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ABSTRACT

With rapid development of Internet, ICT-drive forces for stimulating productivity and economic growth are becoming hot issues nowadays. Chengdu, Chongqing, Xi'an and Kuming are representatives of advanced productivity in Southwest China. Digitalization of economic system in these cities has raised a topic of great importance regarding transforming capabilities on Internet. To accelerate transforming and to foster sustainable growth, the research moves beyond ICT adoption to explore internal factors to speed up transforming in economic systems of the four cities. Evaluation Framework of Transforming Capabilities (EFTC) and Fuzzy Comprehensive Evaluation Model (FCEM) are proposed, and empirical data of the observing cities' during 2010-2015 has been collected. We further our research to the extent of internal regional economic system, and try to identify common factors in transforming based on industrial theory. Our research yields four findings. 1) Transforming capabilities range slightly in growth poles in South-west China; 2) New growth poles are shaping when economic society transforming on Internet; 3) Regions will face increasing pressure to develop on Internet;4) Internal industrial structure has dominant impact on transforming capabilities. Finally, we offer recommendations regarding accelerating economic system transforming on Internet.

Keywords: economic system; e-business; transforming capability; South-west China; economic growth

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INTRODUCTION

The source of urban growth has received continuous attention from researchers and policy makers for many decades. With rapid extensive expanding of Internet infrastructure, the problem of urban development and its competitiveness have been focused on the role of Internet infrastructure. For information communicate technologies (ICTs) are the key strategic technology concerning the future development of an area, ICT-drive for urban development is becoming a hot issue nowadays. Economic system is the central to urban growth, which constructs the core component to urban competitiveness. Therefore, the future of urban economic system will depend more than ever on whether they adopt digital technologies in their economy operation appropriately.

The Western China's economy has experienced continuous growth in the 21st century, accompanied by wide growing and extensive installation of Internet infrastructure. Research findings have shown that migration on Internet creates significant contribution to economic growth, the future of economic systems (Farjou & Eslami, 2015), therefore, depend heavily on whether they embrace Internet. However, studies also have shown that Internet infrastructure carries benefits as well as risks during the process of economic system transforming. The measurement of transformation capabilities for urban economy on Internet must be involved in, so that holistic long-term strategies for ICT adoption in urban economy can be carried out more efficiently. Then, Internet infrastructure establish a new economic environment based on Information technology, transforming on Internet is becoming an severe challenge for regional economic systems been faced up with, and thus deserve academic exploring. There are plenty of researches focusing on ICT adoption and digitization on economic growth. However, so far there have not been any large-scale attempts to empirically examine transforming capacities on Internet for urban economy, let alone for South-West China. For reasons mentioned above, the paper raises basic questions about the information technology adoption and its impact on economy performance in urban development based on evidences from Western China.

Chengdu, Chongqing, Xi'an and Kunming are important city groups in South-West China, and possess crucial economic systems in South-West China along One Belt and Road. As traditional growth poles, their impetus of economic growth and the capabilities of transforming on new infrastructure have greatly influence on sustainable economic growth in these areas. Over the last decade, the four cities have been investing immensely to build ICT infrastructure and to facilitate Smart cities developing by digitizing their economic system. Moreover, across the South-West China have embraced e-business as an engine of their sustainable growth, and have viewed e-business adoption as new developing opportunity to catch up with Eastern China, it is undoubtedly an important issue to evaluate transformation capabilities in these areas.

Our research paper is organized as follows. Section 1 states purpose and background of our research. Literatures concerning transforming on Internet are presented, and research gap is analyzed as well. Section 2 describes the methodology we use to assess capabilities of transforming on Internet, from the perspective focused on industrial organization and its process when

combing with Internet infrastructure. In this section, we present our research framework and the Fuzzy Comprehensive Evaluation Model (FCEM). We also demonstrate our methods of data preprocessing in this section. In section 3, we focus on evaluating capabilities of transforming on Internet based on four vital growth poles in South-West China. Composite indicators for transforming capacity are shown in this section. In section 4, we draw on the gap of transforming capacities among these cities, and further our research by identify internal reasons of these economic system. In the last section, section5, we summarize our research findings and offer implications for policy making in fulfill local economy develop objectives. Study limitations and future research topics are also addressed in this section.

RESEARCH METHODOLOGY

Evaluation Framework

To address the problem of Internet transforming capabilities in regional socioeconomic system in the four cities, we establish an evaluation system named Evaluation Framework for Transforming Capabilities (EFTC) based on industrial economic theory. This framework includes four categories, 10 sub-categories, and 27 individual indicators. The aforementioned evaluation framework will be translated in to a composite indicator to indicate the transforming capabilities of observed economic system. Based on industrial theory, we extent to inter-structure of regional economic system, and compose the research framework in four parts, information capabilities, production affordability, consumption capacities and innovation capacities. Our research framework is shown below.

A. Information Capabilities
- a1 Information infrastructure
  - a11 fixed line penetration rate
  - a12 mobile phone penetration rate
  - a13 Internet penetration rate
- a2 Information service
  - a21 average output of information service
  - a22 average growth rate of information service

B. Production affordability
- b1 Scale of production
  - b11 total GDP
  - b12 migration direction index
  - b13 migration rate index
- b2 Efficiency of production
  - b21 labor productivity in agriculture sector
  - b22 labor productivity in industry sector
  - b23 labor productivity in service sector
- b3 Efficiency of investment
  - b31 efficiency of investment in agriculture sector
  - b32 efficiency of investment in industry sector
  - b33 efficiency of investment in service sector

C. Consumption capacities
- c1 Scale of consumption
  - c11 proportion of total volume of retail
  - c12 growth rate of total volume of retail
  - c13 GDP per person
- c2 Consumption potentiality
  - c21 disposable income of urban residents
  - c22 growth rate of disposable income of urban residents
  - c23 disposable income of rural residents
  - c24 growth rate of disposable income of rural residents
- c3 Consumption structure
  - c31 Engel coefficient of rural residents
  - c32 Engel coefficient of rural residents

D. Innovation capacities
- d1 Investment in research
  - d11 input intensity of R&D
  - d12 density of R&D personnel
- d2 Labor skills
  - d21 adult literacy rate
  - d22 quantity of college student per 100 thousand
  - d23 quality of math and science education

d3 Openness of regional economy
d31 degree of foreign capital dependency
d32 degree of foreign trade dependency

In the above list, the alphabet and number indicate the pillar to which the variable belongs. For example, indicator a1 belongs to the A category. The weight of each indicator in this framework is decided according to Networked Readiness Index (NRI) pioneered by Word Economic Forum in 2001. This is different from our previous research (Shi et al., 2017), which calculated indicators' weights through analytic hierarchy process (AHP) pioneered by Saaty (1986, 1990). In that research, a decision group is organized with 8 experts from government, research institutes, and enterprises. Delphi method is applied to identify relative weights calculated through AHP by each expert. Weight for each indicator in the framework is arithmetic means from decision results of the experts. Comparing the results of our indicator weights with those of NRI, we find that calculating outcomes are very similar. To compare our results with other results from foreign scholars on a more horizontal level, we adopt arithmetic average mean following Word Economic Forum.

Evaluation Method

To further our research, we establish evaluation model, named Fuzzy Comprehensive Evaluation Model (FCEM). FCEM is established based on fuzzy theory, which is composed of two part， comment matrix and relative-membership grade calculating model. To evaluate transforming capacities more precisely, 1-to-5 comment matrix is divided into 1-to-6 scale, and is assigned value from 6 to1 according to its rank.

The comment matrix is listed in equation 1, and the weights vector is shown in equation 2. The relative-membership grade of transforming Capabilities on Internet belongs to comment matrix is calculated by the following equation 3.

$$\mathrm{V} = (\mathrm{v}_1, \mathrm{v}_{2,} \mathrm{v}_3, \mathrm{v}_4, \mathrm{v}_5, \mathrm{v}_6) \tag{1}$$

$$W = (w_1, w_2, w_3, \cdots, w_n)^T \tag{2}$$

$$\mathrm{S} = W \bullet R = (w_1, w_{2,} \ldots \ w_n) \bullet \begin{bmatrix} r_{11} & r_{12} & \ldots & r_{1m} \\ r_{21} & r_{22} & \ldots & r_{2m} \\ \ldots & \ldots & \ldots & \ldots \\ r_{n1} & r_{n2} & \ldots & r_{nm} \end{bmatrix} = (s_1, s_2, \ldots, s_m) \tag{3}$$

Where W is weight vector of evaluation factors set, R is the fuzzy relation matrix, r_{ij} is membership degree of the i^{th} for j^{th} column element to fuzzy sets. S_m is membership degree of observed economic system to comment set V.

As for membership grade degree, semi-trapezoidal function is used. According to characteristics of indicators in our research framework, increasing semi-trapezoidal function and decreasing semi-trapezoidal function are all used to normalize research data. The former is used for data the higher the better, and the latter is adopted for data the less the better. Equation 4 is increasing semi-trapezoidal function and equation 5 is the decreasing one.

$$r(x) = \begin{cases} 0 & x \le a \\ \dfrac{x-a}{b-a} & a < x < b \\ 1 & x \ge b \end{cases} \tag{4}$$

$$r(x) = \begin{cases} 1 & x \le a \\ \dfrac{b-x}{b-a} & a < x < b \\ 0 & x \ge b \end{cases} \tag{5}$$

Research Data

We collect the research data from China Statistical Yearbook, China Labor Statistical Yearbook, and Education Statistical Yearbook in China. However, some data cannot be obtained directly from yearbook, such as migration direction index, migration rate index. We measure the two index followed our former research (Shi, 2016). Furthermore, before transforming capacities of

regional economic system can be analyzed, data for assessing must be normalized to keep dimension homogenous. Dimensional normalization methods are used to adjust for effects which arise from variation measurement unit.

RESULTS

According to equations listed above and data collected from yearbook, we calculate information capabilities, production affordability, consumption capacities and innovation capacities. Our research results reveal that tradition growth poles in Southwest China still positive in transforming on Internet, although they are lag behind Eastern China. Results from four dimensions listed in EFTC expose that observed urban economic systems are different in their strength when transforming. Chengdu and Xi'an are excellent in their innovation capacities, and Kuming is prominent in its industrial structure. As for Chongqing, its heavy industry contributes much for its GDP growth, but also carry heavy burden to its industrial structure migration.

Information capabilities are composed of information infrastructure and information service. Our results indicate that it still has great gap among western growth poles in their information capabilities after vast investment on Internet for a long time. Different levels of information service can interpret for this.

As for production affordability and consumption capacities, they are both sides of the market, and often viewed as indicators for prosperous of regional markets. The results for these two dimensions reveal that as the tradition growth poles in these areas, their regional economic systems are still positive under 'Internet+' developing environment. As it declared in many researches, prosperous market environment has more impetus to embrace new technology.

Innovation is key characteristic of digital economy. Economic system with higher open and innovation level will more adaptable to transformation on Internet infrastructure. Total value of innovation capabilities is also a composite index made up of three parts, investment in research , labor skill openness of regional economy Innovation results also show a great gap in these tradition growth poles in Southwest China. Membership degree of innovation capacity in Xi'an is 0.4289, belonging to the highest comment value '6', while that in Kuming is o.5396 with comment value '1'.

When comprehensive consideration of these four dimensions in EFTC, we deduce the evaluation results of transforming capabilities of these four regional economic systems. The results are listed in Table 1.

Table 1: Estimation Results of Transforming Capabilities in Observed Economic Systems

Cities	Membership degree						Total value
Chengdu	0.1177	0.3139	0.3075	0.2417	0.0609	0.0000	4.4134
Chongqing	0.0150	0.1636	0.1801	0.2256	0.3639	0.1002	3.3971
Xi'an	0.2047	0.2593	0.2402	0.1601	0.0493	0.0708	4.1135
Kunming	0.0858	0.1876	0.2370	0.2228	0.1805	0.1446	3.6111

As it can be seen in Table 1, transforming capabilities of the four cities are range –but not very much. The highest is Chengdu, with transforming capabilities value being 4.4134. Meanwhile, the lowest one among these cities is Chongqing with the value 3.3.971. Chengdu's outstanding performance is underlying by the fact that it ranks top in Southwest China in all subindexes. Xi'an stays in the 2nd place with some index, such as production affordability and consumption capacities, dropping lightly behind Chengdu, while keeping the first in information capabilities and innovation capacities. Chongqing is the lowest one in the observed economic systems, partly due to its heavy production system and immature production service.

CONCLUSIONS

This research confirms the importance of ICT adoption to urban economic growth, and explores further estimation of transforming capabilities to industrial level. E-business is the central of ICT adoption, and its diffusion extensively across all social economy system is raising both developing opportunities and severe challenges at the same time. Specifically, our findings indicate that urban economic systems are actively in digital transforming, with transforming capacities developing in an obvious trend of heterogeneous. The phenomena confirm that economy still benefit from information technology adoption just as it has done from other former advanced technologies in economic history. Although 'digital gap' is narrowing quickly, new growth centers in urban economy development are still forming rapidly, exposing that advanced social economic system are important for urban economic system transforming. Secondly, our research reveals the phenomenon that services deriving from ICT diffusion are becoming more crucial than basic infrastructure for accelerating digital transforming. Compared with Eastern China, observed urban economies in Southwest China are inferior in services concerning information technologies. Thus, it may be faced up with severe challenge when embracing Internet infrastructure for lack of services helping for transforming. Thirdly, our empirical studies indicate that innovation abilities are not strong enough to facilitate urban economy transforming in Southwest China. As innovation resources, personnel and expenditure in R&D, are much lower than Eastern China. Innovation

capabilities are determinant factors for urban economies adapt to new production basement, and are crucial to develop new economic logic and economic model. Thus, Southwest China should pay more attention to nurture innovation capabilities in these areas, focusing on improving transforming capacities and enhancing urban competitiveness though innovation.

LIMITATIONS AND FUTURE RESEARCH

Our research is limited in several ways. First, Chengdu, Chongqing, Xi'an and Kunming are all growth poles in South-West China, but other urban economic systems are not included for various reasons. For example, Guiyang is not included in our research design because of data absence. However, Guiyang is vigorous in digitalization and makes large investment in big data center. In future research, we will extend our research to include more urban economic system. Second, our framework does not include other potentially important factors, such as political and regulatory factors, labor skills. Literatures have illustrated that the success of an economy system in leveraging ICT depends in part on the quality of the overall operating environment, which is partly decided by an economy's market conditions and regulatory framework. Moreover, making effective use of ICT and transforming on Internet are benefit from higher labor skills, which are captured by education quality in observed urban and are not contained in our research framework. Further studies should investigate more determinants of transforming on Internet and its impact on forming urban competitiveness from ICT transforming.

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