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MACHINE TRANSLATION TECHNOLO GY AND THE PERFORMANCE OF LANG UAGE SERVICE PROVIDERS

ABSTRACT

Along with the rapid development of machine translation technology, language service providers have met with great opportunities and challenges. In this context, from the perspective of creative destruction, the study analyzes the relationship between the technological progress of machine translation and the performance impact of language service providers theoretically and empirically.

The objective of the thesis is to study whether the active adoption of advanced machine translation technologies can improve the performance of language service providers in the long run. The role of machine translation technology in the language service industry is indispensable.

Based on Schumpeter's theory of innovation and from the perspective of creative destruction, the study proposes the concepts of "positive transformation outcomes" and "negative transformation outcomes" of machine translation technology on traditional language service providers. On the one hand, many high-tech companies enter into the language service industry by taking the advantage of machine translation technology, bringing competitive pressure on traditional language service providers, which is considered as "negative transformation outcomes". On the other hand, traditional language service providers themselves can improve translation efficiency, reduce costs and expand business line by adopting the advanced machine translation technology, which is considered as "positive transformation outcomes". The study then collects data from the real language service providers and empirically evaluates the net impact of machine translation technology on the performance of language service providers. The case study based on the business revenue data and the development trend information of two famous language service providers demonstrates that the language service provider that adopts the advanced machine translation technology could significantly increase the business revenue and promote positive development, while the language service provider that avoid the new technology could result in the business revenue decline and development stagnation. The results indicate to some extend that currently the positive impact of the "positive transformation outcomes" from machine translation technology have already exceeded the negative impact of the "negative transformation outcomes" lead by machine translation technology. The role of machine translation technology should be paid more attention, especially within language service providers.

The study firstly gives a full understanding of the language service industry and machine translation technology by literature study, which is based on the predecessors' work. Then the study creates a research framework for analyzing the performance of language service providers based on the theory of creative destruction, which provides a new method for studying the language service industry and its providers. The research findings of this study also have an important significance for language service providers, high tech companies, and the policy makers of the language service industry.

Keywords: machine translation, language service provider, statistical machine translation, neural machine translation, corpus, translation memory, creative destruction

The originality of this thesis has been checked using the Turnitin Originality Check service.

PREFACE

The thesis was written as a summary of my ten years translator work. I was always interested in translation, but never thought I could do it for such a long time. During the work, I witnessed and experienced the leaps and bounds of machine translation technology within the language service industry. At first, I thought it is the translators who changed the machine, while actually, it is the machine who changed the translators and the industry as a whole. By writing the thesis, I satisfied my self-interest to have a more detailed research of the language service industry and machine translation technology. In addition, I also objectively pointed out the important role of machine translation and the great value it has created and has been creating for the industry and the whole world.

The thesis was done in the help of many people. Firstly, I would like to thank Professor Leena Aarikka-Stenroos and doctor Ulla Saari for their patience and detailed guidance, which made my thesis from mediocre to brilliant. Professor Leena is a flexible professional, who inspired me a lot in my writing work. Doctor Ulla also has a great passion for my research topic and gave me many profound suggestions. Besides, I also have to thank for my husband, who went to Finland to help me during such exceptional circumstances.

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LIST OF SYMBOLS AND ABBREVIATIONS

ALPAC   Automatic Language Processing Advisory Committee

SMT   Statistical Machine Translation

CAT   Computer Aided Translation

TM   Translation Memory

NMT   Neural Machine Translation

PESTEL   Politics Economics Society Technology Environment Legal

RMBT   Rule-Based Machine Translation

CMBT   Corpus-Based Machine Translation

GNMT   Google Neural Machine Translation

MSMT   Multi-Strategy Machine Translation

KPI   Key Performance Indicator

API   Application Programming Interface

M&A   Merger and acquisition

1. INTRODUCTION

Currently, the global language service industry is within booming stage. The advancement of information technology has greatly promoted the development of language services industry by accelerating its production efficiency. In 2019, the total revenue of the global language service industry reached 49 600 000 000 US dollars (Common Sense Advisory, 2019), which hits a new record in the history. With the rapid development of globalization and technology, the language service industry not only generates a huge value itself, but also radiates and drives the development of the upstream and downstream industries, which continuously brings more affiliated value. As the basic pillar industry of social and economic development, the language service industry has attracted more and more attention. While as a major technological innovation within the language service industry, machine translation technology is an important driving force for the development of the language service industry, and its impact is getting harder to be ignored, especially to the individual language service providers. Therefore, the study will focus on the micro subjects – language service providers. The study uses interdisciplinary study methods to analyse the impact of machine translation on the performance of language service providers.

1.1   Study Background

Technological innovation is a major driving force of the language service industry, while machine translation is an important representation of technological innovation and revolution. The concept of machine translation was born as early as the 1930s, but it was not until the 1950s that machine translation became a reality based on the application of computer (Hutchins, 2004). In the late 1980s, computer aided translation (CAT) technology, represented by translation memory (TM), was practically used in the language service industry and became an important tool for professional translators (Hutchins, 1986). From 1990, statical machine translation (SMT) developed rapidly, since Brown et al. (1990) of IBM proposed the SMT method based on the idea of source-channel model. However, the method still has some defects such as high dependence on database and relatively low quality. In 2013, Kalchbrenner and Blunsom (2013) proposed the coding and decoding framework for end-to-end neural network machine translation (NMT), which triggered an upsurge in NMT research. After 3 years, Google company replaced its SMT system with newly

developed Google Neural Machine Translation (GNMT) system in Google Translate, which marks the formal commercialization of NMT technology (Wu et al., 2016). In recent years, NMT has greatly improved the translation quality, significantly surpassed SMT in many aspects and gradually approaching human translation level. Therefore, NMT technology has been rapidly promoted and applied on many famous machine translation platforms such as Google Translate, Bing Translate, YouDao Translate and Baidu Translate. The development and application of machine translation technology has brought profound and overwhelming impact to the language service industry (Hutchins, 1998; Bowker, 2002; Kenny, 2011).

In retrospect, the wide application of CAT technology enables language service providers to enhance the efficiency of translation through human-computer interaction and computer assisted human mode. After that, the popularization and application of SMT technology and its quality improvement effect make some language service providers gradually adopt "machine translation plus human post revision" production mode to improve the efficiency (Beaton & Contreras, 2010; Garcia, 2011; Cui, 2014; Depalma et al., 2017). This production model has produced a large number of excellent translators, rather than an improvement in machine translation technology itself. As a result, there is still a big gap between the quality of SMT and that of human translation, which limits the application of machine translation based SMT in the language service industry (Mireia et al., 2011). In recent years, the rapid development and gradual commercialization of NMT has improved the quality of machine translation fundamentally, which further deepened the impact of machine translation technology to the language service industry (Wu et al., 2016). However, these impacts can be summarized from the negative aspects and the positive aspects (Meer, 2003; Sharoff, 2007; Petukhova et al., 2012; Luo et al., 2018; Randhawa et al., 2013; Turner et al., 2014).

From the negative aspects, in the context that machine translation quality has achieved great progress, high-tech companies as Google, Baidu, Amazon and other famous internet companies who are outsiders of the language service industry before will enter into the language service market by taking the advantage of machine translation platforms, which are for example convenient, low or no charge, relatively sufficient quality, etc, which will undoubtedly intensify the competition within the language service industry, because these new and powerful entrants will definitely snatch the market share of traditional language service providers (Randhawa et al., 2013; Turner et al., 2014). From positive aspects, machine translation is playing an increasingly important role in supporting human translation. Especially the recent NMT technology, whose translation quality has been so impressive, which could greatly reduce the workload and working time of human

post revision part in the current mainstream "machine translation plus human post revision" production mode (Wu et al., 2016). Therefore, the adoption of machine translation technology can improve work efficiency, thereby expanding the space to increase business volume and enhance market competitiveness (Olohan, 2007).

On the other hand, instead of the market shrinking caused by the powerful competitors, the overall market for language services industry is probably to expand due to the adoption of machine translation technology. Some language service segments that have been neglected or even abandoned because of the unachievable efficiency and unreasonable cost of human translation, such as the on-site translation of overseas travel, localization of e-commerce website, instant translation of social media messages, etc., have achieved rapid growth along with the maturity of machine translation technology (Esselink, 2000). From this consideration, machine translation technology actually created new market segment for the language service industry. While considering many quality deficiencies of the current machine translation technology, human work is still needed for this new market segment, such as review and revise the work of machine translation. Therefore, for traditional language service providers, no matter whether or not they adopt machine translation in their production process, they will enjoy the benefit from the increased market volume. Facing with the positive and negative aspects of machine translation technology, the net impact of machine translation technology on the performance of language service providers is uncertain.

According to economist Joseph Alois Schumpeter's innovation theory (1934), innovation is a process of creative destruction, which is a basic phenomenon of economic development. Innovation is constantly destroying the existing economic order and pattern, meanwhile fostering a new economic order and pattern. Based on the mechanism, the economic system could innovate from inside and eventually grow up. As an important technological innovation, machine translation will also bring "creative destruction" to the language service industry. Though scholars generally agree that innovation could boost economic growth, especially in the long run (Aghion & Howitt, 1992; Carnoy, 1997; Segerstrom, 2000; Peretto, 2003; Cho et al., 2005; Prajogo, 2006), but in practice, it is very difficult to define the actual effect of the creative development within a particular company and to its future performance. In Schumpeter's creative destruction theory, the final outcome of an innovative company is depended on the game between positive effects and negative effects (Cox & Alm, 1992; Aghion & Howitt, 1992), and the factors that affect the success and loss are very diverse, all the elements in PESTEL macro-environment framework could play a part, which brings very high uncertainty (Huang & Rice, 2009; Otero-Neira et al., 2009). Therefore, the thesis uses Schumpeter's creative destruction theory as the theoretical basis and evaluates

the net impact of machine translation technology to the performance of language service providers in the current macro-environment by comparing the positive and negative aspects, so as to clarify the significance of machine translation technology to language service providers. Then, to correctly guide the decision makers and investigators within the language service industry.

1.2   Study Objective

According to economist Schumpeter's innovation theory, innovation is a process of creative destruction, which is a basic phenomenon of economic development (Schumpeter, 1934). The core of the theory is that innovation constantly destroying the existing economic order and structure, meanwhile fostering a new economic order and structure. Based on the mechanism, the economic system could innovate from the inside and eventually grow up (Schumpeter, 1934; Aghion & Howitt, 1992). As an important technology innovation, machine translation will also bring "creative destruction" to the language service industry.

But when studying individual language service companies, the mechanism of creative destruction is not work directly on the performance of language service providers, but driven by its mediating effects (Liao & Rice, 2010), i.e., the final outcome of machine translation technology to the performance of language service providers is not deterministic, but mediated by the transformation outcomes from positive and negative aspects. Innovation triggered impact, no matter positively or negatively, can drive a company only when the actual changes really happened in the market position and offerings of the companies (Neely et al., 2001; Zott, 2003; Gunday et al., 2011). The thesis employed two types of transformation outcomes for each of positive and negative aspects respectively, namely the threat of new entrants and the threat of substitutes under negative transformation outcomes, meanwhile, lower cost and high efficiency under positive transformation outcomes (figure 1).
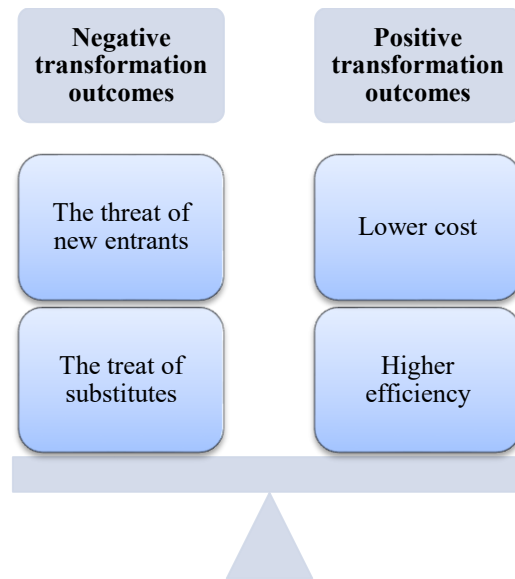
Figure 1. *Figure The transformation outcomes triggered by machine translation technology within the language service industry.*

On the one hand, high-tech outsiders such as Google, Microsoft, Amazon, Baidu etc. have entered the language service industry with the help of machine translation technology and become strong competitors of language service providers, which might have a direct negative impact on the latter by forming the threat of new entrants. Meanwhile, as machine translation becomes more and more intelligent, human translation work is facing with the threat of being replaced by machine translation, which forms the threat of substitute. Both of these are the negative transformation outcomes of machine translation technology. On the other hand, language service providers can increase translation efficiency, reduce cost, then expand business volume by adopting machine translation technologies (Gaspari & Hutchins, 2007). The study calls these impacts the positive transformation outcomes.

By targeting the negative and positive transformation outcomes, and analyzing their mediating effects, the thesis aims to study…

…whether the active adoption of advanced machine translation technologies can improve the performance of language service providers in the long run.

In order to achieve the study objective, the thesis will mainly find ways to answer the following question:

What is the net impact of machine translation technology to the performance of language service providers?

Specifically, the thesis selects a commonly used business key performance indictor - business revenue - to evaluate the performance of language service providers. Meanwhile, the thesis also focuses on the long-term economic development trend of language service providers, aiming to answer the following specific questions concretely through qualitative and quantitative study:

Question 1. How does machine translation technology affect the business revenue of language service providers?

Question2. How does machine translation technology affect the long-term economic growth of language service providers?

To address the objective, the thesis firstly reviews the previous relevant studies, summarizes the uncertain status or the research gap within academic and industrial fields on the relationship between machine translation technology and the language service industry. Then based on creative destruction theory and mediating effects, the thesis establishes an analysis framework, attempts to clarify the net impact of machine translation technology on the performance of language service providers. After that, to actually verify the framework, the author selects two typical language service providers as the case study object. The two language service providers treat machine translation technology with entirely different attitudes. By combining the specific language service provider's development track within the refined framework, and then comparing the business revenue growth and the economic development trend of the two language service providers, the thesis confirms that a positive attitude towards machine translation technology could improve the performance of language service providers. Besides, through the collection of company development data over the years, the thesis also quantitatively verifies that the advanced machine translation technology could support a long-term sound development of language service providers.

1.3   Structure Of The Thesis

Based on the review and analysis of the language service industry and machine translation technology, the thesis focuses on discussing how machine translation technology affects the performance of language service providers. In order to clearly discuss the net impact of machine translation technology on the performance of language service providers, the study is divided into the following five parts (figure 2).

Chapter 1 is the introduction of the study. It makes a general overview of the thesis from the study background, study objective and structure of the thesis.

Chapter 2 is the literature review and analysis. It systematically reviews and analyzes the already published studies and the latest information on the definition, development history, market status and the prospect of the language service industry and machine translation technology. Then, it focuses on the discussion of the interactions and relationships between the two, to find out the study gap within academic and industrial fields.

Chapter 3 establishes the analysis framework of the study. It introduces the theoretical basis, i.e., Schumpeter's innovation theory and the theory of creative destruction. Then, it applies the classic mediating effect model to build an analysis framework of the study, aiming to find out the root of the study gap discussed above and try to address the problem by further empirical study under the guidance of the framework. In order to facilitate the research procedure, the analysis framework is refined by fitting it into the specific environment of the language service industry and further finding out the important influence factors.

Chapter 4 describes the empirical study of the relationship between machine translation technology and the performance of language service providers. It begins with the data collection methods, which plans to be used in the study, then it listed the specific questions that need to be solved in the empirical study. Finally, the thesis applies the refined analysis framework in two case companies, which react differently when facing with the development machine translation technology. By comparing the performance outcomes from the study framework, the study objective was confirmed.

Chapter 5 summarizes and discusses the main findings of the study. In the chapter, the study design and the research track are discussed again to clarify how the objective of the study is finally argued.

Chapter 6 is the conclusion of the thesis. It summarizes the contributions and implication of the study. On this basis, the chapter further provides recommendations to the language service providers, high-tech companies and industrial policy makers. Finally, the limitations of the study are pointed out and the future research directions are prospected.
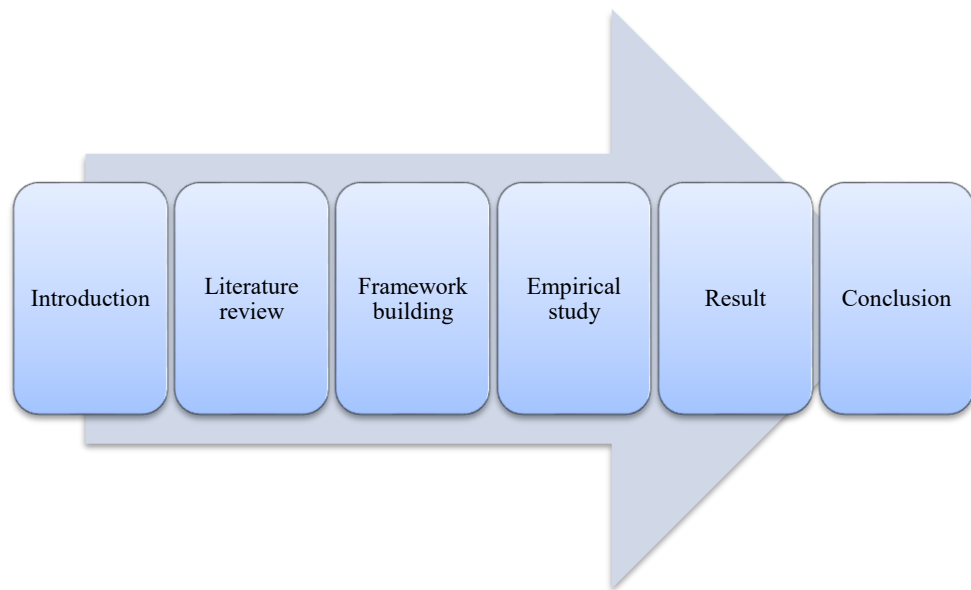
Figure 2. *The structure of the thesis.*

2. LITERATURE REVIEW AND ANALYSIS

The chapter systematically reviews and analyzes the already published studies and the latest information about the definition, developing history, market status and the prospect of the language service industry and machine translation technology. Then, it mainly focuses on the previous studies on the interactions and relationships between the two.

2.1   An Overview Of The Language Service Industry

There are more than 200 countries, 7 billion people and 7000 languages in the world (data resource: Common Sense Advisory). Each country has its own language and culture. In order to bridge the countries, language service comes into being. For the past few years, the language service industry developed rapidly along with the technological and economic progress. Now the language service industry has become a basic industry in the era of globalization. The section will summarize the previous studies about the definition, development and market profile of the language service industry, then based on the PESTEL framework, the section will look into the future of the language service industry from the latest information of the political, economic, social, technological, environmental and legal macro-environment. The main purpose of the section is to have an overall understanding of the language service industry.

2.1.1   The Definition Of The Language Service Industry

A clear and unified definition for the language service industry has not yet been established, because it is a new and emerging service field. Olohan (2007) firstly proposed the concept of translation industry. According to Olohan (2007), translation industry covers businesses carrying out activities which require a high degree of expertise and training in translation. Then, Directorate General for Translation of the European Commission (2009) pointed out that language industry including translation, interpreting, software localization and website globalization, as well as language technology tool development, language teaching and linguistic issues consultation. Dunne (2012) also agrees that the services provided by translation industry include document translation and website localization. In the literature of recent years, Zhang (2018) believes that the language service industry is an industry which satisfies life and business demands by providing translation

and localization services, language consulting and training services, as well as language technology development and application services. In addition, market and business research organizations also published their research work in language industry and language service market. IBIS-World presented in its 2014 research report that translation industry includes companies that translate written material and interpret speech from one language to another. In addition, it also includes companies that provide sign language services (IBISWord, 2014). While Common Sense Advisory - the most authoritative translation market research company - published in its 2017 yearly report that language service market includes language services, language technology services and non-language services (Common Sense Advisory, 2017).

By summarizing and comparing the definitions of experts and institutions from various fields, the author realized that all of them are trying to differentiate and define the language service industry by specifying its working content and business line. In a broad sense, the language service industry includes all the related organizations in the industry chain, while in a narrow sense, the language service industry only includes companies and institutions, which provide language translation service, technology developing service, as well as training and consulting service.

In conclusion, the study defined language service and the language service industry as the following:

> Language service is a kind of cross-linguistic and cross-cultural information conversion service. Language service industry is an industry providing translation and localization service, translation technology developing service, language training and education service, as well as multilingual information consulting service.

The purpose of language service is to enable communication and integration cross-linguistically and cross-culturally. The providers of language service include companies and individuals providing language service and developing translation technology. The author, who worked as a freelance translator is also a mini-scale language service provider within the language service industry.

2.1.2 The Development Of The Language Service Industry

Strictly speaking, the language service industry has already emerged when the trade activities started thousands of years ago (Thomas, 1817). After that, the language service industry devel-

oped constantly along with the development of international communication and economic collaboration. The introduction of computer technology during World War II and the advancement of information technology after that triggered the rapid escalation of the language service industry (Richard, 2016). Then, the emerging of machine translation changed the whole industry fundamentally, it represents a revolutionary technological change of the language service industry (Wu et al., 2016).

The efficiency of translation work is very low for a long time in language service history, because all work has to be done manually. In addition, human translation also tends to make errors. Along with economic globalization, the demand for translation service is not only increased in quantity but also in quality. The price of inadequate translation quality is extremely high. Because inappropriate translation might lead to reputation damage, lawsuit, capital loss, and even business calamity. Therefore, an efficient and accurate trans-linguistic communication is getting increasingly important, a big amount of money and resources have been invested into the language service industry (Lawrence, 2012).

In 1946, the invention of the world's first computer ENIAC set the foundation for machine translation. In 1954, the first machine translation experiment was completed under the cooperation of Georgetown University and IBM company, which kicked off the active research of machine translation (Wu et al., 2016).

While machine translation has not developed without hiccups. In 1966, the famous ALPAC (Automatic Language Processing Advisory Committee) reported that the quality of machine translation is far worse than human translation. Machine translation is expensive, inaccurate and hopeless. Besides, ALPAC also suggested to stop the investment in machine translation research (Pierce et al., 1966). Since then, machine translation was deserted for a period of time, and human translation is still the main working mode in the language service industry.

In the start of 1990s, IBM company proposed the SMT technology (Brown et al., 1990), which became a hottest research topic. Because SMT is far more efficient and accurate than all the machine translation methods before. After continuous improvement, SMT has been used extensively in today's language service industry. The author has been worked as a life science translator from 2011 for a famous SMT based language service provider, and almost all the author's translation work was done with its self-developed SMT translation software, which is the mostly adopted

CAT tool in the language service industry. Till now, a lot of language service providers still use SMT tool as their main working tool. While from the author's usage experience, there is always a big gap of translation quality between SMT and human translation. In addition, SMT is overly dependent on corpus and TM. As a result, SMT plus human post revision is more reasonable to ensure the final translation quality and was broad adopted within the language service industry. As of 2017, 30% of language service providers provided human post revision service, and 4.2% of the total industry revenue has been made from it (Depalma et al., 2017).

In 2013, Kalchbrenner and Blunsom proposed the coding and decoding framework for end-to-end neural network machine translation (Kalchbrenner & Blunsom, 2013), which raised the concern of Google company immediately. After intensive research and development, in 2016, Google launched its NMT system, which is a breakthrough not only to the technology but also to the whole translation service industry. The final translation result of NMT technology surpassed traditional machine translation in almost all aspects, and its translation quality is approaching to human translation gradually and continuously (Wu et al., 2016). Because of the superiority of NMT, many large and well-known enterprises as Google, Microsoft, Baidu, IBM, Facebook, Amazon, SDL, Youdao etc. adopted NMT technology, most of them were not active players of the language service industry before.

The breakthrough of machine translation technology has increased the efficiency and quality of translation substantially. So far, cheap and fast machine translation could be reached by almost all the people. Meanwhile all kinds of powerful translation tools were also commercialized constantly. The language service industry has entered into an unprecedented era of prosperity.

2.1.3 The Market Profile Of The Language Service Industry

According to the statistical data of Common Sense Advisor (2019), the rapid growth trend of the language service industry emerged in 2009 and 2012. After two big ups and downs, the industry starts to grow steadily and slowly (figure 3).
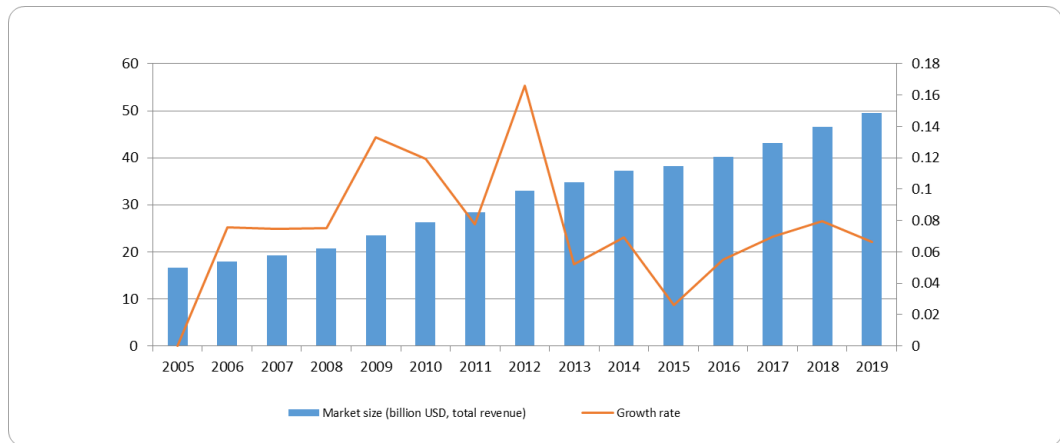
Figure 3. *The market size and growth rate of the global language service industry 2005-2019 (Data source: Common Sense Advisor)*

The revenue growth trend in figure 3 indicates from one side that the language service industry is transforming from growth stage to maturity stage in the industry life cycle (figure 4), and several features of the transformation have presented.
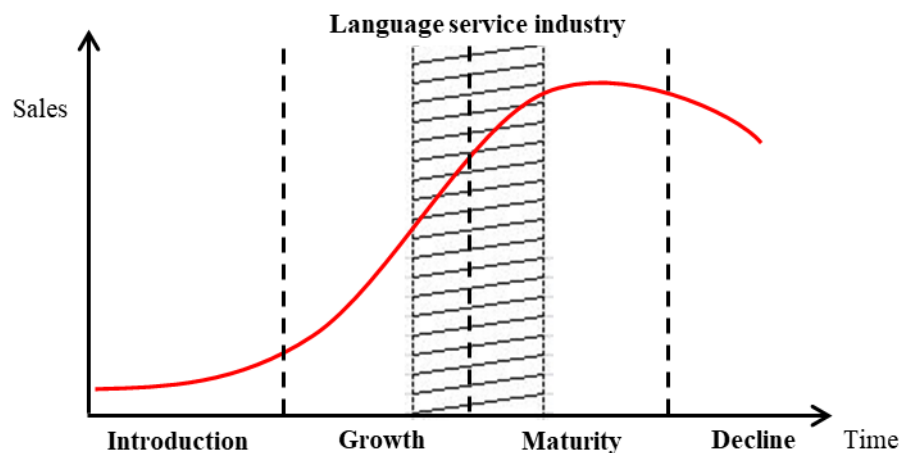
Figure 4. *The current position of the language service industry in industry life cycle (modified according to Porter, 1980, p.156).*

The most obvious phenomenon is the formation of buyer's market, which puts forwards with even higher requirements to language service providers. Firstly, customer demand highly diversified (Common Sense Advisor, 2019; Luz, 2019). Many customers are no longer satisfied with the traditional translation service, but ask the language service providers to provide turn key solutions based on their specific needs. This kind of customized service requires extremely strong multi-capability from language service providers. The second challenge within language service market

is the growth of mega projects (Common Sense Advisor, 2019). The frequent economic, cultural and technology exchange activities in the modern world brought unprecedented demand for language service, the international mega events are getting more and more. As a result, the language service companies need to have even higher throughput, more efficient working procedure and stricter cost control, so as to be qualified for the mega projects. Another core capacity for language service providers is the cross-border cooperation capacity (Common Sense Advisor, 2019). Along with the dramatic development of artificial intelligence, the language service project itself is getting more and more complex. These complex projects need not only linguistic experts, but also experts from other areas. Therefore, the modern language service providers need to integrate multidiscipline resources, so as to survive in the industry.

Another reflexion for the transformation of the language service industry is the large number of entrants and the intensify of competition. According to the data from Common Sense Advisory，currently there are more than 30 000 language service providers around the wrold, and the total revenue of top 100 language service providers takes no more than 20% of the whole market revenue, and the highest record of the number was appeared in 2019, which is 15.7% (Common Sense Advisory, 2019). While according to industrial economist Bain's Company Concentration Rate criteria, if the top 8 companies within an industry takes no more than 20% of the market share, then it could be sure that the industry is decentralized (Bain, 1956). Therefore, it could be confirmed that the language service industry is a typical decentralized industry. Besides, in the recent 10 years, the top 5 language service companies globally are changing all the time (table 1), which indirectly reflected the high mobility and the intensive competition within the industry.

Table 1. *The top 5 language service providers 2005-2019 (Data source: Common Sense Advisor).*

Rank	2019	2018	2017	2013	2009	2005
1	TransPerfect	TransPerfect	Lionbridge	Lionbridge	Global Linguist Solutions	Lionbridge
2	Lionbridge	Lionbridge	TransPerfect	HPE ACG	Lionbridge	L-3 Communications
3	Language-Line Solutions	Language-Line Solutions	HPE ACG	TransPerfect	L-3 Communications	SDL
4	SDL	SDL	Language-Line Solutions	SDL	SDL	STAR Group

				Language-Line Solu-tions	LanguageLine Solutions	RWS
5	RWS	RWS	SDL			

From economics theory, the perfect competition market is considered as the most effective market structure (Gerard, 1972). While when reviewing today's market, the various competitive behaviours of the companies drive the market to move away from perfect competition and enter into fierce monopoly (Ukav, 2017). But competition is not absolute negative. In today's world, monopolistic competition market and oligopoly market are the predominant market structures which located between perfect competition market and monopoly market (Al-Obaidan, 2008). The language service industry shares more features of monopolistic competition, which is still a healthy competition (figure 5).
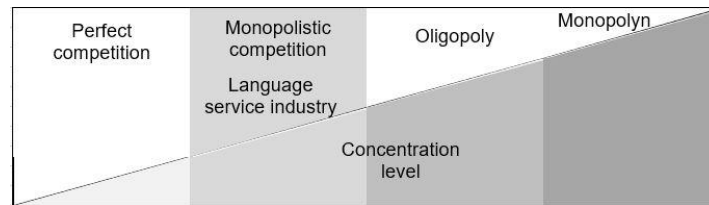
Figure 5. *The current market structure of the language service industry (re-drawn according to Ukav, 2017).*

Because if the market is lack of competition and meanwhile highly concentrated, it will have negative results as disproportionate price system and resource misallocation (Akan, 2002). The various of studies above showed that the language service industry is a decentralized growth industry, which has many evenly matched competitors.

2.1.4 The Prospect Of The Language Service Industry

The section analyzes the opportunities and challenges within the language service industry from political, economic, social, technological, environmental and legal dimensions based on the classical macro-environmental analysis framework - PESTEL framework of Johnson & Scholes (1993), and envisioned the future of the language service industry (table 2).

Table 2.   *PESTEL analysis of the language service industry.*

P	Politics	Governments paid more attention to language services
E	Economics	Big regional difference of economic development Economic globalization trend
S	Society	Deepening international cultural exchange Increasing demand for overseas travel
T	Technology	Artificial Intelligence Cloud computing Mobile Internet
E	Environ-ment	Uncertain and dynamic environment
L	Legal	Indispensable position of human translation in professional industries.

Firstly, governments have given more concerns to language services, which is the main political macro-environment of the language service industry (US Department of Defense, 2005 & 2006). The language capacity of a country related directly to national security and national interests. In recent years, the feature of language service has been transformed from a traditional tool to a national strategic tool. For example, America has combined its language service demands with national defense demands after 911 event，and published *Defense Language Transformation Roadmap* and *National Security Language Initiative*. Besides, governments also support the language service industry in specific aspects, such as industrial policy, institution setting, industry criterion, etc. (Olohan, 2007), which will promote the further development of the language service industry immensely.

Next, the main economic macro-environment of the language service industry is the big regional difference of economic development and the trend of economic globalization, which increased the vitality of international trade, especially for multinational corporations (Gaspari & Hutchins, 2007; Gaspari et al., 2015). As a branch of the modern service industry, the development of the language service industry is closely related to the economic structure and developmental stage of a country. The language service industry of Europe and north America are obviously more prosperous than other areas around the world (DePalma et al., 2017). Along with the strong trend of economic globalization, international trade has become an important part of the country's national economy. For example, the booming of cross-border e-commerce triggered a surge of instant language service. But the reverse globalization trend, such as China vs US trade conflict and

Brexit hindered the growth of international trade, which brought uncertainties to the future of the language service industry.

Thirdly, the deepening of international cultural exchange and the increasing of outbound tourism demand constructed the main social macro-environment of the language service industry. Language is the core carrier of cultural diffusion (Wang, 2014). Superior quality of translation service is needed to transfer a variety of video, musical and literature works into locally acceptable products. The prosperous of cultural industry in today's world drove the growth of the language service industry. In addition, as one of the fastest-growing industry, tourism industry is taking more and more shares in international service industry (Song, 2019), the continuous growing of outbound tourism in the recent years boosted the demand for language service, but the global outbreak of coronavirus hindered the encouraging momentum, which indirectly delayed the progress of the language service industry (EU language industry survey, 2020).

Fourthly, the predominant technological macro-environment of the language service industry is that artificial intelligence and cloud computing technology promoted the active development of machine translation technology, meanwhile, the extensive application of mobile internet greatly enriched the multimedia contents (Esselink, 2000; Doherty, 2016). According to IDC report, the public cloud services market in 2019 totalled 233.4 billion USD and increase by 26% compared with 2018 (IDC, 2020). In the language service industry, the spring up of cloud translation platform decreased the cost and increased the efficiency greatly by integrating the information, language specialists, study data and industrial resources (Esselink, 2000). Furthermore, could computing also resolved the problem of local storage restriction (Mahmood et al., 2013). As a result, more and more language service companies choose to process their data in the cloud, and complete the translation tasks. As time goes on, even more data will be accumulated in the cloud, so as to better train or educate the human professionals for SMT or the AI for NMT (Common Sense Advisory, 2019). In general, the development and integration of new technologies are remoulding the language service industry as a whole. At the same time, the acceleration of internet technology promoted the information content industry by decreasing the threshold for content creation, which increased the demand of language service tremendously (Doherty, 2016). Therefore, internet technology is a driver for the language service industry. Facing with the booming of technology, high-tech companies, like Google, Amazon, etc., which were previously outsiders of the language service industry entered into it as strong competitors, the technology development is an opportunity as well as a challenge for language service companies.

Fifthly, the current uncertain and dynamic environment promotes the innovative activities within the language service industry. In a stable market environment, all the parties within the industry chain do not tend to change (Huang et al., 2009), which trapped the innovators into negative position (Hargadon & Douglas, 2001). While according to the market profile discussed in section 2.1.3, the competition is relatively fierce (table 1 and figure 5) in the current language service market, so it could be reduced that, the environment of the language service industry is no longer stable, but dynamic. In a dynamic industry, change is normal (De Clercq et al., 2011). The enterprises must innovate to keep pace with the change (Grag, et al, 2003), therefore, in the language service industry, the language service providers should also tend to search new things, for example, new technology, new market segment, etc. But within the dynamic environment, the new entrants usually are more innovative (Zahra & Neubaum, 1998), and innovative enterprises most of the time will beat or squeeze out the non-innovation enterprises in the dynamic environment (Grag, et al, 2003). The current dynamic market environment will definitely place more challenge to the traditional language service providers.

Finally, is the legal macro-environment of the languages service industry. Currently, the machine translation technology has achieved great progress and is continuously approaching to excellent human translation level (Wu et al., 2016). As a result, in many of the causal application, for example, the shopping website, social media and chatting platform, machine translation could substitute human work completely. But in some professional fields, considering the legal importance and the serious consequence caused by translation errors, human translation still holds an important place, for example, Life science industry (Gaspari et al., 2015) and national defense industry (US Department of Defense, 2006). Nowadays, the most popular production mode in the language service industry is "machine translation plus human post revision" (Beaton & Contreras, 2010; Garcia, 2011; Cui, 2014; Depalma et al., 2017). Then, the human revision part has became the most valuable market share for language service providers (Depalma et al., 2017).

Based on the PESTEL analysis, the macro-environment of the language service industry is mixed with hope and uncertainty, opportunities and challenges. Therefore, a reasonable theoretical and practical guidance is very important for the growth of the language service providers.

2.2   An Overview Of Machine Translation Technology

From about 1980 onwards, machine translation technology has undergone three major changes in succession, facing with such rapid progress, the recognition of the public or even the industry insiders to machine translation are probably out of date. The section systematically reviews and analyzes the definition, development sequence, the present application situation and the future trend of machine translation technology based on the previous literatures and the latest information. The aim is to present a whole history and future roadmap of machine translation in front of the readers, so as to let them have an objective and comprehensive meanwhile professional recognition of machine translation.

2.2.1 The Definition Of Machine Translation

Machine translation could be traced back to the years without computers (Thomas, 1817). Because of the hardware limitation, the early machine translation is just an idea. In 1949, the vice president of Rockefeller Foundation Warren Weaver published his famous work *The "Translation" Memorandum*, within which the idea of machine translation was officially proposed. The main points are: firstly, machine translation is similar to decoding. Secondly, some general language or intermediate language could be used to translate the source language to the target language (Locke & Booth, 1955). For the next fifty years, machine translation transferred from idea to reality, and got matured rapidly along with the development of technology and globalization (Doherty, 2016). Therefore, the author summarizes the definition of machine translation from two aspects - technological carrier and application purpose, i.e., machine translation is a procedure which transforms one nature language to another nature language by computer programs.

2.2.2 The Development Of Machine Translation

The core task of translation is to recreate the source content with the target language on the basis of source meaning understanding (Nida & Taber, 1982). If machine translation is used in the program, it will experience three stages, which are source analysis stage, source target transformation stage and target generation stage (figure 6).
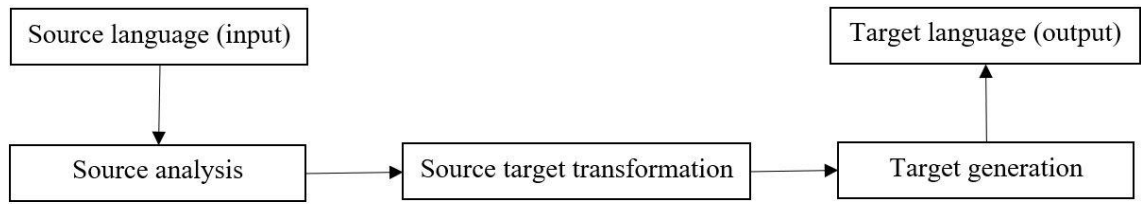
Figure 6. *The stages of machine translation (modified from Musatafa et al., 2018).*

In 1954, the machine translation firstly changed from idea to reality under the cooperation of Georgetown University and IBM company, they used IBM-701 computer translated thirty sentences from Russian to English (Pugh et al., 1955), which becomes the earliest application of CAT. In the following years, the dominantly adopted machine translation technology is Rule-Based Machine Translation (RBMT), whose core is manually composed language rules (Musatafa et al., 2018). The procedure is: firstly, language rules are composed by linguists, then computer algorithm is generated based on these rules, so as to instruct the computer to do the translation work (figure 7). From the perspective of artificial intelligence, the RMBT procedure is similar to the language learning process of adults (Ronald, 2020). Though the language rules could describe semantics and syntax intuitively and accurately, but because language is a flexible and consistently developing thing, the subjective rules cannot cover all the language phenomenon. Besides, the conflicts within the rules also cannot be solved properly (Yuan, 2011). All these major defects hindered the widely adoption of RBMT technology.
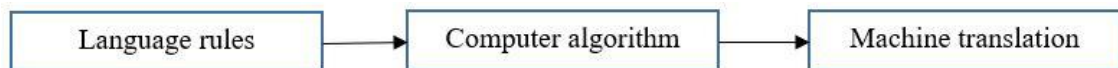
Figure 7. *RMBT procedure (modified from Musatafa et al., 2018).*

In 2007, Johansson realized that semantically corresponding parallel texts are the primary resource for exploring translation procedure (Johansson, 2007). Baker (1993) further analysed the importance of corpus in translation study and opened up a brand-new study field - corpus-based translation study. Then came Corpus-Based Machine Translation (CBMT), whose core is corpus application. CBMT lets the computer automatically learn the nature language rules from the large-scale corpus, then applies the learning results to translation practice (figure 8). From the perspective of artificial intelligence, the RMBT procedure is similar to the language learning process of children (Ronald, 2020). Currently, the main implementation methods of CMBT are SMT and NMT (Devlin et al., 2014).

| Corpus | → | Computer learning | → | Machine translation |

Figure 8. CMBT procedure (modified from Musatafa et al., 2018).

SMT is invented by IBM company (Brown et al., 1990) and it used to be the core translation technology of Google translate, Baidu translate and many other machine translation platforms. The basic idea of SMT is to consider translation as a probability statistics procedure, i.e., any target language sentence is a translation version of any source language sentence, and the final purpose of SMT is to find out the target sentence with the maximum probability (Brown et al., 1990). In SMT method, all the language rules and knowledge are presented in probability forms, the process of machine learning is actually a process of establishing probabilistic model. Therefore, manually composed language rules are no longer needed, and the degree of human intervention is reduced substantially. Theoretically, the larger of the corpus, the smarter of SMT, and then the higher of the translation quality (Ronald, 2020). But in reality, the infinite expansion of corpus could introduce more errors and conflicts, which leads to worse quality of machine translation. So high quality human post-translation revision work is still inevitable for SMT (Su, 2007; Li, 2005).

The above-mentioned defects of SMT could be nicely resolved by NMT - an advanced technology which was just appeared in 2010s (Wu et al., 2016). NMT achieved language transformation directly from nonlinear neural network, it could not only decrease the human revision work load in SMT, but also eliminated the dependence of the machine on large-scale corpus by taking advantage of context materials (Devlin et al., 2014). The NMT technology is started from End-to-End Neural Machine Translation framework proposed by Kalchbrenner & Blunsom (2013), then in 2014, Google company combined NMT with an early technology long short-term memory (Hochreiter & Schmidhuber, 1997). After that, Xu (2015) also introduced the "attention" model, which further improved the performance of NMT. In November 2016, Google company finally changed its previous SMT translation system to GNMT system. According to Google research team, the translation quality of NMT is significantly higher than SMT and its translation result is highly close to human translation in accuracy (Wu et al., 2016).
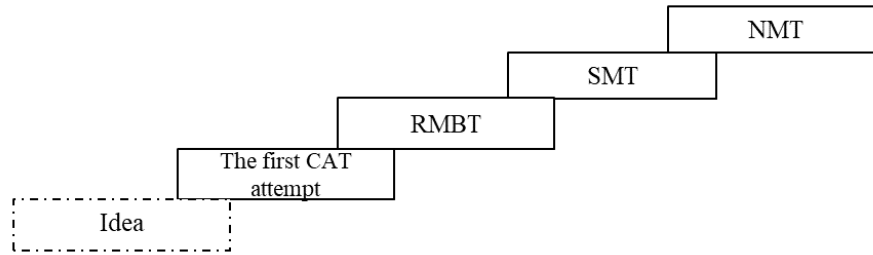
Figure 9. *The development stages of machine translation technology*

In conclusion, the development stages of machine translation technology are illustrated in figure 9. As each machine translation method has its own advantages and disadvantages, the further technology development is actually a process of complementarity and synergy within or without the discipline, i.e., the so-called Multi-Strategy Machine Translation (MSMT) or hybrid machine translation (Li et al., 2015). It could further increase the performance of machine translation by harmonizing different translation strategies, and meanwhile introduce advanced scientific methods from other subject areas. For example, SMT does not abandon RMBT absolutely, but letting the machine to find and learn the semantics and syntax automatically by recording the human revision behaviours (Laviosa, 2002). Similarly, the basic idea of NMT is inherited from SMT (Devlin et al., 2014). In addition, NMT also combined many technologies from psychology and physiology (Wu et al., 2016). Nowadays, the machine translation technology has been developed from machine aids human to human aids machine, the final purpose of machine translation is to eliminate human intervention in translation process (Ronald, 2020).

2.2.3 The Market Application Of Machine Translation

From the perspective of customers, machine translation is fast, cheap and convenient, it could be applied in carriers like computer software, smartphone APP, etc., so as to enable the reading of contents with unknown languages (Hutchins, 2011). For example, Facebook and WeChat embedded machine translation function in their social medias, which simplified and promoted the communication among different language users. Amazon also developed machine translation independently for its shopping platform, which increased the chance of revenue generation by helping customers to check product comments from different languages users and get product information quickly with their own familiar languages. Google company used machine translation system in its search engine, which could help the customers to search for relevant web contents in different languages, and translate the web contents into the target language according to the customer's

requirement. Microsoft Skype provided real-time speech translation function by combining speech recognition technology with NMT technology. After that, Tencent Machine Translation further provided video subtitle generation and translation function on the basis of Skype's achievement.

From the perspective of language service companies, the demand was mainly from the industries with higher translation quality requirements (Depalma et al., 2017). Most of the time, the language service companies need to combine machine translation with human post revision (Garcia, 2011). They could use the software or plug-in from machine translation providers or connect with the machine translation engine by application program interface, so as to get the real time service, then to optimize the translation procedure and increase the productivity (Hutchins, 2014). Since the end of 1990s, so many language services companies had applied SMT in professional fields (Gaspari & Hutchins, 2007). Beaton & Contreras (2010) analysed the application performance of machine translation plus human post revision in airline industry, and found out that the combination of the two could save 30% of cost for language service companies without compromising the translation quality. In the modern world, SMT technology has been broadly used in information-technology, airline, financial, business consulting and administration industries (Gaspari et al., 2015). The earliest SMT application developer SDL plc has become the leader of life Science translation solution under the help of its SMT software Trados Studio (Common Sense Advisory, 2019). In recent years, along with the emergence and local application of NMT, machine translation technology has penetrated into every aspect of human life (Hutchins, 2015).

2.2.4 The Prospect Of Machine Translation

The section envisioned the technology application direction of language service companies by analysing the pros and cons of machine translation. The primary advantages of machine translation are simply fast, cheap and convenient (Gaspari & Hutchins, 2007), but the vocabularies and expressions in natural languages are normally too rich for machine to master (Ronald, 2020). In addition, the language ambiguity, for example polysemy is also a great challenge to machine translation, because most of the time, machine translation cannot handle the problem properly (Yuan, 2011). Furthermore, the meaning of nature language is usually influenced by context and emotion, which is almost undetectable by machine, only the recent NMT technology could handle the problem to some extent, but it still cannot match with the work of human experts (Feng, 2018).

Another drawback of machine translation is the dependence of corpus (Li et al, 2015). As the current two mainstream technologies, SMT and NMT are both corpus dependent machine translation system, the translation quality of them is highly dependent on the size and quality of the corpus, in case of data missing, the machine will be inadequately trained, then consequently limits the quality of the final translation result (Li et al, 2015). Meanwhile, moral and legal issues are usually aroused when sharing and utilizing the corpus resources. The involved interest correlation groups include the developers of machine translation, the users of machine translation, the builders of the corpus, the original authors of the corpus data, etc., and the problems include but not limited to business secret, intellectual property and other confidential data. Therefore, the related work in sharing of these resources is very complex (Drugan & Babych, 2010).

As a result, source text classification will become the primary pre-work for machine translation application of language service companies (Sharoff, 2007; Petukhova et al., 2012; Kong & Cui, 2018). For work concentrates with efficiency instead of quality, for example, social media content, the language service companies will rely entirely on machine translation. But if there are at least a little requirement on quality, such as product leaflets, the language service companies will apply human aids machine model, in which machine is the main productive force and human assists its work. However, for professional text with extremely high-quality requirements, like academic literature, the language service companies will still maintain the dominant role of traditional human translation, and let the machine to supplement the human work, so as to increase the efficiency without messing up the quality (Beaton & Contreras, 2010; Garcia, 2011).

While comparing with the already extensively applied SMT, NMT could study faster and translate better, the studies of Bentivogli et al. (2016) and Wu et al. (2016) have confirmed that the translation quality of NMT is far above SMT. Wu et al. (2016) also proposed that the accuracy of GNMT is close to human translation. Though the entirely replacement of human translation is still unachievable for NMT, along with the development of NMT technology and other areas of technology, the engagement level of machine translation in language service companies is set to get higher and higher.

2.3 Study On The Relationship Between Machine Translation Technology And The Language Service Industry

So far, three major technological revolutions have happened in the language service industry. The first is the extensive adoption of CAT tools in 1980s, the second is the popularization of SMT in 1990s, and finally is the emergence and application of NMT from 2010s (Hutchins, 2014). Except for structure upgrading of the language service industry, machine translation also caused the technological paradigm shift within the language service industry (Kuhn, 1962; Dosi, 1982). Meanwhile, the productivity of the language service industry is facing with unprecedented challenge by increasingly frequent international activities, which indirectly promoted the rapid development of machine translation technology (Hutchins, 1998; Bowker, 2002; Kenny, 2011).

Dunne (2012) believes that the development of machine translation technology in the past 25 years greatly changed the language service industrial structure. Machine translation has become one of the hottest topics for language service researchers since Systran launched the first online machine translation platform in 1988 (Hutchins, 2014). Currently, studies on the relationship between the language service industry and machine translation technology could be classified into three groups: the first group thinks that the development of machine translation technology will significantly promote the structure upgrading of the language service industry (Meer, 2003; Sharoff, 2007; Petukhova et al., 2012; Doherty, 2016; Wu, 2016; Luo et al., 2018); the second group believes that machine translation technology is still too weak to significantly influence the language service industry (Yang & Lange, 2003; Prior, 2010; Drugan & Babych, 2010; Specia & Farzindar, 2010); the third group concentrates on the study of machine translation commercialization and application effect in the language service industry (Koehn & Senellart, 2010; Anastasiou & Gupta, 2011; Gaspari et al., 2015; Doherty, 2016; Wan, 2018).

The study of the first group showed that the development of machine translation can promote the structure upgrading of the language service industry significantly. Meer (2003) reviewed the development history of the language service industry and confirms that the huge commercial demand for language services is one of the major motives for machine translation technology development, while the revolution of machine translation technology changed the production paradigm of the language service industry. Luo et al. (2018) states that the innovation of machine translation and the popularization of internet-based language service platforms will remodel the industrial structure and the growth pattern of the language service industry. While according to the general consensus within the language service industry, machine translation has better translation result only for text with relatively simple language features (Yang & Lange, 2003; Drugan & Babych, 2010). Previous studies have shown that manual and semi-automatic text classification could significantly improve the quality of machine translation, so that machine translation can be

applied more widely in the language service industry and have a profound impact (Sharoff, 2007; Petukhova et al., 2012).

Some of the studies focused on the relationship between the online machine translation platform and the language service industry. Online machine translation platform is an important study field in machine translation (Flanagan, 1997), however, the influences of online machine translation platforms in 1990s, such as, Systran Center and CompuServe, are very limited (Gaspari & Hutchins, 2007). From late 1990s to the early 2000s, breakthroughs have been made in SMT technology, which was widely used in online machine translation (Brown et al., 1990). The Babel Fish online machine translation platform launched in 1997 is the first translation platform for all the internet users, meanwhile, it is also the first influential online translation platform (Gaspari, 2004). The business demand of online machine translation platform was huge already when it firstly appeared, and the demand increasing trend is particularly strong (Brace et al., 1995; Mack-lovitch, 2001; Smith, 2003; Baron, 2003; Gaspari & Hutchins, 2007; Luo et al., 2018), because of the low cost (most of the time even no cost) and high efficiency characteristics (Gaspari & Hutchins, 2007).

With the disadvantages of high cost and low efficiency, the traditional human translation mode experienced tremendous impacts. In some countries, the language service industry has already widely recognized and used online machine translation platforms in specific service areas (Randhawa et al., 2013; Turner et al., 2014). In addition, most of the current online translation platforms are provided by well-known internet companies whose users spread all over the world, such as Google, Microsoft, etc., therefore, the influence to the language service industry is bound to be significant (Doherty, 2016). This kind of influence is further deepened by the recent development of NMT technology, which increased the machine translation quality substantially (Wu et al., 2016).

The study of the second group demonstrated that the current machine translation technology is not enough to make significant influence to the language service industry. Yang & Lange (2003) investigated the early users of online machine translation platform - Babel Fish, and discovered that more than 50% of the source texts translated by Babel Fish are shorter than 5 words, and only 20% of the source texts are longer than 20 words, which indicates that online machine translation platform could only meet temporary needs and the users still need to have some knowledge of the source language, thus the extensive use is difficult. Prior (2010) believes that online machine translation platform cannot provide customized service for different expertise fields, so it is hard

to impact substantially to language services industry. Drugan & Babych (2010) also confirmed the limitations of machine translation by analysing the language distance problem in Google Translation Toolkit. Specia & Farzindar (2010) even proved that because of the inadequate quality of machine translation, more human work is needed for post revision. Besides, the studies mentioned above generally agree that without human post revision, machine translation will still make a large number of errors, though the quality of machine translation has already been improved prominently. In consequence, manual intervention is still an indispensable part (Depalma et al., 2013; Cui, 2014).

The study of the third group discussed the commercializing and the application effect of machine translation technology in the language service industry. Koehn & Senellart (2010) analysed the combination application of machine translation system and the translation memory (MT) in the language service industry. Anastasiou & Gupta (2011) discussed two translation working modes - the crowdsourcing translation mode and the machine translation mode. Wan (2018) reviewed the application of CAT tools and machine translation systems in the language service industry.

In addition, a plenty of studies also focused on the attitude and usage of practitioners - translators, project managers, proof-readers, etc.- to machine translation within the language service industry. According to the early investigation, most of the translation experts just response negatively to machine translation, only few of them recognize its usefulness (Fulford, 2002; Fulford & Granell, 2004). But the situation has changed in the recent years. Roturier (2009) found that many agency translators have improved the quality of machine translation through professional methods. Gaspari et al. (2015) collected questionnaires from 438 freelance translators, and confirmed that the importance of machine translation has been broadly recognized by the practitioners of the language service industry.

Since the start of 2000, machine translation systems based on all kinds of technologies have been used extensively in the language service industry (Doherty, 2016). Besides, more and more researchers have noticed the necessity of adding machine translation and computer aided translation courses in language talents education programme (Bowker & Marshman, 2010; O'Hagan, 2013; Doherty & Kenny, 2014; Mellinger, 2017). Chen et al. (2016) sampled 100 language service companies around the world and investigated the talent demand in the international language service market, which showed that computer operation has become the core competence of language service talents. Yao & Si (2018) also analysed 1 200 job advertisements of language service companies and reported that more than 40% of the language service companies required explicitly for

technology competence of translators. Thus, it can be seen that machine translation technology has been broadly recognized and urgently needed within the language service industry.

From the microscopic aspect, the previous literatures mainly studied the language service industry from its definition, development history and market profile; from the macroscopic aspect, the previous studies considered the impacts of political, economic, social and technological environment to the language service industry.

Most of the relevant studies before are carried out by technical experts and linguistics, who concentrate mainly on the academic significance of machine translation technology instead of its commercial and practical significance. Especially for NMT technology, which is just developed in 2010s.

By reviewing the studies about the relationship between the language service industry and machine translation, 3 research directions are summarized. The first one thinks that the development of machine translation will significantly promote the restructuring of the language service industry; the second one believes that machine translation is still unable to significantly impact the language service industry, and the third one mainly fucuses on the commercialization and application status of machine translation technology in the language service industry.

From the general overview of the previous studies, it is still uncertain whether machine translation technology will influence positively or negatively to the performance of language service providers, the main reason from the author's opinion is that:

> There is a research gap of machine translation technology between academic and industry field, especially the new technology breakthrough – NMT. The current study on the commercial impact of NMT to the language service industry and providers is very rare. Because the commercialization and application of NMT technology are still in early stage. While most of the previous studies are conducted before the emergence of NMT, so the study results cannot properly reflect the current status, which could be one reason that the situation is still unclear about the impact of machine translation technology to the performance of language service providers.

Therefore, the thesis intends to clarify the net impact of machine translation technology on the performance of language service providers, thus eliminating the uncertainty over the topic, so as to confirm the important role of machine translation technology, which is the final objective of the study. To do so, the thesis will establish an analysis framework in the next chapter, then, to use the framework in the specific environment of the language service industry.

3. RESEARCH FRAMEWORK

Innovation has been generally regarded as a key factor affecting the firm performance (Schumpeter, 1934; Roberts, 1999; Cho et al., 2005, Prajogo, 2006). Many companies try their best to achieve higher profits through innovation in different ways (Cho et al., 2005). While in practical terms, the impact of innovation on firm performance is not unconditionally positive (Hargadon and Douglas, 2001). Innovation has its multi-faceted features, which needs to be considered deeply. The chapter focuses on the creative destruction theory (Schumpeter, 1934) and the mediating effects (Liao & Rice, 2010) of innovation on company performance, and established a framework to analyze from the positive and negative aspects of innovation, so as to summarize its net impact on company performance. Then, the framework is further refined in the study topic of the thesis - the machine translation technology and the performance of language service providers. Because machine translation technology is obviously a technological innovation in the language service industry, the framework could well fit into the analysis environment and provide a clearer and stronger argument of the relationship between the two.

3.1   Innovation And Company Performance

The theory of innovation and technological change can be traced back to the economist Schumpeter, because Schumpeter is believed to be the first scholar to introduce the world to the concept of entrepreneurship (Aghion & Howitt, 1992). According to Schumpeter (1934), the entrepreneurs controlled the economy because they are responsible for delivering innovation and technological change. Since Schumpeter put forward the important role of innovation in economic development in 1934, innovation has been widely regarded as the key factor affecting company performance (Schumpeter, 1934; Aghion & Howitt, 1992; Roberts, 1999; Cho et al., 2005, Prajogo, 2006). In Schumpeter's *The Theory of Economic Development* (1934), he interpreted and expounded "innovation" as "new combinations", i.e., innovation is to introduce a new combination of production factors into the production system. In other words, innovation procedure is actually a procedure of setting up a new production function, and there are totally five variables in the function, which are: (1) new product; (2) new method; (3) new market; (4) new source of raw materials; (5) new production organization (figure 10).
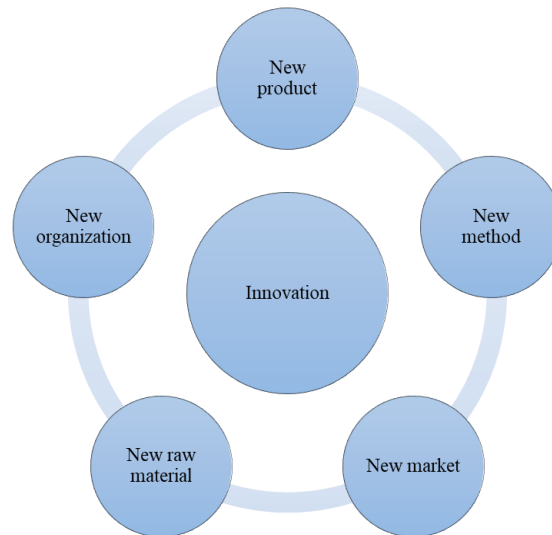
Figure 10.   *The variables of innovation function.*

According to Schumpeter (1942), innovation is a basic phenomenon of economic development, but it is also a process of "creative destruction". The "new combinations" will disrupt the existing economic order and structure continuously and fundamentally, meanwhile establish new economic order and structure. Then, the noninnovative counterparts will be replaced and rendered obsolete. In other words, the competitive advantage created by innovation is superior and could facilitate economic growth and economic performance in the long run. Most of other literatures also support the viewpoint and claim that innovation is one of the key factors for company success and survival (Bell, 2005; Cho and Pucik, 2005; Jimenez & Sanz-Valle, 2011;) and sustainable competitive advantage (Johannessen, 2008; Bartel and Garud, 2009; Standing and Kiniti, 2011). The positive impact of innovation to company performance is direct in academic field. While when discussed in practical situation, the results have not always been in line with the theory, i.e., there are a number of studies suggest that innovations do not necessarily bring better performance (Hargadon and Douglas, 2001). Aiming at the problem, researchers propose the concept of transformation outcomes (Liao and Rice, 2010; Neely, et al., 2001), which refers to the actual efficacy of innovation. The main idea is that the impact of innovation is not act directly on company performance, but driven by innovation derivative effect mediated by the transformation outcomes, and innovation related activities can drive a company's competitive advantage only when transformation outcomes actually happened. By applying the classical mediating effect model (Baron & Kenny, 1986), the mediating effect model of innovation impact on company performance is illustrated in figure 11.
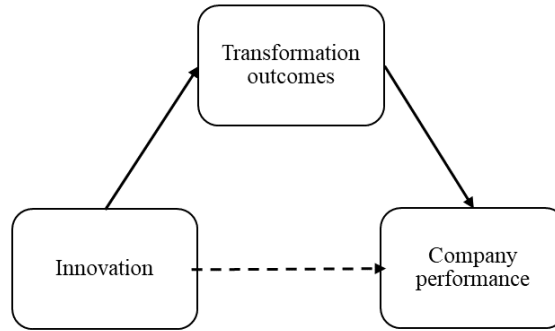
Figure 11. *The mediating effect model for innovation impact on company performance (modified from Baron & Kenny, 1986).*

Meanwhile, though most scholars believe that innovation has done more good than harm to the economy as a whole (Bell, 2005; Cho and Pucik, 2005; Johannessen, 2008; Bartel and Garud, 2009; Jimenez & Sanz-Valle, 2011; Standing and Kiniti, 2011), however, in practise, it is difficult to define the relationship between the rate of creative growth within a particular company and its future growth trend (Hargadon and Douglas, 2001). Considering the two-sided nature of creative destruction theory, the transformation outcomes could have positive aspects and negative aspects. It is the net outcome that finally influences the performance of the company. Therefore, by introducing parallel variables into the mediating effect model of figure 11, the thesis builds up a theoretical framework to research the relationship between innovation and company performance (figure 12).

Figure 12. *The framework to research the relationship between innovation and company performance.*

The framework in some extent points out why there are uncertainty or different opinions within academic and industrial fields on the topic whether machine translation technology impact positively or negatively on th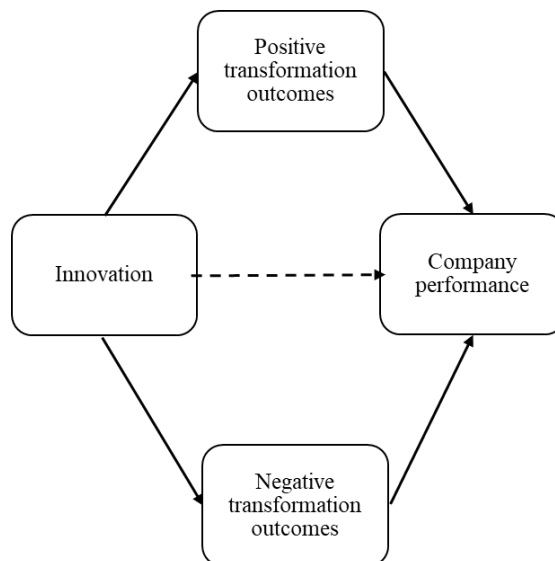e performance of language service providers and within the language service industry. Because the actual transformation outcomes triggered by innovation represented by machine translation technology also has two sides, which needs to be investigated in detail, especially needs to be investigated quantitively.

The primary purpose of the framework is to examine the positive and negative mediating effects of transformation outcomes on company performance, so as to evaluate the net impact of innovation. Meanwhile, the framework does not necessarily deny the possible direct effects on company performance from innovation (Roberts, 1999).

3.2   Framework Refining

As an important technological innovation within the language service industry, machine translation technology could also bring "creative destruction". High-tech companies such as Google, Microsoft, Amazon, Baidu etc. have entered the language service industry with the help of the technology progress of machine translation. In other words, the high-tech companies use a new method - machine translation penetrates into a new market - language service market. According to the variables of innovation function (figure 10), the technology innovation in the language service industry is actually triggered by the combination of new method and new market (figure 13)
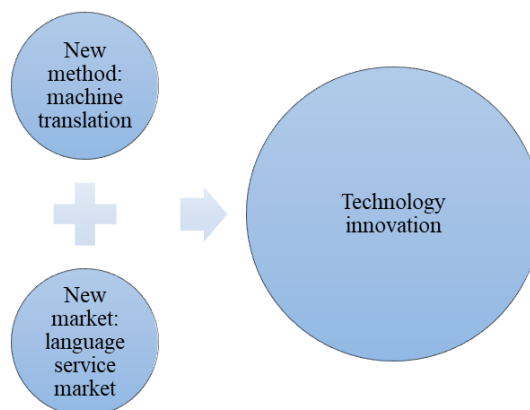
Figure 13.   *The technology innovation within the language service industry.*

The transformation outcome of the innovation is to introduce strong new entrants in to the language service industry, which become powerful competitors of traditional language service providers. To the performance of language service providers, this will be a negative transformation outcome of innovation. While the positive transformation outcomes of the technological innovation are also simple and obvious, which are lower translation cost and higher translation efficiency. According to Beaton & Contreras (2010), the production mode of machine translation plus human post revision could save 30% of cost without compromising the quality of translation. In Beaton & Contreras' time, machine translation mainly refers to SMT technology, which is being replaced by NMT. According to Google investigator Wu (2016), the latest NMT has worked extremely close to human translation. Though there is still no relevant statistical research data to evaluate the combination of NMT and human post revision, while according to the author's actual working experience, the cost saving and efficiency improving outcomes of NMT assisted translation is at least twice as good as the previous SMT. Though the complete replacement of machine to human is still not technically possible currently, however, in some casual conditions, for example, social media content, customers could rely entirely on machine translation (Hutchins, 2015). In addition, in order to expand the corpus, many high-tech companies provide cheap or even free machine translation service to accumulate more and more powerful corpus (Hutchins, 2015), which forms the second forces - substitute - within the language service industry. A part of the market share which belongs to the language service providers before will disappear, and the business volume of traditional language service providers are facing with possible decrease. Therefore, by finding out the specific influence factors of machine translation to the performance of language service providers, the technological innovation of the language service industry represented by machine translation technology has positive transformation outcomes and negative transformation outcomes, which is illustrated in the refined framework in figure 14.
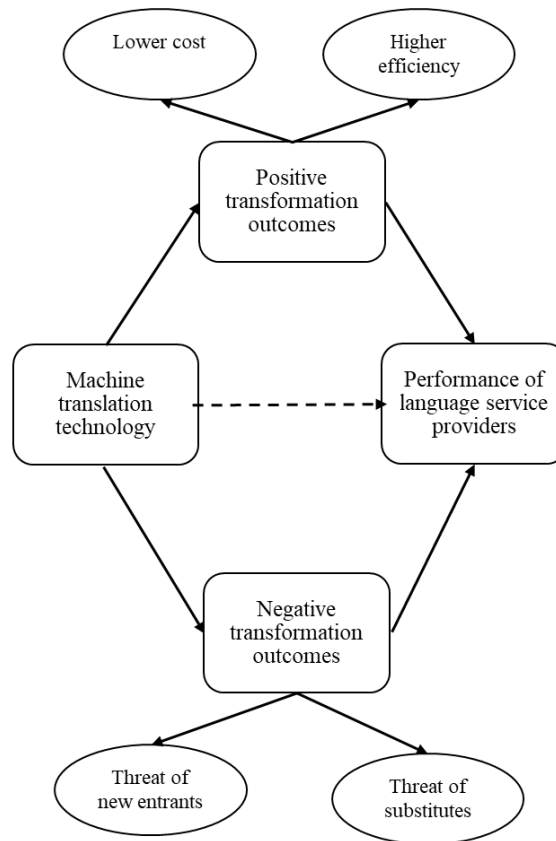
Figure 14.   *The refined framework of machine translation technology and the perfor-mance of language service providers.*

the thesis will explore the mediating effects of machine translation technology on the performance of language service providers based on the discussion of the two-sided influence mechanisms. By specifically targeting the influence factors which forms the positive and negative transformation outcomes, the research could be guided in a clearer line.

Based on Schumpeter's innovation theory (Schumpeter, 1934) and the classical mediating effect model (Baron & Kenny, 1986), the study constructs an analysis framework of the impact of innovation on the company performance from the perspective of "creative destruction". Then, the thesis further applies the framework to the environment of the language service industry, meanwhile considered the mediating effect of positive and negative transformation outcomes, then by targeting the specific influence factors of positive and negative transformation outcomes, the thesis further refined the analysis framework, to make it more proper and practical to analyze the impact of machine translation technology on the performance of language service providers. In the empirical study of the next chapter, the refined framework in figure 14 will be practically used to test the performance result of two case language service providers.

4. EMPIRICAL STUDY

In the empirical study part, the thesis tries to make up the research gap and to clarify the uncertainty discussed in the theoretical part by presenting and analyzing two case studies. Because case study focuses more on concrete details than general theories (Shona, 2019), which is a good supplement to the thesis argument. In case study, the researchers using one or more specific real-world subjects to summarize, verify or supplement some rules or regularities by reducing and constructing concrete, contextual and in-depth knowledge (Yin, 2013).

The author has worked within language service industry for ten years, and has experienced two of the three major revolutions of machine translation technology in the language service industry. During the ten years work, the author has worked for more than ten famous large language service providers, and currently actively worked for four large language service providers, which are ranked top 50 from the latest market research report of Common Sense Advisory (Common Sense Advisory, 2020). As a result, the author has got a comprehensive understanding and in-depth practical experience within the languages service industry and some of the important language service providers within the industry. All of these will qualify the author to select the most proper cases and conduct a convincing empirical study.

Taking a general overview of the current situation, and combining the theoretical study result in chapter 2, it is the uncertainty of the net impact of machine translation technology to the performance of language service providers, which hindered the rapid commercialization and broad application of machine translation technology. The research gap between academic and industry field is the most possible cause of the uncertainty. Considering that the case study can build a concrete and easy understanding alternative to a complex reality (Yin, 2013), the author will conduct a comparative study by selecting and analyzing two typical cases, so as to compare and illustrate different aspects of the research problem.

4.1   Data Collection

The case study could be qualitative and quantitative (Minor et al., 1994). Qualitatively, interviews, questionnaire, observations, as well as analysis and extracting of primary and secondary sources, for example, news publication, official records, and even personal experiences could be used, they are generally non-numerical data; quantitatively, some numerical data will be collected and analyzed. The data resources of quantitative method include company annual reports, official statical reports, etc., which involve wider populations and longer times (Pritha, 2020). Gummesson (1993) categorized data collecting into five methods, and the study will take two of them to collect the needed data (table 3).

Table 3.   *Data collecting methods used in the thesis (Gummesson 1993).*

Method	Description
Existing material	Everything that is conveyed by other media than humans, for example, books, articles, mass media reports, brochures and films.
Action science	The research method can contain all other types of research methods and requires the active involvement of the person doing the research.

The table above shows the data collecting methods used in the thesis and a brief description of what each of the method means. The plan of the thesis is to form the basis of the study by combining the theoretical framework and the empirical data (Groth, 2000). Initially, through literature study from the previous academic papers, market research reports of trusted authorities, company websites and the author's personal knowledge and work experiences, the thesis got a comprehensive understanding of the main topics of the study, including the language service industry and its providers, different machine translation technologies and the relationship between the two. By summarizing the literature study content, the author noticed the core problem, which is the different attitudes to machine translation technology between academic and industry fields, as well as within the language service industry. One of the probable reasons is that the big progress made in the academic field of machine translation technology has still not been fully recognized and well commercialized within the language service industry

Then, the author established a theoretical analysis framework based on well-established and extensively recognized theory – Schumpeter's innovation theory (Schumpeter, 1934), as well as the classic model – mediating effect model (Baron & Kenny, 1986), aiming to find out the root of the problem and try to address it. In order to do so, the theoretical framework will be further refined, to make it more practical to use in the language service industry (figure 14). To firmly demonstrate the objective of the thesis, which is to study whether the active adoption of advanced machine translation technologies can improve the performance of language service providers in the long run, the thesis selects two language service providers as the case study subjects, namely case A and case B. The reason for choosing these two case companies is that:

1. The author has worked as a translator for these two case companies for many years, and from the long-term working experience, some rule of thumb information could be obtained.

2. The two companies treated advanced machine translation technology with entirely different ways, which provides a good chance to compare the pros and cons of machine translation technology. When facing with the development of machine translation technology, Case A language service provider actively took measures to accept the new technology while case B company chose to avoid it. Therefore, the research design of the thesis is to highlight the distinction between two cases, then to clarify the net performance impact of language service providers that embrace new technology and those that reject it.

In empirical study, the author will compare the business revenue and development trend of the two language service providers, and answer the following question:

Question 1. How does machine translation technology affect the business revenue of language service providers?

Question2. How does machine translation technology affect the long-term economic growth of language service providers?

Profitability is an important indicator of company performance. When combing the research framework (figure 14), Under negative transformation outcomes, after high-tech companies penetrating into the language service industry with the help of machine translation technology, they may grab some market share from language service providers and reduce their business revenue. While under positive transformation outcomes, language service providers can improve the efficiency of translation by adopting machine translation technology, thus increase the business vol-

ume and obtain higher revenue without compromising the service quality. Because the two impacts go in opposite directions, the net impact on the business revenue of language service providers is uncertain. As a result, the following sections try to clarify the question through comparing the two cases, which is a fruitful and easy understanding way of argument with indisputable facts (Levy, 2014).

Firstly, the financial information will be collected from the company annual reports and the market research reports of trusted authorities, which could be used for quantitative study. After that, the economic development trend of the companies will be evaluated from concrete financial data of the above listed resources and the author's latest information as an insider. The data collecting methods of each of the study part are illustrated in figure 15.
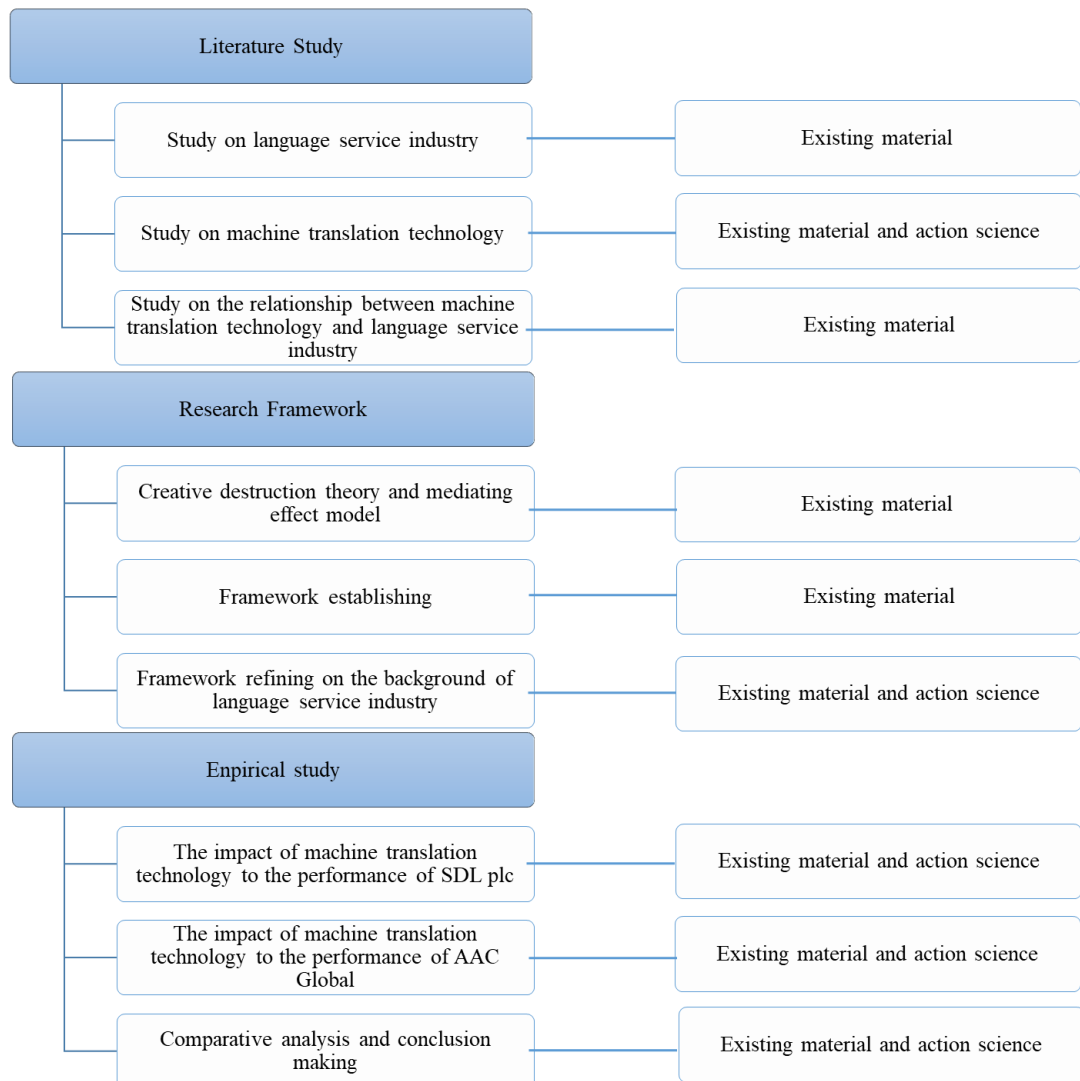
Figure 15.   *The research structure and the corresponding data collection methods.*

4.2   Overview Of the Two Case Companies

Founded in 1992, case A language service provider is a global leader and innovator in language and content management solutions, its customers are scattered across a wide range of industries, including technology development, manufacturing, life sciences, automation, aerospace, retail, business services, government, financial, legal, etc. By the end of 2019, case A language service provider has more than 70 branches in 38 countries, and more than 90 of the world's top 100 companies are its customers. case A language service provider's two core businesses - language service and language technology - had entered into China market from 1990 and established a team of about 300 people in China. The author belongs to the its Life Sciences translation team.

From 2011 to 2015, the author worked with case A language service provider as a life science translator. Almost all the translation project has been done under "machine translation plus human post revision" production mode. The case A language service provider self-developed a machine translation tool, which could not only support the translation, but also support the team work and project management. The author used the machine translation tool as a translator, and helped to maintain the TM of the machine translation tool. During the work, the author used the machine translation tool from developing trial version to the final commercialized version, as well as the following several updated versions. Therefore, the author has an in-depth and comprehensive understanding of the mechanism and features of its machine translation technology, as well as the business development strategy based the technology. Because of the excellent compatibility and user experience, the machine translation tool developed by case A language service provider has been widely adopted by other peers within the language service industry. So, even the author left the case A language service provider from 2015, the author still actively used its machine translation tool for other language service providers.

Founded in 1971, case B language service provider is one of the leading global B2B learning and translation services providers in northern Europe, with the headquarter in Finland. The service of case B language service provider includes translation and localization, training and learning, marketing and content services, etc. In terms of strategic objectives, case B language service provider aims to become one of the top three language service providers in the Nordic region; In terms of translation services, case B language service provider is the market leader in Finnish translation

services. It has an extensive network of partners and a long-term cumulated term base. Based on the minor language - Finnish, case B language service provider provides services to Northern Europe and around the world. But in terms of financial data, the business revenue of case B language service provider presents a trend of overall declining. In 2018, case B language service provider was acquired by a French language service provider, where the author has served for seven years. As a result, the author also got the honour to share the knowledge and experience with the team of case B language service provider.

From the end of 2018, the author started to work for case B language service provider as a translator. Few works have been done by machine translation and the order volume is very low. Most of the author's work is still from the previous project managers of the French language service provider. The case B language service provider, who currently operated as an affiliate of the French language service provider seems still stick to the old pure human production mode.

Both language service providers are same in business line and development mode. They share the same customer populations and vendor resources. As a result, they are in the same industry chain, which creates a very good comparability.

4.3 Business Revenue And Growth Trend

4.3.1 Case Company A

Since 2008, merger and acquisition (M&A) activities among language service providers are getting hotter. Famous language service providers like SDL, Lionbridge, Merrill, RWS, TransPerfect and Semantix have made so many mergers and acquisitions, mostly for the purpose of enhancing their technological strength (Olohan, 2007). Thus, technological progress is an important driver of M&A within the language service industry. The main purpose of the acquirers is to acquire new technology, improve technological strength and then enhance competitiveness (Zollo & Meter, 2008).

On July 2010, case A language service provider announced the acquisition of 85% company stake of company L, a pioneer company in machine translation technology (Common Sense Advisory,

2011). To explore whether the acquisition event created value for case A language service provider, its business revenue and growth rates from 2008 to 2012 is summarized (figure 16). From the figure, before the acquisition event, case A language service provider's business revenue continued to decline, but after the acquisition event in 2010, the business revenue and growth rate recovered significantly, indicating that the technology acquisition behaviour improved the business performance of case A language service provider from economic aspect.
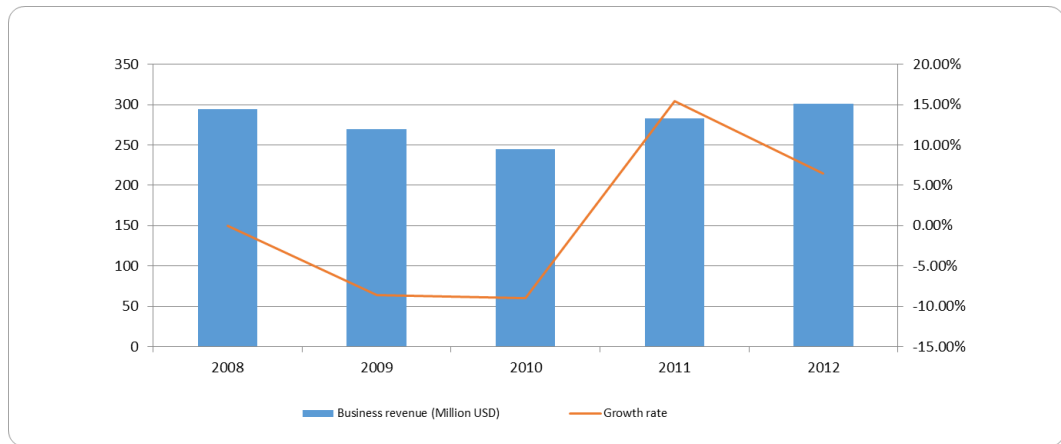

Figure 16. *The business revenue and growth rate of case A language service provider from 2008 to 2012 (data source: company annual report).*

In addition, with the development of the global internet, people are in an era of information explosion. As information is presented in more and more complex ways, internet users need to read a big amount of content quickly, which cannot be satisfied if only relying on human translation (Luo, 2018). So, in the past, the market in this area is mostly abandoned, but just because of the emergence of machine translation, most of the work that should be done by human is substituted by efficient machine, which revitalized the market. This is the two-faceted feature of the substitution threat.

To take the advantage of the good aspect, in the end of 2009, case A language service provider has launched the first trial version of the machine translation tool for in-house translators and project managers, achieved a comprehensive post revision capability for machine translation. After the partly substitution of machine translation to human translation, "machine translation plus human post revision" language service market has become the biggest market for traditional language service providers (Doherty, 2016), and case A language service provider grasped the market share firmly. In addition, the acquisition of company L enhances case A language service provider's technical capabilities in the machine translation market. After the technical acquisition,

case A language service provider developed the cloud-based CAT tool, which supports the collaboration, knowledge sharing and style harmonization among translators. The technical strength makes case A language service provider a strong competitor among other language service providers for a long time.

4.3.2 Case Company B

In 2010, the development and commercialization of SMT technology have reached its peak, and the more advanced NMT technology just come into being, while just from this time, the business revenue of case B language service provider presents a trend of overall declining (figure 17). Especially in 2016, the business revenue has fallen to 17 000 000 USD compared with the peak business revenue of 49 000 000 USD in 2008.
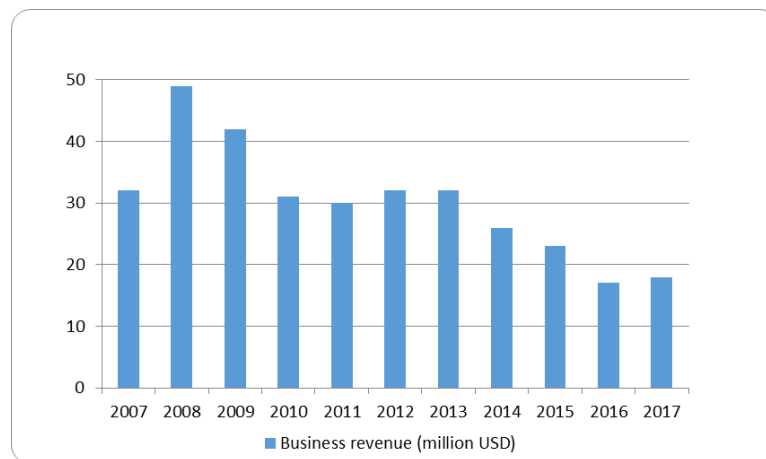
Figure 17.   *The business revenue of case B language service provider from 2007 to 2017 (data source: company annual report).*

However, in 2016, the whole Europe accounts for 50.29% of the global translation service market, and has been the most important market for language translation services for many years. Among them, North Europe and West Europe always occupy the majority of the market, indicating that the overall external market environment has not deteriorated significantly (figure 18).

Figure 18.   *The market share of Europe language service market from 2010 to 2018 (data source: Common Sense Advisory).*

Therefore, the revenue decline of case B language service provider should not be a coincidence, and it must have something to do with its attitude to new technology. Because one the other hand, its Nordic counterpart – company S, which is founded 1969, has the business revenue in 2007 roughly the same with case B language service provider. But in 2017, the revenue of company S was 5 times mo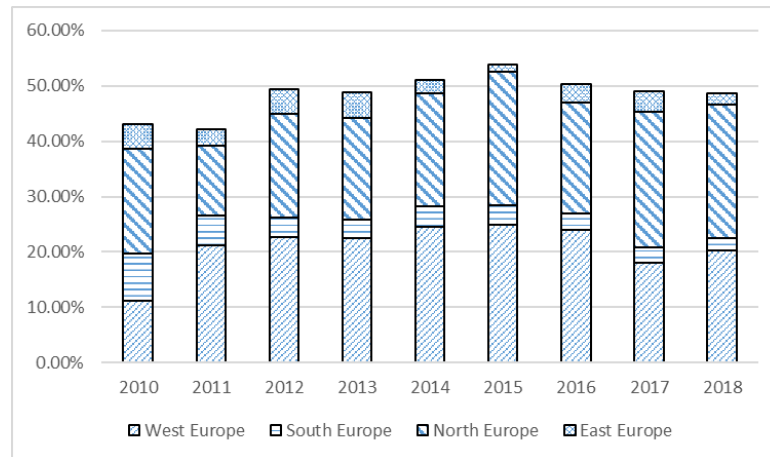re than case B language service provider (data source: company annual report). On the issue of technology innovation, company S is the first language service provider in Europe to adopt the cloud based neural machine translation platform by cooperating with the language technology company M. By taking the advantage of the efficiency and convenience of advanced technology, company S has won a large market share. Compare with its competitor, case B language service provider is much more conservative. The service contents of case B language service provider are mainly minor languages represented by Nordic languages, and its translation services are mainly based on the customer service network and traditional term base translation technology. According to the information on its website, case B language service provider believes that minor languages such as Finnish and Swedish are not necessary to apply machine translation. In other words, the small domestic market limits the profits of technology innovation (Otero-Neira, et al., 2009), then in turn, prevents the active adoption of advanced technologies, such as machine translation and cloud computing.

However, in a dynamic environment where technology changes overwhelmingly, the competitiveness of non-innovators will be weakened when facing with the intense competitive rivalry (Garg, 2003). In 2016, Google announced that they will officially apply the GNMT to Google Translate. Meanwhile, Google also provides paid API service on the basis of free translation service, so that the third-party companies including language service providers can also use GNMT

in their business (Wu et al., 2016). The event marked the first official commercialization of neural machine translation and also constitute a macro-environment of technology innovation within the language service industry. In the thesis, the event provides a perfect example of "positive transformation outcomes" and "negative transformation outcomes" in the theoretical analysis framework (figure 14). On the one hand, Google competes with language service providers through free and paid machine translation services; on the other hand, the technology is also open to language service providers, which could help them reduce costs and increase translation efficiency. However, just in the same year, the revenue growth rate of case B language service provider fell to the bottom (figure 19), and was eventually acquired by a French language service provider in 2018.
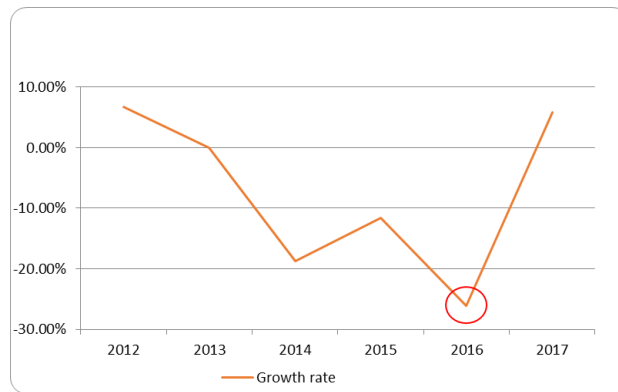

Figure 19. *The growth rate of case B language service provider from 2012 to 2017 (data source: company annual report).*

5. RESULTS AND DISCUSSION

From the above two cases, the rapid development and commercialization of machine translation technology is a double-edged sword for language service providers. Language service providers are facing with new challenges along with the continues updating and spreading technology (Dunne, 2012). Then, how to deal with the constant changes become one of the important topics. But at the same time, new technologies also mean new opportunities and new possibilities (Roturier, 2009).

By conclusion, case A language service provider successfully counterbalanced the negative transformation outcomes introduced by new high-tech entrants and the machine translation substitutions (figure 14). From the language service provider's company financial data and the author's long-term working experience during its most important development stage, the net impact of machine translation technology to the performance of case A language service provider is positive (figure 20).
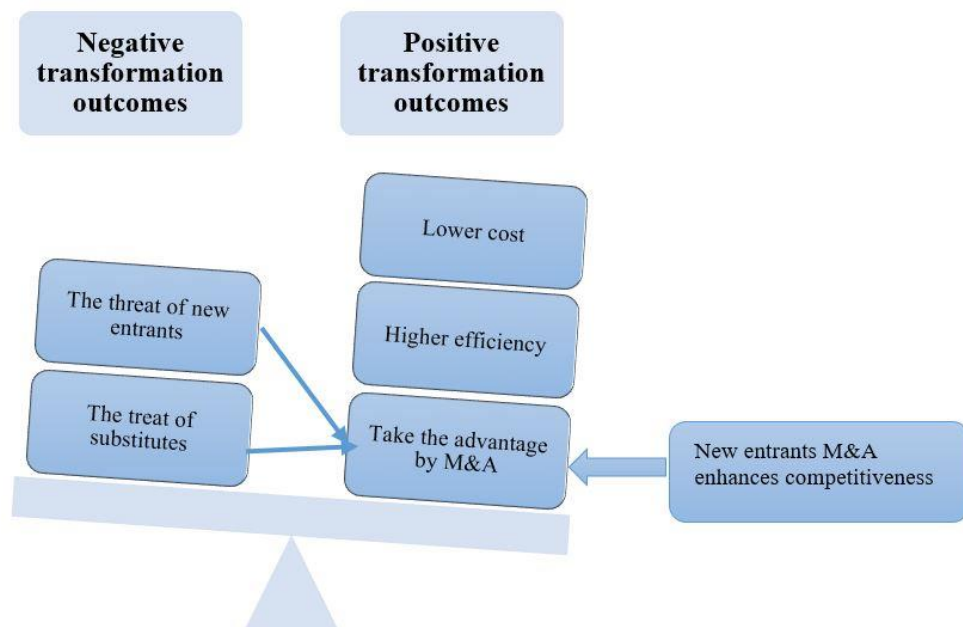

Figure 20.   *Check and balance between negative transformation outcomes and positive transformation outcomes in case A.*

As a new language service provider developed under the progress of typical machine translation technology, company L has produced a huge synergistic effect after integrating with case A language service provider. The traditional language service industry is a labour-intensive industry, the business volume that a language service provider can undertake is basically determined by the staff size of the company. Moreover, due to personnel management problems, the marginal cost of management personnel will also increase as the company grows in size. But machine translation technology, as a new and innovative technology, can not only greatly reduce the language service provider's reliance on translators, but also improve their language processing efficiency. Meanwhile, form the author's personal using experience, with the increase in the amount of services, the accuracy of the machine translation algorithm will continue to improve, which decreases the marginal cost fundamentally. Therefore, case A language service provider gets the full benefits from positive transformation outcomes of machine translation technology (figure 20).

During this period, the author used and participated in the maintenance of the life science TM of all the machine translation tools developed by case A language service provider. From the author's personal experience, on the one hand, the application of machine translation technology has greatly improved the quality of translation of case A language service provider. It better connects the linguistics and industrial experts to meet the diverse needs of customers. On the other hand, the use of technology helps case A language service provider to improve the efficiency of translation. In addition, with the increase of the translation amount, more and more data are available in the TM, then the efficiency of machine translation will be getting higher. The continuous improvement of translation quality and efficiency makes case A language service provider more competitive. For the original customers, case A language service provider connects vertical industries in relevant fields, which is difficult to be substituted and will obtain a large number of re-purchase orders; for potential customers, case A language service provider has obvious advantages in terms of quality, efficiency and cost performance, so it is relatively easy to expand new customers. Thus, the active adoption of advanced machine translation technology keeps case A language service provider the leading position in the language service industry.

So, for innovators like case A language service provider, the adoption of machine translation technology could have both negative transformation outcomes and positive translation outcomes (figure 20), the challenge is how to make the most of the positive effects to neutralize the negative effects. But for non-innovators like case B language service provider, only negative transformation outcomes could be experienced. Therefore, the net impact of machine translation technology to the performance of case B language service provider is negative (figure 21).
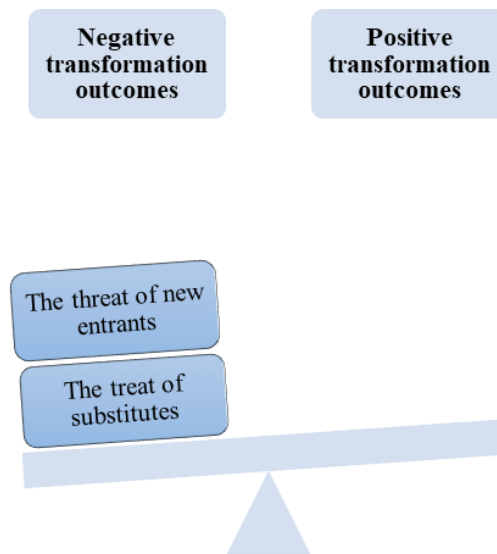
Figure 21. *Check and balance between negative transformation outcomes and positive transformation outcomes in case B language service provider.*

By reviewing and analysing of the language service industry, the study realizes that technology innovation and progress is the important driving force for the development of the language service industry, and machine translation technology is the main representative of technology innovation and progress in the language service industry. However, in the literature review, there is still the uncertainty within academic and industrial fields about the topic whether machine translation technology will impact positively or negatively to the performance of language service providers and within the language service industry. In order to find out the root of the uncertainty, the author cited the classical theory - Schumpeter's innovation theory. According to Schumpeter's innovation theory (1934). The study believes that, as an important technological innovation, machine translation technology will bring creative destruction to the language service industry (Aghion & Howitt, 1992; Cox & Alm, 1992; Cho et al., 2005; Prajogo, 2006). In other words, it will bring both positive and negative impacts to the performance of language service providers. On the one hand, new technology has brought new entrants. Many high-tech companies enter into the language service industry by taking the advantage of machine translation technology, then grab the market share away. Besides, the machine translation itself has been able to replace a lot of human work, which becomes an effective substitute. These two factors could have a negative impact on language service providers. In the theoretical framework of the study, the impact is called "negative transformation outcomes" (figure 14). On the other hand, language service providers adopting advanced machine translation technologies can improve their work efficiency, reduce costs and gain higher business revenue. In the theoretical framework of the study, the impact is called "pos-

itive transformation outcomes" (figure 14). It is the mediating effect of the negative transformation outcomes and the positive transformation outcomes that decided the final net impact (Liao & Rice, 2010). By studying the business revenue and the development trend of case company A and case company B under the guidance of the framework established especially for analysing the mediating effects of machine translation technology on the performance of language service providers, the thesis aims to answer two specific questions:

Question 1. How does machine translation technology affect the business revenue of language service providers?

Question2. How does machine translation technology affect the long-term economic growth of language service providers?

The empirical study result based on the two questions mentioned above is summarized in table 4.

Table 4.   *The result comparison of the two cases.*

Items	Case A	Case B
Machine translation technology	Accepted and actively developed	Rejected
Business revenue	Increased	Decreased
Business revenue growth rate	Increased sharply	Decreased sharply
Long-term economic growth	Enter into benign development	Business volume decreased and be acquired

From the empirical study, the thesis demonstrated that the language service provider actively adopting machine translation technology actually gain more benefits from the "positive transformation outcomes" than the attacks from "negative transformation outcomes". The specific manifestations are:

1. *Business revenue grow faster after the adoption of machine translation technology.*

2. *The development of the language service provider entered into a virtuous circle.*

However, the revenue of the language service provider that did not adopt the new technology showed a declining trend. Furthermore, in the event of a major technological breakthrough, the growth rate of its business revenue showed a remarkable decline.

The case study result is that, the net impact of machine translation technology on the performance of language service providers is largely determined by the company's attitude towards the new technology. Companies that do not adopt new technologies cannot enjoy the benefits brought by the "positive transformation outcomes", so the impact of machine translation technology is mainly manifested as the negative impact (figure 21). While for companies adopting new technologies, the positive impact of "positive transformation outcomes" outweighs the negative impact of "negative transformation outcomes" (figure 20). Except for the significant business revenue growth, the language service provider could also ensure a long-term economic development resulted from the robust technological advantage. Therefore, actively adoption of advanced machine translation technologies can improve the performance of language service providers in the long run. The role of machine translation technology in the language service industry is unignorable.

6. CONCLUSION

6.1   Contributions Of The Thesis

Machine translation technology, as an important driving force for the development of the language service industry, has undergone great changes in recent years, which bringing both challenges and opportunities to language service providers (Hutchins, 2015). According to the core concept of creative destruction under Schumpeter's innovation theory (Schumpeter, 1934), the technological innovation as machine translation will have pros and cons to the performance of language service providers, and the final outcome is determined by the mediating effect of both sides (Liao & Rice, 2010). Therefore, the study focuses on discussing the net impact of machine translation technology on the performance of language service providers, meanwhile tries to confirm the unneglectable role of machine translation technology in the current language service industry. The robust result of the study comes from the empirical study of two real cases selected from the author served language service providers. By combining the refined research framework and the real cases, the objective of the study, which is to study whether the active adoption of advanced machine translation technologies can improve the performance of language service providers in the long run, is well analyzed and argued, in addition, a clear and firm conclusion has been achieved, that machine translation technology could positively influence the performance of the language service provider and its long-term economic growth. The role of machine translation technology in the current language service industry is unignorable. From the definite conclusion, the thesis will have not only academic but also practical contributions.

Academically, the thesis established a refined framework, which is especially useful for analyzing the impact of machine translation technology on the performance of language service providers. This framework has strong applicability when conducting researches on the relationship of traditional production mode and technology innovation. Therefore, it could be used as a reference for further investigations on the related fields.

Practically, the study has important reference contributions for both industry policy makers and language service providers in the language service industry. To industry policy makers, through a systematic analysis of the history and the current situation of the global language service industry, and a comprehensive review of the development of machine translation technology, the study

has clarified the significant influence of technology progress on the development of the language service industry. The progress of computer technology represented by machine translation will promote the development of the language service industry as a whole (Doherty, 2016; Wu, 2016; Luo et al., 2018). The structure upgrading of the language service industry depends on technology progress, which is closely related to the investment in research and development (Kuhn, 1962; Dosi, 1982). By confirming that currently, actively adoption of advanced machine translation technologies can undoubtably improve the performance of language service providers in the long run, the thesis addressed the unignorable role of machine translation technology in the language service industry. The result could ensure the industrial policy makers to truly recognize the need to increase R&D investment in relevant technologies, so as to promote the structural upgrading of the language service industry.

To language service providers, by analyzing the impact of machine translation technology on the performance of language service providers, the study identifies the determinants of language service providers' performance – advanced machine translation technology. The result will provide a right guidance to the vision plan of language service providers. Given that machine translation technology will exert positive and negative impacts on language service providers, then how to maximize the benefits of machine translation technology and properly cope with the corresponding risks and challenges is the most important thing that the decision makers of language service providers need to think about. The few measures mentioned in the case study could even be directly referred. For example, rapid improvement of technology by M&A (Case A) and maintaining long-term competitiveness by independent R&D (Case A).

6.2   The Main Contributions Of The Thesis

The contribution of the thesis is mainly reflected in two aspects: theory development and practical guidance for practitioners.

The theoretical contribution of the study is: based on Schumpeter's innovation theory and combining the classic mediating effect model (Schumpeter, 1934; Baron & Kenny, 1986), the study firstly proposed the concept of "positive transformation outcomes" and "negative transformation outcomes", and then used them to establish a research framework to analyze the relationship of machine translation technology and language service providers.

The practical contribution of the study is: the thesis firstly combined translation technology studies with economic science. The study used the innovation and progress of machine translation technology as the main line, and makes a systematic review and analysis of the language service industry from four aspects: definition, development history, market profile and macro-environment. Then, in the context of machine translation technology innovation and progress, the study is the first to empirically analyzed the impact of advanced machine translation technology on the performance of language service providers based on Schumpeter's innovation theory.

6.3 Limitations and Future Research

The empirical study conducted by the thesis only involved two individual cases, though some of the data comes from the author's first-hand sources and has the strong credibility and persuasiveness, the conclusions drawn from the case may not be universal applicable (Yin, 2013).

In addition, there is no standard analysis method for case study. Therefore, different understanding of the collected data could lead to different conclusion (Yin, 2013). For example, in the thesis, the impact of machine translation technology on the performance of language service providers is reflected through the data of business revenue, but the quantitative analysis of the net impact is not specific because of the limited data sources. Then, different understandings of the data might happen. To address the problem, more comprehensive and detailed data is needed.

Finally, the study hopes to generate more discussion on the relationship between NMT technology and the performance of language service providers, but in the selected cases, only one year of NMT technology commercialization record could be traced. Therefore, only short-term effects of the current latest technology can be observed. In the future study, data can be collected over a longer time span. In this way, not only the long-term effects of NMT technology could be studied, but also the dynamic changes of its impacts could be explored.

REFERENCES

Aghion, P. & Howitt, P. (1992) A Model of Growth through Creative Destruction. Econometrica, Vol. 60 (2), PP 323-351.

Al-Obaidan AM. (2008) Market structure concentration and performance in the commercial banking industry of emerging markets. European Journal of Economics, Finance and Administrative Sciences. 12:104–115.

Akan, M. (2002) Policy Implications of Solutions of Dynamic Optimal Production and Inventory Problems for Turkey. Central Bank Review. 2:64-73.

Anastasiou, D. & Gupta, R. (2011) Comparison of Crowdsourcing Translation with Machine Translation. Journal of Information Science, Vol. 37(6), PP637-659.

Baron, R. M. and Kenny, D. A. (1986) The Moderator-Mediator Variable Distinction in Social Psychological Research – Conceptual, Strategic, and Statistical Considerations. Journal of Personality and Social Psychology, Vol. 51(6), pp. 1173–1182.

Bain, J. (1956) Barriers to New Competition, Cambridge. Mass: Harvard University Press.

Baker, M. (1993) Corpus Linguistics and Translation Studies: Implications and Applications. Text and Technology: In Honor of John Sinclair, Amsterdam: John Benjamins.

Baron, S. (2003) Language of the Internet. Stanford Handbook for Language Engineers, Stanford: CSLI Publications.

Bartel, C. & Garud, R. (2009) The role of narratives in sustaining organizational innovation, Organization Science, 20(1), pp.107-117.

Beaton, A. & Contreras, G. (2010) Sharing the Continental Airlines and SDL Post-Editing Experience. In Proceedings of the Ninth Conference of the Association for Machine Translation in the Americas.

Bell, G. G. (2005) Clusters, networks, and firm innovativeness, Strategic Management Journal, 26, pp.287-295.

Bentivogli, L., Bisazza, A., Cettolo, M. & Federico, M. (2016) Neural versus Phrase-Based Machine Translation Quality: A Case Study.

Bowker, L. (2002) Computer-Aided Translation Technology. Ottawa: University of Ottawa Press.

Bowker, L. & Marshman, E. (2010) Toward a Model of Active and Situated Learning in the Teaching of Computer-Aided Translation: Introducing the CERTT Project. Journal of Translation Studies, Vol. 13(2), PP199-226.

Brown, P., Cocke, J., Pietra, S., Pietra, V., Jelinek, F., Lafferty, J., Mercer, R. & Roossin, P. (1990) A Statistical Approach to Machine Translation. Computational Linguistics, Vol. 16 (2), PP79-85.

Brace, C., Vasconcellos, M. & Miller, L. (1995) MT users and usage: Europe and the Americas. In Proceedings of the MT Summit V.

Cantillon, R. (1931) Essai Sur la nature du commerce en general, Macmillan, London.

Carnoy, M. (1997) The New Information Technology International Diffusion and Its Impact on Employment and Skills: Review of the Literature. International Journal of Manpower, Vol. 18, PP10-12.

Chen, Y. Q., Chen, H. J., Wang, H. N. & Zhang, P. (2016) Investigation and analysis of talent demand in language and translation service industry. East Journal of Translation, 4: 32-39

Cho, H. & Pucik, V. (2005) Relationship between innovativeness, quality, growth, profitabil-ity, and market value, Strategic Management Journal, 26(6), pp.555-570.

Chomsky, N. (1955). The logical structure of linguistic theory. PhD diss., Univ. of Pennsylva-nia.

Common Sense Advisory. (2005) The Language Services Market: 2005, Lowell.

Common Sense Advisory. (2006) The Language Services Market: 2006, Lowell.

Common Sense Advisory. (2007) The Language Services Market: 2007, Lowell.

Common Sense Advisory. (2008) The Language Services Market: 2008, Lowell.

Common Sense Advisory. (2009) The Language Services Market: 2009, Lowell.

Common Sense Advisory. (2010) The Language Services Market: 2010, Lowell.

Common Sense Advisory. (2011) The Language Services Market: 2011, Lowell.

Common Sense Advisory. (2012) The Language Services Market: 2012, Lowell.

Common Sense Advisory. (2013) The Language Services Market: 2013, Lowell.

Common Sense Advisory. (2014) The Language Services Market: 2014, Lowell.

Common Sense Advisory. (2015) The Language Services Market: 2015, Lowell.

Common Sense Advisory. (2016) The Language Services Market: 2016, Lowell.

Common Sense Advisory. (2017) The Language Services Market: 2017, Lowell.

Common Sense Advisory. (2018) The Language Services Market: 2018, Lowell.

Common Sense Advisory. (2019) The Language Services Market: 2019, Lowell.

Common Sense Advisory. (2020) The Language Services Market: 2020, Lowell.

Cox, M. & Alm, R. (1992) The Churn: The Paradox of Progress. Annual Report of the Federal Reserve Bank of Dallas.

Cui, Q. L. (2014) The role of human post revision in machine translation. Chinese Translators Journal, 6: 68-73.

DePalma, Donald, A., Robert, G. S., Arle, L., Hélène, P. (2017) The Language Services Market: 2017. Retrieved from http://www.commonsenseadvisory.com/AbstractView/tabid/74/ArticleID/ 39815/Title/TheLanguageServicesMarket2017/Default.aspx [online].

De Clercq, D. et al. (2011) The Moderating Role of Organizational Context on the Relationship Between Innovation and Firm Performance. IEEE transactions on engineering management. [Online] 58 (3), 431–444.

Directorate General for Translation of the European Commission. (2009) The Size of the Language Industry in the EU. Brussels & Luxembourg.

Dosi, G. (1982) Technological Paradigms and Technological Trajectories. Research Policy, Vol. 11, PP147-162.

Dunne, K. (2012) The Industrialization of Translation: Causes, Consequences and Challenges. Translation Spaces, Vol. (1), PP143-168.

Devlin, J., Zbib, R., Huang, Z., Lamar, T., Schwartz, R. M. & Makhoul, J. (2014) Fast and Robust Neural Network Joint Models for Satistical Machine Translation. In Proceedings of the 52nd Annual Meeting of the Association for Computational Linguistics.

Doherty, S. & Kenny, D. (2014) The Design and Evaluation of a Statistical Machine Translation Syllabus for Translation Students.", The Interpreter and Translator Trainer, Vol. 8(2), PP295–315.

Doherty, S. (2016) The Impact of Translation Technologies on the Process and Product of Translation. International Journal of Communication, Vol. 10, PP947-969.

Drugan, J. & Babych, B. (2010) Shared Resources, Shared Values? Ethical Implications of Sharing Translation Resources. In Proceedings of the Second Joint EM+/CNGL Workshop "Bringing MT to the User: Research on Integrating MT in the Translation Industry".

EU language industry survey: before and after COVID-19 (2020) Retrieved from https://ec.europa.eu/info/sites/info/files/2020_language_industry_survey_report.pdf [Online].

Feng, Z. W. (2018) Parallel development of machine translation and artificial intelligence. Journal of Foreign Languages, 6: 35-48.

Flanagan, M. (1997) MT today: Emerging Roles, New Successes. Machine Translation, Vol. 12(1), PP25-27.

Fulford, H. (2002) Freelance Translators and Machine Translation: An Investigation of Perceptions, Uptake, Experience and Training Needs. In Proceedings of the 6th EAMT Workshop.

Fulford, H. & Granell-Zafra, J. (2004) The Uptake of Online Tools and Web-based Language Resources by Freelance Translators: Implications for Translator Training, Professional Development, and Research. In Proceedings of the 2nd International Workshop on Language Resources for Translation Work, Research and Training.

Gartner, W. B. (1985) A Conceptual Framework for Describing the Phenomenon of New Venture Creation. The Academy of Management Review. [Online] 10 (4), 696–706.

Garcia, I. (2011) Translating by Post-Editing: Is It a Way Forward? Machine Translation, Vol.25 (3), PP217-237.

Garg, V. K., Walters, B. A., Priem, R. L. (2003) Chief executive scanning emphases, environmental dynamism, and manufacturing firm performance. Strategic Management Journal, 24(8),725-744.

Gaspari, F. (2004) Integrating on-line MT services into Monolingual Web-sites for Dissemination Purposes: An Evaluation Perspective. In Proceedings of the 9th EAMT Workshop.

Gaspari, F. & Hutchins, W. J. (2007) Online and free! Ten Years of Online Machine Translation: Origins, Developments, Current Use and Future Prospects. In Proceedings of the MT Summit XI.

Gunday, G., Ulusoy, G., Kilic, K. et al. (2011) Effects of innovation types on firm performance. International Journal of Production Economics, 133(2): 662-676.

Esselink, B. A. (2000) Practical Guide to Localization. Amsterdam: John Benjamins.

Gaspari, F., Almaghout, H. & Doherty, S. (2015) A Survey of Machine Translation Competences: Insights for Translation Technology Educators and Practitioners. Perspectives: Studies in Translatology, Vol. 23(3), PP333-358.

Gerard, D. (1972) Theory of Value: An Axiomatic Analysis of Economic Equilibrium. Yale University Press, New Haven CT.

Groth, L. (2000) Doing research in Business and Management: An Introduction to process and method, European Journal of Information Systems, vol. 9, no. 3, pp. 201-202.

Gummesson, E. (1993) Case study research in management: Methods for generating qualitative data, Department of Business Administration, Stockholm University, pp. 1-60.

Hargadon, A. B. & Douglas, Y. (2001) When innovations meet institutions: Edison and the design of the electric light. Administrative Science Quarterly, 46(3), 476-501.

Hochreiter, S. & Schmidhuber, J. (1997) Long Short-Term Memory. Neural Computation.9(8): 1735-1780.

Hockett, C. F. (1952) A formal statement of morphemic analysis.Studies in Linguistics.10:27–39.

Huang, F., Rice, J. (2009) The role of absorptive capacity in facilitating Open innovation outcomes: A study of Australian SMEs in the manufacturing sector. International Journal of Innovation Management, 13(02), 201-220.

Hutchins, W. J. (1998) The Origin of the Translator's Workstation. Machine Translation, Vol. 13(4), PP287-307.

Hutchins, W. J. (1986) Machine translation: past, present, future. (Ellis Horwood Series in Computers and their Applications.) Chichester, Ellis Horwood, 1986. 382p.

Hutchins, W. J. (2004) Two precursors of machine translation: Artsrouni and Trojanskij. International Journal of Translation 16(1) Jan-June 2004, 11-31.

Hutchins, W. J. (2011) Recent applications of machine translation. In: Oxford Handbook of Translation Studies, ed. Kirsten Malmkjær and Kevin Windle. Oxford University Press, pp.441-454.

Hutchins, W. J. (2014) The history of machine translation in a nutshell. Retrieved from http://www.hutchinsweb.me.uk/Nutshell-2014.pdf [online].

Hutchins, W. J. (2015) Machine translation: history of research and applications. Retrieved from http://www.hutchinsweb.me.uk/Routledge-2014.pdf [online].

IBISWorld. (2014) Translation Services in the US.

IDC. (2020) Retrieved from https://www.idc.com/getdoc.jsp?containerId=prUS46780320 [Online].

Jimenez, J. D. & Sanz-Valle, R. (2011) Innovation, organizational learning and performance, Journal of Business Research, 64(4), pp.408-417.

Johannessen, J. A. (2008) Organisational innovation as part of knowledge management, International Journal of Information Management, 28(5), pp.403-412.

Johansson, S. (2007) Seeing through Multilingual Corpora, Amsterdam: John Benjamins.

Johnson, G. & Scholes, K. (1993) Exploring Corporate Strategy: Text and Cases. Hamel Hempstead: Prentice-Hall.

Kalchbrenner, N. & Blunsom, P. (2013) Recurrent Continuous Translation Models. In Pro-ceedings of the 2013 Conference on Empirical Methods in Natural Language Processing.

Kenny, D. (2011) Electronic Tools and Resources for Translators, in The Oxford Handbook of Translation Studies. [Online]. Oxford University Press. p.

Koehn, P. & Senellart, J. (2010) Convergence of Translation Memory and Statistical Machine Translation. In Proceedings of the Second Joint EM+/CNGL Workshop.

Kong, L. R. & Cui, Q. L. (2018) The impact of information technology on translation. Journal of Bejing International Studies University, 3: 44-57.

Krueger, N. F. (1993) The Impact of Prior Entrepreneurial Exposure on Perceptions of New Venture Feasibility and Desirability. Entrepreneurship: Theory and Practice, 18(1): 5-22.

Krueger, N. F., Reilly, M, D., Carsrud, A. L. (2000) Competing Models of Entrepreneurial Intentions. Journal of Business Venturing, 15(5): 411-432.

Kuhn, S. (1962) The Structure of Scientific Revolutions, Chicago: The University of Chicago Press.

Laviosa, S. (2002) Corpus-based Translation Studies: Theory, Findings, Application, Amsterdam: Rodopi.

Lawrence V. (2012) The Translator's Invisibility: A History of Translation. [Online]. Taylor and Francis.

Levy, J. (2014) Case Studies: Types, Designs, and Logics of Inference. Case Studies, SAGE Publications Ltd, pp. II113.

Li, Y. G., Huang, H. Y., Shi, S. M., Feng, C. & Su, C. (2015) A review of multi-strategy machine translation. Journal of Chinese Information Processing, 2: 1-23.

Liao, T. S. & Rice, J. (2010) Innovation investments, market engagement and financial per-formance: A study among Australian manufacturing SMEs. Research Policy, 39(1), 117-125.

Liñán, F., Fayolle, A. (2015) A Systematic Literature Review on Entrepreneurial Intentions: Citation, Thematic Analyses, and Research Agenda. International Entrepreneurship and Management Journal, 11(4): 907-933.

Locke, N. & Booth, A. (1955) Machine Translation of Languages, Cambridge: MIT Press.

Luo, H., Meng, Y. & Lei, Y. (2018) China's Language Services as an Emerging Industry. Babel, Vol. 64, PP370-381.

Luo, HF (2018) An Empirical Study on Relationship between China Language Service Industry and Foreign Trade. Doctoral Dissertation, China University of Geosciences.

Luz M. S. (2019) 2019 China Language Service Industry Development Report. published by the Translators Association of China.

Macklovitch, E. (2001) Recent Trends in Translation Technology. In the Proceedings of the 2nd International Conference of Translation Industry.

Mahmood, Z. et al. (2013) Cloud Computing: Concepts, Technology & Architecture. 1st edition. Pearson.

Meer, V. (2003) At Last Translation Automation Becomes a Reality: An Anthology of the Translation Market. Retrieved from http://mt-archive.info/CLT-2003-VanDerMeer.pdf [online].

Mellinger, C. (2017) Translators and Machine Translation: Knowledge and Skill Gaps in Translator Pedagogy. The Interpreter and translator Trainer, Vol. 11(4), PP280-293.

Mireia, F. et al. (2011) Overcoming statistical machine translation limitations: error analysis and proposed solutions for the Catalan—Spanish language pair. Language Resources and Evaluation. [Online] 45 (2), 181–208.

Neely, A., Filippini, R., Forza, C., Vinelli, A., Hii, J. (2001) A framework for analysing business performance, firm innovation and related contextual factors: Perceptions of man-agers and policy makers in two European regions. Integrated Manufacturing Systems, 12(2), 114-124.

Minor, E. D., Hensley, R. L. & Wood, D. R. (1994) A review of empirical manufacturing strategy studies, International Journal of Operations & Production Management, 14 (1). pp. 5-25.

Musatafa, A., Sabrina, T., Fahad, T. A. (2018) Evaluation of machine translation systems and related procedures. Journal of Engineering and Applied Sciences, 13(12):3961-3972.

Neely, A., Filippini, R., Forza, C., Vinelli, A., Hii, J. (2001) A framework for analysing business performance, firm innovation and related contextual factors: Perceptions of managers and policy makers in two European regions. Integrated Manufacturing Systems, 12(2), 114-124.

Nida, E. & Taber, C. (1982) The Theory and Practice of Translation, Leiden: Brill.

Olohan, M. (2007) Economic Trends and Developments in the Translation Industry. The Inter-preter and Translator Trainer, Vol.1, PP37-63.

O'Hagan, M. (2013) The Impact of New technologies on Translation Studies: A Technologi-cal Turn." In Millán, C. & Bartrina, F. (eds.), The Routledge Handbook of Translation Studies. London: Routledge.

Otero-Neira, C., Lindman, M. T., Fernández, M. J. (2009) Innovation and performance in SME furniture industries: An international comparative case study. Marketing Intelligence & Planning, 27(2), 216-232.

Petukhova, V., Agerri, R., Fishel, M., Georgakopoulou, Y. & Penkale, S. (2012) SUMAT: Data Collection and Parallel Corpus Compilation for Machine Translation of Subtitles. Paper presented at the International Conference on Language Resources and Evaluation.

Pierce, J. & Carroll, J. (1966) Language and Machines - Computers in Translation and Lin-guistics - ALPAC Report, Washington, D. C.: National Academy of Sciences & Nation-al Research Council.

Pugh, E., Johnson, L. & Palmer, J. (1995) IBM's 360 and Early 370 Systems, Cambridge: MIT Press.

Peretto, P. (2003) Fiscal Policy and Long-run Growth in R&D-based Models with Endogenous Market Structure. Journal of Economic Growth, Vol. 8(3), PP 325-347.

Porter, M. (1980) Competitive Strategy: Techniques for Analyzing Industries and Competitors, The Free Press.

Pritha, B. (2020) An introduction to quantitative research. Retrieved from https://www.scribbr.com/methodology/quantitative-research/ [Online].

Prior, M. (2010) Google Translate (Put Down your Crucifixes). ITI Bulletin. The Journal of the Institute of Translation & Interpreting, Vol.3, PP8-11.

Prajogo, D. I. (2006) The relationship between innovation and business performance—a comparative study between manufacturing and service firms. Knowledge and Process Management, 13(3): 218-225.

Randhawa, G., Ferreyra, M., Ahmed, R., Ezzat, O. & Pottie, K. (2013) Using Machine Translation in Clinical Practice. Canadian Family Physician, Vol. 59(4), PP382-383.

Richard B. (2016) Translators at War. Retrieved from https://k-international.com/blog/translators-at-war/ [Online].

Ridder, H. G. (2017) The theory contribution of case study research designs. Business Research. 10 (2): 281–305.

Ries, E. (2011) The lean startup: how today's entrepreneurs use continuous innovation to create radically successful businesses, Crown Business, New York, p 69-87.

Roberts, P. W. (1999) Product innovation, product-market competition and persistent profitability in the US pharmaceutical industry. Strategic Management Journal, 20(7): 655-670.

Ronald, S. (2020) Where are we with machine translation in AI? Retrieved from https://searchenterpriseai.techtarget.com/feature/Where-are-we-with-machine-translation-in-AI [Online].

Roturier, J. (2009) Deploying Novel MT Technology to Raise the Bar for Quality: A Review of Key Advantages and Challenges. In Proceedings of the twelfth Machine Translation Summit.

Schumpeter, J. (1934) The Theory of Economic Development. Harvard University Press, Cambridge, MA.

Schumpeter, J. (1942) Capitalism, Socialism and Democracy; Routledge: London, UK, pp. 82–85.

Segerstrom, P. (2000) The Long-run Growth Effects of R&D Subsidies. Journal of Economic Growth, Vol. 5(3), PP 277-305.

Shona, M. (2019) How to do a case study. Retrieved from https://www.scribbr.com/methodology/case-study/ [online].

Sharoff, S. (2007) Classifying Web Corpora into Domain and Genre Using Automatic Feature Identification. Cahier du Cental, Vol. 5, PP1-10.

Smith, R. (2003) Overview of PwC/Systranet on-line MT Facility. In the Proceedings of the 25th Translating and the Computer.

Song, R. (2019) Report on World Tourism Economy Trends. Published by World Tourism Cities Federation and Tourism Research Center, Chinese Academy of Social Sciences.

Specia, L. & Farzindar, A. (2010) Estimating Machine Translation Post-Editing Effort with HTER. In the Proceedings of the Second Joint EM+/CNGL Workshop.

Standing, C. & Kiniti, S. (2011) How can organizations as wikis for innovation? Technovation, 31, pp.287-295.

Su, M. Y. (2007) The current situation and the implications of the translation memory system. Journal of Foreign Language Studies, 5: 70-74.

Timmons, J. A., Adams, R., Spinelli, S. (2012) New Venture Creation: Entrepreneurship for the 21st Century. New York: Mcgraw Hill Higher Education, p 210-221.

Timmons, J. A. (1999) Opportunity Recognition. New York: John Wiley &Sons P 34.

Thomas Y. (1817) Remarks on the Ancient Egyptian Manuscripts with Translation of the Rosetta Inscription. in Archaeologia, vol. 18 pp 1–15.

Turner, A., Bergman, M., Cole, K. & Kirchhoff, K. (2014) A Comparison of Human and Machine Translation of Heath Promotion Materials for Public Health Practice: Time, Costs and Quality. Journal of Public Health Management and Practice, Vol. 20(5), PP523-529.

Ukav, I. (2017) Market Structures and Concentration Measuring Techniques. Asian Journal of Agricultural Extension, Economics & Sociology. [Online] 19 (4), 1–16.

US Department of Defense (2005) Defense Language Transformation Roadmap. [Report].

US Department of Defense (2006) National Security Language Initiative. The DISAM journal of international security assistance management, Vol.28 (2), p.115.

Wan, J. (2018) The role of Computer Aided Translation from the perspective of language service industry. Journal of Education and Culture Studies, 12: 28-30.

Wang, C. Y. (2014) Development and enlightenment of language service industry. Chinese Translators Journal, 2: 78-82.

Wu, S. (2016) Google's Neural Machine Translation System: Bridging the Gap between Human and Machine Translation.

Xu, K. et al. (2015) Show, Attend and Tell: Neural Image Caption Generation with Visual Attention.

Yang, J. & Lange, E. (2003) Going live on the Internet." In Somers, H. (ed.), Computers and Translation: A Translator's Guide, Amsterdam: John Benjamins.

Yao, Y. Z. & Si, X. Z. (2018) Talent demand analysis of language service industry based on big data. Chinese Translators Journal, 3: 80-86.

Yin, K. (2013) Case Study Research: Design and Methods. Thousand Oaks: SAGE Publications.

Yuan, X. Y. (2011) Review of rule-based machine translation technology. Journal of Western Chongqing University，3: 56-59.

Zahra, S. A., Neubaum, D. O. (1998) Environmental adversity and the entrepreneurial activities of new ventures. Journal of Developmental Entrepreneurship, 3(2), 123-140.

Zott, C. (2003) Dynamic capabilities and the emergence of intraindustry differential firm performance: Insights from a simulation study. Strategic Management Journal, 24(2), 97-125.

Zhang, H. Y. (2018) Language service industry of China under the background of "One Belt, One Road": environmental analysis and solution suggestion. Foreign Language World, 5: 19-26.

Zollo, M. & Meter, D. (2008) What Is M&A Performance? Academy of Management Perspectives, 22, pp 55-77.