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China's development disconnect†

Richard Florida
Rotman School of Management, University of Toronto, Toronto, Ontario M5G 1L7, Canada;
e-mail: florida@rotman.utoronto.ca

Charlotta Mellander
Jönköping International Business School, 553 38 Jonkoping, Sweden;
e-mail: charlotta.mellander@ihh.hj.se

Haifeng Qian¶
Maxine Goodman Levin College of Urban Affairs, Cleveland State University, 2121 Euclid Ave, UR 315, Cleveland, OH 44115, USA; e-mail: h.qian@csuohio.edu

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Abstract. China is currently seeking to transform its economic structure from a traditional industrial to a more innovative, human-capital driven, and knowledge-based economy. Our research examines the effects of three key factors on Chinese regional development in an attempt to gauge to what degree China has transformed from an industrial to a knowledge-based economy, based on higher levels of (1) technology and innovation, (2) human capital and knowledge/professional/creative occupations, and (3) factors like tolerance, universities, and amenities which act on the flow of the first two. We employ structural equation models to gauge the effects of these factors on the economic performance of Chinese regions. Our research generates four key findings. First, the distribution of talent (measured both as human capital and as knowledge – professional and creative occupations) is considerably more concentrated than in the US or other advanced economies. Second, universities are the key factor in shaping the distribution both of talent and of technological innovation. Third, tolerance also plays a role in shaping the distribution of talent and technology across Chinese regions. Fourth, and perhaps most strikingly, we find that neither talent nor technology is associated with the economic performance of Chinese regions. This stands in sharp contrast to the pattern in advanced economies and suggests that the Chinese economic model, at least at the time of data collection, appears to be far less driven by the human capital or technology factors that propel more advanced economies. This, in turn, suggests that China is likely to face substantial obstacles in moving from its current industrial stage of development to a more knowledge-based economy.

Keywords: China, talent, human capital, creative class, tolerance, technology, regional development

Introduction

Over the past three decades China's massive economic growth, rapid urbanization, and expansion of its cities have put it on the world scene. China's economy has grown at an average rate of above 9% per year. In addition, 46.6% of China's population lived in urban areas in 2009, compared with only 17.9% in 1978 (Xinhuanet, 2010), and today China has 118 cities with more than a million people (Xinhuanet, 2010).

The conventional wisdom and a large body of the academic literature (eg, Cai et al, 2002; Chow and Li, 2002; Wang and Yao, 2003) have identified physical capital accumulation as a major source of China's economic growth. China has been presented as a major miracle—the world's factory, producing manufactured goods especially for the developed world. Despite its rapid growth, China ranks 27th on the Davos Global Competitiveness Index (Schwab, 2010) and 89th on the UN Human Development Index (UNDP, 2010).

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¶ Corresponding author.

But another perspective has emerged. The OECD (2008) has noted that China is increasing its innovative capabilities. According to its report, *Reviews of Innovation Policy: China*, the country's R&D spending exhibited an annual growth rate of 19%, and R&D intensity (R&D/GDP) doubled in the decade of 1995–2005. Since 2000 China has had the second-largest number of researchers in the world; however, the productivity of those researchers in publications and patents is low compared with advanced countries. Enrollment in Chinese universities has expanded significantly and the quality of those universities has improved. A growing number of American, European, and Asian multinational companies have opened laboratories and R&D facilities there. According to its Ministry of Science and Technology, China devoted 461.6 billion Yuan to R&D in 2008—ranking fourth in the world. China's economic development has been oriented toward increased human capital and knowledge-based industries. Meanwhile, a top national policy priority has been to build an innovative country. Figure 1 illustrates the growths of human capital and high-tech industries for the period of 1995–2004.

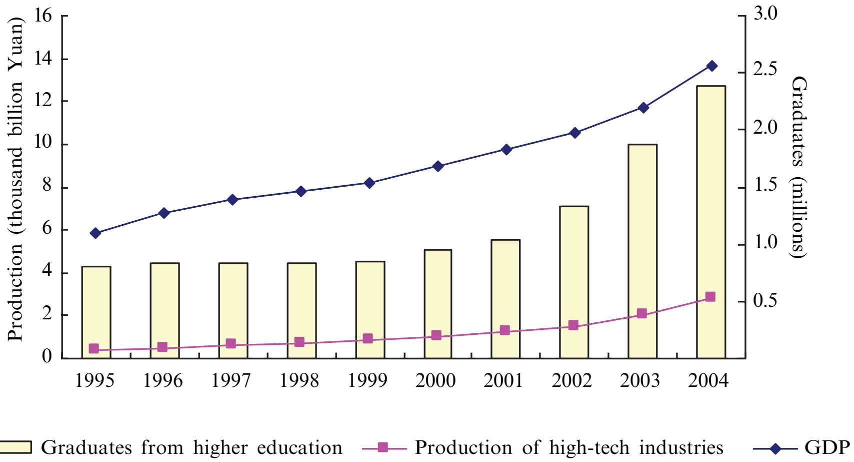

Figure 1. [In color online.] Graduates from higher education, production of high-tech industries, and GDP of China (1995–2004) (source: NBS, 2005a; 2005b).

Scholars have also started to examine innovative activity in China (eg, Sun, 2002; Zhou et al, 2011). This leads to an important and understudied question. We know that cities are key organizing units for knowledge, human capital, creativity, and innovation (Florida, 2002c; Glaeser et al, 1992; Jacobs, 1961; 1969). To what degree have China's rapidly growing cities and regions come to reflect the underlying human capital, technology, and creativity required for innovation-led economic growth? Do China's cities and regions reflect the underlying characteristics associated with the high human capital, creative class, and innovative cities, characteristic of knowledge-based economic development in more advanced economies?

To answer this question, our research looks at the role of three key clusters of factors in economic development. The first of these is technology, long identified by scholars such as Schumpeter (1942), Solow (1956), and Markusen (2004), as shaping knowledge-based economic development and as key to economic development. The second is the effect of human capital or talent, identified in the work of Barro (1991; 1997), Lucas (1988), Jacobs (1969), Glaeser et al (1992) among others. Although there is a general consensus as to the important role played by human capital in regional development, debate has emerged on two key issues. The first involves the efficacy of educational versus occupational measures of talent. In this study we use both. This brings us to the third, somewhat more contentious, factor. Recent research has argued that there are other place-based factors which shape the distribution both of technology and of human capital. Florida et al (2008), in particular, argues that these are better conceived less as stocks and more as flows. We examine several factors that have been shown to affect the distribution of technology and human capital in studies of advanced economies: universities (Anselin et al, 1997; Cheshire and Magrini, 2000; Florida et al, 2006), consumer amenities (Glaeser et al, 2001; Roback, 1982), and openness, diversity, and tolerance (Florida et al, 2008; Mellander and Florida, 2011; Page, 2007). We now turn to a broader discussion of the theory and constructs which lie behind the effects of these three factors on regional development and which, in turn, motivate our empirical research.

Theories and concepts

Our understanding of the transformation from traditional industrial to knowledge-based economies is based largely on the experience of the advanced nations. A key feature of this study is that it tries to examine this transformation as it is currently occurring in China, a country which is actively developing policies to pursue this transformation. Three key factors have been found to shape such economic transformation.

The first is technology. Initially identified by Marx (Marx et al, 1848) and Schumpeter (1942), Solow (1956) famously isolated the role of technology in the form of the error term, which is associated with productivity gains which cannot be explained by changes related to labor or capital. In other words, he treated technology as an exogenous factor. Romer (1986; 1987; 1990) allowed technology to be explained endogenously. Investment in R&D is thereby seen as a purposeful activity, one which generates technology and productivity improvements.

The second is human capital. Initially identified by Adam Smith (1776) as the fourth factor of production, empirical studies by Barro (1991; 1997) document the role of human capital in national economic development. Following Jacobs (1961; 1969), Lucas (1988) noted that human-capital externalities found in cities are the primary mechanism of economic development. Lucas (1988) let the human-capital factor be embodied in individuals and investments in human capital which generate productivity gains and growth. He also stressed the role of cities as interactive places for human capital: places where knowledge is exchanged and created. By reducing the transaction cost of knowledge generation, cities become engines for economic growth.

The role of cities has also been identified by Jacobs (1961; 1969), who argued that a diversity of firms and individuals is associated with economic growth. She also illustrated the role of the scale and diversity of cities in the generation of new ideas. Anderson (1985a; 1985b) explored the subject of creativity in cities and metropolitan regions historically, stressing the importance of knowledge, culture, and communication in stimulating regional growth.

On the empirical side, Barro's large-scale empirical tests of the human-capital influence on national economic performance (1991; 1997) have been followed by several influential studies, including those of Rauch (1993), Simon and Nardinelli (1996), Simon (1998), and others. Further studies have shown that talent (human capital, or the creative class) can serve as an attractor for the technology industry (Florida, 2002b; Florida et al, 2008; Mellander and Florida, 2011).

The third cluster of factors revolves around those which affect the distribution of technology and of human capital across regions. Economists have typically conceptualized these factors as stocks, but Florida et al (2008) contend that they are more appropriately conceived as flows. A number of key factors have been shown to affect the distribution of human capital and technology. The role of amenities was introduced in a neoclassical framework by Roback (1982). The traditional attractor for households in general is higher living standards, through higher wages or lower living costs. In the Roback context, migration patterns not explained by those two factors could be explained by regional differences in amenity levels. Later, Glaeser et al (2001) suggested that several factors help increase the competitiveness of the city: a variety of consumer services and goods; aesthetical and physical settings; good public services; and transport speed, to make the city accessible. Florida (2002a; 2002b; 2002c) stressed the importance of lifestyle, culture, nightlife, and entertainment as talent attractors. Shapiro (2006) illustrated the importance of quality of life over and above the employment-growth effect of college graduates.

A second approach has focused on the role of diversity and openness. Jacobs (1961) stressed the importance of a diversity of individuals. Quigley (1998) argued that we have a 'taste for variety', and that firm-based diversity is associated with economic growth. The importance of diversity, as expressed in higher levels of tolerance and openness, has been demonstrated by Inglehart and Norris (2003) and Inglehart and Welzel (2005) in the World Value Surveys. They examine the relationship between cultural attitudes and economic development. According to Inglehart, one of the best proxies for tolerance is openness toward gay and lesbian individuals. Studies by Florida and Gates (2001) found a positive relationship between gay concentrations and economic development in the US. Openness and tolerance may also be expressed in relation to immigrants: Florida (2002c) demonstrated a relationship between the proportion of immigrants in a population and regional economic performance. Ottaviano and Peri (2005) showed how diversity, in the form of immigrants, increases regional productivity. Qian and Stough (2011) demonstrated a positive association between cultural diversity and regional innovation. Page (2007) found that diversity leads to better decision making, and that diversity within groups provides new perspectives. Florida (2002a) has also argued that openness and tolerance lead to a lowering of regional barriers to entry.

A third factor with a strong influence on the distribution of human capital is the location of universities, which serve as talent producers. The value of such production depends on the mobility of graduates. If graduates are highly mobile and are insufficiently attracted to the region, universities may become talent exporters. This kind of migration is something which several US regions have experienced, and has been highlighted by Florida et al (2006). When talent is less mobile or is restricted from migrating through various institutions, the role of universities may be of greater importance. In the case of China the local universities are likely to be the key source of regional talent.

It is important to note that there has been a considerable debate over the role of tolerance, openness, and diversity. Clark (2003) suggests that the 'gay index' and regional development relationship only holds for larger regions. Glaeser (2004) shows that the traditional, education-based, human-capital measure outperforms the gay index when examining the change in population between 1990 and 2000. However, Florida et al (2008) suggests that the ordinary least squares (OLS) framework and models are insufficient and do not capture the interactions among the system of factors that affect regional development. Florida (2002c) suggests that all three factors or the '3Ts' must act together as complementaries and not substitutes in order to achieve higher levels of development.

There has also been considerable debate over the work of Florida (2002c). Markusen (2006) questions the creative-class concept, arguing that jobs included in this category have little to do with an underlying creative process but are based on education level. She also questions the causality of talent attracting jobs, which she believes should work the other way around. On the first point, McGranahan and Wojan (2007) use detailed data on skills to reconstruct the creative-class definition. They find the definition to be robust with the exception of a small number of health and education occupations. They further find a substantial correlation between Florida's original and their revised definition and that the basic conclusions hold as well. Research by Florida et al (2008) directly tests the effects of human capital and the creative class on wages and income, and they find that, while human capital has a significant effect on income, the creative class has a more powerful effect on wages. Independent research by Gabe (2009) and McGranahan and Wojan (2007) also suggests that the creative class has a significant effect on wages, controlling for other factors. Kätke (2010) suggests that the use of the 3Ts is far too simplified and would not take, for example, sectorial mix into account, which may affect regional success and innovative potential. Pratt (2008) argues that it is more appropriate to approach creativity through an industrial lens than an occupational one. This is perhaps a step backward. Research by King et al (2010) in Canada, the US and Sweden shows the interaction of industrial and occupational approaches, focusing on the difference and similarities between education-based human capital and the creative class, and the role of the occupational differences within industries. Their conclusion is that occupational structures differ between regions and nations, holding industries constant.

There is also debate over whether or not the creative-class approach applies outside the US context (eg, Lorenzen and Vaarst Andersen, 2009). Boyle (2006) suggests that Florida's ideas may very well apply to the Celtic Tigers, in order to explain migration to Dublin, but that the situation needs more nuances to be fully understood. A similar finding is presented by Houston et al (2008) in an examination of the Scottish regions. Kätke (2010) uses the 3T theories to explain GDP growth in Germany, and finds that industry structures alone will explain as much as industry structures in combination with creative class. Boschma and Fritsch (2009), on the other hand, find that the creative class outperforms the education-based human-capital measure in explaining growth and new-firm formation in Germany. They find that tolerance and openness have strong explanatory power to explain the distribution of the creative class, and that city size will not explain as much. Additional comparative studies show that the creative-class measure outperforms conventional human-capital measures in accounting for regional wages in Sweden (Mellander and Florida, 2011) and The Netherlands (Marlet and Van Woerkens, 2004).

A number of recent studies have examined the role of these factors, individually or in combination, in Chinese regional development. Zhang and Fan (2006) constructed a descriptive indicator system to explain the regional disparity of human capital in China. The system involved four categories of indicators: (1) economic performance; (2) education, science, and education investments; (3) health-system and medical care investments; and (4) communication investments. Jiang et al (2005) mentioned the possible influences of urbanization, universities, amenities, wage levels, and government policies on China's regional talent densities. Their statistical analysis reported significant and positive effects of universities and urbanization on talent distribution. Li and Florida (2006) examined the effects of nonmarket factors on talent production using city-level data and concluded that there was a positive impact of openness on the number of local universities. Qian (2010) analyzed the impacts both of market factors (wages and employment) and of nonmarket factors (universities, amenities, and openness) on China's regional talent stock: the presence of universities was reported to have a strong influence on talent distribution and the effects of openness on talent, innovation, and regional economic performance were also highlighted.

We now turn to our data, variables, and methods.

Model, variables, data, and methods

Model

A schematic picture of our general model of talent, technology, and regional development is provided in figure 2. The model allows us to accomplish several useful analyses. First, it enables us to test conventional human-capital measurements against occupational or creative class definitions. Second, it allows us to isolate the independent effects of talent and technology. The model also enables identification of regional cultural and institutional factors—namely, the presence of universities, level of amenities, and tolerance—as they affect the geographic distribution of talent in the first place. The arrows identify the hypothesized structure of relationships among the key variables.

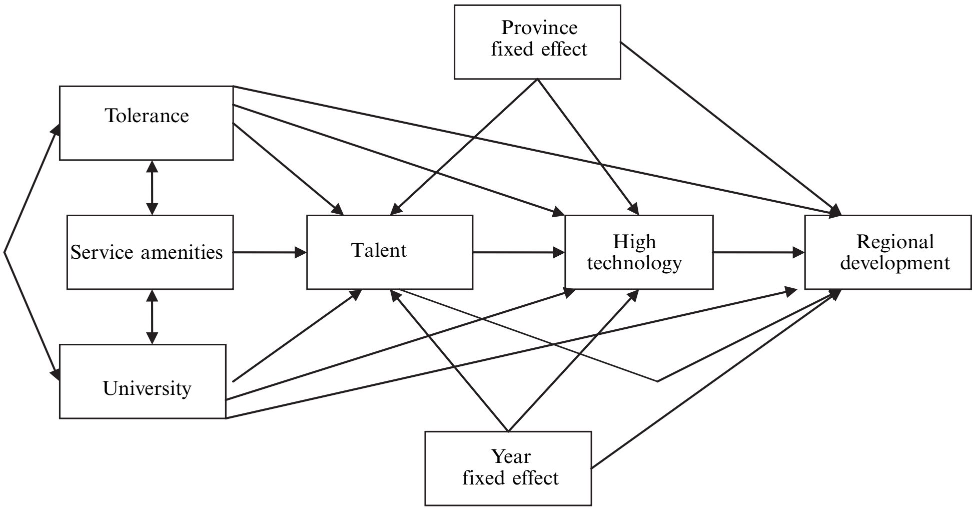

Figure 2. Path model of the regional development system.

Variables and data

We now describe the variables and data used in the empirical model. Our analysis covers all provincial-level regions in mainland China except Tibet (which is generally considered an outlier) for the years 2001–05, resulting in 150 (30×5) observations. Descriptive statistics for all measures and variables are provided in table 1.

Dependent variable: regional development

Gross domestic product (GDP) is the most widely used indicator for economic performance. In China, GDP is the single most important indicator for the promotion of local officials, and GDP statistics are available at all the jurisdictional levels above counties. Accordingly, and we use 2001–05 GDP per capita (all in 2001 constant values) as the measure of regional economic performance.

While some researchers use population or job growth as measures of development, these measures fail to control for the quality of development and productivity. Not all jobs are created equal: some pay better than others. Regions increasingly specialize in different kinds of economic activity, and therefore different kinds of jobs (Markusen, 2004; Markusen and Barbour, 2007). By 'regional development', we mean the overall level of development and living standards underlain by productivity. Although GDP per capita is not a perfect measure of overall standards, it remains a reasonable proxy for regional development.

Table 1. Descriptive statistics.

	Observations	Mean	Standard	Minimum	Maximum
Regional institutional and cultural factors					
University	150	1.701	1.315	0.400	7.800
Tolerance	150	0.108	0.070	0.025	0.400
Service amenities	150	1.007	0.148	0.742	1.500
Talent					
Human capital	150	7.087	4.310	2.210	26.280
Creative class	150	3.490	1.631	1.960	11.750
Technology					
High technology	150	0.026	0.026	0.001	0.128
Patents	150	11.033	15.528	1.299	97.434
Regional development					
GDP per capita	150	12 140	8 754	2 893	48 490

Note: The data in this paper, except where specifically noted, are from *China Statistical Yearbook* (NBS, 2002–06a).

Independent variables

Talent

Talent can be understood as human capital or as the creative class. Earlier studies (Florida et al, 2008; Mellander and Florida, 2011) have shown that the traditional human-capital measure based on educational levels and the creative-class measure based on occupational tasks perform differently. As a result, we employ two different talent measures: we measure 'human capital' as those graduating with a college or higher-level degree, standardized by the local population aged 15 years or older; and we measure the 'creative class' as the proportion of certified professional and technical workers (*zhuanye jishu renyuan*) within the local population aged 15 years or older. Since specific occupational data are not available in China, an exact replication of the measurement methodology employed by Florida (2002c) is not possible. However, China's zhuanye jishu renyuan mirrors Florida's creative class to a large extent. Zhuanye jishu renyuan includes scientists and engineers, university professors, teachers, agricultural and sanitation specialists, aviators and navigators, economic and statistical specialists, accountants, translators, librarians, journalists, publishers, lawyers, artists, broadcasts, athletes, etc. Both the human-capital and the creative-class measures are based on 2001–05 data. Data for zhuanye jishu renyuan are available from the *China Labor Statistics Yearbook* (NBC, 2002–06c).

Technology

Since technological innovation is most likely to occur in high-tech industries, we have defined 'high technology' as the proportion of value added in high-technology industries to GDP. In China, the high-tech industries are officially defined as electronic and telecommunications, computers and office equipment, pharmaceuticals, medical equipment and meters, and aircraft and spacecraft. The high-tech value-added data (2001–05) are available from *China Statistical Yearbook on High Technology Industry* (NBS, 2005–07b).

However, the high-tech industries are not necessarily high-tech based. In China, less than 5% of the value added in the high-tech industries is used for R&D expenditure—much lower than in most developed countries. To evaluate regional technology and innovation better, we have used officially approved patents per 10 000 population (2001–05) as a supplementary measure. In China three types of patents are granted:

inventions; utility models; and designs. Innovation can be measured either from the input side, such as R&D expenditures, or from the output side, such as patents. The output side is more reliable because high input does not necessarily lead to high output.

Universities
Universities are where most talent is produced. Regions with more universities and university students possess potential advantages in talent attraction, providing they can retain graduates. University students are often reluctant to seek a job in other places after graduation due to their well-established local network and the costs of adapting to a new environment. In China, institutional barriers (in the form of the inhabitant registration, or *Hukou* system) further prevent the flow of university students. As a result, the university is hypothesized to play an exclusively important role in China's talent distribution. This is measured by the number of university students per 1000 local population (2001 – 05).

Amenities
The term 'amenities' in this paper refers to service amenities, as measured by the 2001 – 05 location quotient of urban employment in the tertiary sector, including: wholesale and retail trade, catering services; finance and insurance services; real estate trade; social services; health care, sport and social welfare; and education, culture and arts, radio, film, and television.

Tolerance, diversity, openness
Most research uses the diversity index, or gay index, to measure tolerance/diversity/openness (Florida, 2002a; 2002b; 2002c; Florida et al, 2008; Mellander and Florida, 2011). Not surprisingly, statistical data on gays are not available in China. Following Qian (2010), we have adopted the 'Hukou index' as a proxy for openness. In the case of China, it is a compelling measure—perhaps better than the gay index. The rules of Hukou (or the inhabitant-registration system) are used by the central government to control internal migration. The system determines which city or county a person belongs to and whether she or he has 'rural' or 'urban' status. Those with a locally registered Hukou are always permanent residents and receive local economic, social, and political benefits, such as social welfare, education, and voting rights. Those who live in a jurisdictional area for which they do not have local Hukou, in contrast, are always 'marginal' workers or visitors. If a large proportion of an area's population is without a locally registered Hukou, this indicates that a large proportion of the population is from outside the region. The Hukou index of openness is defined as the proportion of the population without a locally registered Hukou (2001 – 05). Accordingly, the higher the Hukou index, the more open the region.

Methods
Following our previous work (Florida et al, 2008), we used path analysis and structural equations to examine the relationships between variables in the model. Structural equation models (SEMs) may be thought of as an extension of regression analysis and factor analysis—expressing the interrelationship between variables through a set of linear relationships, based upon their variances and covariances. In other words, structural equation modeling replaces a (usually large) set of observable variables with a small set of unobservable factor constructs, thus minimizing the problem of multicollinearity [for further technical description, see Jöreskog (1973)]. The parameters of the equations are simultaneously estimated by the maximum-likelihood method. For the analysis we employ a panel dataset for thirty regions over a five-year time period. We assume this is a pooled dataset, controlling for time and province fixed effects.

It is important to stress that the graphic picture of the structural model (figure 2) expresses direct and indirect correlations, not actual causalities. Rather, the estimated parameters (path coefficients) provide information on the relations between the variables. Moreover, the relative importance of the parameters is expressed by the standardized path coefficients, which allow for interpretation of the direct as well as the indirect effects. We do not assume any causality among the university, tolerance, and service amenities factors but, rather, treat them as correlations.

From the relationships depicted in the model (figure 2) we estimate three equations simultaneously:

$$\begin{aligned}\mathsf{Talent} = {} & \beta_{11}\mathsf{University} + \beta_{12}\mathsf{ServiceAmenities} + \beta_{13}\mathsf{Tolerance} + \beta_{14}\mathsf{Year} \\ & + \beta_{15}\mathsf{Province} + e_1 \ ,\end{aligned} \tag{1}$$

$$\begin{aligned}\mathsf{HighTechnology} = {} & \beta_{21}\mathsf{University} + \beta_{22}\mathsf{Tolerance} + \beta_{23}\mathsf{Talent} + \beta_{24}\mathsf{Year} \\ & + \beta_{25}\mathsf{Province} + e_2 \ ,\end{aligned} \tag{2}$$

$$\begin{aligned}\mathsf{RegionalDevelopment} = {} & \beta_{31}\mathsf{University} + \beta_{32}\mathsf{Tolerance} + \beta_{33}\mathsf{Talent} \\ & + \beta_{34}\mathsf{HighTechnology} + \beta_{35}\mathsf{Year} + \beta_{36}\mathsf{Province} + e_3 \, .\end{aligned} \tag{3}$$

Findings

Table 2 presents a correlation matrix for the major variables. Although bivariate relations tell us little about how these relations hold in a multivariate context, we still include them in order to check for possible collinearity problems in our structural equation modeling. According to this table, the presence of universities has a strong and significant correlation with talent—in terms both of human capital and of the creative class. It also shows a significant relationship with technology and patents. Relatively speaking, the university shows a stronger association with patents than with high-tech industries. This is not surprising, considering that university professors and students form one of the key groups which apply for patents and given the low level of R&D activity in China's high-tech industries. In addition, the university is significantly associated with regional economic performance in terms of GDP per capita. There are no significant correlations between service amenities and any of the other variables. As with the presence of universities, tolerance is significantly associated with talent, technology, and regional economic performance.

A further exploration of the data shows that the thirty provincial-level regions form two clusters, when Xinjiang is excluded as an outlier.(1) One cluster includes Beijing, Shanghai, and Tianjin, showing high levels of talent, technology, and economic performance. Those regions share several distinguishing features. First, they are all municipalities directly under the central government, with the highest political status among provincial-level regions. Second, they benefit from preferential (economic and social) central government policies. Third, they all have a high level of urbanization (with more than 70% of the population living in the cities). These commonalities shed light on the spiky distribution of talent in China.

Most other regions gather as another cluster, showing little connection between talent and economic performance or between talent and technology. This implies that China as a whole is not a talent-driven knowledge economy. Regional innovation and economic performance, where they exist, are likely to rely on something other than

(1) The scatter-plot graphs supporting the discussion here are not included due to space constraints. They are available from the authors upon request.

Table 2. Correlation matrix.

	University	Service amenities	Tolerance	Human capital	Creative class	High-technology	Patents	GDP per capita
University	1							
Service amenities	0.055	1						
Tolerance	0.424***	−0.149	1					
Human capital	0.739***	0.044	0.604***	1				
Creative class	0.566***	0.028	0.626***	0.829***	1			
High-technology	0.484***	0.009	0.489***	0.309***	0.246***	1		
Patents	0.690***	−0.116	0.731***	0.650***	0.585***	0.688***	1	
GDP per capita	0.795***	−0.124	0.762***	0.757***	0.693***	0.566***	0.912***	1
Year [a]	0.594***	0.040	0.019	0.237***	−0.024	0.058	0.131	0.312***
Province [a]	−0.486***	−0.409	−0.472***	−0.402***	−0.394***	−0.407***	−0.504***	−0.578***

*** significant at the 0.01 level (2-tailed).

[a] Fixed effects.

Note: We use the natural logarithm term for all variables in our statistical analysis except for the fixed effect variable.

human capital or the creative class. Even so, the few talent-intensive regions (Beijing, Shanghai, and Tianjin) that make up the first cluster have better technology and economic performance than the others.

Compared with studies by Florida et al (2008) and Mellander and Florida (2011), we can see that the economic geography of talent in China is even more concentrated than in the West. In other words, talent distribution is 'spikier' in China. This may be a result of the contrast between the more market-based economies of the West and a Chinese system in which the government and related nonmarket factors appear to be at least as important as market factors. The enormous political, economic, and social resources brought to bear by the central government render Beijing, Shanghai, and Tianjin unbeatable in attracting talent and high-tech industries and in fostering economic growth. These hard-to-measure government factors have not been incorporated into our model.

Results from path analysis and structural equations models

Model 1: human capital, high technology, and GDP per capita

We now turn to the results of the SEM models and path analysis. Figure 3 and table 3 show the statistical results when talent is measured by human capital. It can be seen that the university holds a significant association with human capital after keeping tolerance and service amenities constant. Tolerance is also significantly associated with human capital. But this relationship, according to the path coefficients, is not as strong as that between the university and human capital. In addition, there is no significant association between service amenities and human capital.

The results are different from those observed in the West. Amenities, which appear to be a significant contributor to human-capital distribution in the US and Sweden (Florida et al, 2008; Mellander and Florida, 2011), are not important in China. This reflects the difference between developing and developed economies. At this earlier stage of development, Chinese talent, while experiencing higher living standards than other Chinese people, does not use quality of life as a key factor in location choice.

The presence of universities plays the leading role in forming regional human-capital stock. This is in line with findings by Qian (2010). According to his study, the university is the single most important factor affecting talent distribution in China, outweighing market and other nonmarket factors. This is also in accordance with findings in the Western context by Berry and Glaeser (2005), Florida (2006), and

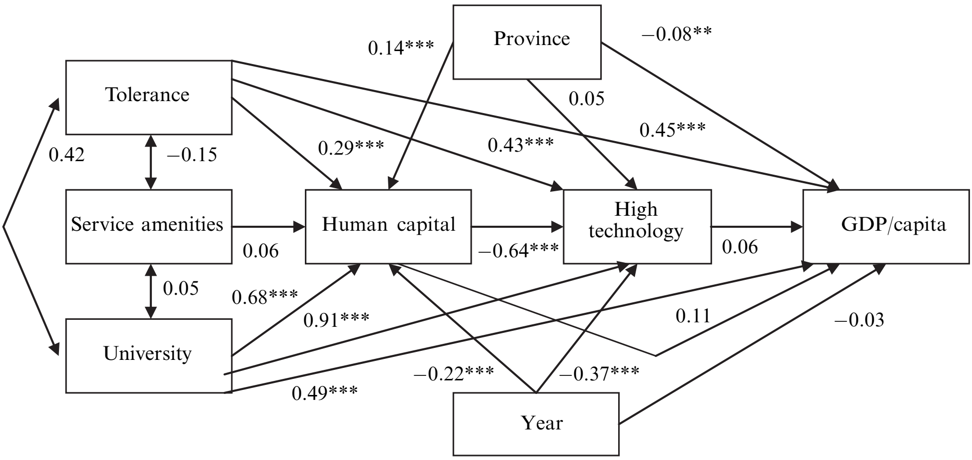

Figure 3. Path analysis for human capital, high technology, and GDP per capita (*** significant at the 0.01 level; ** significant at the 0.05 level).

Table 3. Regression results for human capital, high technology, and GDP per capita.

GDP per capita	Human capital		
variables	talent	high technology	GDP/capital
	equation (1)	equation (2)	equation (3)
Tolerance	0.294***	0.788***	0.470***
Service amenities	0.222		
University	0.583***	1.417***	0.432***
Talent		−1.170***	0.111
High technology			0.036
Year	−0.084***	−0.259***	−0.003
Province	0.009***	0.005	−0.005**
Observations	150	150	150
R^2	0.788	0.524	0.855

*** significant at the 0.01 level; ** significant at the 0.05 level.

Mellander and Florida (2011). Even so, it is reasonable to say that the university is more important in China than in the West. Florida et al (2006) point out that US cities with good university systems do not necessarily retain talent, partially due to labor-market mobility. In China, by contrast, the government controls the local population through the Hukou system. Most employers in big cities, especially in star cities like Beijing and Shanghai, have quotas of local Hukous they can issue. The local university graduates, due to their networks and other advantages in accessing job information, are better able to find and compete for opportunities, and subsequently become locally registered. This process is much more difficult for graduates from outside the local area. Therefore talent in China is much less mobile than in the US. This reinforces the power of local universities in influencing the local talent stock. It also locks in place jurisdictional advantage and prevents efficient allocation of talent or resources.

Even in China, where mobility is restricted, tolerance or openness plays a significant role in the distribution of talent. This is consistent with the research on developed countries (Florida et al, 2008; Mellander and Florida, 2011) and further proves the indispensable role of tolerance in attracting talent.

Similarly, the university and tolerance are significantly associated both with high technology and with GDP per capita. High-tech firms like to locate themselves near universities which provide technologies, scientists, and engineers. It is also possible that open and diversified regions can better attract high-tech industries than can relatively closed and homogenous regions.

Interestingly enough, there are some counterintuitive relationships between human capital, high technology, and GDP per capita, once the university and tolerance factors are controlled for. Human capital exhibits a significant but negative relationship with high technology. While this could in part be a multicollinearity effect, the equilibrium between talent supply and demand is distorted and the market forces 'disappear'. Moreover, unlike in the correlation matrix, the significant and positive associations between human capital or high technology and GDP per capita no longer exist. This is not in line with the empirical results of analysis of developed economies. Why does this happen for China?

One possible explanation, similar to the perspective of Qian and Stough (2012), is that the restriction of population mobility decreases the role of talent in high-tech industries and economic performance. Because of the Hukou system, talent cannot migrate freely to places with high-tech industries. Talent demand by high-tech industries and the supply by talent itself thus cannot reach market equilibriums.

Another possible explanation lies in the characteristics of China's high-tech industries. Those so-called high-tech industries are primarily based on manufacturing, processing, and assembling, rather than on innovation and services. Compared with developed countries, innovative activity in the Chinese high-tech industries is very limited. According to the *China Statistical Yearbook on High Technology Industry* (NBS, 2005b), R&D expenditures in 2004 accounted for 4.6% of the total value added of the Chinese high-tech industries—much lower than the 27% in the US in 2002 and 18.2% in Korea in 2003 (for knowledge economies, this percentage is generally above 20%). With limited innovative opportunities, the link between human capital and high-tech industries is weakened. A negative sign in our results suggests that high-tech firms would rather locate themselves in places with less talent. This is reasonable in that the total costs of production (including, for instance, land-use costs) in those places are likely to be low. Consistent with our results, Wang et al (2010) find no significant relationship between spatial agglomeration of ICT manufacturing and productivity in China.

A third possible explanation is the role of government. Although implementing economic policies of liberalization and decentralization, Chinese governments, both central and local, still exert tremendous influence on economic and social activity. For instance, Beijing is home to the nation's best education institutions and health systems, which serve as talent magnets, and benefits considerably from housing the central government. National Economic and Technology Development Zones in China are most attractive places for high-tech firms, largely because of preferential policies approved by the central government. Tianjin and Beijing have two of the largest and best such zones in China. Shanghai is home to four such zones and is the only city with more than two. In addition, Shanghai, as the economic center of China, receives economic development support from the central government in all possible forms. The government, to sum up, might affect talent, technology, and economic growth in ways which diminish their intrinsic relationships.

Statistically, the negative relation between talent and technology may be partly a result of the very close correlation between the university and talent. To see whether talent, the university, and tolerance include the same information, we ran an OLS separately, letting high technology be explained by these three variables, including a variance inflation factor (VIF) test for multicollinearity. The VIF values are distributed between 1.6 and 2.8, indicating that, to some extent, they do include the same information. But with values less than 5, we concluded that they did not include identical information. Instead, to explore further the relation between talent and innovation, we substituted patents for high technology in the original model.

According to the results shown in figure 4 and table 4, the relationship between talent and patents is still negative and significant. Consistent with our explanation for the high-technology case, patents in China are not necessarily innovation based. As mentioned above, patents consist of three types: inventions; utility models; and designs. Inventions, which are the most likely to be innovation based, accounted for only 12% of the total number of patents in 2004. In contrast, the less innovation-based utility models and designs represented 46% and 42%, respectively. However, patents have a stronger explanatory value in relation to GDP per capita.

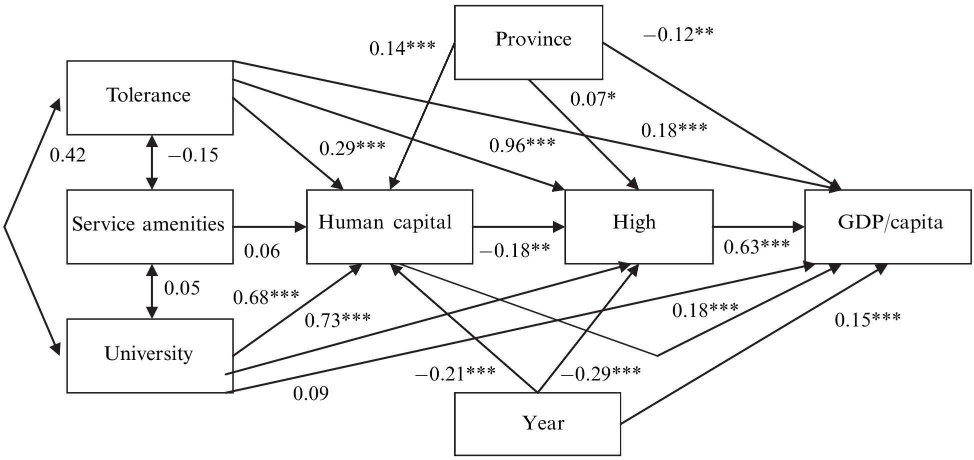

Figure 4. Path analysis for human capital, patents, and GDP per capita (*** significant at the 0.01 level; ** significant at the 0.05 level).

Table 4. Regression results for human capital, patents, and GDP per capita.

GDP per capita variables	Human capital talent equation (1)	patents equation (2)	GDP/capital equation (3)
Tolerance	0.294***	0.965***	0.192***
Service amenities	0.222		
University	0.583***	1.272***	0.079
Talent		−0.363**	0.184***
Patents			0.318***
Year	−0.084***	−0.229***	0.061***
Province	0.009***	0.009*	−0.008***
Observations	150	150	150
R^2	0.788	0.815	0.928

*** significant at the 0.01 level; ** significant at the 0.05 level; * significant at the 0.1 level.

To make sure that this result is not driven by outliers, we reran this path/SEM, excluding the very obvious outliers of Beijing and Shanghai. The negative significant relation between human capital and high technology still holds (see figure 5 and table 5).

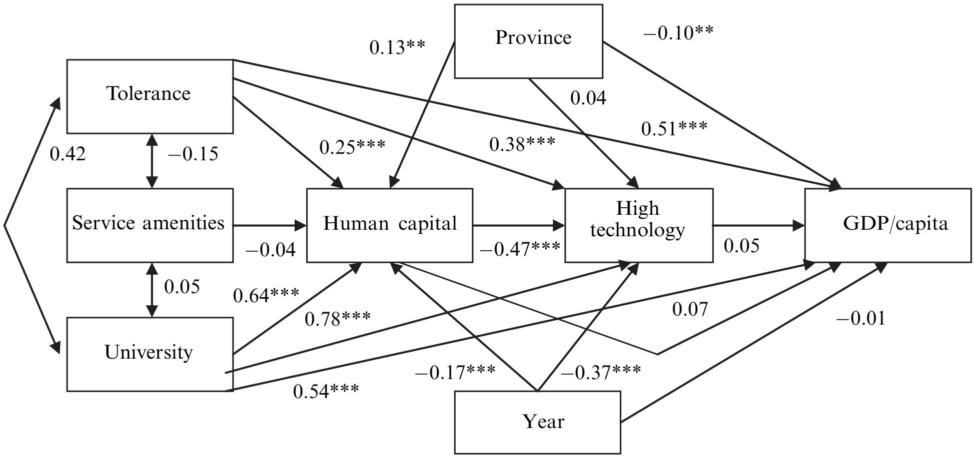

Figure 5. Path analysis for human capital, high technology, and GDP per capita, excluding outliers (*** significant at the 0.01 level, ** significant at the 0.05 level).

Table 5. Regression results for human capital, high technology and GDP per capita, excluding outliers.

GDP per capita	Human capital		
variables	talent	high technology	GDP/capital
	equation (1)	equation (2)	equation (3)
Tolerance	0.210***	0.816***	0.507***
Service amenities	−0.114		
University	0.442***	1.416***	0.448***
Talent		−1.217**	0.007
High technology			0.021
Year	−0.046***	−0.262***	−0.005
Province	0.006**	0.005	−0.006***
Observations	140	140	140
R^2	0.596	0.518	0.803

*** significant at the 0.01 level; ** significant at the 0.05 level.

The role of high technology in relation to GDP per capita does not change with the exclusion of outliers: again, it is not significant. The association between tolerance and talent remains at approximately the same level. Tolerance also remains important for high technology and GDP per capita. The university still plays a significant role in relation to high technology as well as in relation to GDP per capita. In summary, the key relations still hold after excluding outliers: the university and tolerance are still significantly associated with human capital, high technology, and GDP per capita; and the relationships between human capital, high technology, and GDP per capita are again counterintuitive. We also reran these regressions, substituting patents for high technology and excluding the outliers: the relationship between talent and patents remained negative and significant.

Model 2: creative class, high technology, and GDP per capita

Earlier research (Florida et al, 2008; Mellander and Florida, 2011) has shown that talent, when viewed in the form of the creative occupations, may reveal a different role in this economic context. Therefore, we substituted the creative class for human capital, and reran the same regressions as for model 1 above. The results are presented in figure 6 and table 6.

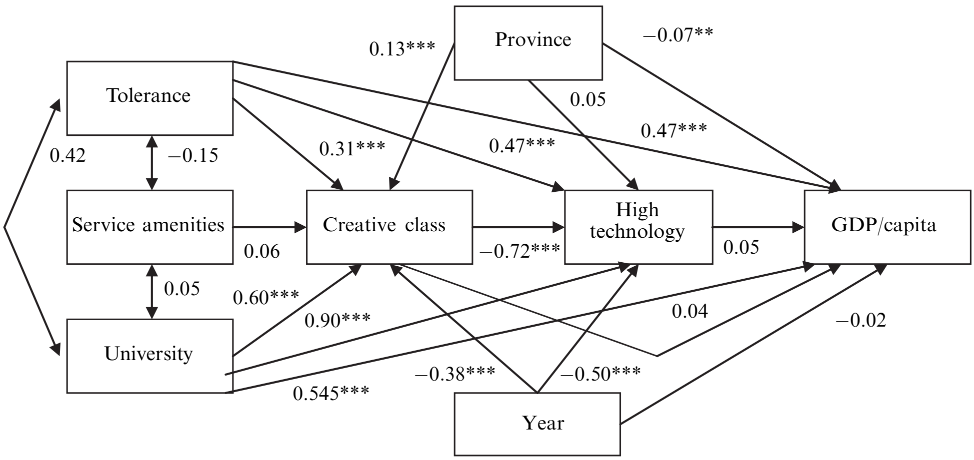

Figure 6. Path analysis for creative class, high technology, and GDP per capita (*** significant at the 0.01 level; ** significant at the 0.05 level).

Table 6. Results for creative class, high technology, and GDP per capita.

GDP per capita	Creative class		
variables	talent	high technology	GDP/capital
	equation (1)	equation (2)	equation (3)
Tolerance	0.246***	0.816***	0.493***
Service amenities	0.172		
University	0.391***	1.403***	0.483***
Talent		−1.704***	0.052
High technology			0.028
Year	−0.113***	−0.353***	−0.008
Province	0.006***	0.006	−0.005**
Observations	150	150	150
R^2	0.776	0.553	0.854

*** significant at the 0.01 level; ** significant at the 0.05 level.

The effects of the university, service amenities, and tolerance on the creative class here follow a similar pattern to human capital. The university is again the dominant factor in the distribution of the creative class. The university and tolerance are still significantly associated with both high technology and GDP per capita. As with human capital, the creative-class variables are negatively and significantly associated with high technology.

As in the human-capital case, we substituted patents for high technology in an effort to get closer to innovation. The significant and negative relation between the creative class and innovation is still negative and significant (as shown in figure 7 and table 7).

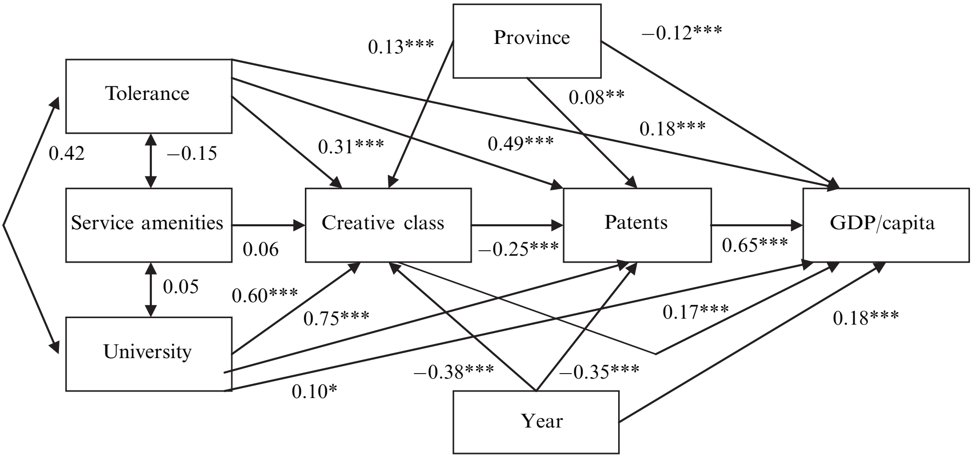

Figure 7. Path analysis for creative class, patents, and GDP per capita (*** significant at the 0.01 level; ** significant at the 0.05 level; * significant at the 0.1 level).

Table 7. Regression results for creative class, patents, and GDP per capita.

GDP per capita	Creative class		
variables	talent	patents	GDP/capital
	equation (1)	equation (2)	equation (3)
Tolerance	0.246***	0.020***	0.185***
Service amenities	0.172		
University	0.391***	1.323***	0.092*
Talent		−0.670***	0.223***
Patents			0.325***
Year	−0.113***	−0.274***	0.072***
Province	0.006***	0.010**	−0.008***
Observations	150	150	150
R^2	0.776	0.823	0.927

*** significant at the 0.01 level; ** significant at the 0.05 level; * significant at the 0.1 level.

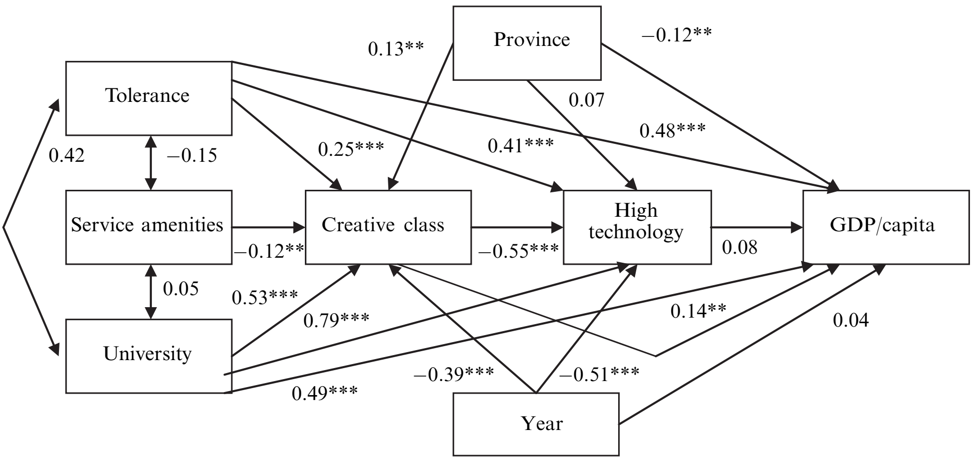

Figure 8. Path analysis for creative class, high technology, and GDP per capita, excluding outliers (*** significant at the 0.01 level; ** significant at the 0.05 level).

Table 8. Regression results for creative class, high technology, and GDP per capita, excluding outliers.

GDP per capita	Creative class		
variables	talent	high technology	GDP/capital
	equation (1)	equation (2)	equation (3)
Tolerance	0.156***	0.909***	0.474***
Service amenities	−0.252**		
University	0.272***	1.439***	0.403***
Talent		−1.953***	0.229***
High technology			0.036
Year	−0.078***	−0.368***	0.014
Province	0.005**	0.008	−0.006***
Observations	140	140	140
R^2	0.625	0.559	0.807

*** significant at the 0.01 level; ** significant at the 0.05 level.

This is in line with what occurred when patents were substituted for high technology in the human-capital model.

To rule out the possibility that the results are driven by a few outliers, we corrected for this, and reran the same regressions without the most extreme outliers, Beijing and Shanghai, as we did in the human-capital case. Without the outliers, the connection between the creative class and high technology remains negative and significant and so do the roles of the university and tolerance (see figure 8 and table 8). The relationship between high technology and GDP per capita remains insignificant. We also reran the regressions with the outliers excluded and patents substituted for high technology. Here again, the relation between the creative class and patents remains similar.

Discussion

Our research has examined the effects of three key factors—technology, talent, and tolerance—on Chinese regional economic development. We used path analysis and structural equation approaches and established a three-stage model. In the first stage we explored the institutional and cultural factors affecting the distribution of talent. Second, we examined the impact of talent distribution on regional technology. Third, we investigated the effects of the university, tolerance, talent, and technology on regional economic performance. Our path/SEM model allowed us to test for the direct, indirect, separate, and joint effects of those factors on regional economic performance, while minimizing the problem of multicollinearity.

To achieve solid conclusions, we used two different measures for talent (human capital versus the creative class) and two variables for technology (high-tech value added versus patents), and we examined the effects of outliers. No matter how we changed the model, the different path/SEM analyses produced four general findings. First, we found the distribution of talent in China to be very concentrated—more so than in the US or other advanced economies. Second, we found universities to be the key factor in shaping the economic geography both of talent and of innovation in China. Universities not only supply educated talent to the region, but also produce new knowledge and technology through their professors, scientists, and even students. However, university graduates do not necessarily stay put. A region's ability to retain and attract talent plays an even more important role in determining its talent stock. In China, mobility restrictions imposed by the inhabitant-registration (Hukou) system make talent migration more difficult than in the West. Thus in China the region finds it easier to retain local university graduates. This indicates that the university is even more important for talent concentration in the Chinese context.

Third, we found a reasonably strong association between our variables for tolerance/openness/diversity and both talent (measured as human capital or the creative class) and our technology measures. This pattern is similar to that for advanced nations. Although not as powerful as the effects of the university variables, tolerance is an additional significant factor in the distribution of talent across China's regions. Tolerance is likely to increase educational and occupational skill in a region by lowering the barriers to entry for talented people across gender, race, and sexual orientation. A tolerant and open social climate also nurtures new knowledge and entrepreneurial activity which, in turn, underpin innovation-based economic growth. To build a knowledge-based creative economy, China will have to recognize the role of such social factors, and further socially 'emancipate the mind' (*jiefangsixiang*).

Fourth, we found a weak relationship between talent (measured as human capital or the creative class) and innovation and regional economic performance. This is in many ways our most interesting, if counterintuitive, finding. It suggests that the Chinese system has not yet made the transition from an industrial to more knowledge-based model. And it stands in some contrast to China's stated efforts to invest in R&D and talent to promote domestic innovation. To gain competitiveness, high-tech firms generally invest tremendous resources in R&D and require plenty of talent to perform innovative activity. In China, however, R&D expenditures in high-tech industries are very low compared with those in advanced nations. Also, most patents granted in China tend to be of the less innovation-based, utility model and design, varieties. Without mature platforms for innovative activity, the Chinese talent pool, though growing rapidly, makes only a limited contribution to technological and economic development. Furthermore, even if high-tech firms have a high demand for talent, they may not be able to recruit what they need, since the spatial supply and demand of talent have been distorted by the government. China's inhabitant-registration system prevents talent from migrating to locations where its utility can be maximized. The government also intervenes in the talent market by bestowing upon a few regions, such as Beijing and Shanghai, enormous social, economic, and political resources. This has hyperconcentrated human capital and the creative class in these places. These regions are obviously talent-intensive, but not necessarily knowledge based.

It is nonetheless intriguing that tolerance matters to the distribution of human capital and of technology in China, even at the same time as human capital and technology are not associated with regional economic performance. We find this perplexing. Openness and universities are shaping the distribution and concentration of talent and technology. Talent and technology are more concentrated than in the US or in advanced economies. Yet human capital and technology do not turn out to be important factors in regional growth. It may be that, even though China is not yet a knowledge economy, the highly concentrated and uneven distribution of human capital sets it up to pave the road ahead for this transformation later on.

Despite its efforts to build an innovation-based economy, China remains a developing country, with a different industrial and urban structure, and the country has long restricted internal migration. Generally speaking, our empirical results suggest that China is likely to have quite some way to go before it makes the shift from the industrial stage to the knowledge/human-capital/creative stage of economic development.

In our research we have tried to frame empirically some of the key issues affecting regional development as China seeks to move from an industrial to a knowledge-based economy. We hope that our findings and approach encourage additional studies of the connection or disconnect between talent/human capital, innovation, and economic performance in China. The relationship between amenities and talent, which is insignificant in our results and thus inconsistent with the literature, also deserves further exploration with improved measures for amenities.

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