de Fitzgerald et al. (2014), répondre efficacement et rapidement face aux technologies numériques est primordial pour la survie de l'entreprise. Le résultat de l'enquête montre que la gestion efficace des technologies numériques génère déjà des gagnants et des perdants sur des échelles mesurables, comme la part de marché et le niveau de profit.

***1. L'économie digitale est florissante à grande échelle en Chine***

Durant les dernières années, la Chine a attaché une grande importance au développement des technologies numériques et s'est consacré à la construction d'une économie digitale, la promotion d'une convergence numérique au sein d'une économie substantielle. Dans ce contexte, l'économie numérique en Chine fleurit à grande échelle, ce qui est déterminant pour la croissance économique et la qualité.

Selon un papier de recherche (Woetzel et al., 2017) du McKinsey Global Institute, la Chine possède l'un des plus vigoureux systèmes d'investissements numériques dans un écosystème de start-ups au monde. À l'échelle mondiale, la Chine a l'une des trois meilleurs cadres d'investissement en capital-risque, tels que la réalité virtuelle, les véhicules autonomes, l'impression 3D et l'intelligence artificielle.

Il y a 262 start-up licornes dans le monde, mais environ 87, soit un tiers d'entre elles sont chinoises, constituant 43% de la valeur globale .

Woetzel et al. (2017) ont prouvé que trois facteurs peuvent expliquer pourquoi l'économie digitale fleurit en Chine et pensent qu'il demeure encore un énorme potentiel pour doter lIl y a 262 start-up licornes1 dans le monde, mais environ 87, soit un tiers d'entre elles sont chinoises, constituant 43% de la valeur globale de ces sociétés.

La première raison est que la Chine est à la tête d'un grand marché qui permet la rapide comercialisation de la digitalisation à grande échelle. Le nombre d'interfaces centrées sur l'utilisateur chinoises assure des expérimentations perpétuelles et permet aux consommateurs de rapidement atteindre une économie numérique. Il a été rapporté que la Chine comptait 731 millions d'utilisateurs internet en 2016 et ce chiffre représente plus que la totalité de l'Union Européenne et les Etats-Unis. De plus, de jeunes acteurs numériques chinois sont passionnés de technologie, ce qui encourage la croissance numérique et facilite l'adoption de l'innovation et permet donc une économie numérique plus compétitive.

L'émergence et les applications invasives des smartphones contribuent aussi à la digitalisation active de la Chine.

Le second facteur est que les trois grands de l'Internet chinois ont établi un écosystème digital fluide qui profitent à bon nombre d'usagers, comme par exemple Baidu, Alibaba et Tencent (connues sous le nom de BAT). Pour le numérique, les entreprises BAT ont établi des positions clefs en efficacité informatique, et ont développé un éconsystème digitale multi-industries aux multiples visages qui concerne quasimment tous les aspects de la vie du client. Au-delà de ces trois géants chinois, d'autres sociétés numériques comme Xiaomi et Ping définissent aussi leur propre système. Beaucoup d'entreprises profitent de l'avantage du numérique parce qu'ils entretiennent des liens étroits avec les fabriquants de matériel informatique dans les zones littorales de la Chine. Ces grandes entreprises créent de l'innovation digitale en adoptant les technologies numériques afin de contribuer à la floraison de l'économie digitale chinoise.

Le troisième facteur est que le gouvernement chinois a accordé aux acteurs digitaux assez d'espace pour expérimenter leur modèle avant d'implémenter des mesures officielles et tient maintenant un rôle essentiel. Le marché gagnant en maturité, le gouvenrnement et le secteur privé sont rapidement devenus de plus en plus ouvert à façonner une digitalisation

[1] NdT, start-up avec une valorisation d'un milliard de dollars ou plus.

saine à travers des lois régulatoires. Le gouvenrmement chinois joue un rôle proactif dans la mise en place d'infrastrucutre de haut niveau pour faciliter la digitalisation, en tant qu'investisseur, dévloppeur et client.

2. ***Petites et moyennes entrprises (PMEs) font face à de nouveau défis de l'innovation digitale.***

Les PMEs sont les unités de base pour créer de l'emploi, un développement économique et des activités innovantes. Ils constituent les parts les plus dynamiques sur le marché financier. Le développement contrôlé et active des PMEs est lié à la structure sociale, les moyens économiques de transformations et la montée des sciences et de la technologie. En 2009, les PMEs constituent plus de 99,7% du nombre total de sociétés en Chine, générant plus de 80% de métiers urbains, créeant 60% du produit fini et services équivalant au PIB et payant plus de 50% des bénéfices et taxes. Les PMEs possèdent 65% des brevets d'innovation chinois et ont une part de 75% dans le dévloppement des technologies d'innovation et développent 80% d'un nouveau produit. (http://www.miit.gov.cn).

Les PMEs vont inévitablement jouer un rôle cruciel pour prendre en charge l'innovation digitale quand elles font face à un environnement strict et ulta-compétitif. L'émergence des nouvelles technologies, comme Internet et les ordinateurs ont commencé par les applications et pratiques du gouvermement et des grandes entreprises. Avec la montée de la technologie essentielle, l'amélioration constante de domaine d'application et avec un coût amoindri, les PMEs devraient représenter l'acteur pricipal qui adoptera et mettra en pratique les nouvelles technolgies à grande efficacité et à grande échelle. De fait, la position dominante au balbutiemments de la digitalisation doivent être les institutions à grande échelle, comprenant les grandes entreprises dans les structures de l'information. Cependant, comme les technologies numériques sont dépassées, les PMEs qui occupent la grande majorité des parts de la Chine vont prendre la place dominante sur le marché.

La floraison des technologies numériques représentées par la réalité virtuelle, le big data et l'intelligence accèlerent l'intégration avec l'économie réelle conduisant l'innovation à s'étendre dans tout leur potentiel. L'intégration des technologies numériqus par les PMEs permet non seulement leur transformation numérique mais procurent de nouveaux moyens et modèles pour leur innovations digitales et développment et élargi la nouvelle frontière commerciale pour le développement durable des PMEs. Les statuts et rôles financiers continuent d'améliorer, mais leurs taille, capacités de leurs ressources et caractéristiques managériales, il est difficile de soutenir leurs propres réponses individuelles pour la transformation digitale. Ainsi, comment guider efficacement et aider un grand nombre de PMEs quant à l'adoption des technologies numériques afin de présenter l'innovation digitale, a de l'importance.

### 3. *Le problème principal pour le SMEs dans un monde digitalisé. Comment créent-elles de la valeur en adoptant les technologies numériques, afin d'améliorer la performance de leur entreprise ?*

Les technologies numériques modifient les qualités des objets en les convertissant en structures d'éléments à couplage lâche et composants qui ne sont pas limités à des opérations ou fonctions (Yoo et al., 2010). Ceci indique que les créateurs de composants ne seraient pas totalement aptes à prévoir comment et dans quelle association digitale leurs produits numériques et services sont finalement adoptés. La limite du produit ne peut plus être vue comme limitée. Avec de telles hypothèses, créer de la valeur est devenu de plus en plus difficile, (Koch and Windsperger, 2017), notamment pour les PMEs. Sur la base des fabricants de produits traditionnels, les entreprises sont considérées comme créant de la valeur en augmentant les architectures de produits et en améliorant ainsi la qualité des produits (Vargo et al., 2008). Cependant, plutôt qu'une séquence linéaire d'activités le long d'une chaîne où les firmes contribuent individuellement en ajoutant de la valeur d'activité (Porter et Millar, 1985), les processus de création de valeur dans un monde numérique émergent sont basés sur la participation de multiples PMEs qui intègrent et usent de ressources pour elles-mêmes et pour les autres. La valeur est ainsi co-crée, (Lusch et Vargo, 2014 ; Barrett et al., 2015). De ce fait, les possibilités d'innovation sont exponentielles puisque les sources numériques et produits numériques font que les entreprises intègrent les ressources au-delà des limites de l'industrie, qui sont traditionnement strictement réduit à des produits physiques. (Yoo et al., 2012 ; Selander et al., 2013).

Une chaîne de valeur de l'innovation numérique peut aider à expliquer comment les PME créent de la valeur en adoptant la technologie numérique. Une chaîne de valeur de l'innovation numérique peut être considérée comme des réseaux d'entreprises et d'autres institutions interconnectées par une technologie numérique pour créer et maintenir de la valeur autour des réseaux hétérogènes numérique. Par conséquent, les PME contribuent à la faisabilité des produits ou services numériques en améliorant les effets de réseaux ainsi qu'en intégrant et en appliquant leurs ressources et capacités séparées afin d'améliorer les performances commerciales des entreprises.

L’innovation est une stratégie cruciale pour que les firmes développent des avantages durables compétitifs sur le marché, ce qui explique pourquoi beacoup d’universitaires ont perpétuellement étudié l’innovation sous diffrents angles ces dernières annnées. Les premiers chercheurs se basent souvent sur l’approche Schumpeterienne, qui est expliqué dans la Théorie du Développement Economique. En ceci que l’innovation est considérée comme de ‘nouvelles combinaisons’ de facteurs de productions, c’est-à-dire la production de nouveaux marchés, and l’accès à de nouvelles sources de matières première et intermédiaire, la réorganisation d’une industrie. (Schumpeter, 1934).

Alors que le nouvel environnement est devenu de plus en plus dynamique et incertain, l’innovation est vue comme une réponse organisationnelle aux menaces, aux indécisions et fluctuations des environnements internes et externes. (Damanpour, 1991). De plus, l’innovation peut être le premier véhicule pour augmenter productivité et profitabilité dans des environements très fluides (Ettlie et al., 1984).

De ce fait, il est essentiel que les firmes développent des stratégies d’inovations (Gupta et al., 2006). Les entreprises doivent constamment fournir des efforts pour porter l’innovation et créer de la valeur afin d’être d’efficaces compétiteurs et produire un marché durable. (Lee et al., 2012).

Au sens traditionnel, les études de management de l’innovation se sont centrées sur soit le processus ou les résultats qui mobilisent l’innovation. (Sivasubramaniam et al., 2012). Mais, il a une dixaine d’année, quelques contributions ont observé l’innovation à travers le prisme de la capacité d’apprentissage d’une organisation, en mettant l’accent sur le côté cognitif de l’innovation. Ils étaient convaincus que l’innovation permet d’instroduire de nouvelles connaissances au sein de l’économie, ou que l’on peut la combiner à la connaissance existante. (Edquist et Johnson, 1997).

Quand l’innovation est considérée comme nouvelle connaissance, sa dimension devient plus globale : la génération de nouvelles connaissances ne se limite pas seulement à l’architecture et les phases de production d’un nouveau procédé ou produit, cela comprend toutes les étapes de la chaîne, ensuite des travaux de recherche sont menés pour liér connaissance et innovation.

Bientôt, la chaîne de valeur de l'innovation a été paternellement modélisée comme un processus répété par lequel les entreprises s'approvisionnent en connaissances pour entreprendre l'innovation, elles transforment ces connaissances en nouveaux produits et processus, puis exploitent leurs innovations pour générer de la valeur ajoutée (Roper et al., 2008). Le principal avantage de la chaîne de valeur de l'innovation est de souligner la structure et la complexité du processus d'innovation et elle peut clairement montrer plusieurs liens incluant toutes les activités dans le processus d'innovation du début à la fin.

Ses enjeux, cependant, ne peuvent pas être passés sous silence. Avec la digitalisation, les liens entre les processus d'innovation et leurs résultats sont plus complexes et plus dynamiques. Boland et al (2007) ont par exemple découvert que dans les projets de construction innovants, le choix d'adoption d'outils numériques 3D comme infrastructure de processus numérique généraient des interfaces et ds intégrations inattendues entre les différents acteurs, traders, designers et autres parties-prenantes, générants plusieurs 'vagues dans l'innovation'. Les technologies numériques ont rendu le processus d'innovation plus ouvert - un passage de frontières discret, imperméable et stable à des frontières de plus en plus poreuses et fluides. Par conséquent, l'étude sur la chaîne de valeur de l'innovation numérique doit être approfondie.

Par conséquent, cette thèse vise à découvrir la voie de l'adoption de la technologie numérique pour les performances des PME. Pour ce faire, cette étude a recours à la théorie de la chaîne de valeur de l'innovation, dans laquelle les technologies numériques jouent un rôle essentiel dans l'émergence de l'innovation. De par sa nature complexe, la valeur de l'innovation numérique comprend trois secteurs. Le premier est la source de la connaissance numérique, cela se réfère aux réseaux hétérogènes rendu existant par l'adoption des nouvelles technologies.

Le second est la transformation numérique qui requièrent des produits numériques innovants, de l'innovation au niveau des services numériques proposés, et l'innovation liée au business model basé sur le partage et la dissemination de connaissance parmi les différents acteurs impliqués. Le troisième est l'exploitation numérique, soit l'impact qu'a l'innovation numérique sur la performance des PMEs.

L'ossature de la problématique est formulé ainsi: Comment l'adoption des technologies numériques dans le cadre de la chaîne de valeur de l'innovation crée de la valeur afin d'améliorer la performance des PMEs ?

La recherche doit découvrir et comprendre quel est le cheminement des PMEs vers les technologies numériques innovantes qui conduit à l'amélioration de la performance des PMEs. Ce chemin mobilise la perspective de l'innovation de la chaîne de valeur afin de prendre en compte le contexte numérique dans lequel les réseaux hétérogènes rendus possibles par les technologies numériques et la transformation numérique et l'exploitation par l'étude de la chaîne de valeur de l'innovation.

L'étude de l'état de l'art sur le sujet et l'appréhension de la chaîne de valeur de l'innovation dans la perspective de l'apprentissage organisationnel et de l'adoption de la technologie et de l'innovation dans le contexte de la numérisation a conduit à formuler les questions suivantes :

Question 1: L'adoption des technologies numériques influence t-elle les réseaux hétérogènes pour les PMEs ?

Question 2: Quelles sont les dimensions de l'innovation digitale en tant que nouvelle texture ?

Question 3: Comment l'adoption des technologies numériques ont un impact sur la performance des PMEs au sein des activités de la chaîne de valeur d'innovation digitale ?

### *4. Epistémologie and Methodologie*

Il est primordial qu'un chercheur ou scientifique construise une réflexion épistémologique. Cela guide non seulement cette thèse dans le développement de la recherche en permetant d'évaluer à la fois le développement ainsi que la pertinence et la cohérence de l'approche, mais permet aussi de constituer la légitimité et validité de la recherche. (Perret et Seville, 2007). Pour Martinet (1990), cette réflexion est consubstantielle à cette recherche. De fait, il faut accorder une importance particulière au choix d'une position épistémologique, selon l'objectif de la recherche. Avenier (2011) considère qu'en tant que science sociale, le management doit appartenir au champ de la science artificielle. En définissant la réflexion de la connaissance dans un cadre théorique, celui des sciences artificielles, cette étude expliquera ensuite sa perception de la connaissance et cinq paradigmes épistémologiques contemporains. Cette section a pour but d'amener une approche de recherche qui délimite le paradigme épistémologique au moyen d'une méthode hypothético-déductive.

Le processus global et la visée de la recherche. Il comprend six étapes. Dans l'étape 1 et 2, est élaboré le modèle de la chaîne de valeur conceptuelle au sein du champ de l'innovation digitale, et quatorze hypothèses, qui se sont développées sur la précédente revue de littérature. Dans l'étape 3, est développé un instrument qui inclut 31 items de mesure pour tester le modèle conceptuel. Le développement de l'instrument est basé sur les études précédentes et leurs détails sont délimités dans cette section. Dans l'étape 4, cette étude a mené une étude de terrain afin d'examiner ces questions de recherche parce qu'il n'y a pas de base de données archivales qui fournit de l'information sur la chaîne de valeur de l'innovation et l'adoption de l'innovation.

Les questions de l'enquête de terrain sont basées sur l'état de l'art et l'expérience des practiciens qui sont très activement impliqué dans l'innovation digitale. Avec l'appui de l'administration locale chargée de la zone high-tech, le chercheur a ciblé les réponses de personnes incluant les fondateurs, les managers en technologie, les consultants, les directeurs, les leaders, le marketing, le projet, le programme, pour créer la liste de diffusion. Pour le questionnaire mis en ligne, un lien comprenant le questionnaire a été envoyé à 1680 répondants potentiels. Un total de 267 questionnaires à données exploitables ont été collectées. L'étape 5, emploie la technique SEM. En particulier, cette technique inclus un facteur d'analyse exploratoire, une analyse confirmatoire et une analyse de trajectoire. Une analyse de facteur confirmatoire (AFC) et la modellisation d'une équation structurale ont été computannionnées via les logiciels SPSS (Version 20.0) et AMOS (Version 18.0) pour tester les hypothèses développées et répondre aux questions de recherche. Pléthores de chercheurs ont choisi le modèle SEM puisque ce modèle fournit une approche statistique pour considérer explicitement les erreurs de mesure dans les variables observées, dépendantes et indépendantes. (Kline, 1998). Les chapitres qui suivent se consacrent à expliciter le modèle conceptuel, le développement d'hypothèse, le développement de l'instrument, la collecte et l'analyse de données et résultats glanés et les conclusions de recherche.

### *5. Organisation et plan de la thèse*

Cette thèse se découpe en sept chapitres. Chaque chapitre comprend trois ou quatre sections. Au début de chaqu'un deux, une introduction du contenu est proposée.

L'intoduction générale décrit la toile de fond et la problématisation de l'innovation dans le contexte de la digitilisation de bon nombre de PMEs en Chine, et pointe du doigt les objectifs et questions académiques spécifiques à explorer. Ensuite, l'épistémologie et la méthodologie adoptée dans cette recherche est présentée, et enfin vient l'organisation et le plan de la thèse qui seront mises en œuvre.

Le chapitre 1 présente la revue de littérature sur l'abordabilité des technologies numériques et la typologie des réseaux hétérogènes. Dans ce chapitre, les concepts, les propriétés et les formes existantes des technologies numériques sont d'abord résumées selon les études précédentes. Et ensuite, est aussi abordé dans ce chapitre l'effect du numérique qui peut expliquer pourquoi les technologies numériques le processus d'innovation se transforme en digitisation. Ensuite, à travers la revue de la théorie de réseau, la typologie des réseaux hétérogènes est présentée afin d'identifier le réseau comme réseaux professionnels et personnels.

Le chapitre 2 illustre les dimensions de l'innovation numérique. Les concepts et caractéristiques des technologies numériques sont délimitées selon la littérature existante. Et à travers des études systématiques sur l'innovation digitale, ses dimensions sont catégorisées, comme suit : l'innovation des produits digitaux, l'innovation des services numériques, et l'innovation liée au business model. Le fait de considérer les dimensions de l'innovation numérique peut aider à mieux comprendre sa nature et cette recherche.

Le chapitre 3 se propose d'explorer la littérature sur la chaîne de valeur de l'innovation, depuis la perspective du knowledge management afin de comprendre son émergence, la variété de sa source de données. En examinant une variété de points de vue sur la chaîne de valeur de l'innovation, on peut comprendre les différentes activités innovantes implémentées par les organisations. A travers l'étude de la chaîne de valeur de l'innovation, cette recherche excaves les liens et explique la logique de la chaîne de valeur de l'innovation.

Le chapitre 4 démontre comment la chaîne de valeur de l'innovation digitale s'est formée, en se basant sur une toile de fond théorique. Il construit le modèle de recherche, puis 14 hypothèses sont proposées. La première section met l'accent sur le lien entre adoption digitale et réseaux hétérogènes des PMEs selon la nature des technologies numériques. La seconde section se consacre à lier les impacts des réseaux hétérogènes sur l'innovation digitale selon les effects digitaux. La troisième section tâche d'introduire l'impact de l'innovation digitale sur la performance des PMEs.

Le chapitre 5 présente l'implémentation du but de la recherche à travers différentes étapes méthodologiques choisies. En particulier, seront d'abord présentés les manières dont les mesures opérationnelles sont définies en incluant les variables latentes et leurs métriques. Dans une seconde étape, une étude pilote est implémentée afin d'éviter l'ambiguité des questionnaires. Ensuite, la situation de l'échantillon est décrite en discutant les données collectées et des tests sont faits pour des biais potentiels dans le questionnaire. De plus, les méthodologies présentées incluent un et une analyse factorielle et une analyse de trajectoire.

Le chapitre 6 mène une analyse thématique en utilisant les logiciels SPSS et AMOS qui furent développés pour examiner les hypothèses qui découlent de l'analyse textuelle et thématique. En particulier, ce chapitre présente les résultats associés au test des quatorze hypothèses, ainsi que les estimations de fiabilité et test de validité.

Ensuite, le chapitre 7 déploie une discussion des résultats qui offrent des découvertes clefs découlant des résultats empiriques.

Les conclusions générales rappellent la progression du projet de recherche. Plusieurs pistes d'action pour les practiciens sont formulées. Les contributions principales de cette recherche seront spécifiées, avant de cadrer les limites de ce travail, pour ensuite proposer de futrues pistes de recherche. La figure 1 permet d'avoir une vue d'ensemble de l'organisation de la thèse.

***6. Exposition des conclusions clefs***

Dans cette thèse, un cadre théorique a été mis en place pour étudier les effets des activités d'innovations de la chaîne de valeur numérique pour les PMEs en Chine. En particulier, les effets entre les réseaux hétérogènes, l'innovation digitale et la performance des PMEs, portée par l'adoption des technologies numériques furent examinées. Sur la base des résultats obtenus au cours de cette recherche, on peut tirer les conclusions suivantes :

Les résultats ont montré que l'adoption des technologies numériques a un impact positif sur les deux types de réseaux hétérogènes qui concernent à la fois les réseaux personnels et professionnels. Il est vivement recommandé aux PMEs qui souhaient faire usage des technologies numériques en tant que stratégies qu'elles se tissent un réseau avec d'auttes acteurs.

Les résultats ont indiqué que les réseaux de l'entreprise avait un impact positif sur les services numériques d'innovation, alors que les relations entre réseaux professionls et produits umérique et l'innovation dans le cadre du business model sont peu significatifs. Les résultats ont aussi montré des effets positifs directs dans le cadre des réseaux personnels sur les trois types d'innovation numérique : produits inovants, services numériques innovants, et business model innovant.

Les PMEs qui visent à développer leur innovation digitale devraient mettre l'accent sur leur réseaux personnels qui accélère l'innovation.  Cependant les réseaux professionnels qui peut apporter l'innvation des services numériques en excluant l'amélioration est l'innovation digitale pour les PMEs.

Enfin, les résultats ont révélé que des produits numériques innovantes ont eu un impact positif sur la part de marché des PMEs et sur leurs profits. Des services numériques innovants apportent aussi cet impact positif sur la performance des PMEs. Un business model innovant a influencé les parts de marché des PMEs de manière significative, alors que le lien entre un business model innovant est le taux de profit ne s'est pas montré parlant.

### *7. Contribution théorique*

Cette étude enrichit la recherche sur la chaîne de valeur de l'innovation digitale en introduisant un cadre conceptuel théroique qui permet de comprendre comment les PMEs adoptent les technologies numériques afin de créer de la valeur dans le cadre d'activités numériques innovantes afin d'améliorer leur performance. Ici est défendue l'idée que les réseaux hétérogènes, comprenant le réseau de l'entreprise et les réseaux personnels rendus possible par l'adoption de technologies numériques permet aux PME de constamment prendre en charge des activités numériques innovantes.

Cette thèse étend la littérature existante concernant la chaine de valeur de l'innovation en illustrant empiriquement l'importance des technologies numériques en regard des activités d'innovation digitale, en particulier pour les produits d'innovation digitale, le numérique dans le contexte du support en ligne, et l'innovation dans le cadre du business model, qui a une influence indirecte sur la performance de PMEs.

Les résultats démontrent de plus que les réseaux hétérogènes des PMEs ont différents impacts sur l'innovation digitale des PMEs. Est notamment montré ici comment les réseaux personnels influencent l'innovation digitale des PMEs. De là, si les réseaux hétérogènes sont perçus comme un important facteur d'innovation digitale, il est fait un meilleur usage des réseaux personnels des PMEs. Ce résultat est en adéquation avec la recherche en management qui suggère l'impact direct entre les réseaux, l'innovation produit et la performance de la firme. (Mitrega et al., 2017). Cette recherche étend alors la littérature sur les réseaux hétérogènes en examinant de manière empirique un facteur important pour l'implémentation d'innovation digitale pour les PMEs. Les résultats de ce cadre théorique conceptuel de la chaîne de valeur d'innovation numérique tente de fournir un socle supportant l'idée que les SMEs peuvent construire leur réseaux personnels à travers l'adoption des technologies numériques afin d'atteindre un stade d'innovation numérique et, in fine, accroître la performance de leur entreprise. Cette étude confirme donc que seul les réseaux professionnels ont un impact positif sur des services digitaux innovants pour les PMEs.

Cette recherche s'inscrit comme une contribution dans le domaine de l'innovation numérique dans le but de catégoriser les dimensions de l'innovation digitale en suggérant que l'innovation numérique requiert des produits numériques innovants, des services numériques innovants et des business models innovants, confer la revue de littérature sur des précédentes études dans le domaine de l'innovation.

En somme, les résultats de cette recherche fournissent une preuve en ce qui concerne l'impact positif qu'a l'adoption des technologies numériques dans le cadre de la chaîne de valeur de l'innovation. Ceci étant, la recherche montre que les réseaux hétérogènes rendus possibles par l'adoption des technologies numériques souligne le rôle des réseaux personnels des PMEs, lorsque l'on considère l'importance de cette relation pour la performance des PMEs. Cette étude pourra répondre au besoin de rendre l'innovation digitale plus fluide, facilitant aisni la diversité et flexibilité de la chaîne de valeur de l'innovation numérique, lorsque la considère au sein d'un environnement dynamique dépourvu de frontières. Les technologies numériques maturant, les moyens d'obtenir de la valeur se diversifiant, les firmes qui réussisent le mieux auront peut-être besoin de maneuvrer dans le temps afin de maîtriser ces technologies numériques dans un contexte digital.

### *8. Implications managériales*

Les résultats ont à la fois des implications manégériales et réglementaires. D'un point de vue stratégique, la chaîne de valeur d'innovation numérique permet de prioriser la mise à jour, en centrant l'attention managériale sur à la fois les liens forts et faibles contenus dans le processus. La clef se trouve ici dans le besoin qu'on les PMEs de construire non pas seulement des réseaux professionnels, mais aussi des réseaux personnels qui peuvent directement profiter à l'innovation digitale à travers un schéma complémentaire. Un exemple de cela réside dans le rôle des réseaux personnels. Ainsi, même lorsque les résultats des réseaux professionnels sur les produits d'innovation digitales et ceux du business model ont peu de sens, comme dans le cas des réseaux professionnels dans un contexte d'innovation digitale, leur influence globale peut être positive pour l'équilibre entre les effets 'directs' et les effets 'de la chaîne de valeur de l'innovation'. Considérons que les réseaux professionnels sont une partie des réseaux hétérogènes, ce qui souligne que s'établir au sein des réseaux professionnels peut produire de l'innovation digitale indirecte, même si, comme dans le cas des PMEs, les réseaux professionnels sont restreints à la ressource limitée.

Le bénéfice clef de l'approche de la chaîne de valeur de l'innovation est donc sa capacité à souligner le rôle de facteurs variés à différentes étapes du noyau performant des réseaux hétérogènes de l'entreprise dans l'innovation digitale, et pour montrer leurs relations directes et indirectes. Comme signalé plus haut, le rôle des technologies numériques est clef, associant les PMEs avec les trois élements des réseaux hétérogènes de la chaîne de valeur de l'innovation, l'innovation digitale et la performance de l'entreprise. Ceci suggère que les PMEs sont fortement incitées à investir dans les technologies numériques, pas seuelement parce que leur adoption a un impact direct sur l'innovation digitale, mais aussi parce que cela peut renforcer les trois éléments de la chaîne de valeur de l'innovation numérique, et ainsi améliorer la capacité innovante des PME.

Premièrement, our les dirigeants, l'analyse de la chaîne de valeur de l'innovation a trois implications principales. D'abord, il est possible d'identifier les moteurs des parts de marché et les taux de profits parmi les PMEs, et en particulier s'intéresser au rôle joué par les réseaux professionnels et personnels. Ceci émet un signal clair que chaque facteur est important et a une influence sur l'innovation et la performance d'une entreprise, à la fois à travers ses résultats directs mais aussi potentiellement à travers les influences complémentaires d'autres moteurs de l'innovation. L'approche de la chaîne de valeur numérique montre également par lesquels les facteurs influencent la performance des PMEs, fournissant un cadre potientiel pour l'évaluation de futures lois ou réglementations destinées aux PMEs.

Deuxièmement, les résultats de cette thèse fournissent un appui considérable pour Ganotakis et al. (2012) que les firmes qui usent des réseaux hétérogènes sont porteurs d'innovation pour de nouvelles sociètes dont l'ossature est batttie sur les technologies numériques, ce qui sera bientôt attendu afin d'améliorer les taux de croissance des entreprises. Une façon pour la Chine d'adopter les technologies numériques afin d'améliorer à la fois les résultats de leurs innovations numériques et la performance de leurs entreprises.

Enfin, grâce à la chaîne de valeur d'innovation numérique, il est possible d'identifier comment les moteurs de l'innovation numérique se comportent, en se concentrant sur le rôle des technologies numériques comme ayant à la fois une influence directe et indirecte sur le succès de l'innovation digitale, et également sur le rôle des réseaux hétérogènes pour l'innovation digitale.

L'enjeu est que l'implémentation d'une politique pour améliorer l'adoption des technologies numériques ont un bénéfice direct pour les réseaux personnels et professionnels mais peuvent aussi avoir des effets indirects sur l'innovation digitale. Par exemple, il y a des preuves que l'apport financier du gouvernment pour soutenir les technologies numériques auprès des PMEs est associé positivement sur non seulement le plan du réseau mais aussi avec l'innovation digitale sur l'échantillon de PMEs étudiées. Ceci peut signifier qu'implémenter d'autres mesures pour améliorer ce groupe majeur de PMEs pourrait avoir de grandes répercussions positives.

### *9. Limites de la recherche et cadre pour des recherches futures*

Premièrement, il y a d'évidentes limites à la recherche actuelle. D'abord, l'utilisation de n'importe quel instrument sous forme de questionnaire a des effets sur ce type de données. Dans cette recherche, par exemple, les données sont obligatoires à travers les échelles de Likert, qui sont perçues par les personnes interrogées mais ne sont pas l'objectif. Même si cette approche convient à beaucoup de questionnaires dans le domaine de la stratégie et de l'innovation, on pourrait utilement l'enrichir avec une analyse qui est capable d'explorer des variables latentes, comme par exemple quelle est le dégré d'accord avec ces déclarations : « Ces dernières annnées, notre firme a développé des services numériques intégrant les technologies numériques comme les réseaux sociaux, les analyses de données, les technologies sur smartphone et dans le nuage. » Il est possible de considérer une approche méthodologique différente de celle utilisée ici, qui aurait besoin de plus de données quantitatives afin de mesurer les données de manière plus nuancée, telles que l'innovation digitale et la performance d'une entreprise.

Deuxièmement, au moment de la création du questionnaire afin d'estimer la chaîne de valeur de l'innovation, il y a des défauts qui la composent parce que la chaîne de valeur de l'innovation des PMEs interrogées se modifient avec le temps et l'influence qu'elle peut avoir sur leur nnovation numérique et leur performance.

De ce fait, deux domaines potentiels pour la recherche suivante se dessinent. L'un est celui du développement d'un panel de données qui concerne le questionnaire répété d'une population cible. Cela va aider à mieux comprendre le processus. L'autre est celui qu'une étude de cas longitidinale pourrait être considérée comme méthodologie complémentaire car cette approche fournirait des informations plus détailées sur comment les modifications dans la chaîne de valeur de l'innovation ont un impact sur la performance d'une enteprise, et définirait encore mieux quel maillon de la chaîne de valeur de l'innovation est le plus suceptible de subir une transformation.

L'utilisation de données longitudinales et/ou études de cas permettrait de comprendre nettement les liens entre innovation digitale et performance des PMEs. Les résultats faisant l'objet d'une discussion ci-dessus semblent adhérer à l'idée que, dans le processus, l'innovation digitale est directement liée à la performance d'entreprise. Cependant, peu d'encre coule concernant les situations spécifiques durant lesquelles une innovation numérique fonctionne, ou sur la nature exacte de l'innovation numérique. Par exemple, les services numériques innovantes sont-ils seulement pris en compte quand les ressources des PMEs sont moindres, ou des facteurs de l'innovation plus obscurs sont-ils à l'œuvre ? Et si cela est vrai, alors quels sont -ils ?

Une compréhension détaillée des clusters de ces facteurs ne peut-être obtenue à travers les échelles de Likert.

Le dernier angle dans lequel plus de recherche doivent être ménées concerne les études par pays. Toute la recherche sur les PMEs et la chaîne de valeur de l'innovation vient de Chine. Il serait très intéressant de comparer les résultats de l'étude actuelle avec des pays ayant un contexte culturel et institutionnel différent, notamment ceux dans lequel le réseau est bien plus différent de l'enviromment chinois d'une grande partie de la recherche en gestion. Ceci permettrait d'avoir une indication plus claire concernant les mesures dans lesquelles les formes et natures de de chaîne de valeur de l'innovation numérique dans d'autres pays est vérifiée culturellement et institutionnellement.

# General Introduction

## 0.1 Background and problematization

### 0.1.1 Digital technology is everywhere in a connected world

During the last decades the world has been undergoing a novel technological revolution and industrial transformation. Impressive developments in digital technology such as big data, virtual reality, cloud computing and artificial intelligence have been continually and thoroughly penetrating various fields, which have reshaped the innovation landscape by accelerating the growth of the internet of everything, data-driven computation, platform support and the intelligence industry. Due to the development of connectivity technologies such as pervasive computing, digital convergence, service-oriented architectures, cloud computing, and the open source, the boundaries of time, distance and function in the traditional sense have been bridged (Yoo et al., 2010; Merali et al., 2012; Bharadwaj et al., 2013;Koch and Windsperger, 2017). Digital technology once played a supplementary role in efficiency promotion and labor productivity, but due to the emergence of smart devices, digital technology has taken up a more central place and thus rapidly evolved as the enabler of fundamental innovation.

*"The big thing is, technology change is happening so rapidly*

*that every industry is being affected by this."*

This was said by George Westermam, research scientist at MIT's center for Digital Business, and he is also one of the investigators leading the Center's Digital Transformation. The survey conducted by Fitzgerald et al. (2014) showed that executives know that digital technology really matters: a full 78% of respondents expressed the view that achieving digital transformation will become critical to their organizations within the next two years. Less than 5% of respondents made clear that digital transformation will never become crucial for their organizations. At the same time, 81% of executives said their organizations were already trying to achieve digital transformation (see Figure 1). Previous studies by Capgemini Consulting and MIT's Center for Digital Business discovered that companies that invest in digital technologies and run them very well are more profitable than their industry peers. Interviewees in the above-mentioned survey agreed upon on this view: they deeply believe that failure to effectively conduct digital transformation will damage their firms' capacity to compete (Fitzgerald et al.,2014).


*Figure 1: Digital maturity (Source: MIT Center for Digital Business and Capgemini Consulting; Fitzgerald et al.,2014 )*

The emergence of digital technology in various industries is causing rapid change in the innovation landscape. Lori Beer, executive vice president of information technology and specialty business at WellPoint, one of the nation's largest Blue Cross/Blue Shield licensees, expressed the view that

> *"Currently, our products and services are actually supporting consumers, providing capabilities for employers, information, data, much more like a financial services type of scenario. Technology has always been critical to business, whereas it really is becoming much more strategic, especially in this era, when you are seeing the emergence of digital technology. You are seeing a transformation of how consumers are engaging with digital technology."*

The rise of digital technology, affecting every facet of industry and society, has changed the ways and process of innovation, regardless of the business involved. With digital technology now being so pervasive in our everyday lives, it's vital to keep up-to-date from a strategic business point of view. According to the survey by Fitzgerald et al. (2014), responding effectively and rapidly to digital technology impacts the bottom line, and even business survival. The results of their study showed that effective management of digital technology is already generating winners and losers in measurable scales, like market share and profit level. From Figure 2 it is shown that Digirati outperform their rivals. Business leaders who adopt digital technology will get boosts in their operations, customer relations and business models.

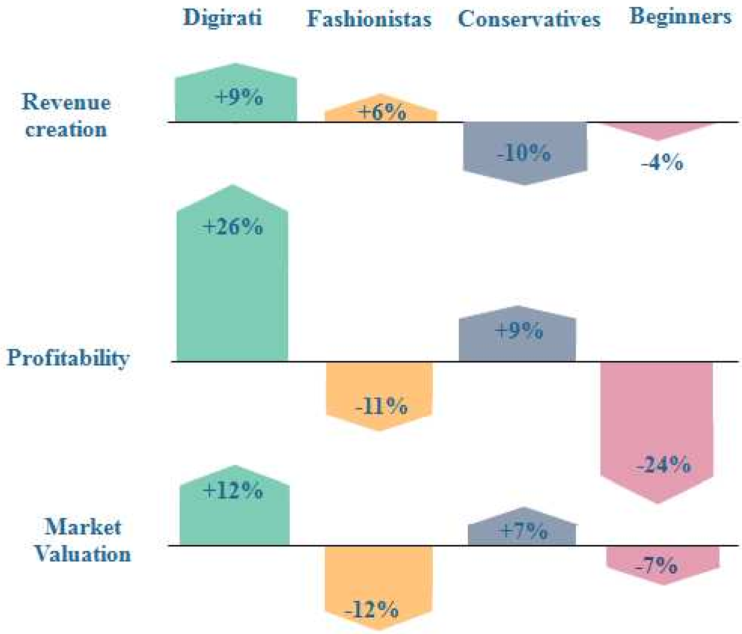



*Figure 2: Digital cash register (Source: MIT's Center for Digital Business and Capgemini Consulting; Fitzgerald et al.,2014 )*

## 0.1.2 The digital economy is mushrooming on a large scale in China

In the past few years, China has been attaching great importance to the development of digital technology and has determined to build a digital economy, promoting digital convergence with the offline economy. Under this context, the digital economy in China is mushrooming on a large scale which is critical to economic growth and quality.

According to a discussion paper (Woetzel et al., 2017) from McKinsey Global Institute, China has one of the most vigorous digital-investment and start-up ecosystems in the world. Globally, China is one of the top three for venture-capital investment in digital technology such as virtual reality, autonomous vehicles, 3-D printing and artificial intelligence. China owns the world's largest e-commerce market, comprising more than 40% of the value of global e-commerce transactions, up from less than 1% ten years ago. China has also transformed to a major global force in mobile payments with enormous transaction value which is 11 times that of the USA. There are 262 unicorns in the world, but around 87 (one in three) are Chinese, accounting for 43% of the overall value of these companies (See Figure 3).

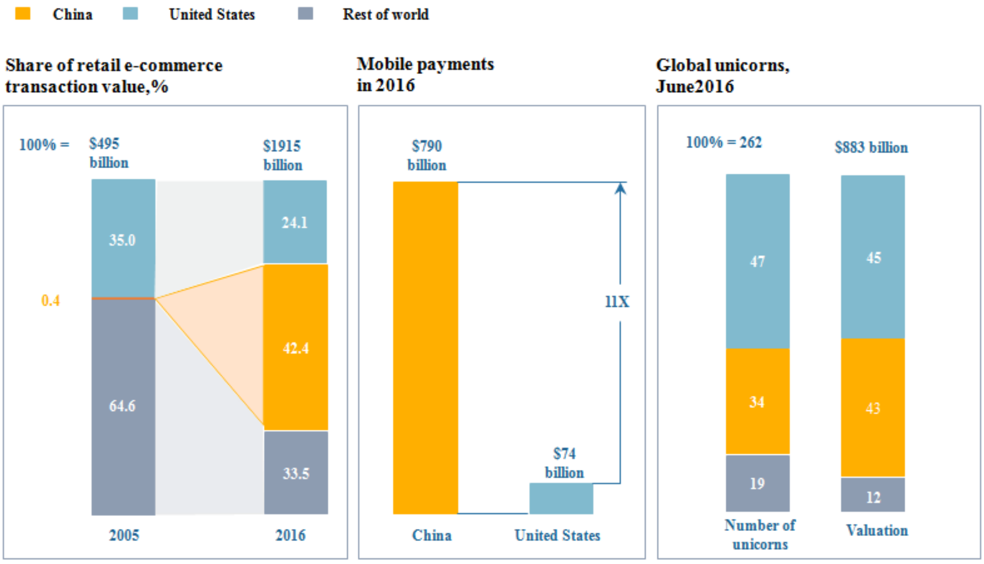



*Figure 3: China's digital economy is a story of commercial success and excitement among investors (Source: McKinsey Global Institute Analysis; Fitzgerald et al.,2014 )*

Woetzel et al. (2017) proposed that three factors can explain why the digital economy is mushrooming in China and believed that there is still a huge potential for digitization of Chinese companies. The first one is that China has a big market that enables the quick commercialization of digitization on a large scale. The enormous size of China's Internet user-base assured continuous experimentation and enables consumers to join the digital economy rapidly. It was reported that China had 731 million Internet users in 2016 and this figure is more than the totals of the European Union and the USA combined. Besides, young Chinese online consumers have a passion for digital technology which will encourage digital growth and facilitate the adoption of innovation, and thus enable the digital economy to become more competitive. The emergence and pervasive application of smart phones also contribute to the active digitization in China. The second factor is that the three Chinese Internet giants have established a fluid digital ecosystem that is beneficial to many users, for example, Baidu, Alibaba and Tencent (known as BAT). For digital , the BAT companies that have been building a leading position in computing efficiency are developing a multifaceted and multi-industry digital ecosystem that penetrates nearly every aspect of consumer life. Beyond China's three giants, other digital companies including Xiaomi and Ping An are also building their own systems. Many companies enjoy the advantage of digital technology because they have close links to hardware manufactures in coastal areas of China. These large companies create digital innovation through adopting digital technology in order to contribute to the mushrooming of the digital economy in China. The third factor is that the Chinese government provided digital actors enough space to experiment before implementing official regulation and is now adopting a supportive role. With the market growing mature, the government and private sector have steadily become more positive about shaping healthy digitization through regulation. The Chinese government is now playing a proactive role in establishing top infrastructure to facilitate digitization as an investor, developer and consumer.

### 0.1.3 Small and medium-sized enterprises (SMEs) meet new challenges from digital innovation

SMEs are the basic units to promote employment, economic development and innovative activities. They are the largest and most dynamic parts in the market economy. The stable and active development of SMEs is related to the social structure, way of economic transformation and upgrading of science and technology. In 2019, SMEs accounted for 99.7% of the total number of enterprises in China, of which small and micro enterprises took up 97.3%, providing more than 80% of urban jobs, creating 60% of the final products and services equivalent to GDP, and paying 50% of profits and taxes. SMEs own 65% of China's invention patents and make 75% of enterprises' technological innovation and develop 80% of new product (http://www.miit.gov.cn).

SMEs will inevitably play a vital role in dealing with digital innovation when they face the severe competitive and turbulent environment. The emergence of new technology, like the Internet and computers, started with the application and practice by government and large companies. With the breakthrough of key technology, the continuous improvement of applicability and the decrease of cost, SMEs shall be the main body to adopt and practice new technology with high efficiency and large scale. Therefore, the dominant position in the early stage of digitalization must be large-scale institutions, including big companies in information infrastructure. However, as the initial problems are overcome, and digital technology is adopted, SMEs that account for the major part of the Chinese economy will take up the principle position in the market.

The mushrooming of digital technology represented by virtual reality, big data and artificial intelligence is accelerating the integration with the real economy, driving digital innovation to expand to its fullest extent. The ADT in SMEs not only promotes their digital transformation, but also provides new ways and models for their digital innovation and development, and expands the new business boundary for the sustainable development of SMEs.

The status and market role of SMEs are continuing to improve, but their size, resource strength and management characteristics make it difficult for them to support their own independent response to and achievement of digital transformation. Therefore, the question arises how to effectively guide and help a large number of SMEs to adopt digital technology in order to foster digital innovation.

### 0.1.4 The basic problem for numerous SMEs in the digitized world: How do they create value through adopting digital technology in order to improve their business performance?

Digital technology alters the qualities of objects by converting them into structures of loosely coupled elements and components that are not limited to particular operations or functions (Yoo et al., 2010). This indicates that creators of components may not be able to fully foresee how and in what mixture their digitized products and services are eventually adopted. The product boundary cannot be seen as limited anymore. Under these assumptions creating value has become more complicated (Koch and Windsperger, 2017) especially for SMEs. Based on the traditional product makers, firms are considered to create value through enhancing product architecture and thereby improving product quality (Vargo et al., 2008). However, rather than a linear sequence of activities along a chain where firms individually contribute by value-adding activities (Porter and Millar, 1985), value creation processes in an emerging digitized world are based on the contribution of multiple SMEs who integrate and apply resources for themselves and for others. Value is thus always co-created (Lusch and Vargo, 2014; Barrett et al., 2015). Therefore, the possibilities for innovation have been increased since digital sources of products and service make companies integrate resources across the industry boundaries, which are traditionally strictly related to physical products (Yoo et al., 2012; Selander et al., 2013). The DIVC can help us to explain how SMEs create value through adopting digital technology. The DIVC can be regarded as a network of companies and other institutions that is inter-linked by a digital technology to create and sustain value around digital heterogeneous networks. Consequently, SMEs contribute to the feasibility of digital products or service through enhancing network effects as well as integrating and applying their separated resources and capabilities in order to improve firms' business performance.

Innovation is a crucial strategy for firms to develop sustainable competitive advantage in the market, that's the reason why many scholars have been continually studying innovation from different aspects in the past few years. Early academic studies are often based on Schumpeter's approach, which was explained in "The theory of Economic Development". It regarded innovations as "new combinations" of production factors – namely, the production of new goods, the introduction of new processes, the opening of new markets, and the access to new sources of raw materials and intermediates, the re-organization of an industry (Schumpeter, 1934).

As the environment became more and more dynamic and uncertain, innovations are seen as organizational responses to threats, uncertainties, and changes in the organization's internal and external environments (Damanpour, 1991). Additionally, innovation can serve as the primary vehicle for improving productivity and profitability in highly fluid environments (Ettlie et al., 1984). Therefore, it is essential for firms to develop innovative strategies (Gupta et al., 2006). Enterprises have to make efforts constantly to drive innovation and create value in order to effectively compete and produce sustainable business (Lee et al., 2012).

Traditionally, innovation management studies have concentrated either on process or the innovation outcome (Sivasubramaniam et al., 2012). But there were some contributions, which considered innovation from the perspective of organization learning capabilities, emphasizing the cognitive parts of innovation. They believed that innovation is the introduction of new knowledge in the economy, or as the new combination of existing knowledge (Edquist and Johnson, 1997). When innovation is observed as new knowledge, the dimension becomes more comprehensive: the generation of new knowledge is not restricted to the architecture and production phases of a new process or product, it comprises all stages of the chain and then some researches connecting innovation and knowledge are investigated.

Soon the innovation value chain was formally modeled as a repeated process through which firms source the knowledge they need to undertake innovation, transform this knowledge into new products and processes, and then exploit their innovations to generate added value (Roper et al., 2008). The main advantage of the innovation value chain is to underline the structure and complexity of the innovation process and it can clearly show several links including all the activities in the process of innovation from beginning to end.

The complexities, however, cannot be ignored. With digitalization, paths between innovation processes and innovation outcomes are more complicated and dynamic. For example, Boland et al (2007) discovered that in innovating construction projects, the adoption of 3D tools as a digital process infrastructure led to unexpected interfaces and integration between different traders, designers, and other stakeholders, generating various waves of innovation. Digital technology has rendered the innovation process more open – a shift from discrete, impermeable, and stable boundaries to increasingly porous and fluid boundaries. Consequently, the study on DIVC needs to be investigated further.

Therefore, this thesis aims to discover the path of ADT to SMEs' business performances. To do this, the research mobilizes the theory of innovation value chains, where the digital technology plays a crucial role in the emergence of innovation. Due to its complex nature, the digital innovation value has three parts. The first is the digital knowledge source; it refers to the heterogeneous networks afforded by ADT. The second is digital transformation involving digital product innovation, digital service innovation, and business model innovation based on the sharing and dissemination of knowledge among the different actors involved. The third part is digital exploitation referring to the effect of digital innovation on SMEs' business performance.

Thus, the research formulates the basic problematization as follows: how does the ADT within an innovation value chain create value in order to improve SMEs' business performance?

## 0.2 Objectives and questions of the research

The aim of the research is to describe and understand how the adoption of digital technology and digital innovation affect SMEs' business performance. This approach studies the adoption of digital technology from the perspective of the innovation value chain taking into account the heterogeneous networks thru which the transformation and exploitation of digital technology may be effected by SMEs in today's digital context.

The review of the literature on the study and the apprehension of the innovation value chain from the perspective of organizational learning and adoption of technology and innovation in the context of digitization led the study to formulate the following questions: The first question deals with whether the ADT influences heterogeneous networks. This would also partly explain "why" these SMEs are willing to adopt digital technology. Next, the second question is on the dimensions of digital innovation. The idea is to consider whether digital innovation comprises three dimensions with digital products innovation, digital service innovation and business model innovation. This is to answer the question "What?". Then the third question presents how digital technology has an effect on digital innovation among activities of DIVC. This question tries to understand and probe the results of this adoption on digital innovation and SMEs' business performance to identify the impact of digital technology. The aim is to discover the affordance of digital technology in the DIVC which allows to answer the question "How?". The research questions can be summarized as follows:

Question 1: Does the ADT influence heterogeneous networks for SMEs?

Question 2: What are the dimensions of digital innovation as a new form?

Question 3: How does adoption of digital technology have an effect on SMEs' business performance among activities of DIVC?

## 0.3 Epistemology and methodology

It's vital for a researcher or a scientist to construct an epistemological reflection. Not only does it guide scholars in developing the research work by allowing it to evaluate the development as well as the relevance and coherence of the approach, but it makes it possible to establish validity and legitimacy of the research (Perret and Seville, 2007). For Martinet (1990), this reflection is consubstantial with the research. Hence, the research should pay a great deal of attention to the choice of epistemological positioning in accordance with the objective of research. Avenier (2011) considers that management science as social science should belong to the field of artificial science. By defining reflection of knowledge within a scientific framework: artificial sciences, the thesis will then explain the perception of knowledge and five contemporary epistemological paradigms. The purpose of this section is to introduce a research approach that delineates the epistemological paradigm based on the hypothetic-deductive method.

### 0.3.1 What is epistemology and methodology? And what is the distinction between two terms?

Althought the term "epistemology" was first coined in English in 1847, philosophers have long been concerned with questions of how we know what we know, and how we can prove whether or not what we think we know is true. They were central to the work of Descartes in his Discours de la Methode in 1637. Later, this term came to represent a branch of philosophy specialized in the study of the theories of knowledge. It has gradually become accepted as synonymous with the philosophy of science. According to Piaget (1967), epistemology is the study of the constitution of valid knowledge. Epistemology is therefore mainly concerned with the following three questions: What is knowledge? How is it developed? How to justify the validity of knowledge?

Therefore, for the purpose of developing knowledge when conducting research, it is crucial for a researcher to ask about:

- The content of knowledge;
- The foundational hypotheses on which conception of knowledge replies;
- The methods to justify the validity of the knowledge we develop.

These three elements are essential for a researcher to reflect on the relevance and the validity of the knowledge-building process in accordance with the objective pursued that is what is commonly called the research methodology.

After redefining Piaget's interpretation on epistemology, Avenier and Gavard-Perret (2008) strive to distinguish between epistemology and methodology in order to differentiate these two terms which had been confusing scholars for a long time. She assumes that these "two notions being very often confused in the literature, especially in research that claims to be constructivist" (Igalens et al.,2005). Avenir and Gavard-Perret (2008) define methodology as "the study of methods for knowledge". They consider that epistemology is interested in the value of knowledge, while methodology deals with the process of building knowledge. The distinction made between valid knowledge (epistemology) and validated knowledge (methodology) leads them to remind researchers not to limit their epistemological reflections to the validity of their approach. They then describe what the value of knowledge being developed is. In the field of management science, this value can be understood from at least two levels: the epistemic, that is to say, the value of knowledge considered for knowledge in the field of management; and pragmatics, that is, their value for the managerial practice ( Avenir and Gavard-Perret, 2008).

Since methodology is generally defined as the study of methods for developing knowledge, valid knowledge is not limited to knowledge validation according to the criteria of the positivist paradigm. However, scientific research, for the purpose of building up valuable knowledge, presupposes the reference to worldviews shared by a scientific community, described as "epistemological paradigms". A paradigm that is a constellation of beliefs, values, techniques, etc., is shared by a given community (Kuhn, 1962). Every researcher must be aware that the epistemological paradigm in which his research is constructed determines the permissible research practices and the means of justification of the knowledge developed. These decisions can therefore lead to very different representations of the phenomenon which the research investigates. So epistemological questioning is an integral part of the construction of research as well as a component of epistemology. But epistemology is not reduced to methodology.

### 0.3.2 The epistemological paradigm: post-positivism

According to Piaget (1967), an epistemological paradigm is a conception of knowledge shared by a community that is based on a coherent system of foundational hypotheses relating to the issues studied in epistemology.

In the field of management science, there are five contemporary epistemological paradigms: logical positivism, post-positivism, pragmatic constructivism, interpretivist and constructivism conceptualized by Guba and Lincoln (Gavard-Perret et al., 2012). In this thesis, it made the choice to position this research in the framework of the epistemological paradigm of post-positivism by Popper and Kuhn, because the posture of identification of insufficient literature posed by this paradigm corresponds to the model with regard to digital innovation.

Two main paradigms of post-positivists epistemologies evolved, namely the Epistemological Paradigm of Post-positivism developed by Popper and Kuhn (1963), then represented by the Scientific Realism proposed by Hunt (1991) and Bunge (1993) and Critical Realism (transcendental) (Bhaskar,1998). Any epistemological positioning can be characterized by three hypotheses. The first hypothesis is ontological. It refers to the nature of what is considered as real. The second hypothesis is epistemic. It's about what you consider as knowable. The third hypothesis is based on the states, the generation and evaluation of knowledge.

The Epistemological Paradigm of Scientific Realism is based on an ontological hypothesis that reality itself is independent of what is perceived and people can know its representations. In this case, the hypothesis of epistemic order is based on the fact that the purpose of research is to know and explain observable phenomena (possibly via unobservable concepts) and to acquire knowledge through representational conceptions with a posture of neutrality and objectivity. Internal validity research is carried out by the explication of the process of research. External validity is done through logic of generalization of knowledge via replications in a hypothetic-deductive logic on a representative sample of the target population, whose causal laws take the approach of statistical tests of hypotheses.

The Epistemological Paradigm of Critical Realistic is based on a hypothesis of ontological order according to which the world is composed of three layers: deep reality, actual reality and empirical reality. The epistemic hypothesis considers that deep reality is not observable but the scientific explications aim to imagine the function of the generating mechanisms which are at the origin of perceived events. To uncover the generating mechanisms and their modes of activation, the knowledge is generated through abduction, because the function of structures of deep reality can be imagined. The justification of knowledge is carried out by the detailed explanation of the research process with regard to internal validity and external validity through successive tests in quantitative or qualitative research.

### 0.3.3 The classical scientific approach in a post-positive perspective based on the hypothetic-deductive method.

The thesis follows the principles in the frame of classical scientific approach in a post-positive perspective based on a method of hypothetic-deductive recommended by Evrard et al. (1997) to constitute the research work. First of all, it is necessary to choose a general subject and the clarification of the main questions of research. This was done using a type of induction/abduction methodology, that is, by successive round trips between empirical observations and academic readings to find out the incoherencies between theories and what has been done. It was found that growing attention has been paid to the theme of digital innovation during the past few years. We made a selection of representative references in order to carry out a review of the academic literature, which allowed us to examine whether the literature offered sufficient knowledge to shed light on the pragmatic problem in order to provide a solution for practitioners. The literature, presented in Chapters 1, 2 and 3, has in fact illustrated the knowledge in terms of digital technology, digital innovation and the theory of the innovation value chain.

But beyond the questions raised, the literature examined only gave relatively few leads to understand the studies of innovation. So the research has decided to direct the questioning towards the process of DIVC. The first task was to define digital technology. It was from that moment that the thesis chose the word "adoption of digital technology". Then the theories of digital innovation and the theory of the innovation value chain appeared particularly useful, because both allow for the study of activities during the innovation value chain in a digitized world. At this point, the question of departure could be reformulated into a problematic integrating the conceptual framework of analysis: how? The problem itself has been broken down into questions of research, in order to orient the analysis more precisely. The methodology of the research, arising from the questioning and the theoretical choices, was then established in such a way as to carry out a survey from the literature review. The research from the paradigm, the thesis then formulates hypothesis, or proposals from the outset. The empirical analysis will however lead to proposals in the final discussion.

The epistemological positioning of the doctoral student is among the expected exercises of a thesis. It is a difficult exercise and requires a reflexive effort. Reflexivity that by definition requires a step back, a re-reading of his work, and therefore requires a certain maturity, which can be difficult to reconcile with the initiatory status of doctoral research.

Figure 4 depicts the overall research design and process. The research includes six steps. In step 1 and 2, the authors built the conceptual DIVC model and 14 hypotheses, which were developed based on the previous literature review. In step 3, the thesis initiated an instrument that includes 31 measurement items to test the conceptual model. The instrument development is based on the previous studies and its details are later delineated in this section. In step 4, this study conducted a field survey to examine these research questions because there is no archival database providing detailed information on DIVC and adoption of innovation. Questions for the survey were developed based on the literature review and input from practitioners who are actively involved in digital innovation. With the help of the Administration of a Chinese local high-tech zone, the researcher searched for the target survey respondents with job titles including the founders, technology managers, senior directors, leaders, marketing managers, project managers, program managers, to create the mailing list. For the Web-based survey, a questionnaire link was sent to 1680 possible respondents. A total of 267 usable questionnaires were collected. In step 5, the thesis employed the SEM technique to analyze the data. Specifically, the SEM technique includes an exploratory factor analysis, a confirmatory analysis and path analysis. Confirmatory factor analysis (CFA) and structural equation modeling were run on SPSS (Version 20.0) and AMOS (Version 18.0) to test the hypotheses developed to answer research questions. Many researches have chosen SEM models since they provide a statistical approach for explicitly considering measurement errors in the observed dependent and independent variables (Kline, 1998). The following chapters elaborate on the conceptualized model, hypothesis development, instrument development, data collection, data analysis and findings and conclusions.

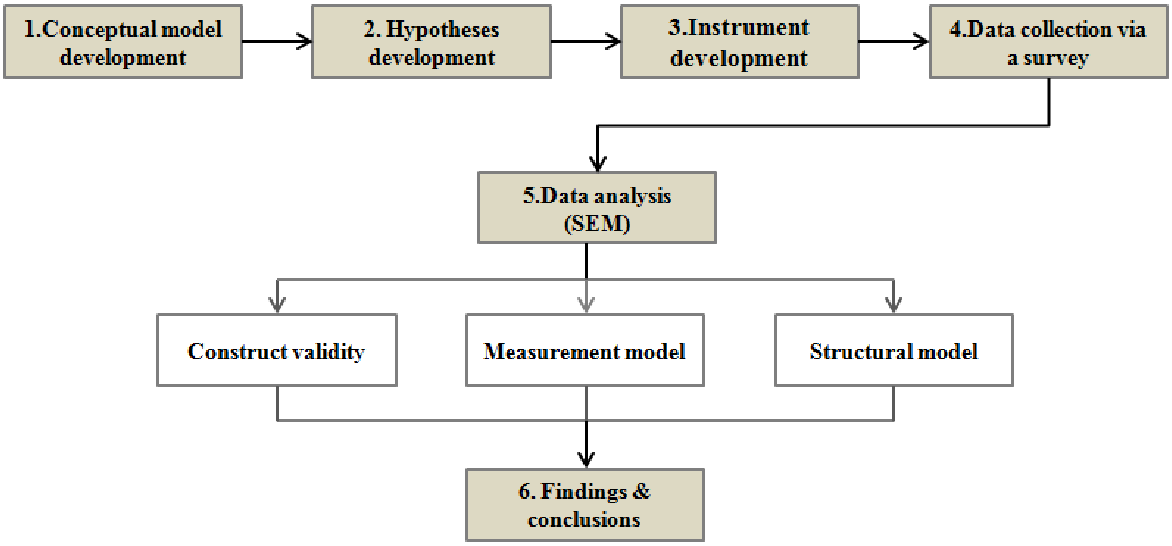



*Figure 4: Research design and flowchart*

## 0.4 Organization and plan of the thesis

The thesis is in the form of seven chapters, as shown in the figure below (Figure 5). Each chapter has three or four sections. At the beginning of each chapter an introduction of the content is proposed.

The General introduction describes the background and problematization of innovation under the context of digitization for numerous SMEs in China, and then points out the objectives and specific academic questions to be explored. Next the epistemology and methodology adopted in this study is presented, and lastly the organization and plan of the thesis to be employed are also shown as well.

Chapter 1 presents the literature review on the use of digital technology and the typology of heterogeneous networks. In this chapter, concepts, properties and existing forms of digital technology are firstly summarized according to the previous studies. And then it also discusses why and how digital technology affects the innovation process. Next through the review on network theory, the typology of heterogeneous networks is presented in order to identify, and explore the relationship between, business and personal networks.

Chapter 2 illustrates the dimensions of digital innovation. The concepts and characteristics of digital technology are delineated according to the previous literature. And through systematic studies on digital innovation, its dimensions are categorized specifically as follows: digital products innovation, digital service innovation and business model innovation.

The recognition of the dimensions of digital innovation can help us to better understand its nature and pursue our research.

Chapter 3 proposes to return to the literature on innovation value chains from the perspective of knowledge management for understanding its emergence and the variety of knowledge sources. Examining varieties of points of view on the innovation value chain allows us to understand the various innovation activities implemented by the organizations. Through the study of the innovation value chain, the thesis draws up the links and explains the logic during the DIVC.

Chapter 4 discusses how the DIVC has been formed based on the theoretical background. It builds the research model and then 14 hypotheses are proposed. The first section emphasizes the link between the ADT and heterogeneous networks for SMEs according to the nature of digital technology. The second section focuses on linking the effect of heterogeneous networks on digital innovation based on the digital effects. The third section concerns itself with introducing the effect of digital innovation on SMEs' business performance.

Chapter 5 presents the implementation of research design through different choices of methodological steps. Specifically, the thesis first presents the ways in which the operational measures are defined including latent variables and their metrics. In a second step, a pilot study is implemented to avoid the ambiguity of surveys. Then, the research describes the sampling situation through discussion of data collection and tests for possible bias in the self-report survey. Moreover, methodologies are presented including confirmatory factor analysis and path analysis.

Chapter 6 conducts a thematic analysis using the SPSS and AMOS, which was developed to examine the hypothesis following the statistical analysis. Specifically, this chapter features the results associated with tests of the fourteen hypotheses, as well as reliability estimates and tests of validity.

Next, chapter 7 presents a discussion of the results which gives the key findings from the empirical results.

The general conclusion recalls the progress of the research project. Various possible courses of action for practitioners are formulated. The main contributions of this research will be specified, before setting out the limits of this work and then proposing some future paths for further research. Figure 5 provides a graphical overview of the dissertation's organization.

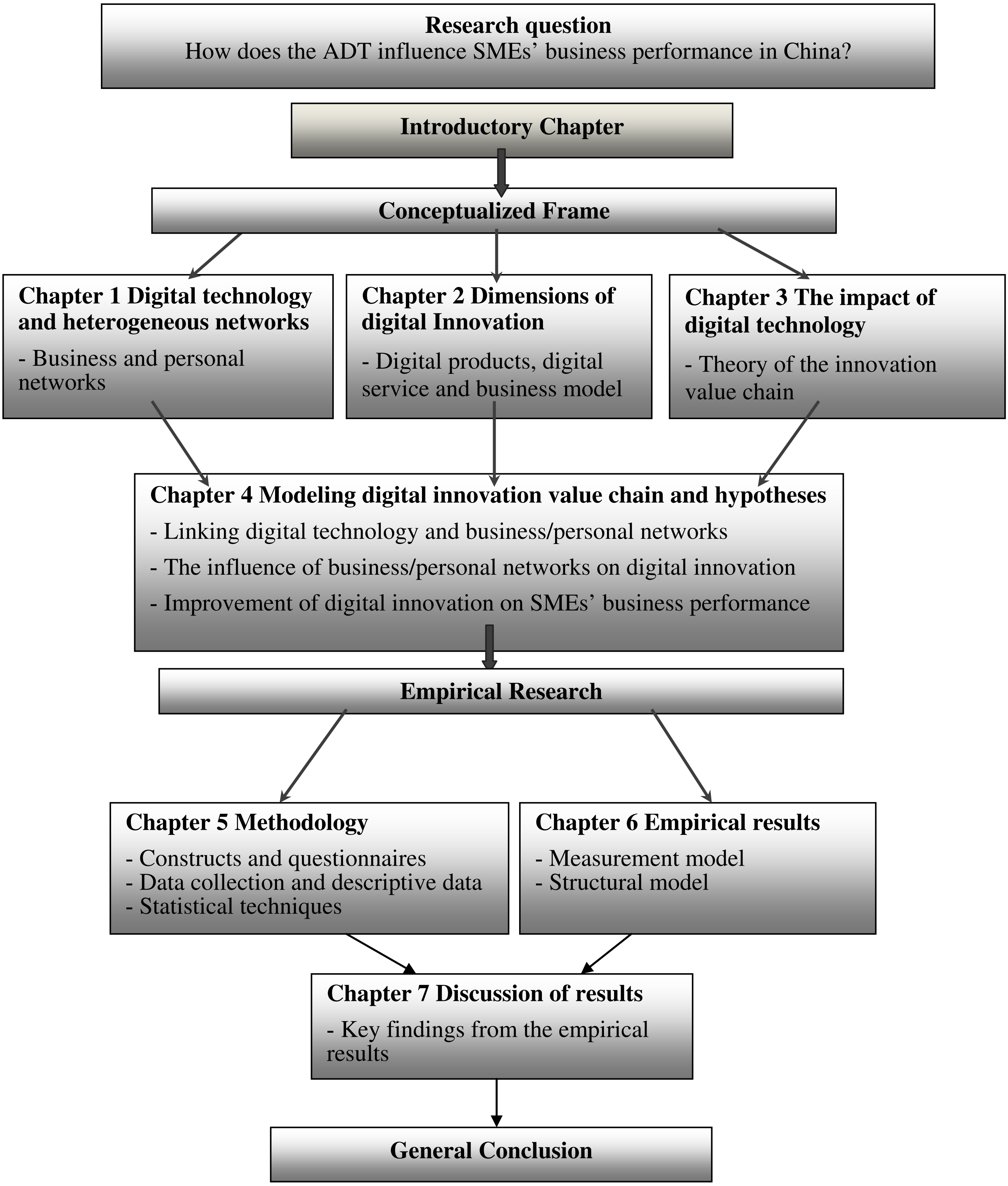



*Figure 5: Plan of the thesis*

# Part I : Conceptual Frame

# Chapter 1 : Use of digital technology and heterogeneous networks

In the last few decades, the emergence of digital technology has completely altered the perceptions of human beings and their ways of living. Firms operate in an environment that is increasingly penetrated with digital technology. It is inserted in the very core of the products, services, and management and business of many firms. Each day products now have added software-based digital competence, and firms are continually generating management systems consisting of intelligent machines with digital sensors, networks and processors (Yoo et al., 2012). For example, the emergence of novel digital technology, such as big data, virtual reality, artificial intelligence, cloud computing and block chain, has converted the nature of the innovation process. Thus, some scholars have provided their insightful thoughts on digital technology. This research also summarized and interpreted its definition, properties and existing forms. Furthermore, it differentiated digital technology from information technology and high technology, which can give a better understanding of the nature of digital technology.

## A) Digital technology affords a new way of pursuing knowledge

### *1) What is digital technology ?*

Digital technology can be regarded as digital artifacts, which are quasi-objects defined as relational entities (Ekbia, 2009), comprising a processing unit that operates digitally encrypted instructions and a storage component that possesses both instructions and the data being operated in the identical setup and in the same locations. Those digital artifacts including files, images, and films or videos that are often fluid and editable, infused in multifaceted, distributed, and flowing digital environments (Kallinikos et al., 2013). With the help of digital technology, non-material contents separate objects from their material carriers such as CDROMs, hard drives etc. (Faulkner and Runde, 2013).

Digital technology is also seen as "products or services that are either embodied in information and communication technologies or enabled by them" (Lyytinen et al., 2016). Because digital technology comprises reprogrammable and self-referential entities, it is closely related to data homogenization. Digital technology is embedded into layered, modular architectures thru which it is able to separate content from devices and information infrastructures (Yoo et al., 2010; Yoo et al., 2012).

The two terms “information technology” and “high technology” are similar which leads to confusion with digital technology. According to the definition by Turban et al. (2008), information technology (IT) is the use of computers to store, retrieve, transmit, and manipulate data, or information, often within a business or enterprises. The purpose of IT is to maintain information such as its storage, communication and systemization, etc. It processes with both hardware (machines and tools) and software (programs). Information technology has features analogous to digitalization. The analogy is where information is regarded as several qualities such as graphic and audio. But digitalization in the context of IT is without the customer at its center. Information technology versus digital technology is the same as internal versus external outlook. IT involves processes, assets and technology working with a focus on operations inside organizations while DT are more about the continuous interaction of the users with these outputs and the perceptions gained from them. The processes for digital technology are more co-created.

High technology that is often abbreviated to high-tech is a technology at the cutting edge. It is the most developed technology and its opposite is low technology, signifying simple and traditional technology (Cortright and Mayer, 2001), for example, outdated manufacturing technology is facing the upgrade. The categorization of high technology can be illustrated by such fields as electronics, biology technology, new material, energetic technology, aerospace technology, etc. Therefore, high technology has a broader scope of meaning which is not just limited to digital technology.

### *2) Properties of digital technology*

In the past few years, some scholars have been trying to describe and explain the properties of digital technology (Ekbia, 2009 ; Yoo et al., 2010 ; Nambisan et al., 2017 ; see Table 1: summary of relevant literature on digital technology). According to the above-mentioned literature, firstly, digital technology is editable. It is liable and always likely (at least in principle) to be modified or updated continuously and systematically. There are many forms of editability. It can be achieved by rearranging the elements that make up a digital object (such as items in a number list or subroutines in a software library), by deleting existing elements or adding new elements, or even by modifying some functions of a single element.

In other cases, editability is infused into the objects in the form of regular or continuous updates of content, items, or data fields, just as in the case of various digital repositories; its usability is closely related to continuous updates (such as blog or Wiki pages, trading or booking systems, currency exchange systems)( Nambisan et al., 2017).

Secondly, digital technology is interactive, which provides another way through which human agents can activate functions in embedded objects, or explore permutations or potential information items. Although ultimately linked to the editability of digital technology, interaction is considered different from editability because it does not result in any immediate change or modification of digital objects. Its key quality is information exploration, which is due to the responsiveness and loose bundling of the project, which makes it possible to take occasional actions (depending on the user's choice), the burden of distinguishing the fixed response of digital technology and physical objects, and the inertia of paper and non digital records. Of course, all technologies need a certain degree of malleability (Orlikowski, 2000). However, as the thesis will further elaborate below, interactivity is closely related to the loose coupling of modular architecture and digital object elements and the greater freedom these conditions provide.

Third, digital technology can be accessed and modified through other digital objects, such as when using image editing software to change digital images, or when content from different sources is aggregated to form a new title. It can also be implemented in a deeper way by accessing the basic principles or rules of programs that control the behavior of digital objects or their source code, usually by experts or powerful amateurs. Therefore, digital objects can be accessed and modified in principle (if not in practice) through programs (digital objects) rather than programs that control their own behavior (Kallinikos et al., 2013), so they are open and reprogrammable. Openness or reprogrammability is closely related to change and modification, so it is different from interactivity. It is also different from editability because the latter is recognized as simply reorganizing, adding or deleting the contents and items that make up a digital object, or updating information (for example, in a database), without interfering with control objects and information production and processing mechanisms. It is thus envisaged that openness is linked to the interoperability of digital technology (Ekbia, 2009). Of course, using other information to edit written information is a widespread social practice. You can also extend, modify, repair, or destroy a physical object through another physical object, or combine two or more physical objects to accomplish a specific task. But, digital objects allow deeper interpenetration of the items and operations that make them up. Interoperability is an important condition for a digital ecosystem (Yoo et al., 2010).

Yoo (2010) pointed out that a descriptive feature of pervasive digital technology is the incorporation of digital competence into previously purely physical objects. For example, adding a software application to a screwdriver or adding a medical sensor to a garment. Materiality refers to artifacts that can be seen and touched, are usually difficult to change, and contain a sense of place and time. In contrast, digital substantiality refers to what software can do by manipulating numbers. The basic characteristics of digital technology include reprogrammable function, data homogenization and digital technology self reference.

Yoo et al. (2010) believed that digital technology needs to be different from early technology because of its reprogrammability, data homogeneity and self-referentiality. First, the digital computer is based on the von Neumann architecture, which means that both the processing unit and the storage unit are integrated in the same digital device. As a result, programs and data are stored in the same format and location (Yoo et al., 2010). As a result, digital objects can perform multiple functions (Selander et al., 2013). Second, data homogenization refers to the fundamental difference between digital signal and analog signal. Although analog data is tightly coupled to analog devices (for example, in vinyl records, VHS cassettes or photographic films, but also in books or magazines), digital data can be stored, transmitted, processed, and displayed by the same device, regardless of the actual content (Tilson et al; Yoo et al., 2010). Therefore, homogenization of data separates content from media. Third, the self-referentiality of digital technology is related to digital innovation, which in turn depends on digital technology (Yoo et al., 2010).

Fourth, as a product of interoperability and openness, digital technology is distributed, so it is rarely contained in a single source or institution. In this sense, digital technology is temporary collection of functions, information items or components distributed on the information infrastructure and the Internet, which makes them strongly different from the physical objects and artifacts composed of non digital components. For example, hypertext hidden in many digital documents is just a network of various web resources, connected by various and interrelated items, devices and producers. Distribution gives digital objects some interesting properties. Digital objects are unbounded. Compared to packaged and single media like books, they lack inherent boundaries that bind them as distinct entities. As the thesis will explain later, these boundaries must be maintained technically. In addition, distribution makes it possible for various combinations in the larger ecosystem of projects, processes, and programs, which is a condition for digital objects to become fluid and crucially deformed (Tilson et al; Yoo et al., 2010).

According to Nambisan et al. (2017), extensibility (e.g., reprogrammability), homogeneity (e.g., standardized software language), and transferability (e.g., digital representation that is easy to transfer to any object) are the core of digital technology, usually comprising physical substance that enables and constrains, but is also interwoven with, human behavior (Leonardi et al., 2008 ; Yoo et al., 2010; Lakhani et al., 2012; Altman et al., 2015; Flyverb et al., 2016).

*Table 1. Summary of relevant literature on digital technology*

| Study | Focus | Definition of digital technology | Properties |
| --- | --- | --- | --- |
| Benkler (2006) | Generativity and innovation | Not mentioned | • Leverage<br>• Adaptability<br>• Ease-of mastery<br>• Accessibility<br>• Transferability |
| Ekbia , 2009 | Open source software | Digital artifacts are quasi-objects defined as processual and relational entities. | • Largely unstable<br>• Unbounded<br>• Resisting reification |
| Faulkner and Runde (2011) | Economics and organization | Non-material bitstrings separate objects from their material bearers such as CDROMs, hard drives etc. | • Reproducibility<br>• Non-rivalry in use<br>• Infinite expansibility<br>• Recombinability |
| Yoo et al., 2010;<br>Yoo et al., 2012 | Information systems | Digital artifacts as reprogrammable and self-referential entities, whose distinct functional make-up is closely tied to data homogenization. Digital artifacts are embedded into layered, modular architectures that help separate content from devices and information infrastructures. | • Programmability<br>• Self-referential entities<br>• Data homogenization<br>• Decomposability<br>• Adaptability<br>• Traceability<br>• Interoperability |
| Kallinikos et al. (2013) | Information systems, communication and | Digital artifacts such as files, images, and films or videos as fluid and editable, often embedded in complex, | • Editability<br>• Openness |

| | | | |
|---|---|---|---|
| | media studies | distributed, and shifting digital environments. | • Transfigurability<br>• Distributedness<br>• Interactivity |
| Lyytinen et al., 2016 | Network | Digital technology is ‘‘products or services that are either embodied in information and communication technologies or enabled by them’’. | • Digital Connectivity<br>• Digital Convergence |
| Lusch and Nambisan, 2014; Nambisan et al., 2017 | Entrepreneurship | Digital technology has three elements: digital artifacts, platforms and infrastructure. | Not mentioned |
| Von Briel et al., 2018 | IT hardware sector | Not mentioned | • Specificity<br>• Relationality. |

### *3) Existing form: layered architecture of digital technology*

The combination of non digital objects with digital technology has fundamentally changed their nature and has had a huge impact on design, production, distribution and use (Sosa et al., 2004; Tilson et al., 2010; Yoo et al., 2010). Yoo et al. (2010) indicated that the features of digital technology lay the foundation for layered architecture. Thus, this may be the best example of the Internet. These layers show two key separations: (1) the separation between device and services is due to reprogrammability; (2) the separation between network and contents is due to data homogeneity.

Yoo et al. (2010) provides a practical concept through which digital objects have a four-layered architecture for all types of digital objects and related services (Benkler, 2006). These four layers are devices, networks, services and contents. Firstly, the device layer includes hardware, which can be any type of device (such as cell phone and mobile car) or administering system to control the hardware and link it with other layers. Secondly, the network layer can transmit data according to physical requirements (cables or transmitter) and logical requirements (i.e. protocol standards). Thirdly, the service layer provides applications through which users can create, manipulate, store, and use contents. For example, users can listen to music online, send e-mails, etc. Lastly, the content layer carries data such as sound, image or video. Because of the characteristics of digital technology, the four layers of digital products can be separated, which means that the design decisions of components in each layer can be independent of other layers, which makes it possible for different companies to participate in the value creation process by integrating different levels of components to generate new digital products (Gao and Iyer, 2006). Components do not need to derive from a major design level of a single product, but can be designed without knowing the actual product (Yoo et al., 2010). Therefore, the development of components does not consider the specific product environment. Components providers may not even be able to foretell how their digital products and services are used and combined. In turn, it breaks out the product boundaries and enables products new meanings. For example, when Apple launched the iPhone in 2007, it not only integrated mobile phones, cameras and music/media players, but also offered other companies a platform to develop mobile applications in terms of mobile, social media or multimedia. Thus, iPhones can not only be seen as a mobile phone, but also as a collection of many functions including payment system, e-book reader, video-game device and camera, etc. Products, services and operations transformed from digital technology produce a new supply characterized by convergence and generativity.

As shown in Figure 6, the layered architecture is made of four layers: devices, networks, services and contents (Farrell and Weiser 2003; Benkler 2006). The device layer can be further separated into the physical machinery layer (for example, hardware) and the operating layer (for example, operating system). The operating layer provides control and management of machines and connects them to other layers. The network layer is analogously divided into the physical transmission layer (including cables and transmitter, etc.) and the logical transmission layer (including network standards such as TCP). The service layer copes with application functions that directly provide services to users when they create, manipulate, store, and consume content. Lastly, the contents layer includes stored and shared data such as text, sound, image and video. The contents layer also provides metadata and catalog information about the source, ownership, copyright, encoding techniques, content tags, geographic timestamp, etc. These four layers represent different design orders, and the individual design decisions of components in every layer can consider other layers to the minimum. As a result, designers can create alternative digital products by using a set of protocols and standards to glue components from different layers together to achieve combinatorial innovation (Gao and Iyer 2006). With the rapid popularization of personal computers and the Internet, the layering of digital technology has brought extraordinary levels of generativity.

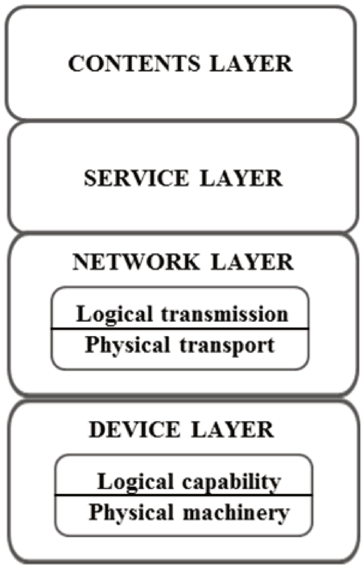



*Figure 6: Layered architecture of digital technology (Benkler 2006; Farrell and Weiser, 2003)*

## B) Digital technology turns innovation into digitization

Owing to the layered-architecture of digital technology, entrepreneurs need to participate in digital innovation by means of digital technology, a process known as digitalization. Specifically, digital technology helps to digitize the innovation process by breaking down the boundaries during various innovation stages, and brings greater unpredictability and overlap within its time frame. For example, new digital tools or techniques can quickly form, develop, modify and implement product ideas through repeated experiments and implementation cycles, so it is not clear when specific innovation process stages start or end (Nambisan et al. , 2017).

Likewise, digital infrastructure, such as cloud computing, can help scale (or shrink) product implementation plans quickly. These create new levels of fluidity in the innovation process, allowing them to unfold nonlinearly in time and space (Nambisan et al., 2017). In terms of innovation outcomes, digital platforms and open standards enable groups (organizations or individuals) to work together to pursue innovation (Bresnahan and Greenstein 2014; Gawer and Cusumano 2014). In the process of innovation, the collaboration among collectives is realized through digital infrastructure capabilities such as knowledge sharing and work operation interface, digital platforms, digital media, virtual world, digital manufacturing space, etc. The space, function and other characteristics of digital technology thus completely determine the content and direction of distributed innovation institutions (Majchrzak and Malhotra, 2013; Smith et al., 2013).

Organizations operate in a world where digital technology is increasingly pervasive. It is infused into the core of many organizations' products, services and operations. Nowadays, daily products have digital functions based on embedded software. Firms usually create management systems composed of intelligent machines, including digital sensors, networks and processors (Yoo et al., 2012).

With the development of digitalization, the dependencies between innovation process and innovation outcomes become complex and dynamic. For example, Boland et al. (2007) demonstrated that innovative construction projects and the use of 3D tools as digital process infrastructure resulted in unexpected interactions and collaboration among different industries, designers and other actors, producing multiple "innovation awakenings". At the same time, Dougherty and Dunne (2012) also showed that the use of digital technology in new drug discovery generated the reorganization of the innovation locus and the creation of a necessary set of new activities among scientists, which in turn had an impact on innovation outcomes.

Digitalization makes it possible for different companies to participate in the value creation process by combining different levels of components to create new digital products (Gao and Iyer, 2006). Components do not need a major design level from a single product, but can be designed lacking of much knowledge about the real product (Yoo et al., 2010). Therefore, the development of components does not consider the specific product environment. Component vendors may not even be able to foretell how their digital products and services will be used and combined. In turn, it clears the product boundary and opens the door to new meanings. The products, services and operations transformed by digital technology generate a new development path characterized by digital effects.

### 1) Digital effects: convergence and generativity

Digital technology is reprogrammable and is able to separate the symbolic functional logic of the machine from the physical embodiments that perform it. The reprogrammability permits digital devices to perform a variety of functions. The digital representation transforms any analog signal into a series of binary numbers, that is, bits. This will result in the homogenization of all data accessible to digital machines. The same digital machines and networks can store, transmit, process and display any digital contents. In addition, compared with analog data, digital data comes from heterogeneous data sources and can be effortlessly merged with other digital data to provide multiple services, thus eliminating product and industry boundaries (Yoo et al., 2010).

Digital convergence can be described as "the necessary, universal and interactive reallocation of modern social technology and information infrastructure" (Tilson et al., 2010). It refers to the integration of media, storage and distribution technologies, which combines the previously separated user experiences (Yoo et al., 2012). This creates new possibilities for integrating and reconfiguring machines, networks, services, and contents, which were primarily produced for various purposes, and expressions are now found in the layered product architecture. As a result, "computing, telecommunications, and broadcasting all merge into discrete bitstreams supported by the same ubiquitous network" (Odlyzko, 2001). Generativity signifies the dynamic design of digital objects (Zittrain, 2006). Since the layers in the digital product architecture are only loosely linked, they can be reintegrated in various ways, resulting in new unexpected combinations (Yoo et al., 2012). Therefore, generativity is the result of the dynamic and extensibility of digital objects, whose designs are considered permanent and independent of its actual intended use (Zittrain, 2008). Therefore, the modular layered architecture makes products inconsistent and offers new possibilities for new meanings (Yoo et al.,2010).

Firstly, compared with analog technologies, digital technology can separate contents from digital devices (Yoo et al.,2010). This indicates that digital contents, including image, music or social media application, can be spread across different platforms as long as it follows the same standard (such as TCP / IP), so that heterogeneous digital devices can encode the data in the expected way. This also signifies that knowledge is scaling in a inexpensive way after the initial design (Henfridsson et al., 2014), because the marginal cost of its subsequent reproduction is negligible. To put it another way, the marginal cost for making reproductions and capabilities bears little relation to the speed by which digital entities and its reflective actors can expand the user base (Brynjolfsson and Saunders 2010).

Secondly, digital technology is able to separate form from function. It is derived from the von Neumann computing architecture and its storage-program concept (Langlois 2002). Because the digitally encoded instructions that make up functions are independent, the digital devices (forms) make digital technology more flexible by allowing them to execute a wide variety of instructions. (Yoo et al., 2010). For example, new features can be added to digital products without a complete revamp of existing designs. This enables agents of digital enterprises to re-position innovation in their business strategy and find ways to cultivate and revitalize the growth rate of their user base (Kallinikos et al., 2013; Henfridsson et al., 2014).

Self-reference shows that digital technology is necessary for digital innovation. The radical increase in the computer price and performance and the development of the Internet of Things (IOT) have made the digital tools that are needed for innovation become more affordable for various economic and innovation activities that were previously excluded. As a result, digital technology democratizes innovation, allowing almost anyone to play a part in it (Kallinikos et al., 2013; Henfridsson et al., 2014).

In order to understand the rapid expansion of digital enterprises, Yoo et al. (2010) summarized the research on digital innovation and digital infrastructure (Tilson et al., 2010) in order to thoroughly investigate the meaning of generativity of digital technology when deployed in the hands of reflective actors. To understand scaling as a generative development instead of a self-referential one, it is necessary to pay attention to the fact that digital technology is usually "designed with an incomplete understanding of 'holistic' design". In fact, the flexibility provided by digital technology shows that innovation plays an increasingly critical role in fostering reproductive capacity. Therefore, the research tracked mechanisms that could lead to rapid expansion of the user base (Yoo, 2013).

### 2) Digital effects: specificity and relationality

According to Von Briel et al. (2018), the particularity of digital technology is that it describes the behavior and interaction of actors. Digital technology presents the value by making some actors' behavior possible, thereby changing the nature of their work. Thus, digital technology plays a mediating role, enabling them to control inputs, outputs, and their transformations. Namely, digital technology can determine what types of resources actors can provide as input, and how those resources are converted into output and provided as output. Therefore, particularity is related to what DeSanctis et al. (1994) termed *restrictiveness* (the set of possible actions that can be performed) vis-à-vis *comprehensiveness* (the diversity of features provided by technology). Specificity, however, also involves a focus on additivity (the degree to which a technique's tasks are optimized), which is at the heart of digital technology. The more specific a technology is, the more bounded the set of controlled actions and interactions it implements.

The degree of specificity of digital technology is important because it reflects its adaptability and malleability (Zittrain, 2006; Kallinikos at al., 2013). In principle, digital technologies are adaptable and malleable because their logic is separate from their embodiment and their information is separate from their function: they can be updated. Nevertheless, highly specific digital technologies are usually relatively rigid because their specialization and constraints limit their ability to be reprogrammed into different functions. By contrast, less specific digital technologies are adaptable and malleable because they are restrictive: they can be appropriated and modified to facilitate new functions (Yoo et al., 2010).

The inherent capacity for specificity of digital technology might vary. At one extreme is digital technology with a high degree of specificity which transforms a predefined set of specific inputs into specific outputs in a deterministic manner. At the other extreme is digital technology with a low degree of specificity which accepts a large number of ill-defined or uncertain inputs and lets other actors decide how to transform the inputs into outputs and provide them as outputs. For instance, 3D printers are optimized to create physical objects from scratch, which is a more specific and restrictive task because input and output formats are tightly controlled. By comparison, social media can accomplish a variety of tasks, such as creating, managing, and distributing various kinds of content, establishing conversations and relationships between content providers, and providing opportunities for content providers to promote themselves. These digital technologies inherently have low input and output controls (Yoo et al., 2010).

From the perspective of process boundaries, the thesis focuses on the relationality of digital technologies, which describe their structural connections. The relationality is based on the assumption that digital technologies are to some extant different from and respond to other actors (Orton and Weick, 1990), which allows them to interact (Kallinikos et al., 2013). Digital technologies are essentially interdependent, and they rely on at least one interaction with other actors to formulate their agency. In addition, due to the self-referential ability of digital technologies (Yoo et al., 2010), they can establish relationships and interact with social and other technological actors.

Just like specificity, the inherent capability for relationality of digital technology might also be different. At one extreme are digital technologies with a low degree of relationality that connects to a single type of actor at a time. For instance, a typical 3D printer has a low degree of relationality because it usually interacts with one actor to perform a print job through only one operating device at a time. At the other extreme are digital technologies with a high degree of relationality, which is associated with a large number of potentially diverse actors. For instance, social media has a high degree of relationality because it can establish various connections with a large number of users who create content at the same time (Yoo et al., 2010).

The focus on changes in the specificity and relationality of digital technology allows us to assess the potential for the realization of any digital technology, whether it already exists or is likely to appear in the future. Any type of digital technology can exhibit multiple variations in its characteristics, functions, etc. Therefore, variants of one type of digital technology can exhibit different degrees of specificity and relationality, thereby producing different influences on venture creation processes (Yoo et al., 2010).

With the digitization of innovation, companies have to acquire new capabilities to quickly articulate and rearticulate distant knowledge within and outside their boundaries. Digitalization in innovation also provides opportunities to connect with external stakeholders and resources, thereby expanding opportunities for open innovation (Nambisan et al., 2017). Established companies and start-ups adopt new business models that combine new knowledge and resources provided by digital technology (Yoo et al., 2012).

### *3) The role of digital technology in the innovation process*

Von Brie et al. (2018) proposed that digital technology plays three important roles in the innovation process. First of all, the role of digital technology is to explore a wide range of low-cost markets and technologies to identify potential demand, and develop ideas to satisfy them. Hence, the key success factor is the ability to obtain different information sources and explore customer needs and technological feasibility (Verworn, 2009). For instance, rapid prototyping technologies such as 3D printers and small factories reduce traditional barriers to process time and resource intensity. Social media can access a wide range of information and expertise, which greatly reduces external dependence. Digital platforms increase flexibility and diversity of prototypes.

Secondly, digital technology can be viewed as a process of transformation. It is a deeper, usually more expensive exploration of narrower possible development routes, and thus is increasingly committed to a specific business model, product and target market. The crucial factors are to obtain and accumulate the necessary resources, minimize development costs and time to market (Pavlou and El Sawy, 2006). For instance, crowdfunding platforms reduce the traditional high external dependence (for example, on traditional funding sources and market research), and help meet resource needs.

Thirdly, digital technology leverages the creation of efficient and scalable systems and routines to produce, market, and distribute products developed in the previous phases. The crucial factors are minimizing production and distribution costs and maximizing value delivered to customers (Pavlou and El Sawy, 2006). Digital technology can bundle diverse resources together to create new artifacts, such as devices, functions, and business models thru changing existing ones. It still operates much as it did in the transforming phase, for example, by expanding the product functions and crowdsourcing platforms through smartphones, thus replacing the traditional sources required to maintain and grow the business. In addition, cloud computing services such as those offered by Alibaba reduce traditional rigid barriers through making physical products accept changes even after the product is released.

The relationship between digital technology and other actors in the channel through which resources flow (Podolny, 2001) makes more relationships mean potentially more access to the resources inherent in these relationships. The centrality of digital technology in their networks allows them to direct the flow of resources and accumulate resources flowing through them. Therefore, relationality refers to a set of relationships with other actors that digital technology can utilize to promote their functionality (Kallinikos et al., 2013). Through affecting which actors and how many actors can participate in the processes supported by digital technology, relationality affects the boundaries of venture creation processes.

## C) Typology of the heterogeneous networks

### *1) Network theory*

Over the past few decades, the network approach has become increasingly popular for providing explanations of organizational phenomena (Zaheer et al., 2010; Borgatti and Halgin, 2011; Snow and Fjeldstad, 2015). Because it shifts the focus from the attributes of a single actor to the relationship between systems that depend on the actors (Smith et al., 2014). Therefore, the behavior of the companies is interpreted as “the structural constraints of activity, rather than the force within the units” (Wellman, 1988). Hence, the network theory provides a holistic view, because the results are not only explained by the characteristics of actors, but also attributed to the network environment of actors (Smith et al., 2014). Organizational research starts from a network perspective to understand a range of results, such as individual, team and organizational performance, power, turnover, job satisfaction, promotion, stakeholder relations, innovation, leadership, creativity, inter-enterprise cooperation, and immorality behavior, etc. (Kilduff and Brass, 2010). Similarly, network analyses have become normative tools in management consulting. Some scholars make the criticism that network research is vacillating between metaphor and methodology, lacking theory (Knoke, 2008). In response to these critics, many literature reviews attempt to make network research meaningful by summarizing the theoretical foundations of network theory (Borgatti and Halgin, 2011; Smith et al., 2014).

Granovetter’s theory of the strength of weak ties (Granovetter,1973) and Burt’s structural holes theory (Burt and Celotto, 1992) are crucial to network theory. The former holds that if the network consists of weaker ties, the spread of ideas or information is apt to have a greater impact. Granovetter presumes that strong ties are built between actors in similar social environments. Strong ties probably describe the relationships between actors of the same third-party. However, weaker ties emerged between actors who did not have much in common. Weak ties link actors who do not share similar social environments, and because they connect different networks of similar actors, they can bridge ties. Granovetter believes that bridging ties are a source of new ideas and information because there are exclusive connections between actors. Therefore, bridge ties promote the spread of new ideas and information (Smith et al., 2014).

Burt's structural holes theory (Burt, 1992) serves as the second fundamental network theory. Burt indicates that if the network of actors shows more structural holes, the actors will perform better than other actors with the same number of ties in similar strength. Structural holes are ties between an actor and other cohesive networks. Although information in a network is viewed to be redundant, structural holes offer actors with new information and thus have a competitive advantage. Burt's theory provides a strategic view of networks, as opposed to Granovetter's view of the random appearance of networks. Nonetheless, both network theories highlight the value of new information provided by structural holes and bridging ties respectively. Burt's theory of structural holes provides a theoretical explanation for Granovetter's observation that weaker ties are more likely to bridge cohesive networks. According to Burt, weak ties are correlate rather than a cause of value generated from bridging ties. Hence, the two theories are closely related (Borgatti and Halgin, 2011).

Essentially, network theory is based on two explanatory concepts. First it focuses on using structure and location as key features for predicting organizational results. According to Burt (2001) and Granovetter (1973), the structure of the network and the position of the actors are the determinants of the network and the outcome of the actors. By associating actors' attributes with the structural aspects of the network, it can be taken into account. However, attributes are only a secondary role, and the emphasis is still on structure. Second, networks are based on the pipeline or flow model, which means they are distributors of information (Borgatti and Halgin, 2011).

The flow model demonstrates that the position and distance between nodes have an effect on the length and frequency of flows, which in turn are related to more general results. The flow model shows that the point of time when nodes receive the flow, the degree of certainty and the redundancy of flow are important to understand the organizational phenomena (Borgatti and Halgin, 2011). Therefore, "network theory consists of elaborating how a given network structure interacts with a given process (such as information flow) to generate outcomes for the nodes or the network as a whole" (Borgatti and Halgin, 2011).

Nodes that occupy a central position may have an advantage because they are more likely than other nodes to receive the flow earlier. The content of ties is not significant to flows, yet the patterns of interaction have a great influence on which and when flows are received. Actors at the center gain advantages because they can more easily access the resources (Borgatti and Halgin, 2011).

Borgatti and Halgin (2011) proposed another essential model of network theory. The bond or coordination model of networks indicates that networks give nodes the opportunity to align and collaborate (Borgatti and Halgin, 2011). Structure also has an impact on the power relationship between nodes. However, in contrast to the flow model, the underlying mechanism is different. Power in networks can be expressed through dependency relationships (Cook and Yamagishi, 1992). The status of nodes in the network is not important, because one position is more likely to receive flows than others, and network power is related to virtual merging, in which there is an interweaving solidarity between interdependent nodes, which may lead to the union of nodes (Uzzi, 1996). Ties of solidarity and exchange may be interwoven, as in the so-called network organization (Powell, 1990), where independent actors appear to act as an entity (Borgatti and Halgin, 2011). Therefore, the bond model treats network ties as bonds, which align nodes with each other and coordinate their actions. If the positions of actors are not excluded from the exchange transaction, they will gain an advantage.

### 2) Value creation by heterogeneous networks

Digital products and services are rooted in the idea of digital effects. The value created through digital effects is markedly different from other sources, and innovation occurs in unpredictable ways, ignoring previously established value chains (Tilson et al.,2010; Yoo et al., 2012). The value creation processes are not a centralized process in which a focal company determines the product architecture and coordinates the actors to add value to the product, but rather develop through discordant interactions between distributed and heterogeneous companies. Enterprises create value by creating networks that connect diverse enterprises and encompass multiple layers that may act as products or networks (Yoo et al., 2010). Because the layers in the heterogeneous networks can be decoupled, digital objects can act as platforms on the basis of their own installation at one layer and as components at the other. Enterprises can rely on specific layers for cooperation and competition at the same time. In addition, heterogeneous networks form hubs or control centers for multilateral markets, connecting companies, coordinating exchanges, and enabling unrealistic strategies. In multilateral markets, heterogeneous networks play a mediating role in facilitating service exchange, without having ownership and control of components and modules (Thomas et al., 2014). Therefore, the ubiquity of digital technology has made digital heterogeneous networks a central focus of value creation activities, enabling companies in various industries to develop and integrate new devices, services, networks and contents (Yoo et al., 2012). Yoo et al. (2010) claimed that the organizational logic behind such digital objects is doubly distributed. It is distributed since digital effects, as a source of value creation, need to be achieved through a combination of heterogeneous resources across layers, and because control and knowledge are distributed across multiple companies, it is doubly distributed.

The digital effect has triggered new market dynamics and formed a heterogeneous network of innovation activities among market actors. Vargo and Lusch introduced a service-oriented logic that takes into account digitally driven value-creation transformations (Vargo and Lusch, 2008; Vargo et al., 2008). Service is defined as “the application of specialized knowledge and skills for the benefit of another actor or the actor itself” (Lusch and Nambisan, 2016). This would reflect a shift in the process of value creation from being output-centric to doing something beneficial. Service-led logic does not focus on tangible, static resources which require some action to become valuable (products and service), but rather regards economic exchange as a process of deploying knowledge and skills for the benefit of others and oneself (Vargo et al., 2008). Accordingly, commodities are regarded as appliances (tools, distribution mechanisms), which are specialized forms of service provision (Lusch and Nambisan, 2016). Therefore, value is the “comparative appreciation of reciprocal skills or services that are exchanged to obtain utility” (Vargo and Lusch, 2008). Utilizing use value means that value will only appear when providing services in a specific context is beneficial or useful to another actor (customer). Consequently, value must always be co-created since “there is no value until an offering is used-experience and perceptions are essential to value determination” (Vargo and Lusch, 2008). Value is co-created via the integration of diverse resources of multiple actors (Vargo et al., 2008). The value creation process involves at least the enterprise terminals that the beneficiary may use during the acquisition, usage and disposal process. Thus, value can only be realized if the beneficiary participates in value creation. Given the multi-tier architecture of digital objects, where various companies may provide components and elements, the environment for value creation is described by several relationships that are directly and indirectly connected to the exchange. It is formed by the interactions among market actors who apply and integrate various resources through value propositions to achieve mutual benefit. All these interrelationships offer an environment in which companies experience value. As relationships are constantly changing, use value is dynamic in nature (Lusch and Nambisan, 2016). The companies do not offer value per se, but provide value propositions to interact with other market actors to co-create value. According to this, Normann (2001) focuses on the relationships among market actors building creation networks, in which a single company first acts as "an organizer of value creation".

Therefore, service-led logic shifts the place of value creation from company value to network level. In the emerging digital environment, value creation processes are not based on the linear sequence of events on a chain of the company's respective contribution through value-added activities, but on the contributions of multiple stakeholders who integrate and apply resources for themselves and others (El Sawy and Pereira, 2013; Lusch and Vargo, 2014; Barrett at al., 2015). Service-led logic is not only a re-conceptualization of economic exchange, but also helps to understand how companies create value in a digitally penetrated economy. The digital effects of digital technology make products inherently uncompleted. Companies continue to create new meanings of goods and services through redefining product boundaries (Verganti, 2009; Chandler and Vargo, 2011). The dynamic nature and flexibility of products make it necessary to reconsider the static value-added approach. Therefore, the transition from the output of something to the process of doing something, and the focus on use value rather than exchange value, are results of dynamic development. Digital effects are the main sources of relationships to search for the ways to create value. As a result, the obvious distinction in the industries involved began to disappear (Koch and Windsperger, 2017).

### *3) Business networks and personal networks*

Different terms are employed to classify heterogeneous networks, for example, social and business network relationships (Loane and Bell, 2006), informal and formal contacts (Hutchinson et al., 2016), and personal and inter-firm networks (Manolova et al., 2010). According to Jin and Jung (2016), they thought that all of those networks can be classified generally into informal personal networks or formal business networks.

Concerning informal personal networks, previous researchers have employed various terms, for example, social networks, social ties, interpersonal relationships, personal connections, personal networks, social relations, and relational networks. The concepts and interpretations of these terms vary from research project to research project; this study uses the term “personal networks” and defines it as an informal structure of personal relations built through family, marriage, school, and living experiences (Zhao and Hsu, 2007; Jin and Jung, 2016). Personal network are characterized as a robust, consistent, identity-based and informal connection which is formed upon goodwill and trust (Hite and Hesterly, 2001). Many scholars have paid great attention to personal networks under the context of SMEs due to the vital role that SMEs’ personal networks play especially when they consider the knowledge sources for innovation. They are found to be particularly instrumental for the innovation activities (Jin and Jung, 2016).

Business networks refer to intimate and lasting relationships with the firms’ important actors, built largely through established interdependencies among different companies conducting business together, for example, partner firms (i.e. suppliers, dealers, buyers, etc.) (Jin and Jung, 2016). For the construction of business networks, SMEs with strong big data analytics are able to grab a slice of market that is growing and shows no sign of slowing. SMEs show more flexibility and agility compared to large ones when facing the digital transformation, even large firms that possess high-end technologies and abundant resources which used to occupy the dominant place in the business networks (Jin and Jung, 2016).

Many significant prior studies focus on the advantages of personal networks for SMEs, which involve decreasing transaction costs, risk and uncertainty with the market entry, and improving credibility and trust among exchange partners. To be more specific, SMEs’ social networks allow them to perceive and recognize market opportunities (Ellis, 2011), gain access to digital market and recognize and establish exchange partners (Ellis, 2000; Freeman et al., 2006).

Personal networks can also facilitate the entry modes and entry timing. Potential partners recommended by strong connections were selected twice as often as weak ties (for example, casual friends and connections). However, personal networks also display some disadvantages because they only permit access via some channels, for example, friends or relatives, which leads to restricted choices and information. Like business networks, personal networks can also help SMEs make entry mode choices, for example, re-timing of market entry (Jin and Jung, 2016).

Despite substantial amounts of existing research on heterogeneous networks and their effects, it is still unclear how networks, either personal or business, are related to digital technology and digital innovation. As demonstrated above, many researchers have found contributions of networks on SMEs' decisions to market recognition, market entry and entry timing and so on. Both personal networks and business networks allow SMEs gain access to resources; yet the way in which each contributes to creating value still remains unanswered. Whether heterogeneous networks contribute to digital innovation and SMEs' business performance directly or indirectly is even less explicitly studied. In the following chapter, this research will review digital innovation to explain its key dimensions (Jin and Jung, 2016).

# Chapter 2 : Dimensions of digital innovation

This chapter mainly discusses the different definitions and key characteristics of digital innovation based on the literature. Moreover, this assessment of the dimensions of digital innovation is categorized according to the prior studies. This chapter proposes that digital innovation is the innovation afforded by the ADT, and digital innovation has three distinctive features including reprogrammability, homogenization of data and the self-referential nature. For the purpose of this study, the dimensions of digital technology can be described as digital products innovation, digital service innovation and business model innovation. Digital products innovation is significantly new products that are either embodied in or supported by digital technology. Digital service innovation is the service that is integrated with digital technology. Business model innovation is the change of the target market of the organization, the design of business activity systems and how the organization interacts with customers, channel partners or other stakeholders.

## A) Definition of digital innovation

With the advent of digital innovation and digital transformation, more and more scholars believe that new theories are needed. Because the innovation process itself is submitted to digitization, some think that the accepted theories of innovation are no longer applicable (Yoo et al., 2012; Nambisan et al., 2017). As an example, Nambisan et al. (2017) said that "there is a critical need for novel theorizing on digital innovation management" which is able to fully respond to the promptly varying nature of the innovation process in the digital world.

Digital innovation is related to the creation and putting into practice of innovative products and services (Hinings et al., 2018).

According to Nambisan et al. (2017), digital innovation refers to the application of digital technology in innovations extensively: the term "digital" can be understood as the conversion from mainly analog information into the binary language understood by computers. In this case, digital innovation is the process of concerted orchestration of new products, new processes, new services, new platforms, or even new business models in a given context (Nambisan et al., 2017).

According to Nambisan et al. (2017), digital innovation is the use of digital technology in the process of innovating. Digital innovation can also serve to describe the results of innovation in whole or in part. Digital innovation has fundamentally transformed the nature and structure of novel products and services, spawned new ways of value creation and value appropriation, enabled innovation collectives which involve dynamic participants with various goals and capabilities, created a new category of innovation processes, and changed the entire industry extensively in its wake (Boudreau and Lakhani, 2013; Iansiti and Lakhani, 2014; Porter and Heppelmann, 2014).

According to Nambisan et al. (2017), digital technology and digital innovation are different to some extent, The definition of digital technology aims to capture three important and coincident phenomena. Firstly, the definition of digital innovation involves a series of innovation results, such as new products, platforms, and services as well as new customer experiences and other value channels; so long as these results are made possible through the application of digital technology and digitized processes, there is no need for outcomes themselves to be digital. Secondly, the definition of digital technology involves extensive digital tools and infrastructure (for example, 3D printing, big data analytics, cloud computing, etc.) to make innovation possible. Thirdly, the definition contains the probability that the results may be dispersed, absorbed, or adapted to particular situations such as digital platforms typically encounter. The broad definition thus allows for research to focus on intra-organizational innovation management, digital products, platform, ecosystems, and infrastructure (Tilson et al., 2010; Yoo et al., 2012; Bharadwaj et al., 2013).

With the rise of digitalization, scholars have increasingly questioned the explanatory power and practicability of existing innovation theories and related organizational scholarship (Yoo et al., 2012; Barrett et al., 2015; Benner and Tushman, 2015).

The conversion from innovation to digital innovation is a golden opportunity for researchers. For the past four decades, researchers have been at the forefront to observe the dawn and successive waves of digitization in organizing and explaining its consequences in society. Generally, their efforts were mainly centered on effects of digitizing internal organizational process (Fichman et al., 2014). More recently, it has expanded to identify and elucidate unique aspects of digitization in industries, specific organizational fields, or product families. They have particularly highlighted the paradoxes and dilemmas that digitalization brings to development and deployment of organizations, and management of digital innovation (Yoo et al., 2010; Tilson et al., 2010; Tiwana et al., 2010; Kallinikos et al., 2013;

Lyytinen et al., 2016; Nambisan, 2017). Scholars have also been increasingly focused on the materiality of digitization within innovation processes and outcomes (Boland et al., 2007; Lee and Berente, 2012; Majchrzak et al., 2013).

Digital innovation can also be defined as the reorganization of digital constituent in a layered, modular architecture to create new useful value for users or potential users of services. This definition indicates that digital innovation is not only a process but also an outcome (Lusch and Nambisan 2015).

*Table 2: Summary of relevant literature on digital innovation*

| Study | Topic | Definition of Digital Innovation | Characteristics |
|---|---|---|---|
| Yoo et al., 2010; 2012 | Digital Source & transformation | Digital innovation is defined as the carrying out of new combinations of digital and physical components to produce novel products. | Convergence<br>Generativity |
| Boudreau and Lakhani, 2013 | Innovation process | Digital innovation is the use of digital technology during the process of innovating. Digital innovation can also be used to describe, fully or partly, the outcome of innovation | Fluidity<br>Heterogeneity |
| Fichman et al., 2014 | Digital transformation | Digital innovation is defined quite broadly as a product, process, or business model that is perceived as new, requires some significant changes on the part of adopters, and is embodied in or enabled by IT. | Digitalization<br>Moore's Law<br>Network Effects |
| Nylén and Holmström, 2015 | Digital innovation strategy | Digital innovation is a means for new entrants to leverage digital technology in order to challenge incumbent firms——ultimately causing radical industry-level transformation——it also provides opportunities for incumbent firms to enhance and products, its digital environment, and organization-al properties. | Complexity<br>Rapid Pace<br>New constellation of actors |

| | | | |
|---|---|---|---|
| Lyytinen et al., 2016 | Network | Digital product innovation is defined as significantly new products and services that are either embodied in information and communication technologies or enabled by them. | Connectivity<br>Convergence |
| Nambisan et al., 2017 | Digitization of innovation | Digital innovation is the creation of (and consequence change in) market offerings, business processes, or models that result from the use of digital technology. | Not mentioned |
| Hinings et al., 2018 | Institutional digital innovation | Digital innovation is about the creation and putting into action of novel products and services; digital transformation means the combined effects of several digital innovations bringing about novel actors (and actor constellations), structures, practices, values, and beliefs that change, threaten, replace or complement existing rules of the game within organizations and fields. | Not mentioned |

## B) Key characteristics of digital innovation as a new form

In order to understand the essence of digital innovation, the thesis must consider the difference between digital technology and earlier technologies. Some scholars summarized three unique features: (1) reprogrammability, (2) the homogenization of data, and (3) the self-referential nature of digital technology.

First of all, based on the von Neumann architecture, a digital device is constituted by a processing unit which executes digitally encoded instructions and a storage unit which holds both instructions and the data being manipulated in the same format and in the same locations (Langlois, 2002). This architecture provides flexibility in the way data is manipulated, so long as users agree on the meaning of digital data and have the wisdom to work out new instructions to manipulate the data. Therefore, a digital device is different from analog technology. The former is reprogrammable, enabling separation of the semiotic functional logic of the device from the physical embodiment which executes it. The reprogrammability permits a digital device to implement a variety of functions (such as calculating distances, word processing, video editing, and Web browsing) (Hanseth and Lyytinen 2010).

Secondly, the analog signal is able to map changes of an uninterruptedly varying quantity onto another continuously changing quantity. As such, analog data connotes a tight coupling between data and dedicated devices which are used to store, transmit, process, and display the data. By contrast, a digital representation is able to map any analog signal onto a set of binary numbers, i.e., bits (a contraction of binary digits). This results in the homogenization of all data which is accessible by digital devices. By using the same digital equipment and network, one can store, transmit, process and display any digital contents. Additionally, digital data is different from analog data. The former emanates from heterogeneous sources and can easily be combined with other digital data to provide diverse services, eliminating product and industry boundaries. Therefore, with the emergence of new media, the homogeneity of data separates the content from the media (Hanseth and Lyytinen 2010).

Finally, self-reference indicates there is a need to use digital technology for digital innovation. Hence, the proliferation of digital innovation creates positive network externalities, further accelerating the creation and availability of digital devices, networks, services, and contents (Benkler 2006, Hanseth and Lyytinen 2010). This, in turn, promotes further digital innovation through a virtuous cycle of lower entry barriers, reduced learning cost and accelerated diffusion rates. The dramatic increase in the price/performance of computers and the advent of the Internet have made the digital devices required for innovation more affordable to a broad range of economies and innovative activities that were previously excluded. Consequently, digital technology democratizes the innovation process at the same time as almost anyone can participate in it (Benkler 2006, Hanseth and Lyytinen 2010).

## C) Assessment of the dimensions of digital innovation

### 1) Digital products innovation

Digital technology presents highly complicated innovation challenges. Scholars have witnessed how companies suffered major consequences due to failing to deal with them appropriately (Lucas and Goh, 2009). That raises the question: how can digital innovation be analyzed? In other words, can it be analyzed at all? A large number of management researches (Holmström and Stalder, 2001) have explored the relationship between technological innovation and fundamental change. To this end, new technologies can completely challenge existing markets. Nevertheless, the competitiveness of existing enterprises actually hinders their innovation (Nazarenko, 2011). Scholars have elaborated macroscopic strategic models that can help the enterprise to overcome this dilemma. For instance, companies can learn how to cope with both radical and incremental innovation by building up ambidextrous structures and accumulating dynamic capabilities (O'Reilly and Tushman, 2008).

Although these established strategic models of technological innovation management are helpful, recent studies apply new digital technology, such as digital cameras, as objects of research. Yet, the unique and distinctive characteristics of digital technology tend to merge into the background. In this context, the existing researches on digital technology and organizational have two limitations(O'Reilly and Tushman, 2008):

Firstly, it is apt to not fully open up the black box of technology (Orlikowski and Iacono, 2001). It is a crucial first step for firms to take when devoting to managing digital innovation. For those companies which strive to innovate their product and service offering with digital technology it is vital to have managers who are well versed in the specific characteristics of digital technology(O'Reilly and Tushman, 2008).

Secondly, research on technological innovation is prone to adopt a macro-level perspective on its research object, often leading to high-level descriptions of strategic recommendations. To fill this gap, the study turns the focus on the critical areas that need to be addressed when the process of managing digital innovation unfolds in practice (Nazarenko, 2011).

Digital innovation not only serves as a means for new entrants to utilize digital technology to challenge incumbent companies and ultimately lead to fundamental transformation at the industry level, but also provides opportunities for incumbent companies to enhance and expand their product and service portfolios into new areas. Yet, understanding the unique nature of the digital innovation process is a key challenge for any company seeking to manage digital innovation (Yoo et al., 2010).

In the process of participating in digital innovation, existing firms and new entrants are faced with challenges and opportunities that demonstrate extraordinary complexity. One pivotal aspect of this intricacy is the fast pace of digital innovation processes (Yoo et al., 2010). Ultimately the malleability of digital technologies makes this rapid pace possible and they can be easily reconfigured (Tiwana et al., 2010; Yoo et al., 2010). When companies engage in the design of 'hybrid' or 'smart' products where digital constituents are embedded in traditional products, the rapid pace of digital innovation processes is especially challenging. Take this as an example, while a major car manufacturer faces complex challenges in embedding a GPS system, the independent analog and digital innovation processes unfolded simultaneously at vastly different pace (Henfridsson al., 2014). The generativity of digital technology is one of the reasons why digital innovation processes are especially difficult to control and forecast (Avital and Te'eni, 2009; Yoo et al., 2012) ——that is, ''a technology's overall capacity to produce unprompted change, driven by large, varied, and uncoordinated audiences'' (Zittrain, 2006). When users apply digital technology as constituents or platforms to invent new products and services that go beyond the original design intent (Yoo et al., 2010), it can lead to cascades of innovation, whereby each innovation serves as a platform for the next cascade. Ultimately, digital technology continuously evolves into higher processing capacity and lower cost. Along with digital technology becoming more ubiquitous and affordable, barriers to digital innovation are removed, hence enabling new groups of actors to generate, develop and fund new digital products and services (Yoo et al.,2010). They deem that the features of digital technology need to be highlighted when probing how companies cope with the complexity associated with digital innovation (Orlikowski and Iacono, 2001). These unique characteristics of digital innovation processes require companies to challenge established viewpoints and conceptions about the role and configurations of their product and service portfolios, their relationships to the digital environment, and how organizational characteristics are configured in order to support innovation work (Yoo et al.,2010).

Digital products innovation is significantly new (from the perspective of a typical community or market) products that are either embodied in or supported by digital technology. Typical instances include new enterprise platforms, updated consumer products, and existing products that have been significantly enhanced by the addition of digital technology (Yoo et al., 2010). Lyytinen et al. (2016) extended Swanson’ s typology so as to identify Digital product innovation within four classes of innovation networks. These typologies have largely applied to studying the drivers of digital innovation, either the contextual factors that associated with each type of digital innovation.

Researches on digital process innovation mainly put emphasis on technology adopters, while researches on digital product innovation focuses on the enterprises that produce novel digital products and the assorted supply-side processes, institutions, structures, and market dynamics that support and mold product development and propagation. As for process innovations, the boundary on what comprises a given product innovation can be drawn narrowly around a core technology, or more broadly to also encompass complementary products and services that are necessary to fulfill the value proposition for intended users, or what has been called the whole product solution (McKenna, 1985).

Emerging digital technology is not only a product innovation from the standpoint of the provider but also at the heart of process innovation from the standpoint of the customer (for example, a company adopting that analytics device for the first time). In addition, companies can choose to “productize” their internal process innovations and then achieve innovations of product or business model. For instance, Pixar developed a technology called Renderman which served to create 3D images for their own movies, yet licensed this technology to many other companies later on (Yoo et al.,2010).

In a related concept, one kind of digital innovation might enable or become a constituent of other digital innovations. In the realm of mammography for breast cancer detection, digital detection technology has enabled radiologists to substitute analog mammography based on film tape, resulting in a new product: digital mammography. Through digital mammography, a radiologist not only is able to focus on an area on a computer, then enhance it and change the contrast settings but also achieve many things that analog mammography fails to do. A new set of "best practices" that emerges from these capabilities -- including possible changes to bringing remote process experts into the work organization -- can also be viewed as digital innovations. Returning to the example of Pixar, in order to make their digital animation alive (product innovation), Pixar has continuously challenged the limit of the digital technology used to create those films (Lyytinen et al., 2016).

### *2) Digital service innovation*

In the past decade, researches in the field of service innovation have grown substantially. The quantity and diversity of such studies highlight the significance of service innovation in different realms, including marketing (Nijssen et al., 2006; Oliveira and Von Hippel, 2011), economics (Gallouj, 2002; Cainelli et al., 2004) and information systems (Lyytinen et al., 2016), and operations (Metters and Marucheck, 2007; Oke, 2007). These studies reflect two streams of thought. The first holds that there are significant differences between product innovation and service innovation, consequently it is necessary to update service innovation theories and models. This viewpoint is also mirrored in the emphasis on companies as service producers and customers as service consumers (Berry et al., 2006) and on innovation in business processes (Sheehan, 2006), which has largely preserved the essential distinction between product and process innovation.

The second school of thought does not emphasize the distinction between product innovation and service innovation and focuses on the adjustment of existing innovation theories and models to accommodate to the environment of service innovation (Nijssen et al., 2006). Although the insights originated from both schools are valuable, they have been criticized as being too narrow, ad hoc, piecemeal, and biased toward technology-based innovations (Ordanini and Rubera, 2010). Since then, the latest researches have advocated taking an integrated or synthesized measure in investigating service innovation (Gallouj, 2002; Ordanini and Rubera, 2010). Literature on service innovation in the information systems field has taken a different path, mainly because it focuses on software as the central artifact. This literature can be traced back to Swanson and Burton's (1994) research on developing a typology of IS innovation, namely the tri-core model composed of functional, administrative, and technological IS innovations, even though Swanson's emphasis was not on service innovation per se.

More recent researches in this trend have focused on inspecting the impact of explicit types of IT service innovation on company performance (Ordanini and Rubera, 2010) and on adjusting these models of IT service innovation to accommodate particular application contexts. While these researches are valuable, they focus narrowly on IT applications and process innovation (albeit affecting different "cores" of an organization) and therefore neglect the broader perspective of services (and the associated themes) that they proposed. A more nascent stream of study in information systems has begun to recognize the broader impact of IT on service innovation. Yoo et al. (2010) indicate the necessity for IS scholars to investigate the underlying product structure of such digital innovations via emphasizing the increasing importance of digital technology in those industrial-age products. They consider how to combine the layered structure of digital products with the modular structure of physical products, and the impact of this layered modular structure on organizational innovation. Tilson et al. (2010) argue that a similar emphasis on fundamental digital infrastructure is crucial for understanding the broader impact of digital convergence on society. They place special emphasis on the "sociotechnical process of applying digitizing techniques to broader social and institutional contexts". Likewise, Woodard et al. (2013) constructed the concept of software engineering technical debt to consider how enterprises develop their digital business strategy in a digital structure. Similarly, Tiwana et al. (2010) focused on product architecture; but they address it from the standpoint of platforms and the ecosystems that surround it. Although their focus is on the software-based platforms, a wider range of information is for IS scholars to admit the importance of platforms and ecosystems in molding the evolution of markets and industries. More recent empirical researches have further highlighted the significance of the perspective of ecosystem. Ceccagnoli et al. (2012) empirically demonstrated the benefits of enterprises participating in platform-based closed ecosystems. In addition, Han et al. (2012) indicates that enterprises participating in the IT-based "open innovation alliance" or ecosystem can not only enhance the value of enterprises, but also the value of other participants in the ecosystem. Even though the above researches do not specifically focus on (or even use the term) service innovation, the perspectives they take—for example, digital innovation (Yoo et al. 2010), digital infrastructure (Tilson et al. 2010), and software-based platform—reflect the critical concepts and essential issues that the study should consider when designing a broader concept of service innovation. One might argue, however, that the lack of focus on service innovation has resulted in a narrower treatment of these concepts in the above conceptual researches. The goal is to adopt some of these concepts -- particularly platforms and ecosystems -- in a larger context of service innovation to provide a broader range of research topics for IS scholars (Tiwana et al. 2010).

### *3) Business model innovation*

*a) Development, concepts and elements of business model innovation*

In the late 1990s, with the application of digital technology, a large number of new business models emerged, making the concept of business model innovation widely known (Zott et al., 2011). In general, business model innovation developed in three stages (Wieland et al., 2017) .

In the first stage, the business model innovation is regarded as one of the decisive variables, for example, firms can change various elements of business model innovation, such as value proposition, critical resources, key processes, key partners, key activities, customer relationships, customer segmentation, cost structure, revenue sources, etc., so as to make the company gain competitive advantage (Magretta, 2002; Morris et al., 2005). This mode, which is firm-oriented, creates and delivers value for customers.

In the second stage, the business model innovation is not only emphasized as the combination of variables, but is also integrated with more broader and networked participants. Scholars began to study the interaction between the combination, participants and various activity processes (Zott et al., 2011; Mason et al., Coombes et al., 2013). For this mode, the main body of creating and delivering value is expanded from the firms to their stakeholders, such as customers.

In the third stage, the business model innovation is considered from the perspective of systems and institutions, and advocates the notion that the business model is a series of dynamic meaning construction tools that can connect participants, markets and technologies (Doganova et al., 2009). At this stage the business model has gone beyond a firm-centered view, and value creation requires the connection and interaction between the participants in the system. The typical point of view in this stage is the business model under a service-oriented logic, i.e. in which all economic activities are rooted in a broader social environment, while the participants are restricted by the value hypothesis, cognitive framework, rules and regulations (i.e., the role of the system) in a complex environment due to their limited cognitive ability (Simon, 1996).

Currently, different scholars still have different interpretations of the concepts of business model innovation. Chesbrough (2003) believed that business model innovation is "the bridge connecting technology and business value realization". Johnson et al. (2008) indicated that business model innovation includes four interwoven elements: value proposition, profit model, key resources and business process, and ultimately aims to create and transfer value. Osterwalder (2004) believed that business model innovation is a principle, describing "how to create value, transfer value and obtain value".

As for the elements of business model innovation, Osterwalder (2005) proposed that the elements of business model innovation include value proposition, customer relationship, customer segmentation, channel access, key business, core resources, important partners, cost structure and revenue source. Innovation in any of these nine elements means business model innovation.

### *b) Business model innovation in the context of Chinese digitization*

With the development of business model theory, whether an enterprise can evolve over time, improve its business model and realize business model innovation become the key factors to determine the success of an enterprise (Chesbrough and Rosenbloom, 2002). Business model innovation is the change of the target market of the organization, the design of business activity systems and how the organization interacts with customers, channel partners or other stakeholders (Zott and Amit, 2007; Sorescu et al., 2011). Therefore, business model innovation fundamentally affects the value creation and dedicated logic of the organization (Zott and Amit, 2010; Sorescu et al., 2011). The implementation of business model innovation is usually due to one of the following two main reasons: firstly, it is essential to improve the organization and develop new business opportunities (Chesbrough, 2007; Amit and Zott, 2012). Secondly, due to market saturation or competition with similar companies that provide higher value to customers, the existing business model has become obsolete and needs to be replaced by a new business model. In both cases, in order to remain competitive and create sustainable value for customers, partners and themselves, companies must redesign their existing business models or introduce new ones to achieve model innovation (Chesbrough, 2007).

Some Chinese scholars also have their understanding of the characteristics of business models in the digitized era. Luo and Li (2015) thought that the organizational environment of manufacturers was vague, and because of the higher mobility of information flow, information creation was "decentralized", "information was generated by the public, participated by the public and shared by the public", and its unique elements were community, platform, cross-border transactions, resource aggregation and product design. As for the form of AI business models, Wu (2017) proposed an AI driven BOT business ecosystem model of cloud integration, which includes the essential elements of common business models: value proposition, user interface, supply system and financial system (including profitability and cost structure). There are two unique elements: BOT (robot) intelligent interactive platforms based on big data, cloud computing and cloud integration, and artificial intelligence based on the three sides of supply, demand and platform.

A BOT intelligent interactive platform is the heterogeneous resource of an enterprise, and plays a decisive role in customer relationship management. After learning and training the user data on the platform, the intelligent interactive platform can provide more accurate services for the demanders and the suppliers. However, it is worth noting that the nature of intelligent interaction is Unicom, that is, Unicom data within different platforms, such as the cooperation between JD and Tencent to launch the "Jingteng plan". JD provides user purchase behavior data on its platform, Tencent provides user life and other data on its platform. Users are served by the connection between these two platforms. Through the data connection, the study can form a more comprehensive analysis of the users, so as to more accurately predict the user's behavior and carry out customer relationship management. However, as data becomes more and more important as a resource, data connection becomes more and more difficult. For example, the internal data of Baidu, Ali and Tencent, the three giants of China's Internet platform enterprises, is not connected and hence isolated from each other. Because the data acquisition of the platform and the training of artificial intelligence are based on the data of the platform, the external user has a high isolation mechanism for the acquisition of the internal data of the platform, that is, there is both connectivity and isolation in the intelligent interaction. Understanding three-party artificial intelligence refers to understanding the artificial intelligence of the supplier, the demander and the platform. After in-depth learning through big data and algorithms, artificial intelligence will have a certain understanding of the growing data of "feeding", so as to provide more accurate services, connect suppliers, demanders and platforms, and better match the demand and supply among the three. The whole model achieves business success through the interaction of all necessary elements of the business model, brings competitive advantages to enterprises and users through BOT intelligent interaction, while the user interface and supply system jointly construct new value propositions and interact with the three-way artificial intelligence.

*Table 3: Summary of relevant literature on dimensions of digital innovation*

| Research Focus | Authors and Year | Methodology | Main View |
|---|---|---|---|
| Digital products innovation | Yoo et al., 2010 | Conceptual | A digitized product with layered modular architecture can serve as a platform courting for its own installed base at one layer and serve as a component at another layer. |
| | Fichman et al., 2014 | Conceptual | Digital production innovations are significantly new products that are either embodied in IT or enabled by IT. |
| | Lyytinen et al., 2016 | Conceptual | Four types of emerging innovation networks supported by digitalization are distinguished: project innovation network, clan innovation network, federated innovation network and anarchic innovation networks. |
| Digital service innovation | Lusch and Nambisan, 2015 | Conceptual | (1) Service ecosystems,<br>(2) Service platforms<br>(3) Value co-creation |
| | Den Hertog, 2000 | Conceptual | Digital service innovation includes four dimensions of: service concept, client interface, service delivery system and technology. |
| | Vargo and Lusch, 2011; Yoo et al., 2012 | Conceptual | Digital service in an ecosystem facilitates the exchange of service among loosely coupled heterogeneous actors through digital technology. Digital service is (1) co-producing service offerings; (2) engaging in mutual service provision, and (3) co-creating value |

| | | | |
|---|---|---|---|
| Business model innovation | Osterwalder (2005) | Conceptual | Osterwalder (2005) proposes that the elements of business model innovation include value proposition, customer relationship, customer segmentation, channel access, key business, core resources, important partners, cost structure and revenue source. Innovation of any of these nine elements means business model innovation. |
| | Zott and Amit, 2007; Sorescu et al., 2011 | Conceptual | Business model innovation is the change of the target market of the organization, the design of business activity systems and how the organization interacts with customers, channel partners or other stakeholders |
| | Teece et al., 2010 | Conceptual | Business model innovation is defined as how the enterprise creates and delivers value to customers, and then converts payments received to profits. |
| | Fichman et al., 2014 | Conceptual | Business model innovation is defined as a significantly new way of creating and capturing business value that is embodied in or enabled by IT. |

# Chapter 3 : Impact of digital technology on the digital innovation value chain

In this chapter, literature is firstly reviewed to learn about innovation value chains and during which specific activities are involved: namely, knowledge source, knowledge transformation and knowledge exploitation. Many scholars have explored the topics of those activities over the years. Thus, this chapter summarizes the definition and concept of this theory from the strategic literature and then gives an overview of the essential IVC literature. Next, the DIVC will be elaborated to delineate how the value will be created during the process of digital innovation activities.

## A) An overview of innovation

### *1) Definition*

The famous definition of innovation proposed by Schumpeter in his "Theory of Economic Development" (1943) still serves as a fundamental reference for contemporary innovation researches. Schumpeter regarded innovation as the "new combination" of factors of production, that is, the production of new products, the introduction of new processes, the opening of new markets, the new sources of raw materials and intermediates, and the restructuring of industries. Contemporary definitions are usually based on Schumpeter's method. There is a widely used dichotomy between "product innovation" and "process innovation". The former defines the design, introduction, and propagation of a new production process. Even though the two concepts are often related in practice, this dichotomy is useful conceptually. For example, a product innovation of one company can turn into a process innovation of another company, if the service is in the context of the dominant design, product architecture, or existing requirements. On the other hand, radical innovations involve a radical breakthrough in existing products and processes, often opening up new industries and markets. Radical and progressive innovation can be considered as extreme prototypes, but in practice it may be difficult to distinguish them. Because the impact of innovation on economic systems is often unknown in advance, and all innovation, even radical innovation, is to some extent based on existing knowledge, it can often be distinguished only after the fact (Son et al.,2011).

According to Son et al. (2011), innovation is a mixture of processes and product outputs, including new or modified products and services, patents, new marketing techniques, new management devices and administrative processes, licenses and broader thought leadership which can be embodied in presentations at conferences and publications (Sundbo, 1998).

Latest researches from the field of organization focus on the cognitive nature of innovation, which is viewed as the introduction of new knowledge in an economy, or as the new combination of established knowledge (Edquist and Johnson, 1997). When innovation is considered as new knowledge, the dimensions become broader because the creation of new knowledge involves all stages of the chain instead of being confined to the design and production period of a new process or product. For example, when users apply a technology or when a technology is limited by a rival company new knowledge can also be generated. What the knowledge is and how such knowledge can be viewed as "new" (with respect to what) are questions that need to be clarified to make the concept operational and analytically useful (Son et al.,2011).

Because of its universality, "innovation" is a concept that can be explained in numerous ways. Thus, the proxies used in trying to find an empirical approach to innovation are so numerous and so different that what is marked and measured as "innovation" is often a very different phenomenon.

### *2) An overview of innovation studies*

Innovation in traditional microeconomic methods is seen as applying technological and scientific knowledge to established products and processes. Since scientific and technical knowledge is commonly codified and readily available to anyone it is non-competitive and non-exclusive, which often leads to market failure. Therefore, the degree of appropriability of knowledge is regarded as an important factor in a company's innovation tendency. In turn, this appropriability is influenced by the characteristics of the patent system, the existence of knowledge spillover effects, and the nature of technology (Gertler, 2010).

Owing to the contributions of historians, economists and sociologists, important progress has been made towards a greater understanding of the characteristics of the innovation process. In fact, some of these first underlined phenomena such as the cumulative and irreversible nature of technology, the existence of material and social " focusing devices" that guide technological change in specific directions. The definition of technological paradigm and trajectory is cognitive in nature, which also influences the direction of technological change and the role of social factors in molding the characteristics of technological change (Gertler, 2010).

Organization theories provide another series of important contributions to the research of the characteristics of innovation. In the 1990s, the idea of the enterprise as an "information processor" has been replaced by the competence theory of enterprise, in which the enterprise is regarded as a producer of knowledge. The important tacit dimension of enterprise knowledge (Gertler, 2010) is the case that the ability of the company to develop is unique and stable over time. An interesting analogy can be made between the stability of competence mix of an enterprise and the concept of technological paradigm. In fact, competences and paradigms are cognitive concepts that define the likely direction of technological change (Pralahad and Hamel, 1990).

Innovation is no longer considered as a simple application of codified knowledge, but as a process of creating new knowledge, often implicit. The analogy between innovation and new knowledge helps explain many of the characteristics of technological change mentioned earlier: the characteristics of knowledge itself are actually path dependence, uncertainty, and localization (Gertler, 2010).

The growing focus on the cognitive side of innovation has generated an interest in the interaction among subjects as sources of new knowledge: direct interaction among people is actually the main way of dissemination and creation of tacit knowledge. Researchers have begun studying the networks of innovators, which are increasingly taking various forms in the real world (Freeman, 1991; Mowery and Teece, 1996). One explanation for this phenomenon is that in most industrial sectors today, innovation requires the acquisition of external capabilities on an enterprise’s part (Smith, 2000).

Sociologists and organizational theorists have emphasized the significance of cognitive distance among agents during the period of stimulating innovation (Nooteboom, 1999). Other scholars have argued that sometimes the geographical proximity of firms often means the cognitive proximity that promotes innovation. This has resulted in some convergence among different research directions, particularly in terms of competence theory and regional competence theory, national and regional systems of innovation methodology, and literature on industrial areas.

One way the thesis can compare different perspectives with innovation analysis is to look at how they view the unfolding of the process that leads to innovation. In public discourse, the "linear" perspective of innovation still dominates. The development of an innovation is regarded as a process composed of successive stages characterized by unidirectional causal relationships, which are different in terms of time and concept. Technology is considered as the application of science, that is, basic research equals pure science, applied research equals technology, and the "development" phase of new products and processes equals innovation. Neoclassicists and many empiricists, especially those who support the "demand pull" and "technology push" views of technological change, are inspired by the linear vision of the innovation process. It was the analysis of the qualitative features of technological change (particularly the contributions of “actor-networks” theorists) that first underlined how innovation arises from the dynamic interrelationship among diverse elements. Kline and Rosenberg (1986) first suggested that the "linear" model be replaced by the "chain-linked" model, in which different facets of economic and scientific activities internal and external to the enterprise are linked together through multiple causal relationships and feedback. Economic problems, technical problems and the existence of innovation demand are interdependent elements in the process of innovation. This model is crucial because it paved the way for the systematic concept of the innovation process, which is now viewed as the consequence of dynamic interactions among heterogeneous elements systematically related. The metaphor of systems is considered by many as the best device for understanding the processes that lead to innovations.

Another way is that the study can compare and relate to some of the theories that scholars have developed and these theories focus on the role of innovation in economic systems. Neoclassical microeconomics regards innovation as a temporary adjustment mechanism. When external disturbances disturb the equilibrium of the system, an adjustment process is immediately initiated in order to establish equilibrium, in the form of innovation. Hence it is precisely because of the dynamic nature of innovation that it is in a marginal position in the neoclassical framework (Gertler, 2010). At the macroeconomic level, neoclassical analysis has gradually incorporated innovation into economic growth models, although this has resulted in the abandonment of some restrictive assumptions, like atomistic competition, substituted by the monopolistic competition framework. On the other hand, according to Schumpeter (1934), evolutionary theory holds that innovation is the driving force of the economy: innovation is the source of the activities that enable systems to develop over time. Later, the elements of interaction and networking with other companies and institutions have been incorporated into the basic framework of evolution. The economic system is regarded as driven by the selection mechanism, which is not only economic, but also social in essence (Frenken, 2000).

## B) Innovation value chain

### *1) Definition and antecedents of innovation value chain*

The innovation value chain framework has been increasingly employed in the literature to describe the inter-relationships between external interaction, innovation and productivity as part of the innovation system (Doran and O'Leary, 2011). The concept of the innovation value chain which was first proposed in 2007 refers to the process whereby firms generate an idea, and convert this idea into products or practices and finally diffuse those products and practices (Hansen and Birkinshaw, 2007). Innovation can be seen as the process of turning ideas into commercial outputs, an integrated process, like Michael Porter' s value chain of raw materials into finished products. The first stage of the chain is to generate ideas, which might happen inside a unit, across units in a company, or even outside the company. The second phase is the conversion of ideas, or more specifically, the selection of ideas to fund and develop into products or practices. The final stage is to propagate those products and practices. Let us now examine each of the related activities and challenges(Doran and O'Leary, 2011).

Soon, the innovation value chain was further molded as a recursive process through which enterprises acquire the knowledge needed to innovate and translate that knowledge into new products and processes, then exploit those innovations to create added value (Roper et al., 2008). The main advantage of IVC is that it highlights the structure and complexity of the innovation process. This increasingly popular view is echoed in the chain-link model of Kline and Rosenberg (1986). This model captures the systemic nature of the innovation process. Their central chain of innovation starts with a design based on potential markets, and then advances from development, production to marketing. At each stage, feedback links market requirements to potential improvements in design and implementation. The feedback link describes the experience gained in marketing and represents the most important source of knowledge for improvement. According to this perspective, knowledge gained from the market can affect the sustainable development and utilization of innovation outputs. This may leverage the knowledge that the organization has accumulated through past experience (Doran and O'Leary, 2011).

This view is broadly in line with the approach, namely innovative (or knowledge) production function approach, adopted by an increasing number of empirical researches (Crépon et al., 1998; Lööf and Heshmati, 2006). This approach is distinguished by a detailed focus on econometric specification, but also tends to take a very narrow perspective of knowledge sourcing activities, i.e., regarding internal R&D as the only source of knowledge for innovation, and considering a very finite set of control variables (Doran and O'Leary, 2011).

Another view, drawn from the strategic management literature, takes a broader but more discursive approach. Hansen and Birkinshaw (2007) put forward the concept of IVC as a general framework in which almost all enterprise innovation activities can be considered. Based on the consequences of a series of research projects with U.S. and European multinationals, they believe that IVC is a "continuous, three-stage or links in the innovation process, including the generation of ideas, the development of ideas and the dissemination of developed concepts". The central point is that this universal framework emphasizes the interdependence of different stages or links in the innovation process – if any link goes wrong or weak, the whole process is likely to go wrong, regardless of the strength of the others. This presents a strategic approach that encourages managers to use innovation as an end-to-end process and to focus development on the weakest areas.

However, Robbins and Gorman (2016), by analyzing the research on innovation-active Irish SMES, indicated that three-quarters of the companies reported that they did not cooperate in the formal innovation process, which had nothing to do with the poor revenue performance of new products and services. In each stage of the entire innovation value chain, there is little difference between enterprises with formal innovation processes and those with informal innovation processes. Nonetheless, having a more informal innovation process is associated with bringing new products to market successfully (Doran and O'Leary, 2011).

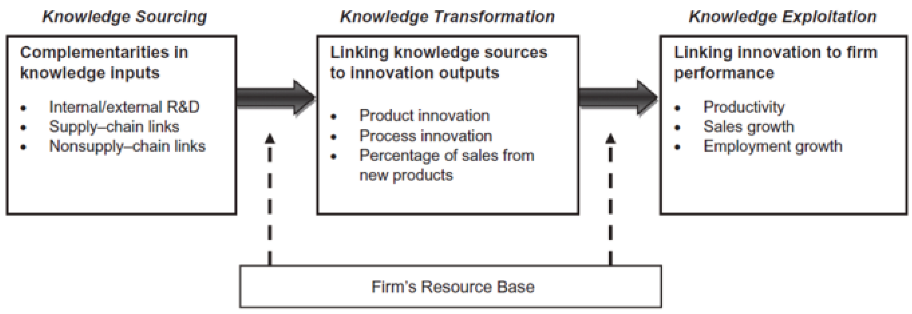



*Figure 7: The innovation value chain: structure and indicators (Ganotakis, 2012)*

## 2) Knowledge sources

### a) Internal sources

Crépon et al. (1998) and Lööf and Heshmati (2006) focused on innovation from a production function approach (Crépon et al., 1998; Lööf and Heshmati, 2006). This approach is distinguished by a detailed focus on econometric specification, but also tends to take knowledge sourcing activities into consideration, for example, regarding internal R&D as the only source of knowledge for innovation, and considering a very finite set of control variables.

Jordan and O' Leary (2008) discussed the impact of Higher Education Institutions (HEIs) on the innovation output of Irish high-tech enterprises in the context of interaction with other agents. The paper estimates the significance of internal R&D activities and external interactions with HEIs, support agencies and other enterprises for product and process innovation, based on a survey of 184 companies in the fields of Chemical and Pharmaceutical, Information and Communications Technology and Engineering and Electronic Devices. An important finding is that the more frequently they interact directly with HEIs, the less likely they are to innovate their products and processes.

In evaluating innovation and productivity, Doran and O' Leary (2011) indicated that feedback effects are crucial, namely, enterprises being more innovative with higher productivity and vice versa. External knowledge sources have an effect on innovation decisions, but have no effect on innovation performance, which indicates that the internal process is the first priority in the key task of knowledge development.

### b) External sources

In a research study on the innovation activities of manufacturing companies in Ireland, the IVC approach combines insight and breadth with the econometric model of the knowledge production function (Roper et al., 2008). This might include R&D activities within the company, as well as supplementing or replacing external knowledge sources (Pittaway et al., 2004). The next link of IVC is to transform knowledge into physical innovation following the knowledge resource activities of enterprises. This is captured through the innovative production function, which associates innovative outputs (new products or new processes) with knowledge inputs that come from both internally generated knowledge – the result of internal R&D and different types of knowledge provided by external partners. The final link in IVC involves the exploitation of enterprise innovation and its impact on business growth and productivity. The recursive process of knowledge acquisition, transformation and exploitation constitute the innovation value chain. In terms of knowledge sources, it is found that there is a strong complementarity between horizontal, forward, backward, public and internal knowledge source activities (Roper et al., 2008).

The benefit in the IVC approach is that it clearly shows several connections throughout the innovation process. For instance, Roper et al. (2008) demonstrated that for manufacturing plants in Ireland, there were synergies between the knowledge gathering activities within and outside the enterprise, which suggested the benefits of openness. Ganotakis and Love (2012) used IVC to emphasize key complementarities, such as that between internal R&D, external R&D and other external knowledge sources. Roper and Arvanitis (2012) noticed that there are significant similarities in some aspects of enterprise innovation behaviors in Ireland and Switzerland, namely strong complementarities existing between external knowledge sources and between the internal and external knowledge of an enterprise. Moreover, in both countries, internal R&D and links to customers proved an important driving force for innovation.

*Table 4: Summary of relevant literature on innovation value chains*

| **Authors and year** | **Research Focus** | **Methodology** | **Main Conclusions** |
|---|---|---|---|
| Pittaway et al.,2004 | Knowledge transformation: network relationships on innovation | Conceptual | Network relationships with suppliers, customers and intermediaries such as professional and trade associations are vital factors affecting innovation performance and productivity. Where networks fail, it is due to inter-firm conflict, displacement, lack of scale, external disruption and lack of infrastructure. |
| Love and Roper, 2004 | Knowledge source: institutional and social norms on collaborations | Empirical analysis | In Germany, institutional and social norms are found to encourage collaborative inter-plant innovation, but aspects of the German skills training and industrial relations systems make the adoption of more flexible internal systems more difficult. In the UK, by contrast, the more adversarial nature of inter-firm relations makes it more difficult to establish external collaborations based on mutual trust, but less restrictive labor market structures make it easier for UK plants to adopt multifunctional working. |

| | | | |
|---|---|---|---|
| Hall and Martin, 2005 | Knowledge transformation: stakeholder ambiguity complexity on innovation | Case study | Contemporary innovation management frameworks need to encompass a broader range of stakeholders, and not only those within the innovation value-added chain. The study then suggested an evaluation framework based on generalized areas of innovative uncertainty facing the new technology. Under low stakeholder complexity and ambiguity, The study argues that a conjecture–refutation approach is an effective means for evaluating an innovation. However, high stakeholder ambiguity and complexity may create too many conflicting demands and often the lack of a common framework for acceptance. |
| Hansen and Birkinshaw, 2007 | IVC:<br>Idea generation<br>Idea transformation<br>Ides exploitation | Interview &Survey | Innovation can be regarded as the process of transforming ideas into commercial outputs as an integrated flow—rather like Michael Porter's value chain for transforming raw materials into finished goods. The first of the three phases in the chain is to generate ideas; this can happen inside a unit, across units in a company, or outside the firm. The second phase is to convert ideas, or, more specifically, select ideas for funding and developing them into products or practices. The third is to diffuse those products and practices. |

| | | | |
|---|---|---|---|
| Jordan and O'Leary, 2008 | Knowledge transformation: in-house R&D activity and external interaction on innovation | Empirical analysis | The importance of in-house R&D activity and external interaction with HEIs, support agencies and other businesses for product and process innovation. The finding that performing R&D is important for innovation, rather than having a dedicated R&D Department, has implications for policymakers. A key finding is that the greater the frequency of direct interaction with HEIs the lower the probability of both product and process innovation in these businesses. There is some evidence of a positive indirect HEI effect, through complementarities of interactions with suppliers and support agencies. |
| Roper et al., 2008 | Knowledge source: complementary activities | Empirical analysis | The recursive process of knowledge sourcing, transformation and exploitation comprises the innovation value chain. In terms of knowledge sourcing, the research finds that strong complementarity between horizontal, forwards, backwards, public and internal knowledge sourcing activities. Each of these forms of knowledge sourcing also makes a positive contribution to innovation in both products and processes although public knowledge sources have only an indirect effect on innovation outputs. In the exploitation phase, innovation in both products and processes contribute positively to company growth (sales and employment), with product innovation having a short-term 'disruption' effect on labor productivity. |

| | | | |
|---|---|---|---|
| Love and Roper, 2009 | Knowledge transformation: external networking on innovation | Empirical analysis | Tests some differences between the UK and Germany in terms of the optimal combination of innovation activities in which to implement external networking. Broadly, there is more evidence of complementarities in the case of Germany, with the exception of the product engineering stage. By contrast, the UK exhibits generally strong evidence of substitutability in external networking in different stages, except between the identification of new products and product design and development stages. |
| Spithoven et al.,2010 | Knowledge source: knowledge externalities and research collaboration | Empirical analysis | Stresses the heterogeneity of innovative firms in their dealing with knowledge exchange and the effect this has on their performance: knowledge externalities and research collaboration are vital for those opening up their firm for new ideas and who are, at the same time, reluctant to protect their findings through specific appropriation measures. |
| Guan and Chen, 2010 | Knowledge transformation & exploitation: Upstream R&D process on downstream commercialization process | Empirical analysis | It provides systematic and simultaneous efficiency measures for the overall process and internal sub-processes, i.e., upstream R&D process and downstream commercialization process. |

| | | | |
|---|---|---|---|
| Doran and O'Leary, 2011 | Knowledge transformation: external knowledge sources on innovation | Empirical analysis | Innovation performance has a strong positive influence on productivity and that productivity influences innovation performance, for both new-to-firm and new-to-market innovation. External knowledge sources affect the innovation decision but not innovation performance, thus pointing to the primacy of internal processes for the crucial task of knowledge exploitation. There is evidence of dichotomous knowledge sourcing in Ireland, with some firms sourcing from market and others, especially high-technology businesses, from non-market agents. |
| Ganotakis and Love, 2012 | IVC | Empirical analysis | The value of the IVC is demonstrated in showing the key interrelationships in the whole process of innovation from sourcing knowledge through product and process innovation to performance in terms of the growth and productivity outcomes of different types of innovation. The use of the IVC highlights key complementarities, such as that between internal R&D, external R&D, and other external sources of knowledge. Other important relationships are also highlighted. Skill resources matter throughout the IVC, being positively associated with external knowledge linkages and innovation success, and also having a direct influence on growth independent of the effect on innovation. A key benefit of the IVC approach is therefore its ability to highlight the roles of different factors at various |

| | | | |
|---|---|---|---|
| | | | stages of the knowledge–innovation–performance nexus, and to show their indirect as well as direct impact |
| Roper and Arvanitis, 2012 | Knowledge transformation: internal & external knowledge on innovation | Empirical analysis | Significant similarities exist between some aspects of the innovation behavior of Irish and Swiss enterprises: strong complementarities emerge between external knowledge sources and between firms' internal and external knowledge. And, in both countries, in-house R&D and links to customers prove important drivers of innovation. Innovation drives productivity growth in different ways in the two countries; however, through product change in Switzerland and through process change in Ireland. Other differences in the determinants of innovation performance linked to ownership and firms' institutional context emphasize the systemic nature of innovation and the legacy of past patterns of industrial development. |
| Olson et al., 2013 | Knowledge source: multi-stakeholders | Empirical analysis | Introduces the green innovation value chain (GIVC) as a tool for analyzing the financial viability of green products using a multi-stakeholder perspective that includes manufacturers, distribution channels, consumers, the environment, and governments as separate links in the chain. |
| Berchicci, 2013 | Knowledge transformation : R&D configuration on innovation | Empirical analysis | The influence of R&D configuration on innovative performance and the moderating role of a firm's R&D capacity are exmined. The findings suggest that firms that increasingly |

| | | | |
|---|---|---|---|
| | | | rely on external R&D activities have a better innovative performance, yet up to a point. Beyond this threshold, a greater share of external R&D activities reduces a firm's innovative performance. And such substitution effect is larger for firms with greater R&D capacity. |
| Herstad, 2013 | Knowledge source: global innovation network& industrial knowledge bases | Empirical analysis | Sources of behavioral differentiation derived from the literature on industrial knowledge bases and technological regimes condition the degree of involvement in international innovation collaboration. This is significantly influenced by the nature of knowledge and the cumulativeness of knowledge development, the active use of measures to protect intellectual property, the inherent need to innovate and the opportunity to generate sales from this activity. The likelihood that the firm establishes and maintains a truly global network configuration is influenced accordingly. |
| Lai et al., 2014 | Knowledge transformation: industrial clusters on innovation | Empirical analysis | A survey, regression analysis, and correlation analysis probe into the effects of the special resources and relationships among industrial clusters on corporate knowledge management and innovation performance. |
| Moilanen et al., 2014 | Knowledge transformation: External complementary knowledge inflows on innovation performance | Empirical analysis | Compares SMEs that do not report doing their own R&D to SMEs in general by testing four important hypotheses related to the idea of absorptive capacity (AC) as a mediator for the relationship between external complementary knowledge inflows (KIs) and innovation performance (IP): KIs relate |

| | | | |
|---|---|---|---|
| | | | positively to AC (H1), AC relates positively to IP (H2), the relationship between KI and IP is mediated by AC (H3), and the relationship between KI and IP is fully mediated by AC (H4). |
| Bornkessel et al., 2014 | Knowledge transformation | Empirical analysis | Analyzes industry convergence in four probiotics innovation value chains based on the following indicators: cross-industry relationships along the innovation value chain as well as knowledge, technological, regulatory and competence convergence. |
| Liao and Barnes, 2015 | Knowledge transformation: knowledge acquisition on innovation | Empirical analysis | In SMEs knowledge acquisition mediates the effect of relationship quality on product innovation flexibility, and that knowledge acquisition partially mediates the relationship between information capability and product innovation flexibility. |
| Cui and Wu, 2016 | Knowledge source: customer knowledge | Empirical analysis | Antecedents and impact of three forms of customer involvement in innovation are examined: customer involvement as an information source (CIS), customer involvement as co-developers (CIC), and customer involvement as innovators (CIN). It proposed that the three forms of customer involvement employ different ways of utilizing customer knowledge and thus are influenced differently by the nature of customer knowledge, the firm's knowledge management strategy, and organizational support for knowledge management implementation. The impact of |

| | | | |
|---|---|---|---|
| | | | customer involvement on new product performance is contingent upon the firm's technological capability, and the contingent effect also varies across different forms of customer involvement. |
| Robbins and Gorman, 2016 | Knowledge exploitation | Empirical analysis | A study of innovation-active Irish SMEs suggests that three quarters of firms report that they do not operate a formal innovation process, yet this is not associated with poorer performance in terms of revenues from new products and services; and there are few differences between firms with formal innovation processes and firms with informal innovation processes across each stage of the innovation value chain. Having a more formal innovation process is, however, associated with success at bringing novel products to market. |

### *3) Knowledge transformation and exploitation*

The next stage of the innovation value chain is to transform knowledge into innovation output. On the one hand, some papers use R&D as a synonym for innovation output (Griffith et al., 2006). On the other hand, some scholars believe that innovation output can take the form of product, process, marketing or organizational innovation. Product innovation involves the introduction of new or improved goods/services that might be novel to the market or the enterprise.

Roper (2001), Love and Roper (2002) and Roper et al. (2008) analyzed how enterprises use the single equation estimations of binary innovation production function to generate innovation output in the context of Ireland. In general, they found that both R&D and external interaction had a positive impact on the likelihood of product innovation. For instance, Roper (2001) found that networks play an important role in determining the possibility of innovation in Irish manufacturing plants. Interestingly, only when their analysis expanded to the determinants of innovators' innovation performance, the importance of external interactions diminished. Therefore, Roper (2001) and Love and Roper (2002) found that the network had no influence on innovation intensity and innovation success. Likewise, when Roper (2008) examines the model innovation process, only forward linkage is significant. Roper's (2001) interpretation of these results is that the network might assist companies overcome the initial obstacles faced during the period of becoming innovators, but once this threshold is overcome, its role is less important.

The final stage of the innovation value chain is to exploit innovation output through the utilization of innovation output for the overall benefit of the company's productivity or profitability. Only Roper et al. (2008) have analyzed this stage under the Irish circumstances. They noticed that innovation output had a positive effect on a company's performance. In particular, the success of product innovation and process innovation have a strong and significant impact on turnover and employment growth. However, the success of product innovation has a negative effect on productivity, which the authors attribute to the disruptive effect.

Berchicci (2013) investigated the influence of R&D allocation on innovation performance and the regulatory role of enterprises' R&D capability. The results show that the enterprises that rely more on external R&D activities perform better in innovation to some extent. Beyond this threshold, a larger share of external R&D activities reduces a company's innovation performance. And this substitution effect is even greater for companies with strong R&D capabilities.

Cui and Wu (2016) investigated the antecedents and influences of three forms of customer involvement in innovation: customer involvement as an information source (CIS), customer involvement as a co-developers (CIC), and customer involvement as innovators (CIN). They proposed that the three forms of customer involvement utilize customer knowledge in different ways, which are influenced differently by the nature of customer knowledge, the enterprise’s knowledge management strategy, and the organizational support for implementing knowledge management. The effect of customer participation on the performance of new products depends on the technical ability of the enterprise, and contingent impact also varies in different forms of customer involvement.

## C) Digital technology helps to create value as an enabler within the innovation value chain

Digital technology helps to create value by having two types of impact on the innovation value chain for SMEs: it is able to facilitate the innovation value chain itself by providing tools for ameliorating the performance of innovation value chain tasks, and it may produce new kinds of digital innovations mostly by adding new features to the existing non-digital innovations (Yoo et al., 2010).

After examining the prior research, Nambisan (2017) categorized four critical dimensions of digital technology. Firstly, digital technology for innovation may help to facilitate integration between new products development and other organizational functions. Secondly, digital technology allows access to collect information from various sources, which facilitates management and task coordination in the innovation process. Thirdly, digital technology can support information grasping, sharing and integration across the organization. Finally, digital technology provides new kinds of collaboration and communication, for example, virtual invocation groups.

Recent studies also consider the influence of digital technology on innovation outcomes (Yoo et al., 2010; Svahn and Henfridsson, 2012). Digital technology can improve opportunities for digital innovation. For example, for the manufacturing industry, digital technology such as cloud computing and big data can be integrated into non-digital products and services so as to generate networked “digital factories” featuring flexible and adaptive innovation processes and it can offer the previous products or services with novel properties.

Yoo (2010) put forward seven properties of digital artifacts, they are: programmability, addressability, sensibility, communicability, memorability, traceability, and associability, which enable digital artifacts to have the competence to cope with and respond to a turbulent environment, correlate messages over time and connect and identify with other actors. These properties offer great opportunities and possibilities for digital innovation.

The potential of digital technology has been attracting significant attention from numerous scholars, while few studies address how digital technology creates value in the DIVC. This study addresses this issue.

# Chapter 4 : Modelling the digital innovation value chain

This chapter discusses how the DIVC has been formed based on the theoretical background. It builds the research model and then 14 hypotheses are proposed. The first section emphasizes the link between the ADT and heterogeneous networks for SMEs according to the nature of digital technology. The second section focuses on linking the effect of heterogeneous networks on digital innovation based on the digital effects. The third section is interested in introducing the effect of digital innovation on SMEs' business performance.

## A) Formation of the digital innovation value chain

Digital technology alters the natures of goods by converting them into combinations of loosely coupled elements and components that are not restricted to certain functions or purposes (Yoo et al., 2010). This indicates that creators of elements may not be able to foresee how and in what mixture their digital products and services are finally employed. The boundary of products cannot be regarded as fixed anymore. Under these assumptions creating value becomes more complex. Based on traditional product manufacture companies are seen to create value through adding product traits and therefore improving the products' quality (Vargo et al., 2008). Yet, rather than a linear sequence of occurrence along a chain where companies individually contribute by value-adding events (Porter and Millar, 1985), value creation processes in a digital context are based on the contribution of various stakeholders who share and integrate resources for themselves as well as for others. Value thereby become co-produced (Lusch and Vargo, 2014; Barrett et al., 2015). Traditional innovation studies examined value chains from a firm's positioning within a specific industry (Porter, 2014). However, the present research seldom investigates innovation value chains in the context of ADT.

The key of value is created from the firm-level to the network-level. The productive characteristic of digital technology makes innovation inherently unlimited. Firms constantly generate new forms of products and services by redefining the innovation boundaries (Chandler and Vargo, 2011). The dynamic and flexible nature of digital technology makes it necessary to reconsider the traditional value-added framework. The shift from the single knowledge source to the heterogeneous networks of digital sources, and the focus on digitization of value chains instead of the traditional added-value approach is, thus, a consequence of the evolving digital technology. Heterogeneous networks are the present digital source of value creation: SMEs engage in increasingly digital technology to build complex and diverse networks of relationships in order to create value (Chandler and Vargo, 2011).

Generally speaking, prevailing innovation studies have not yet considered the role of digital technology on the underlying innovation value chain. Thus, the research must consider not only what is the DIVC but also how it forms. Previous research on innovation value chains has paid little attention to the field of digitization. But digital innovation presents a big change compared with the traditional innovation activities, it's essential to dig into the DIVC. We apply Ganotakis 's (2012) model, which was developed in the knowledge management and value chain context of innovation and which has a recursive process that is applicable for this research purpose. The model involves around three distinct stages: digital source, digital transformation and digital exploitation. Figure 8 presents the framework by describing the three process stages and associated indicators.

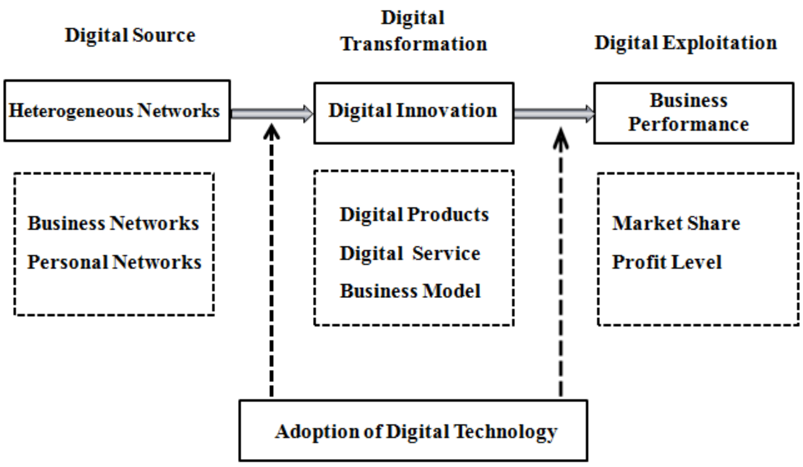



*Figure 8: Research model of digital innovation value chain*

### 1) Linking effect of digital technology on a heterogeneous networks

Prior models of innovation activities focus on firm-level processes, resources or innovative competences, while value creation in the DIVC results from the heterogeneous networks generation afforded by ADT to SMEs' business performance. In order to achieve value creating activities, SMEs have started to pursue their value creation process building heterogeneous networks. Large firms are able to maintain large and vertically integrated networks, but SMEs try to establish heterogeneous networks to build on a strategy of continuous exploration of an expanding collection of digital source whose actors constantly adopt digital technology to create new value. Accordingly, the key of value creation as well as the shape of SMEs has shifted from a single source of knowledge towards heterogeneous networks.

SMEs have become increasingly embedded in heterogeneous networks with respect to social, professional, and exchange relationships. Digital technology has become an enabler for this development to the extent that SMEs have changed their source of innovation from limited channels to unbound and fluid networks due to the technological conditions. Heterogeneous networks encompass a firm's relationships to suppliers, customers, competitors, or other entities across boundaries of industries or countries (Snow et al., 2015). They are categorized into business networks and personal networks according to Ge and Wang (2012). The former (i.e. business networks) refers to the linkages that a company has established in connection with business stakeholders including government agencies, authorities, governments, competitors and customers. The concept of personal networks is defined as an informal structure of personal relations that are greatly characterized as personal ties and connections, which are built based on goodwill and trust. Such connections in the context of this paper include family members and friends both at home and abroad, with overseas Chinese groups a notable feature of the personal networks of Chinese entrepreneurs.

Through building heterogeneous works, in order to purse knowledge, they can take different forms such as strategic alliances, joint ventures, franchising, long-term marketing and licensing contracts, reciprocal trade agreements, R&D partnerships, buyer-supplier relationships, director interlocks, investment bank ties, personal movement links or cross-patent citation ties (Zaheer et al., 2010). Heterogeneous networks are composed of actors which are connected through a wide range of business and personal relationships. Usually, a network is regarded as "a set of nodes and the set of ties symbolizing some relationship, or absence of relationship, between nodes" (Brass et al., 2004). Nodes are considered to be actors (for example, persons, teams, units, organizations) which are linked by ties to a set of binary social relations. Ties can have flexible contents, strengths, and directions, "limited only by a researcher's imagination" (Brass et al., 2004). The pattern of ties develops a particular structure in a network whereas actors have positions within this structure. Nodes in heterogeneous networks in this research are referred to as SMEs connected by ties which represent business and personal relationships. Prior scholars have developed a huge and diverse network-related research producing profound insights about the fragmented field of heterogeneous networks (Baker and Faulkner, 2002; Zaheer et al., 2010). According to various theoretical frameworks, network-oriented research has gained many contributions on how firms may intentionally influence structure and ties of networks to create positive outcomes by gaining valuable and inimitable resources and capabilities (Gulati, 1999; Gulati et al., 2000), accessing power and control (Santos and Eisenhardt, 2009) and establishing trust (Beamish and Lupton, 2009) .

In order to participate in the DIVC, SMEs need to have access to digital technology. Consequently, the pervasive availability of digital technology entails positive heterogeneous networks that further speed up the creation and availability of digital products, services and contents. Moreover, the ADT has decreased the entry barriers for SMEs. This digitization, i.e., the process by which digital technology is adopted into heterogeneous networks, enhances digital products, digital services and the business model by becoming programmable, addressable, sensible, communicable, memorable, traceable, and associable (Yoo et al., 2010).

Innovation can be regarded as collective and social activities. A number of empirical research studies have proposed that innovation by individuals or higher-level collectives (i.e., teams, organizations or countries) is affected by their social relationships and the networks they compose by enabling or constraining them to obtain, absorb, examine and apply knowledge and information (Pittaway et al., 2004). But, in fact, an innovation by individuals or collectives is embedded not only in social networks but also in heterogeneous networks. Digital elements or components form personal networks and business networks with one another in the digital innovative process leading to the formation of heterogeneous networks in which digital technology facilitates its formation. Investigation on the critical roles of digital technology influencing both personal and business networks needs to be examined.

The reason why digital technology enhances the formation of heterogeneous networks is because digital technology features relationality. Tradition techniques or knowledge sources have a low exchange of resources with a limited number of homogenous actors, which allows the knowledge to adapt to the distinctive interface requirements of these actors and, thus, to improve coordination, efficiency and the speed of resource flows. Whereas, for digital technology, it can increase the relationality and therefore the number and diversity of actors with which they can interact increase. As a result, more interactions with more diverse actors enhances digital technology's ability to pursue and channel resources that flow through them, implicitly improving homogeneity of inputs and outputs. Moreover, digital technology with high specificity can guarantee the reliability of inputs and outputs even with an enormously large and heterogeneous set of actors, so SMEs adopting digital technology can positively influence heterogeneous networks due the relationality and high specificity of digital technology which can expand the volume of resources and enable them to channel in a more efficient way (Robert and Grover, 2012), Thus, the thesis puts forward the following hypotheses (Robert and Grover, 2012) :

*Hypothesis 1a: Adoption of digital technology has a positive influence on the business networks .*

*Hypothesis 1b: Adoption of digital technology has a positive influence on the personal networks.*

## 2) Effect of heterogeneous networks on SMEs' digital innovation

Heterogeneous networks can have an effect on SMEs' digital innovation through helping SMEs to access market knowledge for digital innovation. Eriksson et al. (1997) categorized market knowledge into institutional knowledge or societal knowledge (knowledge about macro-environment institutions of the countries, for example, laws and regulations enacted by local governments, cultural customs and norms); business knowledge (for example, knowledge about market customers, competitors and market environment) and internationalization knowledge (for example, knowledge about companies' competence and resources to deal with international business).

In general, SMEs' resources are so constrained that they may not have an opportunity to conduct systematic market analysis of knowledge. Alternatively, they often rely on their "trusted" personal connections with market contacts to access opportunities thru entering the markets. This idea is supported in the literature that present personal networks play a more vital role in accepting market opportunities than does information accumulated through systematic market research (Harris and Wheeler, 2005). Similarly, close relationships and interactions through personal connection with market contacts can offer profound information about market environments that can not be immediately obtained through market research.

Moreover, SMEs' other method to gain market knowledge for digital innovation is through connection with business networks. That is, the market knowledge for digital innovation is obtained primarily through relationships with diverse actors in certain business networks, such as providers, customers and competitors (Jin and Jung, 2016).

This study posits two factors that drive SMEs to achieve digital innovation: SMEs' business networks and personal networks. The literature agrees that SMEs' personal networks help them acquire information and resources needed for digital innovation. These resources are thought to help them enlarge knowledge sources and gain enormous amounts of information successfully (Koch and Windsperger, 2017). Beyond their approach to resources and information, Harris and Wheeler (2005) showed that firms' relationships, both through personal and business networks, can further direct strategies, serving as a vital asset for SMEs. By having more access to information, resources and strategic guidance, SMEs with personal networks will, therefore, facilitate digital innovation in the market. To draw in empirical support, *guanxi* networks in China (equivalent to personal networks) were found to improve innovation activities in the market (Ivan, 2013). That is, Chinese SMEs sought guanxi networks to obtain more knowledge about innovation and personal advice, which enhanced the innovation performance and profitability performance. In the context of digitization, personal networks improved digital innovation including digital products innovation, digital service innovation and business model innovation. Therefore, the thesis presents the following hypotheses:

*Hypothesis 2a: Business networks have a positive influence on digital products innovation.*

*Hypothesis 2b: Business networks have a positive influence on digital service innovation.*

*Hypothesis 2c: Business networks have a positive influence on business model innovation.*

*Hypothesis 3a: Personal networks have a positive influence on digital products innovation.*

*Hypothesis 3b: Personal networks have a positive influence on digital service innovation.*

*Hypothesis 3c: Personal networks have a positive influence on business model innovation.*

### 3) The effect of digital innovation on SMEs' business performance

Digital innovation is a crucial factor in SMEs' competitiveness and it is unavoidable for SMEs which hope to develop and maintain a competitive advantage in pursuing entry to a new market. Digital innovation is seen to have the potential or competence to facilitate growth both at the micro and macro level. Thus, digital innovation is the key to economic change and a vital source of productivity and growth for SMEs.

Innovations play a vital role in improving performance and increasing value (Bowen et al., 2010). Therefore, innovative firms show a higher level of economic growth and productivity than non-innovative ones. (Cainelli et al., 2004). Firms achieve excellence in operational performance perspectives such as cost, quality, delivery, and flexibility as a results of emphasizing their resources and efforts on innovations. (Tan et al., 2007).

Some empirical studies showed a strong positive relationship between innovation and firms' performance. Kafetzopoulos and Psomas (2015) discovered that the level of innovativeness was significantly related to productivity and performance. Hassan et al. (2013) summarized that innovations (i.e. products and process) were significantly related to production performance because of the novel operational and business techniques applied. Likewise, Saunila et al. (2014) indicated that firms which tend to be more successful in innovation had higher financial performance than others. Evangelista and Vezzani (2010) demonstrated that product innovation provides firms with benefits by empoloying novel technology to facilitate effiency and productivity in order to improve products performance. They then showed that process innovation facilitates performance through efficiency-productivity gains pursued by introducing more effective methods of production leading to decreased response time, improved quality and reduced costs. Ou et al. (2010) showed that process innovation greatly enhances production operations leading to reduced cost and improved performance. They further indicated that product innovation facilitates the ability to respond to changes effectively by improving new abilities that lead to better performance. Thus, the thesis puts forward the following hypotheses:

*Hypothesis 4a: Digital products innovation has a positive influence on the market share.*

*Hypothesis 4b: Digital products innovation has a positive influence on the profit level.*

*Hypothesis 5a: Digital service innovation has a positive influence on the market share.*

*Hypothesis 5b: Digital service innovation has a positive influence on the profit level.*

*Hypothesis 6a: Business model innovation has a positive influence on the market share.*

*Hypothesis 6b: Business model innovation has a positive influence on the profit level.*

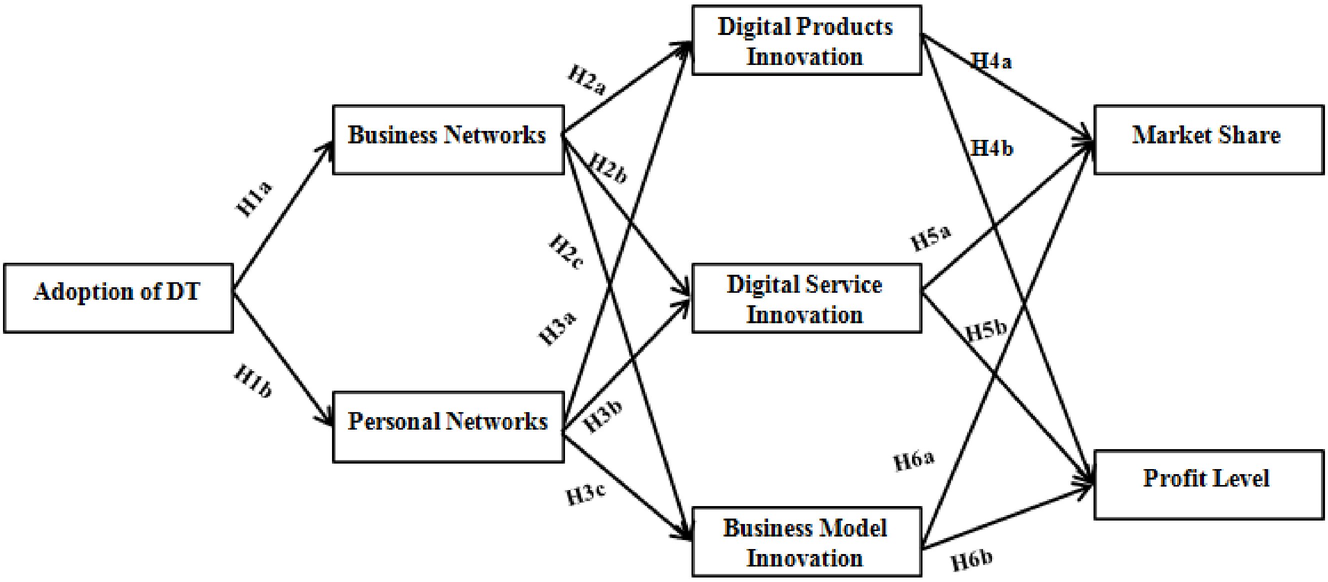



*Figure 9: Conceptual model*

# Part II : Empirical Research

# Chapter 5 : Research methodology

This chapter mainly presents the methodology employed to test the hypotheses in this research. First, the selection of items to be measured is based on the relevant literature review covering digital technology, heterogeneous networks, digital innovation and SMEs' business performance. There are 8 constructs and 31 items in this model. To ensure the content validity of the questionnaire, the techniques of double translation protocol and a pilot study were conducted. After assessing the recommendations from senior executives and experts who are working on digitalization, the questionnaire was refined by adding specific definitions of terms and correcting sentences for clarity. Next, the survey was administered using a Chinese online app[2] to a target sample that was selected in line with the research objective and thus tests of possible bias were conducted in the self-survey report to avoid the possible bias. The results of tests indicated that there was no non-response bias or common method variance problem. In order to test the research hypotheses, SPSS 25.0 and AMOS 15.0 programs were performed.

## A) Questionnaire and measurement

The questionnaire (in Appendix) started with the introduction of the research background and author's academic information and then the purpose of the questionnaire, procedure, confidentiality and consent were also briefly provided. The layout of the questionnaire involves five parts, namely, the general information of respondents and firms, digital technology adoption metrics, business networks and personal networks metrics, digital innovation metrics and business performance metrics. The first part of the questionnaire asked for information including the respondents' position in the firm, the type of digital technology the firm used, its main activities, the firm's size and the firm's age.

To guarantee the content validity of the questionnaire, the measurement development process was designed in three steps as follows:

First, an extensive literature on adoption of digital technology, heterogeneous networks, digital innovation and SMEs' business performance was reviewed based on which the measurement items were selected and developed.

Second, a double translation protocol was employed in forming the questions of the questionnaire in order to avoid information loss and misunderstanding in the translation

[2] This app is called "Questionnaire star", which is a Chinese survey platform.

process. A preliminary questionnaire that was written in English was initially translated into Chinese by a professional translator, the translation was then examined by a third party, and it was finally retranslated back into English. The purpose of this adoption was to keep the equivalence of measurements both in English and Chinese. Through comparing the two English versions, no significant difference was found.

Third, a panel of experts including five experts from academic institutions and three senior executives who work in digital firms in China were selected to examine the contents, scope, item expression and the overall framework of the questionnaire. The reason for conducting this pilot study is that the constructs in this study were adopted and used in various countries, for example, the United States of America, which may lead to ambiguity in understanding and/or misrepresentation of items from the original when translating from English to Chinese. This pilot study asked the senior executives to assess and verify that the measurement items were able to reflect the constructs or whether there were any discrepancies. For example, two experts stated that they couldn't fully understand the question "Which main activities does your firm engage: device layer; contents layer; service layer; network layer".

Digitalization makes firms span their activities from a specific activity to multiple activities crossing various industries, so it's difficult to distinguish what main activities these digital firms take part in. However, Yoo et al. (2010), classified digital technology as layered architecture consisting of four layers: devices, networks, services, and contents. In this research, this classification was adopted and used to categorize the digital activities but the experts were not familiar with this terminology and thus the solution was to give the detailed explanation on each term.

Through examining and evaluating each item, the expressions and the overall layout of the questionnaire were revised and improved according to experts' suggestions. After finishing the three steps above, the scales are fully considered to be reliable and valid. Table 5 summarizes the measurement items.

*Table 5: Measurement items*

| Constructs and Item Measures | Literatures |
|---|---|
| **Adoption Digital Technology (ADT)**<br>ADT1: Stage of digital technology deployment.<br>ADT2: Expected year of adoption of digital technology. | Thiesse et al., 2011 |
| **Business Networks (BN)**<br>BN1: Networking with other government agencies.<br>BN2: Networking with industrial authorities.<br>BN3: Networking with governments.<br>BN4: Networking with domestic competitors.<br>BN5: Networking with domestic customers. | Ge and Wang, 2012 |
| **Personal Networks (PN)**<br>PN1: Networking with overseas' family members and friends.<br>PN2: Networking with domestic friends.<br>PN3: Networking with overseas' Chinese groups.<br>PN4: Networking with domestic family members. | Ge and Wang, 2012 |
| **Digital Products Innovation (DPI)**<br>DPI1: Introduced a new product built on digital technology such as big data, analytics, cloud computing, mobile and social media platforms.<br>DPI2: Introduced a new product, significantly improving existing products by integrating digital technology such as social media, big data, analytics, cloud and mobile technologies.<br>DPI3: Development of a totally new product based on digital technology such as social media, big data, analytics, cloud and mobile technologies.<br>DPI4: Development of a totally new product based on digital technology for your establishment. | Fichman et al., 2014;<br>Lyytinen et al., 2016; Nwankpa et al., 2016 |

| | |
|---|---|
| **Digital Service Innovation (DSI)**<br>DSI1: Developed digital services integrating digital technology such as social media, big data, analytics, cloud and mobile technologies.<br>DSI2: Improved existing services and promoted digital services.<br>DSI3: Repackaged existing services and promoted digital services.<br>DSI4: Extended existing service lines and promoted digital services.<br>DSI5: Introduced digital services that competitors do not offer in the market.<br>DSI6: Tried to reduce the risks of failure of digital service development. | Avlonitis and Papastathopoulou, 2001; Lusch and Nambisan, 2016 |
| **Business Model Innovation (BMI)**<br>BMI1: Our firm can deliver new value to customers by utilizing digital technology.<br>BMI2: Our firm can find new ways to increase revenue by utilizing digital technology.<br>BMI3: Our firm can find new ways to reduce cost by utilizing digital technology. | Fichman et al., 2014; Brege et al., 2014 |
| **Market Share (MS)**<br>MS1: Your position on your sales growth rate compared to your competitors'.<br>MS2: Your satisfaction with your sales growth rate compared to your competitors'.<br>MS3: Your market-share gains relative to you competitors'. | Ward et al., 1998; Roth et al., 2008; Kristal et al., 2010 |
| **Profit Level (PL)**<br>PL1: Return on corporate investment position relative to competition.<br>PL2: Net profit position relative to competition.<br>PL3: ROI position relative to competition.<br>PL4: Return on sales position relative to competition. | Ward et al., 1998; Roth et al., 2008; Kristal et al., 2010 |

### 1) *Adoption of digital technology construct and metrics*

All the measurement scales were operationalized by adopting items from prior research and adapting them to the specific context of digital technology. For most studies, they treat use behavior as a mere binary variable; instead, the research models the dependent variable by following the approach from Thiesse et al. (2011). Two items were used to measure the adoption behavior: the stage of digital technology deployment at this moment and how soon it will happen if the company is expected to use digital technology. The first question is that at what stage of digital technology deployment your organization currently is engaged. The items were based on a five-point scale: 5-currently using digital technology, 4-have evaluated, and plan to adopt, 3-have evaluated, but do not plan to adopt, 2-currently evaluating, 1-not considering. The second question is that if you are expecting that your company will use digital technology in the future, how soon do you think it will happen. The items were also based on a five-point scale: 5-one year, 4-one to two years 3-two to five year, 2- 5yeard, 1- not at all.

#### *a) Heterogeneous networks: business networks and personal networks constructs and metrics*

There is no universal measurement for the heterogeneous networks. This study followed the previous measurement items developed by Ge and Wang (2012). They divided heterogeneous networks into two types: business networks and personal networks. Business networks refer to the linkages that a company has established in connection with business stakeholders including government agencies, authorities, governments, competitors and customers. Personal networks are defined as an informal structure of personal relations that are greatly characterized as personal ties and connections, which are built based on goodwill and trust. Such connections in this study involve family members and friends, domestic friends, overseas' Chinese groups, domestic family members.

Both business networks and personal networks are measured by five-point Likert scales. In the questionnaire, each respondent was asked to choose a number (1= very little, 3= average, 5=very much) that best described the degree of business networking between the focal company and other institutions, for instance, competitors, suppliers, consumers, different levels of government, industrial parties and other commercial administrations. Each respondent was asked to clarify the extent of their personal networks with family members and relatives, friends including previous and present ones and colleagues in China and overseas (1= very little, 3= average, 5=very much).

### *b) Digital innovation: digital products innovation, digital service innovation and business model innovation constructs and metrics*

*Digital products innovation* In this study, measurement items of digital products innovation followed the previous studies (Fichman et al., 2014; Lyytine et al., 2016; Nwankpa et al., 2016). Digital products innovation is defined as significantly new products that are either embodied in information and communication technologies or enabled by them. Examples include new consumer products (smartphones and Amazon's instant video service) and existing products substantially enhanced by the addition of digital technology (e.g. digital information systems in automobiles).

Items are measured by 5-point Likert scales. Each respondent was asked to circle a number (1= strongly disagree, 3= neutral, 5=strongly agree) that represented the extent of his/her agreement or disagreement: if their companies introduced a new product built on digital technology such as big data, analytics, cloud computing, mobile and social media platform; if their companies introduced a new product, significantly improving existing products integrating digital technology such as social media, big data, analytics, cloud and mobile technologies; if their companies developed a totally new product based on the digital technology such as social media, big data, analytics, cloud and mobile technologies; if their companies developed a totally new product based on digital technology for their establishment.

*Digital service innovation* Measurement items of digital service innovation followed the previous studies (Avlonitis and Papastathopoulou, 2001; Lusch and Nambisan, 2016). Digital service innovation can be described as the intregration of various resources that generate resources that are beneficial (i.e. value experiencing) to some actors in a given context. According to the above-mentioned references, they further delineate the conceptualization of service innovation through a tripartite framework consisting of service ecosystems, service platforms and value creation.

Items are measured by 5-point Likert scales. Each respondent was asked to circle a number (1= strongly disagree, 3= neutral, 5=strongly agree) that described the extent they agree or disagree with the following statements: in recent years, his/her firm has developed digital services integrating digital technology such as social media, big data analytics, cloud and mobile technologies; has improved existing services and promoted digital services; has repacked existing services and promoted digital services; has extended existing service lines and promoted digital services; has introduced digital services that competitors do not offer in the market; has tried to reduce the risks of failure of digital service development.

*Business model innovation* The BMI construct in this study includes three items: new value to customers, new ways to increase revenue and new ways to reduce cost. The identification of these three items is driven by the previous studies (Fichman et al., 2014; Brege et al., 2014).

Items are also measured by 5-point Likert scales. Each respondent was asked to circle a number (1= strongly disagree, 3= neutral, 5=strongly agree) that described the extent they agree or disagree with the following descriptions: our firm can deliver new value to customers by utilizing digital technology; our firm can find new ways to increase revenue by utilizing digital technology; our firm can find new ways to reduce cost by utilizing digital technology.

### *c) SMEs' business performance: market share and profit level constructs and metrics*

The construct of business performance in this study was captured in terms of two widely adopted measures: profit level and market share (Rosenzweig et al., 2003; Kristal et al., 2010). The items are based on the balanced scorecard, which is comprised of lagging measures and leading indicators of profit performance (Kaplan and Norton, 1996).

*Market share* Market share is described as the relative sales and market growth (Ward et al., 1998; Roth et al., 2008; Kristal et al., 2010). Items are measured on a five-point Likert scales based on the question "how do you perceive your firm's market share relative to your competitors ((1=relatively weak, 3=average, 5= market leader)". The items are: your position on your sales rate compared to your competitors'; your satisfaction with your sales growth compared to your competitors'; your market-share gains relative to your competitors'.

*Profit level* Profit level is considered as relative profit performance (Ward et al., 1998; Roth et al., 2008; Kristal et al., 2010). Items are also measured on a five-point Likert scales according to the question "how do you perceive your firm's profit level relative to your competitors (1=relatively weak, 3=average, 5= market leader)". The indicators are: return on corporate investment position relative to competition; net profit position relative to competition; return on investment position relative to competition.

## B) Data collection and descriptive statistics

The questionnaire in Chinese was sent via online tool to presidents, vice presidents, directors and senior executives of 1680 digital small and medium-sized enterprises. The number of employees was below 100 in accordance with the SME criteria defined by Grinstein and Goldman (2006). The data collection began from June, 2018 and it lasted six months to December, 2018. An online questionnaire was used and sent to these digital firms. In order to make the respondents completely understand the research purpose and get fully involved, a clear introduction of digital technology was given and a promise that all the respondents would received the findings of the research was kept. It must be noted that the questionnaire had to be filled in by the senior executives of SMEs, for example presidents, vice presidents, directors and general managers, etc.

During the first phase from June to September, 2018, 185 questionnaires were received. In the second period from September to December, 2018, a follow-up email was sent again to those respondents who didn't reply, as a result 128 further responses were obtained. In the end a total of 313 responses were generated, leading to an overall rate of 18.6%. This figure is in line with the previous studies on digital technology (Thiesse et al., 2011, 13% response rate; Oliveira et al., 18.5% response rate). However, 46 respondents were not from the senior executives and thus they were regarded as invalid responses for this research, resulting in an eligible sample of 267.

There are possibly two reasons for the low response rate to the questionnaire. On the one hand, the respondents are mainly senior executives of firms. Due to the characteristics of their high positions, they perhaps do not have time to make the extra effort to complete the questionnaire; the other is the way of the data collection. The questionnaires are mainly completed by sending emails, and when executives receive emails, they tend to open the ones which they are familiar with. Thus they are reluctant to click the link because they might worry about virus files. The respondents and the way of collection can thus explain the low rate of data collection.

For the purposes of this study, 267 observations of digital companies were analyzed. The respondents worked primarily for SMEs. The sample characteristics including the digital technology in which companies engage, the layered architecture of digital technology (Yoo et al., 2010) and a profile of respondents are given in Table 6. Accordingly, digital technology involves big data (16.85%,), VR/AR (17.98%), cloud computing (10.11%), blockchain

(8.24%), and artificial intelligence (11.99%). Among them, is was found that the largest group, representing 29.59% of the total utilized more than one digital technology at the same time. Consistent with Yoo et al. (2010), they classified digital technology as layered architecture consisting of four layers: devices, networks, services, and contents. The result shows that 18.73% of respondents characterized their organization as “device layer”, 21.72% as network layer, 34.83% as “contents layer” and 24.72% as “service layer”. The sample profile is presented in Table 6.

*Table 6: Respondents and firms’ characteristics*

| | **Frequency** | **Percent** |
|---|---|---|
| **Respondents’ characteristics** | | |
| Job Title type | | |
| President | 83 | 31,09% |
| Vice President | 49 | 18,35% |
| Director | 56 | 20,97% |
| General Manager | 79 | 29,59% |
| Total respodents | 267 | 100,00% |
| **Firms’ characteristics** | | |
| Digital Activities | | |
| Big data | 45 | 16,85% |
| VR/AR | 48 | 17,98% |
| Clouding Computing | 27 | 10,11% |
| Blockchain | 22 | 8,24% |
| Artificial Intelligence | 32 | 11,99% |
| Multi | 79 | 29,59% |
| Others | 14 | 5,24% |
| Total | 267 | 100,00% |

| | | |
|---|---|---|
| **Architecture Layer** | | |
| Device Layer | 50 | 18,73% |
| Network Layer | 58 | 21.72% |
| Service Layer | 66 | 24,72% |
| Contents Layer | 93 | 34.83% |
| Total | 267 | 100,00% |

## C) Testing for possible bias in the self-report survey

Sampling error in a questionnaire may emerge due to the significant difference between the respondents and non-respondents and thus a non-response bias test is necessary. In this research, the test was conducted following Armstrong and Overtons's (1997) assumption that late respondents and non-respondents may have similar tendencies. Respondents who filled in the questionnaire were separated into two teams according to the completion date of the online survey: 185 respondents (59.11%) that finished the questionnaire in September, 2018 and 128 respondents (40.89%) that completed the survey in December, 2018. A t-test was performed by using firm size variable (measured by the number of employees). The final result indicated that there was no significance difference between the response from the first round and second round (p=0.316). Consequently, the research does not have the problem of non-response bias.

Self-reporting measures from a particular source lead to the common method variance problems (Campbell and Fiske, 1959). In order to deal with the above-mentioned problem, the Harman one-factor test is able to assess the potential for common method variance in the data (Podsakoff and Organ, 1986). An unrotated factor analysis utilizing Eigenvalue-greater-than-one criterion results in a solution that presents seven factors exceeding one accounting for 66% of the total variance, while the first factor explains only 28% of the variance. As a result, it is unlikely to have a serious problem produced by common method bias. This result is also confirmed through performing the confirmatory analysis. If a one-factor model that can load all of the measurement items into one single factor demonstrates a poor fit, the common method variance is not likely to cause problems.

## 2) Exploratory factor analysis

This term is actually a combinative one for a class of multivariate analysis techniques. By using it, the size of a dataset is decreased and reduced to an underlying dimensionality. In other words, a smaller amount of previously unobserved dimensions, refered to as factors, will be produced by means of reducing a large quantity of variables. For this research, principle components analysis (PCA) will be used (Harman, 1976; Janssens et al., 2008).

Unlike regression analysis for example, factor analysis does not categorize the data into dependent and independent variables. The power of the association between the variables is quite vital, because, to the extent it is possible able to define a smaller set of dimensions, each of which can keep the majority of the information. In addition to the exploratory analysis, the thesis also involves confirmatory factor analysis, which makes a priori statements about the expected number of potential dimensions and the nature of these. This technique will be discussed in the next section (Hair et al., 2006; Janssens et al., 2008).

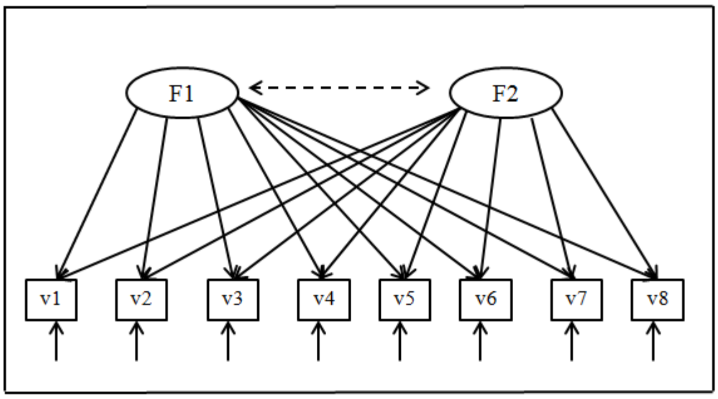



*Figure 10: Exploratory factor analysis (Janssens et al., 2008)*

- Paths from every factor to every variable
- Uncorrelated measurement errors
- Factors are often not correlated (unless oblique rotation is applied)
- The presence of a good fit between model and data is not tested
- No unique solution: rotation leads to a simpler interpretation

There are three assumptions for performing a factor analysis (Harman, 1976; Tacq, 1997; Hair et al., 2006; Janssens et al., 2008):

- As far as the data type is concerned, interval or ratio variables form the input for traditional factor analysis. A Likert scale, which measures the degree of agreement with a descriptive statement according to a limited number of response classifications (5, 7 or 9), will, technically, generate an ordinal variable and thus does not qualify for this type of analysis. Statistics has demonstrated that the application of these types of measurement in factor analysis is capable of producing reliable results per se, and that the bias decreases as the number of response classifications increases.
- The use of variables, which are registered in various measurement degrees for example, 5-, 7- and 9-point scales, could be used in the same factor analysis after the raw data have been standardized. By this, the mean of data will be 0 and the standard deviation will be 1 for each variable, and the response degrees will be comparable to one another. When the study uses SPSS to perform "correlation matrix" for the factor analysis, meaning that it's not necessary to standardize the variables beforehand in the case of various measurement degrees; the standardization emerges automatically in this situation. If the purpose of the analysis is to discover an underlying dimensionality and to produce factors, the choice that is for an analysis of the correlation matrix should also be made due to the standardization of the variables even if all of the variables have the same level of measurement.
- Considering the number of observations required for the performance of a factor analysis, some scholars think that there are at least ten times as many as observations for each construct. There is no strict rule; however, an absolute minimum should necessarily be one hundred respondents.

There are several steps that should be taken to perform factor analysis, among which it is important to pay close attention to the following five points (Harman, 1976; Tacq, 1997; Hair et al., 2006; Janssens et al., 2008):

a. Decide if it is meaningful to perform a factor analysis for the variables selected

Considering the fact that factor analysis is based on discovering a number of underlying dimensions according to the correlation between the variables, a first step should be the calculation of the "Pearson" correlation coefficient for each pair of variables. For the factor analysis, it's more reasonable to have the resulting correlation matrix which contain a number of correlations greater than 0.30. Some other complementary indications may be acquired by examining the anti-image correlation matrix, for example, “Bartlett’s test of sphericity” and “Kaiser-Meyer-Olkin” measure of sampling adequacy.

b. Select a method to extract factors: Principle components analysis

There are some factor analysis techniques for example, “Image factoring”, “Principle axis factoring”, “Principal components” and “Unweighted least squares”, and they differ from one another regarding the calculation of the weighting coefficients. In this research, the principle components analysis will be used for performing factor analysis. This calculation will produce factor scores which can explain a maximum possible share of the variance. Because the first factor is able to explain the largest part of the total variance, the second factor explains the largest possible part of the remaining variance. Additionally, the factors acquired will not be correlated, and the number of underlying factors will be equal to no more than the number of original variables.

c. Determine the number of factors

With regard to the fact that an increasingly smaller portion of the variance in the original data is explained as more factors are extracted, it’s necessary to limit the number of relevant factors despite possible loss of explanatory strength. The selection of the number of underlying factors is quite a subjective procedure. Some ways can be used to determine the number of factors: (1) the “Kaiser criterion”, which will only keep those factors for which the Eigenvalue is greater than one, and thus only those factors that explain a minimum of the variance; (2) the “Scree plot”, which presents the evolution of the Eigenvalue for successive factors, and suggests retaining that amount of factors which corresponds to the “elbow” in the curve; (3) an amount of expected factors stated a priori.

d. Select an orthogonal or oblique rotation or no rotation at all

An ideal factor structure is manifest if every factor has a strong correlation to a number of initial variables, and correlates either insignificantly or not at all with all of the others. In this way, an ideal interpretation maybe given to every factor and every underlying dimension of the data set. The criteria for the variables is that factor loadings for some of the variables are as close as possible to 1 for some of the factors, and as close as possible to 0 for the other factors. It is suggested that factors need to be rotated. Two typical types of rotation: the orthogonal rotation means that the factors are also uncorrelated after rotation, and oppositely, the oblique rotation means that the factors are correlated after rotation, and thus no longer independent from one another. Specifically, each type may be regarded as "varimax", "quartimax" and "equamax' in the case of orthogonal rotation while "direct oblimin" and "promax" exemplify the case of oblique rotation. For this research, the varimax rotation will be used , whereby the number of variables which have high loads on each of the factors is minimized, so making the interpretation of the factors more simple.

e. Calculate factor scores

If the factor structure has been satisfied, the calculation of factor scores on the basis of linear combinations of the original scores for the input variables can be shown in the following form:

$$F_j = a_{1j}X_1 + a_{2j}X_2 + \cdots + a_{nj}X_n \tag{1}$$

Where $F_j$= factor j

$X_i$= original variable $a_{nj}$

$a_{ij}$= weighting coefficient

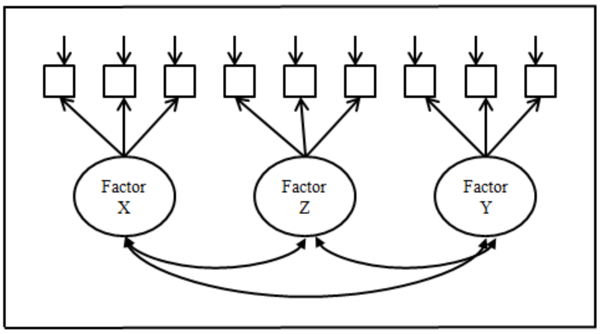
Filling in certain values for these original variables and weighting coefficients will thus produce the calculation of factor scores: i.e. scores for each respondent for each of the factors. These scores, which retain the interesting feature of being uncorrelated, will often perform as input for regression analysis in order to deal with the problem of the multi-collinearity present regarding the original variables.

According to Equation (1), the calculation of factor scores for factor j is each of the original variables and thus also those which have a low factor loading on this, the scores acquired will be less "pure". The calculation of a "summated scale" for factor j is able to solve this problem, because it might be limited to those variables which have a high score for this factor, and typify it. A summated scale is calculated as the sum or the mean of the qualifying variables, but these variables have been subjected to a reliability analysis: the calculation of "Cronbach's Alpha'.

### *3) Confirmatory factor analysis and path analysis using SEM*

Structural equation Modelling (SEM) is one method applied to estimate a set of regression equations simultaneously. SEM is thus also adaptable for the estimation of traditional models (e.g. regression analysis). Two specific statistical techniques will be utilized in this study: confirmatory factor analysis and path analysis. CFA refers to the estimation of a measurement model with latent variables; path analysis is the testing of structural relationships between latent variables. The fundamental principle behind the SEM model is to estimate the model in such a way that the sample covariance matrix corresponds as closely as possible to the model covariance matrix. In this thesis, the SPSS (version 25.0) module which is employed to perform SEM is AMOS (version 25.0) (Arbuckle, 1999; Bollen, 1993).

**Model A: Measurement Model**




**Model B: Structural Model**

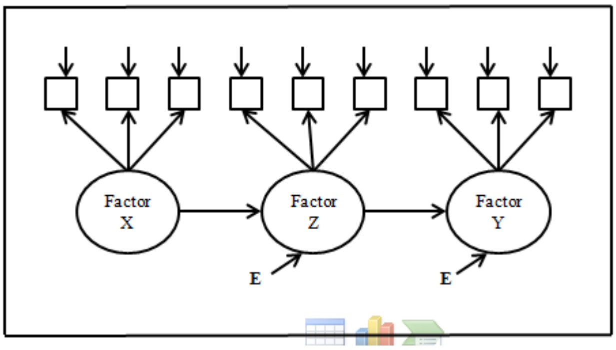



*Figure 11: Path diagrams of measurement model and structural model*

SEM involves some particular terminology and agreements. This thesis lists three types of variables that are manipulated and discussed in the following conduction section (Byrne, 2001) (see also Figure 11 in which each of the concepts covered is displayed in graphic form).

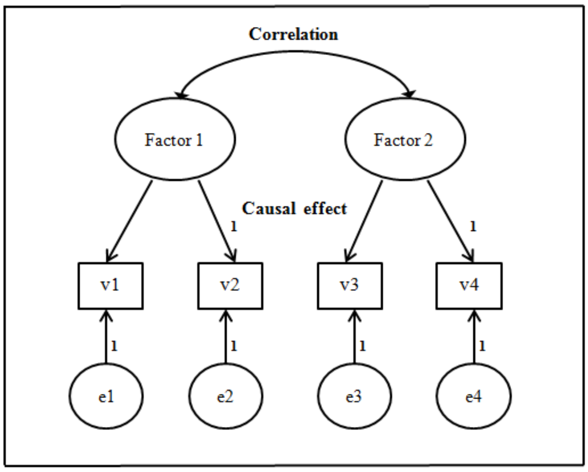



*Figure 12: Path diagrams of measurement model and structural model*

- Observed or manifest variables are variables which are measured effectively (e.g., score on 5 or 7-point Likert scales). Squares or rectangles (v1, v2,v3 and v4 in figure 12) represent these variables.
- Non-observed variables or latent variables are ones which cannot be measured directly, but maybe derived/calculated according to the score for and the variance of the observed variable. Circles and ovals show that they are latent variables.
- Error terms that refer to non-observable ones determining the unique variance of a variable are therefore indicated with a circle (e1,e2,e3 and e4 in figure 12). It should be noted that there are still mutual relationships which must be created.
- Correlations and covariances are indicated by double-pointed arrows and causal effects are showed by single-pointed arrows.

In order to allocate a measurement scale to the latent factors and error terms, the numbers "1" in the figures are fixed.

Therefore, to formulate and estimate the SEM model in this research, two consecutive steps are necessary: first the study needs to verify if and which variables indeed discover underlying dimensions (step 1: confirmatory factor analysis ) and in the following the relationships between underlying dimensions need to be checked (step 2: path analysis ) (Arbuckle, 1999; Janssens et al., 2008 ).

**a. Step 1: confirmatory factor analysis**

This is a type of structural equation modeling (SEM) that fits particularly well with measurement models, that is, the relationships between variables or indicators (for example, items, scores, observed measures) and latent variables or underlying factors. An essential characteristic of CFA is its hypothesis-driven feature. Unlike exploratory factor analysis (EFA), CFA models can estimate some parameters that cannot be evaluated within EFA. And researchers must assume all facets of the CFA model. Thus, the researcher must have a firm a priori sense, based on the qualitative study or theory building. In addition to its greater focus on theory and hypothesis testing, the CFA framework provides many possibilities for analytic evaluation including invariance of the factor model over time or informants. For the above-mentioned reasons, CFA should be performed prior to the specification of an SEM model (Brown, 2006; Janssens et al., 2008).

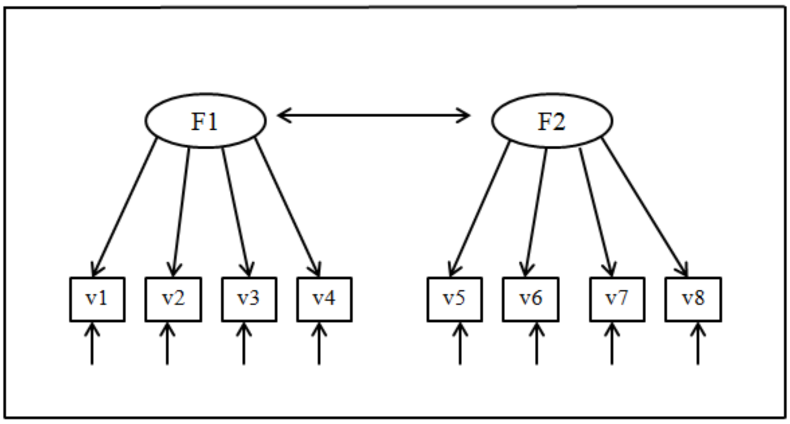



*Figure 13：Confimatory factor analysis (Janssens et al., 2008)*

- Paths from every factor to only a few variables
- Measurement errors may be correlated
- Factors are usually correlated
- Paths may be limited to specific values
- The values for paths may be set equal to one another
- The presence of a good fit between model and date is tested

CFA is one part of the process of scale development to examine latent structure of a test instrument (e.g., a questionnaire). Under this situation, CFA is applied to verify the number of underlying dimensions of the instrument (factors) and the pattern of item-factor relationships (factor loadings). CFA is an important analytic tool for aspects of latent variable evaluation. It can be used to estimate (Brown, 2006)

- the scale reliability of test instruments in manner that solves the problems of traditional methods (e.g. Crombach's alpha)
- Construct validation.

The results of CFA can provide unconvincing evidence of the convergent and discriminant validity of theoretical constructs. Convergent validity is verified when various indicators of theoretically similar or overlapping constructs are strongly interrelated. Discriminant validity is indicated by evidence demonstrating that indicators of theoretically different constructs are not highly correlated. The factors are not quite highly correlated as to show that a broader construct has been incorrectly divided into two ore more factors (Formell, 1981; Brown, 2006).

CFA models include factor loadings, unique variances, and factor variances. Factor loadings are the regression slopes for estimating the indicators from the latent factor. Unique variance is variance indicators that is not accounted for by the latent factors. Unique variance is typically assumed to be measurement error and is thus often regarded as such (other synonymous terms include "error variance" and "indicator unreliability"). It is a non-standardized solution to view a factor variance as the sample variability or dispersion of the factor; that is, the extent to which sample respondents' relative standing on the latent dimension is similar or different (Brown, 2006).

**b. Step 2: path analysis**

Path analysis is a technique of multiple regression statistical analysis that is suitable to estimate causal models by testing the relationships between a dependent variable and two or more independent variables. By using this method, researchers can evaluate both the magnitude and significance of causal connections between variables. Through performing a path analysis, one can better understand the causal relationships between different variables (Byrne,2001).

Path analysis is an extension of the regression model which is normally applied to test the fit of the correlation matrix against two or more causal models that are being compared by the researchers. The model is often represented in a circle-and-arrow figure where single-headed arrows suggest causation. A regression is performed for each variable in the model as a dependent on others which the model indicates are causes. The regression weights estimated by the model are compared with the observed correlation matrix for the variables, and a goodness-of-fit statistic is predicted. The best-fitting of two or more models is decided by the researcher as the best model for advancement of a theory (Garson, 2013).

Two steps are employed to conduct a path analysis: first, researchers draw a diagram that serves as a visual representation of the relationship between variables. Next researchers use a statistical tool (SPSS 25.0 and AMOS 25.0 in this research) to compare their prediction to the actual relationship between the variables (Janssens et al., 2008).

Some assumptions of regression are necessary for conducting a path analysis which is particularly sensitive to model specification because failure to include relevant causal variables or inclusion of extraneous variables often substantially influences the path coefficients that aim to estimate the relative significance of various direct and indirect causal routes to the dependent variable.

This analysis should be performed in the context of comparing substituted models, after calculating their goodness of fit in the structural equation modeling. If the variables in the model are non-observed or latent variables measured by some observed indicators, path analysis is termed structural equation modeling, and treated separately. In this research, the conventional terminology is adopted in which path analysis means modeling single-indicator variables. The assumptions for conducting a path analysis are thus: (Garson, 2013)

- Relationships among variables are linear (though, of course, variables may be nonlinear transforms).
- Additivity: no interaction effects found (but some variables may be interaction crossproduct terms)
- Data type should be interval. For all variables, if regression is used to calculate path paremeters, it is acceptable to use interval level data.
- Residual (unmeasured) variables should not be correlated with any of the variables in the model except the one they cause.
- Disturbance terms should not be correlated with endogenous variables. As the result of the above-mentioned assumption, path analysis supposes that for each endogenous variable, its disturbance term should not be correlated with any other endogenous variable in the model. This is an important assumption, violation of which may lead to the inappropriate regression when predicting parameters.

- Low multicollinearity. If the multicollinearity is high the model will have large standard errors of the b coefficients used in eliminating the common variance in partial correlation analysis.
- Appropriate sample size is needed to estimate significance. Kline (1998) recommends 10 times as many cases as parameters (or ideally 20 times). He indicated that 5 times or less is not sufficient for significance testing of model effects.
- The same sample is also required for all regressions used to estimate the path model. This may need reducing the data set down so that there are no missing values for any of the variables included in the model. This might be achieved by listwise dropping of cases by data imputation.

# Chapter 6 : Empirical results

This study analyzes the results of the digital technology adoption model operated by SPSS25.0/AMOS25.0. First, exploratory factor analysis (EFA) using Varimax factor rotation was used to assess unidimensionality of the measurements and then Cronbach's alpha was used to measure the reliability of scales. Second, the confirmatory factor analysis (CFA) verified the internal structure of the model by examining convergent validity and discriminant validity. Finally, the overall fit of model and hypotheses testing was presented.

The statistical analysis on the measurements, and the structural models used, are also reported in this chapter. The results showed that the measurement data fit the model very well. Each construct owns unidimensionality because convergent and discriminant validity were validated. The thesis also checked the structural model's overall fit which demonstrates it is consistent with the data quite well. Lastly, the hypotheses were tested according to the structural path links. Figure 15 presents the model's significant path coefficients.

## A) Statistical assumptions

The maximum likelihood estimation (MLE) method was adopted to analyze the data for its smallest variance and unbiasedness and the scale is free. MLE is moderately unbiased to deviations from normality. A Q-Q plot can be used to test the normality (Shama, 1995). According to the Q-Q plot, all plots are observed in a linear way. Further more, the largest kurtosis value was 0.825, adequately below the recommended maximum value of 10.00. The largest skewness value dropped below 3.00 (Kline, 1998). All items were within the range of univariate normality.

Mardia's coefficient was used to examine multivariate normality. AMOS was performed to show that the Mardia's coefficient was 52.604, giving strong evidence of multivariate non-normality. To modify multivariate normality, a 1000 bootstraps procedure was conducted (Byrne, 2001). Bootstrapping is a resampling process that concerns constantly sampling from the original parent sample data (Nevitt and Hancock, 2001). The bootstrapping procedure leads to the same diagnostics as regression analysis but permits the researchers to have more assurance in the standard errors that were manipulated to test for non-normality.

Moreover, the variance inflation factor (VIF) was used to examine the multicollinearity of all variables. High multicollinearity is significant because it indicates the problem of unreliability between independent variables, and thus it's necessary to conduct the multicollinearity analysis in the SPSS. The results indicated the values of VIF for the variables were acceptable because they were all below 3 (1.282, 1.815, 1.705, 1.575) (Diamantopoulos and Siguaw, 2006).

## B) Measurement model

This research adopts a two-stage procedure for data analysis according to Anderson and Gerbing (1988). Before analyzing the structural model, CFA was employed to test the measurement model. The estimation of a measurement for all the variables minimizes the extent to which the measurement items of each construct share variance and gives more stable parameter estimates (Fitzgerald et al., 1997). All latent variables are associated by covariance for exogenous variables. For making decisions concerning reliable constructs, the following traits of solutions need to be examined: unidimensionality, reliability, convergent validity and discriminant validity .

- **Unidimensionality**

Unidemensinality refers to the feature that a series of variables only has one primary dimension in common. To meet this criteria the variable measures first all need to have a high loading ( > 0.5) on the latent variables, and must be significant (Critical Ratio = C.R. = t-value > 1.96). Meanwhile, the measures must have a low cross-loading (< 0.4) on the other variables. The Varimax factor rotation (Table 8) showed each scale had a high loading on the construct it was intended to measure, with a low loading on those it was not intended to measure. For example, the lowest factor loading of the constructs is pn_2 (0.643) and the value of the highest cross-loading is 0.386, which all meet the criteria. Next, the Kaiser-Meyer-Olkin measure of sampling adequacy (Kaiser, 1974) was tested as well for the data with the resulting value of 0.917. 73.54% accounting for the relevant variance.

Additionally, the goodness of fit of the model was assessed by several criteria (Breivik and Olsson, 2001; Brown, 2006) to ascertain how well the specified model reproduces the covariance matrix among the indicator variables. The criteria to evaluate the goodness of fit of the model include the Chi-square statistics, degree of freedom, Chi-square value/number of freedom ( x 2/df), Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), Normed Fit Index (NFI), Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square (SRMR).

- The chi-square statistics show how well the data are actually reflected by the model. In the output of this model, the Chi-square value (discrepancy) is 682.639 with a p-value of < 0.001, therefore the null hypothesis is rejected. But it should be noted that the chi-square statistical test is very sensitive to sample size and when the number of samples increases, it will make it difficult to retain the null hypothesis (Brown, 2006). So it is commonly regarded as problematic, since even if the value is relatively high, the data can only consider the relationship between the Chi-square value and the number of degrees of freedom.

- The degree of freedom of the structural equation model is the number of limited parameters, which can be calculated by subtracting the number of estimated parameters from the total number of parameters q(q+1)/2.

- For the large samples, the relationship between Chi-square value and the number of freedom must satisfy the assumed criterion (x 2/df < 2). The value for the measurement model (1.711 < 2) indicates that the quality of the model is good.

- The Goodness of Fit Index (GFI) should preferably be greater than 0.90 and the Adjuested Goodness of Fit Index (AGFI) greater than 0.80. In the model, the GFI and the AGFI are equal to 0.904 and 0.831, respectively, which demonstrates an accepted model.

- The Normed Fit Index (NFI) should be greater than 0.9 and the value for this model is 0.907, which meet the criteria.

- The Comparative Fit Index (CFI) contrasts fits of the present model with ones of uncorrelated latent variables, which make the covariances between all input parameters be fixed to zero. CIF indicates the extent to which the target model is superior to the uncorrelated model. A value of above 0.95 is considered acceptable. It is in this case 0.95, equal to the cut-off value.

- The Root Mean Square Error of Approximation (RMSEA) is in an accordance with the Chi-square statistics, degree of freedom and sample size. The RMSEA is used to compare the model with the population's covariance matrix by unknown but optimally chosen indicator estimates. The RMSEA is sensitive to the number of parameters estimated and less sensitive to sample size. The RMSEA is 0.052. Values less than or equal to 0.06 indicate a good fit.

- The Standardized Root Mean Square (SRMR) is the standardized root of the mean square residuals and means the extent by which the sample variances and covariances varies from their estimates acquired under the assumption that the measurement or the structural model is true. The value here is 0.0478 which is lower than the usual cut-off of 0.08.

*Table 7: Checking the goodness-of-fit for measurement model*

| Goodness-of-Fit | Recommended Value | Result |
|---|---|---|
| The Chi Square ($x^2$) | N/A | 682.639 |
| degree of freedom (df) | N/A | 399 |
| $x^2$/df | < 2 | 1.711 |
| Goodness of Fit Index (GFI) | > 0.9 | 0.904 |
| Adjusted Goodness of Fit Index (AGFI) | > 0.8 | 0.831 |
| Normed Fit Index (NFI) | > 0.9 | 0.909 |
| Comparative Fit Index (CFI) | > 0.9 | 0.950 |
| Root Mean Square Error of Approximation (RMSEA) | < 0.06 | 0.052 |
| Standardized Root Mean Square (SRMR) | < 0.08 | 0.0478 |

Note: * The recommended values have been taken from Breivik and Olsson (2001)

**Reliability**

Reliability is "the degree to which parameters are free from error and therefore generate consistent results" (Peter, 1979). For examining internal reliability (the correlations among measurement items), Cronbach's alpha was calculated for each construct by weighting the equal factor as shown in Table 9. Cronbach's alpha values for the six constructs in the model are above 0.70, meeting the cut-off value of 0.70 as recommended by Nunnally and Bernstein (1994), which means that the yielded factors are considered to be reliable.

**Convergent validity**

Convergent validity indicated that variable measures that must be related are actually related (Mentzer et al., 1999). To ensure a sufficient degree of the convergent validity, it is required to examine item reliability, composite reliability (CR) and average variance extracted (AVE). First, all items of standardized regression weights have loadings greater than 0.6 and are statistically at the 0.01 level. Second, the composite reliability must be calculated manually for every latent variable.

$$\text{Composite reliability} = \frac{(\Sigma\ \text{standardized loadings})^2}{(\Sigma\ \text{standardized loadings})^2 + \Sigma\ \text{measurement errors}}$$

The guideline is that the composite reliability must be higher than 0.70 (Henseler et al. 2009). Table 9 provides evidence that the composite reliability values were greater than the recommended value.

Another criterion for ensuring the reliability of a latent variable is the average variance extracted, which demonstrates which part of collective variance of the measurements may be discovered in the latent variable. It can be calculated from the following formula:

$$\text{Variance extracted} = \frac{\sum(\text{standardized loadings})^2}{\sum(\text{standardized loadings})^2 + \sum \text{measuremnet errors}}$$

The instruction here is that each construct should have a value greater than 0.50 (Fornell and Larcker 1981). The average variance extracted for each latent variable is shown in Table 9. All AVE values were greater than the recommended value.

**Discriminant validity**

Discriminant validity means that measures that should not be related are actually not related (Mentzer et al., 1999). It can be achieved by two methods. The first one is to compare the change in the Chi-square between the restrictive model (model in which the correlation between two constructs is restricted to a value equal to one) and the accepted model. Any such change is considered statistically significant (Koufteros, 1999). For this research, the second method was adopted, which is to compare AVE with the squared correlation between constructs (Fornell and Larker, 1981). As shown in Table 10, the AVE square root for constructs was higher than the correlation between constructs. Thus, discriminant validity was established.

*Table 8: Factor loadings (**in bold**) and cross-loadings of constructs*

| | Component | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Adoption of DT (ADT)** | **Business Networks (BN)** | **Personal Networks (PN)** | **Digital Products Innovation (DPI)** | **Digital Service Innovation (DSI)** | **Business Model Innovation (BMI)** | **Market Share (MS)** | **Profit Level (PL)** |
| **adt_1** | **0.686** | 0.158 | 0.052 | 0.225 | 0.188 | 0.386 | 0.007 | 0.112 |
| **adt_2** | **0.749** | 0.208 | 0.191 | 0.139 | 0.197 | 0.161 | 0.137 | 0.037 |
| **bn_1** | 0.127 | **0.763** | 0.141 | 0.083 | 0.226 | -0.023 | 0.087 | 0.020 |
| **bn_2** | 0.194 | **0.766** | 0.091 | 0.027 | 0.157 | -0.058 | 0.226 | 0.068 |
| **bn_3** | 0.203 | **0.780** | 0.135 | 0.173 | 0.150 | 0.014 | 0.126 | 0.018 |
| **bn_4** | -0.023 | **0.793** | 0.142 | 0.060 | 0.141 | 0.234 | -0.010 | 0.033 |
| **bn_5** | -0.104 | **0.707** | 0.079 | 0.122 | 0.110 | 0.335 | 0.114 | 0.120 |
| **pn_1** | 0.103 | 0.246 | **0.714** | 0.085 | 0.195 | 0.144 | 0.303 | 0.074 |
| **pn_2** | 0.119 | 0.123 | **0.643** | 0.235 | 0.235 | 0.266 | 0.189 | 0.149 |
| **pn_3** | -0.008 | 0.170 | **0.710** | 0.235 | 0.256 | 0.078 | 0.207 | 0.206 |
| **pn_4** | 0.141 | 0.164 | **0.726** | 0.222 | 0.267 | 0.110 | 0.065 | 0.129 |
| **dpi_1** | 0.019 | 0.066 | 0.242 | **0.712** | 0.156 | 0.188 | 0.147 | 0.223 |
| **dpi_2** | 0.238 | 0.228 | 0.166 | **0.718** | 0.226 | 0.147 | 0.107 | 0.185 |
| **dpi_3** | 0.076 | 0.130 | 0.160 | **0.788** | 0.220 | 0.140 | 0.150 | 0.147 |
| **dpi_4** | 0.153 | 0.082 | 0.167 | **0.692** | 0.342 | 0.188 | 0.101 | 0.205 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **dsi_1** | 0.095 | 0.167 | 0.067 | 0.218 | **0.698** | 0.199 | 0.203 | 0.178 |
| **dsi_2** | 0.123 | 0.167 | 0.151 | 0.192 | **0.784** | 0.075 | -0.010 | 0.067 |
| **dsi_3** | 0.116 | 0.191 | 0.094 | 0.138 | **0.771** | 0.194 | 0.227 | 0.079 |
| **dsi_4** | 0.182 | 0.229 | 0.214 | 0.144 | **0.698** | 0.109 | 0.140 | 0.128 |
| **dsi_5** | -0.089 | 0.129 | 0.301 | 0.204 | **0.654** | 0.048 | 0.151 | 0.187 |
| **dsi_6** | 0.117 | 0.125 | 0.277 | 0.118 | **0.673** | 0.155 | 0.002 | 0.246 |
| **bmi_1** | 0.046 | 0.152 | 0.131 | 0.182 | 0.178 | **0.710** | 0.221 | 0.165 |
| **bmi_2** | 0.208 | 0.134 | 0.214 | 0.170 | 0.155 | **0.756** | 0.166 | 0.153 |
| **bmi_3** | 0.298 | 0.063 | 0.140 | 0.225 | 0.257 | **0.719** | 0.081 | 0.132 |
| **ms_1** | -0.017 | 0.206 | 0.170 | 0.095 | 0.124 | 0.259 | **0.729** | 0.197 |
| **ms_2** | 0.042 | 0.248 | 0.185 | 0.199 | 0.169 | 0.071 | **0.773** | 0.164 |
| **ms_3** | 0.219 | 0.054 | 0.347 | 0.188 | 0.229 | 0.174 | **0.682** | 0.103 |
| **pl_1** | 0.012 | 0.063 | 0.118 | 0.174 | 0.210 | 0.131 | 0.052 | **0.818** |
| **pl_2** | -0.017 | 0.026 | 0.089 | 0.161 | 0.160 | 0.072 | 0.079 | **0.855** |
| **pl_3** | 0.014 | 0.098 | 0.164 | 0.104 | 0.184 | 0.097 | 0.247 | **0.816** |
| **pl_4** | 0.148 | 0.029 | 0.069 | 0.140 | 0.049 | 0.114 | 0.065 | **0.832** |
| **Kaiser-Meyer-Olkin Measure of Sampling Adequacy** | | | | | | | **0. 917** | |
| **Total Variance Explained** | | | | | | | **73.54%** | |

Note : Extraction Method: Principal Component Analysis ; Rotation Method: Varimax with Kaiser Normalization ; a. Rotation converged in 7 iterations.

*Table 9: Measurement model results*

| Constructs and item measures | Cronbach's Alpha | Composite reliability | AVE | Mean | Std.Dev | Factor loading | C.R. | Estimates | p-value |
|---|---|---|---|---|---|---|---|---|---|
| *Adoption of DT (ADT)* | 0.716 | 0.719 | 0.562 | 4.11 | 0.71 | | | | |
| adt_1 | | | | 4.04 | 0.83 | 0.745 | - | 0.791 | [a] |
| adt_2 | | | | 4.17 | 0.77 | 0.745 | 9.804 | 0.706 | *** |
| *Business Networks (BN)* | 0.866 | 0.872 | 0.578 | 4.45 | 0.56 | | | | |
| bn_1 | | | | 4.58 | 0.64 | 0.684 | - | 0.773 | [a] |
| bn_2 | | | | 4.53 | 0.66 | 0.717 | 13.238 | 0.795 | *** |
| bn_3 | | | | 4.48 | 0.65 | 0.736 | 13.956 | 0.835 | *** |
| bn_4 | | | | 4.43 | 0.70 | 0.730 | 12.023 | 0.730 | *** |
| bn_5 | | | | 4.25 | 0.82 | 0.684 | 10.658 | 0.655 | *** |
| *Personal Networks (PN)* | 0.863 | 0.860 | 0.606 | 3.99 | 0.62 | | | | |
| pn_1 | | | | 3.95 | 0.76 | 0.745 | - | 0.791 | [a] |
| pn_2 | | | | 3.93 | 0.76 | 0.682 | 13.196 | 0.776 | *** |
| pn_3 | | | | 4.01 | 0.75 | 0.745 | 13.348 | 0.796 | *** |
| pn_4 | | | | 4.07 | 0.68 | 0.727 | 12.398 | 0.750 | *** |
| *Digital Products Innovation (DPI)* | 0.877 | 0.878 | 0.644 | 3.92 | 0.66 | | | | |
| dpi_1 | | | | 3.99 | 0.80 | 0.701 | - | 0.747 | [a] |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| dpi_2 | | | | 3.91 | 0.73 | 0.770 | 13.341 | 0.822 | *** |
| dpi_3 | | | | 3.89 | 0.81 | 0.781 | 13.197 | 0.813 | *** |
| dpi_4 | | | | 3.90 | 0.76 | 0.741 | 13.397 | 0.825 | *** |
| *Digital Service Innovation (DSI)* | 0.897 | 0.899 | 0.597 | 4.04 | 0.61 | | | | |
| dsi_1 | | | | 4.10 | 0.70 | 0.688 | - | 0.783 | [a] |
| dsi_2 | | | | 4.11 | 0.72 | 0.728 | 13.461 | 0.775 | *** |
| dsi_3 | | | | 4.04 | 0.76 | 0.767 | 14.558 | 0.826 | *** |
| dsi_4 | | | | 4.02 | 0.76 | 0.687 | 13.849 | 0.793 | *** |
| dsi_5 | | | | 3.96 | 0.82 | 0.645 | 12.158 | 0.712 | *** |
| dsi_6 | | | | 4.00 | 0.77 | 0.657 | 12.736 | 0.741 | *** |
| *Business Model Innovation (BMI)* | 0.842 | 0.851 | 0.657 | 3.93 | 0.72 | | | | |
| bmi_1 | | | | 3.94 | 0.91 | 0.688 | - | 0.722 | [a] |
| bmi_2 | | | | 3.89 | 0.82 | 0.782 | 12.894 | 0.853 | *** |
| bmi_3 | | | | 3.97 | 0.75 | 0.770 | 12.853 | 0.849 | *** |
| *Market Share (MS)* | 0.825 | 0.827 | 0.615 | 3.94 | 0.66 | | | | |
| ms_1 | | | | 3.87 | 0.81 | 0.733 | - | 0.741 | [a] |
| ms_2 | | | | 4.01 | 0.73 | 0.795 | 12.188 | 0.802 | *** |
| ms_3 | | | | 3.92 | 0.75 | 0.765 | 12.253 | 0.807 | *** |
| *Profit Level (PL)* | 0.903 | 0.903 | 0.700 | 3.58 | 0.71 | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| pl_1 | 3.57 | 0.81 | 0.781 | - | 0.852 | a |
| pl_2 | 3.58 | 0.80 | 0.803 | 17.112 | 0.851 | *** |
| pl_3 | 3.53 | 0.81 | 0.817 | 17.636 | 0.869 | *** |
| pl_4 | 3.65 | 0.81 | 0.759 | 14.760 | 0.772 | *** |

Note : [a] regression weight was fixed at 1 The S.E., C.R. and p-value were not estimated in these cases. While, by fixing a different parameter, the research verified that the estimates of these scaled values are also statistically siginificant with p<0.01;***p<0.01.

*Table 10: AVE square root and correlation*

| **Constructs** | **ADT** | **BN** | **PN** | **DPI** | **DSI** | **BMI** | **MS** | **PL** |
|---|---|---|---|---|---|---|---|---|
| Adoption of DT (ADT) | 0.750 | | | | | | | |
| Business Networks (BN) | 0.497 | 0.760 | | | | | | |
| Personal Networks(PN) | 0.538 | 0.535 | 0.778 | | | | | |
| Digital Products Innovation (DPI) | 0.637 | 0.446 | 0.684 | 0.802 | | | | |
| Digital Service Innovation (DSI) | 0.596 | 0.539 | 0.705 | 0.680 | 0.773 | | | |
| Business Model Innovation (BMI) | 0.733 | 0.412 | 0.609 | 0.642 | 0.591 | 0.810 | | |
| Market Share (MS) | 0.487 | 0.510 | 0.754 | 0.608 | 0.601 | 0.592 | 0.784 | |
| Profit Level (PL) | 0.318 | 0.245 | 0.543 | 0.637 | 0.596 | 0.446 | 0.488 | 0.837 |

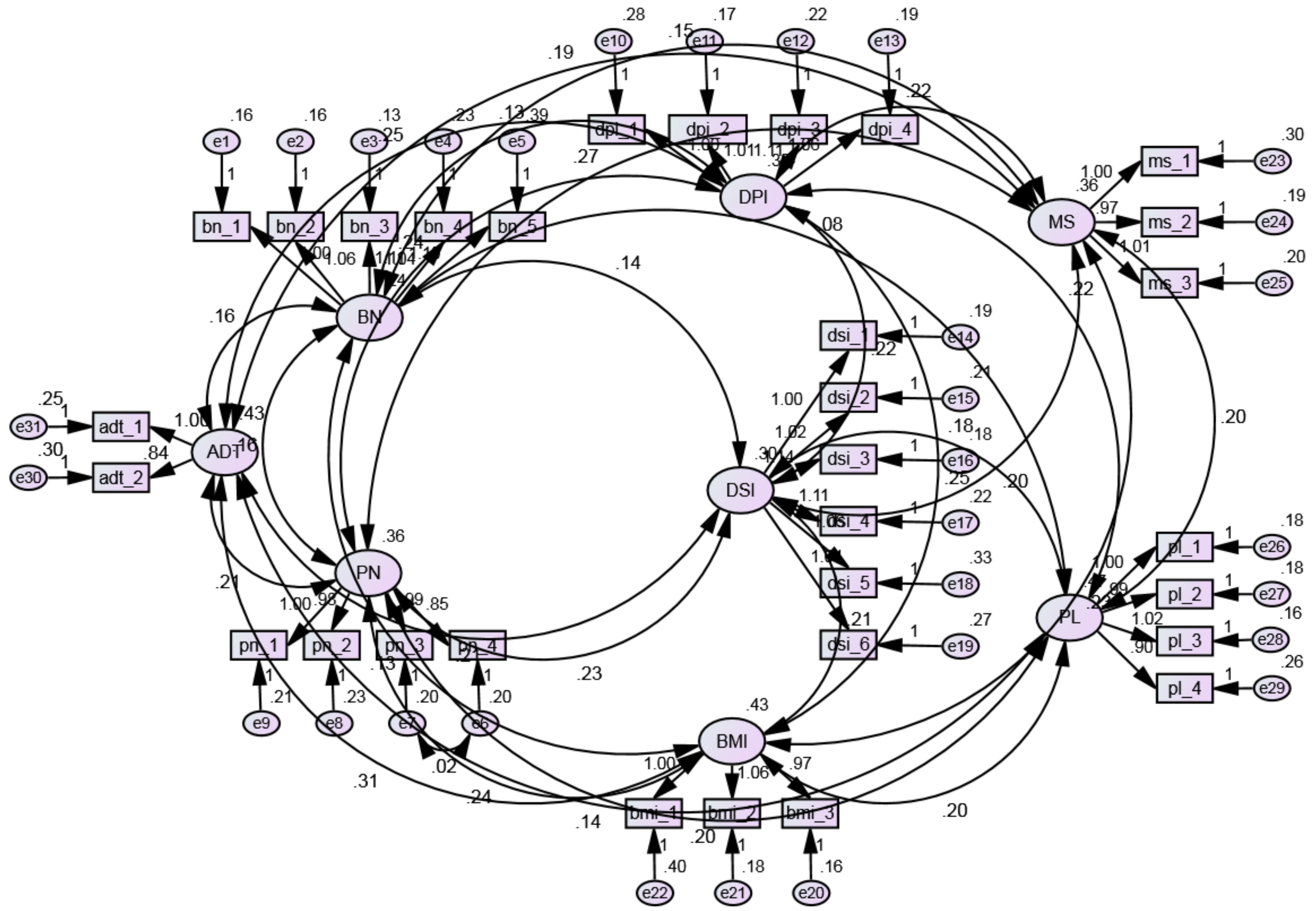


*Figure 14: Confirmatory factor analysis : Measurement model*

## C) Structural model

After examining unidimensionality, reliability and validity, the structural model was analyzed to test the research hypotheses. Initially, the fit of the solution was checked. In Table 11, indications are provided that the model is acceptable.

The Chi-square value here is 720.529, the Chi-square value/number of freedom (x 2/df) is 1.770. The structural model had satisfactory model fit results according to the good scores for GFI (0.907), AGFI (0.826), NFI (0.902), CFI (0.951), RMSEA (0.054) and SRMR (0.0489).

*Table 11: Checking the goodness-of-fit for structural model*

| Goodness-of-Fit | Recommended Value | Result |
|---|---|---|
| The Chi Square ($x^2$) | N/A | 720.529 |
| Degree of Freedom (df) | N/A | 407 |
| $x^2$/df | < 2 | 1.770 |
| Goodness of Fit Index (GFI) | > 0.9 | 0.907 |
| Adjusted Goodness of Fit Index (AGFI) | > 0.8 | 0.826 |
| Normed Fit Index (NFI) | > 0.9 | 0.902 |
| Comparative Fit Index (CFI) | > 0.95 | 0.951 |
| Root Mean Square Error of Approximation (RMSEA) | < 0.06 | 0.054 |
| Standardized Root Mean Square (SRMR) | < 0.08 | 0.0489 |

Note: * The recommended values have been taken from Breivik and Olsson (2001)

It should be noted that while the models indicate the causal relationships among constructs, the present statistical results from empirically examining the relationships can only reflect associations between constructs, not causal links. Among the first link of digital value chain that connects ADT and digital source, the positive and significant path loadings linking ADT to business networks (β=0.536, $p < 0.001$) and personal networks (β=0.742, $p < 0.001$) confirmed Hypothesis 1a which predicted that ADT would be positively related to business networks, and Hypothesis 1b which represented that ADT would be positively related to personal networks. It means that ADT can positively influence the heterogeneous networks for SMEs. Therefore, Hypothesis 1a and 1b were all supported.

For the digital transformation linking the heterogeneous networks and digital innovation, Hypothesis 2a, 2b and 2c suggested that the business networks would be positively related with digital innovation. The results revealed negative links between business networks and digital products innovation ($\beta$=0.139, $p > 0.05$) and business networks and business model innovation ($\beta$=0.141, $p > 0.05$), but a significant relationship between business networks and digital service innovation ($\beta$=0.264, $p < 0.001$). Thus Hypothesis 2a and 2c were not supported but Hypothesis 2b was supported. Hypothesis 3a, 3b and 3c proposed that the personal networks would positively influence digital innovation. The results indicated positive links between personal networks and digital products innovation ($\beta$=0.750, $p < 0.001$), personal networks and digital service innovation ($\beta$=0.609, $p < 0.001$) and personal networks and business model innovation ($\beta$=0.769, $p < 0.001$). So Hypothesis 3a, 3b and 3c were all supported.

In the last chain of the digital value chain where the relationship between digital innovation and SMEs' business performance is involved, Hypothesis 4a and 4b proposed that digital products innovation would be positively associated with market share and profit level. The results showed a significant relationship between digital products innovation and market share ($\beta$=0.307, $p < 0.001$) and digital products innovation and profit level ($\beta$=0.368, $p < 0.001$). Hypothesis 5a and 5b suggested that digital service innovation would positively affect the market share and profit level. The structural model showed a positive link between digital service innovation ($\beta$=0.327, $p < 0.001$) and market share and digital service innovation and profit level ($\beta$=0.257, $p < 0.05$). Hypothesis 6a and 6b suggested a positive impact of business model innovation on market share and profit level. The results revealed a positive link between business model innovation and market share ($\beta$=0.209, $p < 0.001$) and no significant relationship between business model innovation and profit level ($\beta$=0.152, $p < 0.001$). So Hypothesis 4a, 4b, 5a, 5b and 6a were all supported but Hypothesis 6b was rejected. Table 12 summarizes the results of the significance test for the paths of the DIVC model and Figure 15 presents visually the significance and path coefficients in the research model.

*Table 12: Results of the significance test for the model's paths*

| Predictor | Outcome | Hypotheses | Path Coefficient | S.E. | C.R. | P-value |
|---|---|---|---|---|---|---|
| Adoption of Digital technology (ADT) | Business Networks (BN) | H1a Supported | 0.536 | 0.078 | 6.890 | *** |
| | Personal Networks (PN) | H1b Supported | 0.742 | 0.096 | 7.713 | *** |
| Business Networks (BN) | Digital Products Innovation (DPI) | H2a Not Supported | 0.139 | 0.072 | 1.924 | 0.054 |
| | Digital Service Innovation (DSI) | H2b Supported | 0.264 | 0.063 | 4.200 | *** |
| | Business Model Innovation (BMI) | H2c Not Supported | 0.141 | 0.082 | 1.705 | 0.088 |
| Personal Networks (PN) | Digital Products Innovation (DPI) | H3a Supported | 0.750 | 0.084 | 8.932 | *** |
| | Digital Service Innovation (DSI) | H3b Supported | 0.609 | 0.069 | 8.844 | *** |
| | Business Model Innovation (BMI) | H3c Supported | 0.769 | 0.095 | 8.093 | *** |
| Digital Products Innovation (DPI) | Market Share (MS) | H4a Supported | 0.307 | 0.071 | 4.311 | *** |
| | Profit Level (PL) | H4b Supported | 0.368 | 0.095 | 3.884 | *** |
| Digital Service Innovation (DSI) | Market Share (MS) | H5a Supported | 0.327 | 0.079 | 4.122 | *** |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Profit Level (PL) | H5b Supported | 0.257 | 0.102 | 2.512 | * |
| Business Model Innovation (BMI) | Market Share (MS) | H6a Supported | 0.209 | 0.060 | 3.465 | *** |
| | Profit Level (PL) | H6b Not Supported | 0.152 | 0.081 | 1.886 | 0.059 |

Note : ***p < 0.001, **p < 0.01, *p < 0.05.

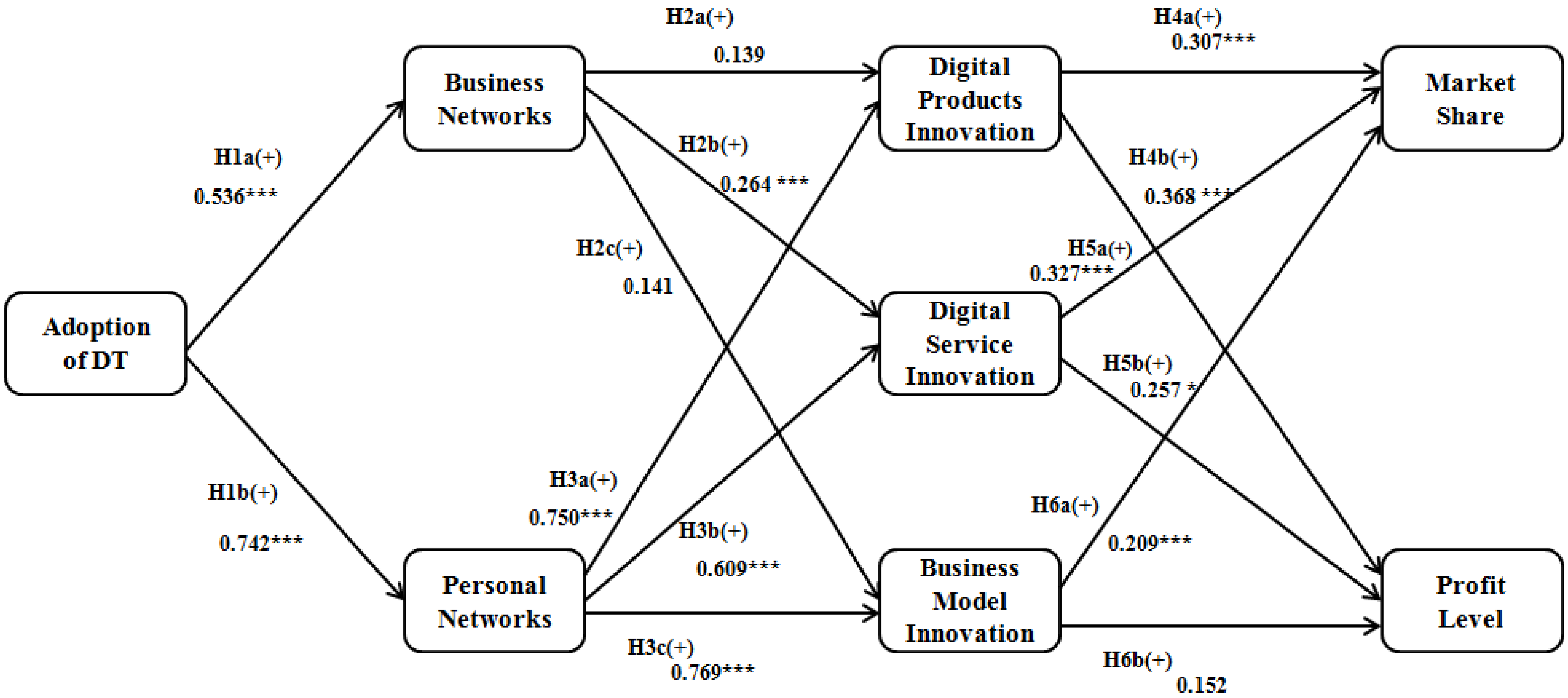



*Figure 15: Structural equation model : significance path coefficients in the model*

# Chapter 7 : Discussion of results: key findings

This chapter presents findings from the discussion. The findings first show that the relationship between the ADT and the heterogeneous networks is positively significant. Thus, SMEs considering building a network are strongly recommended to adopt digital technology as a strategy to establish connections with other actors.

The research findings then show that SMEs' business networks positively affected digital service innovation while the relationships between business networks and digital products innovation and business model innovation are not significant. The results also prove a positive direct effects of personal networks on all three types of digital innovation: digital products innovation, digital service innovation and business model innovation. SMEs aiming at developing their digital innovation are better off placing an emphasis on personal networks which contribute more to digital innovation because the path from ADT-personal networks to personal networks-digital innovation is positive. Additionally, business networks only positively influence digital service innovation for SMEs. This means that SMES should pay more attention to building personal networks in order to develop digital innovations.

Finally, the findings reveal that digital products innovation positively affected SMEs' market share and profit level. Digital service innovation also showed a positive effect on SMEs' business performance. Business model innovation significantly influenced SMEs' market share while the relationship between business model innovation and profit level proved to be not significant. The findings provide SMEs with possible ways to improve their business performance.

## A) Linking the effect of adoption of DT on heterogeneous networks

***H1a : Relationship between adoption of DT and business networks***

Results of this study indicated the adoption of DT has been proved to have a significant impact on business networks and thus hypothesis (H1a) has been confirmed. The result is consistent with the previous studies in that digital technology as an external enabler has the trait of relationality (Von Briel et al., 2018). Relationality of digital technology that describes the structural connections are to some extent distinct from and responsive to other actors which makes them frequently interactive (Kallinikos et al., 2013). Digital technology is basically interdependent, and depends on at least one interaction with other actors to enact their agencies.

Further more, digital technology is capable of entertaining relationships and interaction with more online customers and other agencies. For example, the digital technology of virtual reality can provide entertainment and thus attract numerous customers. The SMEs who adopted this digital tool have more chance to collaborate with government agencies or industrial authorities to visualize the work process or products production.

Digital technology enables business actors and agencies to form networks through the resources flow (Podolny, 2001) because through building more networks, SMEs can potentially have more access to the resources that are intrinsic in these networks. The central role of digital technology in the networks makes boundaries more fluid and business agencies more dispersed in venture creation processes (Nambisan, 2017) and thus SMEs channel and accumulate resources in a relatively flowing way.

Moreover, adoption of DT can leverage efforts to facilitate functionality through SMEs building networks with more business actors. For example, Alibaba is the biggest commercial online platform in China and owns huge amounts of customers data which need to be analyzed. SMEs with strong big data analytics are able to grab a slice of market that is growing and shows no sign of slowing. Even though large firms that possess high-end technologies and abundant resources used to occupy the dominant place in business networks, SMEs now show more flexibility and agility compared to large ones when facing digital transformation.

***H1b : Relationship between adoption of DT and personal networks***

The positive significance has been proved in the relationship between adoption of DT and personal networks, so the hypothesis (H1b) has been confirmed. Building personal networks is very important for SMEs for the four following reasons: First, personal networks "play the role of 'infomediaries' in facilitating exchange of the most valuable information (Zhou et al., 2007), thus enhancing the awareness of digital innovation activities. Second, personal networks in the context of digitalization provide tacit and implicit knowledge about digital innovation and help SMEs to generate new knowledge spanning various industries. Third, personal networks bring referral trust and solidarity, which can be an efficient way to facilitate legitimacy and credibility. This is because personal networks can be regarded as a vital referral for endorsement and assurance of economic transactions with the third parties

(Ge and Wang (2012)). Fourth, SMEs rely more on personal networks compared to large firms because both business networks and personal networks are comparatively available for them, whereas SMEs have less options.

The positive effect between adoption of DT and personal networks can be explained the enabling mechanisms of digital technology (Von Briel et al., 2018). Their work tells us that the adoption of DT can help reduce amount of time that is required to perform an action in the personal networks. Digital technology is able to control and optimize the execution of such action because it enhances the reliability of data inputs, transformation and outputs. The more efficient execution of action also takes up less time and thus improves the speed of information exchange, letting more actors engage in the networks.

Moreover, adoption of DT can positively influence personal networks by improving coordination efficiency and efforts. Because digital technology can form a platform that overcomes space problems where more diverse actors interacted, they guarantee the consistency and accuracy of inputs and outputs even with an increasingly large volume of resources flowing.

Additionally, adoption of DT must connect at least one actor that provides access to complementary resources, so technologies can thus bundle resources to create new networks. As the number and variety of complementary actors which DT can connect increases, the networks' ability to enable creation of new resource combinations is enhanced, as its potential to facilitate a more dynamic use of resources through these actors in the personal networks.

## B) The effect of heterogeneous networks on digital innovation

***H2a and H2c: Relationship between business networks and digital products innovation and business model innovation***

The results showed that business networks have no significant influence on digital products innovation and business model innovation. Hypothesis 2a (H2a) and Hypothesis 2c (H2c) have not been supported. The possible explanations for rejecting H2a are as follows. First, the non-significant relationship might be explained by the sample respondents' structure: the thesis discovered that the number of general managers occupies 30.91%. From their perspective, the business networks may not be the most significant factor and other factors should be considered. For example, utilization of artificial intelligence or big data analysis for digital products or business modeling may need more technical staff or computation skills.

Second, the possible reason for the insignificance is that the relationship between business networks and digital product innovation and business model innovation  might by mediated by other factors. So in future research studies the mediation effect between business networks and digital innovation should be considered. Third, perhaps the theory of heterogeneous networks can't fully explain the relationship between business networks and digital innovation, so we should consider a more appropriate theory to explain this phenomenon in the future.

***H2b : Relationship between business networks and digital service innovation***

The results indicated that business networks can positively influence digital service innovation and thus hypothesis (H2b) has been confirmed. This finding is consistent with Hsu (2011)'s studies. The business networks afforded by digital technology differ from traditional business strategies because they have the potential to break down the traditional boundaries of such strategies. For example, they connect agencies or customers domestically or globally to align with businesses in other areas.

Business networks  are critical to digital service innovation by helping the SMEs to build core competences from accumulating customers and resources (Hsu, 2011). Through this network, SMEs can compete on striving to dig into the customer's needs so as to create digital services. At the same time, they are able to respond quickly or predictably to the needs of actors in the networks indicated by how those actors have commented on the products or resources in the innovation process in order to improve the digital service. Consider, for example, Alibaba, one of the biggest online platforms in China which analyzes customers' purchasing data and behavior. Through building business networks with Alibaba, some SMEs can understand and grasp proactively or actively the customers' needs and thus they can respond to them in a short time.

Building  business networks enables the acquisition and accumulation of resources, and facilitates cost reduction. Because digital technology allows for fluid switching and collection across applications and networks to enhance collaboration and knowledge acquisition, digital service innovation is given broader scope. For example, many successful digital SMEs have demonstrated that they can be integrated enterprises or application service providers by exchanging or building business networks.

Generally speaking, business networks built by digital technology may enhance traditional strategies by pursuing personalization to accumulate resources, needs and infrastructure to achieve digital service innovation.

***H3a: Relationship between personal networks and digital products innovation***

The results confirmed that the relationship between personal networks and digital products innovation is significant, and consequently the hypothesis 3a (H3a) has been supported. Different from the large-size enterprises that have close business networks with government and other agencies, SMEs usually face a high degree of uncertainty. Personal networks can help firms reduce the anxiety which is caused by uncertainty by reducing external dependences (Preffer and Salancik, 1978). It acts as a bridge that connects the external environment and the SMEs, by building inter-personal links through which SMEs have the abilities to connect to a wide range of actors and organizations. According to Ge and Wang (2013), personal networks can positively influence digital products innovation in the following two ways.

First, personal networks are able to provide more information – and thus the knowledge base required – for digital product innovation through widening the range of environmental scanning as well well as connecting with the market needs and experience from external sources. This can ease the uncertainty by familiarity built through SMEs' networks so as to help them to acquired local market knowledge and to access relevant business information for digital products (Chetty and Patterson, 2002). Network relationships though personal channels such as friends, relatives and schooling provide various ways to exchange and process information which are also of benefit for digital product innovation.

Second, resources set an obvious limit on SMEs' entry to the market because they are normally constrained by size-related barriers in attracting external financial resources. But financial resources are a key to improve digital products innovation. SMEs' personal networks through family members and friends, could act as a source of financing. For example, Porter and Zhou (1992) pointed out from a sociological perspective that family ties can have an impact on the availability of investment capital from relatives. Cardoza and Fornes (2011) discovered that funds from private sources are vital for Chinese SMEs to product development. Thus, SMEs' personal networks afforded by digital technology enable SMEs to commit more resources to pursuing digital products innovation.

*H3b: Relationship between personal networks and digital service innovation*

The results indicated that personal networks have a significant influence on digital service innovation and the hypothesis (H3b) has thus been confirmed. This study extends the understanding of personal network ties with families and friends domestic and overseas. In the earlier phase of developing market share, SMEs inevitably tended to enter markets where business networks were present. They would be more informed and thus able to identify and grasp profitable opportunities if they were capable of utilizing a wide range of relationships from personal networks. SMEs with strong personal networks will create digital service innovation at a faster pace and be willing to commit more resources. One possible explanation is that personal networks can provide SMEs a safety net in terms of reducing uncertainty, collecting market information, and even providing funding.

The findings of this study echo the significance of personal networks and digital service innovation whereas past studies have mainly emphasized the importance of business network linkages (Hsu, 2011). Personal networks built on the basis of digital technology provide SMEs with much needed information on markets, so that they can respond more quickly compared to traditional enterprises. The key to survival or success for SMEs in today's highly globalized and very competitive business environment is to realize that it's not enough to possess certain unique capabilities for SMEs; they also need to utilize them in an effective way. In China's unique institutional environment, the capability to form personal networks is also imperative to improving digital service innovation.

*H3c: Relationship between personal networks and business model innovation*

This study found that personal networks positively influence business model innovation for SMEs. The positive relationship found between personal networks and business model innovation is consistent with the studies by Jin and Jung (2016). SMEs are sometimes resource-constrained firms which may not have access to systematic customer needs. In contrast, they often depend on their reliable personal networks with the market contacts to grasp customer needs associated with the underlying market. This view is supported in the literature that shows existing personal networks play a more significant role in grasping customer needs than does information acquired through other channels. Meanwhile, close relationships and interactions through personal networks with the market contacts are capable of providing comprehensive information about customers and markets that may not be immediately gained from other ways.

Personal networks can help SMEs to access information and resources needed for business model innovation. These resources are able to aid them develop successfully and gain profit in the market. Beyond access to resources and information, SMEs' personal networks can further attract more opportunities by expanding networks through personal relationships, which is a critical point for SMEs. By having more access to resources, information, and opportunities, SMEs with personal networks will, therefore, achieve more value in business model innovation.

## C) The effect of service innovation on firm performance

***H4a: Relationship between digital product innovation and market share***

The result found out that the relationship between digital product innovation and market share is significant and thus hypothesis 4a (H4a) has been confirmed. We demonstrated that, in order to continue to operate in a market, SMEs must introduce new digital products that become accepted in the market, whether they are the first to introduce innovations or adopt innovations introduced by their competitors. SMEs that are regularly among the first to introduce digital product innovations will tend to maintain their position in the market. On the other hand, firms which do not strive to introduce digital product innovations will eventually suffer declining market share and finally disappear from the market, either by narrowing down their businesses or by selling them to other firms (Banbury and Mitchell, 1995).

Firms may not introduce digital product innovations for the following reasons. First, firms sometimes don't have sufficient capabilities to deal with digital transformation. Capabilities – with their requisite costs – are essential for firms to operate in the digital environment, especially for SMEs. Moreover, competitors' innovation may be protected by strong proprietary rights (Teece, 1986). Additionally, some firms tend to wait to observe whether certain digital technology becomes accepted in the market – or not – which may delay the introduction of digital products for too long.

The previous studies on market entry have shown that firms who introduce product innovations often acquire market share advantages for those specific innovations (Kerin et al., 1992). In the long term, though, it will be the general tendency to lead or follow others in the adoption of digital technology, rather than any single case of digital product innovation, which will have the strongest influence on SMEs's overall performance in the market. Some firms choose to wait because the risk of failure in digital innovation would cost too much money – e.g. in attempts to commercialize digital products in the market – while also perhaps damaging the firms' reputation with customers. In any event, a firm that feels that the digital technology has become accepted by the market will often then face the prospect of being left behind in the introduction digital product innovation. At that time, the opportunity for digital product innovation will have slipped away, while competitors have established their own products. So, SMEs might aim to be the first to introduce digital product innovation for the sake of gaining market share.

***H4b: Relationship between digital product innovation and profit level***

The result indicated that digital products innovation positively influences profit level for SMEs, and hypothesis 4b (H4b) has thus been supported. Product innovation is one of the important sources of competitive advantage to the firm (Camison and Lopez, 2010). Digital product innovation can enhance the quality of digital products, which in turn contributes to profit level and ultimately to SMEs' competitive advantage. Moreover, digital product innovation can offer SMEs potential protection from market threats and competition.

SMEs encounter huge pressure from competitors to lower prices and accept shrinking margins on sales. SMEs are therefore searching for revenue growth from digital products and they can offer customers innovative digital products to allow for a more efficient and effective usage of digital products that best promotes the profit level.

Digital product innovation plays a pivotal in defining the new characteristics of digital products to satisfy customers' needs. The development of digital product innovation is based on collecting and processing data to identify specific customer needs for digital products. Such digital products are ideally developed based on customers' specific needs and take the form of a process of interaction between markets and firms, thus building the knowledge of customers and markets that enable effective digital innovation products to be formulated. That's the reason why digital product innovation can increase the profit level for SMEs.

***H5a: Relationship between digital service innovation and market share***

The results indicated that a positive relationship exists between digital service innovation and market share, thus supporting hypothesis 5a (H5a). This result is consistent with Miles (2008)'s studies which show that digital service innovation can positively influence market share by performing for particular clients in a particular circumstance. Digital service innovation can be considered as emergent, interactive and dynamic knowledge and information obtained thru communication exchange and flows between providers and customers for SMEs in the market. Consequently, digital service innovation can act as improvised innovation arising in service exchanges as well as through anticipatory innovations or formalization of standardized processes across various digital service providers and client interactions (Gallouj, 2002). This view is specially relevant to knowledge-intensive services in which digital service providers customize services for each client, and gradually develop new portfolios of digital service for a marketplace. The interactive feature of digital service innovation is shown as digital innovation emerges and develops along with digital technology and shifts in market conditions and industry structures within SMEs. Through such an interactive means the whole market will open up for digital services (Barras, 1990; Barrett et al., 2015).

For those SMEs who adopt digital technology, they regard this kind of adoption as an important strategic resource. Through client interaction and co-production of digital technology with business or personal partners, SMEs are able to improve market share for value creation. SMEs that develop digital service innovation leverage digital technology to develop new online assurance services in order to diversify into new markets (Barrett et al., 2015).

***H5b: Relationship between digital service innovation and profit level***

The results indicate that, digital service innovation is positively associated with enhancing the profit level for SMEs, and the hypothesis 5b (H5b) has thus been confirmed. The findings in the study are consistent with previous studies in digital service innovation on firm performance (Ordanini and Rubera, 2010), which implies SMEs' growing in firms' adoption to utilize digital technology for better digital service innovation in order to achieve higher profitability.

A number of previous studies in digital technology have emphasized the role of digital technology as an enabler for improving digital service innovation and firms' performance. Although the results of this study are mostly conceptual, it also presents empirical evidence to show that digital service innovation afforded by digital technology is likely to provide benefits when SMEs focus on using digital technology to enhance digital service innovation. SMEs' favorable reaction to digital service-oriented use of digital technology implies that digital technology has the potential to enhance profitability when manipulated for digital service innovation to customers and better collaboration with networks.

Moreover, digital service innovation promises SMEs' provision of resources for firms' customers. Consequently, one of the major benefits that digital service innovation offers is that by using digital technology, SMEs can access all sorts of on-demand resources without initial capital investment. In this way, digital service innovation leads to the transition of capital into operational cost, providing the opportunity for SMEs to make use of the needed resources at affordable prices. Following this notion, the result that is favorable to SMEs that digital service innovation afforded by digital technology is a plausible choice for SMEs seeking to maximize the returns of profit (Son et al., 2011).

In addition to the benefits of a low initial capital, digital service innovation provides customers with a certain degree of flexibility (Ranganathan and Brown, 2006). More importantly, because SMEs can obtain a broad range of digital capabilities through digital technology adoption, they can then concentrate on the dynamic abilities of their business in the market. This, coupled with access to up-dated digital technology, can positively affect SMEs' profit level.

***H6a: Relationship between business model innovation and market share***

The results confirmed that SMEs with business model innovation afforded by digital technology have a superior performance measured in terms of market share, thus supporting hypothesis 6a (H6a). Business model innovation is the practice of assimilating a novel logic of doing business into SMEs to increase market share because it enables SMEs to exploit new business opportunities. SMEs tend to shift from traditional innovation towards a business innovation model because this offers more opportunities, and thus the market share can be lifted. Business model innovation has become an important factor for improving performance of SMEs operating in turbulent markets. In the long run, business model innovation can help SMEs to compete and survive in the dynamic market (Velu, 2015).

Business model innovation is different than digital products innovation and digital service innovation because business model innovation enables SMES on the spot when new opportunity in the form of new market shows (Anwar, 2018). The exploitation of market opportunity in turn can help SMEs to sustain performance. For instance, Bouwman et al. (2019) examined whether SMEs that undergo digital transformation perform better if they allocate more resources for business model experimentation and engage more in strategy implementation. They used data from 321 European SMEs that actively adopted social media, big data, and information technology to innovate their business models. Their results showed a positive overall firm performance as a result of more resource allocation to business model experimentation and more engagement in practices of strategy implementation. These effects were mediated by business model experimentation practices and strategy implementation (Bouwman et al., 2019).

***H6b: Relationship between business model innovation and profit level***

The results showed that the relationship between business model innovation and profit level is not significant, so hypothesis 6b (H6b) was not confirmed. The conclusion also contradicts the previous studies. From one perspective, one possible explanation is that the direct relationship between business model innovation and profit is not obvious, but the interaction with other factors should be taken into consideration. For example, business model innovation based on customers is a fundamental key for SMEs' profit level. Under the context of digitization, customers needs must change which causes an alteration of the business environment and drives new market opportunities. Thus the interaction effect between business model innovation and customer needs may have an influence on SMEs' profit level instead of business model innovation itself. The other solution is that in the follow-up the relationship between business model innovation and digital products innovation and digital service innovation should be further tested, which can also indicate why the results showed a non-significant relationship between business model innovation and SMEs' profit level.

# General Conclusion

The final chapter strengthens the critical findings of this study. Therefore, the objectives of this chapter are to summarize the conclusions from research findings to address possibly useful theoretical and managerial implications of the study. The first section indicates the conclusions drawn from the research framework, research questions, and methodological approach. This part also decribes other significant findings of the study. The second section shows the policy implications of the research, and the third section highlights the limitations and recommendatiosn of the study.

## 0.1 Conclusion

Our research contributes to the existing literature by revealing digital innovation dimensions and modeling the digital innovation value chain of SMEs. The relationships between ADT, heterogeneous networks, digital innovation and business performance presented by the theoretical model were significant; therefore, SMEs intending to achieve higher levels of business performance should consider ADT as a critical factor. Moreover, by combining emprical testing with the theoretical model, the research extends the digital innovation dimensions and innovation value chain literature to show that digital products innovation, digital service innovation and business model innovation are the key types of digital innovation in China. In summary, the present study will provide researchers with some vital aspects to investigate further in this field of study.

### 0.1.1 Adoption of digital technology has a significant effect on business networks and personal networks

To answer **Question 1**, the study undertook an empirical examination of the impact of ADT on heterogeneous networks. Hypothesis 1a and hypothesis 1b were proposed to answer this question. The results generated from the findings (discussed in Chapter 6) indicate that ADT has a significant positive relationship with measures of Heterogeneous networks. The results showed that the adoption activities by SMEs have a positive effect on business networks and personal networks. Besides, the findings revealed that adoption of digital technology has a significant positive impact on both types of heterogeneous networks which involve business networks and personal networks. SMEs considering building networks are strongly recommended to make use of digital technology as a strategy to establish connections with other actors.

### 0.1.2 Dimensions of digital innovation: digital products, digital service and business model innovation

**Question 2** of this study aims to develop an understanding of digital innovation and the relationship between Heterogeneous networks and digital innovation. Six hypotheses (H2a, H2b, H2c, H3a, H3b and H3c) were presented to answer this question. A structural model was developed as reported in Chapter 5 to indicate that the business networks positively affected digital service innovation while the relationships between business networks and digital products innovation and business model innovation are not significant. The results also showed the positive direct effects of personal networks on all three types of digital innovation: digital product innovation, digital service innovation and business model innovation.

The study contributes to the existing literature by describing the types of digital innovation and revealing the critical role of personal networks on digital innovation. The theoretical model demonstrated the relationship between personal networks and digital products innovation, digital service innovation and business model innovation were closely connected. Therefore, SMEs aiming to develop their digital innovation are better off placing an emphasis on personal networks which contribute more to digital innovation. Although the results indicated that the path between business networks and digital products innovation and the path between business networks and business model innovation were not significant, the conclusion was that SMEs must be wary of connecting thru business networks that do not significantly affect their digital products innovation and business model innovation. Additionaly, the empirical testing and theoretical model extend the digital innovation lieterature by providing evidence of the positive relationship between business networks and digital service innovation. Thus, SMEs should be critical in their approach to ADT if they are aiming to achieve digital service innovation.

### 0.1.3 The nexus linking Heterogeneous networks-digital innovation-SMEs' business performance

How does ADT affect SMEs' business performance in the major areas of the DIVC? **Question 3** is the central question of this study, requiring an empirical examination of relationship between digital innovation and business performance. Six hypotheses (H4a, H4b, H5a, H5b, H6a, H6b) were presented to answer this question. The structural model was developed as reported in Chapter 5 to indicate the relationship between digital innovation and business performance.

The findings revealed digital products innovation positively affected SMEs' market share and profit level. Thus, to enhance the level of market share and profit level, SMEs can consider the path from ADT-personal network-digital products innovation to business performance. Secondly, the results of the study highlight that digital service innovation also showed a positive effect on SMEs' business performance. This means that SMEs can also consider the path from ADT-personal networks-digital service innovation to business performance and the path from ADT-business networks-digital service innovation to business performance. Thirdly, the results of the study revealed that business model innovation significantly influenced SMEs' market share while the relationship between business model innovation and profit level proved to be not significant. Therefore, to enhance the level of market share, SMEs should be thinking about the nexus ADT-personal networks-business model innovation –market share.

## 0.2 Policy implications

### 0.2.1 Theoretical implications

This study informs research on DIVC by introducing a conceptual framework that provides an understanding of how SMEs adopt digital technology to create value during the digital innovation activities in order to enhance their business performance. The research argues that heterogeneous networks including business networks and personal networks afforded by ADT allow SMEs to continuously deal with digital innovation activities. The study extends existing knowledge about innovation value chains by empirically illustrating the importance of digital technology with respect to digital innovation activities, in particular for digital product innovation, digital service innovation and business model innovation, which has an indirect influence on SMEs' business performance. Furthermore, the thesis empirically shows that ADT can have a positive influence on both business networks and personal networks for SMEs.

The results further indicate that SMEs' heterogeneous networks have a direct effect on SMEs' digital innovation. The research specifically shows how personal networks influence SMEs' digital innovation. Thus, if the heterogeneous networks are perceived as an important factor of digital innovation, SMEs' personal networks will be better utilized. This result is in line with the research in management that points to a direct effect between networks and product innovation and firm performance (Mitrega et al., 2017). The research thus extends the literature on heterogeneous networks by empirically examining an important factor for SMEs' digital innovation. The results of the DIVC framework provide tentative support for the thesis that SMEs may build personal networks through ADT to achieve digital innovation and ultimately SMEs' business performance. It is therefore confirmed that business networks only have an effect on digital service innovation for SMEs.

The research provides a contribution in the area of digital innovation aimed at categorizing dimensions of digital innovation by suggesting that digital innovation involves digital product innovation, digital service innovation and business model innovation according to reviews based on previous studies of innovation.

In sum, these research results provide evidence for the positive influence of ADT during the development of the DIVC. At the same time, the research shows that the heterogeneous networks afforded by ADT highlight the key role of SMEs' personal networks regarding the importance of relationships for SMEs' business performance. It is believed that this research also corresponds with the need to make today's digital innovation more fluid, thereby facilitating the diversity and flexibility of DIVC with regard to a dynamic and boundless environment.  As digital technology gets more mature, sooner or later, ways to get value diversify, so the most successful firms may need to maneuver over time to master the relevant technology in a digital context.

### 0.2.2 Managerial implications

The results have both managerial and policy implications. From a strategic perspective, the DIVC helps prioritize upgrading, focusing management attention on both the strong and weak links within the process. The key here is the need for SMEs to build not just business networks but also personal networks that can directly assist digital innovation through complementary patterns. An example is the role of the business networks. Thus even where the direct outcomes of business networks on digital product innovation and business model innovation are insignificant, as in the case of business networks in digital innovation, their overall influence may still be positive to the balance between "direct" and "innovation value chain" effects. For example, business networks are one part of heterogeneous networks, suggesting that the establishment of business networks can bring indirect digital innovation, even if, as in the case of SMEs, the business networks are restricted due to limited resources.

The crucial benefit of the DIVC approach is therefore its ability to highlight the role of various factors on business performance at different stages of the development of the heterogeneous networks thru digital innovation, and to show their direct and indirect relationships. As mentioned above, the role of digital technology is key here, with SMEs positively associated with all three elements of the DIVC: heterogeneous networks, digital innovation and business performance. This suggests that SMEs have a strong incentive to invest in digital technology not simply because adoption has a direct influence on digital innovation, but because it can strengthen all three elements of the DIVC, and so improve the innovative capacity of SMEs.

For policy makers, the DIVC analysis has three main implications. First, it's possible to identify the drivers of market share and profit level among SMEs, and in particular, to address the roles of the business networks and the personal networks. This provides a clear signal that that every factor is important in affecting digital innovation and business performance both through their direct results but also potentially through complementary influence with other digital innovation drivers. The DIVC approach also shows the mechanisms through which factors influence SMEs' business performance, providing a potential structure for the evaluation of future policy or regulations on SMEs.

Second, the results of this thesis provide considerable support for Ganotakis's theory (2012) that firms introducing heterogeneous networks exhibit innovative tendencies for new technology-based companies, which ultimately will be expected to enhance firms' rates of growth. This is a way through which SMEs in China can adopt digital technology in order to increase both their digital innovation output and business performance.

Finally, through the DIVC it is possible to identify the drivers of digital innovation behaviour itself, focusing on the role of digital technology as both a direct and indirect influence on digital innovation success, and also the role of heterogeneous networks for digital innovation. The implication is that policy intervention to improve ADT has direct benefits for business networks and personal networks but may also have indirect benefits for digital innovation. For example, there is evidence that government funding to support digital technology among SMEs is positively associated not only with the networks itself but also with digital innovation among this sample of SMEs. This may suggest that further policy measures to enhance this important group of SMEs could have substantial benefits.

# 0.3 Limitations of research and scope for the future research

## 0.3.1 Limitations

There are many obvious limitations of the present research. Firstly, the use of any survey instrument inevitably depends on the type and quality of data. In this research, for example, data are gathered through Likert scale ratings as perceived by interviewees, but not in any sense objective. While this approach is still consistent with many surveys in the area of strategy and innovation, it could be usefully complemented with analysis that is able to explore latent variables, for example, in assessing the extent of agreement with the statement: "In recent years, the firm has developed digital services integrating digital technology such as social media, big data analytics, cloud and mobile technologies". In this study, respondents may overestimate their ADT, heterogeneous networks, digital innovation and business performance. Thus, the structured questionnaire denies the opportunity to explore many of the related issues of the responses, but all the checks have been undertaken to determine the validity and reliability of the information collected.

Secondly, when designing the survey to allow the DIVC estimation, there are definitely some lags built into it because the DIVC of the surveyed SMEs changes through time, and this could well have an effect on digital innovation and business performance.

Thirdly, the limitation of this analysis is qualitative information for business performance. This study intended to use qualitative information to predict SMEs' business performance because of firms' barriers to obtaining origital data. However, individual information is widely used in strategic innovation research.

Finally, the present study examined the effects between ADT, heterogeneous networks, digital innovation and business performance, but the mediation or moderation are also essential. Therefore, it would be useful to study the mediation between variables or other factors that moderate the relationship beween variables; for example, the external environment is an important factor in moderating the relationships, especially in China. This can be seen in recent years by the Chinese government's encouragement of firms to perform digital innovation by enacting several policies such as tax deductions for technological SMEs, or increasing the number of incubators in order to attract many SMEs at a reduced business cost. Thus, government policy may be regarded as a vital factor.

## 0.3.2 Scope for the future research

The results of this study offer many avenues for future research. It is hoped that, besides its limatations, the results of this research will indicate the scope for future research. With regard to the objectivity of the data, the primary indication for future research is to consider a different methodological approach to that used above, and this may require the use of more quantitative data to obtain a more nuanced measurement of digital innovation and business performance.

Secondly, two potential fields for the follow-up research emerge in order to solve the problem of data lags as mentioned in the limitations. One is the development of panel data based on repeated surveys of a targeted population. This will help to understand the process better. The other is longitudinal case studies which may be considered as a complementary methodology since this approach would provide much more detailed information on how changes in the DIVC impact on business performance, and may shed further light on which parts of the DIVC are most subject to alteration.

Thirdly, the usage of longitudinal data and/or case studies is able to further explore the links between digital innovation and business performance for SMEs. The results discussed above appear to support the view that, at least for digital SMEs, digital innovation is directly linked to business performance in the process. However, relatively little is known about the specific situations under which digital innovation is working, or the exact nature of digital innovation. For example, is digital service innovation considered only when the resources of SMEs are scarce, or do more external factors influence digital innovation. If so, what are these factors? A detailed understanding of the factors cluster cannot be gained from the Likert scales survey.

Fourthly, future studies should discuss the mediation between ADT, heterogeneous networks, digital innovation and business performance. Research could thus indicate whether, and to what extent, Heterogeneous networks and digital innovation mediate the ADT and SMEs' business performance among the activities of DIVC. Besides, future research is also recommended to consider exploring the moderation by external environmental factors such as government policy, competitor pressure, and the industrial environment. These factors have an increasingly important practical impact on business development. Future studies should thus provide more in-depth insights into how different variables are connected in the improvement of SME's business performance.

The last direction in which more research is needed is in terms of country studies. All the research on SMEs and the DIVC derives from China. It would be very interesting to compare the results of the present study with those from countries with quite different institutional and cultural contexts, especially those in which networks are more different from the Chinese environment of much management research. This would allow a clearer indication of the extent to which the shape and nature of DIVC in different countries are culturally and institutionally determined.

# Bibliography

Altman, E. J., Nagle, F., Tushman, M. (2015). Innovating without information constraints: Organizations, communities, and innovation when information costs approach zero. The Oxford Handbook of Creativity, Innovation, and Entrepreneurship. Oxford University Press, New York, USA.

Anwar, M. (2018). Business model innovation and SMEs performance—Does competitive advantage mediate?. International Journal of Innovation Management, 22(07), 18500571-185005731.

Anderson, J. C., Gerbing, D. W. (1988). Structural equation modeling in practice: a review and recommended two-step approach. Psychological Bulletin, 103(3), 411-423.

Arbuckle, J.L., Wothke, W. (1999), Amos 4.0 User's Guide. Small Waters Corporation, Chicago, USA.

Armstrong, J., Overton, T. (1977). Estimating nonresponse bias in mail surveys. Journal of Marketing Research, 14(7), 396-402.

Avenier, M. J., Gavard-Perret, M. L., Gavard-Perret, D., Gotteland, C., Haon., A., Jolibert. (2008). Inscrire son projet de recherche dans un cadre epistemologique. Methodologie de la recherche:Reussir son memoire ou sa these en sciences de gestion. Paris: Pearson Education: XVI- 383.

Avenier, M. J., Thomas, C. (2011). Mixer quali et quanti pour quoi faire? Méthodologie sans épistémologie n'est que ruine de réflexion. l'Atelier Méthodologie de Recherche de l'AIMS. Les approches mixtes: combiner quantitatif et qualitatif, 31 mars 2011, Caen, France.

Avital, M., Te'Eni, D. (2009). From generative fit to generative capacity: exploring an emerging dimension of information systems design and task performance. Information Systems Journal, 19(4), 345-367.

Avlonitis, G. J., Papastathopoulou, P. (2001). The development activities of innovative and non-innovative new retail financial products: implications for success. Journal of Marketing Management, 17(7-8), 705-738.

Banbury, C. M., Mitchell, W. (1995). The effect of introducing important incremental innovations on market share and business survival. Strategic Management Journal, 16(S1), 161-182.

Barras, R. (1990). Interactive innovation in financial and business services: the vanguard of the service revolution. Research Policy, 19(3), 215-237.

Baker W. E., Faulkner, R. R. (2002). Interorganizational networks. In: Baum JAC (ed) The Blackwell companion to organizations. Blackwell, Malden, MA.

Barrett, M., Davidson, E., Prabhu, J., Vargo, S. L. (2015). Service innovation in the digital age: key contributions and future directions. MIS quarterly, 39(1), 135-154.

Beamish, P. W., Lupton, N. C. (2009). Managing joint ventures. The Academy of Management Perspectives, 23(2), 75-94.

Benkler, Y. (2006). The wealth of networks: How social production transforms markets and freedom. Yale University Press, London, UK.

Benner, M. J., Tushman, M. L. (2015). Reflections on the 2013 decade award-"exploitation, exploration, and process management: the productivity dilemma revisited" ten years later. The Academy of Management Review, 40(4), 497-514.

Berry, L. L., Shankar, V., Parish, J. T., Cadwallader, S., Dotzel, T. (2006). Creating new markets through service innovation. MIT Sloan Management Review, 47(2), 56-63.

Berchicci, L. (2013). Towards an open R&D system: internal R&D investment, external knowledge acquisition and innovative performance. Research Policy, 42(1), 117-127.

Bharadwaj, A. S. (2000). A resource-based perspective on information technology capability and firm performance: an empirical investigation. MIS Quarterly, 24 (1), 169-196.

Bharadwaj, A., Sawy, O. A. E., Pavlou, P. A., Venkatraman, N. (2013). Digital business strategy: toward a next generation of insights. MIS Quarterly, 37(2), 471-482.

Bhaskar, R. (1986). The possibility of naturalism: A philosophical critique of the contemporary human science. London and Network: Routledge.

Bouwman, H., Nikou, S., de Reuver, M. (2019). Digitalization, business models, and SMEs: How do business model innovation practices improve performance of digitalizing SMEs?. Telecommunications Policy, 43(9), 101828.

Bollen, K.A., Long, J.S. [Eds.] (1993), Testing Structural Equation Models. Newbury Park, CA: Sage.

Boland Jr., R. J., Lyytinen, K., Yoo, Y. (2007). Wakes of Innovation in Project Networks: The Case of Digital 3-D Representations in Architecture, Engineering, and Construction. Organization Science, 18(4), 631-647.

Bornkessel, S., Bröring, S., Omta, O. S. (2014). Analyzing indicators of industry convergence in four probiotics innovation value chains. Cognitive Neurodynamics, 5(4), 361-71.

Bowen, F., Rostami, M. and Steel, P. (2010). Timing is everything: a meta-analysis of the relationships between organizational performance and innovation. Journal of Business Research, 63 (11), 1179-1185.

Boudreau, K. J., Lakhani, K. R. (2013). Using the crowd as an innovation partner. Harvard Business Review, 91(4), 60-9, 140.

Borgatti, S.P. Halgin, D.S. (2011). On Network Theory. Organization Science, 22(5), 1168-1181.

Brass, D. J., Galaskiewicz, J., Greve, H. R., Tsai, W. (2004). Taking stock of networks and organizations: A multilevel perspective. Academy of Management Journal, 47(6), 795-817.

Breivik, E., Olsson, U. H. (2001) Structural equation modeling: Present and future: A Festschrift in honour of Karl Jöreskog. Chicago, IL: Scientific Software International.

Brege, S., Stehn, L., Nord, T. (2014). Business models in industrialized building of multi-storey houses. Construction Management and Economics, 32(1-2), 208-226.

Bresnahan, T., Greenstein, S. (2014). Mobile computing: the next platform rivalry. The American Economic Review, 104(5), 475-480.

Browne, M. W., Cudeck, R. (1993). Alternative ways of assessing model fit' in Bollen, K. A. and Long, J. S. [Eds.]. Testing structural equation models. Newbury Park, CA: Sage.

Brown, T. A. (2006). Confirmatory factor analysis for applied research. New York: Guilford Publications.

Brynjolfsson, E., Saunders, A. (2009). Wired for innovation: How information technology is reshaping the economy. The MIT Press.

Byrne, B.M. (2001), Structural equation modeling with Amos-Basic Concepts, Applications, and Programming. Mahwah, N.J.: Erlbaum.

Bunge, M. (1993). Realism and antirealism in social science. Theory & Decision, 35(3), 207-235.

Burt, R. S., Celotto, N. (1992). Network structure of management roles in a large matrix firm. Evaluation & Program Planning, 15(3), 303-326.

Burt, R. (2001) Structural holes versus network closure as social capital. In: Lin, N., Cook, K.S. and Burt, R.S., Eds., Social Capital: Theory and Research, Aldine de Gruyter.

Carroll, N., Whelan, E., Richardson, I. (2010). Applying social network analysis to discover service innovation within agile service networks. Service Science, 2(4), 225-244.

Camison, C., Lopez, A. V. (2010). An examination of the relationshio between manufacturing flexibility and firm performance: the mediating role of innovation. International Journal of Operations and Production Management, 30 (8), 853-878.

Campbell, D. T., Fiske, D. W. (1959). Convergent and discriminant validation by the multitrait-multimethod matrix. Psychological Bulletin, 56(2), 81-105.

Cainelli, G., Evangelista, R. and Savona, M. (2004). The impact of innovation on economic performance in services. Service Industry Journal, 24 (1), 116-130.

Ceccagnoli, M., Forman, C., Huang, P., Wu, D. J.(2012). Cocreation of value in a platform ecosystem: the case of enterprise software. MIS Quarterly, 36(1), 263-290.

Chetty, S., Patterson, A. (2002). Developing internationalization capability through industry groups: the experience of a telecommunications joint action group. Journal of Strategic Marketing, 10(1), 69-89.

Chandler, J. D., Vargo, S. L. (2011). Contextualization and value-in-context: How context frames exchange. Marketing Theory, 11(1), 35-49.

Chesbrough, H., Rosenbloom, R. S. (2002). The role of thebusiness model in capturing value from innovation: evidence from XeroxCorporation's technology spin-offcompanies. Industrial and Corporate Change, 11(3), 529-555.

Cortright, J., Mayer, H. (2001). High tech specialization: a comparison of high technology centers. Washington, DC: Brookings Institution, Center on Urban and Metropolitan Policy.

Cook, K. S., Yamagishi, T. (1992). Power in exchange networks: a power-dependence formulation. Social Networks, 14(3), 245-265.

Coombes, P. H., Nicholson, J. D. (2013). Business models and their relationship with marketing: asystematic literature review. Industrial Marketing Management, 42(5), 656-664.

Convergenomics, collaboration, and co-creation for organizational values. Management Decision, 50 (5), 817-831.

Crépon, B., Duguet, E., Mairesse, J., (1998). Research, innovation and productivity: An econometric analysis at the firm level. Economics of Innovation and New Technology, 7(2), 115-158.

Cui, A. S., Wu, F. (2016). Utilizing customer knowledge in innovation: antecedents and impact of customer involvement on new product performance. Journal of the Academy of Marketing Science, 44(4), 516-538.

Doganova, L., Eyque, M., Renault, M. (2009). What do business models do?: Innovation devices in technology entrepreneurship. Research Policy, 38(10), 1559-1570.

Damanpour, F.(1991). Organizational innovation: a meta-analysis of effects of determinants and moderators. Academy of Management Journal, 34 (3), 555-590.

DeSanctis, G., Snyder J., Poole M. S. (1994). The meaning of the interface: a functional and holistic evaluation of a meeting software system. Decision Support Systems, 11(4), 319-335.

Den Hertog, P. (2000). Knowledge-intensive business services as co-producers of innovation. International Journal of Innovation Management, 4(4), 491-528.

Diamantopoulos, A., Siguaw, J. A. (2006). Formative versus reflective indicators in organizational measure development: a comparison and empirical illustration, British Journal of Management, 17 (4), 363-282.

Dougherty, D., Dunne, D. D. (2012). Digital science and knowledge boundaries in complex innovation. Organization Science, 23(5), 1467-1484.

Doran, J., O'Leary , E., (2011). External interaction, innovation and productivity: An application of the innovation value chain to Ireland. Spatial Economic Analysis 6 (2), 200-222.

Edquist, C., Johnson, B. (1997) Institutions and Organizations in Systems of Innovation, in: Edquist,C. (ed) Systems of Innovation. London: Pinter.

Ellis, P.D. (2000). Social ties and foreign market entry. Journal of International Business Studies, 31(3), 443-469.

Ellis, P.D. (2000). Social ties and international entrepreneurship: opportunities and constraints affecting firm internationalization. Journal of International Business Studies, 42(1), 99-127.

Ekbia, H. R. (2009). Digital artifacts as quasi-objects: qualification, mediation, and materiality. Journal of the American Society for Information Science & Technology, 60(12), 2554-2566.

Ettlie, J. E., Bridges, W.P., O'keefe, R.D. (1984). Organization strategy and structural differences for radical versus incremental innovation. Management Science, 30 (6), 682-695.

Evangelista, R., Vezzani, A. (2010). The economic impact of technological and organizational innovations. A firm-level analysis. Research Policy, 39 (10), 1253-1263.

Evrard, Y., Bernard, R. E., Choffray, J. M. (1997). Market: études et recherches en marketing - fondements, méthodes. Economics papers from University Paris Dauphine, 25(3), 216-233.

Faulkner, P., Runde, J. (2013). Technological objects, social positions, and the transformational model of social activity. MIS Quarterly, 37(3), 803-818.

Farrell, J., Weiser, P. J. (2003). Modularity, vertical integration, and open access policies: towards a convergence of antitrust and regulation in the internet age. Competition Policy Center Working Paper, 17(303007), 47-55.

Fitzgerald, L. F., Drasgow, F., Hulin, C. L., Gelfand, M. J., Magley, V. J. (1997). Antecedents and consequences of sexual harassment in organizations: a test of an integrated model. Journal of Applied Psychology, 82(4), 578-589.

Fitzgerald, M., Kruschwitz, N., Bonnet, D., Welch, M. (2014). Embracing digital technology: A new strategic imperative. MIT Sloan Management Review, 55(2), 1-5.

Formell, C., Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error, Journal of Marketing Research, 18(1), 39-50.

Fichman, R. G., Dos Santos, B. L., Zheng, Z. E. (2014). Digital innovation as a fundamental and powerful concept in the information systems curriculum. MIS Quarterly, 38(2), 329-353.

Flyverbom M, Leonardi P, Stohl C., Stohl, M. (2016). Digital age| the management of visibilities in the digital age—introduction. International Journal of Communication, 10(12),98-109.

Freeman, C. (1991). Networks of Innovators A Synthesis of Research Issues. Research Policy, 20(5), 499-514.

Freeman, S., Edwards, R., Schroder, B. (2006). How smaller born-global firms use networks and alliances to overcome constraints to rapid internationalization. Journal of International Marketing, 14 (3), 33-63.

Frenken, K.(2000). A complexity approach to innovation networks. the case of the aircraft industry (1909-1997). Research Policy, 29(2), 257-272.

Gao, L. S., Iyer, B. (2006). Analyzing complementarities using software stacks for software industry acquisitions. Journal of Management Information Systems. 23(2), 119-147.

Gavard-Perret, M. L., Gotteland, D., Haon, C., Jolibert, A. (2012). Méthodologie de la recherche en sciences de gestion. Réussir son mémoire ou sa thèse, 11-62.

Garson, G. D. (2013). Path analysis. Asheboro: Statistical Associates Publishing.

Gallouj, F. (2002). Innovation in the Service Economy: The New Wealth of Nations, Northhampton, MA: Edward Elgar Publishing, Inc.

Ganotakis, P., Love, J. H. (2012). The innovation value chain in new technology‐based firms: Evidence from the UK. Journal of Product Innovation Management, 29(5), 839-860.

Ganotakis, P. (2012). Founders' human capital and the performance of UK new technology based firms. Small Business Economics, 39(2), 495-515.

Gawer, A., Cusumano, M. A. (2014). Industry platforms and ecosystem innovation. Journal of Product Innovation Management, 31(3), 417-433.

Ge, G. L., Wang, H. Q. (2013). The impact of network relationships on internationalization process: An empirical study of Chinese private enterprises. Asia Pacific Journal of Management, 30(4), 1169-1189.

Gertler, M. (2010). Rules of the game: the place of institutions. Journal of Small Business and Enterprise Development, 20(2), 279-295.

Granovetter, M. S. (1973). The strength of weak ties. American Journal of Sociology, 78(6), 1360-1380.

Griffith, R., Harrison, R., Van Reenen, J. (2006). How Special Is the Special Relationship? Using the Impact of U.S. R&D Spillovers on U.K. Firms as a Test of Technology Sourcing. American Economic Review, 96(5), 1859-1875.

Grinstein, A., Goldman, A. (2006). Characterizing the technology firm: an exploratory study. Research Policy, 35(1), 121-143.

Guan, J., Chen, K. (2010). Modeling macro-R&D production frontier performance: an application to Chinese province-level R&D. Entometrics, 82(1), 165-173.

Gulati, R. (1999). Network location and learning: The influence of network resources and firm capabilities on alliance formation. Strategic Management Journal, 20(5), 397-420.

Gulati, R., Nohria, N., Zaheer, A. (2000). Strategic networks. Strategic Management Journal, 21(3), 203-215.

Gupta, A.K., Smith, K.G., Shalley, C.E. (2006). The interplay between exploration and exploitation. Academy of Management Journal, 49 (4), 693-706.

Harman, H. (1976), Modern Factor Analysis. 3rd ed. Chicago: University of Chicago Press.

Hair, J., Anderson, R., Babir, B., Tatham, R., Black, W. (2006), Multivariate Data Analysis. 6th ed. Upper Saddle River, New Jersey: Pearson Education.

Hanseth, O., Lyytinen, K. (2010). Design theory for dynamic complexity in information infrastructures: the case of building internet. Journal of Information Technology, 25(1), 1-19.

Harris S, Wheeler C. (2005), Entrepreneurs' relationships for internationalization: functions, origins and strategies, International Business Review, 14(2), 187-207.

Hassan, M., Shaukat, S., Nawaz, M., Naz, S. (2013). Effects of innovation types on firm performance: an empirical study on Pakistan's manufacturing sector. Pakistan Journal of Commerce and Social Sciences, 7(2), 243-262.

Han, K., Oh, W., Im, K. S., Chang, R. M., Oh, H., Pinsonneault, A. (2012). Value cocreation and wealth spillover in open innovation alliances. MIS Quarterly, 36(1), 291-315.

Hansen, M., Birkinshaw. J. M. (2007). The Innovation Value Chain. Harvard Business Review, July, 85(6), 121-135.

Herstad, S. J., Aslesen, H. W., Ebersberger, B. (2014). On industrial knowledge bases, commercial opportunities and global innovation network linkages. Research Policy, 43(3), 495-504.

Henseler, J., Ringle, C. M., Sinkovics, R. R. (2009) The use of partial least squares path modeling in international marketing. Bingley, UK: Emerald Group Publishing Limited.

Henfridsson, O., Mathiassen, L., Svahn, F. (2014). Managing technological change in the digital age: the role of architectural frames. Journal of Information Technology, 29(1), 27-43.

Hite, J.M., Hesterly, W.S. (2001). The evolution of firm networks: from emergence to early growth of the firm. Strategic Management Journal, 22(3), 275-286.

Holmström, J., Stalder, F. (2001). Drifting technologies and multi-purpose networks: the case of the swedish cashcard. Information & Organization, 11(3), 187-206.

Hinings, B., Gegenhuber, T., Greenwood, R. (2018). Digital innovation and transformation: an institutional perspective. Information and organization, 28(1), 52-61.

Hutchinson, K., Quinn, B. and Alexande, N. (2006). SME retailer internationalization: case study evidence from British retailers. International Marketing Review, 23(1), 25-53.

Hunt, S. D. (1991). Positivism and paradigm dominance in consumer research: toward critical pluralism and rapprochement. Journal of Consumer Research, 18(1), 32-44.

Igalens, J., Neveu, J. P., Rojot, J., Roussel, P., Wacheux, F. (2005). Conclusion: ouvertures épistémologiques. Management des Ressources Humaines: Méthodes de recherche en sciences humaines et sociales, 405-428.

Ivan, Arribas., Penelope, HernXandez., Jose, E. Vila. (2013). Guanxi, performance and innovation in entrepreneurial service projects. Management Decision, 51(1-2), 173-183.

Koch, T., Windsperger, J. (2017). Seeing through the network: Competitive advantage in the digital economy. Journal of Organization Design, 6(1), 1-30.

Janssens, W., De Pelsmacker, P., Wijnen, K., Van Kenhove, P. (2008). Marketing research with SPSS. New Jersey: Pearson Education.

Jin, B., Jung, S. (2016). Toward a deeper understanding of the roles of personal and business networks and market knowledge in SMEs' international performance. Journal of Small Business and Enterprise Development, 23(3), 812-830.

Johnson, M. (2010). Seizing the White Space: Business ModelInnovation for Growth and Renewal. Boston: Harvard Business School Press.

Hall, J. K., Martin, M. J. C. (2005). Disruptive technologies, stakeholders and the innovation value-added chain: a framework for evaluating radical technology development. R& D Management, 35(3), 273-284.

Hsu, C. (2011). Hyper-networking of customers, providers, and resources drives new service business designs: E-commerce and beyond. Service Science, 3(4), 325-337.

Kallinikos, J., Aaltonen, A., Marton, A. (2013). The Ambivalent Ontology of Digital Artifacts. MIS Quarterly, 37(2), 357-370.

Kafetzopoulos, D., Psomas, E. (2015). The impact of innovation capability on the performance of manufacturing companies. Journal of Manufacturing Technology Management, 26 (1), 104-130.

Kaplan, R. S., Norton, D. P. (1996). Linking the balanced scorecard to strategy. California Management Review, 39(1), 53-79.

Kerin, R. A., Varadarajan, P. R., Peterson, R. A. (1992). First-mover advantage: A synthesis, conceptual framework, and research propositions. Journal of Marketing, 56(4), 33-5.

Kilduff, M., Brass, D. J. (2010). Organizational social network research: core ideas and key debates. Academy of Management Annals, 4(1), 317-357.

Koufteros, X. A. (1999), Testing a model of pull production: a paradigm for manufacturing research using structural equation modeling. Journal of Operations Management, 17(4), 467-488.

Knoke, D. (2008). Networks and Organizations. The Blackwell Companion to Sociology. John Wiley & Sons, Ltd.

Kuhn, T. S. (1962). IX. The Nature and Necessity of Scientific Revolutions.

Kuhn, T. S. (1963). The function of Dogma in Scientific Research in A. C. Crombie (ed), Scientific Change. New York: Basic Books.

Kline, R. B. (1998). Software review: Software programs for structural equation modeling: Amos, EQS, and LISREL. Journal of Psychoeducational Assessment, 16(4), 343-364.

Kline, S. J., Rosenberg, N. (1986). An Overview of Innovation. The positive sum strategy. Harnessing technology for economic growth.

Kristal, M. M., Huang, X., Roth, A. V. (2010). The effect of an ambidextrous supply chain strategy on combinative competitive capabilities and business performance. Journal of Operations Management, 28(5), 415-429.

Lai, Y. L., Hsu, M. S., Lin, F. J., Chen, Y. M., Lin, Y. H. (2014). The effects of industry cluster knowledge management on innovation performance. Journal of Business Research, 67(5), 734-739.

Lakhani, K. R. , Hila, L. A. , Michael, T. (2012). Open innovation and organizational boundaries: the impact of task decomposition and knowledge distribution on the locus of innovation. Working paper, no. 12-057, Harvard Business School, Boston, USA.

Iansiti, M., Lakhani, K. R. (2014). Digital ubiquity: how connections, sensors, and data are revolutionizing business. Harvard Business Review, 92(11), 72-88.

Langlois, R. N. (2002). Modularity in technology and organization. Journal of Economic Behavior & Organization, 49(1), 0-37.

Lee, S. M., Olson, D. L., Trimi, S. (2012). Co-innovation: convergenomics, collaboration, and co-creation for organizational values. Management Decision, 50(5), 817-831.

Leonardi, P. M., Barley, S. R. (2008). Materiality and change: Challenges to building better theory about technology and organizing. Information and Organization, 18(3), 159-176.

Liao, Y., Barnes, J. (2015). Knowledge acquisition and product innovation flexibility in SMEs. Business Process Management Journal, 21(6), 1257-1278.

Loane, S., Bell, J. (2006). Rapid internationalisation among entrepreneurial firms in Australia, Canada, Ireland and New Zealand: an extension to the network approach. International Marketing Review, 23(5), 467-485.

Lööf, H., Heshmati, A., (2006). On the relationship between innovation and performance: a sensitivity analysis, Economics of Innovation and New Technology, 15(4), 317-344.

Love, J.H., Roper, S. (2002). Internal versus External R&D: A Study of R&D Choice with Sample Selection. International Journal of the Economics of Business, 9(2), 239-256.

Love, J.H., Roper, S. (2009): Organizing the innovation process: complementarities in innovation networking. Industry and Innovation, 16(3), 273-290.

Luo, M., Li, H. L. (2015). Business model innovation in the digitized era: From the perspective of value creation. China Industrial Economics, 57 (1), 95-107.

Lusch, R. F., Vargo, S. L. (2014). Service-dominant logic: Premises, perspectives, possibilities. Cambridge: Cambridge University Press.

Lusch, R. F., Nambisan, S. (2016). Service innovation: A service-dominant logic perspective. MIS Quarterly, 39(1), 155-175.

Lucas, H. C., Goh, J. M. (2009). Disruptive technology: how Kodak missed the digital photography revolution. Journal of Strategic Information Systems, 18(1), 46-55.

Lyytinen K, Yoo Y, Boland Jr R.J. (2016). Digital product innovation within four classes of innovation networks. Information Systems Journal, 26(1), 47-75.

Mason, K., Spring, M. (2011). The sites and practices of business models. Industrial Marketing Management, 40(6), 1032-1041.

Manolova, T.S., Manev, I.M. and Gyoshev, B.S. (2010). In good company: the role of personal and inter-firm networks for new-venture internationalization in a transition economy. Journal of World business, 45(3), 257-265.

Majchrzak, A., Malhotra, A. (2013). Towards an information systems perspective and research agenda on crowdsourcing for innovation. Journal of Strategic Information Systems, 22(4), 257-268.

Martinet, A. C. (1990). Epistémologie de la stratégie. In A. C. Martinet (Ed.), Epistémologies et sciences de gestion: Economica.

Magretta, J. (2002). Why Business Models Matter. Harvard Business Review, 80(5), 86-92.

Mckenna, W., F. (1985). Measuring customer preferences for load management service options. IEEE Power Engineering Review, 5(9), 2306-2314.

Mentzer, J. T., Flint, D.J., Kent, J.L. (1999). Developing a logistics service quality scale. Journal of Business, 20(1), 9-32.

Miles, I. (2008). Patterns of innovation in service industries. IBM Systems Journal, 47(1), 115-128.

Merali, Y., Papadopoulos, T., Nadkarni, T. (2012). Information systems strategy: Past, present, future?. The Journal of Strategic Information Systems, 21(2), 125-153.

Metters, R., Marucheck, A. (2007). Service management academic issues and scholarly reflections from operations management researchers. Decision Sciences, 38(2), 195-214.

Mitrega, M., Forkmann, S., Zaefarian, G., Henneberg, S. C. (2017). Networking capability in supplier relationships and its impact on product innovation and firm performance. International Journal of Operations & Production Management, 37 (5), 577-606.

Moilanen, M., Østbye, S., Woll, K. (2014). Non-R&D SMEs: external knowledge, absorptive capacity and product innovation. Small Business Economy, 43(1), 447-462.

Morris, M., Schindehutte, M., Allen, J. (2005). The entrepreneur’s businessmodel: toward a unified perspective. Journal of Business Research, 58(6), 726-735.

Mowery, D. C., Teece, D. J. (1996). Strategic alliances and industrial research. World Scientific book chapters, 315-333.

Nambisan, S. (2017). Digital entrepreneurship: Toward a digital technology perspective of entrepreneurship. Entrepreneurship Theory and Practice, 41(6), 1029-1055.

Nambisan, S., Lyytinen, K., Majchrzak, A., Song, M. (2017). Digital innovation management: reinventing innovation management research in a digital world. MIS Quarterly, 41(1), 223-238.

Nazarenko, K. (2011). Innovation-investment activity as component of competitiveness of enterprise. Journal of Hepatology, 21(4), 646-655.

Nevitt, J., Hancock, G. R. (2001). Performance of bootstrapping approaches to model test statistics and parameter standard error estimation in structural equation modeling. Structural Equation Modeling, 8(3), 353-377.

Nijssen, E. J., Hillebrand, B., Vermeulen, P. A. M., Kemp, R. G. M. (2006). Exploring product and service innovation similarities and differences. International Journal of Research in Marketing, 23(3), 241-251.

Nunnally, J. C., Bernstein, I. H. (1994) Psychometric Theory. New York: Tata McGraw-Hill Education.

Normann, D. (2001). On choosing the correct model for computability over the reals. Normat 49 (3), 97-104.

Nooteboom, B. (1999). Innovation and inter-firm linkages: new implications for policy. Research Policy, 28(8), 793-805.

Nwankpa, J., Roumani, Y., Roumani, Y. F. (2016). Exploring ERP-enabled adoption: a real options perspective. Communications of the Association for Information Systems, 39(1), 529-555.

Nylén D, Holmström J. (2015). Digital innovation strategy: A framework for diagnosing and improving digital product and service innovation. Business Horizons, 58(1), 57-67.

Odlyzko, A. (2001). Internet pricing in light of the history of communications. Scalability and Traffic Control in IP Networks, 45(26), 237-243.

Oke, A., Burke, G., Myers, A. (2007). Innovation types and performance in growing UK SMEs. International Journal of Operations & Production Management, 27(7), 735-753.

Oliveira, P., Von Hippel, E. (2011). Users as service innovators: The case of banking services. Research Policy, 40(6), 806-818.

Olson, E. L. (2013). Perspective: the green innovation value chain: a tool for evaluating the diffusion prospects of green products. Journal of Product Innovation Management, 30(4), 782-793.

Ou, C., Liu, F., Hung, Y., Yen, D (2010). A structural model of supply chain management on firm performance. International Journal of Operations and Production Management, 30 (5), 26-545.

Ordanini, A., Rubera, G. (2010). How does the application of an IT service innovation affect firm performance? A theoretical framework and empirical analysis on e-commerce. Information & Management, 47(1), 60-67.

Orlikowski, W. J. (2000). Using technology and constituting structures: a practice lens for studying technology in organizations. Organization Science, 11(4), 404-428.

Orton, D. J., Weick, K. E. (1990). Loosely coupled systems: a reconceptualizan. Academy of Management Review, 15(2), 203-223.

O'Reilly, C.A., Tushman, M. (2008). Ambidexterity as a Dynamic Capability: Resolving the Innovator's Dilemma. Research in Organizational Behavior, 28(1), 185-206.

Orlikowski, W. Iacono, S. (2001). Research commentary: Desperately seeking the "IT" in IT research−A call to theorizing the IT artifact. Information Systems Research, 12(2), 121-134.

Osterwdlder A. (2004). The business model ontology-a proposition in a design science approach. Switzerland: Doctoral Thesis, University of Lausanne.

Pavlou, P. A., Sawy, O. A. E. (2006). From it leveraging competence to competitive advantage in turbulent environments: the case of new product development. Information Systems Research, 17(3), 198-227.

Peter, J. P. (1979), "Reliability: a review of psychometric basics and recent marketing practices", Journal of Marketing Research, 16(1), 6-17.

Perret, V., Seville M. (2007), Fondements épistémologiques de la recherche, in R.A. Thietart, Dunod: Recherche en management.

Piaget, J. (1967). Logique et connaissance scientifique. Gallimard, Paris: Éncyclopédie de la Pléiade.

Pittaway, L., Robertson, M., Munir, K., Denyer, D., and Neely, A., 2004. Networking and innovation: A systematic review of the evidence. International Journal of Management Reviews 5 (3/4), 137–68.

Podsakoff, P. M., Organ, D. W. (1986). Self-report in organizational research. Journal of Management, 12(4), 531-544.

Podolny, J. M. (2001). Networks as the pipes and prisms of the market. American Journal of Sociology, 107(1), 33-60.

Popper, K. R. (1963). Conjectures and Refutations. London: Routledge.

Porter, M. E., Millar, V. E. (1985). How information gives you competitive advantage. Harvard Business Review, 63(4),149-160.

Porter, M. E., Heppelmann, J. E. (2014). How smart, connected products are transforming competition. Harvard Business Review, 92(11), 64-88.

Powell, W. W. (1990). Neither market nor hierarchy: network forms of organization. Research in Organizational Behavior, 12(6), 295-336.

Podolny, J. M. (2001). Networks as the pipes and prisms of the market. American Journal of Sociology, 107(1), 33-60.

Pralahad, C.K., Hamel, G. (1990). The Core Competence of the Corporations. Harvard Business Review, 68(5-6), 81–91.

Preffer, J., Salancik, G. R. 1978. The external control of organizations: A resources dependence perspective, New York: Harper & Row.

Rosenzweig, E. D., Roth, A. V., Dean Jr, J. W. (2003). The influence of an integration strategy on competitive capabilities and business performance: an exploratory study of consumer products manufacturers. Journal of Operations Management, 21(4), 437-456.

Roberts, N., Grover, V. (2012). Leveraging information technology infrastructure to facilitate a firm's customer agility and competitive activity: An empirical investigation. Journal of Management Information Systems, 28(4), 231-270.

Robbins, P., O'Gorman, C., (2016). Innovation processes: do they help or hinder new product development outcomes in Irish SMEs? Irish Journal of Management 35(1), 88-103.

Roper, S. (2001). Innovation, networks and plant location: some evidence for Ireland. Regional Studies, 35(3), 215-228.

Roper, S., Du, J., Love, J. H. (2008). Modelling the innovation value chain. Research Policy, 37 (6-7), 961-977.

Roper, S., Arvanitis, S. (2012). From knowledge to added value: a comparative, panel-data analysis of the innovation value chain in Irish and Swiss manufacturing firms. Research Policy, 41(6), 0-1106.

Roth, A. V., Miller, J. G., Huang, X., Kristal, M. M. (2008). Handbook of Multi-item Scales for Research in Operations Management. Sage Publications, Thousand Oaks, CA.

Sawy, O. A. E., Pereira, F. (2013). Digital business models: review and synthesis. Business Modelling in the Dynamic Digital Space, 13-20.

Saunila, M., Pekkola, S., Ukko, J. (2014). The relationship between innovation capability and performance. International Journal of Productivity and Performance Management, 63 (2), 234-249.

Santos, F. M., Eisenhardt, K. M. (2009). Constructing markets and shaping boundaries: Entrepreneurial power in nascent fields. Academy of Management Journal, 52(4), 643-671.

Schumpeter, J. A. (1934). The theory of economic development. Boston: Harvard University Press.

Selander, L., Henfridsson, O., Svahn, F. (2013). Capability search and redeem across digital ecosystems. Journal of Information Technology, 28(3), 183-197.

Sharma, S. (1995), Applied multivariate techniques, John Wiley & Sons, Inc., Hoboken, NJ.

Sheehan, J. (2006). Understanding service sector innovation. Communications of the ACM, 49(7), 42.

Sivasubramaniam, N., Liebowitz, S. J., Lackman, C. L. (2012). Determinants of new product development team performance: a meta-analytic review. Journal of Product Innovation Management, 29(5), 803-820.

Simonh, A. (1996). The sciences of the artificial. Boston: MIT press.

Smith, K. (2000). Innovation as a systemic phenomenon: rethinking the role of policy. Enterprise and Innovation Management Studies, 1(1), 73-102.

Smith, J. M., Halgin, D. S. , Kidwell-Lopez, V. , Labianca, G., Brass, D. J., Borgatti, S. P. (2014). Power in politically charged networks. Social Networks, 36(1), 162-176.

Spithoven, A., Clarysse, B., Knockaert, M. (2010). Building absorptive capacity to organise inbound open innovation in traditional industries. Technovation, 30(2), 0-141.

Snow, C. C., Fjeldstad, Ø. D. (2015). Network paradigm: Applications in organizational science.In:Wright M(ed) International Encyclopedia of the Social & Behavioral Sciences, 16(2), 546-550.

Son, I., Lee, D., Lee, J. N., Chang, Y. B. (2011). Understanding The Impact Of IT Service Innovation On Firm Performance: The Case Of Cloud Computing. Pacific Asia Conference on Information Systems. 7-11 July, 2011. Brisbane, Australia.

Sorescu, A., Frambach, R. T., Singh, J., Rangaswamy, A., Bridges, C. (2011). Innovations in retail business models. Journal of Retailing, 87(July), 3-16.

Sosa, M. E., Eppinger, S. D., & Rowles, C. M. (2004). The misalignment of product architecture and organizational structure in complex product development. Management science, 50(12), 1674-1689.

Sundbo, J. (1998). The theory of innovation: entrepreneurs, technology and strategy. Economist, 148(2), 114-115.

Swanson, Burton, E. (1994). Information systems innovation among organizations. Management Science, 40(9), 1069-1092.

Svahn, F., Henfridsson, O. (2012). The dual regimes of digital innovation management, 45th Hawaii International Conference of System and Science. HICSS, 3347-3356.

Tacq, J. (1997), Multivariate Analysis Techniques in Social Science Research: From Problem to Analysis. London: Sage Publications.

Tan, K., Kannan, V., Narasimhan, R. (2007). The impact of operations capability on firm performance. International Journal of Production Research, 45 (21), 5135-5156.

Tilson, D., Lyytinen, K., Sørensen, C. (2010). Research commentary—Digital infrastructures: The missing IS research agenda. Information Systems Research, 21(4), 748-759.

Tiwana, A., Konsynski, B., Bush, A. A. (2010). Research commentary—Platform evolution: Coevolution of platform architecture, governance, and environmental dynamics. Information systems research, 21(4), 675-687.

Thiesse, F., Staake, T., Schmitt, P., Fleisch, E. (2011). The rise of the “next-generation bar code”: an international RFID adoption study. Supply Chain Management: An International Journal, 16(5), 328-345.

Teece, D. J. (1986). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. Research Policy, 15(6), 285-305.

Turban, E., Leidner, D., McLean, E., Wetherbe, J. (2008). Information Technology for Management, (with cd). Hoboken：John Wiley & Sons.

Uzzi,B. (1996). Sources and consequences of embeddedness for the economics performance of organizations. American Sociological Review, 61(4),674-698.

Vargo, S. L., Lusch, R. F. (2008). Service-dominant logic: continuing the evolution. Journal of the Academy of Marketing Science, 36(1), 1-10.

Vargo, S. L., Maglio, P. P., Akaka, M. A. (2008). On value and value co-creation: A service systems and service logic perspective. European Management Journal, 26(3), 145-152.

Vargo, S. L., Lusch, R. F. (2011). Service-dominant logic foundations of E-novation. Chapter 1 in E-Novation for Competitive Advantage in Collaborative Globalization:

Technologies for Emerging E-Business Strategies, H. M. Pattinson and D. R. Low (eds), Hershey, PA: IGI Global.

Velu, C. (2015). Business model innovation and third-party alliance on the survival of new firms. Technovation, 35 (2015), 1-11.

Verworn, B. (2009). A structural equation model of the impact of the 'fuzzy front end' on the success of new product development. Research policy, 38(10), 1571-1581.

Von Briel, F., Davidsson, P., Recker, J. (2018). Digital technologies as external enablers of new venture creation in the IT hardware sector. Entrepreneurship Theory and Practice, 42(1), 47-69.

Ward, P. T., McCreery, J. K., Larry P. R. (1998). Competitive priorities in operation management. Journal of Operation Management, 29(4), 1035-1046.

Wellman, B. (1988). The community questions re-evaluated. In M. P. Smith (Ed.), Power, community, and the city. New Brunswick, NJ: Transaction.

Woetzel, J., Seong, J., Wang, K. W., Manyika, J., Chui, M., Wong, W. (2017). China's digital economy: A leading global force.: McKinsey Global Institute, New York, USA.

Woodard, C. J., Ramasubbu, N., Tschang, F. T., Sambamurthy, V. (2013). Design capital and design moves: the logic of digital business strategy. MIS Quarterly, 37(2), 537-564.

Wieland, H., Gartmann, N. N.,Vgrgo, S. L. (2017). Business models as service strategy. Journal of the Academic Marketing Science, 45(6): 925-943.

Wu. J.H. (2017). Future map: the business model to create artificial intelligence at the trillion-industrial level. Beijing: CITIC Press Group.

Yoo, Y., Henfridsson, O., Lyytinen, K. (2010). Research commentary—the new organizing logic of digital innovation: an agenda for information systems research. Information Systems Research, 21(4), 724-735.

Yoo, Y., Boland, Jr R. J., Lyytinen, K., Majchrzak, A. (2012). Organizing for innovation in the digitized world. Organization Science, 23(5), 1398-1408.

Zaheer, A., Gözübüyük, R., Milanov, H. (2010). It's the connections: The network perspective in interorganizational research. Academy of Management Perspectives, 24(1), 62-77.

Zittrain, J. L. (2006). The generative internet. Harvard Law Review, 119(7), 1974-2040.

Zhao, H., Hsu, C. (2007). Social ties and foreign market entry: an empirical study. Management International Review, 47(6), 815-844.

Zott, C., Amit, R. (2007). Business model design and the performance of entrepreneurial firms. Organization Science, 18(2), 181-199.

Zott, C., Amit, R., Massa, L. (2011). The business model: recent developments and future research. Journal of Management, 37(4), 1019-1042.

# Appendix: Questionnaire

**Cover Letter**

You are invited to participate in a project study conducted by Prof. Fen LYU, a doctoral student at Université Paris 1 Panthéon-Sorbonne (Paris 1). This project investigates the digital innovation value chain to discover how firms improve business performance thru developing heterogeneous networks based on digital innovation.

If you agree to be in this project as a participant in this project, please answer the survey questions. The questionnaire should take about 10 minutes to complete. The data will be processed anonymously and treated and retained for research purposes in strict confidence.

Any information that is collected relating to this project and that can be identified with you will be held confidentially. There are no known risks involved. And all the data based on your responses will be used solely for the purpose of my doctoral dissertation. If you have any questions, please do not hesitate to let me know.

Thank you so much for your contribution to this survey.

Fen LYU

Ph.D. Candidate, Université Paris 1 Panthéon-Sorbonne

École Doctorale de Management Panthéon-Sorbonne/Laboratoire PRISM Sorbonne Pôle SEE

17 Rue de la Sorbonne, Paris 75005, France

E-mail : Fen.Lv@etu.univ-paris1.fr

**Purpose of Research**

The purpose of this dissertation is to empirically investigate how digital technology makes it possible for firms to form heterogeneous networks that have an effect on digital innovation, and therefore, improve firm performance.

**Procedure**

The survey questionnaire is to be handed out to high officials of firms. Targeted respondents are those having executive titles of president, vice president, director, general manager, etc. in their respective firms. It takes approximately 20 minutes to finish the questionnaire.

**Confidentiality**

All information and data collected from respondents are anonymous. The analysis and findings will be used exclusively for academic purposes including publication in journals and presentations at academic conferences.

**Consent**

Respondents in this project are voluntary. By completing this survey, your consent to participate is implied. You should keep this page for your records.

**Part I General Information on Respondents and Firms**

**1. What is your position in your firm?**

[ ] President

[ ] Vice President

[ ] Director

[ ] General Manager

[ ] Other, please name it

**2. Which type of digital technology do you adopt in your firm?**

[ ] Big Data

[ ] VR/AR

[ ] Cloud Computing

[ ] Blockchain

[ ] Artificial Intelligence

[ ] Other, please name it

**3. Which main activities does your firm engage in? (Multiple Options)**

[ ] Device Layer

[ ] Contents Layer

[ ] Service Layer

[ ] Other, please name it

**4. What is your firm's number of employees?**

[ ] under 30

[ ] 30-60

[ ] 60-100

[ ] over 100

**5. How old is your firm?**

[ ] under 5 years

[ ] 5-10 years

[ ] 10-15 years

[ ] 15-20 years

[ ] above 20 years

**Part II Digital Technology Adoption**

**6. At what stage of digital technology deployment is your organization currently engaged?**

[ ] Currently using digital technology

[ ] Have evaluated, and plan to adopt

[ ] Have evaluated, but do not plan to adopt

[ ] Currently evaluating (e.g. in a pilot study)

[ ] Not considering

**7. If you are expecting that your company will use digital technology in the future, how soon do you think it will happen (implementations – no pilot tests)?**

[ ] 1 year

[ ] 1 year-2 years

[ ] 2 years-5 years

[ ] 5 years

[ ] Not at all

**Part III Heterogeneous Networks**

**Listed below are criteria indicating whether your firm is building the heterogeneous networks. Please indicate your level of agreement with these statements (1=Very little, 3=Average, 5=Very much).**

Business Networks (BN): business networks are defined as the linkages that a company has established in connection with business stakeholders, such as business partners, suppliers, distributors, and government institutions.

8. Networking with other government agencies

9. Networking with industrial authorities

10. Networking with governments

11. Networking with domestic competitors

12. Networking with domestic customers

Personal Networks (PN): personal networks refer to an informal structure of personal relations, which are mostly characterized as personal ties and connections that are built upon goodwill and trust (Ge and Wang, 2012).

13. Networking with overseas' family members and friends

14. Networking with domestic friends

15. Networking with overseas' Chinese groups

16. Networking with domestic family members

**Part IV Digital Innovation**

Wording of Question Headings: Listed below are dimensions of digital innovation. Please indicate your level of agreement with these statements (1=Strongly Disagree, 3=Neutral, 5=Strongly Agree).

Digital Products Innovation (DPP): Digital product innovation is significantly new (from the perspective of a particular community or market) products that are either embodied in information and communication technologies or enabled by them. Examples include new consumer products (smartphones and Amazon's Instant Video service) and existing products substantially enhanced by the addition of digital technology (e.g. digital information systems in automobiles).

17. Introduced a new product built on digital technology such as big data, analytics, cloud computing, mobile and social media platform.

18. Introduced a new product, significantly improving your existing products integrating digital technology such as social media, big data, analytics, cloud and mobile technologies

19. Development of a totally new product based on the digital technology such as social media, big data, analytics, cloud and mobile technologies

20. Development of a totally new product based on digital technology for your establishment.

Digital Service Innovation (DSI): Digital service innovation can be considered the rebundling of diverse resources that create novel resources that are beneficial (i.e. value experiencing) to some actors in a given context. The broadened conceptualization of service innovation are delineated through a tripartite framework consisting of service ecosystem, service platforms, and value creation.

In recent years, our firm has…

21. Developed digital services integrating digital technology such as social media, big data analytics, cloud and mobile technologies.

22. Improved existing services and promoted digital services.

23. Repackaged existing services and promoted digital services.

24. Extended existing service lines and promoted digital services.

25. Introduced digital services that competitors do not offer in the market.

26. Tried to reduce the risks of failure of digital service development.

Business Model Innovation (BMI): Business model innovation can be regarded as a significantly new way of creating and capturing business value that is embodied in or enabled by digital technology.

27. Our firm can deliver new value to customers by utilizing digital technology.

28. Our firm can find new ways to increase revenue by utilizing digital technology.

29. Our firm can find new ways to reduce cost by utilizing digital technology.

Part V Firm Performance

How do you perceive your firm's market share relative to your competitors (1=relatively weak, 3=average, 5= market leader)?

Market Share (MS): Relative sales and market growth.

30. Your position on your sales growth rate compared to your competitors'.

31. Your satisfaction with your sales growth rate compared to your competitors'.

32. Your market-share gains relative to you competitors'.

How do you perceive your firm's profit level relative to your competitors (1=relatively weak, 3=average, 5= market leader)?

Profit Level (PL): Relative profit Performance.

33. Return on corporate investment position relative to competition.

34. Net profit position relative to competition.

35. ROI position relative to competition.

36. Return on sales position relative to competition.

## Figures

## Tables