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Influence evaluation of producer services agglomeration on economic resilience: Evidence from China's cities

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ABSTRACT

As a new engine of economic development after urbanization's structural deceleration stage in China, producer services agglomeration on urban economic resilience (ER) requires analysis. Using data from 264 prefecture-level cities and above in China after the global financial crisis, we examine producer services' impact in terms of diversification (PSD) and specialization (PSS) on urban ER, and also the mediating effect of industrial structure upgrading (ISU). The results show that Cities with more diversified producer services are more resilient to crises, while the effect direction of PSS is the opposite. ISU is partly how PSD and PSS affect ER. Finally, producer services agglomeration's impact on ER has significant regional heterogeneity. PSD is very conducive to urban ER in the economically developed eastern region and the less developed western region. The more specialized the development of producer services in eastern and north-eastern regions, the less conducive it is to enhancing ER. Our findings can help stabilize China's economy and achieve high-quality economic development.

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Producer services; economic resilience; diversification; specialization; industrial structure upgrading

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1. Introduction

Uncertainties have increased worldwide, not only in relation to the global financial crisis of 2008, but also to numerous risk factors including global economic slowdown, Sino-US trade friction and the COVID-19 pandemic. Uncertainties triggered many problems, including production cuts, layoffs by enterprises, sluggish domestic consumption, and insufficient investment. Some cities exhibited strong sensitivity and volatility, while others have maintained stability and recovered quickly post-crisis (Ron Martin, 2011). As a core concept to measure differentiated performance, economic resilience (ER) has become a research hotspot in evolutionary economic geography and an important perspective on how China can cope with complex environment (Cainelli et al., 2019; Cheng & Zhang, 2020; Hu et al., 2022). Related

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studies argue that ER may depend on government policy, dominant industry types, innovation, entrepreneurship, diversification and specialization of the industrial structure (Cheng & Zhang, 2020; Mai et al., 2021; R. Martin et al., 2016; J. Tan et al., 2020). Some scholars found that industries with more development prospects, such as service industry, are more resistant and capable of transformation to shocks. Cities with predominantly manufacturing, due to the existence of higher sunk costs and exit barriers, are easy to form road dependence and poor ER performance.

Indeed, even in regions where manufacturing is the dominant industry, improving supply and industrial chains may reduce the interference of external environment changes on economic operation (Mai et al., 2019). Producer services, consisting of financial services, information services, R&D services, technological services, etc., have gradually separated from the manufacturing, and have become an important component of industrial chain of manufacturing. The spatial agglomeration of producer services not only enables related enterprises to achieve scale economies of intermediate inputs and share similar labor, but also tends to create positive knowledge spillovers. It plays a significant role in promoting the manufacturing industry upgrading and the economic resilience improvement through specialized division of labor, reducing transaction costs and promoting regional innovation. Moreover, the collaborative agglomeration of producer services and manufacturing can also promote the full participation of producer services in all production links of manufacturing, and accelerate the transformation from primary manufacturing to knowledge-intensive and technology-intensive high-end manufacturing. The collaborative agglomeration can also accelerate the decomposition, extension and reorganization of value chain, and give more core technologies and services to the new value chain, which is conducive to value chain upgrading and economic resilience enhancing (Mai et al., 2021). Therefore, producer services agglomeration not only helps manufacturing to break away from path dependence and structure upgrading, but also plays an important role in effectively withstanding shocks.

However, there is a lack of research on the mechanism between producer services agglomeration and economic resilience. Related studies mainly focused on the correlation between producer services agglomeration and manufacturing development, regional innovation level or efficiency and green economic growth (Peng et al., 2022; Ren et al., 2019; Z. Yu et al., 2022). Although the literature has demonstrated the role of producer services agglomeration in the transformation of urban economic development patterns and the acceleration of regional industrial innovation and restructuring, it has not been included in the crisis shock framework. Moreover, producer services agglomeration constitutes a breakthrough in promoting industrial structure upgrading (ISU). ISU is crucial for smooth economic transformation and rapid recovery after external shocks. However, the literature has ignored the mediating role of ISU. Hence, we scientifically measure the level of producer services diversification (PSD), specialization (PSS), and ER after the 2008 global financial crisis. Using a panel regression model, we explore whether and to what extent producer services agglomeration explains ER in 264 Chinese cities. Additionally, we also test whether ISU is a mediating variable for the impact of producer services agglomeration on ER. We further examine heterogeneous influences by dividing the cities into four regions.

These results provide a basis for regional policymaking and a reference for other emerging economies to enhance urban resilience.

This study contributes to the literature as follows. First, we propose a novel perspective of connecting producer services agglomeration with ER. Our analysis extends relevant literature with an exploration of whether and to what extent PSD and PSS impact ER. We also explore the intermediary role of ISU. Second, by evaluating ER of 264 cities in China, we not only emphasize the universal role of producer services agglomeration in ER, but also highlight regional differences. Third, by using Chinese cities as the research area, this paper can provide an empirical basis for improving economic resilience in China, and also has reference value for many developing countries. The remainder of the paper is organized as follows. Section 2 provides a brief literature review. Section 3 elaborates on the theoretical framework. Section 4 introduces data sources, variables measures, and regression models. We provide our results and discussion in Section 5. Section 6 concludes the main findings, and provides implications and limitations of our conclusions.

2. Literature review

2.1. Origin and concept of economic resilience

The phrase ER originates from ecology. It refers to the ability of a system to maintain its stability and recover from external shocks (Holling, 1973). Recent years, especially after the 2008 global financial crisis, ER has become a research hotspot in regional economics and economic geography (Ron Martin, 2011), which is primarily used to understand the differences in the ability of different regions to withstand and recover from various shocks or disturbances. The concept of ER has gradually transformed from engineering and ecological resilience, based on equilibrium theory, to adaptive resilience based on evolutionary theory. Adaptive resilience emphasizes unbalanced development of economic trajectories and openness to adaptation, which is widely recognized (Balland et al., 2015). Martin and Sunley (2015) further standardized and perfected the concept, and defined it as a path-dependent process of continuous adjustment and adaptation, including resistance, recovery, re-orientation and path renewal.

2.2. Measurement and determinants of economic resilience

Related studies on ER have mainly focused on measurement methods and determinants. Currently, it is generally accepted to use different resilience indicators to assess cities' ER, such as employment, gross domestic product (GDP), export value, and industrial added value (Doran & Fingleton, 2016; Ron Martin, 2011; Ubago Martínez et al., 2019). Many scholars revealed differences in resilience of some countries or regions after the 2008 financial crisis or COVID-19, and empirically found the determinants of ER, such as industrial structure, network relations, technology network structure, and government regulatory behavior (Cainelli et al., 2019; Faggian et al., 2018; Toth et al., 2022). It is widely believed that industrial structure is an important influencing factor, which is manifested in industry's agglomeration forms and

dominant industry types. Diversified agglomerations are better at spreading risk and reflecting resilience than single-industry agglomerations (R. Martin et al., 2016). Moreover, areas dominated by heavy industry generally have a higher degree of industrial structure specialization. Due to high silent costs and exit barriers, the regional ability to resist risks is weak (Mai et al., 2021). Service industries, especially producer services, interact closely with manufacturing and facilitate knowledge spillovers and innovation formation, thus helping cities to adapt to industrial structure upgrading and ER enhancing (Cuadrado-Roura & Maroto, 2016).

2.3. Producer services agglomeration and economic resilience

The relationship between producer services agglomeration and ER has been less studied by scholars. However, studies on the effects of producer services agglomeration on manufacturing development, regional innovation level and green development, provide theoretical references for mechanism exploration in this paper. Z. Yu et al. (2022) adopted data from 18 industries in 44 countries, and empirical results showed that imported inputs of producer services had a positive impact on domestic manufacturing exports. Based on data of three major urban agglomerations in China, Peng et al. (2022) empirically found that urban agglomeration was not the way to improve innovation efficiency, and the collaborative agglomeration of high-tech manufacturing and producer services had an inverted U-shaped relationship with innovation efficiency. Ren et al. (2019) found that PSS and PSD negatively and positively contribute to green economic efficiency, respectively. PSS even has a negative spatial spillover effect on neighbouring regions.

The literature examining the impact of producer services agglomeration on economic growth and industrial structure is most relevant to our paper. However, there is little relevant literature. Lundquist et al. (2008) used 30 years of development experience in Sweden to verify the great role of the renewal and transformation of producer services in driving economic growth. Wen (2020) showed that the specialization agglomeration of producer services can positively contribute to the industrial structure upgrading in China through accelerating innovation and allocating market efficiency. Christopher et al. (2016) found that different sectors of producer services have different effects on economic growth after studying the Washington D.C. metropolitan area. Specialized design and management consulting have the function of promoting economic development, while computer services restrict economic development.

2.4. Research gap

In summary, the above literature has deepened the research on relationship between producer services agglomeration and industrial structure or economic growth, and has yielded many enlightening findings. However, following questions are still worth exploring. First, related researches have not been placed in the context of a crisis. Whether and how producer services agglomeration can help regional economies to against risk, needs to be further explored. Second, studies on ER have mainly focused

on cities that were developed countries, emerging economies, large cities, etc. Relatively few studies have been conducted at the city level in China, which is the largest developing country. Third, there is little research in the existing literature on differences in the performance and influencing factors of ER in Chinese different regions post-crisis. Large differences exist between the northeastern, eastern, central and western regions of China in terms of economic development level, leading industries types and resource endowments. Therefore, it is necessary to explore the regional heterogeneity in the relationship between producer services agglomeration and ER.

3. Theoretical framework

Based on the research of Martin (2011) and Aghion et al. (2015), we combine producer services agglomeration with ISU, not only emphasizing agglomeration's key role in enhancing ER, but also explaining structural changes and sector upgrading in the post-crisis economic growth process. The specific intrinsic mechanisms are shown below.

3.1. Direct impact of producer services agglomeration on economic resilience

The effects of agglomeration economy can be divided into specialization and diversification effects. Hence, producer services agglomeration can be divided correspondingly into specialization and diversification (Neffke et al., 2011). PSD reflects the agglomeration of different types of producer services in the same city, it can affect ER in three ways (see Figure 1): First, diversified producer services can play the role of risk buffers. The existing literature shows that manufacturing is prone to path locking and thus less ER. Close interaction between producer services and manufacturing enables a diversified producer services to absorb manufacturing's economic fluctuation. Second, diversified producer services can help the manufacturing to reduce production costs and increase productivity, thus contributing to economic recovery and transformation after a crisis (H. Chen, 2019). Third, the more diversified producer services are, the easier they are to achieve the creation, dissemination, and internal and external diffusion of knowledge. It can attract the inflow of high-level human

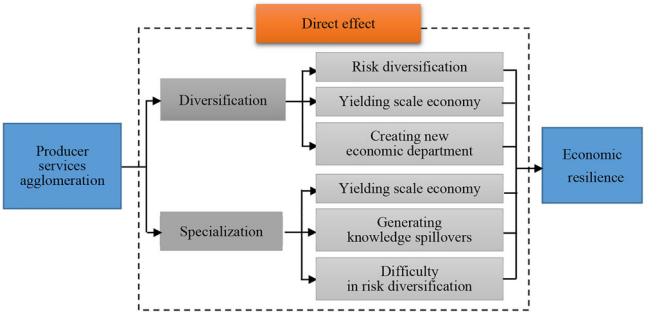

Figure 1. Direct influence mechanism of producer services agglomeration to economic resilience.
Source: Authors' own calculation.

resources, promote a new economic equilibrium by creating new sectors, and ultimately enhance urban ER.

PSS reflects agglomeration state of the same type of producer services in a certain city (Hong et al., 2020). First, PSS can generate scale economy effects, thus reducing trade costs between different industries, improving technological level and production efficiency (M. Chen, 2017). Second, PSS can also generate knowledge spillover effects. Specialization agglomeration allows employees with similar production service technologies to engage in formal or informal learning and exchange within the industry and between producer services and manufacturing. This can facilitate the emergence of new technologies, products and pathways, and improve the urban transformation capacity (H. Chen, 2019). However, PSS may also be detrimental to economic resilience. First, specialization agglomeration forms a close connection among producer service enterprises. Employees who master similar or related technologies are highly concentrated, so it cannot act as a buffer in an economic crisis. This not only leads to unemployed workers, but also decreases the likelihood of new growth paths (Boschma, 2015). Second, manufacturing is less selective in adjusting and optimizing the supply of intermediate suppliers in the regions with high concentration of producer services specialization. Especially, when manufacturing is closely linked to specific producer services, there may even be difficulties in some areas where it is impossible to restore normal production order by seeking alternative suppliers. Therefore, whether PSS has a positive or negative impact on Chinese urban ER after a crisis deserves further discussion.

3.2. Indirect impact of producer services agglomeration on urban economic resilience through industrial structure upgrading

ISU refers to the gradual transition from primary and secondary industries to tertiary industries, while improving technology as well as labor productivity. It plays an important role in promoting high quality and sustainable development of urban economy. As a tertiary industry with high knowledge content and industrial correlation, producer services agglomeration has a significant impact on ISU (see Figure 2).

The role of PSD in ISU is shown below. First, PSD can be a lubricant between different industries. PSD not only increases closeness to upstream enterprises, but also provides downstream enterprises with more abundant and convenient intermediate products. This improves cooperation efficiency between industrial departments, optimizes input structure, and promotes ISU. Moreover, PSD promotes transactional or non-transactional exchange activities between enterprises, expands the spread and scope of knowledge, and facilitates the formation of new ideas and innovative. Technological innovation is regarded as the primary driving force of ISU (Wen, 2020). Finally, PSD can also increase segmented industries, expand related market demands, and promote ISU through scale economics. PSS also plays a positive role in ISU (Zhao et al., 2021). It can not only promote knowledge spillover by giving full play to targeted service advantages, but also encourages other industries to regard producer services as intermediate input products, freeing up more time and human resources for improving labor productivity. This helps technological innovation and

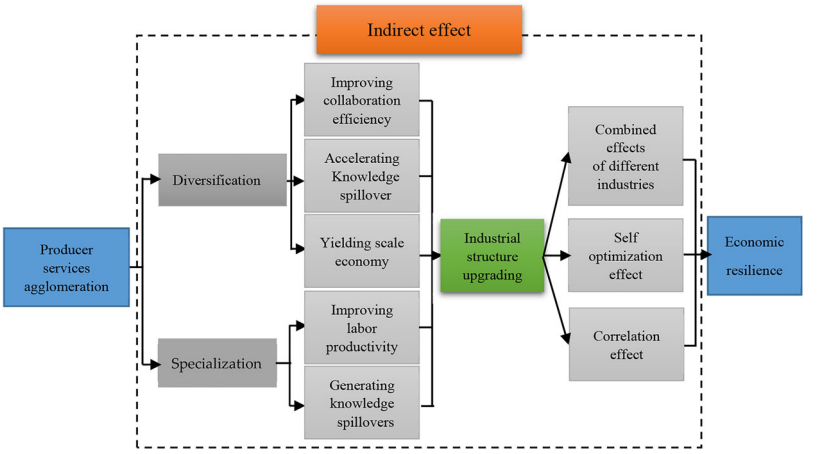

Figure 2. Indirect influence mechanism of producer services agglomeration to economic resilience.
Source: Authors' own calculation.

ISU. Moreover, PSS also enables the accumulation of specialized human resources and the transfer of production processes to high value-added and high-tech levels, thus achieving knowledge and technology spillovers through collective learning. This can effectively promote ISU.

ISU plays a role in stabilizing economic fluctuations. First, ISU brings different industrial combination effects. A typical sign of ISU is significant increase in the share of services. Services can effectively absorb the economic and total factor productivity fluctuations brought by the crisis to the manufacturing, thus enhancing urban economic resilience. Second, ISU has self-optimization effect. ISU enables the application of information technology, digital economy and other high technologies to more enterprises, which can effectively increase technological innovation, total factor productivity and economic aggregate (Burren & Neusser, 2013), thus promoting economic transformation and recovery in the post-crisis era. Thirdly, ISU's linkage effect enhances ER. Services and manufacturing have strong demand on human capital and material capital respectively, and human capital is more stable than material capital. Therefore, along with the continuous increase of the share of services in the process of ISU, economy may be more resilience to volatility during external shocks.

4. Data sources and methods

4.1. Data sources

Based on the availability of data during the study period, this study excludes some cities due to administrative division adjustment or serious data loss, such as Chaohu, Bijie, Tongren, Sansha, etc. Our research covers 264 of the 297 cities at the prefecture or higher level, i.e., 88.89% of total number of cities in China. The sample cities account for 93.71% of the national GDP. These cities consist of four municipalities directly under the Central Government, 30 provincial capital cities, sub-provincial capital cities, and other cities at prefecture level or above. Therefore, the selected city samples are typical, representative and diverse. The data of research area are derived

from the *China City Statistical Yearbook* and the *China Statistical Yearbook* from 2009 to 2015, both of which are collected by the China's National Bureau of Statistics (CNBS). However, these official data on China's cities are not without discrepancies and errors (Lin, 2002). Obvious outliers (outliers in the scatterplot of the data) and some missing values are supplemented by the Quadratic Match Average Method. Despite some limitations, the data provided by CNBS is still the most systematic, comprehensive and authoritative in China, and widely used in the literature (Fan et al., 2021). According to the Statistical Classification of Producer Services (2019), producer services consist mainly of the following sub-industries: transportation, warehousing and postal service; information transmission, computer services and software industry; wholesale and retail; financial; leasing and business services; scientific research, technical services, and geological survey.

Global financial crisis of 2008 caused GDP growth rate to drop from 14.16% in 2007 to 9.21% in 2009. Chinese government's RMB 4 trillion investment policy had helped GDP rebound temporarily. However, against the backdrop of a slowdown in the world economy, Chinese government also emphasized that China had entered the new normal stage of stable (characterized by sustainable and stable economic growth) economic growth for the first time in December 2013, which led to a new downward trend for China's GDP growth rate. Therefore, the 2008 to 2014 period is defined as a recession here (J. T. Tan et al., 2020), which accurately describes China's economic performance after the global financial crisis, and discards the influence of other factors on China's economic fluctuations.

4.2. Variable measurement

4.2.1. Dependent variable: Economic resilience

The method proposed by Martin et al. (R. Martin et al., 2016) has been widely used to measure urban ER. The basic idea is to measure ER based on the difference between real and expected or counterfactual economic output or employment. Considering that employment is the most sensitive to the crisis, and its recovery is more difficult than GDP, we measure ER based on the employee number of Chinese cities as follows:

$$\mathrm{ER}_i = \frac{(E_i^t - E_i^{t-k})/E_i^{t-k} - (E_r^t - E_r^{t-k})/E_r^{t-k}}{\left|(E_r^t - E_r^{t-1})/E_r^{t-1}\right|} \tag{1}$$

where E_i^t and E_i^{t-k} respectively indicate number of employees in city i at ending time t and starting time t-k. E_r^t and E_r^{t-k} are the number of employees nationwide, as expected or counterfactual changes. When ER is positive, it indicates that variation of employment in city i is greater than national level, and the ER level is significantly higher than national average.

The descriptive statistics of ER (see Table 1) indicates that 264 cities showed weak crisis resistance, with mainly negative ER value. −0.312 and 1.690 are mean and standard value of ER respectively, indicating that cities' employment growth rate contracted more than the nation as a whole, and there are large disparities between cities.

Table 1. Descriptive statistics of variables.

	Variable name	Variable symbol	Mean	Std. Dev.	Min	Max
Dependent variable	Economic resilience	*ER*	−0.312	1.690	−10.404	19.395
Independent variables	Producer services diversification	*PSD*	0.322	0.110	0.000	1.023
	Producer services specialization	*PSS*	0.830	0.300	0.000	3.238
Mediating variable	Industrial structure upgrading	*ISU*	0.589	0.532	.007	4.417
Control variables	Opening to the outside world	*Open*	0.140	0.188	0.000	1.443
	Human capital	*HumCap*	9.329	0.941	7.416	16.759
	Market vitality	*MarVi*	0.985	0.601	0.052	6.089
	Financial development	*FinLe*	0.528	0.321	0.044	4.542
	Government intervention	*GovInter*	0.201	0.170	−2.093	2.463

Source: Authors' own calculation.

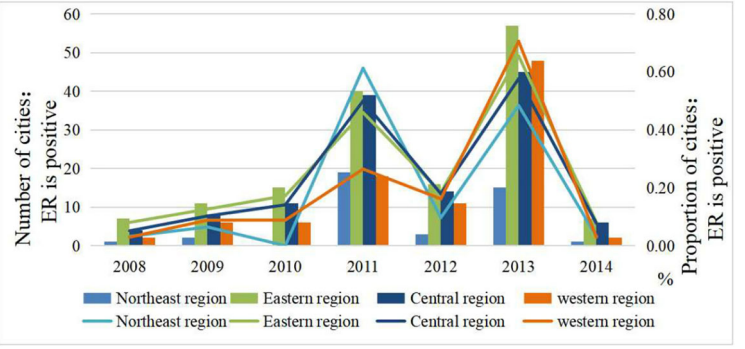

Figure 3. Economic resilience of four major regions in China.
Source: Authors' own calculation.

Due to regional differences in geographical location, resource endowment, and economic growth level, ER values show significant regional heterogeneity (see Figure 3). Cities in the eastern and central regions routinely can withstand shocks higher than national average, while northeast region's resilience is weaker due to difficulties in the transformation of heavy industry and path dependence. We observe two high values in 2011 and 2013, indicating a significant increase in the number of cities above national resilience level in both years. Probably because Chinese government invested RMB 4 trillion from 2008 to 2010 to stimulate domestic demand, as well as focusing on ISU and improving services competitiveness.

4.2.2. Independent variables: Producer services diversification and specialization

At present, measurement of industrial agglomeration is mainly carried out on the aspects of agglomeration scale and density, and the effects of different types of agglomeration are not considered (Xie & Li, 2021). Combes (2000) measured industrial agglomeration level from the aspects of diversification and specialization, which has important reference significance. Hence, we measure PSD and PSS by measurement method of Combes (2000).

$$\mathrm{PSD}_i = \sum_s \frac{E_{is}}{E_i} \left[\frac{1/\sum_{s'=1, s' \neq s}^{n} \left[E_{is'} / (E_i - E_{is}) \right]^2}{1/\sum_{s'=1, s' \neq s}^{n} \left[E_{s'} / (E - E_s) \right]^2} \right] \tag{2}$$

where PSD_i means the PSD of city i, n is type number of producer services. E_i indicate numbers of employees in city i. E_{is} is number of employees in producer services industry s in city i. E is the number of employees nationwide. E_s is number of employees in producer services industry s in China. $E_{is'}$ represents the total number of employees other than producer services industry s in city i. $E_{s'}$ is number of employees other than producer services in China. The larger PSD is, the higher the degree of PSD is.

$$PSS_i = \frac{E_{is}/E_i}{E_s/E} \tag{3}$$

where PSS_i means the PSS of city i, other variables in the formula have the same meaning as PSD formula. The higher the index value of PSS_i, indicates the city is more specialized in services agglomeration.

4.2.3. Mediating variable: Industrial structure upgrading

The literature shows that economy servitization (Also known as Tertiarization) is typical fact of ISU (Wang & Wei, 2021), and the improvement of total factor productivity (TFP) is its driving force. Measuring ISU level should not only consider transfer from primary and secondary industry to tertiary industry, but also the transfer from low productivity to high productivity. Therefore, we follow the method proposed by Yu (2019) to measure ISU.

$$ISU_i = Ind_i \times Pro_i \tag{4}$$

where Ind_i is output value ratio of tertiary industry to the secondary industry of city i in t, Pro_i is the labor productivity ratio of the tertiary industry to the secondary industry.

4.2.4. Control variables

Based on mature literature, we select a series of control variables to mitigate the estimation bias caused by missing variables. We measure the degree of opening-up (*Open*) by the proportion of total output value of firms with foreign investment above a certain level in the total industrial output value (R. Martin et al., 2015). According to the method of Han and Yang (2020), The human resource level (*HumCap*) is expressed by the per capita years of education. The calculation formula is as follows: $HumCap = (Coll \times 16 + Hi \times 12 + Mid \times 9 + Pri \times 6)/Total$. *Coll* is the number of people with college education or above, *Hi* is the number of people with high school education in the same year, *Mid* and *Pri* represent the number of people with middle school and primary education respectively, *Total* is the total numbers of labor force. Degree of market vitality (*MarVi*) is represented by the proportion of private and self-employed workers in the total number of urban employed (Xu & Zhang, 2019) . We refer to calculation method of financial development level (*FinLe*) by Li and Liu (2012). The formula is as follows: $\text{FinLe} = Loans_{city}/GDP \times (1 - State\ Asset_{province}/social\ Asset_{province})$. $Loans_{city}$ is total city loan of a city, $State\ Asset_{province}$ represents total investment in state-owned fixed assets of the

province where the city is located. $Social\ Asset_{province}$ is gross investment in social fixed assets of province. We use growth rate of fixed asset investment to measure government management ability (*GovInter*) (J. Tan et al., 2020). The key variables are summarized in Table 1.

4.3. Regression models

We employ a panel regression model to analyze effects of PSD and PSS on ER. To solve missing variables problem over time and individual city, a time-city binary fixed effects model is established in our paper. The model of panel regression is as follows (Liu et al., 2019; J. T. Tan et al., 2020).

$$ER_{it} = \beta_0 + \beta_1 PSA_{it} + \beta_2 Controls_{it} + \mu_i + \gamma_t + \varepsilon_{it} \tag{5}$$

where ER_{it} is economic resilience in region i of t year, PSA is the core independent variable, including PSD_{it} and PSS_{it}. $Controls_{it}$ are control variables. ε_{it} is the error term. μ_i and γ_t are the city and time fixed effect, respectively.

To further explore whether ISU plays a mediating role between producer services agglomeration and ER, we use Mediation Effect model based on the research of Baron and Kenny (1986).

$$ISU_{it} = \alpha_0 + \alpha_1 PSA_{it} + \alpha_2 Controls_{it} + \mu_i + \gamma_t + \varepsilon_{it} \tag{6}$$

$$ER_{it} = \varphi_0 + \varphi_1 PSA_{it} + \varphi_2 ISU_{it} + \varphi_3 Controls_{it} + \mu_i + \gamma_t + \varepsilon_{it} \tag{7}$$

In models (5) to (7), ISU_{it} is industrial structure upgrading in city i of t year, β_0, α_0, φ_0 respectively represent the intercept term. Whether there is a mediating effect must meet the following conditions. If β_1 is not statistically significant, the mediating effect is directly rejected. If both β_1, α_1, and φ_2 are statistically significant, there is a partial mediating effect when φ_1 is significant and smaller than β_1, and a complete mediating effect when φ_1 is not significant. If at least one of α_1 and φ_2 is not significant, the Sobel test is required to judge the mediation effect's significance.

5. Empirical results

First, to observe the relationship more intuitively, we present the scatter plot between ER and two core explanatory variables (see Figure 4). The lines in the figure are two fitted lines. It is clear that PSD and ER are significantly associated with urban ER in post-crisis period. The slope of fitted lines of PSD and ER (1.388) is positive, indicating that there is a significant positive correlation between them. This is consistent with the view of Martin et al. (2016), that industrial structure diversification is conducive to economic resistance to crisis and recovery of transformation capacity. The slope of fitting line of PSS and ER is −1.121, showing a significant negative correlation.

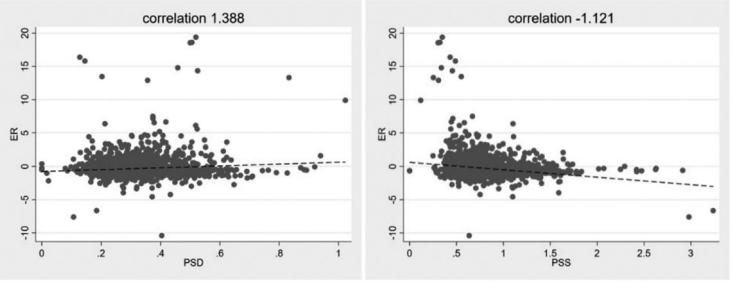

Figure 4. Scatter plots of ER and explanatory variables.
Source: Authors' own calculation.

Table 2. Direct and indirect influence of producer services agglomeration on ER.

	ER		ISU		ER	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
ISU					1.086***	0.870***
					(0.331)	(0.329)
PSD	7.397***		1.485***		5.784***	
	(1.637)		(0.279)		(1.578)	
PSS		−5.247***		−0.298***		−4.99***
		(0.683)		(0.076)		(0.664)
Open	−0.379	0.0279	−0.864**	−0.772**	0.559	0.700
	(1.089)	(1.069)	(0.340)	(0.326)	(0.997)	(1.006)
HumCap	−0.0843	0.000207	−0.087***	−0.080***	0.010	0.070
	(0.127)	(0.133)	(0.024)	(0.024)	(0.138)	(0.137)
MarVi	−0.872***	−0.762***	−0.085**	−0.093**	−0.780***	−0.681***
	(0.187)	(0.180)	(0.035)	(0.038)	(0.166)	(0.158)
FinLe	0.463**	0.411**	0.065*	0.054	0.393*	0.364**
	(0.209)	(0.163)	(0.039)	(0.039)	(0.218)	(0.174)
GovInter	−0.225	−0.0585	0.043	0.045	−0.272	−0.097
	(0.172)	(0.167)	(0.036)	(0.036)	(0.172)	(0.163)
Constant	−1.726	4.094***	0.977***	1.620***	−2.787*	0.296
	(1.447)	(1.224)	(0.236)	(0.244)	(1.548)	(3.338)
Time-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
City-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1839	1839	1839	1839	1839	1839
R-squared	0.256	0.408	0.340	0.278	0.2717	0.4189
Sobel Z					3.014***	3.865***
Mediating effect ratio					10.92%	−5.95%

Note: T values in parentheses are calculated according to urban clustering robust standard errors. ***, ** and * are significant at 0.01, 0.05 and 0.1 level respectively, which are the same without special instructions in the table below.
Source: Authors' own calculation.

5.1. Baseline regression

To explore the direct and indirect effects of PSD and PSS on urban ER, we conduct regression analysis on the empirical model set up in Part 4. Considering multicollinearity between variables, we calculated variance inflation factor (VIF). The results show that the maximum VIF is 1.75, which is far less than the cut-off value 10 commonly used. This indicates that there are no serious multicollinearity problems. The results of the regression models are presented in Table 2.

In Table 2 (Model 1 and Model 2), both PSD and PSS have significant effects on ER at the 1% level. PSD has a positive effect, while PSS has a negative effect. This indicates that cities with more diversified producer services can better cope with the

economic shock, while cities with more specialized experience more serious economic recession. PSS has a negative effect on ER partly for the following reasons: The development of China's high-end manufacturing is still immature. To deal with risks, there is an urgent need to transfer to services industry, especially production services. However, the convergence of manufacturing and producer services is inadequate, which results in the weak ER. Besides, specialization agglomeration of producer services leads to fewer opportunities for generating new industries and paths to generate, making the economic structure less flexible. From the results of control variables, we can draw that *MarVi* has a significant negative impact, related to vitality lack, poor business environment, and the declining private investment growth rate in most Chinese cities. As expected, cities with higher *FinLe* level are better to withstand crises.

According to Model 3 and 4 in Table 2, PSD has a significant positive impact and PSS has a negative impact on urban ISU. The impact of PSD was expected. However, the negative impact of PSS is partly due to the following factors: First, most Chinese cities are still located at the middle and low-end manufacturing links of the value chain, with low and simple demand for producer services. Therefore, the specialized and high-end level of the producer services is insufficient, which is unfavorable to ISU. Second, path dependence effect of PSS in Chinese cities is greater than scale economy effect, which is not conducive to ISU.

Table 2. (Model 5) exhibits the regression results with ISU and PSD added to the model, which show that they both have significant effects on urban ER. The regression coefficient value of PSD is smaller than that of Model 1. Similarly, Table 2 (Model 6) indicates that ISU and PSS also have significant effects. Furthermore, the absolute value of PSS regression coefficient is smaller than that of Model 2. These results indicate that ISU plays a mediating effect on the impact of PSD and PSS on urban ER. Then, Sobel test is conducted in our paper. Sobel Z statistics all passed the statistical test at 1% level, which fully confirmed the significance of the mediation effect. Specifically,10.92% of positive impact of PSD on ER is achieved through ISU, while 5.95% of negative impact of PSS is achieved through ISU.

5.2. Regional heterogeneity test

China encompasses a vast territory. Different resource distributions, economic development levels, institutional environments, and other factors lead to differences in regional producer services agglomeration's impact on resilience during a crisis. Therefore, based on the National Bureau of Statistics' classification standards (CSY, 2018), we divide Chinese cities into four regions (i.e., northeast, eastern, central, and western regions). The interaction terms of producer services agglomeration and dummy variables of eastern, central, and western are added to Equation (5). The results are reported in Table 3.

In the eastern and western regions, PSD positively affects ER (Model 1 in Table 3). The economic contribution of the tertiary industry in the eastern developed region is greater, and the level of producer services agglomeration is higher. Moreover, manufacturing development prefers more diversified producer services, which further

Table 3. Results of four regional groups.

	Model 1				Model 2		
PSD	1.110	*FinLe*	0.461**	*PSS*	−4.429***	*FinLe*	0.402**
	(1.699)		(0.205)		(1.193)		(0.161)
PSD× *eastern*	9.485***	GovInter	−0.269	*PSS*× *eastern*	−4.584**	GovInter	−0.134
	(3.213)		(0.184)		(1.865)		(0.161)
PSD× *central*	3.505	Constant	−1.779	*PSS*× *central*	1.481	Constant	3.700***
	(2.464)		(1.274)		(1.276)		(1.082)
PSD× *western*	7.341*	Observations	1839	*PSS*× *western*	−1.768	Observations	1839
	(4.184)				(1.613)		
Open	0.000***	Period-fixed effect	Yes	*Open*	0.000***	Period-fixed effect	Yes
	(0.000)				(0.000)		
HumCap	−0.0820	City-fixed effect	Yes	*HumCap*	0.0966	City-fixed effect	Yes
	(0.113)				(0.126)		
MarVi	−0.817***	R-squared	0.265	*MarVi*	−0.582***	R-squared	0.451
	(0.174)				(0.135)		

Source: Authors' own calculation.

stimulates the development of innovation and PSD in the eastern region. Therefore, negative impact caused by external shocks can be quickly absorbed, and transferred. Although PSD level in the western region is low, cities there focus on developing producer services that match the industrial structure, competitive factors, and economic development level by relying on their factor endowments. Therefore, PSD can also help western region withstand the crisis. PSD in the northeast and central regions has no significant impact on urban ER. Because the economic structure of these regions is still dominated by manufacturing, and diversified development of producer services generally lags (Wen, 2020). The level of coordination and convergence between producer services and manufacturing is low, and a good interactive relationship cannot be formed. Hence, it restricts the promotion of ER.

Based on Table 3 (Model 2), we find that PSS in the northeast and eastern regions has negative impacts on ER. PSS in the central region positively affects ER, but not significantly. The manufacturing structure in central region is relatively single, so PSS, which meets the demands of dominant industrial development, more easily gives full play to scale economy effects and knowledge spillover effects. However, due to development level of producer services, this positive effect is not significant. The negative impact of PSS on ER in the western region is not significant. The main reason is that the producer services established under local government intervention are divorced from local comparative advantages and industrial development needs. Moreover, producer services in such cities have a low level of specialization, which is not conducive to forming a positive interaction with manufacturing in the face of crisis.

5.3. Robustness test

To test for robustness, firstly, we changed the measure method of ER. Economic output is the overall indicator to measure a country's economy, so the change of real GDP is substituted into Equation (1) to get *ER1*. Furthermore, based on the method proposed by Ron Martin (2011), we assume that all cities expand or contract at the same speed when they encounter a financial crisis. *ER2* is calculated by the following formula:

Table 4. Robustness Test.

	ER1		ER2		Added provincial-time combined fixed effects	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
PSD	5.283***		15.63**		6.612***	
	(1.431)		(7.377)		(1.505)	
PSS		−4.143***		−7.045***		−4.560***
		(0.915)		(1.240)		(0.587)
Open	0.427	0.713	−0.892	0.0216	−0.314	0.165
	(0.902)	(0.925)	(1.538)	(1.358)	(1.020)	(0.986)
HumCap	−0.187*	−0.122	0.480	0.608	−0.0919	0.002
	(0.102)	(0.078)	(0.667)	(0.748)	(0.135)	(0.148)
MarVi	−0.539***	−0.445***	−1.055***	−0.985***	−0.686***	−0.655***
	(0.154)	(0.149)	(0.220)	(0.242)	(0.181)	(0.172)
FinLe	0.461*	0.424	0.627**	0.512**	0.303*	0.332**
	(0.237)	(0.200)	(0.275)	(0.205)	(0.163)	(0.132)
GovInter	−.174	−0.039	−0.387*	−0.205	−0.207	−0.113
	(0.201)	(0.177)	(0.219)	(0.254)	(0.207)	(0.168)
Constant	−0.587	3.845***	−7.972	1.513	−1.005	3.855***
	(1.087)	(1.058)	(7.887)	(5.876)	(1.530)	(1.408)
Observations	1839	1839	1839	1839	1804	1804
Period-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
City-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.2233	0.3417	0.242	0.309	0.545	0.626

Source: Authors' own calculation.

$$ER2 = (\Delta E_{it}/E_{it})/(\Delta E_t/E_t) \tag{8}$$

where $\Delta E_{it}/E_{it}$ is rate of change in the number of employed people in city i. $\Delta E_t/E_t$ is the change rate in total employment in the province where the city is located. Based on the results of Model 1 to 4 in Table 4, we find that PSD is good for enhancing ER, while PSS is unfavorable. The conclusion does not change with different methods of measurement.

Second, we add provincial-time joint fixed effects to Equation (5). In different years, provinces issued various policy documents to promote producer services agglomeration, which can lead to different efforts to promote it in different provinces. To control the time-varying characteristics of provinces, the combined province-time fixed effect is added in Equation (5). Regression results are shown in Model 5–6 in Table 4. The results indicate that the regression results of PSD and PSS on urban ER are consistent with the baseline regression results in Table 2.

6. Conclusions and prospects

In recent years, people have conducted extensive and in-depth research on how to improve regional economic resilience. Our exploration has contributed to theoretical and empirical research in this field. Our study first establishes a theoretical mechanism for the effects of PSD and PSS on economic resilience. Then, based on the panel data of 264 cities in China, the direct effects of PSD and PSS on economic resilience and the mediating effects of ISU are investigated. We also conducted heterogeneity test and robustness test. The empirical results show that PSD has a significant positive effect on enhancing urban ER, while PSS has a significant negative effect. ISU is a

partial mediating factor that leads to PSD positively enhancing ER and PSS negatively effecting it. Additionally, The effects of PSD and PSS on ER show heterogeneity in different regions. PSD positively affect ER in eastern and western regions, but this effect is not significant in northeast and central regions. PSS in northeast and eastern regions have a negative influence on ER, while the influence in central and western region don't pass the significance test.

These conclusions don't mean that cities should ignore PSS and actively promote PSD. Instead, the agglomeration model should be selected by comprehensively considering various characteristics, such as local comparative advantage, factor endowment conditions, convergence degree between manufacturing and service industries, and the industrial structure's status quo. As a difficult area for industrial transformation, northeast region should avoid large and complete industrial layouts. According to its own characteristics, it should find new dominant industries, such as advanced manufacturing, photoelectric information, and other strategic emerging industries. On this basis, appropriate producer services should be selected for specialization development, such as information technology services, business services, etc. To stabilize the economy, the eastern region should further improve the level of PSS and the quality of PSD, so as to provide an inexhaustible power source for ER by promoting high-quality agglomeration of producer services. For example, for transportation, warehousing and postal services, as well as leasing and business services, PSD should be chosen to strengthen the coordinated promotion of inter-regional transportation, logistics and business services. This is conducive to giving full play to spatial spillover effect of industrial agglomeration, so as to enhance the regional resilience. The financial industry should adopt a specialization agglomeration mode to serve local competitive industries, strategic emerging industries and high-end service industries.

Meanwhile, more attention should be paid to the co-agglomeration of producer services and manufacturing. Regions should not neglect the supporting role of the producer service sector simply to achieve economic growth targets. While consolidating the development of the real economy, regions should take into account the supportive role of producer service agglomeration in promoting manufacturing development and ISU. For example, central and western regions should selectively undertake manufacturing of the eastern region, and select appropriate producer services for specialization agglomeration. This way can improve the ability of the producer services to accurately support manufacturing development, and reduce the spatial mismatch effect between the producer services and the manufacturing through blind imitation among local governments.

This study has some limitations. Firstly, producer services include high-end and low-end sub-industries, and their specialization and diversified agglomeration may have different impacts on economic resilience. This is a direction of future research, which is helpful to find out the regional competitive advantages of each sub-industry, and can provide reference for regions to formulate ER improvement policies according to local conditions. Second, the convergence of producer services and manufacturing is important for enhancing ER. However, this indicator is not included in our paper due to a lack of data. The convergence index of manufacturing and producer services is best measured by the input-output tables of the national economy, which are, however, produced only every five years.

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