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Rising Despite the Odds: Analyzing ICT Diffusion and Regional Breakthroughs in Mainland China, 2011-2022

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Abstract

This thesis explores the dynamic relationship between the diffusion of Information and Communication Technology (ICT) and regional development in mainland China from 2011 to 2022, with a particular focus on how lagging regions can achieve development through ICT. The thesis employs both quantitative and qualitative methods, analyzing the number of employees in the ICT service industry over this period, and delves deeply into the unique path of ICT diffusion and development in Sichuan Province through a case study, combining statistical data, ethnography and interviews. The theoretical framework is primarily inspired by neo-Schumpeterian thoughts, emphasizing the role of technological innovation and diffusion in regional economic development while considering the institutional background of the regions. And bridging technology and regional development through diffusion theories that highlight micro perspective and temporal wisdom. Finally we find that ICT diffusion in mainland China exhibits a clear hierarchical pattern. Leading regions such as Beijing, Shanghai, and Guangdong benefit first from advanced ICT, while some lagging regions also make significant progress in the ICT field. Sichuan Province is a typical case where labor mobility, i.e., individuals moving to higher-tier regions to acquire ICT skills and then returning to Sichuan, has driven local development. This indicates that while economically developed region naturally attract and benefit from new technologies, underdeveloped regions can also make breakthroughs in adopting ICT by strategically utilizing human capital and local potential.

Keywords: ICT; Technology diffusion; Regional development; Regional system; Lagging regions; Population mobility; Mainland China

Word count: 15552

Acknowledgments

I remember when I first started writing this thesis, most of the trees were still bare. Over the past few months, they've gradually become lush, just like my thesis has grown alongside them. To finish this thesis, I have to first thank my supervisor, Karl-Johan Lundquist, for his guidance and advice. I'm sure the experience I've gained from him will continue to shine for a long time. I want to thank all my teachers. While writing, I often looked back at materials from previous courses, which made me feel happy and grateful. Thanks to my parents for their emotional support; even though we're seven time zones apart, I still feel like we've never been separated. And of course, thanks to ICT for allowing us to stay connected instantly despite the distance. Also, I'm grateful for the improving weather, especially after spring arrived, which made the time spent writing this thesis more enjoyable. The warmth of the sun on my skin and the breeze are things normal on sunny days but can't be shared through ICT. Last, I want to thank myself.

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1.Introduction

1.1 ICT and different regional development stories

Information and communication technology (ICT) has dramatically transformed the global socioeconomic landscape over the past few decades. The impact ranges from the convenience of everyday life to the new vitality of regional development. However, significant regional disparities exist in the process of spreading this technology. On one hand, some regions have thrived due to the ICT; on the other, many regions still feel despair in the face of technological innovation. I seek to understand this phenomenon by following the dynamic pace of ICT diffusion, recognizing its spatial patterns, and explaining instructive success stories in regional systems. The exploration begins with the context of the different development stories between ICT and different regions.

1.1.1 ICT brings hope for regional development

I wonder how this paper will appear to you - on a computer or a smartphone? Or maybe it will be printed on traditional paper. In any case, it was first uploaded to the application platform via the web, thanks to the advancement of ICT . Beyond everyday activities, the rapid development of ICT has brought about a huge socioeconomic transformation (Graham, 1996). ICT has even enabled the social environment to start digitizing, like the meta-universe that has been so much touted by tech companies, where the distinction between offline and online is gradually blurring, and even, in some expects, the cyberspace is gradually absorbing other spaces (Floridi, 2007). Whether in big cities or small villages, people are connecting via the internet and sharing information. As the slogan goes, "The world is a global village", and ICT seems to hold the promise of a future with broadly shared knowledge.

Despite early skepticism (Haywood, 1998), academic research (Jin & Cho, 2015) and practical application results (Jonsson et al., 2024) have shown that ICT can be a great driver for regional development. Famous examples such as Silicon Valley, which has become the world's ICT center since the 1980s, influence the global economy (Kenney & Zysman, 2016). In China, ICT-led Shenzhen, known as “China's Silicon Valley”, has transformed itself from a small fishing village to a global innovation center since its development in the early 1990s

(Zhou, 2013). The success of these Silicon Valleys has tugged at the ambitions of other places. And even though ICT has been developing for many years, it is still going strong and can bring great vitality to the development. In a recent report by the International Data Corporation, the technological changes will continue at least for the next decade, and ICT still has great potential (2023). Does the vast future of ICT also mean endless opportunities for all regions, especially those that are currently lagging?

1.1.2 Inter-regional differences in the ICT diffusion process bring regional development despair

Those of you who are able to read this thesis may have become accustomed to the existence of ICT, yet it is an often overlooked fact that until today, there are still many areas that do not have access to the internet. Despite the fact that “coded information” could spread quickly, reducing the cost of moving across actions and spatial and temporal barriers (Pick & Johanson, 2015), the diffusion of ICT is still geographically constrained. This process inevitably generates spatial and temporal differences, and different regions are affected differently. At the meso level, industries that are more digitized are also more concentrated (Calligaris et al., 2018), and the ICT industry is no exception. This clustering development poses a monopoly risk, which, together with the ICT industry's property of increasing returns and very low marginal cost of production, provides a natural fertile ground for monopolization. Typically, clusters are in regions that are already prosperous and able to deliver agglomeration benefits, making it more difficult for backward regions to develop ICT industry. At the micro level, backward regions experience an outflow of labor due to a chronic lack of development opportunities and persistent poverty. Some policymakers argue that people should be moved to places where there are opportunities (World Bank, 2009). These places are usually already well developed and have the earliest exposure to new knowledge and technologies. Although this approach has been noted as potentially exacerbating interregional inequality and leading to negative political, economic and social consequences (Rodriguez-Pose, 2018), in reality, this is still happening in many places, further eroding the space for lagging regions to thrive in the process of ICT diffusion.

1.2 Problematization of regional development in the Chinese context

Scholars have explored the mystery of regional development from different perspectives. The debate started with the term "regional development". For a very long time, regional development has been dominated by economic issues such as employment and growth (Armstrong & Taylor, 2000). This tradition has been criticized for neglecting the quality of life and well-being of people, among other things. As society continues to evolve, its connotations have been enriched. The constant in our consideration of what regional development is the priorities of local people and their value-based judgments about what is appropriate for local “development” (Pike et al., 2006). In other words, defining the development of a particular region depends on the expectations of local people. There is a popular modern proverb in China that says, "Economic backwardness leads to beatings, and development leads to self-reliance." Looking back at the history of China's development in recent decades, one can also see the efforts made by the Chinese authorities to achieve economic growth. It can be said that economic prosperity has always been the centerpiece of the "development" that the Chinese expect. Implicit in this idea might worry Harvey, who sees a politically progressive local and regional development is underpinned by critiques of capitalism and a belief in the need to challenge the social injustice of uneven development and spatial disparities (2000). There is nothing really wrong with escaping economic backwardness, but if it is premised on the idea that backwardness is going to be bullied, it seems to imply that it is reasonable for regions that are economically backward to be oppressed by those that have achieved growth. The world is inherently non-homogeneous, and it will not be possible in the foreseeable future for all regions to have the same level of economic performance. Despite this concern, and despite widespread criticism, I still identify the economy as a core requirement for China's regional development, especially for those regions that are still less development. According to the government's report, China only be fully free from poverty in 2021 (The State Council of People's Republic of China, 2022), and many people are still struggling to get enough to eat. This, of course, does not prevent the pursuit of a more holistic and sustainable future along with the economy.

"Regional development" is diverse, and so is how to achieve it. There is a stereotype that when talking about China's regional economy, one must start from institutionalism, perhaps

because the authorities have for a long time abandoned the market model common in developed economies to stimulate economic growth (Gregor, 2017), making development everywhere in China extremely dependent on the institutional environment. Scholars studying China's regional development, whether from Europe or locally, are also really keen to talk about the various problems in terms of institutional changes (Fan, 1997; Demurger et al., 2002). The shift came in the 21st century, when the Chinese authorities made a number of reforms in the economic system as China's participation in the globalization process deepened. One of the most important of these changes was the amplification of the role of the free market. This has freed up not only market forces, but also individuals, or entrepreneurs, and many other elements that were difficult to play in a strictly planned economy. In the academic world, there is also more diversity to discuss, and although the institution is still at the center of the discussion, there has been a tendency to borrow from other theoretical frameworks, no longer a simple monism (Wei & Liefner, 2012). With the transformation of China's overall economy has been accompanied by a paradigm shift in academic research on China's regional issues. In exploring the role of technology on regions, a number of conjunction products have been formed, such as placing Schumpeterian entrepreneurial innovation spirit under institutional logic (Li et al., 2019). Institutional logic can be understood as socially constructed historical patterns of material practices, assumptions, values, beliefs, and rules through which individuals produce and reproduce their material lives, organize time and space, and give meaning to their social reality (Thornton et al., 2012). This combination allows the free-market based Schumpeterian paradigm to be better utilized in research in the Chinese context.

With the rise of the knowledge economy, words such as technological innovation are appearing more and more, and we could see in the daily news many regions that have achieved development through technological innovation, as well as very many stories of regions that have started out with great ambitions but ended up failing. Just as ICT has brought hope to some regions and despair to others in the process of diffusion, the regional development brought about by technological innovations has also resulted in interregional disparities. As well as the specificity of China's economic system and other complex social realities. These factors fit with the basic starting point of the neo-Schumpeterian explanation

of economic development. Talking about China's regional development from this perspective is still lacking. And those regions that have made breakthroughs only in recent years have always lacked attention, the regions that are talked about are always the resident developed regions, such as Beijing and Shanghai (Qiu & Bu, 2013; Wen et al., 2023). In addition, as we move from academia to reality, in this information generation, every region seems to be eager to get a piece of the development pie through ICT, regardless of the status of these places. Economic growth is always dynamic with technological development, and recessions are part of the economic cycle. In the long run, lagging is a state of affairs that all regions have to face. In turn, when a region is lagging, it is still could have confidence and expectation in the future. The lessons that can best be learned by regions with weak foundations may come from regions with similar pasts.

1.3 Research aim and questions

From what has been discussed above, this thesis aims to follow the pace of the technology diffusion process to understand regional development and to look into how regions in a weaker position in the technology diffusion model can explore their local potential and realize development.

The specific research questions are:

RQ1: What were the interregional dynamics of ICT diffusion in mainland China from 2011 to 2022?

Through the exploration of RQ1, we can not only understand the characteristics of ICT diffusion in mainland China during the study period but also identify regions that started slowly in this technological field but later caught up. These regions, which could be called "winner". And The discovery of these regions will directly support RQ2.

RQ2: How could a region that started lagging in the ICT diffusion process gradually become a winner?

RQ2 steps closer and looks into the "winner" to identify the forces at work in the development process that explain such changes. It helps provide new insights for regions previously lagging that are now poised for development.

Here, I would like to make a special note of the time selection and the delineation of the

regional scope of the study.

a) Why the time period of 2011 to 2022 was selected: China's socioeconomic system is unique, a socialist market economy under state macro-control, and a five-year plan has been in place since the middle of the 20th century, with a five-year cycle of planning for the national economy and social development ("Five-year plans of China", 2024). Each development cycle has a set of objectives, ranging from technological and industrial development to regional development. During the course of the plan, a number of new policies are introduced to facilitate the achievement of the goals. For localities, development is very much a matter of participating in the development of an overall regional network, and is also very much influenced by institutions (Liu et al., 2011). 2011 was the beginning of the 12th Five-Year Plan, and 2024 is the fourth year of the 14th Five-Year Plan. Unfortunately, official statistics are not released until the September each year through the National Bureau of Statistics, and the data released is from the previous year. The latest official data that can be accessed is currently in 2022. For these two reasons, the time period chosen for the study seems a bit "strange".

b) What is the scope of a region and what is included in mainland China: In our study area China, the oldest and most basic way of dividing a region is by administrative divisions. The current highest level of administrative division is the provincial level, of which there are 34. The division of the various provincial administrative regions can be traced back as far as more than two thousand years ago, with a long history which makes a relative uniformity within the region. Most of the nationwide data are also categorized by province. Therefore, a region in this article refers to a province. Yet, there are three regions, Hong Kong, Macau and Taiwan, which are special due to their history, and their political and economic systems are very different compared to the other 31 provinces, and are generally discussed separately when discussing China's regional development. This thesis follows this custom and discusses only the remaining regions other than these three, which are also referred to as mainland China.

1.4 Structure of the thesis

This thesis is divided into five parts. The first part, a theoretical framework with the main thread of technology diffusion, links ICT to regional development. And emphasize the micro and temporal perspectives in addition to the classical arguments in understanding technology diffusion.

The second part is a description of the methodology and data selection used in the study.

The third and fourth parts are empirical studies, corresponding to two research questions. The first one is exploratory. By investigating the interregional diffusion trend of ICT in mainland China in terms of administrative provinces, it helps to develop a general understanding of the interregional diffusion characteristics of ICT in mainland China over the past decade or so, and therefore serves as the basis for the second research question.

The second research question aims at explaining the success of a region that has achieved significant growth in ICT in the recent past, therefore the fourth part is analytical and bases its discussion mainly on the long time dimension and a neo-Schumpeterian perspective that focuses more on the interactions between individual actors and the region.

The last part is a review of the research results, as well as a summary of the possible heuristics and shortcomings of this study.

2. Literature Review

Before actually conducting the research, I tried to review some of the past academic research findings in the research area. Since the research problem is very broad, I hope to be able to connect all the elements with one core theory.

Evolutionary economics, as heterodox economics and one of the theoretical origins of neo-Schumpeterianism, is committed to applying the idea of biological evolution in the natural world to the economic evolution of human society. Opposing the assumption of rational economic man under the conditions of social atomization, utility maximization, and complete information, stressing the irreversibility of the time dimension, historical accumulation, and the process of economic development. It argues that the outcome of economic evolution is not optimal, but the result of heterogeneous "satisfier" decisions driven by limited rationality and organizational practices. Innovation and new things are the driving force behind self-transformation (He, 2018). "New", according to the Oxford dictionary, when used as an adjective, can be used to describe something that has never existed before, or has existed but has only recently been discovered or acquired, or a transformation (2024). A subtle temporal relationship can be glimpsed in this. For a region, something new means that there was nothing there before. Yet such a thing may have already existed, just not in a particular region at an earlier time, and only spread later. For most places, new things are spread from elsewhere. ICT, as a technological innovation, exists as a new thing and through the process of diffusion is connected to different regions and thus plays a role in regional development. Technology diffusion thus becomes the link between ICT and regional development and the central theory that ties the whole thesis together.

2.1 The concept of technology diffusion

Although it is easy to be attracted by "technology" when one sees technology diffusion, technology diffusion first belongs to the category of diffusion, so we need to understand diffusion first. There are many geographic studies that focus on the characteristics of a region at a specific time, which we could call distribution. If we ask, as Enequist did, why such distributions form (1949), then diffusion is one of the answers. Thus, diffusion can be

understood as a process of distributional change between neighboring points in time (Hagerstrand, 1968). Hagerstrand pioneered the theory of spatial diffusion in the 1960s. He argued that diffusion is a fundamental geographic process, and that whatever the spreading phenomenon (or the spreading "information"), it can be considered in the context of a larger spatial diffusion process. In the case of technology diffusion, the diffusion phenomenon is technology, that is, is the process of spreading a certain technology in space. It is important to mention here that in combing through the previous literature I have found that the notion of technology diffusion innovations often appears in the literature, or that technology diffusion is directly interpreted as the diffusion of innovations both within the economy and in economic space (Stoneman, 1985). This view takes Schumpeter's view of diffusion as its starting point. Again, in this thesis I do not make a particular distinction, because for non-origin regions diffusion implies an element of newness , and because the process of generating and diffusing knowledge and technology is the basis of innovation.

2.2 Spatial patterns of technology diffusion

There is a mechanism of influence in the diffusion process. In the era when Hagerstrand was active, people were the main medium of contact in the mechanism. People's attitudes and receptivity to the phenomenon of diffusion, as well as the associations between people, are important factors influencing diffusion patterns. Thus, the pattern of diffusion that unfolded in space and time depended on the spatial distribution of acquaintances who were knowledgeable and uninformed about the diffusion phenomenon. At the same time, Hagerstrand found that people have more information closer to home and vice versa. This bias toward local information is known as the "neighborhood" effect, which makes the diffusion process show a clear distance decay characteristic. It is easier to obtain relevant information first in regions closer to the place of origin, and more difficult in regions farther away (Morrill et al., 2020). Discussions of diffusion patterns have focused not only on spatial processes, but also on temporal processes. In general, diffusion processes have been categorized into an early period of pioneering, a middle period of diffusion, fastest change and a later period of "condensing" and saturation.

After Hagerstrand, many economic geographers further enriched the thought of spatial

diffusion, especially the spatial diffusion of innovations. The core idea of this thought is that innovations/new technologies can occur in any space, but their diffusion takes place along certain paths. There are mainly two patterns of spatial diffusion of technology: wave diffusion (Morrill, 1970) and hierarchical diffusion (Gould & Huang, 1974; Hanham & Brown, 1972; Hudson, 1969).

Wave diffusion means that technological innovation spreads from a center to its hinterland. New technology first spreads to neighboring regions, and then gradually spreads to more distant regions, showing spatial continuity, strictly following the law of distance attenuation, with obvious "neighborhood" effects. On the micro scale and in the early stage of growth, intense market competition and the heavy dependence of enterprises on information force them to cluster around high-tech parks. This distribution criterion mirrors the wave diffusion process. Therefore, the locational growth of high-tech industries is mainly governed by the process of wave diffusion at the micro level and in the early stages of diffusion. Additionally, general technology diffusion that requires a low technological base for potential adopters is often realized in this way.

Hierarchical diffusion refers to the fact that technological innovations do not diffuse in a homogeneous space, but first diffuse from the source of the innovation to other, larger regions and then, over time, to the next tier of regions. The main reason for this is that larger regions tend to be the first choice for technology diffusion because of their concentration of abundant human resources, good infrastructure and supporting services, and the location of the headquarters of large firms. Since the size of a region (usually expressed in terms of population) represents the size of the market potential and the possible spatial agglomeration of industries, it is an important factor in measuring the technology diffusion. According to the law of hierarchical diffusion, the technology diffusion between regions is orderly, spreading first to larger regions with larger populations and then to smaller regions, a mode of diffusion seen mainly in developed countries and regions and applicable to the diffusion of more complex and advanced technologies. What determines the direction and speed of technology diffusion here is not the distance, but the difference in the absorption capacity and adaptability of the region to the innovation. The technology is diffused in a jumping manner in the non-homogeneous diffusion space according to the size of the regional hierarchy, and

the hierarchical effect of technology diffusion is very obvious.

2.2.1 Interregional time lags in the diffusion process

An empirical study in Sweden shows that there is a systematic interregional time lag in the process of technology diffusion, and this is reflected in the different regional tiers according to the size of the population. At the beginning of a technological shift, industries that are able to utilize the new technology early are generally located in the top of the regional hierarchy, such as large cities. Lower tier regions, with lower regional receptivity and development capacity, will only be affected by spillovers from higher tier regions as the new technology matures. It may even be the case that a new round of technological shifts has already begun in the higher tier regions but none of the core technologies of the previous round have yet reached the lower tier region (Henning et al., 2016; Lundquist et al., 2017). This Swedish empirical study focuses on general purpose technology (GPT) that are generalized in the traditional sense, and the data were selected from the more traditional parts of the industry. However, I searched for newer, on network generations, studies on the spatial technology diffusion based on online social media data, which similarly emphasize the dominance of regional hierarchies in spatial diffusion (Bokanyi et al, 2022). This Hungarian study shows that new technologies will only flourish in large cities in the early stages. Only after the diffusion rate accelerates in the middle period do other smaller cities in the lower tiers have access to innovations that have long since emerged in the larger cities in the upper tiers. This time lag between different levels of regions is a feature of the hierarchical pattern of technology diffusion reflected in practice. Of course, such a feature is rooted in the actual context in which the empirical research is conducted. China's situation is different from that of Europe, so the Swedish or Hungarian models cannot be directly applied to Chinese studies, especially in terms of the specific division of regional hierarchies. In these two European countries, the average population of each tier correlates well with the acceptance of new technologies, but the number and size of Chinese cities are too large, so it is questionable whether the same correlation can be achieved in the same way. What is certain is that the general framework is that new technologies will always tend to flow first to areas that can generate economies of scale and higher profits, and lagging regions tend to lag behind in

receiving new technologies. This is consistent with the neo-Schumpeterian paradigm's understanding of the process of economic development: everything does not happen at the same time, and the driving effect of new technologies on innovation does not manifest itself equally across different regional tiers over the same period of time. When the main driver of economic development comes from the disruption of regular circular flows due to the introduction of novelty (Hanush & Pyka, 2006), which means that in this paradigm there is a serious lack of incentives for economic growth in lower tier regions. This is a good explanation for why lagging regions are chronically stuck in development bottlenecks.

2.3 The introduction of new perspectives

I refer to the micro and time perspectives as "new" perspectives, does not mean they have not existed before.

2.3.1 Micro Perspective

In fact, in the early stage of the formation of technology diffusion theory, the role of the micro level has been emphasized, but generally speaking, it is in a small area, and the diffusion mode associated with it is often wave diffusion. Most of the modern elaborations on the process of knowledge and technology diffusion have been carried out from the meso-industry level. This in turn limits the discussion of certain forms of knowledge diffusion, such as the individual's role as a boundary wrench and the identification of external technology by the technology broker (Abell et al., 2008). Innovation is a process driven by many different actors, and the same is true of the technology generation and diffusion that underpins it. Neo-Schumpeterianism itself places a strong focus on entrepreneurs as economic actors who initiate economic development (Hanush & Pyka, 2006). Thus bringing a micro perspective, especially the role of the individual, into the understanding of the process of technology diffusion becomes necessary. Actually, there are some previous studies in this field that discuss people as agents in introducing new technologies into the region. These studies have attempted to analyze the adoption of new technologies in a given region from the perspective of an individual with his or her own attitudes and beliefs, with differences in learning ability (Foster & Rosenzweig, 2010; Briscoe et al., 2011), or to

understand the dynamics of technology diffusion based on social networks between people (Shi et al., 2021). Typically, they focus on people who are more spatially static. Nonetheless, technology diffusion as a spread must be mobile and dynamic. Similarly, people can be moblie and dynamic. Saxenian, in her book The New Argonauts, discusses a phenomenon where technical experts and entrepreneurs from various countries worldwide, after studying and gaining experience in Silicon Valley, return to their home countries to start businesses and drive technological development, thus helping their countries establish innovative environments similar to that of Silicon Valley. These tech migrants, referred to as "the new Argonauts," have facilitated the global flow of knowledge and technology (2006). When changing the understanding of people from spatially static to spatially dynamic, not only the spatial location is changed, but also, as mentioned earlier, the attitudes and beliefs towards the new technology, the ability to learn, all these individual characteristics of people, and even the social relations, will be changed as well. Then furthermore, its connection with the region and technology will also be different. The micro perspective introduced in this thesis to understand technological diffusion is also dynamic. However, our ultimate focus is on regional development. A certain number of talents is required to generate a group effect that can impact the region. Just like the "new Argonauts" analyzed in Saxenian's book, they are not mere isolated examples. Therefore, the micro perspective in this thesis is relative to the industry, not solely from the viewpoint of individuals, and will still be mainly discussed at the group level.

2.3.2 Time perspective

Spatial movement is accompanied by the passage of time, and space-time behavior is always one and the same, so the introduction of a time perspective is equally important. We need to understand spatial behavior with the help of time, such as the movement of technology in different regions in technology diffusion, such as the medium of contact in technology diffusion, the movement of people. Time in these cases is absolute. At the beginning of this section, I have taken a more pluralistic view of "new" based on the Oxford Dictionary's definition. In one case, the same new thing is new to some regions and not to others. This reflects a temporal relativity. Time is important in understanding the evolution of a region. In

understanding it, this thesis draws on Henning's definition in a paper on evolutionary geography that should deepen the historical perspective (2019). Henning distinguishes between abstract time and real time while also distinguishing between history and time (Table 1).

Table 1. Time and space concepts in a two-by-two matrix, where a specific regional approach may emphasize time and/ or history, as well as abstract or real, including examples of features

	Abstract	**Real**
Time	"Laboratory time"(Corpataux & Crevoisier, 2007)	Hours
		Days
		Weeks
		Periods,e.g., 1900-80
History	Industry life cycles	Temporal wisdom
	Succession models: technology shifts, long waves	Industrial revolutions
		Empirical knowledge of diffusion of technologies
		Empirical knowledge of institution change

Souce: Henning, 2018, p.603

The time perspective of this thesis, rather than making a distinction between time and history, is divided into two dimensions based on abstraction and reality. Our research examines regional development in terms of technology diffusion, linking development to the fact that the entry of new technologies into the region is chronological. Regional economic development is the result of a process (Storper, 1997). Technology diffusion is also a process; it takes time for ideas and innovations to grow, develop and spread. When these two processes intersect, friction in time may arise, where time, in this case, is relatively and could correspond to the long waves and industry life cycles in the abstract dimension of Table 1. When we understand diffusion in micro terms, time at the diffusion level can be viewed as the time of the person carrying the technology. At this point, the diffusion time is micro, while the time for regional development is macro. In order to more systematically clarify the relationship between abstract times, the thesis also tries to incorporate the life course theory in the discussion. Life course theory was earlier widely used in the field of migration studies, and it provides a perspective to study behavior from the full life cycle of a person or a group. In life course theory, time is categorized into three dimensions: individual time, generational

time, and historical time (Elder, 2007). Individual time represents where an individual is in the life cycle; generational time is the usual time spent playing a specific role; and historical time implies where an individual is in a specific historical context. By reconstructing the concept of time, a connection from the micro to the macro is realized. In the integration of the life course with more diverse disciplines, some scholars have used it to study economic life, such as the impact of family life course and migration events on the economic well-being of families (De Jong & Graefe, 2008), as well as the connection between economic policy and life stance and human capital (Bovenberg, 2008). Through these studies, we are able to get a clear sense of the interaction between the social and historical time of individuals. Such a process of interaction will ultimately not only have an impact on the individual, but will also trigger broad socioeconomic change. Change, of course, also includes regional development. Especially when the change goes against the overall trend, this new temporal time after the deconstruction of the traditional concept of time may provide us with new ideas. The other time dimension used in this thesis is real, corresponding to the specific time lengths and temporal wisdom in history in the real-time division of Table 1. This links the particularities of regional development with the events that have actually occurred within the regions and combines with abstract time when analyzing the specific case.

2.4 ICT and regional development

In the literature review that has been completed, the technology we discussed is still at a relatively general level. ICT is of course characterized as a "technology", but it is also specific as a technology of great significance in the information age. A separate explanation of the links between specialized ICT diffusion and regional development will therefore be presented here. The regional impact of ICT diffusion can be divided into two main channels. On the one hand, it leads to the creation of new technology-intensive sectors, and on the other hand, it is applied in other sectors and fundamentally changes the mode of operation and output characteristics (Dahl et al., 2011). The new sector in question is the ICT industry, which is defined by the OECD as "products and services that are processed and communicated primarily by electronic means, or that perform information processing and communication functions" (2002), thus including both ICT manufacturing and ICT services.

As technology evolves, so does ICT itself and the meaning of the ICT industry, but nevertheless, information and communication remain at the core. The second channel of influence is through influencing other sectors and thus the region. ICT is widely used as a new GPT (Maggi et al., 2007) in the information age. And compared to other types of technology, ICT itself has information dissemination attributes, it is involved in the diffusion process as a technology while being affected by diffusion influencing factors. For example, it provides new communication channels (Ozcan, 2018), facilitates changes in meta-geography, and helps regions participate in larger networks (Lamberton, 1992). Accordingly, research on ICT diffusion can be categorized into the development of the ICT industry (Caragliu, 2013) and its application as a general purpose technology across the economy (Guzman et al., 2022). As things stand, most ICT diffusion related studies have focused on ICT in its role as a GPT (Vicente & Lopez, 2006; Kallal et al., 2021; Gaudio et al., 2021), with relatively little attention paid to the ICT industry. This thesis attempts to combine the two, as ICT and the ICT industry are inherently inextricably linked. If a region has a high level of ICT, then the development of the local ICT industry will be impressive; if a region's ICT industry is lagging behind, then the local ICT level can hardly be said to be advanced. In the discussion of the first research question, due to data availability, the focus was on the ICT industry. Nevertheless, it is still hoped that the diffusion of this specialized industry can, to some extent, reflect the overall diffusion of ICT as GPT, and its broader effect on economic growth. This aspect is more in focus in the second research question.

3. Research Design

In this section it will be discussed what methodology and methods were used and how it went about finding answers to the research questions. First a quick review of the research question. The research question consists of two parts, an overall view of a larger area involving a large number of observations, and a more in-depth analysis of a specific area, a case study of a single region. Based on this characterization, the methodology, methods and the type of data needed are divided into two accordingly. Each will be specified below.

3.1 Quantitative research for RQ1 - trend survey

The first research question is a very macro perspective. The volume of China is huge in any dimension, and since there is a study period, it is most appropriate and feasible to use statistical data to reflect the dynamics of ICT diffusion across the region, so quantitative research will be used. The data should be collected in a longitudinal section, equivalent to a trend survey. Although such data would mask specific individuals, it would be able to draw conclusions at the regional and national level in general (Schumann, 2012), which is compatible with the research question. Having identified the type of data, the next step is to determine exactly what the specific data is. A longitudinal section is composed of numerous cross-sections, which represent the state of a region at specific points in time. If one wishes to understand the trend of changes in the subject of observation, it involves collecting data related to its development at various time points and then linking these together. For the research question of this thesis, this cross-section is the status of ICT reception in the region, so what kind of indicators are to be used to represent the reception of the technology in the region? In the latest white paper on ICT innovation and development in China (CAICT, 2020), published by the China Academy of Information and Communication Technology (CAICT), ICT development is categorized into two parts: inputs and outputs. Inputs use the indicators of employment and capital investment, while outputs use the number of relevant patent invention applications. By combining different data sources, the results can be more convincing. However, for this study, in addition to reflecting the status of technology acceptance in the region, it is also desirable to have indicators that link the micro and meso

levels. When discussing the micro level, the core is people, and with the consideration of feasibility, the number of people working in the ICT industry was chosen as the indicator. It was mentioned earlier that the ICT industry can be divided into two segments: services and manufacturing, and according to this division, the number of employed people should also include both segments. But during the actual search process, I found that Chinese statistical organizations used to combine ICT manufacturing with the total manufacturing industry and classify the ICT service industry as a separate category. Collecting data only from the service sector leaves a question mark over the representativeness of the data. Nevertheless, I would like to make a case for this: since the mid-1990s, the structure of China's ICT industry has been tilted towards the service sector, with a ratio of roughly 4 to 6. By 2015, the value added of the ICT service sector had officially surpassed that of the ICT manufacturing sector. At least during the study period, the number of employees in the service sector in the region is a good indicator of the development of the ICT industry and the reception of ICT in the region, and has more potential for the future than the indicator of employees in the manufacturing sector.

All statistics for the first research question are taken from the official website of the National Bureau of Statistics of China and the official websites of its subordinate local statistical bureaus, and the raw data are: the number of employees in ICT services by province from 2011 to 2022; the total number of employees by province from 2011 to 2022. According to the Bureau of Statistics, the term “the number of employees” specifically refers to individuals employed by urban legal entities, which are defined as organizations with five or more employees located in urban areas. This statistic does not include individuals employed by private urban enterprises or those working in rural areas (2023). With the increasing diversity of occupational choices and workplaces, it is possible to exclude self-employed or freelance ICT workers in the countryside, but for the time being, the vast majority of the relevant workers are included in the statistical scope of urban establishments. However, in other sectors, such as accommodation and food services, the inclusion of urban units may deviate from the actual employment situation and thus have an impact on the total number of employees.

3.2 Combination of quantitative and qualitative methods for RQ2 - case study

Quantitative research alone is not suitable for explaining the constitutive factors or causal mechanisms behind relationships (Stockemer, 2019). In that case the second research question combines qualitative research while using quantitative. For this research question, data is used to help understand how success in a region occurs. With this purpose in mind, the specific method used was a case study. The quantitative data was still obtained through a search, and was for the migrant population in Sichuan during the study period. The specific time points did not strictly correspond to the two years 2011 and 2022, this is because population data in China is collected on a 10-year cycle. Ethnography and related policy documents of the study site were also collected through searching on internet. Secondly, representative key figure was interviewed through the interview method. The interviewee was contacted through the public email address on the official website of the relevant company and the online conversation was conducted through Zoom. In the selection of the interviewee, I chose an individual who is consistent with the overall characteristics of the region to help understand the feelings, views and attitudes of the individual in being a participant in the regional process. The interview was conducted using a semi-structured approach aided by a number of guiding questions(details see appendix). This allowed interviewee to express views more whilst gaining information about the topic. The questions were centered around spatial-temporal mobility and accumulation with ICT over the study period. To ensure privacy, the results of the interview were anonymous and in the subsequent analysis the interviewee used his last name, Liu, as a surrogate. In fact, the content obtained from the interview is not the main material to be analyzed in this thesis, but as a thesis that focuses on the interaction between technology diffusion and regional development from a micro perspective, I think it is necessary to include some voices from specific people as an appropriate supplement to the analysis. Therefore in this case, the interview is somewhat anecdotal and is used to illustrate a single case of the mechanism of knowledge accumulation in returning mobility.

In addition to above, I must also acknowledge that some of the experiences that I have gained through the observational method in my previous life experiences are also part of the research data. Although it is only a very small part, this may still be criticized by some

commentators, and therefore an additional note is made here. Compared to other human geography topics, the sense of the researcher's personal role presence is actually weaker when discussing the economy, but I still felt the reflexivity of studying something familiar in the research design and subsequent implementation. I was born in a lagging place in southwest China, and as my hometown grew while I was growing up, I could feel its ambition. The factories and enterprises that moved in and built new ones were, for a very long time, products of the elimination of the leading regions in the east. My elders worked there, and my life and the lives of my friends changed as these industries prospered or fell by the wayside. These experiences accumulated over a long period of time allowed me to conduct my research with some knowledge of the subject matter and allowed me as a researcher to understand what is implied behind the surface information that is accessible to everyone (Berger, 2013). Of course there are also risks, such as the presence of stereotypes as well as projection bias and so on (Drake, 2010). How to balance this has always been something to think about when choosing a qualitative research methodology. I am confident that I was able to achieve this balance, which relies on sound method when collecting data and the scientific theories used when analyzing the case. The main theoretical ideas chosen are reflected in the literature review section of the article. Overall, these ideas belong to the category of evolutionary economic geography with a distinctive neo-Schumpeterian character, which views innovation as the fundamental driving force of regional development. In explaining the development history of a given region, technology diffusion is chosen as the link to the dynamics of development, while adopting a more micro and temporal perspective than the more classical theory of technology diffusion, which is widely used.

4. Characteristics of ICT Diffusion in Mainland China between 2011 and 2022

This section will analyze the characteristics of ICT diffusion in mainland China from 2011 to 2022 through comparisons of data, and will identify the winners who have successfully turned the tables.

Due to the great differences between Chinese provinces both in terms of population size and industrial structure, as well as the indicators used are relatively single. In order to minimize bias, comparisons between the absolute numbers of ICT service employment in each province as well as comparisons of ICT service employment growth indices in each province are combined, along with an analysis of the cumulative proportion of ICT service workers to total employment in selected typical regions, to obtain a relatively objective picture of the changes. The winners discussed in this thesis are not places that lead the global ICT wave like Silicon Valley, which would be too demanding for a newly emerging place, but rather places that have achieved a clear breakthrough for themselves.

4.1 Regional hierarchies with Chinese characteristics

Generally speaking, in the field of technology diffusion, regional tiering uses regional population size as the standard. But given China's large population and the wide variation in demographic characteristics such as education and income levels, there is no absolute relationship between the size of a region's population and its attractiveness or receptivity to new technologies. Many studies focusing on China include data on land use and GDP per capita in addition to population when ranking regions (Xue et al., 2020; Cao et al., 2020). In this thesis, we refer to some empirical studies that analyze interregional differences in China's economic development between 2011 and 2022 (Zeng et al., 2012; Li et al, 2018; Xue et al., 2022), and combined with the economic zones, which is widely recognized in China's economic geography field and has become common knowledge. Classifying the 31 mainland China provinces into eight major zones and these zones are divided into different tiers (Table 2). Provinces within the same tier have similar levels of development, while provinces between different tiers have different levels of development. The higher the tier the stronger

the overall competitiveness of the region, and the larger the scale of the region in the Chinese socioeconomic context. The reverse is also true.

Table 2. Eight economic regional divisions and their hierarchical classification in mainland China

Tier	Economic Zones	Provinces
1st	East	Shanghai,Jiangsu, Zhejiang
2nd	South	Fujian, Guangdong, Hainan
3rd	North	Beijing, Tianjin, Heibei, Shandong
4th	Northeast	Liaoning, Jilin, Heilongjiang
5th	Yangtze River Central	Hubei, Hunan,Jiangxi, Anhui
6th	Yellow River Central	Shaanxi, Shanxi, Henan, Inner Mongolia
7th	Southwest	Yunnan, Guizhou, Sichuan, Chongqing, Guangxi
8th	Northwest	Gansu,Qinghai, Ningxia, Tibet, Xinjiang

Souce: Zeng et al., 2012, P1008. Reorganized by author.

It is no exaggeration to say that if you ask a random Chinese person who has not studied regional economies which parts of China are economically developed, the answer will definitely include "Bei Shang Guang". "Bei Shang Guang" is an acronym for Beijing, Shanghai, and Guangzhou, the capital of Guangdong Province, and it has now become a proper noun for leading regions in the Chinese context. In addition to these specific places, the eastern part of the country is doing better than the western part, and the southern part of the country is generally doing better than the northern part.

4.2 Distribution of ICT service industry employment at the beginning and end of the study period

Figures 1 and 2 show the distribution of ICT service industry employees in each province in 2011 and 2022 respectively, using different shades of the same color to indicate the different number of employees. The darker the color the higher the number of people, the lighter the color the lower the number of people. I classified them into 3 categories by natural breaks classification and manually modified the boundary values according to the classification and the actual situation. There are two main reasons why I chose this classification way. One is the characteristics of the data itself. The original data has several characteristics: the data

varies greatly, whether as early as the beginning or the end of the period, the highest value reaches 100 times the lowest value; the distribution is uneven, and there is a clear tendency to concentration, such as in 2011, the interval of 0.22 to 0.67 million people covers the number of employees in more than two thirds of China's provinces, and there is no data at all located in the interval of 197,400 to 490,700 people. The second reason is the purpose of categorizing this data set. By categorizing the number of ICT service employees in different provinces of mainland China over time, the ultimate goal is to present the spatial differences in the distribution of ICT adopters over time in the map. This means to visualize the distribution pattern of the data itself. Different provinces have different ICT reception status and degree of development, and the number of related employees also varies.The natural breaks method of finding breakpoints and thus categorizing the data based on the characteristics of the data itself is both effective in categorizing our raw data as well as making the categorization results meet the needs (Law & Collins, 2021).

Grounded on the fact that people are the wrench as well as the spreader of technology, and that the number of employees can reflect the size of the industry, a regional hierarchical sequence in the ICT diffusion process was classified based on the number of people employed in ICT services in each province (Table 2). To distinguish from regional tiers, the term "class" is used here to refer to different levels. The higher the class, the more "central" it is, and the lower the class, the more "peripheral" it is. In 2011, only Beijing was in the first class. The second class includes Liaoning, Shaanxi, Shandong, Jiangsu, Zhejiang, Shanghai, and Guangdong. The remaining 23 provinces are all in the third class. By 2022, Guangdong joined Beijing to become the first class. While Liaoning, Shandong and Shaanxi dropped out of the second class, Sichuan joined Jiangsu, Zhejiang and Shanghai in the second class. The number of provinces in the third class has increased to 25.

Table 3. Regional hierarchical classification of the distribution of ICT service industry employment in 2011 and 2022

	2011	2022
First Class	Beijing	Beijing, Guangdong
Second Class	Guangdong,Zhejiang, Jiangsu, Liaoning, Shandong, Shanghai, Shaanxi	Shanghai, Jiangsu, Zhejiang, Sichuan
Third Class	Hunan, Sichuan, Heilongjiang, Henan, Hebei, Jilin, Hubei, Fujian,Shanxi, Anhui, Guangxi, Inner Mogonlia, Yunnan, Chongqing, Guizhou, Xinjiang, Tianjing, Gansu, Hainan, Qinghai, Ningxia, Tibet	Shandong, Henan, Hubei, Shaanxi, Liaoning, Hebei, Anhui, Fujian, Hunan, Tianjing, Chongqing, Heilongjiang, Guangxi, Jiangxi, Shanxi, Yunnan, Jilin, Inner Mongolia, Guizhou, Xinjiang, Gansu, Hainan, Tibet, Ningxia, Qinghai

Souce: Oringinal data from National Bureau of Statistics of China. Made by author.

Figure 1. Distribution of Employment in ICT Services in China, 2011

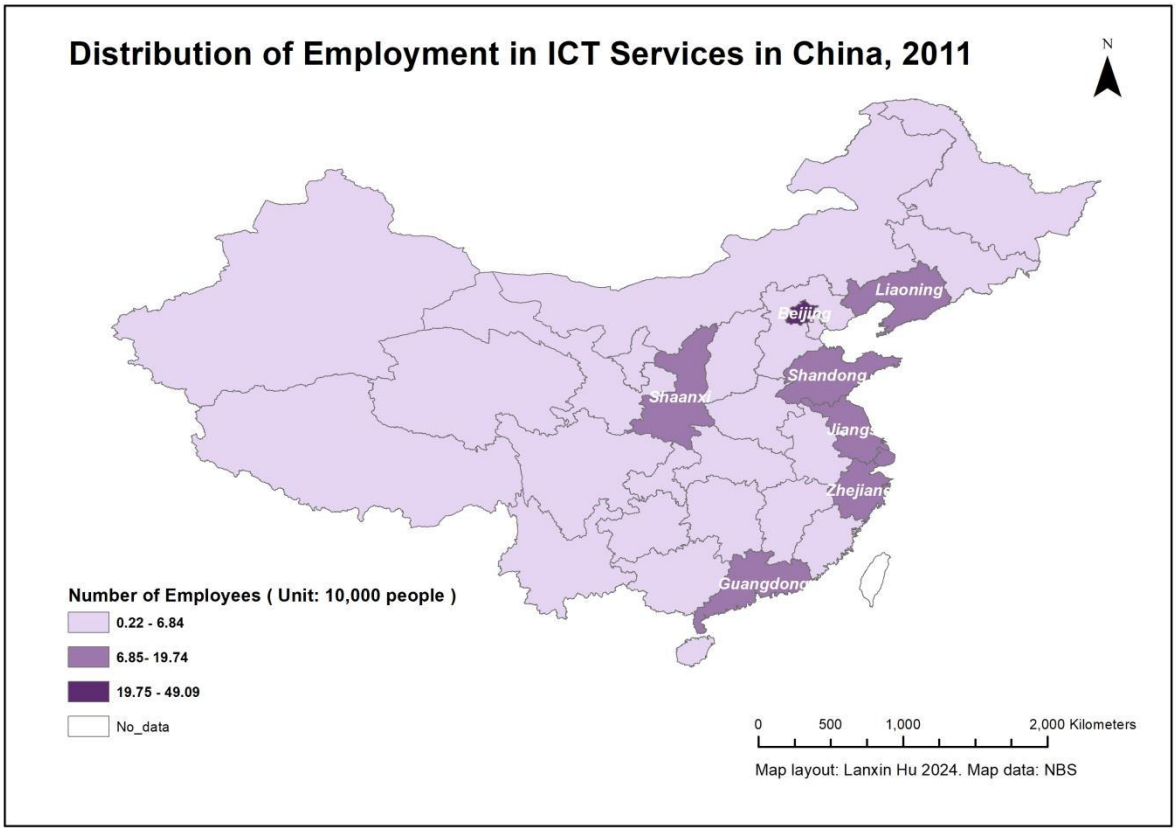
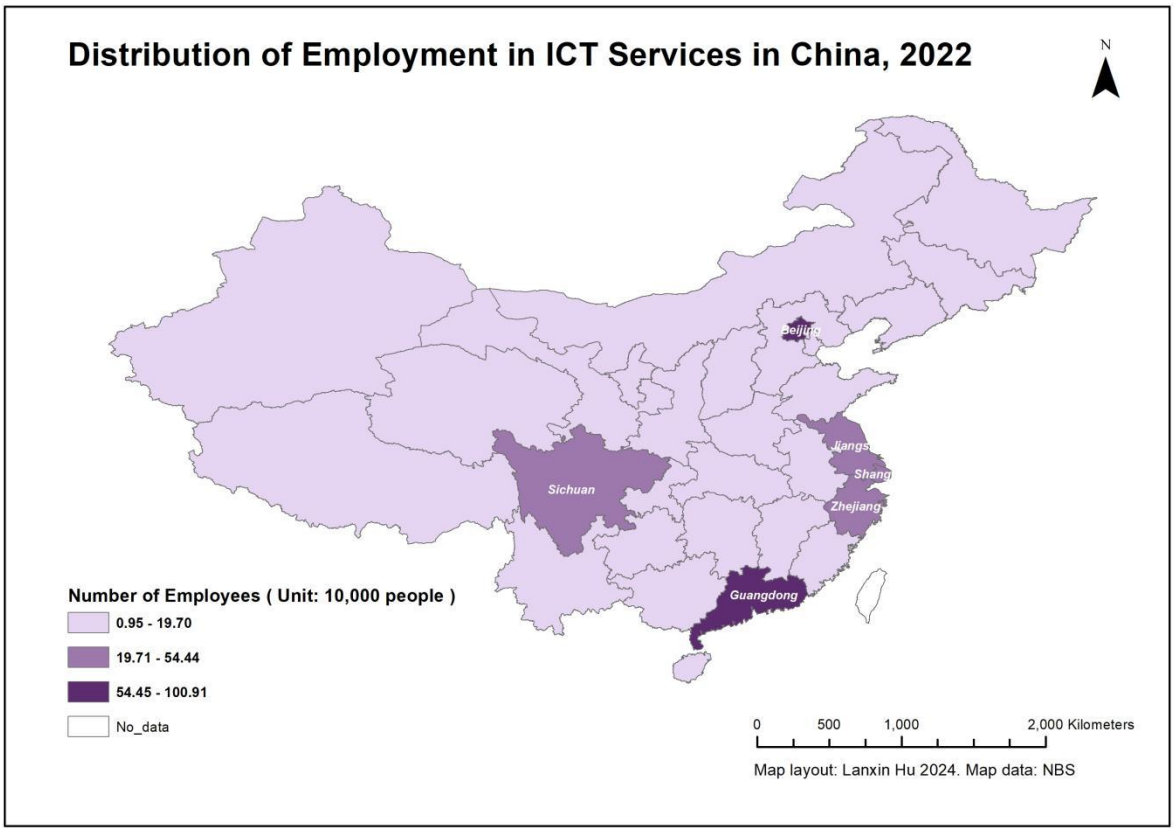


Figure 2. Distribution of Employment in ICT Services in China, 2022



Comparing Figures 1 and 2, it is easy to see that regardless of the year, the distribution of ICT service employment in China is very concentrated, mainly in the southeast coast and Beijing. And the trend of concentration is becoming more and more obvious. In contrast is the vast inland hinterland, where the number of employees has always been relatively small. The provinces that have been able to continuously absorb employment in the ICT industry are not spatially neighboring. On the contrary, this difference in spatial distribution fits right in with China's overall economic spatial disparity, which shows a clear hierarchical character. And most of the regions where employees in this industry are concentrated ,as shown in Table 3, are also at higher regional tiers in Table 2. Beijing, Guangdong, Shanghai, and vast majority provinces that have performed well in the diffusion of ICT are all in the top three tiers of mainland China's regional hierarchy. It does not seem to be a surprise that these economically developed regions have become active ICT regions. The variable happens in the peripheral area. Sichuan Province, in the Southwest Economic Zone, which is located in the penultimate level of the regional hierarchy, has made a leap in the ICT diffusion hierarchy

after around a decade of development, becoming the place with the most ICT service employees in the entire hinterland of the continent, and succeeding in rivaling the eastern coastal areas.

4.3 ICT service industry growth index by province during the study period

The comparison of ICT service industry employment growth index between provinces can understand the vitality and momentum of ICT industry among regions, which is complementary to recognizing the reception of ICT in provinces through the distribution of employment.

Figure 3. Growth indices of ICT services employment by province in China, 2011-2022

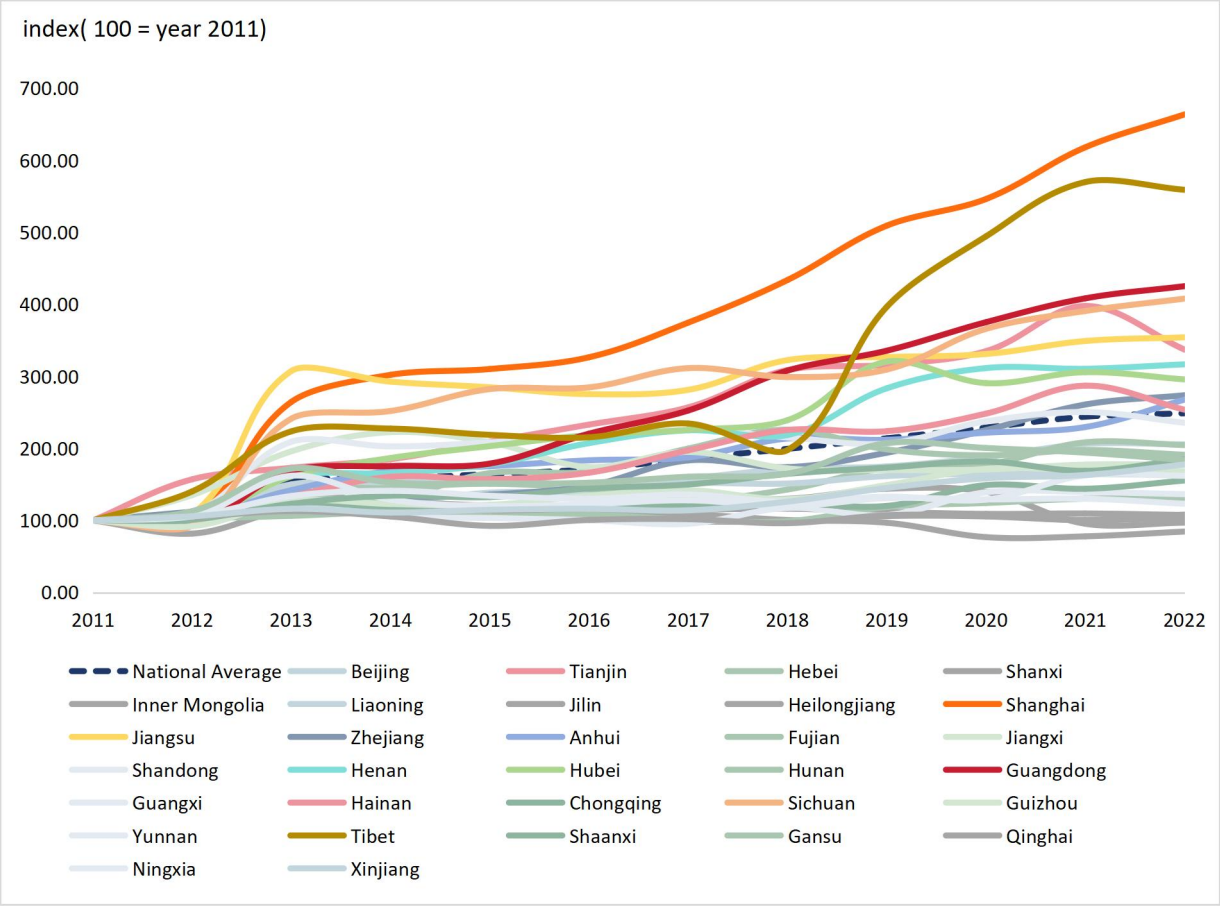


Table 4. Comparison of provinces' ICT growth indices to the national average

Higher than the national average	Lower than the national average
Shanghai, Tibet, Guangdong, Sichuan, Jiangsu, Tianjin, Henan, Hubei, Zhejiang, Anhui, Hainan	Shandong, Beijing, Hebei, Fujian, Shaanxi, Gansu, Xinjiang, Jiangxi, Guizhou, Liaoning, Ningxia, Chongqing, Guangxi, Hunan, Yunnan, Qinghai, Inner Mongolia, Shanxi, Heilongjiang, Jilin

Souce: Oringinal data from National Bureau of Statistics of China. Calculated and made by author.

Looking at Figure 3 as a whole, since 2011, the growth index of ICT service industry in most provinces has been in a state of rise with twists and turns. And a few provinces, such as Jilin, Heilongjiang, Qinghai, and Inner Mongolia, are in reverse growth. By 2022, a total of 11 provinces (Table 4) have exceeded the national average ICT services employment growth index, and these provinces have maintained a high growth rate from the beginning. At the same time, more than half of the regions have growth indices below the national average, and these regions also account for more than half of the population. This indicates that many places still have potential for development in the future, and it also means that the diffusion of ICT in China exhibits significant regional disparities. Such disparities are consistent with the spatial distribution of the absolute number of ICT service industry employees, with provinces that have relatively high employment growth indices also being in relatively high regional tiers. Still, there are some exceptions.

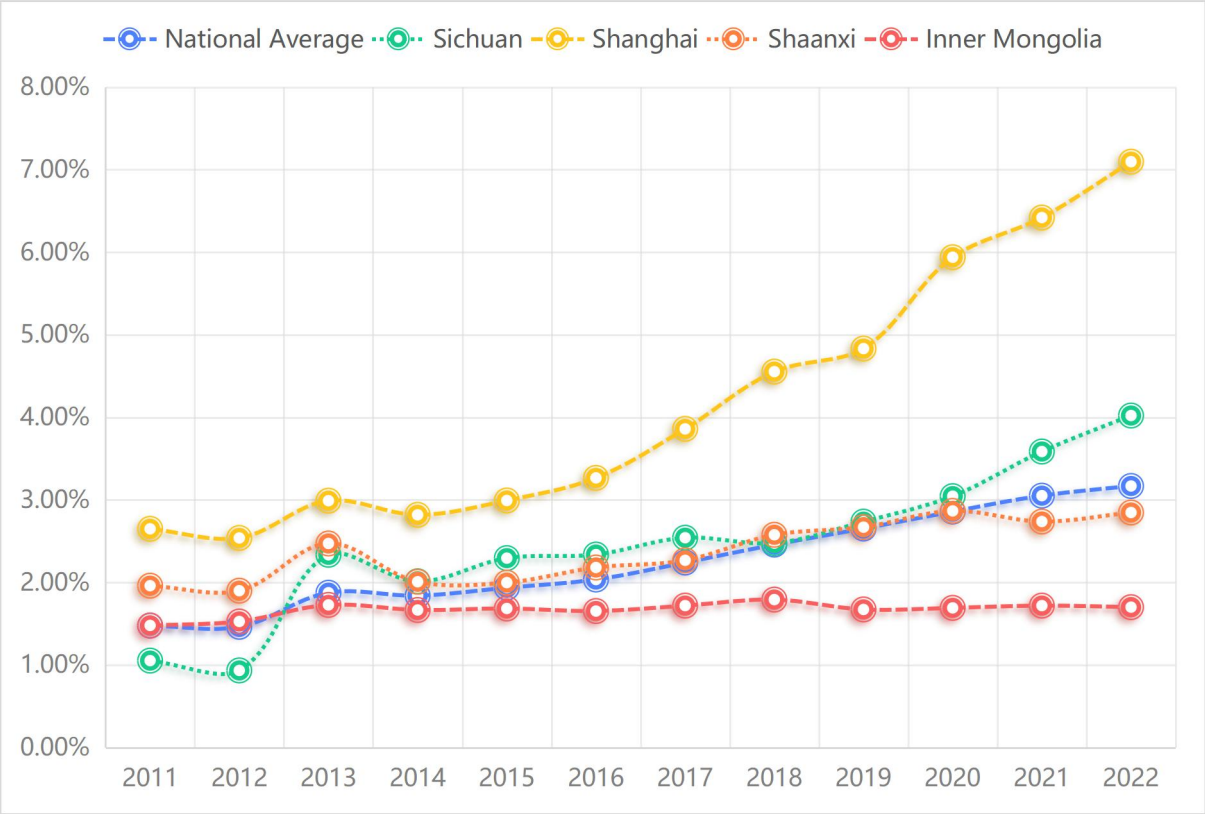
Comparing Tables 3 and 4, two places, Beijing and Tibet, stand out. Beijing, which has the largest number of ICT services employees in the country, has an industry employment growth index that is lower than the national average. Of course the place itself has a large base and has gathered many related employees at the beginning of the study period, which makes it difficult to maintain a high growth rate. Secondly, Shanghai and Guangdong, which also have large bases, still maintain rapid growth, and there is a tendency for the center of gravity of ICT to shift. The situation in Tibet is completely opposite to that of Beijing. An

important reason for such a remarkable growth curve is the very small base. In 2011, it was the province with the smallest number of ICT service workers in the country, at just over 2,000, so a very small increase in absolute numbers can also have a very high growth index. It is also because of this that Tibet, despite its excellent performance in the employment growth index, still does not fall into the category of winners that I am looking for. Comparing Tables 3 and 4 again, I find that one region that has achieved both a rise in tiers and a good growth momentum over the past 11 years is Sichuan. Further insights into the ICT diffusion process in the region follow.

4.4 Cumulative ICT adoption by province during the study period

Comparisons of the spatial distribution of employees as well as the employment growth indices of each province are reflections of the results of ICT diffusion. To better understand the ICT diffusion process, the S-curve, or cumulative adoption curve, of ICT into the regions during the study period is further analyzed next. Sichuan, Shanghai, Shaanxi as well as Inner Mongolia are chosen as references for comparison (Figure 4). Sichuan is a representative of latecomer winners, having achieved its breakthrough in recent years. Shanghai is also represented as a winner, unlike Sichuan, it stays at the top of the ICT diffusion rank sequence for the eleven years from 2011 to 2022. Shaanxi, on the other hand, is represented as a decline, with the province falling from the second to the third level. Inner Mongolia, as a representative of long-term laggards, has always been in the lowest class of ICT diffusion. Because of the short research period, it is difficult to form a complete life cycle of technology diffusion in only eleven years, and it is only possible to have an approximate understanding of the degree of ICT penetration in each province during the period from 2011 to 2022. The vertical coordinate is the proportion of ICT service industry employees to the total employment of the same type (note: the same type refers to employment in urban units), and the horizontal coordinate is time. ICT service industry employees can be interpreted as ICT adopters.

Figure 4. ICT diffusion S curve of the national average, Sichuan, Shanghai, Shaanxi and Inner Mongolia from 2011 to 2022



Souce: Oringinal data from National Bureau of Statistics of China. Calculated and made by author.

In terms of the overall trend of the curve, China's ICT is still in the initial stage of the diffusion process or the transition from initial slow growth to fastest change growth. There are some ups and downs in the middle, but overall it is in an upward trend. the changes around 2013 were more volatile, and then returned to steady after 2015. Over the intervening years, the national average, and the share of ICT service employees everywhere, has seen both large increases and decreases. The reasons for the fluctuations are manifold, but it is difficult to fully identify the causes because of the relatively single indicator used in the study. One of the possible reasons is that the structure of China's ICT industry has been in a phase of great change during these years, and there may have been a remarkable movement of employees between the ICT service industry and the manufacturing industry.

In terms of individual curves, the cumulative ICT adoption curves of different regions have different relationships with the national average at the beginning and end of the study

period. Sichuan's ICT adoption ratio, which was below the national average at the beginning of the period, achieved surpassing it from 2012 to 2013 and has maintained a faster growth rate than the national average. Shaanxi, in contrast, started the period with a higher adoption rate than the national average, even reaching twice that of Sichuan. Later in the period, although growth was still maintained most of the time, it slowed down and was eventually overtaken by Sichuan around 2017 and became below the national level by 2020. Shanghai maintains a very clear and prominent lead from the beginning and has shown faster growth in recent years. Despite starting at the national average, Inner Mongolia has remained at its initial level while the diffusion of ICT over these eleven years has led to an overall increase in the adoption rate across many provinces. The comparison between these different types of regions might indicate that the further the distance from the center, the fewer ICT recipients there are and the slower the rate at which potential recipients become recipients. Distance here is not spatial distance dominated by neighborhood effects, but rather hierarchical distance.

Taken together, the above three comparisons actually give a general idea of the pattern of ICT diffusion in China between 2011 and 2022. In general, the overall number of ICT employees in China is on the rise, reflecting the fact that ICT has also been in a state of progress and continuous diffusion. In spite of that, there are clear regional differences in the speed and efficiency of the rise, again reflecting interregional differences in the ICT diffusion process. Those regions that have benefited more can be categorized into two groups. One category is Beijing, Shanghai, Guangdong, and Jiangsu and Zhejiang. They, as the traditional powerhouses in China's regional development race, have also maintained their leadership in ICT. This just confirms that in the process of diffusion of new technologies, regions with inherently good economic conditions will become the recipients of new technologies earlier and will be able to benefit from them to a greater extent. Another type of region is represented by Sichuan. Traditionally a lagging region, Sichuan has unexpectedly become a recipient of ICT diffusion comparable to the traditional leading region, and has received the radiation of new technologies at an early stage. At the same time, along with the growth of its overall economic level, it has gradually grown into a developed region in a comprehensive

sense. Such a development pattern is characterized by the coexistence of conventional and unconventional factors.

In these two types of regions, those with higher levels of economic development possess certain conventional advantages often considered in discussions of ICT diffusion. These advantages include the overall economic development of the region itself. Further more, infrastructure conditions, and market demand, which are closely related to the regional economic level (Graham & Marvin, 2002; Verma et al., 2023). While regions that were economically underdeveloped in the early stages often lack these conventional drivers. To explain the development of ICT in these regions, we need to turn to unconventional paths. This is why the thesis introduces unusual perspectives on top of classical theories of technology diffusion. Both types of regions can be regarded as regional winners in the ICT diffusion process in China, but the winner that this thesis wants to discuss further is Sichuan, which has unconventional characteristics.

5. Sichuan's Path out of the "box"

Building on the findings of the previous research question, Sichuan has been selected as the case. This section will focus on how the development process in Sichuan has been out of the "box": lagging but relying on new technologies to achieve growth. The previous section can also be seen as an exploration of trends in ICT diffusion at the aggregate level. Trends include both conventional and unconventional components. And we could see the conventional part as a "box". In some discussions of conventional successes, policy and institutional environment is important. However, from countless path studies on economic evolution, policies do not always play a positive role (Etzkowitz & Brisolla, 1999; Iqbal& Starr, 2013; Bergman& Feser, 2020). For the large number of China's backward regions eager to learn from Sichuan's reversal of the experience of the region, that is, the most urgent regions in the new round of technological change in the process of a share of the pie, it is also difficult to put the realization of the breakthrough is entirely dependent on the policy above. Moreover, since this is a discussion of how to get out of the box, I have tried to make the focus a little more unique by also placing it outside the box, focusing on how examples have drawn competence from the backwardness of the past. In other words, that is, how the decaying past of lagging regions plays a role in breaking down the temporal hierarchical order between different regions in the process of ICT diffusion. The discussion starts at the micro level, taking into account empirical research and the actual situation in Sichuan, and analyzes how "new things" affecting the regular circular flow of economic development are introduced to the region from the "past". It is a process of flowing out, accumulating, and returning.

5.1 Micro perspective: labor mobility and accumulation of ICT on individuals

Every action and event of an individual has temporal and spatial properties (Pred, 1997). Assuming that the labor force in each region remains immobile in the local labor market. Then in terms of individual employees, the time sequence of their exposure to ICT will basically be relatively consistent with the regional industries, and the hierarchical differences in the spatial diffusion of the technology will be reflected in the individuals through the impact on employment. In the process of technology diffusion, whether due to the emergence

of new industries or the transformation of old industries, the labor market in high tier regions tends to be greatly enhanced, while low tier regions can only maintain their growth levels under the most favorable circumstances (Henning et al., 2016), and the differences in opportunities between different tiers drive the flow of labor to those regions with a large number of new jobs. When people in lower tier regions move through space to higher tier regions, they have the environment to absorb new technologies.

China's widely varying natural conditions and its extreme dependence on policy for early economic development have led to significant inequality in economic development across regions. Such economic differences are an important reason for people to migrate. As we can see from Table 2, Sichuan belongs to the economic zone with Southwest China, which is one of the regions with the worst level of economic development. According to the Sixth National Population Census (note: the sixth national census receipts were collected at the end of 2010, around one month before the beginning of the research period of this thesis), the population of Sichuan that moved out of the province amounted to 10,505,500 people, which accounted for one-ninth of the province's population. After Anhui, Sichuan is one of the provinces with the most serious population loss in China.

An explanation of what the "Sichuan population" is needed here. When determining where a person is from in the context of mainland China, there are two criteria. One is the place of habitual residence and the other is the place of hukou. Habitual residence can be understood directly and literally as a very everyday concept, referring to the place where an individual actually and regularly lives. Different places may have different standards for the length of time of this type of residence, which in China is generally one year. Hukou location is a concept derived from the household registration system. The modern household registration system in China began as a way for the government to better control the economy, and is strongly characterized by a planned economy. Since the 1980s, the authorities have adopted a more flexible hukou policy, and although the system still differentiates the opportunity structure of the entire population in terms of location within a well-defined spatial hierarchy, people can change their spatial location in order to seek more opportunities (Chen & Selden, 1994). A person's hukou location is typically inherited from their parents, who in turn inherited their hukou location from their own parents. This pattern can

theoretically extend back indefinitely to the inception of the modern hukou system, creating a kind of generational loop reminiscent of a tongue-twister. This humorous analogy highlights how a hukou location often indicates that a family has resided in an area for a substantial period. The population flowing out of Sichuan refers to those whose household registration is in Sichuan but whose usual place of residence is not in Sichuan, in other words, those who used to reside regularly in Sichuan but have since moved to other places. Up to this point, the life course of this part of the population can be divided into two stages and one transition. The turnaround is the choice to migrate, and the two stages are the stage of seeking opportunities locally and the stage of seeking opportunities outside the region.

On the basis of the census data at the beginning of the study period, I have made a brief portrait of this transient population.

a) Age composition is dominated by young adults. The current stage of population mobility in China is essentially the mobility of labor force, and the 2010 census data shows that young people account for the majority of Sichuan's migrant population, with those aged 15-29 accounting for 34.47% of the total migrant population, and those aged 30-39 accounting for 19.94%. Young and middle-aged laborers aged between 15-44 years old are the mainstay of the migrant population, with the proportion of young and middle-aged laborers reaching as high as 64.17%.

b) Occupational composition is dominated by commercial services. The proportion of people engaged in commerce and service industry is the highest among the inter-provincial migrant population, amounting to 40.56%. Operators of production and transportation equipment and related personnel come next, accounting for 25.66%. Other types like those working in agriculture, forestry, animal husbandry, fisheries and water conservancy accounted for only 23.11% in total.

These two demographic characteristics give these outflows from Sichuan Province the potential to become a medium in the ICT diffusion process. In addition to this there is actually another characteristic that I separate from the above two because this characteristic might hinder the reception and diffusion of new technologies by these people.

C) Low educational attainment. The census results show that although the education level of the migrant population aged 6 and above is higher than that of the total population,

still the majority of the population is low-literacy. More than half of the population have junior high school education or less, and 20.01% have senior high school education. Only about one-third of the population has access to higher education.

In China, or it should be said almost everywhere in the world, the vast majority of ICT employees have at least an undergraduate education. The economic mapping project in China by LinkedIn, a social platform for the workplace, has drawn a portrait of Chinese employees from ICT-related jobs across a wide range of industries, including specialized ICT industries as well as parts of other industries that are closely integrated with ICT. And it refers to these people as digital talents (2017). Among all the digital talents registered on the platform, the proportion of employees with less than a bachelor's degree is only 0.6%, and actually most of them are graduate students and above. Even the proportion of employees with doctoral degrees are much higher than the proportion of employees with less than a bachelor's degree, which reaches 2.8%. It can be said that the people who can be associated with ICT have obvious characteristics of high education level. On the other hand, the people who migrate outward from Sichuan show obvious low-education characteristics, with a low level of education. This raises concerns about whether these people can be the medium in the ICT diffusion process. Different individuals have different absorptive capacities for new technologies, and even if they are exposed to something new, not everyone can accumulate and spread it (Lowik, 2017). Not to mention that ICT is high tech, corresponding to high tech talents, and requires a higher level of individual technical wrenching than most common technologies. Fortunately, one of China's often criticized demographic issues: its large population base, plays a role at this time. China is a very populous country, and Sichuan is also a very populous province, with a total population of nearly 100 million at the end of 2010, the fifth largest among the 31 mainland provinces, and more than 10 million people who have migrated outside the province. Even if the potential recipients of ICT represent a low percentage of this population, it is still very large in absolute terms. A large population means a large and varied number of individual life trajectories, with a very large number of possibilities, in which the unexpected can happen to a greater or lesser extent.

So where did these people go. Unlike Anhui, which was the first major outflow province at the time, the Sichuanese traveled much more widely, with their main destination being the

economically developed eastern seaboard. The largest inflow was from Guangdong, accounting for 36.88% of Sichuan's total outflow, followed by Zhejiang with 12.66%. Such a flow tendency is exactly the opposite of the ICT diffusion trend: ICT spreads from leading to lagging regions, while the labor migration in Sichuan is from lagging to leading regions. At the same time there is a slight similarity, with a clear hierarchical effect and a weaker role for the neighborhood effect. Whether it is labor or technology, there is a tendency to choose the best. Individuals want more opportunities, and technology is expected to deliver greater economic benefits.

Both Guangdong and Zhejiang were the center of ICT employees within China around 2011, and were second only to Beijing in terms of the development of the ICT industry, we could know this from RQ1. In other words, it was the center of ICT in China at that time, and ICT overflowed from these places. When ICT was viewed as a general-purpose technology, there was a very high probability that these people would have access to technologies that were more advanced than those in their original regions. At the level of the ICT industry, even so, such an overlap does not yet prove that the people who flowed from Sichuan to these two places or other places with a higher ICT hierarchy than their own are connected to the local ICT industry. This relates to broader issues, such as the extent to which local high-tech industries are receptive to labor form outside. Globally, more positions in the IT industry, which is twinned with ICT, have been allocated to Indian computer specialists, partly because they come from low-cost regions and generally work longer hours, although this can lead to the legitimization of low wages and discrimination in the labor market. A number of region-specific empirical studies have also confirmed the potential of ICT-related industries in developed regions for accommodating expatriates (Krifors, 2019). When potential technology recipients from regions in the lower tiers of the ICT diffusion region come to the higher tier regions and are exposed to technologies that have not yet diffused to the lower tier regions, it also means that in their own timeline they break the original hierarchical order of ICT diffusion and are exposed to something new earlier.

5.2 Time perspective: how changes in an individual's ICT diffusion hierarchy affect the regional ICT diffusion hierarchy

Labor mobility is one of the key mechanisms of technology diffusion and contributes to the form of technology at the regional level (Eriksson et al., 2008), yet as of this discussion, the impact of past poverty in Sichuan is only a massive outflow of labor. Even if these laborers do break away from the regional-level hierarchical sequence of ICT diffusion on an individual level, it has nothing to do with the backward land. And this micro-level breakthrough to the final role of the industry or the region as a whole, but also need a step, a very important step: move back.. In the discussion of "move back", the core issue that needs to be explained is: why go back again. Since we have already placed our sights on a longer timeline, we might as well look farther back and include Sichuan's earlier history in the discussion.

5.2.1 The past lag and the current return

The research time of this thesis is in the period from 2011 to 2022, however many of the potential impact factors were already formed before 2011.

Sichuan has long been considered a backward part of China, known in ancient times as the "land of barbarians," and geographically and economically marginalized. At the beginning of the period covered by this thesis, we can also see that this province ranks second to last in the regional hierarchy (Table 2). China's economic center has always been dominated by small-scale peasant economy, which has stability in small-scale agricultural economy based on family unit, and has formed an agricultural civilization aiming at ease and settlement. Sichuan, as a marginal region, is even more volatile, with population migration activities dating back to the Qin and Han dynasties and experiencing eight large-scale migration waves, the most recent occurring in the late Qing Dynasty. According to the ethnography of Chengdu, the capital of Sichuan, most people in Chengdu in the late Qing Dynasty were descendants of immigrants. These migrations were driven more by war than by the economy, making it easier for Sichuan people to move compare to compared to those in historical economic centers.

Before industrialization, the labor force in southwest Sichuan had a tradition of going

out to make a living. Although Sichuan was far from the economic center, it could not escape the influence of small-scale peasant economy and feudal social system, and the early emigrated population often returned after obtaining economic benefits and continued agricultural production. In this context, the technology accumulated by individuals could not be translated into local technological innovation and development (Office of Sichuan Local Chronicles Compilation Committee, 2021). From the end of the 18th century to the beginning of the 19th century, China's economy entered a transition period, and some areas achieved more efficient production and economic benefits due to modern technology, while Sichuan still riled on traditional technology. Nonetheless, because economic actors are in a specific context inherited from the past (Corpataux & Crevoisier, 2007). The pattern of outflow, accumulation and return due to lack of opportunity that has developed over a long history, ultimately contributed to the formation of the current Sichuan-specific human capital.

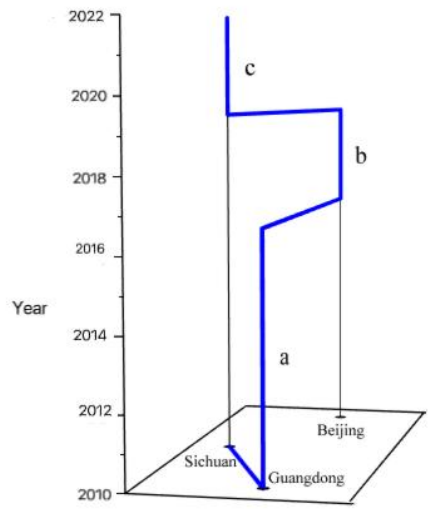
According to the Seventh National Population Census (note: the data collection period for the Seventh National Population Census was at the end of 2020, marking the end period of this study), the resident population of Sichuan Province has increased by approximately 3.61 million compared to ten years ago. During the same period, the natural population growth rate was negative, so this increase in the resident population is due to migration from other regions, including people moving to Sichuan from other provinces and those returning. Although there is currently a lack of comprehensive information on how many of these returning individuals have improved their ICT skills compared to when they left, the internal mobility of employees within large ICT companies such as Huawei indicates that a remarkable number of ICT-skilled workers have returned to Sichuan from higher-tier ICT regions. In particular, Huawei employees, especially those in advanced technical positions, were initially prohibited from returning to work in their hometowns. Starting in 2020, internal management policies were relaxed: "In the future, the professional employees we hire could live locally and choose their place of residence and work freely" (Zhou, 2020). This provided technical staff from less developed areas with the option to return to their hometowns for work. In the same year, the company established an internal ICT talent alliance in Sichuan (Xunfang Technology, 2020). In 2019, Huawei had only 10,000 R&D personnel in the ICT field in Sichuan, but this number rapidly increased to 15,000 by 2020. Some of these were

new local talents, but a remarkable portion were returning employees from the headquarters in Shenzhen, Guangdong (Pang, 2020).

5.2.2 ICT paths of those who left and returned from Sichuan

Next I turned the attention to those individuals who stood out in the group. Liu, the key person interviewed for the study, is the founder of an AI tech company based in Chengdu, Sichuan, and Liu's space-time path between 2011 and 2022 can be seen in Figure 5. Figure 5 does not just include pathways for the 11-year study period, but adjusts the time boundaries to the respondent's actual condition. The space-time path describes the trajectory of individual activities, reflecting the results of activities after overcoming capability, coupling, and authority constraints (Hagerstrand, 1970). The vertical axis represents time, while the horizontal axis is a plane, representing Liu's spatial position at a given point in time.

Figure 5. The space-time path of Liu, from 2010 to 2022



Source: Oringinal data from the interview. Sorted out and made by author.

Liu's life course can be roughly categorized into three periods, before 2010, from 2010 to 2019, and after 2019, which can correspond to the three stages of outflow-technology accumulation-return, respectively. Before 2010, Liu spent his childhood and adolescence in Sichuan. During the period from 2010 to 2017, Liu moved from Sichuan to Guangdong,

where he was still a student, but he moved from middle school stage to higher education stage. In Guangdong, Liu received his bachelor's and master's degrees in computer science. From 2017, Liu's identity shifted from student to employment. After graduation, he streamed from Guangdong to Beijing in search of more job opportunities and managed to join one of the top internet companies in China. Liu worked as an ICT employee in the company until he left the company at the end of 2019. After leaving the company, Liu returned to Sichuan and founded a tech service company that provides industry-specific AI solutions for enterprises, at which point he changed his identity from employee to entrepreneur.

In the above paragraph's description of Liu's life course, it includes the individual time of his own life, i.e. what he did in each year, and the generational time, i.e. his role in society in each year. In addition, the analyses the part about the diffusion of ICT during this period and at the level of the Sichuan population groups are of the historical time in which he lived. As the individual's life time shifted, so did Liu's social time. In the two periods of mobility other than the final return to Sichuan, one was in search of study opportunities and one was in search of job opportunities. And the destinations are both located in the high-level region of the ICT diffusion hierarchy, and even have a tendency to go higher and higher. These two experiences were for Liu the period of his first contact with ICT, and a key stage in his accumulation of ICT as an individual.

(Note: ltalicized parts are ome words from Liu, the original version is Chinese and translated to English by author.)

"When I just arrived in Guangdong, it was completely Grandma Liu entering the Grand View Garden (Note: a traditional Chinese allegory, a metaphor for people who have not seen the world to come to a strange and novel world of flowers and flowers. It is often used to mock someone who is short-sighted or ill-informed. It can also be used as self-deprecating or self-deprecating.) Too many things I haven't touched before. You know QQ (note: an instant messaging software), you may not use QQ today, but more than 10 years ago, it was particularly fashionable. At that time the weekend part-time will pass by Tencent building, every time very excited, is born in this building QQ ah. Later, university organized a visit, took us into the building, and saw those people who I had been out of reach and thought were

very tall, in fact, they were just like us. I thought I could too, and that's when I made up my mind to go down this path."

"Going back to Sichuan to start my own company was partly a matter of luck, but the most important thing was the early accumulation."

When talking about why he chose the AI track, Liu said:

"Because I studied computer science in my undergraduate and master's stages, always been learning this. After graduation, I went to work in Beijing, when China's artificial intelligence was still in the super early development stage, but I happened to be responsible for the creation of an AI content review platform in an Internet company, and I stepped on the tuyere and contacted a lot of cutting-edge things."

Liu is one of the very capable and, as he says himself, lucky ones among the Sichuan outflow population. He is one of the potential ICT recipients among the outflowers. After arriving in a new environment, he has the ability to receive the "newer" ICT and transform it into his own. Returning to Chengdu to start his own business seemed natural to Liu.

"I am Sichuan Meishan people, outside 'floating' for a long time, better understand the good hometown."

"And not only me, but also some of my predecessors have returned to Sichuan from places like Beijing and Shenzhen."

When more people like Liu set out from the low tier regions in the ICT diffusion hierarchy and go to the high tier regions, and then eventually go back. It is like breaking the conventional technology diffusion sequence for those low tier regions, and being exposed to the radiation of new technologies earlier. The reason why they chose to leave Sichuan in the first place, whether they were Sichuanese in history or Sichuanese nowadays, was because of the backwardness of the "past" (note: The past in relative time dimension). The return of modern Sichuanese to Sichuan is also influenced by the contextualization of their historical backwardness.

5.3 Discussion of Other Possible Drivers

"Chengdu, Sichuan is not only a city that is hustle and bustle, but the policy environment is also very suitable for startup ICT companies like our company to take root."

This is another reason why Liu talked about returning to Sichuan. Indeed not every ICT diffusion medium returns as an entrepreneur like Liu. It is still true that regional prerequisites can be an important factor in fueling the return of ICT wrenches as the individual technology diffusion sequence breaks down the regional technology diffusion sequence. Although this might not be a driver that rooted in "lagging" , it is still briefly discussed in this thesis. For there are many factors that would come together to play a role in regional development.

Through Liu's description, I have identified two key words, one is start-up and the other is ICT. Sichuan's economic development environment is attractive to actors with these two characteristics.

The blank industrial base that Sichuan possesses due to its long backwardness, on the contrary, helps the transformation of new things entering the region from the micro level to the industrial level. Because, based on the principle of relevant diversification and differentiation, the existing stock of knowledge and technology in the region delineates the space of possibilities for the creation of new industries in the future. It is often difficult for new industries with weak technological linkages to existing industries to be formed (Boschma et al., 2012). In that case, ICT frontier technologies face fewer obstacles to enter Sichuan and successfully promote new industries.

Meanwhile, between 2011 and 2022, Sichuan's policies on ICT have undergone two adjustments (The People's Government of Sichuan Province, 2012a and The People's Government of Sichuan Province, 2018b). Both policy adjustments had specific regulations explicitly targeting skilled personnel. For the province's key fields of new technology industries and strategic emerging industries, the "the talent leads projects" approach was adopted to attract highly skilled labor to Sichuan through means based on financial assistance and relaxation of restrictive regulations. In 2018, the construction of the ICT industry system in the province and the breakthrough of a number of core key technologies such as high-end chips, sensors, new flat panel displays, and information security were set as a goal. As

mentioned earlier, in the context of China's economy, despite the liberalized role of the market, it is still generally guided by plans. The direction of the plan affects many of the factors that can play a role in ICT diffusion. Capital aspires to higher returns, and one of the reasons why ICT radiates first to economically developed regions is that these regions are able to confer greater economies of scale on technological innovation. So when lagging regions can also make capital profitable through fiscal means, such as lower taxes, it is time to reconsider the flow of ICT in the diffusion process.

6. Conclusion

At the end of the thesis, returning to the research questions raised at the beginning.

The first research question explores the dynamic relationship between ICT diffusion and regional development by analyzing the diffusion trends of ICT at the provincial level in mainland China from 2011 to 2022. Based on the actual conditions of the research area, 31 provinces are classified into different tiers, with higher tiers indicating a higher level of economic development. The employment distribution in the ICT service industry shows a clear regional concentration trend. In terms of absolute numbers of employees, the concentration mostly occurs in high-tier areas such as the southeast coast and Beijing, with only a few low-tier areas achieving breakthroughs. The performance of the ICT service industry growth index in each province is consistent with this trend, and the comparison of this relative data further validates the reliability of the aforementioned conclusions. Additionally, it shows that the diffusion of ICT in mainland China is an ongoing process. And even though low-tier regions have seen positive growth in the number of industry employees exposed to ICT's influence, they still remain at a disadvantage compared to high-tier regions. In the process of ICT diffusion, there are roughly four dynamic types of changes: win-win, lag-win, win-lag, and lag-lag. A comparison between the cumulative acceptance of ICT in representative regions of these four types and the national average further reveals the dynamic development of different regions in the ICT diffusion process. Integrating analyses from these three dimensions, the thesis concludes that the diffusion of ICT in mainland China exhibits a clear hierarchical characteristic. Beijing, Shanghai, and Guangdong, the leading regions in development, are also the areas that first had access to advanced technologies in the diffusion process. At the same time, the facts also prove that there are some outlier regions, like Sichuan, which are underdeveloped but still hold a dominant position in the ICT diffusion process. Therefore, the diffusion of ICT in mainland China does not entirely follow the regional hierarchical order.

The thesis then analyzes the unconventional nature through the second research question, focusing on the specific region of Sichuan. It explains how the regional background of Sichuan facilitated the outflow of labor, the accumulation of ICT skills in higher-tier regions,

and their eventual return to Sichuan. For Sichuan, the regional limitations on its participation in ICT diffusion mainly manifest through the hierarchical patterns of ICT diffusion across different tiers of regions, which is the conventional scenario discussed in the first research question and the "box" most regions find themselves in. What potentially enabled Sichuan to step out of this "box" are the individuals who flowed to regions with earlier ICT exposure to accumulate technology before eventually returning. The reasons for this outflow and return are closely related to Sichuan's early backwardness. The historical backwardness, within the political and economic context of the time, led Sichuan people to form the economic activity habit of seeking opportunities externally and then returning. The backwardness at the start of the study period might have also motivated Sichuanese to move to higher-tier regions to gain opportunities for technological accumulation, then return to Sichuan under the influence of long-established regional habits. It is also crucial to point out that the factors impacting population mobility in modern society are more complex, and these are briefly discussed at end.

Overall, the study enriches the field of technology diffusion and regional development, although it is a theme that has already been extensively developed. ICT is a contemporary technological hotspot. Moreover, whether it is the diffusion of technology or regional development, it is a spatial behavior, so the different political, economic, and cultural backgrounds of the regions studied will impact their relationship. China has a unique political and economic system. Although it has implemented marketization, the government still plays an overall regulatory role in economic development, which has diminished scholars' interest in unconventional cases. Despite that, the reality is that most regions that have not received government support. If these regions want to develop through technological innovation in the information age, need to learn from these unconventional experiences. Additionally, the research framework of this study is built on the foundation of classic diffusion theory while also introducing some uncommon perspectives. Instead of discussing the connection between technology and regional development from the meso-level of industry, it focuses on the role of individuals and draws time inspiration from evolutionary economic geography and life course theories concerning migrant populations in discussing the role of individuals.

Even so, while reviewing the possible contributions of the thesis, I also recognize some

of its shortcomings. Firstly, data limitations are a remarkable issue. Although the study used official Chinese statistical data to track employment changes in the ICT industry, the dataset has limitations in some respects. For instance, data from the ICT manufacturing sector was not fully included in the analysis, which may affect the comprehensive understanding of the dynamics of the entire ICT industry. Secondly, qualitative analysis was introduced in the Sichuan case, but the interview part only with a very small sample size. More extensive interviews might help to more deeply reflect the specific mechanisms and motivations behind unconventional success paths. Rather than simply illustrating them as this thesis did. The consideration of policy impacts is also a bound. Even if the role of policy and institutional environments was analyzed, there is a lack of systematic discussion on how specific policies affect the ICT diffusion and how these policy changes interact with regional development strategies. Plus this might be a direction for further deepening in future research.

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Appendix

1. What has been your life trajectory since leaving Sichuan? Include some of the following elements:

a. Timing of each shift

b. Changes in location (habitual residence)

c.Changes in social roles (if any)

d. your own relationship with ICT

2. what were the reasons for each shift? For example, why did you choose to leave from Sichuan in the first place and why did you choose to come back.