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Agglomeration Externalities and Skill Upgrading in Local Labor Markets: Evidence from Prefecture-Level Cities of China

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Abstract: Skill upgrading, the increase in the percentage of skilled workers in the employment population, boosts the economic growth of developing countries and sustains their industrial competitiveness. The international economics literature discusses the effects of international trade on skill upgrading, ignoring the potential role of agglomeration externalities. This paper takes China as a case study, which has been encountering a serious challenge about how to strengthen its industrial competitiveness in the world through skill upgrading as its population dividend decreases. The panel data of 2005, 2010 and 2015 from prefecture-level cities in China were used for regression analysis to explore the benefits from agglomeration externalities, including specialization and diversification effects, on skill upgrading. The results show that both the specialization effect and diversification effect do promote skill upgrading. Furthermore, there are significant differences in the influence of local agglomeration externalities across different regions, and the positive effect brought about by specialization externalities is usually dominant in undeveloped, inland or small cities, compared with the diversification in developed or coastal cities. Besides, manufacturing agglomerations exhibit positive externalities to skill upgrading mainly through specialization, while the service agglomerations mainly promote skill upgrading by means of diversification.

Keywords: agglomeration externalities; specialization; diversification; skill upgrading; China

1. Introduction

Skill upgrading, the increase in the percentage of skilled workers in the employment population [1], has been boosting in the long run the economic development of a nation and sustaining its industrial competitiveness in the global market. Especially for developing countries, making upgrading from the low end of global value chains to the high end depends partly on their highly skilled workers to improve their product quality with high labor productivity. However, the shortage of highly skilled workers has been a serious challenge and become a global concern since the 1990s [2,3].

The new economic growth theory, with a focus on the growth of human capital, advocates that formal schooling and informal education, such as on-the-job training, have a positive impact on personal skill accumulation [4,5]. International economics generally discusses the impact of trade on skill upgrading in developing countries [6,7]. According to the Heckscher–Ohlin model, trade liberalization leads to a relatively rigid structure of the international division of labor, which makes developing countries constantly lock in the labor-intensive sectors and have little opportunity of skill upgrading. However, another line of recent literature does not support that view. It is believed that trade liberalization increases competition, which forces local firms in those countries to promote

innovation and technological changes in order to cut down production costs and increase their market shares, both at home and abroad [7–9].

Innovation has a strong technical bias in general, and so there is a mutually reinforcing effect between innovation and technological intensity [10]. Technological advances increase employers' demand for skilled workers [11]—called employment effects—and make employers focus more on job training and higher skills. Moreover, as the wage gap between the skilled and unskilled workers increases, the share of highly skilled workers increases subsequently for increasing intentions to improve the level of individual skills [12,13]. This employment effect or the wage effect, skill premium effect, have eventually led to skill upgrading in certain industries of a country [1,10].

However, international trade does not necessarily promote the skill upgrading in developing countries, and the findings vary across different countries [14,15]. Actually, the skill upgrading in some empirical studies is measured only by the increase in wage levels [16], which actually obscures the rise in labor costs due to the labor shortage, rather than workers' skill accumulation. Furthermore, it also implies that the effect of international trade on skill upgrading probably depends partly on national or local conditions, such as the labor market, or the geographical agglomeration. Especially, export-oriented firms in developing countries have tended to conglomerate in some coastal cities [17].

Although extant literature on industrial agglomeration/cluster concerns about industrial upgrading in developing countries rather than skill upgrading with the context of globalization [18,19], externality effects, such as the local labor pool, knowledge spillover, and competition, are actually related to the increases in the demand and supply of highly skilled workers and the individual's skill accumulation, namely, skill upgrading. Therefore, this paper discusses the effect of different agglomeration types on the skill upgrading at the scale of the urban within a country, which is little discussed in the extant literature. It selects Chinese mainland as the research area. Based on its comparative advantages in low-cost factors, including unskilled workers, China has successfully integrated into global production networks as an offshoring manufacturing destination and manufacturing clusters, especially in the coastal area, which have been burgeoning since the late 1970s. However, many clustering regions has been engaging in the low-value-added production and have obtained lower level of profits; moreover, as the demographic dividends have decreased rapidly since the beginning of 2000s for the accelerating population aging and declining fertility, the labor supply decreases while the wage level rises [20]. Under such circumstance, it is urgent for China to make skill upgrading so as to promote industrial upgrading and enhance its international competitiveness [21]. Actually, there are still a supply-and-demand gap in terms of the highly skilled workers and the regional heterogeneity of the demand for skills in China [22]. It is therefore beneficial to make improvements in local governance to explore whether and how industrial agglomeration affects skill upgrading.

This paper is structured as follows. The second section makes a literature review on skill upgrading in international economics, and proposes three hypotheses from the perspective of agglomeration externalities. The third section introduces the modelling methodology and data resources to explore the effect of agglomeration externalities, both specialization and diversification, on skill upgrading through regression analysis. It presents the results and comments in the fourth section, and then makes the conclusions and discussion in the final section.

2. Agglomeration Externalities and Skill Upgrading: Literature Review and Hypotheses

Marshall first put forward the "external scale economies" to explain the benefits of industrial agglomeration, which are internal to the industry and external to the firms in a specific region [23]. There are three kinds of externalities, namely, transport cost reduction, labor pooling, and knowledge spillover-inspiring innovation [24]. Extant academic interests in agglomeration economies are mainly focused on the significance of information and knowledge flows for the innovation of local firms, rather than their impacts on individual skill accumulation or improvement, and the increase in in-migrating higher-level skilled workers, which is related to local skill upgrading.

Actually, burgeoning labor markets accompany increasing industrial agglomerations, especially by providing local firms with (semi-) skilled workers. The industrial atmosphere in a given agglomeration area and the cooperation relationships between enterprises are conducive to providing workers with more formal and informal learning opportunities and knowledge spillover, and competition between peer firms also drives them to make investments in innovation, including by hiring more skilled workers and on-the-job training, thus promoting skill upgrading [25]. Meanwhile, the geographical concentration of the workers can promote the job turnover and improves the matching of labor demand and supply, facilitating the dissemination of ideas and knowledge, which in turn increases labor productivity [26] and the worker's skills by formal and informal learning. However, whether different patterns of agglomeration (such as specialization or diversification) and different types of relationships between enterprises in an agglomeration area (e.g., upstream and downstream relationships or peer relationships) have divergent impacts deserves academic attention.

Glaeser et al. proposed three types of such knowledge spillover as follows [27]. First, the intra-sectoral knowledge spillover is labelled as Mashall-Arrow-Romer (MAR) externalities, which is related to specialization [23,28,29]. Secondly, the cross-sectoral knowledge spillover is labelled as Jacobs externalities, which stands for diversification [30]. The third one is about the competition externalities, labelled as Porter's effect [31]. Although empirical studies on the agglomeration externalities show their positive effects to increase productivity, results are not consistent on which kind of agglomeration externalities, specialization or diversification, is more conductive to local growth [32,33]. This inconsistence adds stimulus by a resurgence of interest in the growth theory and the importance of knowledge spillovers to many modern theories [34]. There is strong geographical perspective to this resurgence that knowledge spillovers are highly localized and may be best promoted through face-to-face contact [35]. Additionally, since debates are generally centered on the former two effects, specialization and diversification, this paper therefore mainly explores the influence of agglomeration externalities on the skill upgrading from these two aspects.

In the MAR model, specialization is considered as a large number of enterprises from the same industry clustering within the specific region, which creates an external economy for local enterprises through labor market concentration, input–output linkage and expertise knowledge spillover [36]. Galliano et al. [37] point out that the externalities of knowledge spillover occur only among enterprises in the same industry, so that they can only be promoted through the geographical concentration of enterprises belonging to similar industries. As an important prerequisite for learning to occur [38], knowledge proximity results in a faster speed and higher frequency of effective expertise, ideas and skills' transformation in a region [39]. This facilitates the occurrence of collective learning and knowledge sharing among workers [40]. Furthermore, since there are a large number of workers with similar skills or knowledge in the agglomeration of specialized areas, the labor market can be shared between different enterprises in the same industry, thus reducing the cost of mutual search between workers and employers [41]. The frequent flow of workers between different firms in agglomeration areas is significantly higher than that in non-clustered areas [42], which further accelerates the flow of information and facilitates the frequent exchange of ideas, knowledge and skills within agglomeration areas [43], thus contributing to individual skill accumulation and local skill upgrading. Besides, it is neglected that neighboring peer competitors also brought about an increasing demand for technological innovation and skilled workers. The high frequent flow of workers decreases local firms' investments in on-the-job skill training; however, increasing peer competition make it real to attract skilled workers from outside by high-level wage, which in turn encourages local workers to improve their skills by themselves. In the long run, it is possible that individual skills' accumulation and the percentage of highly skilled workers increase. Therefore, the following hypothesis is put forward:

Hypothesis 1. *Specialization externality promotes local skill upgrading.*

From Jacobs' point of view, the diversification of externality from an industrial agglomeration of various sectors is an important driving force for local industrial innovation, which can cause the spillover effect of knowledge and technology compared with an industrial agglomeration focusing on a single sector. Diversified sectors attract workers with different cultural and intellectual backgrounds, and they are more productive for new knowledge creation than those with the same knowledge background [44] in that the aggregation of enterprises and workers with different knowledge bases promotes cross-industry communication and knowledge creation. This means that the agglomeration of diversified sectors increases the opportunities for skill upgrading by attracting more skilled workers. Meanwhile, with the expansion of industrial agglomeration, professional training institutions have increased, and become a channel for (potential) workers to improve their skills. Furthermore, new knowledge creation in turn contributes to the accumulation of personal skills and the technological improvement of enterprises in a certain region. In addition, diversification is generally associated with economic resilience, and inter-industry complementarity provides workers with more job opportunities when facing industrial shocks, thus making them more resilient to external risks [45]. In other words, if a certain industry is negatively affected, it is flexible for workers in this industry to move to other related industries [46] which is more appealing from the risk aversion perspective and thus could attract more skilled workers. In addition, although little academic attention has been paid to the effect of diversification externality on skill upgrading, Glaeser and Mare noticed the phenomenon of the wage premium, which is the source of diversified industries in cities. They also pointed out that the processes of human capital accumulation in urban areas are faster than those of non-urban areas [47]. It is supposed that diversified externality has an effect on skill upgrading by local learning and attracting highly skilled workers than specialization externality. Thus, the second hypothesis is put forward as follows:

Hypothesis 2. *Diversification externality promotes local skill upgrading.*

The extant research generally holds that the impact of agglomeration externalities on the regional economic development is somehow different across industries and regions [48]. Such differences are probably shaped on the base of industrial and regional characteristics, such as technological intensity, industrial maturity, and the level of local economic development. The more technology-intensive a sector is, the more diversity its innovation depends on. This coincides with the findings that innovation in European metropolitan areas is mainly the outcome of externalities arising from diversity and to a much lesser extent from specialization [49]. Furthermore, relatively mature industries are more likely to be affected by the specialization effect, while it is diversification that has stronger externalities for emerging industries [50]. In addition, due to the different economic organization and population distribution in different regions, the externalities from the specialization or diversification effect vary correspondingly. For example, in Italy, many local production systems characterized by a large number of small- and medium-sized enterprises in traditional sectors, contribute, in particular, to the externalities triggered by the Marshall-style interaction, namely, specialization [51].

3. Data and Methods

3.1. Model Specification

This paper sets the basic panel regression equations as follows:

$$skill_{it} = \beta_0 + \beta_1 MAR_{it} + \beta_2 Control_{it} + \varepsilon_{it} \quad (1)$$

$$skill_{it} = \beta_0 + \beta_1 Jacobs_{it} + +\beta_2 Control_{it} + \varepsilon_{it} \quad (2)$$

$$skill_{it} = \beta_0 + \beta_1 MAR_{it} + \beta_2 Jacobs_{it} + \beta_3 Control_{it} + \varepsilon_{it} \quad (3)$$

where β_0 is the constant; β_1, β_2, and β_3 are the coefficients of each term; MAR_{it} and $Jacobs_{it}$, respectively, represent the specialization and diversification degrees of city i in year t; $Control_{it}$ represents the control variables of city i in year t; and ε_{it} is the random error term for the corresponding year.

Due to spatial heterogeneity, dummy variables of location, city size and economic condition are further incorporated into the equations. Considering that China's workers have a significant difference in distribution between coastal and inland cities, the location dummy variable is a coastal or inland city. Referring to Jian et al.'s study, coastal cities include 101 cities in 11 provinces (including Beijing, Tianjin, Liaoning, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan), while other cities are defined as inland cities [52]. Meanwhile, considering the difference of city size in the sample of prefecture-level cities, the city-size dummy variable is a large or small city based on the populations of each city. This paper divides the cities into two categories, large cities and small ones, in terms of the population within the Chinese context. Specifically, large cities are those whose population is above 5 million, while small cities are those whose population is below 5 million. In terms of economic condition, we compared the cities' per capita GDP to the national average per capita GDP of each year. Then, Equation (3) takes the following form:

$$skill_{it} = \beta_0 + \beta_1 MAR_{it} + \beta_2 Jacobs_{it} + \beta_3 Control_{it} + \beta_4 loc_{it} + \beta_5 size_{it} + \beta_6 gdp_{it} + \varepsilon_{it} \quad (4)$$

$$\text{which, } loc_{it} = \begin{cases} 1\ (costal\ city) \\ 0\ (inland\ city) \end{cases},$$

$$size_{it} = \begin{cases} 1\ (population\ above\ 5\ millon) \\ 0\ (population\ below\ 5\ million) \end{cases},$$

$$gdp_{it} = \begin{cases} 1\ (above\ national\ average\ per\ capita\ GDP) \\ 0\ (below\ national\ average\ per\ capita\ GDP) \end{cases}$$

The regression model of the panel data can choose the pooled ordinary least squares (pooled OLS) method, fixed-effects general squares (fixed-effects GLS) model or random-effects GLS. According to the Hausman test, the fixed-effects model was chosen in our regression, which has well controlled individual effect.

3.2. Measurement of Variables and Data Description

3.2.1. Dependent Variables

Vind (2008) regards skill upgrading as a way of learning and the result of training or education in the process of (work) experience [53]; while others consider it as more the use of high-skilled workers in production or work, and the proportion of high-skilled workers increases [54–56]. In this paper, skill upgrading not only refers to the increase in the number of highly skilled workers in the local labor markets, but also means the workers' skill accumulation. It is actually a transformation process from low-skilled labor to high-skilled labor.

The extant literature divides high- and low-skilled workers by educational level or work type. In terms of educational level, high skilled workers refer to those with tertiary education (at least 12 years of schooling) [57]. As for the work type, high skilled workers refer to engineering technicians or professional technicians [58]. This paper takes the educational measurement as the standard of high-skill workers, and measures skill upgrading by the ratio of high-skill workers to the employment population in a specific region. Meanwhile, it uses the alternative method to check the robustness of the model.

According to Duranton and Puga [59], this paper uses the distribution of employment among industries to measure the independent variables, the specialization and diversification of the local agglomeration. To make a horizontal comparison among different cities, this paper tends to use relative

indexes to measure the level of specialization and diversification in a given region [59]. According to Melo et al.'s reviews of the indicators of specialization and diversification, the location quotient (LQ) and Hirshman–Herfindahl index are relatively plausible to calculate the specialization and diversification agglomeration respectively [26,32].

The location quotient measures the spatial distribution of regional elements, which reflects the concentration of a certain industrial sector. We then calculate the LQ of the sector that has the max employment among all the industrial sectors in a city. The specification is in the following form:

$$MAR_i = Max_i\left(S_{ij}\right)/S_j \tag{5}$$

where S_{ij} is the share of employment of the industry j as a proportion of total employment in city i, and S_j is the share of employment of industry j as a proportion of the total employment in all cities.

The countdown of the Hirschman–Hefendal index (HHI) indicates the variety and equilibrium of the urban industry, which then represents the diversification degree of the industry in a specific city:

$$Jacobs_i = 1/\sum{}_i\left|S_{ij} - S_j\right| \tag{6}$$

where S_{ij} is the share of employment of industry j as a proportion of the total employment in city i, and S_j is the share of employment of industry j as a proportion of total employment in all cities.

3.2.2. Control Variables

There are other factors affecting skill upgrading, including education investment, trade, technological advancement, economic scale, and enterprise attributes. We used them as control variables in the regression analysis.

- Local education investment (Edu) refers to the per capita expenditure on education. In China, human capital accumulation relies much on local government financial investment. The level of education expenditure reflects the fiscal capability of local governments to support the development of education.
- Foreign trade (Trade). As a channel of technology spillover, foreign trade can cause the change in skill-biased technology, which will lead to the demand for workers' skills. For international factors, we chose the foreign trade volume of both import and export in a specific region. As a channel of technology spillover, foreign trade can cause the change in skill-biased technology, which would bring about the demand for highly skilled workers. To measure international factors, we chose the foreign trade volume of both import and export in a specific region.
- Technological advancement includes the ratio of science and technology funds in fiscal expenditure (Tech) and the number of patent applications per ten thousand persons (Patent). Since technological advancement increases the demand for skilled workers, we took these two factors as the control variable.
- Economic scale. With the expansion of local economy, the demand for workers simultaneously increases, and it has a greater marginal effect on skilled workers than that on unskilled workers. Per capital GDP (GDP) represents the city's economic scale.
- Enterprise attributes. Generally, large enterprises, especially foreign-funded firms, are better able to reap the benefits of the scale economy than small ones, and these firms are more willing and able to provide training services to their employees to improve their skills. These enterprise attributes would further affect local skill upgrading. Therefore, we chose two attributes of local firms—the average output value (Scale) and the proportion of foreign-funded enterprises (FE)—as control variables.

3.3. Data Resources

Following the work of Rosenthal and Strange [60], this paper discusses agglomeration externalities of the specialization and diversification at the scale of the city. Chinese cities have been playing an increasingly important role in the world city networks, and they have improved their international connectivity and workers' skills as well [61]. Moreover, these Chinese cities also exhibit their great resilience or sustainability in the global economic crisis [62,63].

In this paper, 286 prefecture-level cities of the Chinese mainland (see Figure 1) as samples are included, whose statistical data are available in the Statistical Yearbooks of China. The basic characteristics of these sample cities are listed in Table 1. Combined with the available data in the year of the population statistics, the panel data included the three years of 2005, 2010, and 2015. The data on workforce schooling were sourced from Population Census (sample survey) materials provided by the State Statistics Bureau, and the data on prefecture-level employment were from the Statistical Yearbook provided by the Provincial and Municipal Statistics Bureau. In addition, the employment population data of the large category (two-digit industry classification) in the manufacturing industry were further adopted in the comparative analysis of different agglomeration externalities between the manufacturing and service industries.

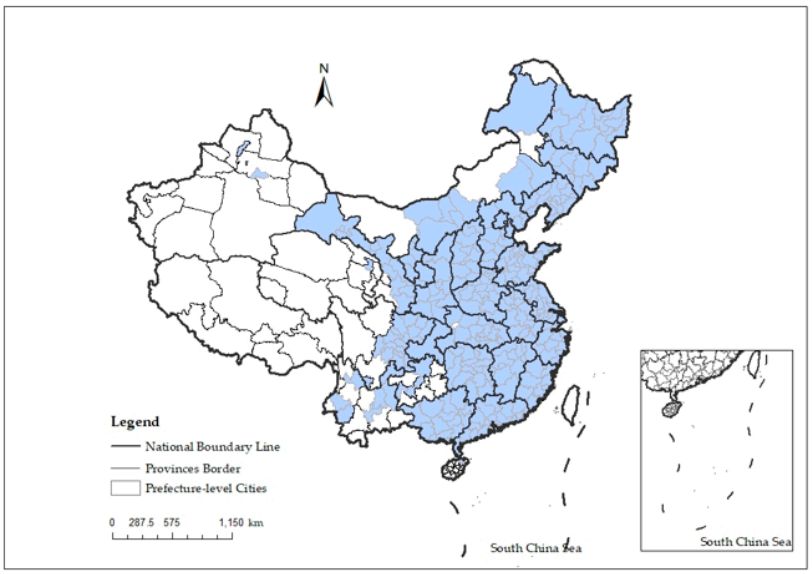

Figure 1. The geographical location of 286 prefecture-level cities in the Chinese mainland.

Table 1. Sample description.

Characteristics	Whole Sample	2005	2010	2015
Total	286	225	286	174
Location				
Coastal Cities	101	101	101	70
Inland Cities	185	124	185	104
Population				
Large Cities	98	70	98	71
Small Cities	188	154	188	103
Economy				
Developed Cities	115	87	115	72
Less-developed Cities	171	138	171	102

Note: (1) coastal cities refer to the cities in the coastal provinces of China, the rest of the cities belong to inland ones; (2) large cities are the cities whose population is over 5 million; (3) developed cities is the cities whose GDP is above the average level of China.

4. Result Analysis

4.1. Effects of Specialization and Diversification on Skill Upgrading

Table 2 shows the regression results of the entire sample. Models (1) and (2) separately measure the agglomeration externalities of specialization or diversification, and Model (3) is the regression result of the total externalities (simultaneously including specialization and diversification effects) to the process of skill upgrading.

Table 2. Overall regression results.

Variables	Model (1)	Model (2)	Model (3)
MAR	0.0010 **		0.0018 ***
Jacobs		0.0052 ***	0.0086 ***
Edu	0.0284 ***	0.0287 ***	0.0286 ***
Trade	0.2530 ***	0.2620 ***	0.2680 ***
Tech	0.0344	0.0355	0.0384
Patent	−0.0004 ***	−0.0004 ***	−0.0003 ***
GDP	0.0142 ***	0.0141 ***	0.0137 ***
Scale	0.0037 ***	0.0040 ***	0.0043 ***
FE	0.1208 ***	0.1273 ***	0.1269 ***
i.loc	−0.0232 ***	−0.0251 ***	−0.0241 ***
i.size	0.0006	−0.0029	−0.0017
i.gdp	0.0209 ***	0.0196 ***	0.0193 *
R^2	0.6206	0.6220	0.6295
N	685	685	685

Notes: *** significant at 1% level, ** 5% level, * 10% level.

The regression results show that all the models met the significant requirements and have a high fitting degree concerning the R square values. From Model (1) and Model (2), the coefficients of MAR and Jacobs were estimated as 0.0010 and 0.0052 under a significance level of 1%. That is, both specialization and diversification show a positive effect on skill upgrading, which means the increase in specialization and diversification level of cities from the Chinese mainland is conducive to the skill upgrading on local labor markets. Moreover, the positive effect of specialization or diversification are consistent with Model (3). These results validate Hypothesis 1 and Hypothesis 2, which are consistent with Marshall's (1890) and Jacobs's (1969) opinion on agglomeration externalities. Concerning the coefficients of specialization and diversification in Model (3), 0.0018 and 0.0086, respectively, we draw the conclusion that diversification has a stronger influence on skill upgrading compared to specialization.

For control variables, most variables are significantly correlated with skill upgrading. Specifically, the influences of education expenditure, trade, GDP, enterprise average output value and foreign-funded enterprise ratio show a positive correlation with skill upgrading. Education expenditure promotes the accumulation of human capital, which leads to local skill upgrading, in line with the relevant conclusions of the existing research [64]. In terms of per capita GDP, a higher level of local economy provides workers with higher income, attracts the inflow of skilled workers, and additionally cultivates high-end industries on the basis of a better business ecosystem so as to create opportunities for more high-skilled jobs. According to the enterprise attributions, it proves that large enterprises are more beneficial to promote local skill upgrading than small ones.

4.2. Comparison among Three Categories of Cities in Population, Economy and Location

This paper further analyzes the influence of urban heterogeneity on the relationship between agglomeration externalities and skill upgrading in three dimensions: geographical location, population and economy. The regression results from Table 3 show that all the models meet the significant requirements and have a high fitting degree. Under seemingly unrelated regression (SUR) testing,

the significance of values reveals that the grouping difference does exist. From the perspective of location, the heterogeneity exists in the diversification externalities between coastal cities and inland cities, due to the significant SUR-chi^2 value of Jacobs (6.81). Similarly, in large cities, the specialization externalities are significantly different from those in small cities. In addition, both specialization and diversification externalities play distinct roles in developed and undeveloped city groups. In other words, the impacts of specialization and diversification on skill upgrading are obviously divergent among cities with different population sizes, economic scale and location characteristics.

Table 3. Grouping the regression results.

Variables	Location		Population		Economy	
	Coastal	Inland	Large	Small and Medium Sized	Developed	Less Developed
MAR	0.035	0.125 ***	−0.095 **	0.158 ***	−0.015	0.270 ***
Jacobs	0.142 ***	0.018	0.043	0.093 **	0.151 ***	−0.048
Edu	0.106 ***	0.125 ***	0.213 ***	0.104 ***	0.082	0.187 ***
Trade	0.307 ***	0.015	0.141 ***	−0.001	0.292 **	−0.181 ***
Tech	0.054	−0.061 *	−0.167 ***	0.035	0.053	−0.098 **
Patent	−0.278 ***	−0.280 ***	0.047	−0.077	−0.173 **	0.190 ***
GDP	0.688 ***	0.484 ***	0.595 ***	0.557 ***	0.449 ***	0.655 ***
Scale	0.075	0.107 **	0.176 ***	0.222 ***	0.242 ***	0.029
FE	0.109 **	0.121 ***	−0.080	0.047	0.042	0.112 ***
R^2	0.676	0.634	0.751	0.52	0.445	0.573
SUR-chi^2	MAR:0.17 Jacobs:6.81 ***		MAR:11.97 *** Jacobs:0.27		MAR:3.68 * Jacobs:9.24 ***	
N	272	406	240	438	274	404

Notes: *** significant at 1% level, ** 5% level, * 10% level.

Specifically, according to the regression results of the location grouping, for coastal cities, the diversification externalities have significantly promoted the skill upgrading, with estimated coefficients of 0.142. In contrast, skill upgrading mainly comes from specialization externalities instead of diversification, with an MAR coefficient of 0.125. As the initiative area of China's opening up and reforming, the coastal cities have developed their export-oriented economies on the basis of serious challenges and competition from global market. Relying on skilled workers instead of unskilled workers has been an alternative to improve their industrial competitiveness. Moreover, due to the increasing labor costs in the coastal areas, many labor-intensive industries there have been moved to the inland areas. Coastal cities have gradually turned to knowledge- and technology-intensive industries, which are more efficient in absorbing and utilizing knowledge and information. Therefore, these cities have made great technological progress [65]. As a consequence, the increasing demand for highly skilled workers instead of unskilled workers [66] leads to skill upgrading there.

From the perspective of economy grouping, the result is somehow similar with that of the former groups. The diversification externalities with the estimated coefficient of 0.151 are positively related to skill upgrading for developed cities, the specialization externalities exert a dominantly positive effect on skill upgrading for undeveloped cities. In general, developed cities have a more diversified economy, which facilitates complementary knowledge exchange and inter-sector spillovers so as to evoke innovation and in turn benefit more from diversification externalities than specialization on local skill upgrading. Furthermore, developed cities tend to be more open, which promotes frequent contact between local enterprises and their partners, increases their mutual familiarity and trust, and thus further enhances the benefits of agglomeration externalities [67].

In addition, it is worth noting that the specialization externalities in large cities have a negative effect on their skill upgrading, with the negative coefficient of −0.095 under a confidence level of 1%. It is reasonable to consider that large cities have much more advantages in diversification externalities instead of specialization externalities than small cities.

In brief, according to the grouping regression results in this subsection, diversification externalities have positive and dominant effects on the skill upgrading of coastal cities, developed or large, especially the former two types cities. In contrast, specialization externalities are more crucial than diversification to incur the skill upgrading of inland, undeveloped or small cities, and specialization even impedes the skill upgrading of large or developed cities.

4.3. Differences between Manufacturing and Service Industries

The manufacturing and service industries occupy a very important position in China's industrial economies. However, the two sectors have some typical differences in such as firm size, technological level, demand for economic factors, etc. Therefore, in this subsection, the authors continue to further analyze the influence of industrial heterogeneity, namely the manufacturing and service industry, on the relationship between agglomeration externalities and skill upgrading. With the reference to the National Statistics Bureau's 2017 National Industry Classification, the manufacturing industry originates from the subdivision sectors of the large category (two-digit industry classification), including 30 manufacturing subsectors, while the service industry includes 14 service sector categories. The results of the regression are shown in Table 4.

Table 4. The comparison between manufacturing and service sectors.

Variables	Manufacturing			Service		
	Model (1)	**Model (2)**	**Model (3)**	**Model (1)**	**Model (2)**	**Model (3)**
MAR_m	0.274 ***		0.257 ***			
$Jacobs_m$		−0.131 ***	−0.049			
MAR_s				0.054		0.035
$Jacobs_s$					0.109 **	0.103 **
Edu	−0.197	−0.004	−0.027	0.030	0.040	0.045
Trade	0.002	0.032	0.007	0.035	0.073	0.065
Tech	0.284 ***	0.294 ***	0.295 ***	0.233 ***	0.203 ***	0.205 ***
Patent	−0.203 ***	−0.269 ***	−0.207 ***	−0.194 ***	−0.194 ***	−0.188 ***
GDP	0.427 ***	0.513 ***	0.504 ***	0.516 ***	0.502 ***	0.493 ***
Scale	0.509 **	0.131 ***	0.066	0.174 ***	0.173 ***	0.187 ***
FE	0.072	0.224 ***	0.256 ***	0.130 **	0.126 **	0.123 **
R^2	0.654	0.612	0.656	0.578	0.585	0.586
N	266	266	266	266	266	266

Notes: *** significant at 1% level, ** 5% level

According to Table 3, all models meet the significance requirements and have a high fitting degree. In terms of manufacturing sectors, MAR_m, referring to the specialization externalities of manufacturing sectors agglomerations (MSAs), in Model (1) and Model (3), passes the significant test, and its coefficients are estimated as 0.274 and 0.257, respectively. It shows that specialization externalities play a positive effect on skill upgrading. $Jacobs_m$, referring to the diversification externalities of MSAs, passes the significant test in Model (2), but does not passes the significant test in Model (3), with the coefficients of −0.131 and −0.049, respectively. It displays comparing with specialization externalities, diversification externalities in manufacturing agglomerations have slight and negative effects on skill upgrading.

In terms of service sectors, though MAR_s, the specialization externalities of service sectors agglomerations (SSAs), does not pass the significant test in Model (1) and Model (3), and it has a slightly positive effect on skill upgrading in that its coefficients are 0.054 and 0.035 in the two models, respectively. $Jacobs_s$, representing the diversification externalities of SSAs, passes the significant test in Model (2) and Model (3), and its coefficients are 0.109 and 0.103, respectively. It shows that the diversification externalities of SSAs can promote skill upgrading, while specialization externalities cannot. That also means that the effects of externalities on skill upgrading vary from one industry to

another. Accordingly, combined with the results of Section 4.2, Hypothesis 3 proposed in this paper has been fully verified.

The authors believe that these differences are mainly due to the differences in crucial attributes between manufacturing sectors and service sectors. Many manufacturing agglomeration areas generally focus on a few specific products and covers a limited variety of sectors with little similarity in professional skills. Specialization is the source of the competitive advantages for these areas, and local manufacturing firms require similar skills. Therefore, it is common to gain frequent exchanges of ideas, knowledge and skills through local face-to-face contacts between different firms in a specific sector, which in turn promotes the individual's skills. In contrast, service sectors, especially producer services, in many Chinese cities have been burgeoning recently, partly as a response to the prosperity of local manufacturing sectors. In many cases, the differences in general skills between different sub-sectors is small, that is to say, skills can be transformed from one sub-sector to another. Therefore, the labor mobility between difference service sectors is much more frequent than that in manufacturing sectors, and it provides a channel of knowledge transformation and skill accumulation between different sub-sectors in the service industry. Accordingly, the positive effect of the service agglomerations on skill upgrading mainly comes from diversification externalities instead of specialization externalities. The more diverse service sectors an agglomeration area has, the more knowledge and skill exchanges local service firms and workers can get based on labor mobility between different sectors.

Second, the difference in competition within manufacturing sectors and service sectors is supposed to be another reason for the different effects of agglomeration externalities on skill upgrading. Compared with the service sectors, manufacturing sectors have been encountering more intense competition at home and abroad. Local manufacturing firms could not depend on comparable advantages based on low cost and low-level quality any longer but have to fall back on innovation for the sake of gaining competitiveness. The increasing competition forces local manufacturing firms to make more investment in attracting and cultivating skilled workers than before, which contributes to the skill upgrading of manufacturing sectors.

5. Conclusions

The extant literature discusses the impact of individual-level and firm-level factors, and international trade on skill upgrading, neglecting the effects of local or geographical factors, especially agglomeration externalities. Taking China as a case study, this paper contrives to fill this gap through dividing agglomeration externalities into two categories, namely specialization and diversification externalities. It proves that agglomeration externalities do exert a promotion effect on skill upgrading, not only because of the increasing demands for highly skilled workers for the sake of promoting innovation and competitiveness as a response to increasing competition, but also because of local learning beneficial to individual's skill accumulation, which the extant literature on skill upgrading does not mention. This finding deepens the understanding of the skill upgrading mechanisms in developing countries, and provides a new insight to the sustainability of local development, namely, taking advantage of the effects of agglomeration externalities on skill upgrading to strengthen industrial competitiveness and resilience. That can be considered as one of the main contributions. It further demonstrates that the externalities of industrial agglomeration vary among different regions, which implies the local factors, such as geographical location, population, economic level, and marketization degree in different regions, play an important role in the impact of industrial agglomeration on the skill upgrading. From the perspective of skill upgrading, if is of significance for local governments to implement agglomeration initiatives and carry out differentiated industrial policies focusing on the characters of the 'place' and the 'industry'. This is another contribution of this research.

This paper obtained the main conclusions as follows. First, both specialization externalities and diversification externalities play an important role in promoting skill upgrading. Second, the impacts of industrial agglomeration on skill upgrading vary in different regions and industries significantly.

Generally, in developed cities, coastal areas and large cities, skill upgrading is more susceptible to the significant promotion of diversification externalities than specialization; while the skill upgrading of relatively backward, inland areas and small cities is mainly affected by specialization externalities. Third, the positive effects of manufacturing agglomeration on the skill upgrading mainly come from specialization externalities instead of diversification externalities, and the latter externalities do not have a significant effect or even have a negative influence on skill upgrading. In contrast, skill upgrading in the service sectors mainly depends on diversification externalities rather than specialization externalities.

There are some limitations in this paper. First of all, education level is not an ideal variable to represent workers' skills in China; however, other professional data concerning skills, such as the number of white-collar and blue-collar workers, are unavailable. Actually, the change in the proportion of skilled workers (highly educated or skilled) is used as a proxy of skill upgrading, which shows the substitution process of skilled workers for unskilled workers and does not really indicate the skill accumulation or upgrading of unskilled workers. This process deserves further investigation. Furthermore, due to the inaccessibility to data of two- or four-digit sectors, this paper only investigated the inter-industry differences between the manufacturing and service sectors, but does not examine further the differences between the subsectors within the manufacturing or service sector. The latter approach is worthy of further attention.

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