An investigation of the relationship between library services and sustainable economic growth

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ABSTRACT

It is well known that knowledge is the source of modern economic growth, but the roles of library and information services on sustainable economic growth had not been well established. Thus, a case investigation was designed to identify the roles of library services in public libraries with the population, education, and income as a comparison on sustainable regional economic development. Such an investigation was based on organically combining correlation calculation, principal component calculation, and linear regression calculation. Results prove that some library services in public libraries have the highest contribution to the first principal component. It also demonstrates that the first principal component explains 85.0%, 95.0%, and 64.2% of the variation in the normalized gross regional products of Jiangsu Province, Hunan Province, and Gansu Province in China, respectively. Library services in public libraries, the population, education, and income appear to have a similarly important effect on sustainable regional development. Component score coefficients and linear relationships between the principal components and regional gross regional product can be used together to investigate the relationship between library services and sustainable economic growth. The proposed method provides new ideas for evaluating the roles of library services in sustainable economic growth.

Keywords: Public libraries; Library services; Sustainable development; Economic growth; Knowledge society.

INTRODUCTION

Sustainable development was defined as "that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission Environment Development 1987). One key component of poverty eradication is "knowledge transfer to developing countries" and technology (technology is knowledge) transfer is important for sustainable development (United Nation 2002). Sustainable development might be described by the complex interrelationships between the natural and social spheres (Kinzig et al. 2000). An accelerated and sustainable economic growth requires organizations to make proper managerial decisions and realize actions and behaviour by obtaining the necessary knowledge at a high-quality level and using it with maxim effectiveness (Sîrbu, Doinea and Mangra 2009). All these imply that knowledge is the basis of sustainable development. At the same time, new principles, methods, and tools should be applied in the modern regional management system. Foresight technologies are valid for optimizing the system of regional management for sustainable

development.

The society can be treated as a system of exchanges that is a transaction in which both the parties who make the exchange are benefited (Knight 1856). The growth of knowledge in societies is one of the central themes of economic change through whole human history. One can note that discoveries, inventions, and scientific breakthroughs are the most exciting works in economic history. At first glance, the relationship between economic performance and knowledge seems obvious. In short, technology is knowledge, even if not all knowledge is technology (Mokyr 2002). It is well known that a person having scientific and technical knowledge in modern societies means that he has the ability to act 'capacities for action'. Knowledge is believed to be the most powerful engine of production. And the importance of knowledge for economic evolution and competitiveness has been underlined by some economists. (Glückler, Meusburger and El Meskioui 2013). Thus, the term "useful knowledge" as the source of modern economic growth has been proposed (Kuznets 1966). In all cultures, knowledge, ideas, and growth had been central to argue economic and political thinking. Knowledge society asserts (one theory of modern society) believes that modern societies are becoming more and more dependent on the production, dissemination, and use of knowledge. The action of scientific and technical knowledge needs knowledge workers (Stehr 2007).

The qualities of government and institutions are widely believed to be important to provide incentives for economic agents to create and diffuse knowledge although such factors are often difficult to measure directly (Fagerberg and Srholec 2013). It implies that there might be no straightforward relationships between knowledge and economic development. A dozen thought-provoking monographs that are directly related to the nature of the technological change to economic growth have been proposed (Mokyr 2016).

Educational institutions and libraries are such institutions for diffusing knowledge. Knowledge can be transmitted to a person in schools and libraries. As the primary source of knowledge, the effect of educational achievement on economic performance has been studied since the sixteenth century. The level of education could exert a very high impact on regional growth (Romão and Neuts 2017). The share of the adult population with tertiary education in value-added emerges as one of the most effective factors enhancing regional economic growth (Sterlacchini 2008). One can note that the younger generation learns knowledge from schools (Swain 2005). On the other hand, public libraries are libraries that are accessible by the general public, which is an organization that satisfies the knowledge, information, and document needs of the general public (Smith and Wong 2016; Sweeney 1994) and offers reference and information services (Sharma 2013). Public libraries are the only publicly funded cultural institutions with a broad social reach. Public libraries via the development and maintenance of publications provide information to any people. Now, most public libraries provide all forms of information via online information retrieval. To convince the funders and the clients that the service is delivering the benefits and to ensure that the resources are used efficiently and effectively in libraries is the reason why library and information services need evaluation (Blagden and Harrington 1990; Crawford 2006; Liu 2007). Because libraries can provide knowledge and satisfy the lifelong learning needs of people, knowledge can help people to achieve sustainable economic development. Therefore, the study of the practice of library services is a rewarding source of insight into the workings of the library and its possible futures because the library services could be the variant of library activity that most fully reveals their power.

Both quantitative and qualitative methods have been used to evaluate library and information services in the aforementioned studies. The quantitative method is the focus

of this paper. For quantitative methods used in the evaluation, survey work is the most widely used method whose data have been mostly collected via the questionnaire (Crawford 2003). Servqual Method is a descriptive method that had been used to identify the quality and effectiveness of the library services (Made 2018). The assessment of library services can be performed by using the quality management model (Mofrad et al. 2016). Net promoter score has been used to evaluate library services in Finland (Juntumaa, Laitinen and Kirichenko 2020). A monetary expression of the utilizable value of cultural services had been considered in the evaluation of library services (Throsby 2003). Researchers show that the output of public service can be defined for the economic evaluation of library services (Aabø 2005). The contingent valuation method that can be used to calculate the average user-assessed value of access has been used in economic studies on the value of public libraries (Cummings and Taylor 1999; Stejskal and Hájek 2015). Methods of determining the economic value of public services can be further divided into two groups based on monitored services and library performance (Missingham 2005). The "study of efficiency" or the study-oriented on output is the first group, which determines values based on operational efficiency in the management via analyzing cost and demonstrating the outputs reached with a used cost. The study of the social value or the justification of the library services is the second group, where the balanced scorecard method and contingent valuation method have been used via cost-benefit analysis application or "return on public investment" calculation (Carson 2012; Lee and Chung 2012). Most of these methods are based on a survey-based technique to estimate the value. This is because it is very difficult in measuring the output values of library services. Economic impact analyses usually are insufficient for evaluating the economic value of library services and thus specific analytical methods are needed (Linhartová and Stejskal 2017).

It is well known that "useful knowledge" is the source of modern economic growth, but few studies have been conducted to investigate the relationship between library and information services and economic development by statistical methods. It is difficult to directly measure the quality of the knowledge services (Fagerberg and Srholec 2013). This implies that the relationship between library services (information services) and sustainable economic growth has not been well clarified. The primary objective of this study was to quantitatively describe how library (information) services interact with sustainable regional economic growth. In detail, the relationship has been statically analyzed based on the data for the public libraries of three provinces in China and their economic development data in recent years. Additionally, if cleaning data is not considered, principal component analysis cannot be used for personalized optimization (Zhao et al. 2017). Therefore, the variable has been selected according to the correlation with sustainable economic growth. In other words, the input data will be cleaned when there is no significant correlation between the input data and the data of economic growth. Based on these calculations, personalized optimization can be done by using principal component analysis and the weight of a given variable on the economic growth can be calculated by the multivariate regression method.

The core of developing the research framework of this paper is how to overcome the shortcoming of principal component analysis, that is, it is impossible to make individual optimization, so it is the key to use the correlation coefficient between the target data and the input data to clean the variables. Secondly, the multivariate regression method is used to calculate the contribution of input data to the target data. The data used in this paper have been obtained from the National Bureau of Statistics of China (http://data.stats.gov.cn). Considering modern societies are becoming more and more

dependent on the production, dissemination, and use of knowledge, a new investigation method studying the roles of library services on sustainable economic growth could be developed based on the combination of correlation analysis, principal component analysis, and multivariate regression methods.

MATERIALS AND METHOD

To check generating theories and hypotheses, it is very important for using data in testing those generating theories and hypotheses. To test most hypotheses, two variables (a proposed cause and a proposed outcome) need to be measured. Variables are things that can vary. After the data of the research have been collected, it is to analyze the data that involves both seeing what the general trends in the data are via graphical data and also fitting the data by using statistical models.

Many researchers study issues in the social sciences by using mathematical methods and statistic models, for example, regression and component analysis are so important and frequently used in social science research (Bowden 2018; Fox 2018; Melnik 2015; Mukherjee, Sinha and Chattopadhyay 2018; Nesselroade and Grimm 2019; Strawinska-Zanko and Liebovitch 2018; Warne 2017). The principal component analysis, a mathematical method, can help us find relationships between two variable sets (a cause variable set and an outcome variable set) that have been collected for an issue in societies. For example, the relationships between some pre- and post-slaughter traits of broilers have been investigated by principal component analysis (Mendes 2011); the relationship between academic performance, substance use, sleep quality and risk of anxiety and depression in young adults have been investigated by principal component analysis (Begdache et al. 2019); principal component analysis has also been used for early disease detection (Karouzakis et al. 2018; Papi and Caracciolo 2018); principal component analysis has also been used for analyzing the performance of semiconductor devices (Fadhel et al. 2019); principal component analysis has also been used to get socio-economic impact (Ali, Shang and Saif 2018); principal component analysis has also been used to predict ozone concentrations (Sousa et al. 2007).

For the analysis, the data of libraries, education, population, and economic development based on the annual data in recent years that come from the website of the National Bureau of Statistics of China (http://data.stats.gov.cn) was analyzed.

Firstly, the correlation between library activity (library services) and regional economic development compared to the case with the education and the population. According to these references (Fox 2018; Ho 2018; Melnik 2015; Strawinska-Zanko and Liebovitch 2018; Yockey 2017), the Pearson correlation coefficient in statistics for a given paired data (x_i, y_i) is

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}} \tag{1}$$

where $\bar{x} = \dfrac{1}{n}\sum_{i=1}^{n}x_i$ and $\bar{y} = \sum_{i=1}^{n}y_i$.

The Pearson correlation coefficient measures the strength of the linear relationship between two variables. For a positive relationship between these two variables, both variables deviate from their mean value in the same way, whereas one variable deviates from its mean, the other variable should deviate from its mean value in the opposite way. A positive (or direct) linear correlation occurs when 1>r>0, whereas a negative (or inverse) linear correlation when -1<r<0. A total linear correlation occurs when r=1, whereas no linear correlation occurs when r=0.

Secondly, regression analysis is used for estimating the relationships between a dependent variable (outcome variable) and one or more independent variables (predictors). According to the references (Fox 2017; Ho 2017; Melnik 2015; Strawinska-Zanko and Liebovitch 2018; Yockey 2017), the following expression has been used for a simple linear regression in statistics

$$y = a + bx + \varepsilon \tag{2}$$

where x is the independent or predictor variables, y is the dependent variable or criterion variable, a is the y-intercept, ε is the disturbance term or error variable, and b is the slope of the regression line. The regression analysis has been mainly used for prediction and forecasting and to infer causal relationships between the outcome variable and predictors. According to the references (Fox 2017; Ho 2017; Melnik 2015; Strawinska-Zanko and Liebovitch 2018; Yockey 2017), the following expression has been used for a multiple linear regression

$$y = a + \sum_{i=1}^{n} b_i x_i + \varepsilon \tag{3}$$

where b_i is the regression coefficient for the i-th independent or predictor variables, and x_i is the i-th independent or predictor variables.

According to these references (Fox 2017; Ho 2017; Melnik 2015; Strawinska-Zanko and Liebovitch 2018; Yockey 2017), the following expression has been used for multiple linear regression with an interaction term

$$y = a + \sum_{i=1}^{n} b_i x_i + \sum_{i,j=1(i \neq j)}^{n} c_{ij} x_i x_j + \varepsilon \tag{4}$$

where C_{ij} is the regression coefficient for the interaction between the i-th and the j-th independent or predictor variables.

Lastly, the variables are somehow similar, which means that the fluctuation of the variables is "approximately" the same. It has been reported that the multicollinearity problem between the independent variables has a large effect on the prediction of the dependent variable(s) in the regression analysis (Jobson 1992; Sharma 1996). One of the approaches to avoiding such a problem is reported to use principal component analysis (Sousa et al. 2007). The principal component analysis is most widely used to reduce the number of variables and reveal hidden variables, which is the general description of the common variance. If x is a vector of p random variables, define a linear function

$$\alpha_1' x = \alpha_{11} x_1 + \alpha_{12} x_2 + \cdots + \alpha_{1p} x_p = \sum_{j=1}^{p} \alpha_{1j} x_j \tag{5}$$

The first step is to look for $\alpha_1' x$ when the elements x have maximum variance. Next, look for a linear function $\alpha_2' x$ that is uncorrelated with $\alpha_1' x$ having a maximum variance. And

so on, the *k*-th step is finished. $\alpha_k' x$ is the *k*-th principal component. Up to principal components can be obtained. It is hoped that *m* (*m<p*) principal components can explain most of the variation in *x*. This is the key idea that complexity can be reduced by transforming the original variables into principal components. The operation of principal component analysis can be thought of as revealing the internal structure of the data in a way that best explains the variance in the data

RESULTS

Considering the different natural conditions and resources, the Chinese mainland can be divided into three major economic regions (zones): Eastern, Central, and Western regions. The Eastern region plays a leading role in the whole economic development. The Central region is the second echelon of China's economic development. The economic development and technical management level of the Western region are far behind that of the eastern and central regions. For comparison, three provinces from the three economic regions have been chosen as the case study. Jiangsu, Hunan, and Gansu provinces represent the Eastern, Central, and Western regions, respectively.

In the following, firstly what the general trends in the data via data graphically are shown. Secondly, the data are fitted by using statistical analysis to identify measurable aspects of the regional economic performance, educational achievement, and the activity of knowledge workers in three provinces in China and how they interrelate is analyzed.

Figure 1 depicts that the gross regional products and the permanent resident population at the end of the year of the three provinces change with time. Figure 1 clearly shows that the gross regional products of the three provinces can be up to one order of magnitude. It also shows that the gross regional products of the three provinces increased rapidly with time, but there was a slowing trend after 2012. The gross regional products of the three provinces can be approximated by two exponential growth stages, and a turning point is 2012. The permanent resident population at the end of the year for all three provinces nearly keeps a constant.
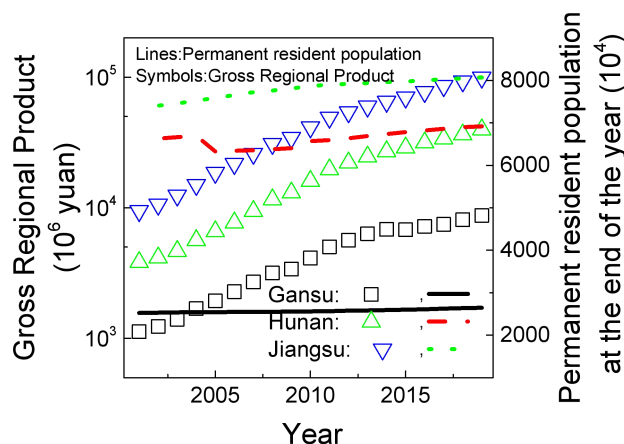

Figure 1: The gross regional products (10^6 yuan or Chinese dollar) and the permanent resident population (10^4 people) at the end of the year in the three provinces in China as a function of time. The data come from the National Bureau of Statistics of China (http://data.stats.gov.cn).

Figure 2 shows that the education expenditure and per capita disposable income of residents of the three provinces in China change with time for the recent 21 years. One can easily find that the education expenditures of the three provinces in China nearly exponentially increase with time. And per capita disposable income of residents of the three provinces in China nearly linearly increases with time.
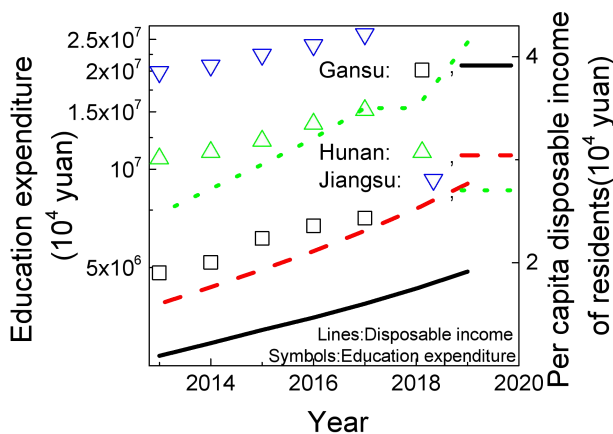

Figure 2: The education expenditure (10^4 yuan or Chinese dollar) and per capita disposable income of residents (10^4 yuan or Chinese dollar) of the three provinces in China as a function of time. The data come from the National Bureau of Statistics of China (http://data.stats.gov.cn).

Figure 3 shows how collections of public libraries owned per person and the accumulated number of library cards distributed in public libraries of the three provinces in China change with time. It can be seen from Figure 3 that public libraries owned per person of the three provinces in China nearly linearly increases with time.
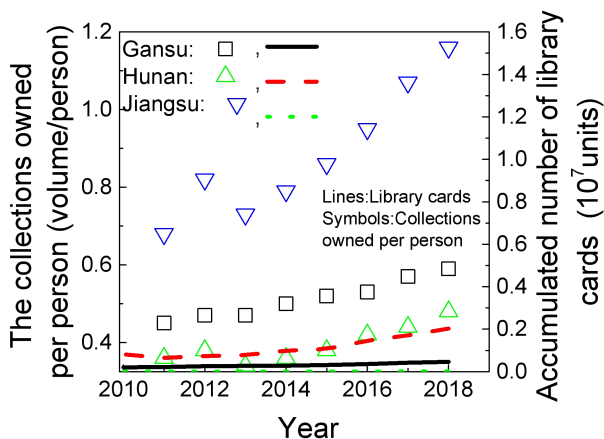

Figure 3: The collections of public libraries owned per person (volume/person) and the accumulated number of library cards distributed in public libraries (10^7 units) of the three provinces in China as a function of time. The data come from the National Bureau of Statistics of China (http://data.stats.gov.cn).

Figure 3 shows that the regions with high gross regional products (Jiangsu) generally have more collections of public libraries owned per person than those regions with low gross

regional products (Gansu). It can be also seen from the figure that the accumulated numbers of library cards distributed in public libraries of the three provinces in China exponentially increase with time. This figure also shows those regions with high gross regional products (Jiangsu generally have a more accumulated number of library cards distributed in public libraries than those regions with low gross regional products (Gansu).

Figure 4 depicts how the total number of circulation of public libraries and the number of circulation borrowing from libraries in public libraries of the three provinces in China change with time. It can be seen from Figure 4 that the total number of circulation of public libraries of the three provinces in China shows an exponential growth trend. It shows once again that the regions with high gross regional products (Jiangsu) generally have a more total number of circulation of public libraries than those regions with low gross regional products (Gansu). Also, the growth trend of the total number of circulation of public libraries in the three provinces in China is similar to the growth of gross regional products, which is also exponential growth. It can be seen that the number of circulation borrowing from libraries in public libraries of the three provinces in China has shown an exponential growth trend.
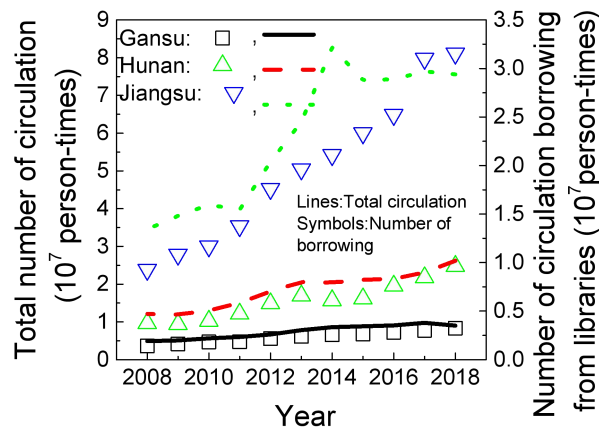

Figure 4: The total number of circulation of public libraries (10^7 person-times) and the number of circulation borrowing from libraries in public libraries (10^7 person-times) of the three provinces in China as a function of time. The data come from the National Bureau of Statistics of China (http://data.stats.gov.cn).

Figure 4 shows once again that the regions with high gross regional products (Jiangsu have more borrowings in public libraries than those regions with low gross regional products (Gansu). Besides, the growth of the number of circulation borrowing from libraries in public libraries of the three provinces in China is similar to the growth of gross regional products which is exponential growth. One can note that library borrowing is the function of library borrowing materials from readers. The circulation of information resources is one of the most important services of the library. Circulation service is an important traditional service of the library. And borrowing service is the most popular service of the library, which is usually listed as the first service type of the library website (Banda and Chewe 2021). Since circulation is a very important service in library services. If library services and economic growth can promote each other. There should be a similar change law between the changing trend of circulation and economic growth. This conclusion is implied in Figure 4.

Figure 5 demonstrates how the number of books and periodicals lent to readers in public libraries and the number of seats of the reading room in public libraries of the three provinces in China change with time. It can be seen from Figure 5 that the number of books and periodicals lent to readers in public libraries of the three provinces nearly exponentially increases with time. It shows once again that the regions with relatively high gross regional products have more books and periodicals lent to readers in public libraries than those regions with relatively gross regional products (Gansu) have. It can be seen that the number of seats of the reading room in public libraries of the three provinces in China shows a linear growth trend. Figure 5 shows once again that the regions with relatively high gross regional products have more seats of the reading room in public libraries than the region with relatively gross regional products (Gansu) have.
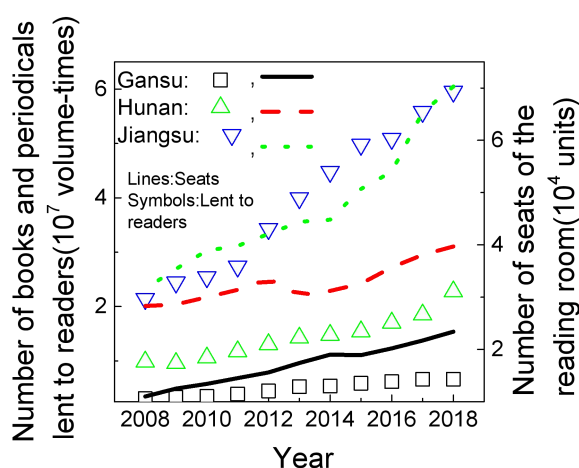

Figure 5: The number of books and periodicals lent to readers in public libraries (10^7 volume-times) and the number of seats of the reading room in public libraries (10^4 units) of the three provinces in China as a function of time. The data come from the National Bureau of Statistics of China (http://data.stats.gov.cn).

Figure 6 depicts how the number of lectures in public libraries) and the number of person-times attending lectures in public libraries of the three provinces in China change with time. It can be seen that the numbers of lectures in public libraries of the three provinces in China nearly linearly increase with time. Figure 6 shows once again that the regions with relatively high gross regional products have more lectures in public libraries than those regions with relatively gross regional products (Gansu) have. It can be seen that the relation between the numbers of person-times attending lectures in public libraries of the three provinces in China and the time presents a complex situation. Figure 6 shows once again that the regions with relatively high gross regional products have more person-times attending lectures in public libraries than those regions with relatively gross regional products (Gansu) have.

Figure 7 shows the changes in the number of exhibitions held in public libraries and the number of person-times visiting exhibitions in public libraries of the three provinces in China. It can be seen from that the numbers of exhibitions held in public libraries of the three provinces in China increase with time. Figure 7 shows once again that the regions with relatively high gross regional products have more exhibitions held in public libraries than those regions with relatively gross regional products (Gansu). It shows that the regions with relatively high gross regional products have more person-times visiting

exhibitions in public libraries than those regions with relatively gross regional products (Gansu).
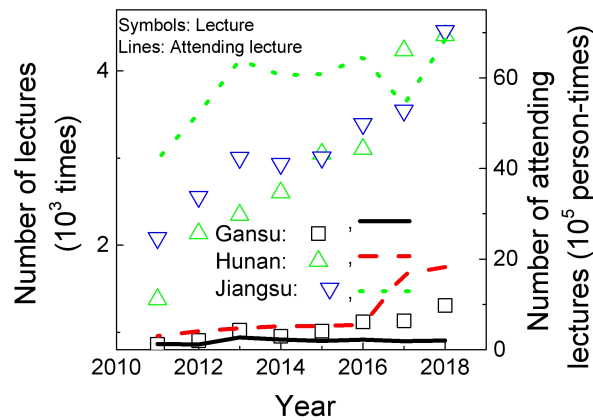

Figure 6: The number of lectures in public libraries (10^3 times) and the number of person-times attending lectures in public libraries (10^5 person-times) of the three provinces in China as a function of time. The data come from the National Bureau of Statistics of China (http://data.stats.gov.cn).
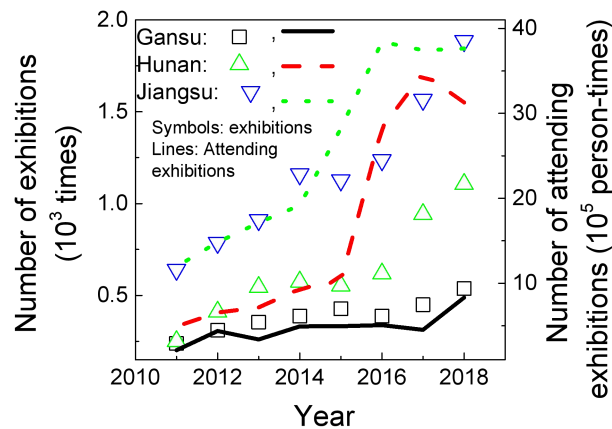

Figure 7: The number of exhibitions held in public libraries (10^3 times) and the number of person-times visiting exhibitions in public libraries (10^5 person-times) of the three provinces in China as a function of time. The data come from the National Bureau of Statistics of China (http://data.stats.gov.cn).

Figure 8 shows the changes in the number of training classes held in public libraries of the three provinces in China. It can be seen that the number of training classes held in public libraries of the three provinces in China shows a complicated situation with the time. Figure 8 demonstrates that the regions with relatively high gross regional products have more training classes held in public libraries than those regions with relatively gross regional products (Gansu). It can be seen that the number of person-times attending training classes in public libraries of the three provinces in China also shows a complicated situation with the time. Figure 8 once again shows that the regions with relatively high gross regional products have more person-times attending training classes in public

libraries than those regions with relatively gross regional products (Gansu). Note that libraries can improve users' ability to retrieve information by offering training courses (Xi et al. 2018). It denotes that users in libraries can improve their ability to acquire knowledge quickly through training courses. Therefore, it can be concluded that people in developed areas have a greater need for knowledge. This implies that there may be mutual promotion between knowledge demand and economic development.
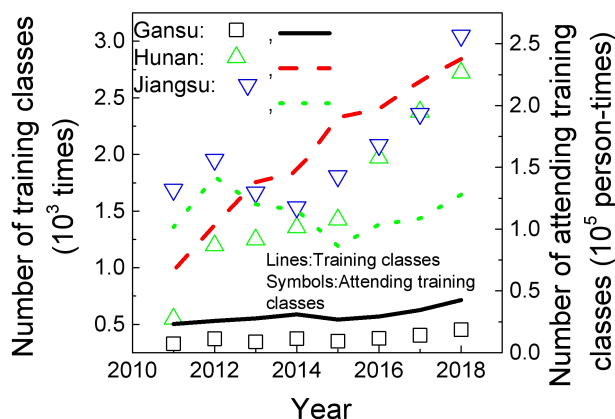

Figure 8: The number of training classes held in public libraries (10^3 times) and the number of person-times visiting training classes in public libraries (10^5 person-times) of the three provinces in China as a function of time. The data come from the National Bureau of Statistics of China (http://data.stats.gov.cn).

It is important to note that the above data have different scales and units, normalization (Z-score) have first been performed before applications of statistics. This is because normalization can adjust values measured on different scales to a notionally common scale (Bowden 2018; Fox 2018; Melnik 2015; Mukherjee, Sinha and Chattopadhyay 2018; Nesselroade and Grimm 2019; Strawinska-Zanko and Liebovitch 2018; Warne 2017).

Table 1 shows the results of eigenvalues, individual, and cumulative by using the normalized data of the population, income, and library services of the three provinces in China. One can easily find the following conclusion from Table 1. There are three, one, and eigenvalues that are larger than 1 for Jiangsu Province, Hunan Province, and Gansu Province, respectively. The first principal components account for 81.61 percent, 92.57 percent, and 83.89 percent of the total variance for Jiangsu Province, Hunan Province, and Gansu Province, respectively. The second principal components account for 7.87 percent, 4.30 percent, and 7.90 percent of the total variance for Jiangsu Province, Hunan Province, and Gansu Province, respectively. The third principal components for Jiangsu Province, Hunan Province, and Gansu Province accounts for 7.19 percent, 2.42 percent, and 5.32 percent of the total variance, respectively. It implies that the largest contribution to the total variance is Factor 1 for all cases. According to statistics, the principal components have been defined as those eigenvalues that are larger than 1 (Bowden 2018; Fox 2018; Melnik 2015; Mukherjee et al. 2018; Nesselroade and Grimm 2019; Strawinska-Zanko and Liebovitch 2018; Warne 2017). In the following, only principal components that are larger than 1 have been discussed. One can note that the first principal components for the three provinces are different. That is because the quality of the knowledge services is often difficult to measure directly (Fagerberg and Srholec 2013) and there are no straightforward relationships between knowledge and economic development (Mokyr 2016).

Table 1: Eigenvalues, individual and cumulative by using the normalized data. The raw data come from the National Bureau of Statistics of China (http://data.stats.gov.cn).

Compo-nents	Eigenvalue			Individual %			Cumulative %		
	Jiangsu	Hunan	Gansu	Jiangsu	Hunan	Gansu	Jiangsu	Hunan	Gansu
1	14.691	16.663	15.100	81.614	92.571	83.887	81.614	92.571	83.887
2	1.416	.774	1.421	7.868	4.302	7.897	89.482	96.873	91.784
3	1.294	.434	.957	7.187	2.412	5.315	96.669	99.285	97.099
4	.599	.129	.522	3.331	.715	2.901	100.000	100.000	100.000
5	7.147E-16	8.407E-16	4.945E-16	3.970E-15	4.670E-15	2.747E-15	100.000	100.000	100.000
6	3.831E-16	4.460E-16	4.374E-16	2.128E-15	2.478E-15	2.430E-15	100.000	100.000	100.000
7	3.397E-16	4.185E-16	3.004E-16	1.887E-15	2.325E-15	1.669E-15	100.000	100.000	100.000
8	3.036E-16	2.532E-16	2.738E-16	1.687E-15	1.407E-15	1.521E-15	100.000	100.000	100.000
9	1.977E-16	1.787E-16	1.390E-16	1.098E-15	9.928E-16	7.725E-16	100.000	100.000	100.000
10	1.185E-16	7.011E-17	5.733E-17	6.581E-16	3.895E-16	3.185E-16	100.000	100.000	100.000
11	4.775E-17	6.771E-18	-1.053E-17	2.653E-16	3.761E-17	-5.848E-17	100.000	100.000	100.000
12	5.161E-18	-7.736E-17	-6.609E-17	2.867E-17	-4.298E-16	-3.672E-16	100.000	100.000	100.000
13	-1.358E-16	-1.567E-16	-7.660E-17	-7.544E-16	-8.706E-16	-4.256E-16	100.000	100.000	100.000
14	-1.531E-16	-2.480E-16	-2.217E-16	-8.504E-16	-1.378E-15	-1.232E-15	100.000	100.000	100.000
15	-2.378E-16	-2.937E-16	-2.562E-16	-1.321E-15	-1.632E-15	-1.423E-15	100.000	100.000	100.000
16	-3.491E-16	-3.798E-16	-4.024E-16	-1.940E-15	-2.110E-15	-2.235E-15	100.000	100.000	100.000
17	-5.722E-16	-4.936E-16	-4.104E-16	-3.179E-15	-2.742E-15	-2.280E-15	100.000	100.000	100.000
18	-7.420E-16	-8.695E-16	-5.413E-16	-4.122E-15	-4.830E-15	-3.007E-15	100.000	100.000	100.000

Table 2 demonstrates the results of loading after the data have been normalized. Loadings indicate the importance of the original variables in the formation of new variables (Bowden 2018; Fox 2018; Melnik 2015; Mukherjee et al. 2018; Nesselroade and Grimm 2019; Strawinska-Zanko and Liebovitch 2018; Warne 2017). The following conclusions can be drawn from Table 2. The permanent resident population, the education expenditure, the collections of public libraries owned per person, the number of seats of the reading room, the floor space of buildings of public libraries owned per 10^4 population, the number of lectures held in public libraries, the number of training classes held in public libraries, the number of computers in public libraries, the number of terminals in electronic media reading rooms in public libraries have the highest correlations with the first principal component. All loads of education expenditure in the first and second principal components are very high. These results agree well with the conclusion that the level of education could exert a very high impact on regional growth (Romão and Neuts 2017; Sterlacchini 2008). Most loads of the library services are comparable with those of education expenditure. This is because knowledge is the most powerful engine of production and it is important to economic development. (Glückler, Meusburger and El Meskioui 2013). In other words, knowledge can accelerate sustainable economic growth (Sîrbu et al. 2009).

Table 2: The loadings after varimax rotation by using the normalized data. The raw data come from the National Bureau of Statistics of China (http://data.stats.gov.cn).

	First principal component			Second principal component		Principal component 3
	Jiangsu	Hunan	Gansu	Jiangsu	Gansu	Jiangsu
Permanent resident population	0.911	0.956	0.867	0.322	0.494	0.247
Per capita disposable income of residents	0.898	0.978	0.825	0.301	0.555	0.311
Education expenditure	0.928	0.996	0.793	0.242	0.549	0.281
Collections of public libraries owned per person	0.932	0.978	0.793	0.278	0.603	0.226
Accumulated number of library cards	0.782	0.986	0.925	0.207	0.367	0.580
Total number of circulation	0.941	0.935	0.865	0.309	0.500	0.122
Number of circulation borrowing from libraries	0.025	0.957	0.751	0.916	0.655	0.232
Number of books and periodicals lent to readers	0.822	0.998	0.860	0.383	0.466	0.421
number of seats of reading room	0.962	0.996	0.845	0.224	0.510	0.110
floor space of buildings of public libraries owned per 10^4 population	0.911	0.984	0.909	0.196	0.367	0.321
Number of lectures	0.979	0.962	0.929	-0.005	-0.016	0.022
Number of person-times attending lectures	-0.583	0.854	-0.401	-0.660	-0.894	0.197
Number of exhibitions held	0.836	0.898	0.495	0.544	0.748	0.056
Number of person-times visiting exhibitions	0.858	0.970	0.040	0.042	0.892	0.464
Number of training classes	0.991	0.990	0.815	0.002	0.343	0.136
Number of person-times attending training classes	-0.112	0.929	0.733	-0.082	0.162	-0.937
Number of computers	0.959	0.981	0.830	0.225	0.539	-0.090
Number of terminals in electronic media reading rooms	0.959	0.956	0.781	0.186	0.620	0.167

The component score coefficient matrix is an output product from the principal components analysis (Bowden 2018; Fox 2018; Melnik 2015; Mukherjee et al. 2018; Nesselroade and Grimm 2019; Strawinska-Zanko and Liebovitch 2018; Warne 2017). The component score coefficient represents the weighting of variables to be used when computing the saved variables of the components. Table 3 gives that the number of lectures held in public libraries, the number of training classes held in public libraries, the number of person-times attending training classes held in public libraries, and the number of computers in public libraries give the largest component score coefficient set in first principal component for Jiangsu Province. It also demonstrates that the education expenditure, the number of books and periodicals lent to readers in public libraries, and the number of seats of the reading room in public libraries gives the largest component score coefficient set in the first principal component for Hunan Province. It can also be concluded that the accumulated number of library cards in public libraries, the floor space of buildings of public libraries owned per 10^4 population in public libraries, and the number of person-times attending training classes in public libraries give the largest component score coefficient set in first principal component for Gansu Province. All component score coefficients of education expenditure in the first and second principal components are also very high. These results further support that education can exert a very high impact on regional growth (Romão and Neuts 2017; Sterlacchini 2008). Most component score coefficients of the library services are comparable with those of education expenditure

because knowledge is the most powerful engine for economic development (Glückler, Meusburger and El Meskioui 2013) and can accelerate sustainable economic growth (Sîrbu et al. 2009).

Table 3 Component score coefficient matrix by using the normalized data. The raw data come from the National Bureau of Statistics of China (http://data.stats.gov.cn)**.**

	First principal component			Second principal component		Principal component 3
	Jiangsu	Hunan	Gansu	Jiangsu	Gansu	Jiangsu
Permanent resident population	0.052	0.057	0.082	0.050	-0.004	0.021
Per capita disposable income of residents	0.045	0.059	0.053	0.034	0.040	0.067
Education expenditure	0.065	0.060	0.046	-0.012	0.046	0.046
Collections of public libraries owned per person	0.067	0.059	0.030	0.016	0.073	0.006
Accumulated number of library cards	0.006	0.059	0.134	-0.028	-0.085	0.270
Total number of circulation	0.077	0.056	0.080	0.043	0.000	-0.067
Number of circulation borrowing from libraries	-0.194	0.057	0.004	0.636	0.112	0.099
Number of books and periodicals lent to readers	0.003	0.060	0.088	0.100	-0.016	0.147
Number of seats of reading room	0.097	0.060	0.071	-0.021	0.011	-0.072
Floor space of buildings of public libraries owned per 10^4 population	0.065	0.059	0.130	-0.044	-0.081	0.078
Number of lectures	0.154	0.058	0.248	-0.183	-0.281	-0.121
Number of person-times attending lectures	-0.001	0.051	0.158	-0.377	-0.336	0.253
Number of exhibitions held	0.027	0.054	-0.090	0.234	0.235	-0.111
Number of person-times visiting exhibitions	0.064	0.058	-0.252	-0.153	0.442	0.191
Number of training classes	0.138	0.059	0.112	-0.186	-0.065	-0.046
Number of person-times attending training classes	0.127	0.056	0.144	0.017	-0.133	-0.611
Number of computers	0.124	0.059	0.059	-0.008	0.030	-0.207
Number of terminals in electronic media reading rooms	0.096	0.057	0.022	-0.051	0.085	-0.032

According to Table 1, out of 18 components, only those factors whose eigenvalues are larger than 1 have been selected for multiple linear regressions between the normalized gross regional products and the principal components. Table 4 demonstrates the results of multivariate multiple linear regression analysis results based on principal component scores; 85.0% of the variation in the normalized gross regional products of Jiangsu Province could be explained by the first principal component, which is determined from the stepwise regression analysis; 95.0% of the variation in the normalized gross regional products of Hunan Province could be explained by the first scores; and 64.2% of the variation in the normalized gross regional products of Gansu Province could be explained by the first principal component. These results reveal that the first principal component gives the most contribution to the normalized gross regional products. These linear relationships between the principal components and the gross regional products of the three provinces ensure consistency with the well-known conclusions that education can exert a very high impact on regional growth (Romão and Neuts 2017; Sterlacchini 2008), knowledge is the most powerful engine for economic development (Glückler, Meusburger and El Meskioui 2013) and can accelerate sustainable economic growth (Sirbu et al. 2009).

And it also means that component score coefficients and the linear relationship between the principal components and the normalized gross regional products can be used together to investigate the relationship between library services and the gross regional products.

Table 4: Multivariate multiple linear regression analysis results between the principal components and the normalized gross regional products. The raw data come from the National Bureau of Statistics of China (http://data.stats.gov.cn).

	Variable	Unstandardized Coefficients		Standardized coefficients	t	Sig.	R^2
		B	Standard Error	β			
	Before stepwise regression analysis						
Jiangsu Province	Intercept	0.151	0.049		3.050	0.202	0.993
	PC1	0.615	0.055	0.922	11.141	0.057	
	PC2	0.193	0.055	0.289	3.496	0.177	
	PC3	0.162	0.055	0.243	2.942	0.209	
	After stepwise regression analysis						
	Intercept	0.151	0.133		1.129	0.341	0.850
	PC1	0.615	0.149	0.922	4.126	0.026	
Hunan Province	**Regression analysis**						
	Intercept	0.205	0.073		2.790	0.068	0.950
	PC1	0.616	0.082	0.974	7.516	0.005	
Gansu Province	**Before stepwise regression analysis**						
	Intercept	0.252	0.059		4.282	0.050	0.954
	PC1	0.348	0.066	0.801	5.291	0.034	
	PC2	0.243	0.066	0.559	3.694	0.066	
	After stepwise regression analysis						
	Intercept	0.252	0.134		1.875	0.157	0.642
	PC1	0.348	0.150	0.801	2.317	0.103	

Figure 9 demonstrates how the normalized gross regional products of the three provinces in China change with the first principal component. It can be seen from Figure 9 that most data of the normalized gross regional products are linear dependent on the first principal component. This demonstrates that the regions with relatively high gross regional products have more training classes held in public libraries than those regions with relatively gross regional products (Gansu).
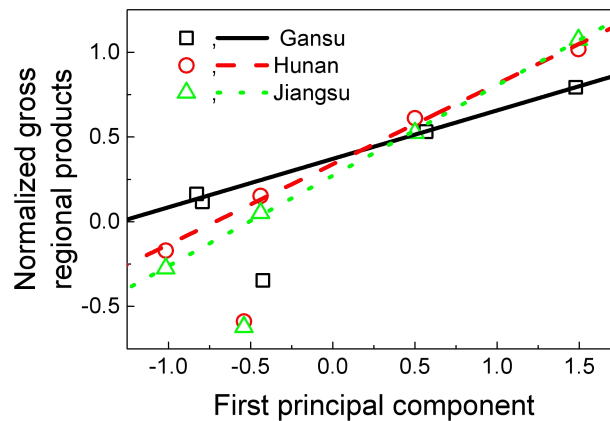
Figure 9: The normalized gross regional products as a function of the first principal component. The raw data come from the National Bureau of Statistics of China (http://data.stats.gov.cn)

DISCUSSION

It is well-known that education can exert a very high impact on regional growth (Romão and Neuts 2017; Sterlacchini 2008). Thus, the relationship between education and economic growth can serve as a reference for comparison.

Firstly, the loading in the first principle component for education is 0.928. It represents that such a variable related to education give an important contribution to the first principal component that is the most important new variable. Such a result agrees well with the conclusion that education can exert a very high impact on regional growth (Romão and Neuts 2017; Sterlacchini 2008). Table 2 demonstrates that although most library activities have a smaller loading than that for educational expenditure. Several activities can be compared to it (for example the loading for the Total Number of circulation is 0.942). In other words, people can learn knowledge in libraries. The economic growth of the region may benefit from the new knowledge that people acquire from the library. This is because knowledge is the most powerful engine for economic development (Glückler, Meusburger and El Meskioui 2013) and can accelerate sustainable economic growth (Sirbu et al. 2009). The typical data that fits this pattern is the Total Number of circulation that is one of the most important services of the library (Banda and Chewe 2021). Secondly, the results of the components score coefficient matrix are similar to those of the loadings. Lastly, the linear relationship between the normalized gross regional products of the three provinces in China and the first principal component further gives that they are potentially interacting. The above results indicate that the contribution of library activities to the target can be quantified using specific target data (such as regional economic growth). However, there are two problems. The first is whether the data collected is comprehensive and whether there are errors. If there are defects in the data, obviously there are problems in the analysis. Although the results depend on how reliable and comprehensive the data are, the above approach is a potential way to investigate the relationship between library services and regional economic growth. Library and information services in public libraries are dedicated to creating literate environments for all (Krolak 2005). It denotes that contributing to regional economic growth is only one of the many contributions of library services to society. Thus, the second problem is that

library services can give many types of contributions to society. It is one-sided to simply use the quantitative relationship between and a certain goal to average all kinds of library activities. This paper only provides an idea of quantitative research on the relationship between library activities and regional gross regional products.

Tables 1, 2, 3, 4, and Figure 9 show that the gross regional products are strong linear dependent on the population, the disposable income, the education expenditure, and the library services in public libraries. Hence, it reflects that the population, the disposable income, the education expenditure, and the library services in public libraries highlight the strong interdependence between the population, the disposable income, the education expenditure, and the library services in public libraries in the process of regional development. These results are new, which are different from the results from the Servqual method (Made 2018), the quality management model (Mofrad et al. 2016), the contingent valuation method (Cummings and Taylor 1999; Stejskal and Hájek 2015), etc. The very good linear relationship between the principal components and the gross regional products of the three provinces ensures consistency with the well-known conclusions that education can exert a very high impact on regional growth (Romão and Neuts 2017; Sterlacchini 2008), knowledge is the most powerful engine for economic development (Glückler, Meusburger and El Meskioui 2013) and can accelerate sustainable economic growth (Sirbu et al. 2009).

One can note that the above method is still valid when another factor is used to substitute the gross regional products. It means that the method proposed in this paper provides a potential new method to evaluate library services-oriented a target.

CONCLUSIONS

It is important to keep in mind that the relationship model used in this paper is not the desired actual answer. Instead, the model is an example of what is expected, an illustration of the form the result might take.

Principal component analysis has been used to avoid the multicollinearity problem in the data used in this article. Through a case study of public libraries and their gross regional products for the three provinces in China, explore the effects of the various library services in public libraries. Results obtained from the correlation calculation demonstrate that input data are correlated with the target data. Results obtained from the principal analysis show that only the first three principal components at the most needed to be considered. Multivariate multiple linear regression analysis based on principal component scores demonstrated that the first principal component gives the most contribution to the gross regional products. And there is a linear relationship between the gross regional products and the first principal component. The contribution of the population, the disposable income, the education expenditure, and the library services in public libraries in the first principal component cannot be neglected. This implies that the library services in public libraries should be given more attention to the process of regional development. Component score coefficients and linear relationships between the principal components and a target can be used together to investigate the roles of library services on economic growth.

All results demonstrate that the library services can give an important contribution to the gross regional products of the three provinces in China. Its contribution to the gross

regional products might have the same importance as the population and the education do. It also demonstrates that the gross regional product, the population, the disposable income, the education expenditure, and the library services in public libraries in the three provinces in China could help each other forward. It also implies that if a region has good work on library services in public libraries might be helpful to its regional economic development. Therefore, a developing region should give attention to library services in public libraries.

The mathematical basis of this paper is to calculate the correlation between high-dimensional data such as population, education and library services and the gross regional products, reduce the dimension of high-dimensional data by principal component analysis, and calculate the target data by linear regression method, and obtain the relationship between the first principal component based on high-dimensional data such as population, education and library services. Based on the organic combination of the above three methods, a new method is developed to quantitatively study the impact of library services on specific targets (gross regional products). The results show the feasibility of this method in the quantitative discussion of the impact of library services on specific objectives. It means that the proposed method provides some new ideas for the development of more appropriate library service evaluation methods.

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