TECHNOLOGICAL UPGRADING AND DECENT WORK IN THE MANUFACTURING SECTOR：EVIDENCE FROM SEVEN COASTLINE PROVINCES, CHINA, 2002-2014

by

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Abstract

This research examines the relationship between technological upgrading and decent work in the manufacturing sector in China. By analyzing data from seven selected coastline provinces (Jiangsu, Guangdong, Zhejiang, Shandong, Fujian, Guangxi, and Hainan), both technological upgrading and an increase in decent work have been observed between 2002 and 2014. Decent work, however, is not distributed evenly among Chinese citizens. The average wage is identified as a key decent work indicator, and selected as the dependent variable in the econometric regression model. The impact of technological upgrading on the average nominal wage is estimated by a time-series-cross-section regression model using provincial level data from 2003-2014. Regression results indicate that technological upgrading accelerates wage growth in the manufacturing sector. My suggestions for future government development strategies are, to firstly, revise the *Hukou* system to promote equal opportunities for all citizens, and secondly, offer preferential policies to attract more FDI and encourage domestic R&D activities.

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Chapter 1: Introduction

1.1 Overview

After an average GDP growth rate around 10% during 1980-2008 in China, GDP growth slowed down to 7.4% in 2014 and will likely to drop to 6.9% in 2017 (World Bank 2015a). In contemporary China, as a high middle-income country, the export-driven and investment-oriented economic growth strategies are facing difficulty in providing sustainable economic growth (Kai Guo and Papa N'Diaye 2009; Gangming Yuan 2013). Firstly, after the global financial crises, the sluggish recovery in global demand makes it a challenge for China to rely on export-driven economic growth strategies. Secondly, the increase in labour cost in China is reducing its comparative advantage in labour-intensive industries compared to lower wage economies. Further expansion of the manufacturing industry has become an insufficient strategy to support a sustainable increase in global market share for China.[1] The industrial transformation towards technology-intensive production or towards higher domestic value-added production has become a challenge for Chinese manufacturers who engage in labour-intensive production.

More sustainable economic strategies are required to enhance economic growth along with social harmony. In recent years, Chinese government policies have continued transitioning to an economic system driven by domestic consumption instead of exports (National People's Congress of the People's Republic of China 2011). One of the ways to raise domestic consumption is to improve social welfare, which will reduce precautionary savings and support economic growth (Guo and N'Diaye 2009). The other way to enhance domestic consumption is to raise people's income. Recent policy guidance on achieving higher income levels emphasize

[1] China has the highest investment rate in the world, which is around 40% of GDP between 2004-2008, and investment is predominantly in the manufacturing sector (30%), the infrastructure sector (18%) and the real estate sector (23%) (Guo and N'Diaye 2009).

technological upgrading by shifting policy preference from labour-intensive industries towards technology-intensive industries. For example, China's five-year plan for 2011-2015 emphasizes technological progress and innovation. One of the important goals in this plan is to climb up the technological ladder through means such as biotechnology, new materials, new information technology, and high-end manufacturing (National People's Congress of the People's Republic of China 2011). Moreover, China has set the innovation target at 3.3 patents per 10,000 people (National People's Congress of the People's Republic of China 2011). This shows the government's determination to maintain prosperity and to shift Chinese economy to a high-income one.

This climbing the technology ladder strategy raises my concern for the implications of the strategy for decent work in the manufacturing sector. The manufacturing industry in China has enjoyed a very fast development since the opening up of China in 1979. In 2011, the Chinese manufacturing sector surpassed the manufacturing sector in the United States and has become the world's largest producer of manufacturing goods (Karel Eloot, Alan Huang and Martin Lehinch 2013). In addition, as an important foundation for economic and social development, the manufacturing sector has become the main driver of urbanization and provider of employment in China. For years, Chinese manufacturing has relied on a low cost labour force, and export tax rebates and other preferential policies. The label of "made in China" is mainly concentrated in low-tech production such as footwear and clothing. Nowadays, however, this label can be easily found in high-tech industries as well, such as aircraft components, smart phones, and medical equipment. This phenomenon raises my curiosity about whether shifting from low-tech products towards high-tech products makes manufacturing workers better off.

1.2 Research goals and methodology

The purpose of this research is to identify the impacts of technological upgrading on decent work in the manufacturing sector in China. This research mainly focuses on how technological upgrading affects wages in the manufacturing sector. Different technological upgrading indicators are used in this research to examine their impacts on wages; therefore, the type of the technological upgrading that raises workers' wages will be identified.

This research also addresses the following questions:

1. Has there been technological upgrading in China?
2. Has there been an improvement in decent work in China?
3. Does everyone benefit from improvement in decent work equally?
4. Does technological upgrading improve decent work in the manufacturing sector?

In order to answer the research questions, the following methodologies are adopted. Firstly, a literature review is used to identify the definition of key concepts. For example, in Chapter 2, by using a literature review, the definitions of technological upgrading and decent work are identified. Secondly, based upon these definitions, indicators of key concepts are identified in empirical research publications, which facilitates building an appropriate database in this research. Thirdly, descriptive analysis is used to answer questions 1, 2, and 3. For instance, in Chapter 3, some technological upgrading indicators are used to examine if there has been technological upgrading in seven selected provinces between 2002 and 2014. Lastly, econometrics analysis is used to examine the relationship between technological upgrading and decent work (which is captured by wage in this research).

1.3 Importance of this research

This research topic is important for two main reasons. Firstly, this research relates to the national development goal as expressed in the Five Year Development Plan 2011-2015. Technological upgrading is emphasized as a national strategy in this five-year plan and is intended to help China achieve its high-income goal (National People's Congress of the People's Republic of China 2011). Secondly, this research examines decent work which relates to one of the United Nation's Sustainable Development Goals (SDGs) (United Nation 2015). Moreover, work is the main factor affecting people's standard of living.

The research contributes to the literature in three ways. Firstly, the research contributes to the analysis of decent work which remains fairly limited in China. I apply the ILO decent work concept to analyze trends and patterns in decent work in seven provinces, although the analysis is limited by data availability. Secondly, the research contributes to the analysis of the relationship between technological upgrading and job quality and expands the existing scope of analysis beyond single indicators of technological upgrading, such as single indicators such as R&D expenditure or FDI, and single labour market indicators, such as employment and wages. This research analyses ten indicators of technological change and multiple indicators of job quality or decent work. More specifically, correlations between technological upgrading and decent work indicators are examined, along with regression analysis of the impact of technological upgrading on wages in the manufacturing sector. Thirdly, the methodological approach taken here to investigate the relationship between technological upgrading and decent work in China may be useful to researchers interested in these questions in other country specific contexts.

1.4 Outline of this research

The thesis is arranged into five chapters. The second chapter is a review of the literature about the definition of technological upgrading, the relationship between enterprise ownership and technological upgrading, the definition of decent work, and the implication of technological upgrading on decent work.

The third chapter provides a descriptive analysis of technological upgrading and increase in decent work in selected provinces. Decent working time will be analyzed in the last part in this chapter as a supplement to the decent work discussion.

Chapter 4, the econometric modeling of wage determination, contains a review of macroeconomic theories of wage determination and an econometrics model to estimate the relationship between technological upgrading and wage.

Finally, Chapter 5 presents conclusions, recommendations, limitations and avenues for future research.

1.5 Key definitions

Key definitions are provided below and they are fully discussed with references to the literature in the following Chapter. Technological upgrading refers to the outcomes of adopting new embodied or/and disembodied technology including process upgrading, production upgrading, functional upgrading, chain or inter-sectoral upgrading, knowledge and knowledge-creating activities.

Disembodied technological upgrading refers to knowledge and knowledge-creating activities arising from research, invention and development.

Embodied technological upgrading refers to increased productivity arising from the efficient use of new or higher quality capital.

Decent work refers to work that is productive and delivers a fair income, it involves security in the workplace and social protection for families, better prospects for personal development and social integration, freedom for people to express their concerns, organize and participate in the decisions that affect their lives and equality of opportunity and treatment for all women and men.

Productive employment refers to employment yielding sufficient returns to labour to permit the worker and her/his dependents a level of consumption above the poverty line.

Chapter 2: Literature review

In this chapter, the literature on technological upgrading and decent work, with particular reference to China, is selectively reviewed in order to guide the methodology and analysis in this thesis. The chapter starts with an examination of the concept of technological upgrading and its contribution to economic growth. The second section examines the evidence to ascertain whether technological change has occurred in China. The meaning of decent work is discussed in the third section and the relationship between technological change and decent work is assessed in the fourth section. The implications of the literature for the thesis are summarized in the final section.

2.1 Technological upgrading

2.1.1 Importance of technological upgrading

Technological upgrading is of importance to national income growth. On the way to achieving national income growth, a developing country is likely to face the "middle-income trap". The middle-income trap has been defined by Breda Griffith (2011, 39) as "a situation where a middle-income country is failing to transition to a high-income country due to rising costs and declining competitiveness". Many studies have highlighted that China is experiencing pressure that could result in this problem (OECD 2013b; Wing Thye Woo 2012; Hongbin Cai 2014). For example, Chinese GDP growth has declined from 10.4% in 2010 to 7.4% in 2014 and will likely drop to 6.9% in 2017 (World Bank 2015a). Increasing labour productivity, promoting innovation and accelerating industrial restructuring and upgrading are suggested as the solutions to the "middle-income trap" (Liqun Jin 2015).

There are many reasons that the middle-income trap occurs. When a growing economy is at the early stages, a large population with low wages makes a low-income country competitive.

Thus, a developing country (like China) may transition from a low-income country to a middle-income one (Hernriue Schneider 2013) through a low-wage, labour-intensive development strategy. According to Homi Kharas and Harinder Kohli (2011), a middle-income country may be trapped because, firstly, as income increases, so do the wage costs; low-technology and labour-intensive manufacturing loses its comparative advantage to lower-wage economies. Secondly, the rural labour surplus declines overtime contributing to wage increases as an economy grows towards a high-income stage; thirdly, imported foreign technology starts to have diminishing marginal returns. Meanwhile, the middle-income country still cannot compete with high-technology and skill-intensive economies.

In order to escape the middle-income trap, suitable strategies are required after a nation has achieved high middle-income status. Researchers emphasize that policy-makers need to concentrate on total factor productivity (TFP) based development or technological upgrading (Kharas and Kohli 2011; Barry Eichengreen, Donghyun Park and Kwanho Shin 2012; Jelle van den Berg 2013; Eva Paus 2012).

Given the emphasis on technological upgrading as a strategy to overcome the middle-income trap, this thesis examines the relationship between technological upgrading and decent work. Decent work is defined below and in general, the relationship between technological change and employment or work is important given that for the majority of people, employment is the major determinant of their economic well-being. The thesis does not examine the direct connection between technological upgrading and economic growth.

2.1.2 Definition of technological upgrading

In this section, the definition of technological upgrading and its classification as well as its measurement will be reviewed. Technological upgrading is an abstract concept that cannot be measured directly. The ways in which technological upgrading is measured in the literature is also reviewed in order to inform the variable selection and facilitate later analysis in this thesis.

Technological upgrading is used to describe the overall progress of invention and innovation as well as diffusion of technology. This term generally has the same meaning as technological development, technological achievement, technical progress and technical change. Technological upgrading is the primary cause of economic growth, and it involves an increase in productivity, the improvement in product quality, and/or the development of new products. Technological change is adopted if it increases productivity.

Technological change or total factor productivity (TFP) is typically measured by a Cobb Douglas production function presented as: $Y=AL^{\alpha}K^{1-\beta}$ (where Y is output, and a function of two inputs, namely labour (L) and capital (K), and technological change or total factor productivity (A); and α and β refer to the output elasticities of labour and capital and capture the returns to scale. Dale Weldeau Jorgenson and Zvi Griliches (1967, 249) state that the "[i]dentification of measured growth in total factor productivity (TFP) with embodied or disembodied technical change provides methods for measuring technical change, but provides no genuine explanation of the underlying changes in real output and input". While the TFP correctly measures the shift in production possibilities and can be traced back to an initial shift in technology, it is still necessary to consider the induced effect as the contribution of capital growth (OECD 2010). Therefore, this research does not aim to measure TFP growth, but it should be clear that TFP growth needs to be considered as a proxy of technological upgrading in the literature review.

Technological progress arises from embodied and/or disembodied technological change. Embodied technological upgrading arises from the efficient use of new or higher quality capital such as machinery, equipment and components that incorporate new technology. Disembodied technological change refers to knowledge and knowledge-creating activities arising from research invention or Research and Development (R&D), technical expertise, or technology in a way that does not necessarily involve the purchase of machinery and equipment (Charles Kennedy and Anthony P. Thirlwall 1972; Renuka Mahadevan 2003; Shuzo Ueda and Kazuo Ogawa 2012). Disembodied technological progress captures scientific and technological innovations or R&D activities. However, Alberto Gabriele (2002, 334) goes beyond this definition:

> In fact, technical progress also encompasses the web of imitative and adaptive changes-in the realms of production organization, product design, materials and energy consumption, procurement, sales and distribution, management, finance, administration, and other economically relevant activities–which result in higher productivity and jointly foster the progressive climbing of the technological ladder and a more favorable positioning in the international division of labor.

Technological upgrading has a broader meaning in Gabriele's (2002) definition above, which goes beyond new technology captured in capital and R&D; it identifies specific types of knowledge-creating activities affecting production (for example, product design) and reflects upon a technological ladder in relationship to a global production system.

Technological upgrading is also the main driving force of industrial upgrading. Technological upgrading facilitates an industry to produce better quality, higher value-added, more environmentally friendly and more competitive products. In terms of the definition of industrial upgrading, it also indicates the connections with technological upgrading. Carlo Pietrobelli and Roberta Rabellotti (2006, 1) state, "[u]pgrading is usually defined as the ability to make better products, to make products more efficiently, or to move into more skilled activities." Also, Pietrobelli and Rabellotti (2006, 1) refer to "innovating to increase value-added" as being part of upgrading. Moreover, Peter Gibbon and Stefano Ponte (2005, 87-88) define industrial upgrading as "the possibility for (developing country) producers to move up the value chain, either by shifting to more rewarding functional positions or by making products that have more value-added invested in them and that can provide better returns to producers”.[2]

From these definitions and discussion, I realize that “better products”, “innovating to increase value-added”, “making products more efficiently” and “move up the value chain” are associated with new machinery purchasing and/or knowledge creating activities. By making connections between the definition of technological upgrading and industrial upgrading, the number of technological upgrading indicators are expanded.

Moving up the value chain is classified as technological progress in this research. Different paths of value chain upgrading have been identified by John Humphrey and Hubert Schmits (2002) and each of the paths indicates technological upgrading. Four value chain upgrading paths are defined as follows:

> 1. Process upgrading: transforming inputs into outputs more efficiently by reorganizing the production system or introducing superior technology; 2. Product upgrading: moving into more sophisticated product lines (which can be defined in terms of increased unit values); 3. Functional upgrading: acquiring new functions (or abandoning existing functions) to increase the overall skill content of activities; 4. Chain or inter-sectoral upgrading: firms of clusters move into new productive activities (Humphrey and Schmits 2002, 1020).

Embodied technological upgrading is associated with paths 1, 2, and 4, as in these paths, the purchasing of new and better equipment and machineries are necessary, in order to produce more efficiently, increase unit values and inter-sectoral upgrading. Disembodied technological upgrading is associated with paths 1, 2, 3, and 4, as all the paths require new knowledge understanding or knowledge creating activities. Under most of the circumstances, both types of technological upgrading take place to contribute to the upgrading. Therefore, it is normal for indicators to be classified under both embodied and disembodied technological upgrading

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2 A value chain is a chain of activities that a firm operating in a specific industry performs in order to deliver a valuable product or service for the market (Michael E. Porter 1985).

categories. The strict distinction between embodied technological upgrading and disembodied technological upgrading is unnecessary for this research. For example, product upgrading could be associated with disembodied technological upgrading and/or embodied technological upgrading. No matter which classification the indicator belongs to, it still captures technological upgrading.

For this research, technological upgrading is defined as the outcome of adopting embodied or disembodied technology including: process upgrading, production upgrading, functional upgrading, chain or inter-sectoral upgrading, following Humphrey and Schmits (2002). Given the definition, a connection between selected technological upgrading indicators and this definition will be made below.

Disembodied technological upgrading refers to knowledge and knowledge-creating activities arising from research, invention and development. It also includes production organization, product design, management and financial activity optimization, technical expertise, or technology in a way that does not necessarily involve the purchase of machinery and equipment incorporating new technology. Based upon those definitions, I classify some indicators that capture disembodied technological upgrading such as: R&D expenditure, the number of patents, FDI technology spillover, improved management, and increased skill level.[3]

Embodied technological upgrading or progress refers to increased productivity arising from the efficient use of new or higher quality capital. According to the definition, indicators of embodied technological upgrading are identified as new capital goods purchasing, new

3 Technology spillover has been defined as the external effects of technological change (Philippe Aghoin and Peter Howitt 1992; Gene Grossman and Elhanan Helpman 1991; Paul Romer 1990). Theories emphasize two aspects of technology change: 1. the marginal cost for an additional agent to use the technology are negligible; 2. the return to technological investments is partly private and partly public. These two characteristics indicate that technological investments offer benefits to not only investors but also other individuals, and these external effects are called technology spillover (Keller 2004).

equipment purchases, and increased productivity. Indicators that involve both embodied and disembodied technological upgrading include new products, FDI, product value-added, product sophistication level, and high-tech products.

2.2 Evidence of technological upgrading in China

By using the definition and categories of disembodied and embodied technological upgrading, the evidence on technological upgrading in China is evaluated in this section. In general, the evidence supports the hypothesis, that technological upgrading has occurred in the manufacturing sector in China.

2.2.1 Evidence of disembodied technological upgrading

Most academic research uses R&D expenditure (or ratio of R&D expenditure to sales, or ratio of R&D expenditure to GDP) as the indicator to capture technological upgrading (Fredrik Sjöholm and Nannan Lundin 2013; Jaejoon Woo 2012; Xiaolan Fu and Yundan Gong 2011; Xiaolan Fu and Carlo Pietrobelli 2011; Ganeshan Wignaraja 2012; Miaojie Yu 2011; Nicholas Bloom, Mirko Draca and John Van Reenen 2011). Innovations or patents are also frequently used as proxies for technological upgrading (see Fu and Pietrobelli 2011; Wignaraja 2012; J. Woo 2009).

J. Woo (2012) finds that China has the second largest stock of human resources in science and technology in the world. He also finds that in China, the R&D intensity has grown beyond 1% of GDP.[4] More specifically, R&D expenditure as a share of GDP was nearly 0.5% in 1990s, then increased to 1% in 2000 and further to 1.5% in 2007 (J. Woo 2012). OECD (2013a) reports that the R&D/GDP ratio was almost 2% in 2012. Moreover, the Medium and Long-Term National Plan aims to lift the R&D intensity to 2.5% of GDP (OECD 2013a). In addition, the

4 R&D intensity indicates the non-personnel R&D expenditure per scientist or engineer.

number of patents that belong to the Triadic Patent Families registered by Chinese researchers has increased more than 7 times from 2000 to 2007 (Xiaolan Fu and Pietrobelli 2011).[5]

For a growing country like China, learning new technology from developed economies is the quickest manner to update its own technology level. It is widely accepted that international trade and FDI are crucial channels for technology transfer from one country to another (David T. Coe and Elhanan Helpman 1995; Amy Jocelyn Glass and Kamal Saggi 1998, 1999; Wolfgang Keller 1998; UNCTAD 2004; Camal Saggi 2002; Lei Zhu and Bang Nam Jeon 2007). Empirical evidence indicates that Chinese firms are learning and benefiting from MNC and/or FDI technology spillover (Sjöholm and Lundin 2013; Ping Lin, Zhuomin Liu and Yifan Zhang 2009; Yiying Zhu 2010).

In general, foreign investment and foreign firms facilitate technological upgrading in China. For instance, Sjöholm and Lundin (2013), based upon a survey of Chinese manufacturing firms over the period 1998-2004, found that FDI has positive effects on technology spillover.[6] Moreover, Lin et al. (2009) have used a large panel data set covering a sample of manufacturing firms from 1998-2005. Their results indicate that FDI has positive vertical technology spillover effects on Chinese domestic firms.[7] Both Sjöholm and Lundin (2013) and Lin et al. (2009), use their own methodology to capture the FDI spillover effect, as it cannot be obtained directly from any database, therefore, FDI spillover effect will not be used as a technological upgrading indicator in this research. Furthermore, Y. Zhu (2010) suggests, by 2002, nearly 90% MNC

5 A Triadic Patent Family refers to a set of patents registered in various countries (i.e. patent offices) to protect the same invention and this indicator is measured as a number (OECD ilibrary n.d.).
6 Sjöholm and Lundin (2013) define the FDI spillover effect as technology externalities from FDI that might affect productivity in domestic firms.
7 Lin et al. (2009) define the FDI horizontal spillover effect as the external productivity effect on domestic firms in the same industry; the FDI vertical spillover effect refers to domestic firms' productivity improvements because of forward or backward linkages with foreign invested firms.

subsidiaries adopted core technology in local production and by 2008, there were about 1200 R&D centers set up in China by MNCs.[8]

2.2.2 Evidence of embodied and disembodied technological upgrading

Based upon the definition of embodied technological change, the following indicators are identified in this research as proxies of embodied technological upgrading: new capital goods purchases (such as capital imports and capital investment). There are many indicators which involve both embodied and disembodied technological upgrading such as the product value-added, FDI (when the investment goes into both R&D activities and machinery purchasing) and the product sophistication level. It is plausible to expect that when more domestic value is added in exports, more profit is earned. Therefore, better equipment, more skillful workers and more sophisticated production procedures are needed to facilitate a value chain upgrading. Many other indicators have been widely used to illustrate technological change such as: an export sophistication index, value of capital equipment imports, and export value chain upgrading or value-added (J. Woo 2012; Stephen Young and Ping Lan 2010; Robert Koopman, Zhi Wang and Shang-Jin Wei 2008; Bin Xu 2010; Yu 2011; Peter K. Schott 2008).

J. Woo (2012) finds that capital equipment has been largely imported in China over the period 1995-2008 and this is associated with a shift in the export structure towards high-tech categories. Precise calculations about Chinese high-tech exports were conducted by Koopman et al. (2008) for Chinese manufacturing exports; they observed that the domestic value-added as a share of the total value of exports increased from 47.1% in 1997 to 51.3% in 2002. Evidence of technological upgrading is also reflected in the share of high-tech exports. The R&D intensive exports increased from 3% in 2000 to 13% in 2008 (Fu and Pietrobelli 2011). Wignaraja (2012)

8 "Core technology is a generic term used to describe the key technology or components used in a product. These key components are vital for the product to work, and in many cases, are patent-protected" (WikiAnswers n.d.).

discovers that electronics have increased in the share of total exports from 5.8% to 9.7% between 2001 and 2009. He also finds that exporting firms have higher technology index scores than non-exporters in this industry. During the same period, China's share of world automobile exports increased from 0.6% to 2.8%, facilitated by the technology diffusion and market network of MNCs (Wignaraja 2012).

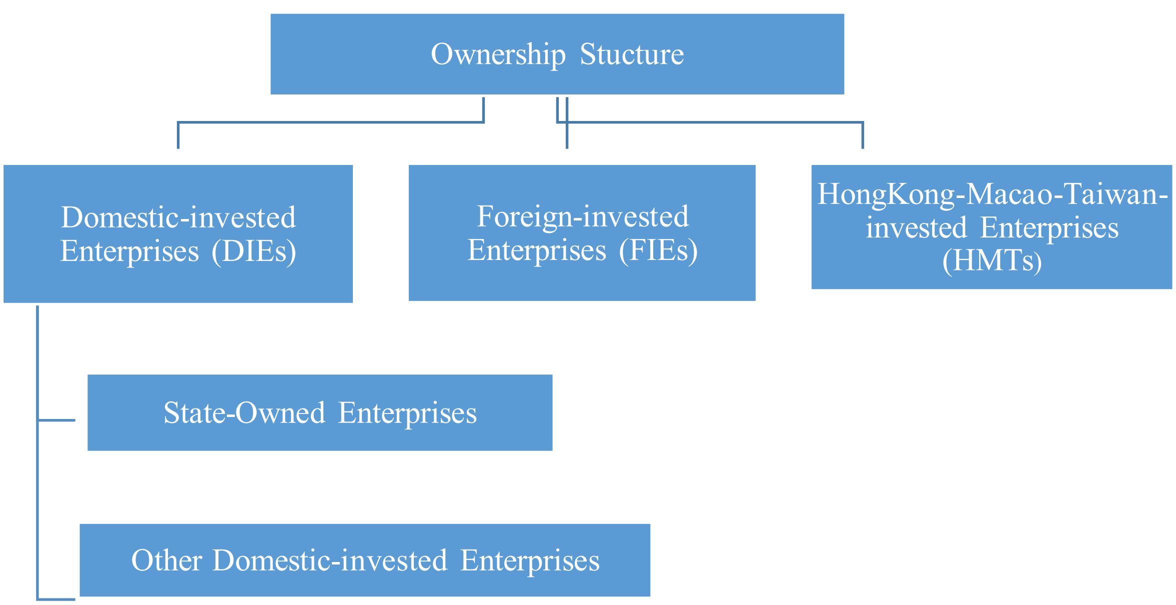
However, the technology level in China is still low. For instance, Schott (2008) discovers that although China's export products have a very high overall sophistication level, the vertical sophistication turns out to be exceptionally low. The "overall sophistication" of Chinese exports indicates the overlap between Chinese exports categories and developed economy exports categories; the "vertical sophistication" of Chinese exports indicates the level of value-added in the products (Schott 2008). J. Woo (2012) indicates that the measured overall technological level is much lower than the technological sophistication of exports. This implies that even though much of the export merchandise belongs to high-tech categories, they are at a very shallow level or in other words, they have very low domestic value-added. Besides, Chinese workers share a meager portion of the value from the processing industry. Kenneth L. Kraemer, Greg Linder and Jason Dedrick (2011) find, for example, for each iPhone 4 or iPad (16GB) that Apple sells at 549 USD and 424 USD respectively, there is only 10 USD or less paid to Chinese workers.

2.2.3 Enterprise ownership and technological upgrading

The purpose of this section is to discover whether the type of enterprise ownership plays a role in technological upgrading. The hypothesis is that different enterprise ownerships have different levels of contribution towards technological upgrading. More specifically, I will argue, following Fu and Gong (2011), Yan Liang (2008) and Albert Guangzhou Hu (2014), that, foreign-invested enterprises are more likely to be the leading power of technological upgrading, while domestic-invested enterprises are less likely to lead technological upgrading in China. Enterprise ownership types are described below in order to aid the analysis of the relationship between enterprise ownership and technological upgrading.

There are three main enterprise ownership types: domestic-invested enterprises (DIEs), foreign-invested enterprises (FIEs), and Hong Kong–Macao-Taiwan-invested enterprises (HMTs) (National Bureau of Statistics of P.R.C. 2006). See Figure 1 for the enterprise ownership structure in China. The first group includes state-owned-enterprises (SOEs), collective-owned enterprises, shareholding cooperative enterprises, associate ownership enterprises, private enterprises, limited liability corporations, shareholding corporations, and other types of enterprises. Generally, the SOEs have higher growth in medium and high technology industries while the other domestic-invested enterprises grow fastest in low and medium technology

Figure 1. Ownership Structure in China



Source: figure compiled by author based upon information in National Bureau of Statistics of P.R.C (2006) industries (Fu and Gong 2011).[9] The FIEs and HMTs are more likely to grow in high-tech sectors because a great portion of the high-tech processing and assembling type exports are produced by them (Liang 2008).

Technological progress and SOEs

In the past, SOEs were considered as the leaders of R&D, but the situation has changed in the last decade. Hu (2014) has found that over the period 1995-1999, the government-funded sectors (including SOEs) undertook more R&D than other domestic-invested enterprises, but after 1999, other domestic-invested enterprises surpassed the government sector. Anming Zhang, Yimin Zhang and Ronald Zhao (2003) state that SOEs have significantly lower R&D efficiency, but second highest R&D intensity compared to non-state owned enterprises. They explain that although SOEs spend more money on R&D activities than others do, the effect of their expenditure on productivity is insignificant. These results are consistent with Hu (2001) who finds the direct contribution of government R&D to firm productivity is statistically insignificant. Therefore, the SOEs or government funded research sectors are less likely to be the leader of technological upgrading in China.

Technological progress, FIEs and HMTs

In general, FIEs and HMTs contribute to technological upgrading in China. However, whether they have positive effects on domestic R&D activities is still under debate as outlined below.

Some of the economics literature suggests that FIEs contribute to technological progress in China. For example, Sjöholm and Lundin (2013) have conducted a study on a large number of Chinese manufacturing firms over the period 1998-2004 and have found FDI is positively related

9 See Fu and Gong (2011, 1224) for the classification of high-technology industry, medium-high technology industry, and low-technology industry. For example, high-tech industry including medical and pharmaceutical products, electronic and telecommunications etc., medium-high technology industry including special purposes equipment, transport equipment etc., medium-low technology industry contains ordinary machinery, artifact and other manufacturing etc., low-technology industry contains printing and record media reproduction, textile industry etc.

to technology spillover. Lin et al. (2009) used a large panel data set covering all state-owned and non-state owned manufacturing firms from 1998-2005, and the results suggest that FDI has positive vertical technology spillover effects on Chinese domestic firms. Moreover, J. Woo (2009) has investigated the effects of FDI on TFP growth in a large sample of countries (including China) over the period 1970 to 2000. He finds a significant positive effect on TFP from FDI and proposes that if the FDI is from OECD countries the effects will be more substantial. Furthermore, Zhu (2010) reports that by 2002, nearly 90% of MNCs subsidiaries had adopted their core technology in local production and in 2008, and there were about 1200 R&D centers set up in China by MNCs. Zhu (2010) also argues that the establishment of high-class R&D will provide good opportunities for local businesses in terms of learning and facilitating local innovation ability, thus creating a positive system for domestic R&D.

However, there are also findings indicating that FDI has a negative effect on R&D in domestic firms. For instance, Lin et al. (2009) find negative spillovers from HMT originated FDI, and positive from OECD countries in China; Fu and Gong (2010) find foreign invested firms have a significant negative effect on R&D of local firms over 2001 to 2005 in China. In other countries, similar cases have been observed, which indicates that a country should never totally rely on imported technologies. Taking Belgium as an example, Reinhilde Veugelers and Peter Vanden Houte (1990) find FDI has a negative effect on domestic R&D. Subash Sasidharan and Vinish Kathuria (2011) addressed the relationship between FDI and domestic R&D in India during 1994-2005; their findings indicate that foreign equity participation acts as a disincentive for investment in R&D in most cases. The reason for this trend is that the use of foreign technology makes local firms rely on imported technology leading to crowding out of local R&D (Fu and Pietrobelli 2011). In addition, the negative effect of FIEs on domestic R&D activities occurs when there is a poor technology absorptive capacity (Fu and Petrobelli 2011). The technology absorptive capacity depends on many aspects such as human capital, financial conditions and R&D expenditures of the receiving county. Therefore, it is also important for a country to enhance its technology absorptive capacity in order to reduce negative effects of introducing foreign technology.

2.3 Definition of decent work

2.3.1 Definition of formal and informal employment

The International Labour Organization (ILO) (1993) defines formal employment as work in the formal sector, and informal employment as work in the informal sector. The informal sector is regarded as a group of household enterprises or unincorporated enterprises owned by households. The formal sector refers to economic activity carried out by enterprises which are typically registered with the government, are larger in scale (compared to informal enterprises) measured by sales revenue or employees, and are monitored and/or taxed by the government.

However, the ILO has moved away from the enterprise-based definition of formal and informal employment to a job-based view, which allows one to identify informal jobs within the formal sector. As an enterprise-based definition cannot capture all the dimensions of informal employment, informal employment now refers to work which is not regulated by legal or regulatory frameworks, such as self-employment, wage employment which escapes regulation, and non-paid work in an income-producing sector (ILO 2002). Although the job-based dimension addresses the shortcomings of the enterprise-based definition, my research will only use the enterprise-based definition, since the job-based data are absent in national, provincial or municipal government statistical yearbooks.

In the Chinese context, the ILO (2003) has defined the informal sector as follows: 1. small or micro-enterprises, which are normally private enterprises; 2. household-based workshops involved in simple production and service activities; and 3. independent service providers. Based on the ILO (2003) definition, Jinjun Xue, Wenshu Gao and Lin Guo (2014) classified the informal sectors as: individual businesses (no more than 7 employees) and household sector. Ralf Hussmanns (2004) suggests that the informal employment emphasizes jobs that remain undeclared to the government to avoid paying social insurance and taxes, and supervision by labour law, as well as to avoid meeting health and safety standards.

The formal sector refers to governmental and institutional organizations, SOEs, collective enterprises and private enterprises (Xue, Gao and Guo 2014). In the past, jobs in the formal sector were considered as formal employment or standard employment, but now there are increasing numbers of formal sectors hiring non-standard workers.[10] Compared to those engaged in the formal employment, non-standard workers have unstable working hour arrangements, lower wages and lower social security. The government does not disclose the number of non-standard workers employed in formal sectors. Therefore, even though the official data of people employed in the formal sector has increased over time, this does not necessarily mean an increase in the number of standard jobs.

My research focuses on the manufacturing industry. Normally, enterprises in the manufacturing industry do not fall into the informal sector, because in order to survive in the

[10] Standard employment refers to "adequately compensated full-time jobs that are fully covered by the social security system, have no contractual time limitation and provide unity of work and appointment" (Marcel Garz 2013, 349). Non-standard work refers to job that fall outside the realm of standard work arrangements, including temporary or fixed-term contracts, temporary agency or dispatched work, dependent self-employment, as well as part-time work, including marginal part-time work, which is characterized by short, variable, and often unpredictable, hours (International Labour Organization b).

manufacturing industry, an enterprise usually needs to produce at a large scale to bring down the cost. Enterprises in the informal sector are unlikely to reach this scale.

This research will use the government statistical yearbooks as the data source, and the informal sector is not included. By using the enterprise-based definition of formal and informal employment, people who work in the manufacturing industry are considered as formally employed. This research cannot answer whether the number of standard workers in the manufacturing industry has increased or not, since the indicator is absent from government statistical yearbooks. Formally, employed workers have access to social security provisions; therefore, social security indicators could capture the change in decent work. The proxy for social security includes the number of social insurance participants, number of employment insurance participants or employment insurance participant ratio (the number of people who have employment insurance divided by the number of employed people over the whole economy), and total pension revenue.

2.3.2 Definition of decent work

Decent work, a concept initially developed by the International Labour Organization, has gained wide support as indicated by its incorporation as the eighth goal in the United Nations Sustainable Development Goals. Decent work has been defined as below:

> Decent work sums up the aspirations of people in their working lives. It involves opportunities for work that is productive and delivers a fair income, security in the workplace and social protection for families, better prospects for personal development and social integration, freedom for people to express their concerns, organize and participate in the decisions that affect their lives and equality of opportunity and treatment for all women and men (International Labour Organization a).

Decent work is a higher quality of employment than formal employment, because formal employment only requires the workers to be employed in the formal sector. Decent work addresses fair income, social protection for families, workplace security, personal development, freedom to express ideas, social integration and equality of opportunity. As the definition of the decent work combines so many aspects (such as access to full and productive employment with rights at work, social protection, and the promotion of social dialogue), measurement of decent work from every aspect is a difficult task. Hence, this research is going to focus on only two aspects of decent work: productive employment and social protection for families.

Productive employment is defined as “employment yielding sufficient returns to labour to permit the worker and her/his dependents a level of consumption above the poverty line” (International Labour Organization 2012, 3). Based upon the definition, whether the monetary wage could support the worker’s annual consumption expenditure and the number of dependents a worker could support becomes a method to identify decent work.

Decent work should provide social protection to workers in terms of supporting families cope with unexpected risks, such as unemployment, illness, maternity, retirement and old age. Therefore, the social security indicators such as, the unemployment insurance participation ratio becomes a quantifiable indicator for decent work.

2.4 Implication of technological upgrading for decent work

The way in which technological upgrading relates to workers’ wages and employment requires explanation. Technological progress has the potential to enhance productivity and living standards, reduce poverty and shift labour from inefficient sectors towards more efficient ones. For example, with the use of machinery, an economy is able to transform inputs into outputs more efficiently. This is also called productivity growth, which has the potential to raise peoples’ real incomes through two main mechanisms. First, higher productivity means lower costs and if these savings are passed on to consumers, it reduces the price of goods; therefore, consumers will be able to purchase more goods and services (John R. Baldwin, Wulong Gu, Ryan Macdonald, and Beiling Yan 2014). Second, technological progress may change the demand for employment type and the demand for labour skills. More specifically, if technological upgrading is capital-saving it leads to more employment, but if it is labour-saving then more workers will be replaced by capital. The technological change may also be associated with a change in the relative demand for high or low skilled labour. In addition, if technological upgrading results in economic growth, even if it is labour-saving, there may be an increase in demand for labour. The impact of technological upgrading on employment also needs to be examined country by country, since different social, political, and economic situations in different areas will affect the result.

Technological upgrading contributes to economic growth, which positively affects the employment rate. In general, empirical research indicates that technology contributes to job creation. For instance, John Van Reenen (1997) and Smolny (1998) discover that technology has a strong and positive effect on job creation in developed economies such as the United Kingdom and Germany. Moreover, with respect to China, Braunstein and Epstein (2002) find that from 1986 to 1999, FDI raised not only employment but also wages. Since FDI is a proxy for technological upgrading, it can be inferred that technological upgrading generates employment in China.

However, there is also evidence to suggest that the technological progress does not affect positively impact employment in China. For instance, Sjöholm and Lundin (2010) have analyzed the relationship between technological progress and employment based on large and medium-sized enterprises in Chinese manufacturing industry between 1998 and 2004. They adopt "the ratio of science and technology (S&T) expenditures to sales" as their technological upgrading indicator (Sjöholm and Lundin 2010, 17). Based upon this indicator of technological change, they conclude that there is no significant effect of technological progress on employment. As the technological upgrading indicator used by Sjöholm and Lundin (2010) is different from the indicator used by Braunstein and Epstein (2002), the difference of the results could be due to the different indicators of technological upgrading used. Changwen Zhao (2010) argues that Sjöholm and Lundin used data from 1998-2004, which is the early stage of Chinese economy. Hence, the comparative advantage of that stage is lower labour costs rather than technology (Zhao 2010). Zhao's argument is persuasive and explains why Sjöholm and Lundin (2010) do not find a significant positive employment effect from their research. Since China is facing higher labour costs in recent years, it is reasonable to expect that now technological progress may have a positive significant effect on employment or wages.

In general, even if technological upgrading has a positive overall impact on the labour market in terms of increased employment and wages, it may not benefit all workers equally (Khalid Nadvi 2004). Peter Knorringa and Lee Pegler (2006) conclude that value chain upgrading is not only increasing flexibility in the labour market but also increasing insecurity and working hours of workers. Besides, they suggest that core workers in the key supplier firms may enjoy improved employment conditions while others may not. Knorringa and Pegler (2006) argue that wokers employed in global value chain (GVC) supplier firms face physical and emotional pressures and stress of new work systems.[11] Workers engaged in higher value-added activities or in firms that supply higher value buyers, gain higher income and have better working conditions comparing with workers engaged in lower value-added activities. Nadvi (2004, 28) argues that, "workers within GVCs, at all points, are increasingly vulnerable to

[11] The global value chain refers to different stages of the production process being located across different countries to facilitate international production, trade and investments (OECD n.d.).

changing employment contracts and the increasing casualization of work". However, Nadvi's view on casualization and vulnerability of work is narrow as he fails to recognize that the vulnerablity of employment depends on whether a worker engages in high value-added activities or low value-added activities. Workers employed at the upper stream of the value chain (for example the R&D sector or design sector) will be less likely to experience vulnerablity in their employment. On the other hand, the situation of workers engaged in low value-added activities will depend on their skill level and learning abilities.

Although the distribution of benefits from technological upgrading is not equal among workers, technological upgrading potentially enhances the working conditions and wages on average or overall. Therefore, technological change may improve decent work through increases in income and improvements in working conditions. By looking at the number of workers with a labour contract helps identify the change in decent work as well, since labour contract offers the opportunity to regulate the rights and the obligations of both the employee and the employer.

2.5 Summary

Based upon this review of the literature, it is reasonable to conclude that there has been technological upgrading in China. By reviewing the relationship between enterprise ownership and technological upgrading, I realize that ownership type does play an important role in technological upgrading. However, this research cannot determine how exactly enterprise ownership would affect technological upgrading, therefore, this ownership will not be considered as technological upgrading indicator. The literature review offers methodologies to capture technological upgrading, appropriate proxies for technological upgrading are listed as: R&D expenditure, the number of R&D employees, FDI inflows, the value of mechanical imports or exports, and the value of high-tech imports or exports.

By reviewing the meaning of decent work and its relationship with technological upgrading in the second part of this chapter, I find that the evidence from various countries does not suggest a strong positive effect of technological upgrading and decent work for all workers. In fact, how technological upgrading affects workers depends on: workers skill level, the stage of an economy, the labour market situation, government policies and so on. But it is clear that with low-value-added industry transferred to underdeveloped areas, the wage levels and benefits to workers are likely to increase in both developed and underdeveloped areas. Technological upgrading also shifts the enterprise labour reqirement from low-skilled towards highly-skill. Comparing with better-educated urban workers, less-educated migrant workers may have difficulties finding skill-intensive jobs in developed areas. Therefore, migrant wokers will be less likely to share in the benefits of technological upgrading. The literature review demonstrates that decent work is comprised of a variety of dimensions and various indicators are used to measure these dimensions. In this thesis, I will use average income relative to the poverty line and annual consumption expenditure to reflect productive employment.

Based upon this literature review, two main gaps in the research are identified. Firstly, the literature focuses on the impact of technological upgrading on productivity growth or employment growth. I have not found literature which studies the relationship between technological upgrading and decent work or wages, and my research is intended to fill this gap. Secondly, research on decent work in China is very limited. This research will contribute the analysis of decent work in the Chinese labour market.

Chapter 3: Technological upgrading and decent work in selected provinces

3.1 Introduction

The purpose of this chapter is to assess the extent of technological upgrading and the improvement of decent work in the seven selected provinces: Jiangsu, Zhejiang, Fujian, Guangdong, Guangxi, Hainan, and Shandong. As discussed in the previous chapter, while an assessment of the impact of technological upgrading on improving decent work is the intended goal of this thesis, unfortunately, data to measure decent work are limited. Therefore, the quantitative analysis will focus primarily upon employment and wages in the manufacturing sector, and will be complemented with an analysis of selected indicators of social security. The analysis in this chapter is intended to establish whether or not technological upgrading and decent work have occurred which provides the foundation for the regression analysis in the subsequent chapter on the association between technological upgrading and decent work. More specifically, this chapter provides an analysis of the:

1. Evidence of technological upgrading and technology endowment in seven selected provinces;
2. Evidence of an increase in decent work in terms of the number of manufacturing employment, manufacturing average annual wage, and social security indicators;
3. Correlation between technological upgrading indicators and decent work indicators;
4. Decent working time.

3.2 Methodology

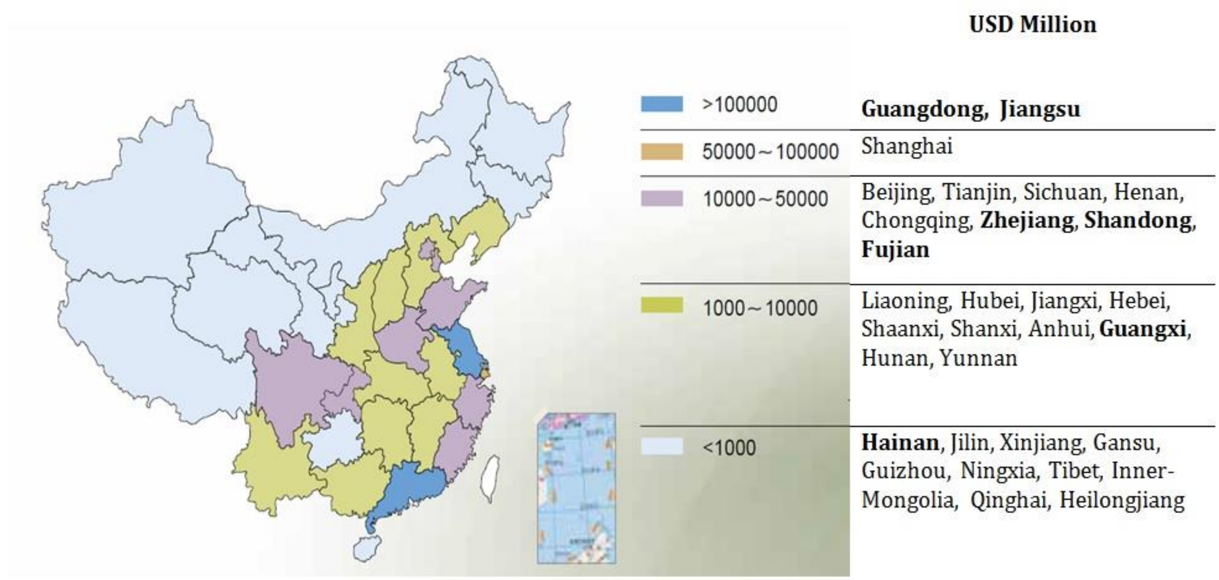
The main methodological challenge addressed in this chapter is to find reliable and publicly available data to capture the concepts of technological upgrading and decent work. The literature review in the previous chapter provides definitions of these key concepts and highlights the types of indicators that have been used in the literature to measure these concepts. I tried to find data on similar indicators.

The data on technological upgrading and decent work in this chapter are collected primarily from provincial statistical yearbooks. Most provincial statistical yearbooks for the most recent decade can be accessed on provincial government websites, with the exception of data from Hainan province, which must be obtained from the National Knowledge Infrastructure (CNKI) website. The CNKI provides the photocopy edition of statistical yearbooks for all provinces in China. I used both provincial government websites and the CNKI web to download statistical yearbooks, and then manually enter the data to complete data set. However, some indicators cannot be found consistently from provincial statistical yearbooks, such as the number of people who participate in unemployment insurance programs. Therefore, the National Bureau of Statistics website is also used to collect data for my database. The time period selection is based upon the availability of two of the technological upgrading indicators, high-tech products imports and exports, which starts from 2002. Although I realized there are other technological upgrading indicators in both the provincial statistical yearbooks and National Bureau of Statistics websites, such as the number of R&D achievements in large and medium enterprises, they are not consistently reported annually. The short time period of the database becomes one of the limitations of this research.

The empirical approach adopted here is to focus upon the change in technological upgrading and decent work over the time period 2002-2014, as well as the variation among the selected provinces. To take account of differences in the size of the economy and population among the provinces, where appropriate, the data are presented relative to the size of the province. After providing a descriptive analysis of the changes in technological upgrading and decent work based upon several different indicators of each concept, the correlation between the two concepts is presented. As discussed further in the section on the correlation, I would expect that indicators of technological upgrading and decent work to be positively correlated.

These seven coastline provinces are selected for analysis because manufacturing enterprises are clustered in coastline provinces. As their products are primarily destined for export, being on the coastline facilitates the transport of these goods to overseas markets. Besides, due to their special geographical location, coastal cities are an important window for foreign trade and communication. The convenience of maritime transport attracts export-oriented and high-tech firms to settle in the coastal cities.[12] Therefore, technological upgrading is more likely to take

Figure 2. Value of high-tech exports by region in 2013



Source: Ministry of Science and Technology of the PRC (2015, 33).

12 There are also high-tech firms located in inland provinces, however, inland provinces do not disclose data on the value of high-tech products that are produced or exported in their statistical yearbooks. Future research could extend the data to other provinces if reliable data resources are available.

place in coastal provinces.[13] Information from Figure 2 indicates that coastal provinces export more high-tech products than inland provinces. For example, five of the seven selected provinces exported more than 10,000 million USD high-tech products in 2013.

3.3 Evidence of technological upgrading in seven selected provinces

One way to identify technological upgrading in selected provinces is by examining the changes in the technology proxies, as illustrated in Table 1. By comparing the number of each technology indicator in 2002 and 2014, we can conclude that there has been technological upgrading in each of the selected provinces. For instance, the actual FDI utilized in Jiangsu is 10.4 billion USD in 2002, and it increased to 28.2 billion USD in 2014. However, the R&D employment in large and medium (LM) enterprises (in '000s people) in Guangxi and Hainan slightly decreased from 20.4 to 20.1 and from 6.2 to 3.4, respectively. This should not change the conclusion that technological upgrading has occurred in these two provinces, since all other five technology indicators have shown an increase.

By comparing the numbers in Table 1 horizontally, the numbers marked in bold indicate the province with highest level of technology for the given year. For example, in 2014, Jiangsu has the highest actual FDI utilized of 28.2 billion USD compared to other provinces in that year. Based upon most indicators, Guangdong province and Jiangsu province have the highest technology endowments compared to other provinces. This conclusion is based upon the technology indicator expressed in absolute terms. Yet, comparison of the indicators in absolute terms ignores the impact arising from the size of each province. For instance, while Guangdong has the highest technology endowments for many indicators, this could be due to its large

13 The original plan for this research was to obtain data for all coastline provinces and cities, however, not every coastline province and city publish statistical yearbooks and some provinces do not report consistent data for some vital technological upgrading indicators. Therefore, in this research I have selected the seven coastline provinces for which consistent data on indicators of technological upgrading exist.

population size and area. Hence, using the indicators in absolute terms is not enough. Using indicators in relative form as presented in Table 2, we can see that Jiangsu has the highest technology endowments rather than Guangdong. I would argue that the results from relative term of numbers are more convincing in terms of understanding which provinces can be considered to have a high technology endowment.

Table 1. Technology indicators in absolute terms, selected provinces, 2002 and 2014

	Year	Jiangsu	Guangdong	Fujian	Shandong	Zhejiang	Guangxi	Hainan
Actual FDI utilized	2002	10.4	**13.1**	4.3	6.5	3.2	0.4	0.5
(in billion USD)	2014	**28.2**	27.3	7.7	16.0	15.8	1.0	1.9
Mechanical and	2002	21.2	**72.7**	2.5	5.0	29.4	0.3	0.1
electronics exports (in billion USD)	2014	221.5	**428.6**	40.4	56.2	112.5	10.7	0.4
High-tech exports	2002	12.1	**31.0**	3.2	1.1	1.4	0.0	0.0
(in billion USD)	2014	129.4	**231.0**	15.0	20.6	15.5	2.9	0.3
R&D expenditure in	2002	**18.3**	16.2	2.3	15.9	8.8	1.3	0.1
LM enterprises (in billion CNY)	2014	96.9	**137.5**	28.0	109.2	68.8	7.5	0.8
R&D employment in	2002	158.1	104.1	25.6	**158.8**	45.0	20.4	6.2
LM enterprises (in ‘000s)	2014	**598.9**	544.9	141.7	342.3	298.9	20.1	3.4
Patents granted (in	2002	7.6	**22.8**	4.0	7.3	10.5	1.1	0.2
‘000s)	2014	**200.0**	180.0	37.9	72.8	188.5	11.4	1.6

Note: LM enterprise refers to large and medium enterprises; *Chinese High-tech Products Catalog 2006* defines high-tech exports (Guangdong High-tech Enterprise Association 2015)*;* mechanical and electronics exports are defined by *Mechanical and Electronics Product Range* (Ministry of Commerce of the P.R.C 2008).
Source: compiled by author from provincial statistical yearbooks 2003 and 2015.

Table 2. Technology indicators in relative terms, selected provinces, 2002 and 2014

	Year	Jiang su	Guang dong	Fu jian	Shan dong	Zhe jiang	Guang xi	Hai nan
FDI per worker (USD)	2002	232.6	**317.1**	248.3	118.0	110.5	16.2	146.0
	2014	**591.8**	441.2	291.2	241.5	425.3	36.2	353.5
Mechanical and electronics exports share (%)	2002	36.4	46.8	20.8	18.0	**78.1**	16.1	13.4
	2014	63.4	**68.0**	33.1	35.2	37.2	30.5	17.7
High-tech exports share (%)	2002	**31.5**	26.1	18.4	5.4	4.7	1.5	1.1
	2014	**38.3**	35.8	13.3	14.2	5.7	11.8	7.5
R&D expenditure share in LM enterprises (%)	2002	**1.7**	1.2	0.5	1.6	1.1	0.5	0.1
	2014	1.5	**2.0**	1.2	1.8	1.7	0.5	0.2
R&D employment share in LM enterprises (%)	2002	**7.3**	3.8	1.9	5.9	4.3	3.6	4.4
	2014	**9.9**	5.4	6.1	8.1	8.5	2.6	3.6
Patents per 1,000 workers	2002	0.2	**0.6**	0.2	0.1	0.4	0.0	0.1
	2014	4.2	2.9	1.4	1.1	**5.1**	0.4	0.3

Note: LM refers to large and medium enterprises; FDI per worker is the actual FDI utilized divided by total number of employed workers over the whole province; Mechanical and electronics export share is the value of mechanical and electronics exports divided by the value of total exports; High-tech exports share is the value of high-tech exports divided by the value of total exports; R&D expenditure share in LM enterprises is the R&D expenditure in LM enterprises as a share of GDP; R&D employment share is the R&D employment as a share of total manufacturing employment; Patents per 1,000 workers is the total number of patents granted divided by total number of employed workers over the whole province (in 000's).
Source: calculated by author from provincial statistical yearbooks 2013 and 2015; and National Bureau of Statistics of P.R.C. (n.d.)

3.4 Evidence of an increase in decent work

3.4.1 Manufacturing employment

Manufacturing employment in urban units will be analyzed as an indicator of decent work. [14]As discussed previously, data in the provincial statistical yearbooks capture the number of manufacturing workers with labour contracts. Therefore, workers without a labour contract but working in the manufacturing sector are excluded from the manufacturing employment number; as discussed further below, it is more likely to be the case that rural-urban migrant workers, rather than workers with an urban identity, will be the workers without contracts. By signing a work contract, workers are officially protected by the labour law in terms of their payments and benefits, although there are problems associated with monitoring and enforcement. Since there is the potential for contracts to be enforced, manufacturing work is considered as decent work.

In 2014, the total population in China reached 1.37 billion, and the urban population and rural population are 0.75 billion (54.8% of total population) and 0.61 billion (45.2% of total population), respectively (National Bureau of Statistics of P.R.C. 2015). In the same year, the number of urban employed persons and rural employed persons are 0.39 billion and 0.37 billion, respectively. Although there is not a large difference between the number of rural and urban employed persons, these numbers can only reflect employed people registered with the government (National Bureau of Statistics of P.R.C. 2015). I would argue that urban areas offer more opportunities for wage employment than rural areas, and wage employment is more likely to provide decent work than non-wage employment. In urban units, the number of people employed in the manufacturing sector accounts for 28.7% of total employment in 2014, which is

[14] The urban unit refers to the independent accounting legal entity which does not include private enterprises and individual industrial and commercial households, including state-owned units, collective units, joint-stock enterprises, joint-stock enterprises, foreign-invested enterprises and Hong Kong, Macao and Taiwan investment enterprises (Beijing Municipal Bureau of Statistics n.d.) .

the largest sector in terms of employment (National Bureau of Statistics of P.R.C. 2015). This is one of the reasons why my research focuses on the manufacturing sector in urban units.

The manufacturing sector in six of the seven selected provinces (including Jiangsu, Guangdong, Fujian, Shandong, Zhejiang and Guangxi) is the largest industrial sector in terms of employment, for urban units in 2014 (See Table 3). Going back to 2002, the manufacturing sector has provided the largest number of jobs in urban units based on data from the provincial statistical yearbook. This evidence suggests that the economy in these provinces is dominated by the manufacturing sector, and this is followed by construction. The total number of workers engaged in these two sectors account for more than 60% of total employment in all selected seven provinces. This phenomenon also indicates that the investment-driven economic growth pattern has not changed substantially over the 2002-2014 period being considered.

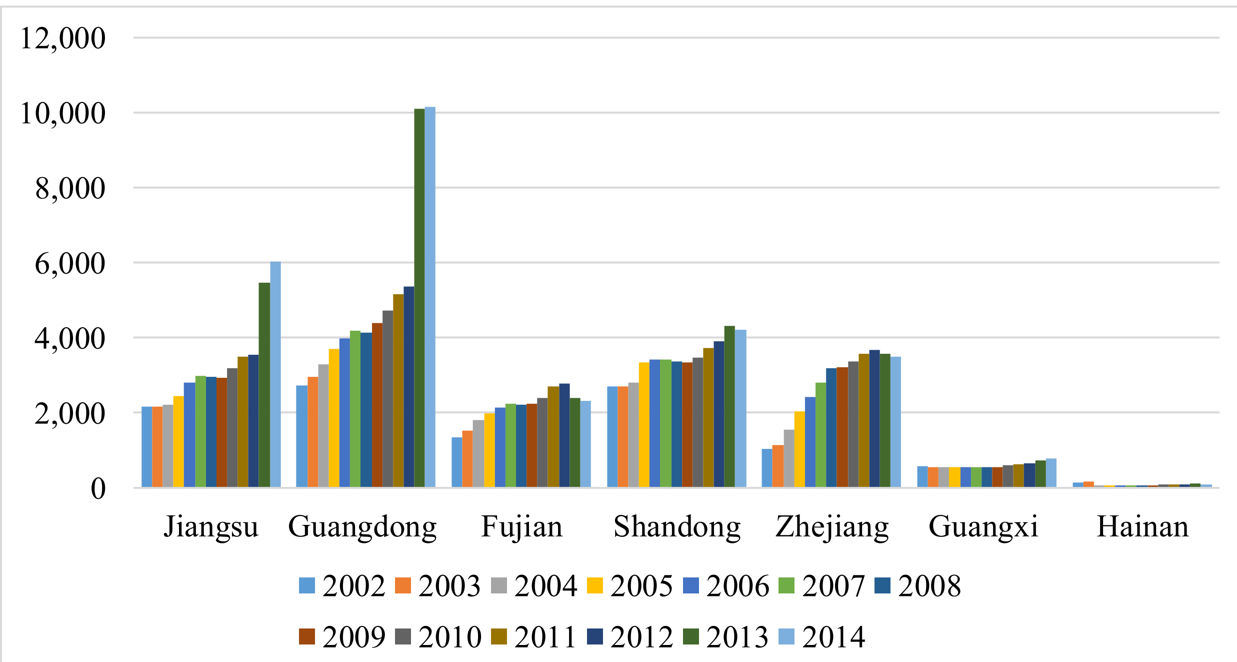
Table 3. Employment by industrial sector (number in '000s), urban units, selected provinces, 2014

	Jiang su	Guang dong	Fu jian	Shan dong	Zhe jiang	Guang xi	Hai nan
Total	**15,128.2**	**19,732.9**	**5,599.5**	**12,663.0**	**11,026.8**	**4,014.6**	**979.4**
Agriculture, forestry, animal husbandry and fishery	59.9	56.7	27.5	17.0	5.6	82.8	99.4
Mining and quarrying	115.8	29.9	23.3	712.0	8.6	38.0	6.9
Manufacturing	**6,026.7**	**10,151.6**	**2,317.6**	**4,258.0**	**3,505.5**	**782.0**	**95.7**
Production and supply of electric power, gas and water	179.2	308.0	84.0	237.0	134.2	140.6	21.7
Construction	4,047.3	1,494.1	1,064.4	1,775.0	3,294.5	609.6	64.4
Wholesale and retail trade	571.3	958.4	189.8	628.0	417.3	132.9	59.0
Transport, storage and postal services	480.4	854.0	55.5	497.0	326.9	209.1	53.3
Hotels and catering services	160.8	370.6	247.0	156.0	138.4	50.1	63.9
Information transmission, computer services and software	284.4	346.3	95.8	170.0	164.4	44.6	15.6
Finance	266.3	431.5	118.7	388.0	379.6	117.6	30.3
Real estate	207.5	558.4	133.3	256.0	197.5	79.5	72.6
Leasing and business services	301.5	606.1	97.4	216.0	284.1	110.7	24.5
Scientific research and technical services	204.5	319.3	77.8	184.0	161.0	97.7	21.4
Water conservancy, environment and public facilities management	130.4	172.8	45.8	167.0	116.8	95.9	26.3
Resident services and other services	36.3	74.9	13.7	31.0	26.2	8.2	4.2
Education	903.4	1,245.0	464.4	1,203.0	700.8	618.6	126.3
Health care and social work	424.1	596.8	187.4	587.0	416.3	298.9	55.7
Culture, sports and recreation	72.3	115.2	34.6	71.0	72.1	33.6	11.8
Public administration and social organizations	656.1	1,043.3	321.5	1,110.0	677.0	464.2	126.4

Source: compiled by author from provincial statistical yearbooks 2015.

According to the information in Figure 3, the number of people employed in the manufacturing sector is large and increasing, in each of the provinces with the exception of Guangxi and Hainan provinces. Guangdong and Jiangsu had a significant increase in manufacturing employment in 2013. The provincial statistical yearbooks for these two provinces in 2014 and 2015 do not indicate a change in statistical standards; hence, this substantial increase cannot be explained.

Figure 3. Employment in manufacturing (in '000s), urban units, selected provinces, 2002-2014



Source: compiled by author from provincial statistical yearbooks 2003 and 2015.

The manufacturing employment has increased not only in absolute terms, but also in relative terms. Comparing those numbers between 2002 and 2014, the manufacturing employment as a share of total employment in urban units has increased in Jiangsu, Guangdong, Fujian and Zhejiang (see Table 4). The ratio has a slight decrease in Shandong and Guangxi and a sharp decline in Hainan. This relatively high share indicates that the manufacturing industry continues to play an important role in these provinces over last decade. Moreover, with the development of the economy, the position of manufacturing sector is still increasing in terms of employment. In 2014, the share of manufacturing employment in Guangdong accounts for 51.45% employment in urban units.

Table 4. Share of manufacturing employment (%), urban units, selected provinces, 2002 and 2014

	Jiangsu	Guangdong	Fujian	Shandong	Zhejiang	Guangxi	Hainan
2002	35.07	34.43	41.21	35.53	28.30	20.79	19.42
2014	39.84	51.45	41.39	33.25	31.79	19.48	9.77

Note: Share of manufacturing employment is the number of people employed in the manufacturing sector divided by the total number of people employed in urban units times 100 percent.
Source: calculated by author from provincial statistical yearbooks 2003 and 2015.

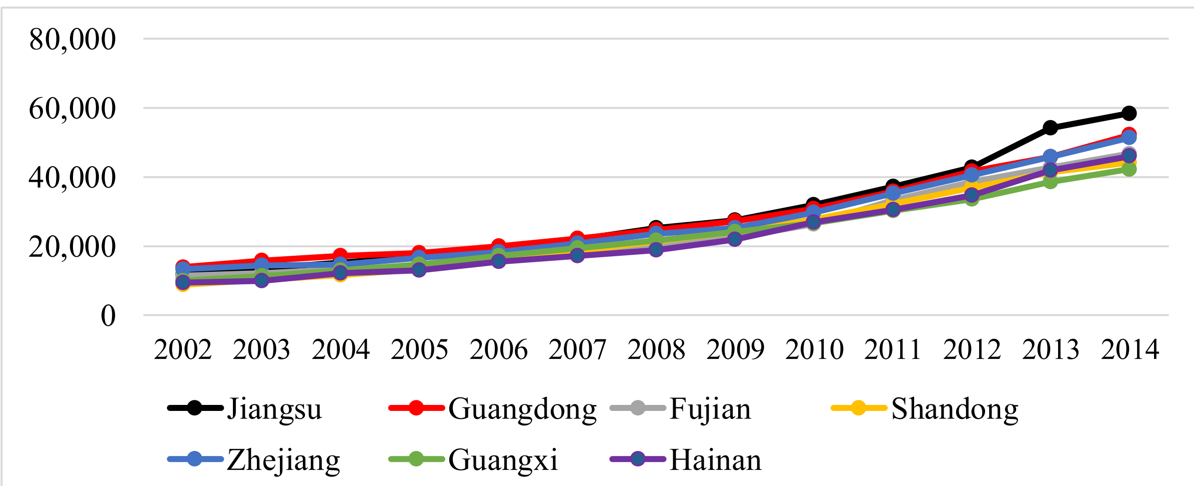
3.4.2 Manufacturing wages

Productive employment emphasizes that a job should "yield sufficient returns to labour to permit the worker and her/his dependents a level of consumption above the poverty line" (International Labour Organization 2012, 3). Hence, the average annual wage and the average annual consumption expenditure are two quantifiable indicators for decent work. Figure 4 indicates that the manufacturing average annual wage in urban units in all the selected provinces exhibits an increasing trend between 2002 and 2014. Guangdong province has the highest average annual wage in the first six years (between 2002 and 2007). In 2008, Jiangsu's average annual wage surpassed Guangdong's and reached 58,409 CNY (approximately 9,513 USD) in 2014.[15] In terms of the lowest average annual wage, Hainan's urban manufacturing average annual wage is at the bottom for most of the given years.

[15] The conversion is based on the average exchange rate in 2014 of USD 100 = CNY 614.28 (National Bureau of Statistics of P.R.C. n.d.)

The poverty line has been set by Chinese government at 2,300 yuan per year (1.33 USD per day in purchasing power parity (PPP) terms) in 2011 (The Economist 2011).[16] By comparing the lowest average annual wage (9,388 CNY, Hainan in 2002) and the poverty line, we can conclude that the manufacturing average annual wage in all the selected provinces is beyond this poverty line. Therefore, workers employed in the manufacturing sector are likely not to trapped in absolute poverty.

Figure 4. Average annual nominal wages (CNY) in manufacturing, urban units, selected provinces, 2002-2014



Source: compiled by author from provincial statistical yearbooks 2003-2015.

While the average manufacturing wage is higher than the absolute poverty level, it is lower than the average annual wage in many other sectors. In 2005, the average manufacturing wage is lower than the average annual wage across all industrial sectors (in urban units), in all selected provinces (Figure 5).[17] The manufacturing wage in Zhejiang is the worst case among all the selected provinces in 2005, since it accounts for only 64% of the average annual wage in urban

16 The new global poverty line was updated to $1.90 per day in PPP term in October 2015 (World Bank 2015b).
17 Year 2005 is selected in this part is due to the absence of some statistical yearbook chapters in my database, therefore, I cannot compile the figure back to year 2002.

units. In comparison, Guangxi's manufacturing industry offers a relatively fair income in 2005, since the average manufacturing wage reaches 95% of the overall average annual wage, for urban units.

Manufacturing workers are better off in 2014 compared to 2005, since the gap between the urban wage averaged across all sectors and the average manufacturing wage had declined (see Figure 6). In 2014, the average manufacturing wage reached more than 80% of average annual wage in urban units, in all the selected provinces. The average manufacturing wage in Jiangsu performs the best, as it reaches 95% of the urban average annual wage. Zhejiang showed the largest improvement in the manufacturing-urban average annual wage ratio, as it increased from 64% in 2005 to 83% in 2014.

In terms of the annual consumption expenditure, the average manufacturing wages in all provinces are able to support the workers' annual consumption expenditures, based upon data from Figures 5 and 6.[18]

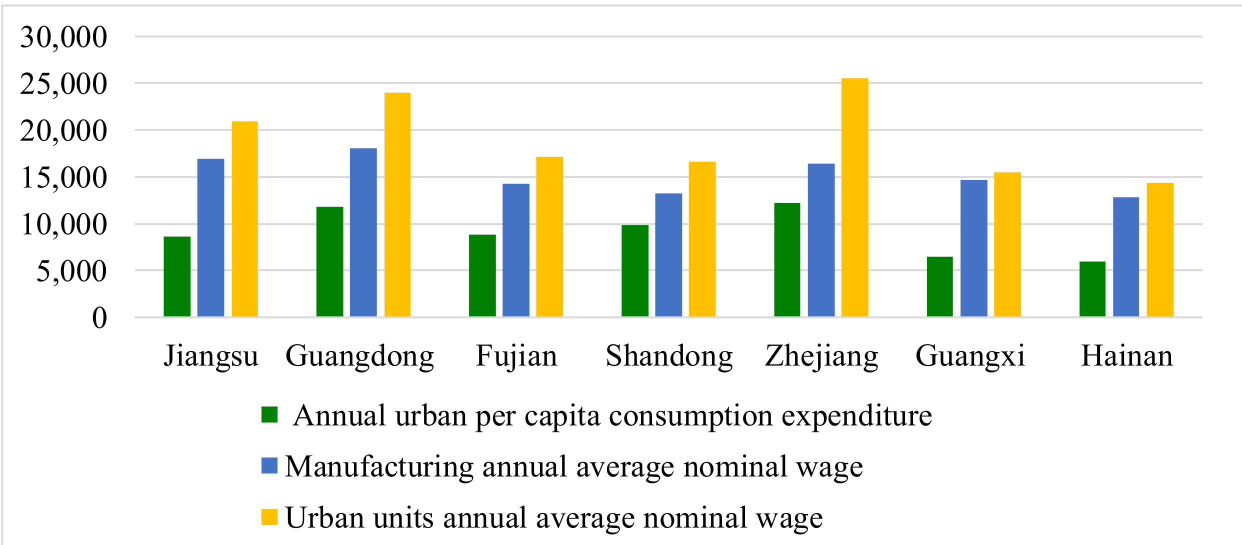
From Figure 5, I find that in Shandong and Zhejiang provinces, manufacturing workers need to spend 75% of their wage to live in the urban area in 2005. In Jiangsu, Guangdong and Fujian, the annual consumption expenditure accounts for more than 50% of manufacturing worker's wage. While in Guangxi and Hainan, workers only need to spend 44% and 46%, respectively, to support their basic annual consumption expenditure.

Data in Figure 6 indicates that manufacturing workers in 2014 use less than 50% of their wage to cover living expenditure, except for workers in Zhejiang. Shandong province had the largest improvement as the expenditure-income ratio decreased from 75% to 42%. Combining Figure 5 and Figure 6, we can conclude that manufacturing workers are able to save more money

18 The urban per capita consumption expenditure includes food, tobacco and liquor, clothing, living, daily necessities and services, transportation and telecommunication, education, culture and entertainment, health service and medical care, other necessities and services (National Bureau of Statistics of P.R.C. 2013).

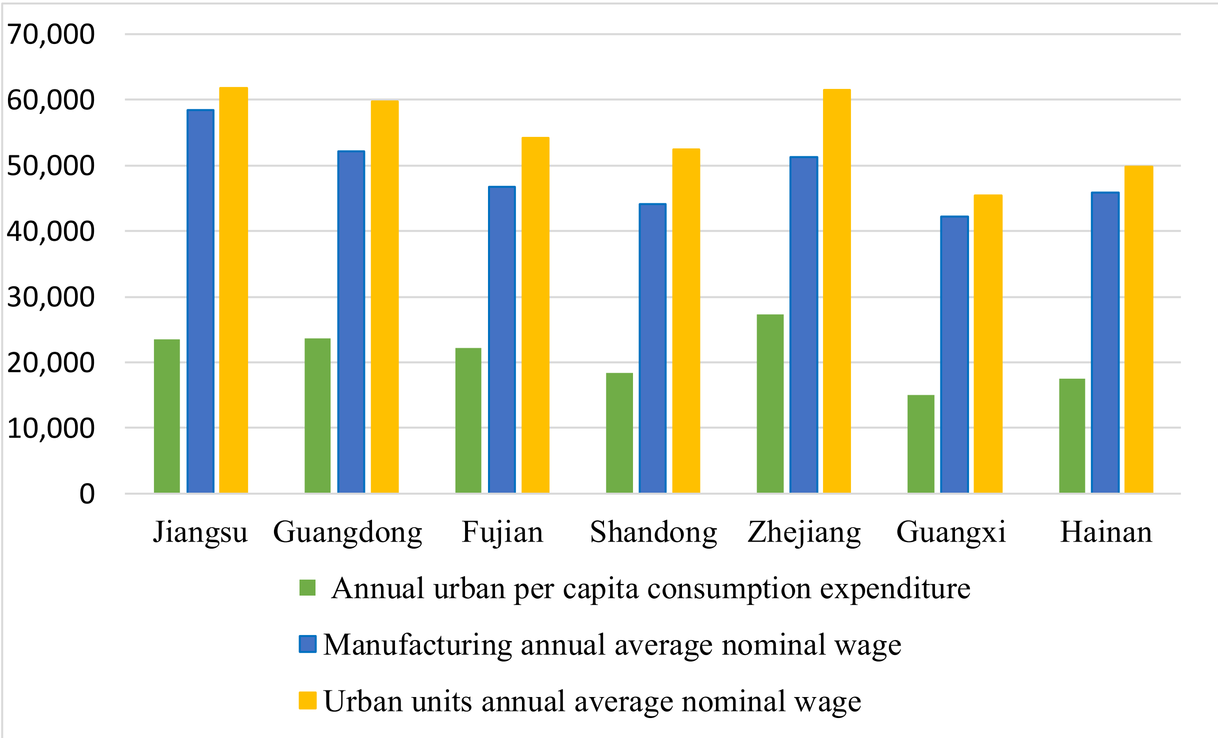
in 2014 than in 2005. This means that workers' living standard has improved given the possibility of greater savings. However, this analysis does not take account of the number of people that each worker is supporting and how this might have changed the workers' living standard.

Figure 5. Average annual nominal wage (manufacturing sector and all urban units) and per capita consumption expenditure (CNY), selected provinces, 2005



Source: compiled by author from provincial statistical yearbooks 2006.

Figure 6. Average annual nominal wage (manufacturing sector and all urban units) and per capita consumption expenditure (CNY), selected provinces, 2014



Source: compiled by author from provincial statistical yearbooks 2015.

The number of dependents that a manufacturing worker can support is not an indicator that can be found in the statistical yearbooks. Therefore, I assume that the basic annual consumption expenditure for an urban dependent equals the urban per capita annual consumption expenditure. This assumption helps me to measure the number of dependents that a manufacturing worker can support and is a method to assess productive employment. The results are illustrated in Table 5. In 2005, a manufacturing worker's wage in Guangdong, Fujian, Shandong, and Zhejiang provinces was insufficient to support even one dependent. However, in 2014, the manufacturing wage in all provinces had risen sufficiently that the average worker could support one dependent. Manufacturing workers in Jiangsu, Guangdong, Fujian, Shandong, Guangxi and Hainan provinces would still have some savings after the consumption expenses associated with one dependent person. From this perspective, one could argue that there has been movement toward decent work in the manufacturing sector in recent years. However, it must be kept in mind that the analysis focuses upon the average annual wage and has not taken into account the wide distribution of wages around the average annual wage; thus, workers in the lower tail of the wage distribution may not be able to cover annual consumption expenditures of dependents.

Table 5. The number of dependents that can be supported by the average manufacturing wage

	Jiangsu	Guangdong	Fujian	Shandong	Zhejiang	Guangxi	Hainan
2005	1.0	0.5	0.6	0.3	0.3	1.3	1.2
2014	1.5	1.2	1.1	1.4	0.9	1.8	1.6

Note: the number of dependents is calculated as the average manufacturing wage divided by per capita annual consumption expenditure minus one; and is based on the assumption that a dependent's annual consumption expenditure equals the average urban per capita annual consumption expenditure.
Source: compiled by author from provincial statistical yearbooks 2015.

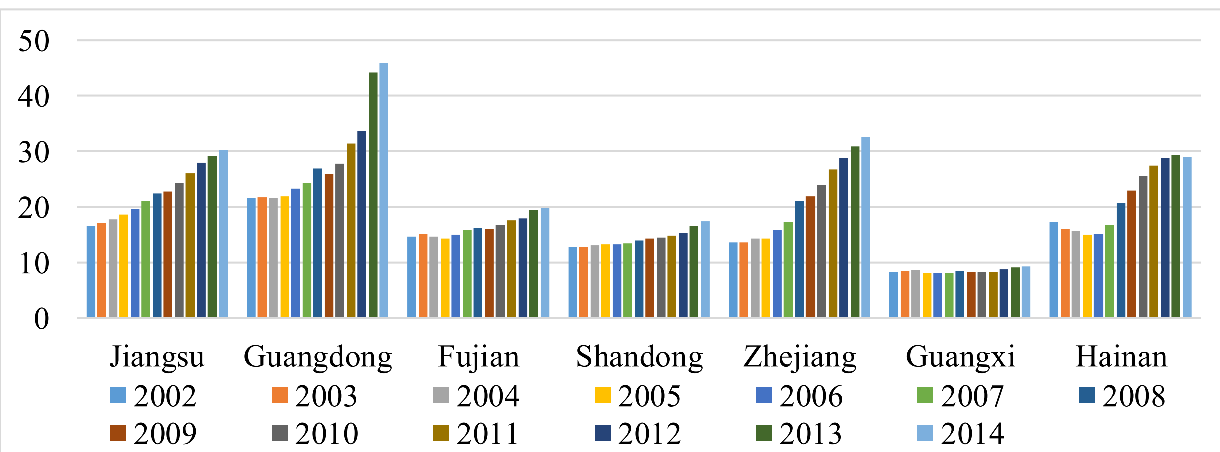
3.4.3 Social security

Social security mechanisms are designed to reduce income losses due to social risks, such as unemployment, sickness, accident, aging, work place injury, and so on. The availability of social security or insurance programs is an important component of decent work. China's social security system is comprised of pension insurance, medical insurance, unemployment insurance, work injury insurance, and maternity insurance and a housing fund. Two social security indicators are selected in this research: the unemployment insurance participant ratio (total number of unemployment insurance participants divided by total number of workers) and the government pension revenue. Unfortunately, data pertaining to these social security provisions are only available at the provincial level aggregated across all industrial sectors and thus, I cannot analyze social security proxies for the manufacturing sector alone. Nonetheless, changes in the indicators demonstrate the changing of social security at provincial level.

Unemployment insurance benefits help individuals and families by assisting them through times of unemployment without a dramatic change in lifestyle. This means that workers losing jobs will have some income for basic expenditures.

Figure 7 illustrates that the unemployment insurance participant ratio increased during the past decade, although the ratio in all provinces is less than 50%.[19] The unemployment insurance participant ratio is only 8-9% in Guangxi which is the lowest ratio of all selected provinces and the ratio does not show any improvement between 2002 and 2014. Data indicate that more than half of the total labour force in each province has no unemployment insurance protection, so they are more vulnerable to income loss if they become unemployed. The absence of unemployment

Figure 7. Employment insurance participation ratio (%), selected provinces, 2002-2014



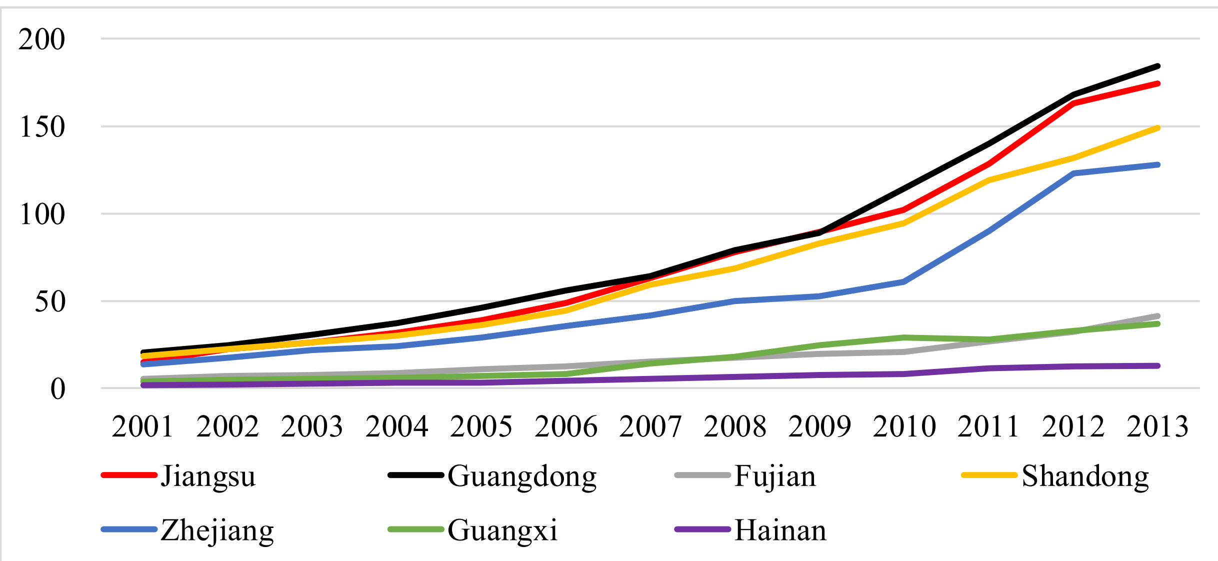
Note: the unemployment insurance participation rate is the total number of the unemployment insurance participants divided by total number of employed people.
Source: compiled by author using National Bureau of Statistics of P.R.C. (n.d.) (selected years).

[19] Unemployment participation ratio is calculated as: the number of workers with unemployment insurance divided by the total number of workers (%)

insurance does not only adversely affect the unemployed workers, but also negatively impacts the dependents and community of the unemployed workers. Since without a regular income, spending would fall sharply, resulting in hardship for the person's dependents, as well as, local businesses and their workers, which depend upon the worker's expenditures.

Figure 8 illustrates the pension revenue in each province over 2002 and 2014. The growth rate of pension revenue in Fujian, Guangxi and Hainan is much lower than that of Guangdong, Jiangsu, Shandong and Zhejiang. The graph still indicates that pension revenue in each province has increased over time. The growth of pension revenue is good for social stability. Pension benefits provide basic living income to retired workers, so that they can have a sense of security.

Figure 8. Pension revenue (in billion CNY)



Note: pension revenue is the total public pension revenue collected by government.
Source: compiled by author using National Bureau of Statistics of P.R.C. (n.d.) (selected years).

The pension schemes in China are organized in five different types, and the formula determining a person's pension income depends on his or her pension scheme (Lijian Wang, Daniel Béland and Sifeng Zhang 2014). The first type is called the basic old-age insurance system for enterprise employees; the second is the basic old-age insurance system for public institutions employees; the third one is old-age insurance system for urban residents; the fourth is the new type of rural social endowment insurance; and the last one is a pension system designed for civil servants (see Wang, Béland and Zhang (2014, 26) for a detailed discussion about these five schemes). The pension income in each scenario in 2011 is illustrated in Table 6.

Employment in the manufacturing sector is classified as enterprise employment; therefore, the basic old-age pension income is 18,095CNY in 2011 on average. Comparing with the average annual consumption expenditure in urban areas at the national level, which was 15,160.89 CNY in 2011 (National Bureau of Statistics of P.R.C. 2012), the basic old age pension income can provide a basic living income for a retired manufacturing worker. However, their pension income only accounts for 44% of their wage, which means that their living standard could drop sharply after retirement if there is no other source of retirement income. Since the data in Table 6 reflects a calculation for all workers in China in 2011, the average pension income within a particular province could be different from the data in this Table. Unfortunately, there are no data available in the statistical yearbooks to measure the average pension income at the provincial level; therefore, I am not able to duplicate a similar table for those selected provinces in this research.

The pension income gap between each group of employment type is substantial. The civil servants, who are also known as government officers, enjoy the highest pension income among all five types of employment. The difference between their annual wage income and retirement income is around 4,800 CNY, which means that their retirement living standard will not have a significant difference compared with their service period. The pension income for public institution employees reaches 26,107 CNY, which is around 57% of their average annual wage.

Therefore, their retirement living standard is lower than their employed living standard but is still well above the absolute poverty line. Rural residents are entitled to only 943CNY annual retirement income, which is lower than the poverty line (2,300 CNY per year). The retirement living standard for rural people is therefore very low, and they have to rely on family members and other sources of income. The old age insurance for urban residents is also lower than the poverty line, and therefore, they also need to rely on other source of income to support retirement life. The fairness of pension income in China is also a problem that should not be ignored and future policy making should address it in order to enhance the social harmony.

Table 6. Basic data for China's pension income (in CNY per year and million people)

Pension scheme	Pension income	Pension contribution	Pension demand	Working generation's average annual wage	Number of retirees
Basic old-age insurance for enterprise employees	18,095.82	7,753.63	6,634.10	40,674.32	63.14
Basic old-age insurance for public institutions employees	26,107.21	8,839.50	6,634.10	46,092.01	5.13
Old-age insurance for urban residents	1,347.25	251.35	6,634.10	23,979.20	2.35
New type of rural social endowment insurance	943.77	192.04	3,978.17	9,833.14	89.22
Pensions for civil servants	40,060.25	0	6,634.10	44,845.21	7.48

Note: numbers in this table are average values except number of retirees.
Source: this table is reproduced from Wang, Béland and Zhang (2014, 31).

For workers in the manufacturing sector who have an employment contract, they may have the potential to obtain access to a pension plan while they are working and receive an income above the absolute poverty line when they are retired. However, there are still a great number of manufacturing workers working without a contract. These workers will be unable to access to the enterprise pension and thus, will need to rely on the pension benefits for rural and urban residents described above which provide very low levels of pension income.

3.5 Correlation between technological upgrading and decent work

Based upon the graphs and the tables above, evidence suggests that there has been technological upgrading and an improvement in decent work in all the seven selected provinces. Moreover, we can find that when a province has higher technology endowments, it also has a higher manufacturing wage, employment, and social security than those provinces with lower technology endowments. For example, Jiangsu is the most technology intensive province based upon the data in Table 2 and it offers the highest manufacturing wage since 2008 (Figure 4); the manufacturing wage reaches 95% of the urban average annual wage and average annual consumption expenditure is only 40% of workers' wages. The correlation between technology indicators and decent work indicators (both in absolute terms) further demonstrates this relationship, as shown in Table 7. The wage, employment and social security are positively correlated with technology indicators, and therefore, it is expected that technological upgrading will improve decent work. The number of observations is ninety-one which covers seven provinces over thirteen years.

Table 7. Correlation between technology indicators and decent work indicators, across seven provinces and years 2002-2014

	FDI	High-tech exports	Mechanical and electronics exports	Patents	R&D employment	R&D expenditure
Wage	0.48	0.42	0.47	0.70	0.58	0.65
Manufacturing employment	0.81	0.78	0.83	0.71	0.88	0.90
Employment insurance	0.85	0.88	0.92	0.76	0.91	0.90
Pension revenue	0.81	0.70	0.75	0.88	0.92	0.96

Source: table compiled by author using provincial statistical yearbooks 2003-2015.

3.6 Decent working time and employment contracts

3.6.1 Overview of decent working time in China

The need for working time to be both healthy and safe is fundamental. Jon C. Messenger (2004) has proposed five significant dimensions of "decent working time" as: "[w]orking time arrangements should be healthy; 'family-friendly'; promote gender equality; advance enterprise productivity; and facilitate worker choice and influence over their hours of work" (Messenger (2004), as cited by Jean-Yves Boulin, Michel Lallement, Jon C. Messenger, and François Michon (2006, v)). For instance, regular long working hours, night work and holiday work are neither preferred by workers nor healthy for workers.

The following discussion of decent working time will mainly address the working hours, rather than other dimensions of decent working time, due to limited data. At the global level, the weekly working-hour limit differs from country to country or sector to sector, and "[i]n the past, work organization in both the manufacturing industry and the service sector was based on full-time employment and the 8-hour day associated with it, and on the 48-hour and, later, the 40-hour week" (Boulin et al. 2006, 45). In China, the standard working hour is regulated by the labour law and "State Council Decree No. 174". The core content has suggested that the standard working hour should not be more than 8 hours a day and no more than 40 hours a week, and with at least one day off per week (General Office of the State Council of the P.R.C 1995). Therefore, the benchmark for decent working time for this research is 8 hours per day and 40 hours per week.

Since there are no provincial level data available for working time, this part of discussion will provide an analysis of working time at the national level. The national level analysis will provide a general view and understanding of working time and the decent work distribution in China.

Overtime working is prevalent in urban China. According to Table 8, the average weekly working time for Chinese urban employees is 46.3 hours, which is 6.3 hours more than the standard working time. If the standard of 8-hour working day and at least one day off per week is applied, workers will have to work 6 days a week in most sectors. Among all sectors, only those people who engage in Agriculture, Forestry, Animal Husbandry and Fishery do not work overtime. Although the average weekly working hours in the manufacturing sector is not the highest among all the sectors, it is still 8.2 hours longer than standard working time and 1.9 hours longer than the average working hours.

Table 8. Average weekly working hours of employees, urban areas, 2012

	Average	Male	Female
Average	**46.3**	**47.1**	**45.2**
Hotels and Catering Services	51.4	51.9	50.8
Wholesale and Retail Trade	50.2	50.9	49.7
Construction	49.4	49.8	47.1
Resident Services and Other Services	49.1	50.0	48.1
Transport, Storage and Postal Services	48.8	49.6	45.3
Manufacturing	**48.2**	**48.2**	**48.0**
Information Transmission, Computer Services and Software	47.8	47.7	47.9
Leasing and Business Services	46.2	46.6	45.7
Real Estate	45.9	46.8	44.5
Mining and Quarrying	45.7	46.2	44.2
Culture, Sports and Recreation	45.6	46.0	45.1
Health Care and Social Work	44.1	45.1	43.4
Water Conservancy, Environment and Public Facilities Management	43.8	43.7	44.1
Scientific Research and Technical Services	43.4	43.2	43.6
Production and Supply of Electric Power, Gas and Water	43.3	43.5	42.9
Finance	43.2	43.6	42.8
Education	42.5	43.2	42.0
Public Administration and Social Organizations	41.8	42.1	41.3
Agriculture, Forestry, Animal Husbandry and Fishery	38.2	40.7	35.7

Source: compiled by author from Desheng Lai, Dahu Meng, Changan Li and Qi Wang (2014, 433) (in Chinese).

3.6.2 Working time and resident registration type

The average working hours depends not only on the sector of employment, but also the type of *Hukou* a worker holds. Based upon Chinese houshold registration system, also known as the "*Hukou* System", Chinese citizens are divided into two types: agriculture citizens (rural people) and non-agriculture citizens (urban people). [20] This household registration system limits rural people from obtaining decent work and many scholars see it as the major source of hardship for rural-urban migrant workers living in cities (Kam Wing Chan and Li Zhang 1999; Peter Alexander and Anita Chan 2004; Au Loong-Yu and Nan Shan 2007). The *Hukou* System in China allows people to work in their hometown legally, however, in order to migrate to other areas it is necessary to apply for different kinds of permits to work and live in that area (Chan and Zhang 1999).

For workers with a non-agriculture *Hukou*, urban citizens, almost 50% of them could work at the standard (40 hours per week) and 45.4% of them work overtime. Turning to workers with an agricultural *Hukou*, rural citizens, who are working in urban areas, as shown in Table 9, 63% work more than the 40 hours per week, while only 37% of work less than or equal to the standard working weekly hours. Among the 37% agriculture citizens, part of them are engaged in Agriculture, Forestry, Animal Husbandry and Fishery sector, which does not require them to work over 40 hours per week in the first place. We can deduce that if an agriculture citizen migrates to urban area, he or she will have a high chance of working more than the standard 40 hour level.

[20] See Chan and Zhang (1999) for a more detailed disscussion of the *Hukou* System and rural-urban migration.

Table 9. Weekly working hours of employed persons by household registration (%), urban areas

Household Registration	Urban Employed Persons	1-8 Hours	9-19 Hours	20-39 Hours	40 Hours	41-48 Hours	48 Hours
Total	100	0.5	1.3	8.4	36.0	19.9	33.9
Agriculture	100	0.8	2.3	13.1	20.6	20.4	42.8
Non-Agriculture	100	0.3	0.4	4.3	49.5	19.4	26.0

Source: compiled from National Bureau of Statistics of P.R.C. (2014, Table 3-30).

Going further, as shown in Table 10, in 2014, rural-urban migrant workers work about 8.8 hours a day and more than 85% of them work overtime.[21] From Table 10, it is also noticed that that around 40% of migrant workers work more than 8 hours a day.

Table 10. Migrant workers' working hours

	2012	2013	2014
Average Daily Working Hours	8.7	8.8	8.8
Proportion of Workers Working Over 8 Hours per Day (%)	39.6	41.0	40.8
Proportion of Workers Working Over 44 Hours per Week（%）	84.4	84.7	85.4

Source: compiled by author from National Bureau of Statistics of P.R.C (2015c) (in Chinese) http://www.stats.gov.cn/tjsj/zxfb/201504/t20150429797821.html.

If migrant workers have a permanent employment contract or a contract longer than 1 year, they are more likely to work less or equal to 8 hours per day than those with a work contract less than 1 year or temporary contract (see Table 11). To be more specific, if a worker has a formal permanent contract, he or she will have 43.1% chance to work less or equal to 8 hours a day, compared with a temporary term contract worker who has only 29.22% chance to do so.

[21] Rural migrant worker refers to an agriculture citizen who engages in non-agriculture sectors in local area or outside registration area for more than six months (National Bureau of Statistics of P.R.C. 2015a).

Table 11. Work contract type and daily working hours, migrant workers, urban areas

	≤8	9~10	11~12	>12
Permanent contract (%)	43.1	38.1	15.0	3.8
Contract ≥ 1 year (%)	39.7	38.6	16.2	5.5
Contract < 1 year (%)	31.0	47.1	15.9	6.0
Temporary contract (%)	29.2	48.6	16.0	6.1

Source: compiled by author from Desheng Lai, Dahu Meng, Changan Li, and Qi Wang (2014, 205) (in Chinese)

The scale of migrant worker in 2014 reached 274 million and 31.3% of them work in manufacturing sector (National Bureau of Statistics of P.R.C. 2015c). From Table 12, in 2014, around 62% of rural migrant workers do not have an employment contract, and only 21.2% have an employment contract for 1 year or more. Therefore, in 2014 almost 80% of rural migrant workers not only engage in unstable employment (with a employment contract duration less than one year or without a contract) but also work long hours. Comparing with the scale of migrant workers, the work permit issue ratio is very low (Qiang Li and Zhuang Tang 2002). This situation also blocks migrant workers from obtaining work contracts. Manufacturing workers data that has been used in this research are for workers with work contracts. The provincial government statistical yearbooks disclose neither the scale of migrant workers in the manufacturing sector nor the duration of their work contracts. Lack of information disclosure blocks further disscussion of decent working time at the provincial level.

Table 12. Migrant workers with employment contracts (%)

	Non-fixed term contract	Less than 1-year contract	1 Year and over contract	Without a contract
2013	13.7	3.2	21.2	61.9
2014	13.7	3.1	21.2	62.0

Source: compiled by author from National Bureau of Statistics of P.R.C. (2015c) http://www.stats.gov.cn/tjsj/zxfb/201504/t20150429_797821.html.

There are not many rural-urban migrant workers that obtain decent work or decent working time in the manufacturing sector. Even though there has been a technological upgrading and an increase in decent work, not everyone shares equally from these changes.

Chapter 4: Econometric modeling analysis

4.1 Methodology

The purpose of this chapter is to empirically assess the impact of technological upgrading on decent work, using the average wage in the manufacturing sector as a proxy for decent work, for seven coastline provinces in China. The methodological approach is to design a regression model and estimate the model using data for China for 2003 to 2014. More specifically, econometric modeling will be used to estimate the relationship between technological upgrading and the wage in manufacturing sector. The model is developed based upon a review of the macroeconomic theories of wage determination and the application of these theories to wage determination in the Chinese context. Appropriate literature was found using a set of search terms and databases including EconLit and Google Scholar. The search terms included the following: technological upgrading and wage; technical change and wage; macro-level wage model; macro-level and wage determinants; wage growth model; trade and wage; and globalization and wage. A positive relationship between technological upgrading and the manufacturing wage is expected, after controlling for other factors affecting the wage.

Before estimating the model, potential econometric issues that I could encounter in the estimation are highlighted so that I can take account of potential biases and procedures for addressing the problems.

The remainder of this chapter will review macroeconomic theories of wage determinants, outline the model to be used in this thesis, identify econometrics issues that may occur, discuss the data, and analyze the results.

4.2 Macroeconomic theories of wage determination

The determinants of wages in macroeconomic theory are generally well known and advanced in standard economics textbooks. Olivier Blanchard and David Johnson (2013), for example, identify the wage determinants as the expected price level, labour market conditions, and all other variables that affect the outcome of wage setting, such as bargaining power, employment insurance, and economic structural change. The following equation (1) captures the main wage determinants:

$$W = P^e F(u, z) \tag{1}$$

where W refers to the nominal wage, P^erefers to the expected price level, u represents the unemployment rate (which captures labour market conditions) and z captures all other factors that affect wage setting (Blanchard and Johnson 2013, 173). Labour market conditions are expected to impact wages and for example, the lower the unemployment rate, the higher the wages. Price expectations, likewise, would influence wages such that the higher the expected prices, the higher the wage. This research will consider technological upgrading as one of the "z" factors and investigate whether technological upgrading has an impact on wages at the macroeconomic level.

The relationship between technology and wages is generally positive and researchers have explored the mechanisms underlying the relationship. On the productivity side, because of technology upgrading, the whole society produces more goods and services within a certain time, which reduces people's living cost and increases their real income (Baldwin, et al. 2014). On the worker side, learning new technology and new skills makes them more competitive, which increase their wages as well. For instance, Wilfred Edward Graham Salter (1960) suggests that technological upgrading is directly linked with increasing labour productivity, and this could be attributed to labour itself, such as greater working skills and efforts. Since industry can improve its productivity by hiring higher-skilled labour compared to other industries, firms are willing to pay the higher wages necessary to attract these wages (Derek Leslie 1985). Moreover, Jeremy Greenwood and Mehmet Yorukoglu (1997) state that rapid technological advancement should be associated with a rise in wages. This occurrence is due to the adoption of new technologies involving a learning process, which offers workers opportunities to gain working skills and eventually contribute to a rise in wages. Therefore, it can be concluded that technological upgrading has a positive impact on labour wage growth.

When it comes to the relationship between wages and technological upgrading, it should be noted that the majority of research is based upon microeconomic level firm data drawn from sample surveys.[22] Using microeconomic level data helps identify the character of technical upgrading and predetermines the applicable wage models. However, the micro level model cannot explore the effects of technological upgrading on overall wage growth. More importantly, the results may be biased by the sample selection.

The macroeconomic theory of wage determination is appropriately used when the focus is on analyzing the impacts across the entire economy. Therefore, the following section will review some macroeconomic wage models.

4.3 Review of macroeconomic wage models

The models reviewed below are selected because firstly, they all use macroeconomic level data, such as national level data or provincial level data, to estimate their model. Secondly, they have some aspect related to this research: for example, Elissa Braunstein and Gerald Epstein (2002)

[22] Derek Leslie (1985) uses two-digit industry level data; Ann P. Bartel and Nachum Sicherman (1997) use National Longitudinal Surveys of firms; Sanna-Mari Hynninen, Jari Ojala, Jaakko Pehkonen (2013) adopt individual level data of workers.

focus on China; António Afonso and Pedro Gomes (2014) use technology as one of the independent variables.

Braunstein and Epstein (2002) construct a macroeconomic-level wage model to determine the impact of FDI on wages in China. The main hypothesis behind the model is that FDI increases labour demand, and thereby increases wages. Besides, foreign enterprises tend to have higher productivity and pay higher wages, and FDI may raise wages through a spillover effect on domestic firms. The FDI spillover effect in their research refers to effects beyond what FDI directly contributes to domestic investment such as managerial know-how, international connections, and advanced production processes that enhance domestic overall productivity (Braunstein and Epstein 2002). They used province-level panel data for China's 29 provinces between 1986 and 1999. Their data are drawn from the statistical yearbooks of individual provinces and regions in China, supplemented by data taken from the China Statistical Yearbook. Their wage data set focuses on the average annual wage across all sectors. Based on their econometric model, they find a statistically significant and positive effect of FDI on wages. Their regression equation is:

$$\mathrm{lnw_{it}} = \alpha_\mathrm{i} + \beta_1\mathrm{lnI_{it}} + \beta_2\mathrm{lnFDI_{it}} + \beta_3\mathrm{lnT_{it}} + \beta_4\mathrm{lnLF_{it}} + \beta_5\mathrm{lnq_{it}} + \beta_6\mathrm{L_{it}^2} + \mathrm{timetrend} + \varepsilon_\mathrm{it} \quad (2)$$

where w_{it} is the annual wage for a particular province i, in year t; α = provincial fixed effect; I =value of total investment; FDI = value of foreign direct investment; T = total foreign trade (imports + exports); LF = total available labour force, defined as the population fifteen and over; q = productivity, which is captured by GDP/employment; L= liberalization variable, the ratio of state sector output to all industrial output; timetrend = a time trend has been added to control for uniform shocks; and ε = random error.

Comparing with the theoretical model (1), we can find that in equation (2) the labour market condition is captured by the total available labour force (LF); but the price expectation has not been considered as an independent variable, which is a weakness of their model. Additionally, they considered investment, FDI, trade, productivity, market liberalization and time trend as variables as “z” factors. The limitation of their model is that they do not have a theoretical framework section for their modeling, which makes their model less convincing. The advantage of their research is that their model is easy to follow and relevant for this thesis, since they use macroeconomic data.

The second example of a wage determination model is a combined micro and macroeconomic one, proposed by Elissa Braunstein and Mark Brenner (2007). Their research focuses on the impacts of FDI on male and female wages in urban China for 1995 and 2002. Their model is a cross-section model shown below:

$$\mathrm{ln}w_{ij} = \alpha + X_{ij}\beta + Z_j\delta + \varepsilon_{ij} \tag{3}$$

where: w_{ij} indicates wage of person i in province j; X_{ij}=a vector of individual-level variables for males and females; Z_j= a vector of province-level variables; and ε_{ij} = error term.

The individual-level (microeconomic level) variables include education, age, ethnic minority, communist party member, ownership of firm, and so on. At the microeconomic level, the wage is determined by worker’s characteristics, while at the macroeconomic level it is affected by labour market conditions and economy-wide conditions. At the provincial level (macroeconomic level), independent variables include: total investment as a share of GDP (affects the demand side of the labour market); SOE output as a share of gross industrial output; cumulative GDP growth; FDI as a share of total investment; and trade (exports plus imports) as a share of GDP.

Braunstein and Brenner (2007) combine macroeconomic-level data and microeconomic-level data, which is the key innovation of their study. They acknowledge that their independent variables are at different levels of aggregation, which causes a downward bias when estimating regression coefficient standard errors. The issue has been addressed by estimating standard errors clustered on provinces (Braunstein and Brenner 2007). However, like Braunstein and Epstein (2002), this model does not contain price expectation as one of the independent variables as well, which is a weakness of this model. As I am interested in a macroeconomics model of wage determination, reviewing this model is helpful. However, I will not be able to adopt the microeconomic variables incorporated by Braunstein and Brenner (2007), since I do not have access to the microeconomic data. Therefore, I will try the macroeconomics level variables and abandon microeconomics level ones. As a result, my research will not be able to capture individual characteristics of workers and its implications on wages.

The third model, proposed by Afonso and Gomes (2014), examines the interactions between private and public sector wages per employee in OECD countries. The model is:

$$\omega_{it}^{p} = \alpha_i + \delta^p \omega_{it-1}^{p} + \theta^p X_{it}^{p} + \pi^p Z_{it}^{p} + k^p E_{it-1} + \mu_{it} \tag{4}$$

where the i (i=1…, N) denotes the country; t (t=1, …, T) denotes the period; α_i stands for the individual effects to be estimated for each country i; μ_{it} indicates the disturbances which are independent across countries; and ω_{it}^{p} is the growth rate of real compensation per employee in the private sector. X_{it}^{p} is a vector of macroeconomic variables that might be endogenous to private sector wage growth. This vector includes: public sector employees' real compensation; the growth rate of the consumer price index (CPI); growth rate of total factor prductivity (TFP); change in the unemployment rate; change in urbanization rate; growth rate of per worker average hours worked; growth rate of trade; change in the tax wedge and growth rate of public sector employment. Z_{it}^{p} is a vector of institutional exogenous variables such as union density changes and central bank independence. E_{it-1} is defined as the percentage difference between public and private sector wages.

This model incorporates the lagged wage as an independent variable to capture price expectations. As price expectation is an important variable in the theoretical framework, it will be adopted in my model. In addition, the TFP is an independent variable in this model, which indicates that technological upgrading has been regarded as an important factor for wage growth. However, because of the data consistency and availability problem of my data source, there are some variables in their model (for instance, urbanization rate and growth rate of average hours worked per worker), which will not be used in my modeling.

The following macroeconomic level wage models will be discussed in a comparatively general manner, since they do not closely align with my research purpose (general wage determination). They mainly focus on specific wage determination modeling, for example, Phillips curve wage determinations, or wage flexibility. Torbjorn Eika (1993) has built a stylized wage equation to estimate wage determination. The model is based on the Phillips curve, where wage growth depends on the tightness of the labour market and the growth in import prices and GDP.[23] Independent variables in Eika's model are the private consumption deflator, output per head, import price, indirect tax rate, direct tax rate, employment tax rate and unemployment rate. Petri Böckerman, Seppo Laaksonen and Jari Vainiomäki (2010) advance a wage model to examine the micro- and macro-flexibility of wages in Finland. In terms of the macroeconomics side, they have regressed the average change in nominal wages on unemployment, productivity

[23] The Phillips curve is a historical inverse relationship between rates of unemployment and corresponding rates of inflation generated in an economy (Irving Fisher1973). However, the Phillips' original curve describes the behavior of money wages. William Phillips (1958) observed an inverse relationship between money wage changes and unemployment in the British economy over 1861-1957.

growth, expected inflation and industry-level bargains (the number of employer and union bargaining rounds). Mark E. Schweitzer (2007) examines wage flexibility in macro level data in UK. The independent variables for his model are the lagged wage, the unemployment rate, time dummy variables, regional dummy variables, productivity growth and inflation.

There are two theoretical frameworks to capture price expectations, namely, adaptive and rational expectations, although adaptive expectations is the most common form in empirical wage determination research. Before moving to the difference between adaptive and rational price expectations, it is noted that in general price expectation can be measured by using inflation expectation (Ignazio Visco 1984).

Adaptive price expectations captures the idea that people's expectation of inflation is based upon the latest known inflation rate (Blanchard and Johnson 2013). "By the 1970s, evidence is that people formed expectations by expecting this year's inflation rate to be the same as last year's" (Blanchard and Johnson 2013, 234). In the empirical literature, adaptive price expectations are typically proxied using some form of the lagged inflation rate in wage determination models (James E. Pesando 1975).

In contrast, rational price expectations considers how price expectations are formed based upon expectations about current or future events. John F. Muth (1961) proposed a rational price expectations framework to capture price expectations based upon the assumption that economic agents use all available information and expectations are affected by the structure of the entire economy system market. Clearly, expectation would be affected by so many factors, rather than the latest known price or inflation rate only.

In the empirical work, I have chosen to use the adaptive price expectation framework. Firstly, empirically estimating how price expectations are formed is beyond the scope of this research. Secondly, unlike other market economies, where inflation is usually caused by private and public consumption, the national economy including inflation is controlled by government in China (Yasheng Huang 1999). In other words, the Chinese government can surprise economic agents through unexpected monetary policy changes. Thirdly, adopting adaptive price expectations and modelling it through the use of lagged inflation rates is consistent with other empirical wage models in the literature. For example, Böckerman, Laaksonen and Vainiomäki (2010) use expected inflation as their price expectation variable, which is measured by using a three year moving average of realized inflation rates. Because of limited data, the three-year moving average of realized inflation rates method is not suitable for my research and therefore, I choose the lagged inflation as my price expectation indicator.

In general, Braunstein and Epstein (2002), Braunstein and Brenner (2007), and Afonso and Gomes (2014) all use the unemployment rate and productivity as independent variables. This indicates that unemployment and productivity are important variables in macro wage models. Including productivity as an independent variable in my modeling may cause a multicollinearity problem. Since technological upgrading contributes to productivity, this makes technology and productivity indicators highly correlated, and result in a multicollinearity problem.

Summary

Reviewing macroeconomic wage models helps me identify independent variables that need to be included in my wage model. I will include:

1. A price expectation variable, such as the lagged inflation rate;
2. A labour market condition variable, such as GDP growth rate;
3. A technology variable, such as high-tech imports, patents granted and so on;

4. A labour market institutions, or institutional power variable, such as the ratio of state sector output to all industrial output.

While it is common to include an indicator of labour market institutions such as union density in the wage models, effective unions do not exist in China. The All-China Federation of Trade Unions is not independent from government, and trade unions with the full right to organize a strike or bargain for better wages and working conditions for workers do not exist. Since employment in the SOE sector is more likely to offer decent work conditions than in the private sector, an indicator for SOE is included as a proxy for labour market institutions.

4.4 The model

4.4.1 Wage model design

In this part, an econometric model is built to investigate how technological upgrading affects wages. The rationale behind this model is that technological upgrading may enhance workers' skill level, which increases workers' wages. For example, when a factory introduces new production technologies, it needs to offer necessary training to workers before they can use the technology. When workers gain more skills, the employer will have to pay higher wages to retain them. Therefore, high-tech firms pay more to keep workers compared to other firms where workers are doing routine activity (Blanchard and Johnson 2013).

In terms of the dependent variable, some research uses wage data in natural logarithm form (Braunstein and Brenner 2007; Braunstein and Epstein 2002; and Luca Nunziata 2005); other research adopts the wage growth rate (Afonso and Gomes 2014; and Ana Lamo, Javier J. Pérez and Ludger Schuknecht 2012). Since wages in the manufacturing sector have increased steadily during the selected years (see Figure 4. in Chapter 3), the growth rate form of the wage data allows some fluctuation in wages and thus, is preferred to the natural logarithm form of wage. In fact, the first difference of wage growth rate will be used as the dependent variable since it allows this model to examine which technological upgrading variable could accelerate wage growth.

As discussed in the theoretical model, the variables that will be included are: price expectations, labour market conditions, labour market institutions, and technology upgrading. The econometric model to estimate how technological upgrading affects the wage is:

$$\mathrm{Wsp}_{it} = \alpha + \beta_1\ \mathrm{priceexp}_{it} + \ \beta_2 \mathrm{labour}_{it}, + \ \beta_3 \mathrm{institution}_{it}^2 + \ \sigma\, \mathrm{Techup}_{it} + \ u_{it} \qquad (5)$$

where i represents province and t represents time:

Wsp = wage growth speed;

a = the constant

priceexp = price expectations

labour = labour market conditions

institution = labour market institution power

Techup = a group of technological upgrading variables.

Based upon the theoretical discussion of wage determination in 4.2, price expectation is one of the factors which is expected to have a positive effect on wages, which means the higher the price expectations, the higher the wages will be.

Labour market condition is expected to have a positive relationship with wages as well, and more specifically, when there are more people employed, wage increases. The relationship between wage and institutional power is uncertain. Lastly, technological upgrading indicators are expected to have positive effects on wage.

The limitation of this model is that it cannot capture how microeconomic level characteristics affect wages. In addition, some other factors that affect wages may not be captured in this model, such as bargaining power. The benefits of this model are that we can see how technological upgrading affects wages in the manufacturing sector and what form of technological upgrading is leading the wage change. Moreover, the macroeconomic level model will not be biased by the sample selection.

4.4.2 Econometric issues and solutions

This research will use Eviews 8 to run all the models. Ordinary least squares (OLS) method is adopted to estimate all the unknown parameters in this linear regression model. The data are constructed as a time-series-cross-section data set rather than simple time-series data set. Econometrics issues, such as non-stationarity, multicollinearity, heteroscedasticity, and autocorrelation may occur, as discussed below.

Non-stationarity

In non-stationary time series, shocks will be permanent, and the mean and the variance will depend on time (Dimitrios Asteriou and Stephen G. Hall 2011). The unit root test is used to determine whether error terms are white noise or not. If errors are not white noise, which means that error terms do not have a mean of zero and they are correlated between values at different times, the time series is non-stationary. The problem with non-stationary data is that "the standard OLS regression procedures can easily lead to incorrect conclusions" (Asteriou and Hall 2011, 338). In other words, the regression results from a non-stationary time series will be spurious.

The augmented Dickey-Fuller (ADF) test for unit roots will be adopted in this research for each variable.[24] Eviews offers the ADF test in its program; the test result indicates whether the variable has a unit root or not, and the number of the unit root. If it is known that a series has a

[24] The mathematical framework of ADF test is beyond the scope of this research; please refer to Asteriou and Hall (2011, 342-344) for an mathematical explanation.

unit root, the series can be differenced to render it stationary. For example, the process is to test a series Yt by using Eviews ADF test. Eviews will produce a ADF test report, and if the ADF test statistics of Yt is bigger than the critical t-statistics (for this research I choose 10% level) listed in the same test result report, the Yt is recognized as a stationary series (noted as I (0)), Otherwise, it is non-stationary, and the first difference needs to be taken: Δ Yt =Yt-Yt-1. It is necessary to take the ADF test again, and if Δ Yt is stationary then Yt is stationary at first order differencing (noted as I (1)). If a series is not stationary after taking the first order differencing, the second differences is taken and tested again; the procedure can be repeated, until the test results indicate the series is stationary.

Multicollinearity

Multicollinearity refers to a phenomenon in which the explanatory variables in a linear regression model are moderately or highly correlated (PennState Eberly College of Science n.d.). In this situation, the estimated model parameters remain unbiased, consistent and effective, but the estimated parameters (including the parameter signs) are very sensitive to small changes to the model or data. Consequences of multicollinearity are summarized as:

> 1. Estimates of the OLS coefficients may be imprecise in the sense that large standard errors lead to wide confidence intervals; 2. Affected coefficients may fail to attain statistical significance because of low t-statistics; 3. The signs of estimated coefficients can be the opposite of those expected; 4. The addition of deletion of a few observations may result in substantial changes in the estimated coefficients (Asteriou and Hall 2011, 101).

To detect multicollinearity, a correlation table can be built for all the variables to disclose the relationships between them. Alternatively, multicollinearity can be identified from the regression results. For instance, there is multicollinearity when the regression result illustrates a high R^2 but low t-statistics for most variables. In order to resolve or avoid multicollinearity, variables should be added into the model one by one. Thus, when there are correlated variables,

variables can be identified and replaced immediately. For this research, the model will be run several times with only one technology variable each time to avoid the problem of multicollinearity.

Heteroscedasticity

The classic linear regression model requires that error terms are homoscedastic, which means the errors have the same scatter regardless of the value of independent variable. When the scatter of the errors is different depending on the value of one or more of the independent variables, the error terms are heteroscedastic (Asteriou and Hall 2011).

Heteroscedasticity may arise from the following issues. Firstly, heteroscedasticity arises if the model excludes some of the explanatory variables (Jingshui Sun and Shuqin Ma 1991). If the model contains only a few major factors, the impact of other factors is included in the random error term, and therefore, the random error term could produce heteroscedasticity. Secondly, it may arise if the form of the regression equation is mis-specified (Sun and Ma 1991). In general, the relationship between the explanatory variables and the dependent variable can be complex. Constructing the linear regression model to estimate the non-linear relationship between explanatory variables and the dependent variables increases the errors and leads to heteroscedasticity. Thirdly, heteroscedasticity occurs if the variables contain measurement errors (Sun and Ma 1991). On one hand, measurement error in the sample data often accumulate over time, which increases the variance of the random error term over time. On the other hand, improvements in sampling techniques and other data collection methods reduce random errors. Thus, in the time series data, items do not have a random homoscedasticity. Lastly, random factors also contribute to heteroscedasticity (Sun and Ma 1991). Economic variables themselves are affected by a number of random factors (such as policy changes, natural disasters or financial crises, etc.), therefore, variables do not have certainty and repeatability.

The consequences of heteroscedasticity are recognized as below:

> 1. Heteroscedasticity does not result in biased parameter estimates; 2. among all the unbiased estimators, OLS does not provide the estimate with the smallest variance. Depending on the nature of the heteroscedasticity, significance tests can be too high or too low; 3. the standard errors are biased when heteroscedasticity is present. This in turn leads to bias in test statistics and confidence intervals; 4. significance tests are virtually unaffected, and thus OLS estimation can be used without concern of serious distortion (Richard Williams 2015, 2-3).

To identify heteroscedasticity, the White test will be used. The White test, proposed by Halbert White (1980), is a statistical test through the establishment of an auxiliary regression method to determine heteroscedasticity. Since Eviews includes a routine for executing the White's test, I am going use the White test (cross-product) function to detect the residual. If the White's test has a Lagrange Multiplier statistic (LM-statistic) bigger than the critical value or if the p-value is less than the level of significance α (usually α=0.05), then there is significant evidence of heteroscedasticity.[25]

If the evidence indicates heteroscedasticity, then autocorrelation consistent (HAC) standard error estimators will be used to resolve it.[26] Eviews can compute White's heteroscedasticity-corrected variances and standard errors automatically, therefore, the manual calculation is unnecessary. By using this method, standard errors of all variables will be corrected and estimators will be more accurate.

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[25] A critical value is used in statistical hypothesis testing, the value of it corresponding to a given significance level. "The critical value approach involves determining "likely" or "unlikely" by determining whether or not the observed test statistic is more extreme than would be expected if the null hypothesis were true. That is, it entails comparing the observed test statistic to some cutoff value, called the "critical value." If the test statistic is more extreme than the critical value, then the null hypothesis is rejected in favor of the alternative hypothesis. If the test statistic is not as extreme as the critical value, then the null hypothesis is not rejected" (PennState Eberly College of Science n.d.)

[26] The mathematical details of this method are beyond the scope of this research, please refer to White (1980) for more details.

Autocorrelation

An assumption of the linear regression is that error terms are independently distributed. If this assumption does not hold, the disturbances are autocorrelated. Autocorrelation is most likely to occur in a time series framework because the error in a certain period may be affected by errors in other periods (Asteriou and Hall 2011, 149). Autocorrelation can occur due to reasons such as omitted variables, misspecification, and systematic errors in measurement (Asteriou and Hall 2011, 149).

Autocorrelation of the errors violates the OLS assumption that the error terms are uncorrelated. The consequences of autocorrelation are summarized as:

> 1. The OLS estimators are still unbiased and consistent; 2. The estimators will be inefficient and no longer the Best Linear Unbiased Estimators (BLUE); 3. The estimated variances of the regression coefficients will be biased and inconsistent, and therefore hypothesis testing is no longer valid (Asteriou and Hall 2011, 152).

To detect autocorrelation, the most frequently used method is the Durbin-Watson (D.W.) test. It is named after James Durbin and Geoffrey Watson (1950) (see Asteriou and Hall (2011, 156-158) for mathematical details about D.W. test). Although Eviews reports the D.W. test result (d) of every regression output, the D.W. critical values still need to be calculated. Since there are 4 variables (excluding the constant) in this model, k'= 4. Based upon the D.W. significance table (Asteriou and Hall 2011, 485) and 84 observations in my data set, the dL and the dU are 1.41 and 1.60 respectively. See Table 13 below for the D.W. critical.

Table 13. The D.W. critical result

$0 \leq d \leq 1.41$	$1.41 < d < 1.60$	$1.60 \leq d \leq 2.40$	$2.40 < d < 2.59$	$2.59 \leq d \leq 4.00$
Positive serial correlation	Test inconclusive	No autocorrelation	Test inconclusive	Negative serial correlation

Source: table compiled by author based upon the D.W. test table in Asterious and Hall (2011, 157)

If the test indicates an autocorrelation of the model, the solution is to add autoregressive errors of order 1 (AR (1)) to estimate the model again. If the new D.W. statistics indicates that autocorrelation still exists, the autoregressive errors of order 2 or/and 3…n will be needed to estimate the model until D.W. test indicates there is no autocorrelation.

4.5 Data for the model

The accessibility of appropriate data is an important part of any empirical research. The quantitative analysis uses data from China at the provincial level. All the data come from government official databases such as the:

1. China statistical yearbook (2002-2015)
2. Jiangsu statistical yearbook (2002-2015)

   Guangdong statistical yearbook (2002-2015)

   Zhejiang statistical yearbook (2002-2015)

   Fujian statistical yearbook (2002-2015)

   Guangxi statistical yearbook (2002-2015)

   Hainan statistical yearbook (2002-2015)

   Shandong statistical yearbook (2002-2015)

4. National Bureau of Statistics of P.R.C. of the P.R.C. website: http://www.stats.gov.cn/english/
5. State Intellectual Property Office of the P.R.C. website: http://english.sipo.gov.cn/
6. General Administration of Customs of the P.R.C website: http://english.customs.gov.cn/

My database on most indicators covers the time period from 2002 to 2014. However, I extend the wage data back to 2001, as I need to calculate wage growth rate and take first difference of it. The whole modeling data set cannot be extended to 2001 because two of my key high-tech indicators (high-tech exports and high-tech imports) are only available in the statistical yearbooks since the year 2002. Since calculating the change in the wage growth rate (wage growth speed) for a given year requires data for the current year and preceding two years, the data used in the regression analysis covers the time period 2003 to 2014. The data are collected for seven coastline provinces, the total number of observations is 91 (7 provinces and 13 years, from 2002 to 2013) and after the data processing the number of observations that I use in my model is 84 (7 provinces and 12 years, from 2003 to 2014). Only seven coastline provinces are included in this data set due to the data source limitation. The original plan for this research is to obtain data for all coastline provinces and cities, however, this plan cannot be fulfilled because not every coastline province and city publish statistical yearbook and some provinces do not report consistent data for some vital technological upgrading indicators.

The indicator I use for price expectations is the lagged inflation rate as the inflation rate indicates the goods and service price change each year, and therefore I assume that people expect the price change in the next year would be as same as the current year. Labour market conditions is captured by GDP growth rate, as Okun's law indicates that when GDP increases, the labour market tightens. Lastly, ten technological upgrading indicators are used, as listed in Table 14; the indicator selection is based upon literature review of technological upgrading and data availability.

4.6 Model results

Based upon econometric issues addressed in section 4.3.2, necessary procedures are taken to identify and resolve the issues to yield efficient and accurate results. Firstly, an ADF unit root test is used to determine the stationarity of each variable; the results indicate that the following variables have unit roots: FDI per worker, R&D expenditure as a share of GDP, value of high-tech export, value of high-tech import, and the value of high-tech import divided by total number of manufacturing workers. After taking the first difference, all these five variables become stationary. Therefore, they are stationary at first order differencing.

Secondly, the technological upgrading variables are added one by one into the model, and therefore, multicollinearity among the variables is avoided in the ten models. Thirdly, heteroscedasticity is identified in all ten models, and therefore, the HAC standard error estimators is used to resolve it. Lastly, since autocorrelation has been found in all ten models, AR (1) added in to all models to resolve the autocorrelation. The first difference of wage growth rate offers variation in the dependent variable, and therefore wage growth speed is adopted as the dependent variable.

Fourthly, the descriptive statistics in Table 14 offers some information about my data set. The Obs. indicates the total number of my observations, and for this research the number of observations is 84. The Mean indicates the average of the data, which is the sum of all the observations divided by the number of observations. For example, the wage growth speed is -0.2, which means that on average, wage is increasing at a decreasing speed of -0.2% annually. The Max is the largest data value in the data set and the Min is the smallest data value in the data set. These two descriptive statistics are used to identify a possible outlier or a data-error in the data set. For instance, the wage growth speed has a Max of 15.8 and Min of -18.4; and the big difference between these two data observations led me to verify the data entry and calculation. The Standard deviation (Std. Dev.) is used to measure how the data vary around the mean. The higher the standard deviation, the greater the spread of the data. For instance, the standard deviation of annual GDP growth is 5, which means that on average, the GDP growth rate for a province deviates from the mean (which is 15.5%) by about 5%.

Table 14. Model variable details

Variables	Definition	Obs.	Mean	Max	Min	Std. Dev.
Wage growth speed	Wage growth speed is the first difference of the wage growth rate; it is also known as the change in wage inflation[27]; The original wage data is the annual nominal average annual wage of staff and workers in the manufacturing industry in urban units	84	-0.2	15.8	-18.4	5.8
Price expectations	Lagged inflation rate	84	2.8	7.8	-2.3	2.0
Labour market conditions	Nominal GDP annual growth rate (%)	84	15.5	24.8	6.3	5.0
Labour market institutions	Value of total SOE output divided by the value of total industry output (%)	84	12.0	65.0	0.7	11.6
Technological upgrading variables	1. Value of mechanical and electronics exports as a share of the value of total exports (%)	84	42.9	69.9	10.0	18.4
	2. Value of mechanical and electronics imports as a share of the value of total imports (%)	84	40.0	73.8	1.4	19.8
	3. First difference of actual FDI utilized divided by total number of employed workers for the entire province (USD/worker)	84	14.2	122	-213.5	49.4
	4. R&D employees in LM enterprises divided by the total number of staff and workers in the manufacturing sector[28](%)	84	5.7	16.0	1.1	2.8

[27] Staff and Workers are people who signed a labour contract with the employer and are paid by the employer. The employer has to pay salary and offer social security package and housing fund. Staff and Worker includes people who are on injury leave, maternity leave, learning leave, sick leave, but still getting paid by their employer (National Bureau of Statistics of P.R.C. 2015a)

[28]The classification of large- and medium-sized (LM) enterprise is based on a combined firm-size indicator, where operating income and numbers of employees, total assets are taking into account. For the manufacturing industry, large-enterprise requires more than 1,000 employees and over 0.4 billion CNY operating income; while medium-enterprise requires more than 300 employees and over 20 million CNY operating income (National Bureau of Statistics of P.R.C. 2013).

5. First difference of R&D internal expenditure in LM enterprises as a share of GDP (%)[29]	84	0.0	0.4	-0.8	0.2
6. Number of patents granted divided by total number of employed worker (in 000's) over the whole province (case)	84	1.1	5.7	0.0	1.4
7. First difference of the value of High-tech exports (billion USD)	84	4.4	36.0	-25.4	9.8
8. First difference of the value of High-tech imports (billion USD)	84	3.3	33.9	-25.4	8.3
9. Value of high-tech exports divided by the total number of staff and workers in the manufacturing sector (USD/worker)	84	10,179.1	41,251.1	56.8	12,320.9
10. First difference of the value of high-tech imports divided by the total number of staff and workers in the manufacturing sector(USD/worker)	84	457.4	10,124.0	-13,032.3	3,191.4

Note: the descriptive statistics for the raw data are presented in the Appendix. The first difference of variable is used to address the non-stationary issue as discussed in the section above.[30]

[29] R&D internal expenditure refers to the actual expenditure on basic research, applied research, experimental development, direct expenditure on research project, management and service, that spent by the R&D unit. It does not include expenditure on production activities, repay loans and cooperation or commission expenditure transferred to external R&D units (National Bureau of Statistics of P.R.C. 2015a).

[30] An Augmented Dickey-Fuller (ADF) unit root test (including both intercept, and trend and intercept in the equation) is used to determine non- stationarity for each variable.

Table 15. a Wage equation for 7 provinces, using data for 2003-2014
(Estimation with HAC standard errors and covariance; dependent variable: wage growth speed)

variable	model I	model II	model III	model IV	model V
c	-5.43***	-5.92***	-4.95***	-5.84***	-5.29***
	(1.13)	(1.41)	(1.02)	(1.39)	(1.07)
Lag inflation rate	0.72***	0.73***	0.75***	0.74***	0.68***
	(0.23)	(0.23)	(0.23)	(0.23)	(0.25)
GDP growth rate	0.18**	0.19**	0.14*	0.19**	0.19**
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
SOE share^2	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Mechanical & electronics import share	0.00				
	(0.02)				
Mechanical & electronics export share		0.01			
		(0.02)			
Δ FDI per worker			0.02**		
			(0.01)		
R&D employment share				0.08	
				(0.12)	
ΔR&D expenditure/ GDP					3.26**
					(1.56)
R square	0.32	0.32	0.36	0.32	0.33
N	84	84	84	84	84

Note: Δ means first difference, and it is used to address non-stationary in the variables;
Standard errors in parentheses.
* Denotes significant at the 10 percent level.
** Denotes significant at the 5 percent level.
*** Denotes significant at the 1 percent level.

Table 15. b Wage equation for 7 provinces, using data for 2003-2014
(Estimation with HAC standard errors and covariance; dependent variable: wage growth speed)

variable	model VI	model VII	model VIII	model IX	model X
c	-7.27***	-5.22***	-5.69***	-5.23***	-4.88***
	(1.58)	(1.13)	(1.08)	(1.12)	(1.25)
Lag inflation rate	0.75***	0.72***	0.73***	0.72***	0.73***
	(0.23)	(0.23)	(0.23)	(0.23)	(0.23)
GDP growth rate	0.27***	0.18**	0.19**	0.18**	0.16*
	(0.10)	(0.08)	(0.08)	(0.08)	(0.09)
SOE share^2	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Patent per (1000 worker)	0.51**				
	(0.24)				
Δ High-tech export		0.01			
		(0.04)			
High-tech export per manufacture worker			0.00		
			(0.00)		
Δ High-tech import				0.02	
				(0.05)	
ΔHigh-tech import per manufacturing worker					0.00
					(0.00)
R square	0.34	0.32	0.32	0.32	0.32
N	84	84	84	84	84

Note: Δ means first difference, and it is used to address non-stationary in the variables;
Standard errors in parentheses.
* Denotes significant at the 10 percent level.
** Denotes significant at the 5 percent level.
*** Denotes significant at the 1 percent level.

Turning to my regression results, Table 15.a and Table 15.b present estimates for each model. "In traditional statistics the significance level is usually set at 1%, 5%, and/or 10%" (Asteriou and Hall 2011, 9), and therefore, this research follows the traditional way of confidence level setting. Corresponding to the significance levels, the t-critical values are 2.57, 1.96, and 1.64.[31] The significance level is used as a way to identify whether an independent variable has a statistically significant impact on the dependent variable or not. More specifically, if the t-statistic of an independent variable is greater than the 1% significance level of 2.57, then with 99% of confidence, I can conclude that this independent variable has a statistically significant effect on the dependent variable. The following discussion of regression results is based upon the statistical significance test results in Table 15.a and Table 15.b

For the macroeconomic variables, the results are as expected. Starting with the price expectations variable, which is proxied by the lagged inflation rate, and looking horizontally through Table 15.a and Table 15.b, I find that it has positive and significant effects on the manufacturing wage growth speed in all ten models, which means the higher the lagged inflation rate, the faster the wage growth speed.

The Labour market conditions variable, which is proxied by the nominal GDP growth rate, plays a positive significant role in all wage models. The results indicate a higher GDP growth rate will speed up the wage. This is consistent with the theoretical hypothesis of Okun's law that when GDP increases, the labour market tightens, which further raises wages.

Labour market institutions, which is proxied by squared SOE production share, does not play a role in manufacturing wage growth speed in all models. The SOEs' production share is also regarded as a market liberalization variable since SOEs are owned by the state. From this perspective, the modeling results suggest that whether the economy dominated by the state or not

[31] This research uses the t-table with right tail probabilities in Asteriou and Hall (2011, 479).

does not affect the wage growth in the manufacturing sector. In other words, for workers in the manufacturing sector, the ownership type of the enterprise does not make a significant difference in terms of their wage growth.

In terms of technological upgrading indicators, three of them pass the critical level of t-statistics: the first difference of FDI per worker; the first difference of R&D expenditure as a share of GDP; and Patents per 1,000 workers. The FDI indicator suggests that when there is an increase in FDI per worker, the average annual wage in manufacturing sector grows faster. Given that the FDI variable is measured as the first difference of FDI per worker, the magnitude of the regression coefficient can be interpreted as follows. If FDI per worker increases by 1 dollar from one year to the next, the wage growth rate will increase by 0.02 percent in the manufacturing sector. Therefore, introducing more FDI speeds up the wage growth and it can be a good strategy for development. This result is consistent with Braunstein and Epstein (2002) and Braunstein and Brenner (2007) results, in which FDI has a statistically significant and positive impact on wages in China.

The R&D expenditure variable suggests that an increase in R&D expenditure in large and medium enterprises as a share of GDP accelerates the wage growth significantly in the manufacturing sector. This result is reasonable since the Chinese government at different levels (national, provincial and municipal) is promoting domestic technological upgrading in recent years. Economic and technology development zones are being built to facilitate high-tech, high-value-added firms to operate and expand production. To attract high-tech enterprises, Chinese governments at different levels are providing tax benefits and subsidies on equipment. To promote domestic technological upgrading, local governments encourage the resource based and labour intensive industries to relocate from developed areas to underdeveloped areas within the province, so that they can provide enough land for high-tech firms. For instance, in 2002, the Jiangsu Municipal Commission of Development & Reform started organizing the industrial transfer from south Jiangsu (a more developed area) to north Jiangsu (an underdeveloped area). As of 2012, there are 17,439 projects that have been moved to north Jiangsu (including Xuzhou, Yancheng, Huaian, Lianuangang, Suqian). Each project is worth more than five million CNY (0.8 million USD), and total investment reached about 1,015.1 billion CNY (160.9 billion USD) (Nanjing Municipal Commission of Development 2012).[32] The strategy has two main implications for workers: 1. the shift in industries to underdeveloped areas will increase the numbers of jobs in underdeveloped areas; 2. for workers who stay in the developed areas, they are likely to get more training and higher wages from those high-tech firms. The first implication will reduce the number of migrant worker in developed areas. It will also push industries' technological upgrading towards high-value-added production or towards labour-saving production in developed areas. The second implication can be explained as that high-tech enterprises located in developed areas (coastline areas) need to offer training to workers, which can push the wage increases further. High-tech enterprises do not normally concentrate on labour-intensive products and they normally engage in skill-intensive products that requires a labour force with higher education levels. The education requirement of labour will increase over time, and workers who stay in developed areas will earn higher wages. For instance, in the past, most recruitment criteria used to be "no academic requirements" in the Guangzhou labour market, but in recent years there is a significant increase of "college and higher education" job requirement (Ruiqiu Yang 2015).

Turning to the last statistically significant indicator, Patents per 1,000 workers, the results suggest that when patents increase, wages grow faster. This indicator can also be seen as a

[32] The exchange rate is based on 100 USD = 631.0 CNY (National Bureau of Statistics of P.R.C. n.d.).

domestic R&D indicator and consistent with the previously reported findings that R&D expenditure as a share of GDP has a positive and statistically significant impact on wage growth speed. Therefore, encouraging domestic technological upgrading is another good strategy to increase workers' wages.

Surprisingly, the other seven technological upgrading proxies do not have a statistically significant effect on the manufacturing wages. Neither high-tech exports nor high-tech imports indicators are statistically significant which is surprising because these are two very important technological upgrading indicators reflecting the capability of producing high-tech products. Other studies of Chinese high-tech exports may help explain why these two indicators do not affect wages. For instance, Schott (2008) discovers that although China's export products have a very high overall sophistication level, the vertical sophistication turns out to be exceptionally low.[33] This result is supported by Koopman, Wang and Wei (2008) who find that electronic devices, which are likely to be labelled as sophisticated products, have particularly low domestic content (only about 30% or less). Yuqing Xing (2014, 122) finds that the trade statistics reported by Chinese government "mistakenly credit entire values of assembled high-tech products to China". Xing (2014, 122) claims that "China's real contribution to 82% of reported high-tech exports is labor and not technology". These findings imply that even though huge amounts of high-tech products are exported by China, not many are produced in China from the beginning to the end. A lot of so called "high-tech products" are imported as semi-finished products and assembled by the manufacturing sector and exported as finished high-tech products. If the domestic value-added in the high-tech exports is at a low level (less than 30% as Koopman, Wang and Wei (2008) suggest), then this could be an explanation of why high-tech imports or

[33] The "overall sophistication" of Chinese exports indicates the overlaps between Chinese exports categories and developed economy exports categories; the "vertical sophistication" of Chinese exports indicates the level of value-added in the products (Schott 2008).

exports indicators do not affect the manufacturing sector wage. The value-added in Chinese high-tech products is mainly labour rather than technology. Besides, mechanical and electronics imports and exports are also insignificant, which could further verify that the processing activities do not contribute to the wage growth.[34] Therefore, the result from my modeling suggests that low domestic value-added activities cannot be a solution to increasing wages in manufacturing sector.

4.7 Summary

In sum, the empirical evidence indicates that three of technological upgrading indicators have positive and statistically significant effects on wage growth in the manufacturing sector. More specifically, facilitating the increase of FDI and/or R&D activities in large and medium enterprises as well as domestic innovations will accelerate wage growth in the manufacturing sector. Although the correlations between the wage and various indicators of technological upgrading (including high-tech exports, high-tech imports, mechanical and electronic exports, mechanical and electronic imports) are positive, those indicators do not affect the wage growth during the period 2003 to 2014. This further suggests that processing semi-products does not help the wage growth, and domestic value-added needs to be increased in those exported high-tech categories.

The drawback of the model is that the R square of each model is a low level around 0.32 to 0.34. This means that there is only around 32% to 34% of the variation in the dependent variable being explained by the regressors. There could be some other variables that affect wage growth that are not included in my database; therefore, further research needs to examine some new

[34] I find that there are many overlapping parts between high-tech products and mechanicals & electronics products by checking the products' codes in both *High-tech Products Catalog 2006* and *China Custom Statistical Yearbook 2006* (Guangdong High-tech Enterprise Association 2015)

variables or to extend the time horizon for the data set to enhance the explanatory power of the model. For example, the amount of FDI spent on R&D, the amount of domestic value-added in high-tech exports, and the amount of domestic value-added in mechanicals and electronics exports would more accurately capture technological upgrading compared to indicators used in this study and having such data would help in estimating the relationship between technological upgrading and wages.

Chapter 5: Conclusion

5.1 Research goals and achievements

The goal of this research is to identify the impacts of technological upgrading on decent work in the manufacturing sector in China by answering questions:

1. Has there been technological upgrading in China?

2. Has there been an improvement in decent work in China?

3. Does everyone benefit from improvement in decent work equally?

4. Does technological upgrading improve decent work in the manufacturing sector?

The descriptive analysis of trends in technological upgrading and decent work is based upon provincial level data, for 2002 to 2014, for seven coastline provinces: Jiangsu, Guangdong, Fujian, Zhejiang, Shandong, Guangxi, and Hainan. By using descriptive analysis, firstly, I find that during the selected period, technological upgrading has taken place in all provinces; Jiangsu and Guangdong have a higher technology endowment than the other five provinces, in absolute and relative terms.

Secondly, there has been an improvement in decent work in the manufacturing sector, based upon indicators such as the average annual nominal wage, the number of dependents that a worker can support with this annual wage, and social security provisions.

Thirdly, while an improvement in decent work has been observed, the distribution of these benefits is uneven between workers with an agricultural *hukou* (rural workers) and those with a non-agricultural *hukou* (urban workers). Rural workers who migrate to cities have fewer chances to obtain decent work or decent working time compared to workers with a non-agricultural *hukou*. This is demonstrated by data reporting that over 60% of migrant workers have no work contract, and because of this, we could not expect them to have any social security coverage.

Access to decent work differs among workers not only in terms of their residential status but also by industrial sector of employment. Some sectors provide workers with regular working hours and good pension plans such as Public Administration sector. Some sectors in urban area (such as Hotels and Catering Services sector or Wholesale and Retail Trade sector) require regular over-time work, which is neither healthy for workers nor good for employment over the whole economy. It is disappointing that even though the standard working hour in China is regulated, overtime working is still common in 90% of all the sectors. Absence of government supervision blocks the effectiveness of the labour law.

Fourthly, there is some evidence that technological upgrading improves decent work. Provinces with higher technology endowments tend to show better performance in those decent work indicators, such as the monetary wage in the manufacturing sector and employment insurance participation rates. This is demonstrated by the positive correlation between technological upgrading indicators and decent work indicators. For example, Jiangsu and Guangdong, provinces with higher technological endowments, also have higher average annual nominal wages and employment insurance participation rates.

While the fourth question to be addressed in this thesis is whether technological upgrading improves decent work, given that few indicators of decent work exist, the econometric analysis uses the average annual nominal wage as the main indicator of decent work. The regression analysis is based upon data for the time period 2003 to 2014, with the wage data needed to construct the wage growth speed variable being extended back to 2001. Various proxies for technological upgrading are used in the regression analysis. Only three of technological upgrading proxies pass the t-test, and these are: the first difference of FDI per worker; the first difference of R&D expenditure as a share of GDP; and Patents per 1,000 workers. Thus, the regression model results provide some support for the hypothesis that technological upgrading will improve wages. The impacts on wage growth caused by inflation rate and nominal GDP growth rates are significant in all modeling results.

The main contribution of this research is that it focuses on the technological upgrading in manufacturing sector, and the impact of it on decent work. The conclusion of this research is that technological upgrading enhances decent work, as measured by the wage, in China. Moreover, I have not found literature with similar topic. However, not all technological upgrading indicators have had a statistically significant impact on decent work, such as those so called "high-tech" exports.[35] This research finds that although there has been technological upgrading during the transformation from labour-intensive manufacturing to the low domestic value-added but technology-intensive manufacturing, this change has not had a statistically significant impact on workers' wages. This research also confirms that the impact of FDI on wages is significant and positive in China, which aligns with the results from Braunstein and Epstein (2002). Khalid Nadvi (2004) recognized that even if technological upgrading has a positive overall impact on the labour market in terms of increased employment and wages, it may not benefit all workers equally. This research verified this point and find out that workers could be blocked by their *Hukou* type, and working sectors in China.

This research adds to the understanding of the relationship between technological upgrading and decent work and finds that they are positively related. Moreover, this research also fills some gaps in the literature on decent work study in terms of the Chinese labour market. For example, the decent work working time distribution between citizens with different *Hukou* types.

[35] As Xing (2014, 122) claims, "China's real contribution to 82% of reported high-tech exports is labor and not technology".

5.2 Policy implications

Policy implications of this research are organized as follows. Firstly, based upon my estimation results, future policy-making should focus on introducing more FDI, increasing the R&D expenditure in large and medium enterprises and encouraging domestic innovation to accelerate the growth of wage. In other countries, there has been concern that increased FDI is associated with increased income inequality because it raises the demand for, and wages of, skilled workers, relative to unskilled workers, as shown for example, in the case of Mexico (Robert C. Feenstra and Gordon H. Hanson 1997). However, FDI in different countries may have different impacts on the labour market depending upon the nature of the production and demand for skills. For China, Xiaofei Tian, Baotai Wang and Ajit Dayanandan (2008) find that instead of worsening income inequality, the FDI inflows during 1978 to 2006, consistently improved the income distribution in China. They suggest that this finding supports the hypothesis that trade liberalization will increase the demand for the abundant labour force.

However, as firms further engage in technological upgrading this may increase the demand for higher level skilled workers, relative to lower skilled workers, and thus, may contribute to increased income inequality in the future. This is an area for further research and also points to the importance of continuing to increase education and skills of the labour force.

Secondly, my estimation results suggest that low domestic value-added activities (for example, processing or assembling activities) do not affect the wage growth. Therefore, future policy should facilitate the expansion of industries which produce high domestic value-added products (high-tech producing industries). The distinction between high-tech processing and high-tech producing industries should be considered by policy makers. More specifically, high-tech producing industries (high domestic value-added products) emphasize that domestic producers should utilize the technology (in both embodied and disembodied forms) to produce the goods from the beginning to the end; while high-tech processing industries are, those industries are mainly adding labour into semi-finished high-tech products without owning any core technology. The overestimation of Chinese high-tech exports is an issue which needs to be investigated, as it appears that the measurement may not sufficiently distinguish between high-tech processing exports and high-tech producing exports. The inappropriate measurement may limit policy makers' abilities to assess and address the real changes necessary to develop a technological upgrading strategy and move the economy to a higher-income level.

Thirdly, the econometrics regression results also indicate that the inflation rate and GDP growth rate have positive and significant effects on wage growth. Therefore, a set of expansionary monetary policies, such as permitting higher inflation rates or lowering the deposit reserve ratio, may benefit nominal wage growth. However, simply raising the inflation rate does not really bring up the living standard for citizens, therefore, raising inflation rate should not be a long-term policy recommendation. Increasing GDP growth is another method to bring up the income, but what is the right way? As a high middle-income country, the export-driven and investment oriented economic growth strategies are facing difficulties to provide sustainable economic growth for China (Kai Guo and Papa N'Diaye 2009, Gangming Yuan 2013). As I discussed before, China is at an economic stage that it is losing its comparative advantage (low labour-cost) to lower-wage economies, and at the same time, given its technology level it still cannot compete with high-income economies. By depressing the wage to keep its comparative advantages is an unrealistic option. Therefore, future policy-making should find ways to more introduce cutting-edge technology and to facilitate domestic R&D activities.

Fourthly, the *Hukou* system in China is viewed as the major source of hardship for migrant workers living in cities (Kam Wing Chan and Li Zhang 1999, Peter Alexander and Anita Chan

2004, Au Loong-Yu and Nan Shan 2007). This research also find that *Hukou* system makes it unequal for workers to benefit from technological upgrading. Therefore, changes in legislation regarding Hukou system are required. Legislation should not be used to make residents unequal in terms of finding a job or accessing public goods and services (for example, medical care, education and so on).

Lastly, as this research recognizes, overtime work is prevalent in most sectors in China. Daniel Fu Keung Wong, Chang Ying Li and He Xue Song (2007) discovered that overtime work and inadequate rest is one of the most stressful work-related issues for Chinese rural-urban migrants. To protect labour from over-time work and to increase more employment opportunities, government monitoring of labour standards and labour protection is more necessary than ever. On the one hand, long daily working time reduces workers' happiness, increase their stress and the chance of getting occupational injuries (A. E. Dembe, J. B. Erickson, R. G. Delbos and S. M. Banks 2005). On the other hand, the marginal productivity of each worker reduces after certain hours of work, adding more working hours does not bring sufficient output, which is not a wise choice for the employer as well. Cutting down the average working hours to the standard working hours will provide more job vacancies. For example, *ceteris paribus*, cutting down the working hours from 50 hours per week to 40 hours per week for 4 workers on the same position, will create new work positions with 40 hours per week. Besides, when there is more leisure time, workers consume more products and services, which benefits economy growth as well. Technological upgrading will be required to increase wages and decent work, with the reduction in working hours, to maintain and increase individual worker incomes.

5.3 Limitations and recommendations for future research

Several limitations were encountered in undertaking this research. Firstly, the number of observations is small primarily because consistent data could only be obtained for seven provinces. Not all coastline provinces or cities publish statistical yearbooks such as Shanghai and Shenzhen, which makes the data collection impossible for them. The consistency of indicators in statistical yearbooks is another problem; for example, some good technological upgrading indicators exist for years prior to 2003 and then are no longer collected or publicly available (such as the number of R&D achievements in large and medium enterprise). Moreover, inland provinces do not publish data of their provincial exports, and therefore, indicators such as high-tech exports or mechanical exports cannot be found for inland provinces. These problems resulted in a small number of observations being used in the econometric analysis. The regression results may also be weak because the models are estimated on data for coastline provinces which tend to be the most developed provinces and thus, there is relatively little variation in the data. If the data set included more provinces, then greater variation among the provinces might contribute to stronger impacts of technological upgrading on wages, my measure of decent work. Moreover, extending the sample size, for example to a time horizon of more than 30 years or the geographical scope of the sample, may enhance the performance of technological upgrading proxies in the wage modeling.

Secondly, to assess technological upgrading a useful indicator would be the amount of domestic value-added in Chinese high-tech exports. Unfortunately, data on such an indicator is not available in the statistical yearbooks. This indicator should be a better indicator than high-tech exports/imports, since the classification of high-tech products and the statistical standard could offer an overestimation of the Chinese technology level. For example, in 2015, Guangdong province was still using “Chinese high-tech products catalog 2006” (Guangdong High-tech

Enterprise Association 2015). This catalogue is published almost 10 years ago and it is still the most recent edition. There are so many products in this catalog (for example, computer keyboard, mouse, and black and white TV) which should no longer be counted as high-tech products, nonetheless, such products are still classified as high tech in the provincial statistical yearbook.

Finally, there are some other factors affecting wages which have not been captured by my model which makes the R square low in all my models. Better wage determination variables are needed to revise the model. For example, data on the number of strikes in each province, the flow of migrant worker in each province, domestic value added in provincial exports would help enhance the wage modeling.

Future research could focus on obtaining data for more provinces and extending the time horizon so that the data set provides more observations and greater variation. Secondly, obtaining additional indicators for labour market conditions and bargaining power should be considered in future studies, as the SOE share of output is a limited proxy for workers' bargaining power and voice. Moreover, future research may also focus on discovering better technological upgrading indicators to enhance the estimation result.

Technological upgrading, especially the domestic R&D in China, should be the engine of enhancing the national income in the future development strategy. The Chinese manufacturing sector should set its goal towards the global high-end manufacturing center and focus on innovation and creation. Although the research results indicate that technological upgrading is a way to improve decent work in terms of wages, simply relying on technological upgrading is not sufficient. A successful economic development strategy must cooperate with good government regulation and supervision which promotes decent work. Generating more decent work opportunities is a crucial way to drive sustainable social and economic development

(International Labour Organization a). Future policy-making should enhance social equity and justice, so that more people are able to access decent work.

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Appendix: Descriptive statistics for data used in econometric model

Descriptive statistics for raw data (7 provinces, 2002-2014)

	Inflation rate (%)	GDP (in billion CNY)	Value of total SOE production (in billion CNY)	Value of total industry output (in billion CNY)
Mean	2.5	2,118.5	314.7	3,907.5
Median	2.3	1,567.3	197.5	2,483.6
Maximum	7.8	6,779.2	1,822.6	14,301.7
Minimum	-2.3	64.3	12.3	25.0
Std. Dev.	2.2	1,802.8	385.3	3,880.0
Skewness	-0.1	0.9	2.2	1.1
Kurtosis	2.6	2.8	7.8	3.2
Jarque-Bera	0.8	12.7	159.2	18.0
Probability	0.7	0.0	0.0	0.0
Sum	228.9	192,786.6	28,640.1	355,585.2
Sum Sq. Dev.	427.0	292,000,000.0	13,400,000.0	1,350,000,000.0
Observations	91	91	91	91

	Value of total imports (in billion USD)	Total actual utilized FDI (in billion USD)	Value of total mechanical & electronics exports (in billion USD)	Value of total mechanical & electronics imports (in billion USD)
Mean	84.8	10.5	741.9	44.1
Median	38.3	10.1	302.4	14.5
Maximum	455.2	35.8	4,395.7	283.7
Minimum	0.9	0.3	1.2	0.2
Std. Dev.	105.6	8.8	1,034.8	66.1
Skewness	1.8	0.8	1.9	1.9
Kurtosis	5.7	3.1	5.9	5.8
Jarque-Bera	73.5	10.0	85.7	83.9
Probability	0.0	0.0	0.0	0.0
Sum	7,716.6	955.0	67,514.4	4,015.6
Sum Sq. Dev.	1,003,517.0	6,938.2	96,378,655.0	393,017.7
Observations	91	91	91	91

	Total number of employed workers over whole province (in 1,000s)	R&D employees in large and medium enterprises (in 1,000s)	R&D internal expenditure in large and medium enterprises (in billion CNY)	Total number of manufacturing workers (in 1,000s)
Mean	35,539.9	165.2	31.5	2,465.7
Median	34,865.3	139.6	20.2	2,451.7
Maximum	66,065.0	598.9	137.5	10,151.6
Minimum	3,498.9	0.8	0.1	67.4
Std. Dev.	18,797.8	158.0	32.9	1,906.6
Skewness	-0.1	1.0	1.2	1.3
Kurtosis	2.0	3.4	3.8	6.8
Jarque-Bera	4.0	15.9	25.2	79.8
Probability	0.1	0.0	0.0	0.0
Sum	3,234,128.0	15,030.6	2,864.6	224,381.9
Sum Sq. Dev.	31,800,000,000.0	2,248,025.0	97,292.6	327,175,400.0
Observations	91	91	91	91

	Value of total high-tech exports (in billion USD)	Value of total high-tech imports (in billion USD)	Value of total exports (in billion USD)	Manufacturing sector average annual wage (CNY)	Number of patents granted annually
Mean	37.0	29.5	126.7	25,361.4	46,295.3
Median	10.5	7.7	75.1	21,895.0	15,937.0
Maximum	256.4	218.7	646.1	58,409.0	269,944.0
Minimum	0.0	0.1	0.8	8,762.0	199.0
Std. Dev.	59.7	48.3	150.7	12,330.3	63,905.1
Skewness	1.9	2.1	1.6	0.7	1.7
Kurtosis	6.0	7.1	5.4	2.5	5.0
Jarque-Bera	89.9	131.7	62.6	8.6	60.7
Probability	0.0	0.0	0.0	0.0	0.0
Sum	3,364.3	2,680.9	11,531.1	2,307,891.0	4,212,876.0
Sum Sq. Dev.	321,255.9	210,325.7	2,042,677.0	13,700,000,000.0	368,000,000,000.0
Observations	91	91	91	91	91

Descriptive statistics for modeling data (7 provinces, 2003-2014)

	Wage growth speed (%)	Lagged inflation rate	GDP growth rate (%)	SOE share (%)	Mechanical export share (%)
Mean	-0.2	2.8	15.5	12.0	42.9
Median	-0.5	2.5	15.9	6.9	41.2
Maximum	15.8	7.8	24.8	65.0	69.9
Minimum	-18.4	-2.3	6.3	0.7	10.0
Std. Dev.	5.8	2.0	5.0	11.6	18.4
Skewness	-0.1	-0.2	-0.1	2.5	0.1
Kurtosis	4.1	3.0	1.9	9.8	1.9
Jarque-Bera	4.6	0.3	4.7	247.2	4.0
Probability	0.1	0.8	0.1	0.0	0.1
Sum	-15.8	234.6	1,298.9	1,008.6	3602.5
Sum Sq. Dev.	2,761.3	342.4	2,042.4	11,141.6	27980.6
Observations	84	84	84	84	84

	R&D employment share (%)	First difference of R&D expenditure/GDP (%)	Patents per 1,000 workers	Mechanical import share (%)	High-tech export per manufacturing worker (CNY per worker)
Mean	5.7	0.0	1.1	40.0	10,179.1
Median	5.4	0.0	0.5	34.6	4,134.1
Maximum	16.0	0.4	5.7	73.8	41,251.1
Minimum	1.1	-0.8	0.0	1.4	56.8
Std. Dev.	2.8	0.2	1.4	19.8	12,320.9
Skewness	1.0	-2.3	1.8	0.0	1.3
Kurtosis	4.3	10.4	5.4	1.7	3.1
Jarque-Bera	19.1	265.1	67.1	5.9	22.8
Probability	0.0	0.0	0.0	0.1	0.0
Sum	475.7	2.3	95.1	3,359.5	855,048.1
Sum Sq. Dev.	666.9	3.1	167.4	32,424.9	12,600,000,000.0
Observations	84	84	84	84	84

	First difference of high-tech exports (in billion USD)	First difference of high-tech imports (in billion USD)	First difference of high-tech imports per manufacturing worker (USD per worker)	First difference of FDI per worker (USD per worker)
Mean	4.4	3.3	457.4	14.2
Median	0.9	0.6	177.5	14.3
Maximum	36.0	33.9	10,124.0	122.0
Minimum	-25.4	-25.4	-13,032.3	-213.5
Std. Dev.	9.8	8.3	3,191.4	49.4
Skewness	1.2	1.2	-0.5	-1.3
Kurtosis	5.6	7.5	7.4	8.1
Jarque-Bera	42.8	90.6	72.5	115.8
Probability	0.0	0.0	0.0	0.0
Sum	365.9	276.0	38,422.7	1,191.8
Sum Sq. Dev.	7,973.7	5,720.2	845,000,000.0	202,379.9
Observations	84	84	84	84