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Related variety in Chinese cities: local and Foreign Direct Investment related variety and impacts on urban growth

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Abstract : The paper measures agglomeration economies through related variety and their impact on growth and employment in Chinese cities, using prefecture level city-industry data from 2003 to 2010. The results show that it is related variety rather than unrelated variety that promotes spillovers and increases urban per capita income and employment. The paper explores this through analyzing related variety in industrial structure at the city level and also related variety brought into the city through FDI presence. It finds that cities with FDI presence of the related variety type with complementarity but not identity between knowledge bases of the foreign and local industrial sectors have higher local GDP per capita and employment. We hypothesize that there is an inverse U function between knowledge overlap and urban GDP per capita: at low and high levels of overlap with unrelated variety or great similarity between knowledge bases respectively, the capacity for spillovers is low; with related variety with complementarity between knowledge bases, there is sufficient local absorptive capacity and sufficient novelty in the knowledge base to create knowledge spillovers and local growth. Related variety can come from the local industrial structure or through the presence of FDI.

Key Words: Related variety; Jacobs externalities; FDI-knowledge spillovers; Urban growth in China

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1 Introduction

Economic geography has focused on how geographical concentration has fostered knowledge spillovers and hence innovation (Krugman 1991; Paci and Usai 1999; Feldman and Audretsch 1999). The discussion of geographical boundaries of spillovers and innovation is accompanied by a debate on which of the different types of agglomeration externalities: those stemming from specialization in industrial structure (localization economies) and those stemming from diversity (Jacobs externalities) best promote innovation and regional growth (Beaudry and Schiffauerova 2009, Glaeser et al 1992; Jacobs 1969; Marshall 1920). Some scholars have stressed that intra-industrial spillovers from specialization have positive impact on economic growth (Henderson et al., 1995), whilst others hold that urban diversity or Jacobs externalities are more helpful to regional growth (Glaeser et al, 1992). Moreover there are different types of urban diversity: urbanization externalities arising from agglomeration in cities that through proximity produce new ideas, promote knowledge spillovers. Cities are densely populated, house universities and research centres and as agglomerations these urbanization externalities may get passed on to enterprises, independently of industrial structure.

In addition there are what has become known as Jacobs externalities whose precise meaning is not clear-cut. The idea builds on Schumpeter's 'Neue Kombinationen' (Schumpeter 1939, Frenken et al 2007) that such externalities allow for the recombining of knowledge from different industrial sectors thereby promoting knowledge spillovers and creating new products (Jacobs 1969). What the precise combination of industrial sectors is within 'diversity' that produces such innovation however is not clear.

Industrial diversity does not necessarily result in knowledge spillovers and urban growth, since two totally unrelated industries cannot establish channels for knowledge spillovers. Evolutionary economic geographers such as Frenken et al.(2007) , Boschma et, al. (2009) differentiate diversity into related diversity and unrelated diversity. Only those industries with value linkages or complementary capacities can effectively produce knowledge spillovers, the linkage and complementarity being captured by the notion of related variety. By contrast, unrelated variety does not produce knowledge spillovers since there are no shared competences among industrial sectors. However, unrelated variety has benefits as it is associated with a regional portfolio strategy that protects regions from fluctuations in demand when industry-specific shocks occur (Frenken et al., 2007).

Variety theory does not fully deal with the issue of related variety across geographical space such as cities. If the related variety is generated only by local firms, it may not bring enough new knowledge to the region. Linkages external to the region or city may be necessary to bring in different and new knowledge which is significant to urban growth. Effective external relations are important factors preventing the city being locked in at low levels of development. Bathelt et al (2004) refer to these external channels of knowledge transmission as global pipelines (Bathelt et al., 2004). Cities or regions can develop through international trade and through attracting international investment to bring in external knowledge. However,

existing literatures have neglected what kind of external regional linkages may be significant for urban growth. If the new knowledge being brought in is identical or highly similar to the existing knowledge base, there will be no new knowledge added to the urban knowledge base and it will not contribute to urban growth. However if the external knowledge is unrelated to the local knowledge base, local enterprises will lack the absorptive capacity needed to absorb it. Therefore we argue that only when the new knowledge has some relation to and overlaps with the internal knowledge base ie is of the related variety, but is not identical or highly similar to it, can it create externalities that give the urban centre opportunities to grow.

The paper is based on a firm level database in China for the period 2003-2010. The paper investigates two issues: first, how related variety and unrelated variety in the industrial structure of Chinese cities affect urban growth; second, whether FDI-presence has created related variety in each city and how that FDI-induced related variety has affected urban growth. The paper empirically tests how related and unrelated diversity, both locally and through FDI-presence affect urban economic growth. The empirical research extends the theories of knowledge spillover mechanisms.

This paper makes two main contributions. It applies the concept of related variety and unrelated variety at the localized level to the industrial structure of Chinese cities and assesses their impact on growth. This is important because Chinese cities have been the centres of Chinese development over the last 20 years; understanding the determinants of growth and particularly of innovation at the local level is key to understanding both Chinese urban growth and also related variety's contribution to urban growth in the emerging market context more generally. It applies the entropy indicators (Frenken et al 2007) that decompose and assess industrial structure in terms of related and unrelated variety.

The second contribution is in addressing the related variety induced by Foreign Direct Investment (FDI) into Chinese cities and its impact as external sources of knowledge spillovers on urban growth. FDI has been a key contributor to Chinese growth and the issue of its relationship to local industrial structure has only begun to be addressed (Wang et al 2014). This paper applies the concepts of related variety to FDI into China in calculating related and unrelated variety within FDI and in assessing their effect on localized growth in Chinese cities. Boschma and Iammarino (2009) in assessing the effect of inter-sectoral linkages between regions use trade data for Italy to establish that it is related variety in linkages that brings new knowledge into the region and enables them to perform better. If new knowledge is in unrelated sectors, firms cannot absorb it; if it is identical sectors then firms can absorb it but it will not be adding anything to the existing knowledge base. We test a similar idea using FDI-presence for Chinese cities and argue that there is an inverse U shaped relation between the local knowledge base and urban growth: when there is unrelated variety and the city's knowledge base consists of completely discrete and unrelated knowledge bases, then externalities from that knowledge base are limited and do not promote urban growth. When there is total similarity in knowledge base between what

is being brought into the city and the internal knowledge base, then potential for creative recombination of new ideas and processes are also limited, knowledge spillovers are small and do not promote urban growth. In the middle area of related variety, either coming through the internal industrial structure or provided by external presence, then the capacity for knowledge spillovers is higher and urban growth is promoted.

Thus related variety can be created either internally through the industrial structure or through external presence that is bringing new knowledge into the industrial structure. We hypothesize that this latter channel of related variety has been particularly significant in the growth of Chinese cities.

The structure of the paper is as follows. We set out the main theoretical arguments behind related variety, unrelated variety and FDI- presence creating related variety in section two. In section three, we present the dataset and analytical framework for the theoretical hypotheses, and then we present the main findings of the paper. Finally, we summarize conclusions and give policy reflections in section four.

2 Related variety and urban growth

Related and Unrelated variety

Agglomeration externalities theories have dealt with whether specialization or diversification generate knowledge spillovers, that is whether firms within an agglomeration gain more spillovers from the same industrial sector or from other sectors (Glaeser and Kallal et al., 1992; Henderson and Kuncoro et al., 1995; Henderson, 1997; Beaudry and Schiffaneurova 2009). Marshall holds that localization economies come from specialization effects within the industrial agglomeration, including a specialized labor pool, specialized suppliers, and specialized infrastructures which create intra- industry spillovers (Marshall, 1920; Krugman 1991). However, spillovers from localized economies can be limited since they derive from similar enterprises. The result of spillovers from specialization is efficiency promotion leading to productivity increases in the production of existing products, rather than radical innovation and the creation of new products (Frenken et al 2007).

By contrast inter-industry spillovers create more variety, new markets and technologies with a very different impact from intra-industry spillovers (Jacobs, 1969; Glaeser and Kallal et al., 1992). New Economic Geography (NEG) theory has put more emphasis on variety in urban centres, arguing that variety benefits consumer welfare, and also promotes economic growth (Krugman, 1991; Fujita and Krugman et al., 1999). Bathelt (2001) argues that in the long-run regional diversity may be more conducive to escape from regional lock-in. Studies favouring Jacobs externalities hold that greater variety can bring new ideas and induce knowledge spillovers (Glaeser and Kallal et al., 1992; Duranton and Puga, 2001). Inter-industry linkages help generate radical breakthrough innovations. The firm can reorganize new knowledge and create new products or technologies, innovation can create totally new markets and employment and promote economic growth (Saviotti and Pyka, 2004).

However, it still remains to question whether all kinds of variety, including totally unrelated variety can promote innovation and growth. Boschma and Iammarino (2009) have argued that not all kinds of variety can promote growth; they illustrate this with the example of a pig farmer who could not learn anything from the proximity of a microchip producer. Most diversity indicators have not fully considered the functional dimension of knowledge spillovers, which depend on interplay between industries, technology and geographical locations (Iammarino and McCann, 2006). Moreover, the effect of diversity on economic growth can be in protecting against economic risk; unrelated variety can act as a local stabilizer when confronted with economic shocks in one sector. Therefore, as Frenken and Van Oort et al. (2007) put it, variety can be divided into two types: related variety that facilitates effective learning between firms; and unrelated variety that resists sector-specific demand shocks (Frenken and Van Oort et al., 2007).

Previous studies have shown that the relatedness between sectors affect inter-industry knowledge spillovers (Boschma and Iammarino 2009). Related variety can only exist among sectors with complementary competences. Shared competences between firms can create the cognitive proximity which is required to learn and communicate effectively. Nooteboom (2000) argues that effective learning exists among sectors with 'proper' cognitive distance. Too close cognitive distance means that there are not enough new ideas, while too far cognitive distance will inhibit effective learning (Boschma, 2005). Therefore, neither regional diversity nor regional specialization *per se* can stimulate innovation effectively; only related variety has the right cognitive distance to stimulate innovation. The innovation process can be realized by inter-industry learning and a positive feedback mechanism in local related sectors. The diversity environment based on complementary competences helps firms reorganize scattered knowledge into new knowledge (Boschma, 2005). Compared with specialization that can only facilitate tiny spillovers since spillovers come from within the same sector producing similar commodities, related variety is expected to facilitate larger spillovers and create more radical break-throughs through recombining knowledge gathered from different sectors (Boschma, 2005). Porter (1998) emphasizes the importance of clusters because related industries in geographical clusters rather than specialized industry *per se* are beneficial for regional growth. Related variety is especially important for high-tech industries in urban regions (Bishop and Gripaios, 2010) since in such industries innovation is more urgent.

The mechanism through which unrelated variety affects regional growth is quite different from that of related variety. There are no complementary abilities, learning opportunities or input-output linkages among unrelated sectors. In the unrelated variety environment, effective spillovers do not happen among industries, but it could function as a regional shock absorber through the portfolio effect of having diverse industries unrelated in demand characteristics (Frenken and Van Oort et al., 2007). If a demand shock hits an industry sector, the region disperses risk by having other unrelated sectors unaffected by the fall in demand. Since there are seldom input-output linkages among unrelated sectors, the shock would not be

transmitted to other industries and regional unemployment is muted (Frenken et al 2007). Therefore, unrelated variety affects regional growth in different ways from related variety; it is unlikely to facilitate efficient learning across industries since it lacks a complementary cognitive base, but it acts as a stabilizer protecting regions from negative sector-specific shocks.

The existing empirical literatures have shown the significance of related variety for regional growth and have demonstrated the different effects of the two sorts of variety on economic growth. Frenken and Van Oort et al. (2007) have shown that related variety promoted regional employment growth in the Netherlands, while unrelated variety helped lower unemployment. Boschma and Iammarino (2009), based on Italian regional data, have shown that related variety promoted economic growth and productivity growth, while unrelated variety had no significant effect. Other empirical studies based on Spain (Boschma and Minondo et al., 2011), Finland (Hartog and Boschma et al., 2012) UK (Bishop and Gripaios, 2010) all confirmed the significance of related variety contributing to regional growth.

Chinese economic growth has been shown to be regionally diverse, with faster growth in the eastern provinces and least development in the inner provinces. (Naughton 2007; Coase and Ning 2012; Wei, 1996) Moreover Chinese regions have been shown to be regionally differentiated according to whether they have more specialized industrial structures or more diversified structures (Wang et al 2014). Wang et al (2014) also show that FDI has been attracted to the more diverse regional industrial structures, thereby adding to that diversity. However the regions studied have been at the level of the 31 aggregated provinces, with various of the eastern and central regions having populations of upwards of 80 million people covering large geographical distances. First the issue of related and unrelated variety has not been examined, to more finely assess how closely connected industries are to each other within a particular locality. And second this needs to be done at a more finely localized spatial level to make any sense of the notion of knowledge transmission and spillover. Jaffe et al (1993) established geographical knowledge boundaries of around 50 km. It is important therefore to examine these questions at the level of the city, where much of Chinese growth has occurred. This is particularly relevant for assessing the dynamics of Chinese industrial growth, as inequalities between regions have increased dramatically alongside the rapid growth that has ensued.

Therefore, we formulate the following hypothesis:

Hypothesis 1: Related diversity, rather than unrelated diversity promotes urban growth through spillover effects in Chinese cities.

FDI presence and related variety and urban growth

Externality theories have emphasised the effects of inter- and intra-industry relations on economic growth; however, agglomeration theories have neglected the contribution of external linkages to the industrial structure's spatial dimension (Boschma and Iammarino, 2009; Engel and Del-Palacio, 2011). Some new knowledge is obtained through establishing 'global pipelines' of external linkages. Local

development will become insular and locked-in if regional external relations are neglected. Introducing external knowledge is a significant factor in breaking regional lock-in (Asheim and Isaksen, 2002). If urban localities neglect external relations it may lose sustained innovation competences. External linkages bringing in new ideas for local production systems and benefit for local economics are important sources of collective learning (Scott, 2000; Bathelt and Malmberg et al., 2004). There is increasing evidence that access to knowledge from outside the region is essential for regional growth, that new knowledge brought to the region by trade or foreign direct investment are critical in starting a new technology or industrial path (Martin and Sunley, 2006). Studies have shown that most successful clusters are those which are most globally connected, through which regions access markets, resources and technology and accelerate innovation processes (Bresnahan, 2001; Engel and Del-Palacio, 2011).

Over the past two decades, multinational corporations have been entering into foreign countries, particularly into China, building up global production networks and global innovation networks (Sachwald, 2008). Through such networks they establish trade or production inter-regional linkages providing various channels for knowledge flows. However, the vast literature on FDI has been unclear on the contribution that foreign direct investment or trade straightforwardly promotes regional growth (Haddad, 1993; Aitken and Harrison, 1999; Branstetter, 2000), which means that external knowledge does not necessarily promote urban innovation or growth. It is critical that the region has the ability to absorb the external knowledge and transform it into regional endogenous growth abilities. Absorptive capacity is a mediating variable between the firm's environment and its organizational adaptation (Cohen and Rosenthal 1990; Bathelt and Malmberg et al., 2004). The lack of absorptive capacity will block local interaction with global players. If regions receive extra-regional knowledge that is too different from the existing knowledge base, they may ignore it or not take it seriously. Absorptive capacity means that external knowledge can be distributed and reorganized effectively within local firms.

Therefore, we conclude that only knowledge that is both new and that can be effectively absorbed by local enterprises can promote local economic development (Giuliani, 2005). Firms in urban or regional centres need absorptive capacity to understand external knowledge and transfer it into local economic growth. External knowledge needs to be related to local knowledge base but not be totally the same for local firms to gain from interacting with global players (Boschma et, al., 2009). Therefore, when global and local knowledge are of the related variety sort, knowledge can be transmitted and promote innovation and growth. That is to say, when the cognitive distance between global and local knowledge is neither too large nor too small, there can be effective knowledge spillover effects. If local knowledge is too distant from external knowledge, extra-regional investment or trade may become an isolated island which could not be understood, absorbed or used by local entities. On the other hand, if external knowledge is identical with local knowledge, local firms would not gain any new valuable information through the transaction, and it could introduce competition for local factors which may prevent local enterprises

from making breakthrough innovations. Therefore, within the global-local background, external and local cognitive distance should not be too small (to avoid regional lock-in) nor too large (to guarantee efficiently absorbing external knowledge), for knowledge spillovers to be effective. The 'proper' cognitive distance could be achieved by related variety created by external presence and within local industrial sectors.

We integrate these two literatures on agglomeration externalities with that on FDI spillovers to gauge related variety through FDI in the case of Chinese cities. This is particularly significant for China where FDI and spillover effects have been the subject of study (Wang et al 2014).

Therefore, we hypothesize:

Hypothesis 2: FDI or trade *per se* does not necessarily promote Chinese urban growth, but related variety created by FDI-presence in the city promotes Chinese urban growth.

3 Data and Analytical Framework

3.1 Data Sources

The paper tests the above hypotheses. We use Chinese prefecture level city-industrial statistical data during the period of 2003-2010, including 285 prefecture level cities, and the 158 three-digit manufacturing industries within the 29 two-digit industries. The data is aggregated from firm level data collected from the National Statistical Bureau from 2003 to 2010 and China's Urban Statistical Yearbook for each year. The indexes include each city's three-digit sectors value added output, employment, domestic and foreign capital value.

We use industrial gross production data by prefecture level city to measure the effect of agglomeration economies. Mainland China is divided into 333 prefecture-level administrative units and four directly-controlled municipalities (Beijing, Shanghai, Tianjin, Chongqing). The 333 prefecture-level administrative units include 285 prefecture-level cities and 48 other prefecture-level administrative districts such as autonomous prefectures. The latter are mostly in remote backward areas and mainly consist of minorities. Due to limited data availability, we exclude these administrative districts and some prefecture-level cities where data are not available. In the paper we include 275 prefecture-level cities and four directly-controlled municipalities – Beijing, Tianjing, Shanghai, Chongqing. Chinese official data have divided the country broadly into eastern, middle and western regions. There are big disparities between these large regions. Most population, employment and output are agglomerated in the eastern region. In the sample, there are 36.2%, 42.6% and 21.2% cities in the eastern, middle and western regions respectively, with 54%, 31%, 15% employment in those regions. Average per capita GDP was 43.9, 29.3 and 24.2 thousand Yuan in each region respectively in 2010. Average density was 580, 376 and 282 persons per square kilometer in each region in 2010.

We use industrial gross production data by prefecture level city to measure the effect of agglomeration economies. Further, we disaggregate the data into domestic owned firms and foreign owned firms according to shareholding ratio, and analyze related variety created through global-local linkages and how they affect urban economies. Boschma and Iammarino (2009) used trade data to estimate the impact of variety and extraregional linkages on economic growth. Similarly, FDI is an important indicator measuring extraregional linkages; in transition economies like China, FDI has played an important role in driving China's economic growth (He, 2002; He, 2005; He and Wang, 2010). Foreign owned firms not only increased the gross production of China, but also have formed many ties with local firms (He and Wang, 2010). FDI is also a major source of Chinese exports and imports. Although the exact impact of FDI on local economies is still unclear (Tian, 2007; Aitken, 2008), it has played a huge role in Chinese development. In the following sections, we use FDI output and local firms industrial output data to measure the effect of extraregional linkages on urban economies.

In the analysis, we use only manufacturing industrial data to define all kinds of varieties; we do not include services data as detailed services data are not available in China. Moreover since most Chinese cities are still in the industrializing period and manufacturing sectors occupy the largest part of gross domestic product, related and unrelated variety based on manufacturing industries can be used as a proxy for industry structure. Therefore, industrial structure is approximated using the manufacturing sectors.

We use a city-level time series cross-section panel data econometric model to estimate how industry structures and FDI presence in cities affect urban economic growth. Panel data is more suitable than cross-section data used in previous studies, because panel data can consider the effect of the whole period and exclude time-invariant unobserved individual differences, and have more power than cross-sectional observational studies. In the estimation we use urban per capita GDP and employment in the prefectural city as dependent variables.

3.2 Analytical Framework

We estimate the impact of different types of agglomeration economies and different levels and types of FDI presence on urban growth per capita at the Chinese city level. We expect related variety and unrelated variety to affect urban growth through the knowledge spillover effect and the portfolio effect respectively. To assess the impact of the different kinds of agglomeration economy effects, we constructed the following variables.

First, we investigate how related variety and unrelated variety affected urban growth. Following (Frenken and Van Oort et al., 2007), we constructed the entropy index to indicate related variety and unrelated variety at different sectoral levels of aggregation. Related variety was calculated from the weighted sum of the entropy index at the three-digit level within each two digit sector in each city; then we summed related variety for each two-digit class in each city. We suppose the more related variety at the three-digit level within the two-digit level categories, the more

opportunities to learn from others. We expected that the higher the related variety, the higher the knowledge spillovers at city level.

The related variety formula is given as follows. Suppose three-digit industry i belongs to two- digit industry S_g, where g=1,…, G, two-digit industries shares is P_g, three-digit share is P_i, then two-digit share P_g is the summing of the shares of all three-digit industries P_i belonging to a two-digit industry :

$$P_g = \sum_{i \in S_g} P_i$$

Related variety (RV) can be defined as the weighted sum of three-digit sectors entropy within each two-digit industry:

$$RV = \sum_{g=1}^{G} P_g H_g$$

Where

$$H_g = \sum_{i \in S_g} \frac{p_i}{P_g} \ln\left(\frac{P_g}{p_i}\right)$$

The unrelated variety index (UV) was calculated through the entropy of prefecture level city's two-digit industry; it is used to estimate the extent of industrial difference in the city. The greater the unrelated variety of the city, the more the city is endowed with different type of activities. The index measures the portfolio effect of variety that resists demand shocks. The entropy of unrelated variety (UV) is defined as follows:

$$\mathrm{UV} = \sum_{g=1}^{G} P_g \ln(1/P_g)$$

As explained by Frenken and Van Oort (2007), three-digit entropy is equal to the sum of two-digit entropy (unrelated variety) and the weighted sum of the three-digit entropy within each two-digit class (related variety), due to the decomposable nature of the entropy measure.

Further, we also considered how urban FDI presence induced related variety and how that affected urban growth. We first controlled for the openness of the city, measured by FDI and export ratio variables. Openness was proxied by the ratio of inflows of FDI to GDP of the city (fdi) and the ratio of exports to sales value of the city (exp).

We created an index to measure the relationship between the foreign investment and local investment into the city at the three digit level of industry structure. We constructed FDI and domestic investment related variety index (FDVAR) to determine the degree of related variety between foreign and local industries at the city level. We wanted to measure the extent of cognitive proximity between foreign and local investment of the city by comparing the foreign and domestic investment structure and determining to what extent they were related. We excluded the

intra-sectoral relationship between foreign and local investment since the cognitive distance is too small within the sector for any new knowledge to be introduced. The higher the index, the more related variety between foreign and local industries in the city, and we hypothesize that urban centres benefit most from such related variety.

Following Boschma and Iammarino (2009), the index is defined as follows, for each three-digit sector, for each city. First, we calculated the three-digit domestic capital share of domestic capital as a weighted index; then we calculated the entropy index of the foreign capital share from the other three-digit industries within the same two-digit industry; then we multiplied the entropy index and the weighted index of each three-digit industry and summed the product for each city. We supposed that each domestic three-digit industry can learn from other foreign three-digit industries within the same two-digit industry, because cognitive distance is neither too large nor too small in such circumstances. Local sectors can learn from the related foreign sectors and absorb the external knowledge. The higher the related variety between local and foreign sectors, the greater the learning opportunities for the local sectors in the city.

The indicator was constructed as follows. Suppose three-digit industry i belongs two-digit industry g, i=1,…, n, let $FE_3(i)$ be the foreign investment entropy in three-digit industries other than i, but within the same two-digit industry g. Let p_{di} be the ratio of domestic capital to total capital of three-digit industry i, p_{fi} is the ratio of foreign capital to total capital of three digit industry i. Then FDI related variety index can be defined as:

$$FDVAR = \sum_i FE_3(i) * P_{di}$$

Where

$$FE_3\ (i) = \sum_{i \in g} \left(P_{fi} \ln\left(\frac{1}{p_{fi}}\right)\right) - p_{fi} \ln\left(\frac{1}{p_{fi}}\right)$$

The FDI related variety index measures the relations of three digit domestic industries and other three digit foreign industries within the same two digit industries.

The maps of related and unrelated variety distribution are provided in Fig. 1. Cities with higher related variety are mainly distributed in coastal areas and regions along Yangtze River, especially in the Yangtze Delta regions. In such areas, they have established comprehensive manufacturing systems. Some industrial clusters such as the electronic industrial cluster in Suzhou or transport and communication facilities cluster in Chongqing have established the whole industrial value chain system. Related variety is higher in these clusters than in other regions. The Unrelated variety index is also higher in coastal areas such as the Shandong Peninsula, Yangtze River Delta region and southeast of Fujian; some provinces such as Hunan, Jiangxi and Guangxi in middle southern part of China also have higher unrelated variety indexes. Some cities in the southern part of China have long-standing industrial foundations and diverse sectors although industrial linkages, and hence related variety, are not as

dense as in coastal areas. There is some correlation between related variety and unrelated variety but there are distinct differences. For example, Shenzhen has within the city formed the complete electronic industrial value chain, and sixty percent of manufacturing gross value added consists of the electronic and communication manufacturing industry. Therefore, Shenzhen's related variety index ranks number 1 and it has become one of the most innovative cities in China, but its unrelated variety index ranks 276th out of 364 Chinese prefecture level cities or other administrative units.

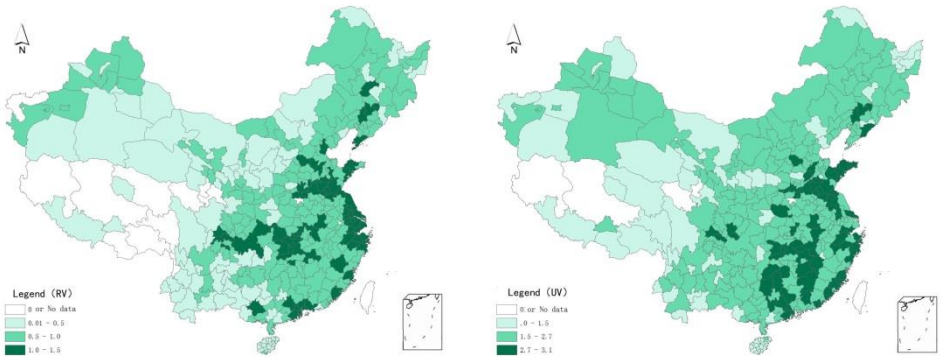

Fig 1 Related variety (left) and unrelated variety (right) distributions in Chinese prefecture level cities (2009)

The FDI related variety index distribution is shown in Fig 2. Higher index cities are mostly distributed in coastal areas, especially in Shenzhen, Shanghai, Wuxi, Foshan, Dalian, and Qingdao. Such cities have attracted more foreign investment and have formed strong linkages between foreign and domestic firms. Foreign owned enterprises are not only expanding markets but also intensifying cooperation with the local value chain system in China. Cooperation covers a wide range from manufacturing supply to product purchase or even joint R&D. Such cooperation is seldom found in middle and western parts of China, where only a few regional central cities such as Chongqing, Wuhan, Chengdu have higher FDI related variety indexes. In other parts of inland China, foreign investment is very limited, the local industrial supporting capabilities are very weak and FDI related variety is correspondingly weak. Therefore, local firms are not able to learn any new knowledge from external relations.

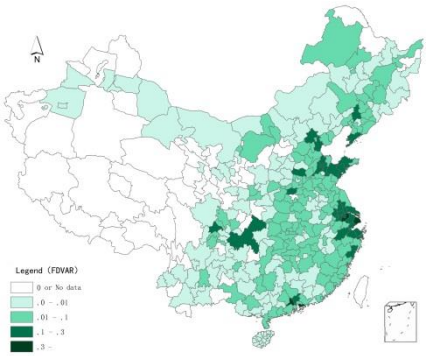

Fig 2 FDI related variety index distributions in Chinese prefecture level cities

(2009)

All the independent variables were measured for each year between 2003 and 2009. Besides the agglomeration economies related variety variables and FDI related variety variables, we controlled for how urbanized economies influence urban growth; we used population density (density) as a proxy to control for the impact of urbanized economies on urban growth, that is, population per square kilometer, and measured in logarithmic form. We expected that the higher the density, the stronger the economic performance (Ciccone, 2002). We also controlled for how labor costs affect urban growth, and introduced the average wage of the prefecture level city in logarithmic form (wage) to measure labor costs, and expected that higher wages may indicate higher local labor quality and thus promote economic performance. In addition a high wage level will raise labor costs and may be a disadvantage to labor intensive sectors but a spur to more capital intensive labour-replacing investment. We also introduced industry structure variables which are proxied by the proportion of manufacturing industry to GDP (ind) and the proportion of tertiary industry to GDP (ter). All variables definition can be seen in table 1.

Table 1 Variables and Definition

variable	Definition
lnpgdp	Per capital gross domestic product
lnemp	Urban employment
RV	Related variety
UV	Unrelated variety
FDVAR	FDI related variety
fdi	Ratio of actual inflow of FDI to GDP
exp	Ratio of export to sales value
lnwage	Average wage of prefecture level city (in logarithmic form)
lndensity	Population density of city (in logarithmic form)
ind	Manufacturing industry output share of GDP
ter	Tertiary industry output share of GDP

The Pearson correlations of dependent variables are shown in Table 2. All variables' correlation is low, except for the correlation between RV and UV. We introduced these variables separately in the estimation.

Table 2 Pearson correlation index among variables

	RV	UV	FDVAR	FDI	exp	lndensity	lnwage	ind	ter
RV	1.00								
UV	0.72	1.00							
FDVAR	0.42	0.21	1.00						
FDI	0.29	0.25	0.24	1.00					
exp	0.37	0.27	0.35	0.43	1.00				
lndensity	0.51	0.51	0.34	0.24	0.36	1.00			
lnwage	0.09	0.00	0.15	0.06	0.11	0.06	1.00		
ind	0.03	-0.17	0.12	0.07	0.10	0.14	0.15	1.00	

ter	0.16	0.25	0.26	0.14	0.16	0.09	0.01	-0.55	1.00

3.3 Regression Results

The main results are shown in tables 3 and 4, where the dependent variables are per capita gross domestic product and urban employment at the city level, respectively. We used panel data to test the hypotheses. The dimensions of the panel used in estimation are T=7 and N=279. The first three columns report the models using OLS, fixed effect and random effect estimations respectively. The Lagrange test selects for fixed or random effects, while the Hausman test selects for fixed effects. Columns 4 - 6 report only the fixed effect results to save space.

Table 3 presents the main results for the dependent variable urban per capita GDP. As the results in columns 1 – 4 show, related variety has a positive and significant effect on urban per capita GDP, while unrelated variety has a significant negative effect on urban per capita GDP. Related variety appears to effectively promote learning opportunities and knowledge spillovers among related industries. However, unrelated variety's portfolio effect on urban growth was not confirmed in the fixed effects models. Generally it seems that unrelated variety did not generate spillovers among industries. Looking at the negative results in the first three models, it may be that unrelated variety gives rise to competition among firms for production factors such as land or infrastructure, which may harm local growth.

The results also confirm the significance of extra-regional linkages on urban growth. FDI related variety (FDVAR) has significant positive effect on urban incomes, which supports our previous expectations. When foreign and domestic sectors are related, external knowledge may effectively increase the urban knowledge base and can be easily absorbed by local enterprises and transformed into economic growth. However, we can conclude from the mixed signs on FDI and export shares (exp) variables that the urban inflow of FDI or trade volumes *per se* would not by themselves increase the local knowledge base and promote urban economic growth. It is more important that they should be related to local sectors and that external knowledge should be different from the local knowledge base; that global and local firms should form a related variety environment.

The signs of the coefficients on control variables are in line with our previous expectations. Average wage levels have significant positive effects on urban growth, meaning that higher quality labor will be beneficial for the economy, but population density does not have a significant positive coefficient in all our estimations, which suggests that, compared with related variety factors, pure urbanization externalities do not necessarily have positive effects on urban growth. The variable of manufacturing industry output shares are significantly positive, while tertiary output shares are negative on urban growth, which means that most cities' development is more dependent on manufacturing industry rather than on services in the industrial age in China.

Table 3 Panel data regression result: Dependent variables, per capita GDP

	(1) OLS	(2) RE	(3) FE	(4) FE	(5) FE	(6) FE
RV	0.558***	0.676***	0.762***	0.707***		
	(0.000)	(0.000)	(0.000)	(0.000)		
UV	-0.138***	-0.156***	-0.132		0.002	
	(0.001)	(0.008)	(0.371)		(0.986)	
FDVAR	1.449***	1.305***	0.230*			0.319**
	(0.000)	(0.000)	(0.085)			(0.046)
Fdi	1.245***	0.678*	-0.414	-0.466	-0.596	-0.584
	(0.005)	(0.071)	(0.297)	(0.257)	(0.145)	(0.162)
Exp	0.236	0.192	-1.995***	-1.965***	-2.239***	-2.225***
	(0.244)	(0.457)	(0.008)	(0.009)	(0.003)	(0.003)
Density	-0.010**	-0.003	0.053	0.055	0.061	0.059
	(0.030)	(0.682)	(0.350)	(0.345)	(0.327)	(0.330)
Lnwage	0.144***	0.126***	0.087**	0.086**	0.098**	0.098**
	(0.004)	(0.006)	(0.018)	(0.021)	(0.012)	(0.012)
Ind	0.043***	0.039***	0.022***	0.022***	0.026***	0.026***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ter	0.025***	0.015***	-0.016***	-0.017***	-0.017***	-0.017***
	(0.000)	(0.002)	(0.001)	(0.000)	(0.001)	(0.001)
Constant	5.254***	5.938***	8.185***	7.973***	8.171***	8.170***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	1,953	1,953	1,953	1,953	1,953	1,953
R-squared	0.390		0.100	0.099	0.090	0.090
Number of code		279	279	279	279	279

Standard errors in parentheses are White corrected for heteroskedasticity.
pval in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4 presents the main results for the dependent variable urban employment (in logarithmic form). The results are similar to those in Table 3 for urban GDP per capita. Fixed effect specifications are selected through Lagrange tests and Hausman tests. The fixed effect estimation results are shown in models 3-5 in Table 4. The results show that related variety has a positive and significant effect on urban employment. That is, having complementarities between sectors has a positive effect on employment. However, unrelated variety does not have a significant effect on urban employment, which suggests that the portfolio effect caused by unrelated variety does not work in Chinese cities. When looking at the effects of extraregional linkages on employment, we can conclude from Table 4 that FDI or exports *per se* do not promote urban employment, but that FDI related variety does. FDI or export ratios have negative coefficients in all models, whereas foreign and domestic related variety (FDVAR) has a positive and significant effect on employment in Chinese prefecture level cities during the period 2003-2010. Therefore, our estimations suggest that being

connected in itself with the global market does not necessarily matter for urban employment. More important is the relationship between the external and the local knowledge bases; when they are related and not totally the same, the related variety between them can create learning opportunities and promote local employment. The result is consistent with our expectations, that FDI-induced relationships can be beneficial for urban employment on condition that they form a related variety environment.

Table 4 Panel data regression result: Dependent variables, employment

	(1) OLS	(2) RE	(3) FE	(4) FE	(5) FE	(6) FE
RV	0.504***	0.357***	0.208***	0.205***		
	(0.000)	(0.000)	(0.001)	(0.001)		
UV	0.233***	0.066	-0.022		0.014	
	(0.000)	(0.169)	(0.637)		(0.765)	
FDVAR	3.051***	0.579***	0.262**			0.286**
	(0.000)	(0.000)	(0.033)			(0.021)
Fdi	0.913***	-0.107	-0.303**	-0.318**	-0.359**	-0.346**
	(0.004)	(0.398)	(0.049)	(0.043)	(0.022)	(0.027)
Exp	-0.491***	-0.650***	-1.315***	-1.318***	-1.391***	-1.384***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Density	0.022***	0.049	0.015	0.017	0.019	0.017
	(0.000)	(0.123)	(0.581)	(0.565)	(0.539)	(0.554)
Lnwage	0.008	0.031***	0.032***	0.031***	0.034***	0.035***
	(0.749)	(0.007)	(0.003)	(0.003)	(0.002)	(0.002)
Ind	0.016***	0.008***	0.008***	0.008***	0.009***	0.009***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Ter	0.026***	0.006***	0.003*	0.003*	0.003	0.003
	(0.000)	(0.004)	(0.083)	(0.093)	(0.117)	(0.124)
Constant	10.196***	11.596***	12.260***	12.226***	12.261***	12.280***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	1,953	1,953	1,953	1,953	1,953	1,953
R-squared	0.558		0.141	0.137	0.127	0.132
Number of code		279	279	279	279	279

Standard errors in parentheses are White corrected for heteroskedasticity.
pval in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4 Conclusions

The paper distinguishes different types of industrial diversity in Chinese cities and explores how they influence urban GDP per capita and employment. We distinguish between related variety and unrelated variety within the city; and then we

go on to identify related variety created through the presence of FDI and investigate how these external linkages affect urban incomes and employment.

Results show that variety *per se* does not affect urban growth, which means that it is not enough to argue simply that urban diversity or Jacobs externalities create urban growth. It is crucial to differentiate between the different types of variety. Following previous studies (Frenken et, al., 2007), we distinguish related diversity and unrelated diversity and test their effects on urban growth. We find that related diversity enhances urban GDP per capita and employment through the mechanism of knowledge spillovers. By contrast, unrelated variety does not effectively promote urban incomes or employment.

The paper is also concerned with how FDI influences urban growth. Although FDI is seen as an important factor influencing local growth, we confirm that only FDI with linkages to local sectors, creating related variety can effectively influence urban incomes and employment. The results confirm that global-local linkages are important factors promoting urban development. However, their positive influence is built on there being a reasonable cognitive distance between the foreign and local knowledge bases; that is, when the extraregional knowledge is related but not the same as that in local industries, intersectoral learning processes across the urban centre can be sustained. Our findings indicate a strong need to specify the nature of urban linkages when investigating their effects on regional growth.

The results have explicit policy implications. Chinese urban governments put great emphasis on promoting industrial output rather than focusing on establishing a related variety environment. In particular, they energetically establish industrial parks or industrial clusters to attract enterprises to settle in the location, rather than focusing on optimizing the development environment through attracting firms within particular industries that have synergies with the local industrial structure. Urban industrial policy should not only avoid specializing on single industries in case of demand shocks, but also should encourage establishing a related variety environment, promoting knowledge learning among related sectors which will stimulate economic growth. When urban governments attract foreign investment, they should encourage investments of a related variety, but not firms that are overly similar to the existing local industrial structure, in order to spark off the intersectoral learning processes within the city and across industries. They should also promote local enterprises' absorptive capacities in order to enhance the learning capabilities of local firms and increase these effects of related variety. It is therefore important that policy-makers recognize the need for more nuanced policy that focuses on creating and nurturing these synergies between particular industrial sectors and between foreign and domestic firms within a particular location, rather than having blanket encouragement for industrial investment and FDI with no heed for these finer but crucial discriminations.

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