1L17 Co-evolution Dynamism between Inter-firm Technology Spillover and Resilient Institution in China's ICT Development

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Abstract

This research focuses on the analysis of China's triangle institutional structure between improvement of education, development of urbanization and economic growth to demonstrate its fragile or resilient characteristic. Based on a resilient system analysis approach, taking China's institutional structure in each respective 31 regions over the last two decades, an empirical analysis is attempted to identify the role of ICT in leading to resilient or fragile institutional structure. The result of empirical analysis indicates that there is a co-evolution between inter-firm technology spillover and resilient institution in China's conspicuous ICT development.

1. Introduction

While China has been demonstrating a conspicuous economic growth, it incorporates institutional fragility. The major source of this fragility can be attributed to its transitional state of its long lasting institutional system including shifting to market economy, rapid industrialization and urbanization, as well as dramatic reforms of its educational system.

Chinese government has made every effort in shifting this fragile institutional system to resilient one by introducing comprehensive informatization strategy. Thus, China's informatization trajectory can be interpreted to be subject to its institutional fragility indigenous to its unique triangle structure between education, urbanization and economic growth.

Figure 1 demonstrates the dynamism between urbanization, economic growth, high education and dependency on informatization in China. During the period of the planning economy move from rural to urban area was strictly prohibited, rural people were restrained in rural area with poor education and low income. While this impediment has removed and move from rural to urban area has been principally encouraged as market economy emerged. People go to big cities getting good education, job opportunities and earning high income. This process of urbanization contributes to economic growth, again contributes to improvement of education and a virtuous cycle of institutional structure between economic growth, education and urbanization is formed. It could be assumed that co-evolutionary relationship between this unique institutional structure and activated inter-firm technology spillover plays a significant role in accelerating enhancing functionality of informatization and resilience of institution in China. Under such circumstances, dependency on informatization constructs China's unique institutional structure with respect to ICT development.

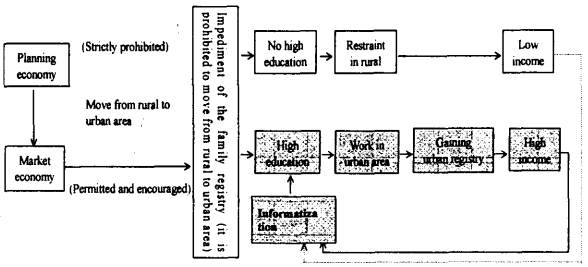

Figure 1. Dynamism between Urbanization, Economic growth, High Education and Dependency on Informatization in China.

2. Cyclical Dynamism between GDP per Capita, Education and Urbanization

2.1 Structure of Cyclical Dynamism

Figure 2 demonstrates the cyclical dynamism structure between GDP per capita, education and urbanization. α, ß, γ represent the elasticity between triangle institutional factors respectively, MIVEU (Mutual Interdependency between GDP per capita, Education and Urbanization: αβγ) represents productivity of the cyclical structure and entropy (ε) represents resilience of the cyclical structure.

(1) Cyclical structure –Elasticity (α, β, γ)

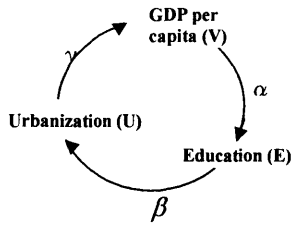

Figure 2. Cyclical Dynamism Structure between GDP per capita, Education and Urbanization.

(2) Productivity of the cyclical structure

$$\ln E = \ln A + \alpha \ln V_{-1}$$
$$\ln U = \ln B + \beta \ln E_{-1}$$
$$\ln V = \ln C + \gamma \ln U_{-1}$$

$$\alpha = \frac{\partial \ln E}{\partial \ln V_{-1}},\ \beta = \frac{\partial \ln U}{\partial \ln E_{-1}},\ \gamma = \frac{\partial \ln V}{\partial \ln U_{-1}}$$

$$\mathrm{MIVEU} = \alpha\beta\gamma = \frac{\partial \ln E}{\partial \ln V_{-1}} \cdot \frac{\partial \ln U}{\partial \ln E_{-1}} \cdot \frac{\partial \ln V}{\partial \ln U_{-1}}$$

(3) Resilience of the cyclical structure – Entropy (ε)

$$\text{Entropy } (\varepsilon) = \sum_{j=1}^{3} P_{jt} \ln \frac{1}{P_{jt}}$$

Here, j represents V, E and U, t represents time series,

$$P_{jt} = \frac{\alpha}{\alpha+\beta+\gamma}, \quad \frac{\beta}{\alpha+\beta+\gamma}, \quad \frac{\gamma}{\alpha+\beta+\gamma}, \quad \sum P_{jt} = 1$$

2.2 Empirical Analysis

Using national level time series data 1978-2003, assuming α, ß, γ as function of time t, given 1978 = 0, we make regression analysis to get elasticities and further compute productivity and entropy. Based on the analysis result we can evaluate the productivity and resilience of the institution structure for the sustainable development.

(1) Elasticity

a. Elasticity of GDP per capita to education (V to E)

$$\ln E = \ln A + \alpha \ln V_{-1} \qquad \alpha = \sum_{i=0}^{n} a_i t^i$$

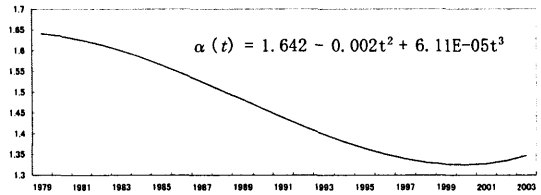

Figure 3. Trend in Elasticity of V to E in China *(1979-2003)*.

b. Elasticity of education to urbanization (E to U)

$$\ln U = \ln B + ß \ln E_{-1} \qquad \beta = \sum_{i=0}^{n} b_i t^i$$

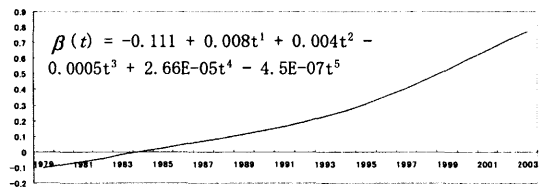

Figure 4. Trend in Elasticity of E to U in China *(1979-2003)*.

c. Elasticity of urbanization to GDP per capita (U to V)

$$\ln V = \ln C + \gamma \ln U_{-1} \qquad \gamma = \sum_{i=0}^{n} c_i t^i$$

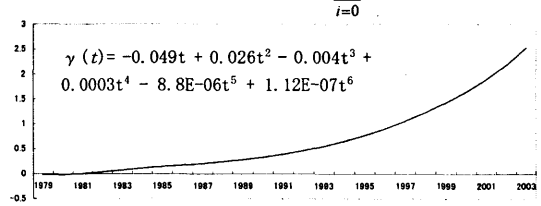

Figure 5. Trend in Elasticity of U to V in China *(1979-2003)*.

(2) Productivity

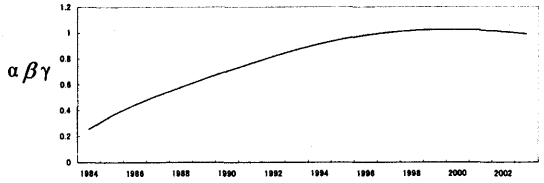

Figure 6. Trend in Mutual Interdependency between GDP per capita, Education and Urbanization in China *(1979-2003)*.

(3) Entropy

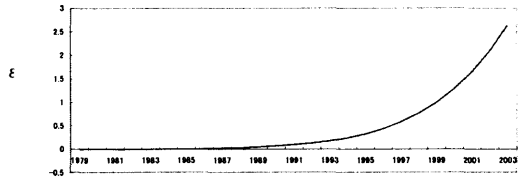

Figure 7. Trend in Entropy between GDP per capita, Education and Urbanization in China *(1985-2003)*.

2.3 Implications of Empirical Analysis

(i) Productivity continues to increase.
(ii) However, entropy stagnates and indicates a trend in slight decrease from 2000.
(iii) These demonstrate the trade-off between productivity and resilience.

3. Informatization Trajectory

- Measurement of Informatization Index over the period of 1984-2003

3.1 Explanation of Information Index

Informatization index is a weighted average index of six factors: (i) Exploiting and using of information resources; (ii) Building of information net; (iii) Application of information technology; (iv) Information products and service; (v) Human resources of informatization; (vi) Development of informatization environment. Weights are identified by Delphi Method. **Figure 8** demonstrates the national informatization index of China (1995-2000), it was measured by China Informatization Evaluation Center in 2002 year.

$$I = \sum_{i=1}^{6} w_i X_i = 15\% X_1 + 16\% X_2 + 18\% X_3 + 15\% X_4 + 20\% X_5 + 16\% X_6$$

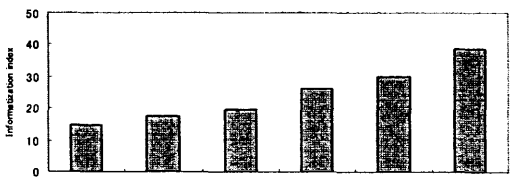

Figure 8. National Informatization Index of China *(1995-2000)*.

3.2 Regional Identify and Cross Regional Regression Analysis of 31 Regions

Using regional informatization index of 31 regions by regression analysis we try to get cross data function I = I (V, E, U). Regional characteristic is identified firstly as **figure 9** that indicates Beijing and Shanxi are conspicuous by using average data of 1998-2000. Then regression analysis is made as function (1) by taking coefficient dummy variable (Beijin, Shanxi = 1, others = 0). Based on function (1), taking weight of regional GDP per capita to compute synchronic elasticity of V to I as function (2), the final cross data function can be obtained as function (3).

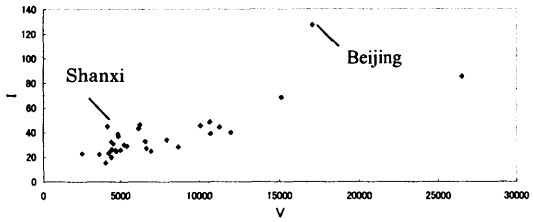

Figure 9. Regional Identify by Average Data of 1998-2000.

$$\ln I = 1.499 + 0.251D\ln V + 0.207(1-D)\ln V + 0.189\ln E + 0.443\ln U \quad (1)$$

(1.45) (2.08) (1.83) (1.35) (2.51)

adj. R^2 0.851

D: dummy variables, Beijing, Shanxi = 1, other regions = 0

$$\text{Synchronic elasticity} = 0.251 * \frac{\sum_{r=1}^{31} D\ln V_r}{\sum_{r=1}^{31} \ln V_r} + 0.207 * \frac{\sum_{r=1}^{31} D\ln V_r}{\sum_{r=1}^{31} \ln V_r}$$

$$= 0.210 \quad (2)$$

D: dummy variables, Beijing, Shanxi = 1, other regions = 0

$$\ln I = 1.499 + 0.210\ln V + 0.189\ln E + 0.443\ln U \quad (3)$$

3.3 Increase Time Trend Effect

Using equation (3) and increase time trend effect, function (4) can be obtained.

$$\ln I_t = A + 0.210\ln V_t + 0.189\ln E_t + 0.443\ln U_t + \lambda t \quad (4)$$

(t: 1984 = 1)

Using following equations to indentify A and λ,

ln I 1995 = ln I (1995)
ln I 2000 = ln I (2000) } Primary national level index

Based on above computing, we can get A = - 0.205, λ = 0.133, so the final time trend informatization function is function (5), and **Figure 10** demonstrates this estimated time trend fits with the primary trend very well.

$$\ln I_t = -0.205 + 0.210\ln V_t + 0.189\ln E_t + 0.443\ln U_t + 0.133t \quad (5)$$

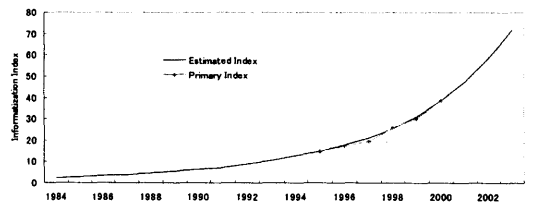

Figure 10. Time Trend of National informatization Index *(1984-2003).*

4. Analysis of the Influence of Informatization to VEU

In this part, we will analyze the influence of informatization to VEU in national level by using estimated time trend informatization index. We also use productivity and entropy to indicate the fragile or resilient characteristic of institutional structure.

4.1 Dynamism Structure

Figure 11 demonstrates the dynamism structure between informatization and VEU, η 1, η 2, η 3 are elasticity of informatization to V, E, U respectively, the computing method of elasticity is as following equations:

$$\ln V = \ln A + \eta_1 \ln V$$
$$\ln U = \ln B + \eta_2 \ln E_{-1}$$
$$\ln V = \ln C + \eta_3 \ln U_{-1}$$

$$\eta_1 = \frac{\partial \ln V}{\partial \ln I} = \frac{\partial V}{\partial I} \cdot \frac{I}{V}$$

$$\eta_2 = \frac{\partial \ln E}{\partial \ln I} = \frac{\partial E}{\partial I} \cdot \frac{I}{E}$$

$$\eta_3 = \frac{\partial \ln U}{\partial \ln I} = \frac{\partial U}{\partial I} \cdot \frac{I}{U}$$

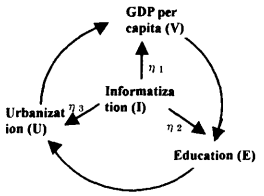

Figure 11. Dynamism Structure between Informatization and VEU.

4.2 Elasticity of Informatization to GDP per Capita, Education and Urbanization

Using model of logistic growth with a dynamic carrying capacity (as equation (6)) to compute elasticity η 1, η 2, η 3, **Figures 12-14** demonstrate the results.

$$N(I) = \frac{K_k}{1 + a\exp(-bI) + \frac{b \cdot a_k}{b - b_k}\exp(-b_k I)} \quad (6)$$

$$\frac{\partial N(I)}{\partial I} = aN(I) * (1 - \frac{N(I)}{K(I)}) \qquad \frac{\partial K(I)}{\partial I} = a_k K(I) * (1 - \frac{K(I)}{K_k})$$

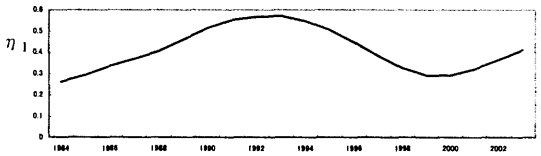

Figure 12. Trend in Elasticity of I to V *(1984-2003).*

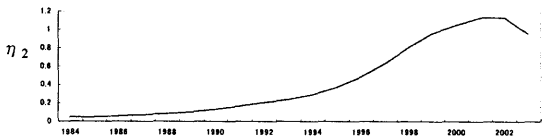

Figure 13. Trend in Elasticity of I to E *(1984-2003).*

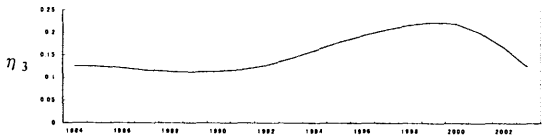

Figure 14. Trend in Elasticity of I to U *(1984-2003).*

Implication from η 1, η 2, η 3

(i) Informatization elasticity to V continued to increase consistently by 1993.

(ii) Dramatic advancement of Inf. in the middle to the later half of the 1990s was not well incorporated in V.

(iii) On the basis of the learning exercise in the later half of the 1990s, the effect of Inf. incorporated in V. from 2000.
(iv) Advancement of Inf. did not provide strong influence to urbanization by 1993 (elasticity was almost stable).
(v) Influence of Inf. to urbanization dramatically increased from the middle to the later half of the 1990s (elasticity dramatically increased).
(vi) Due to advancement of Inf., motivation to rural people to move to urban area decreased from the end of 1990s (elasticity decreased).
(vii) Advancement of Inf. stimulated education.
(viii) Due to decrease in motivation to move to urban area in the 2000s, influence of Inf. to education decreased (elasticity decreased).

4.3 Productivity and Entropy

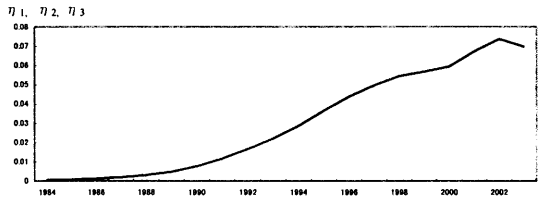

Figure 15. Trend in Productivity of Informatization to VEU *(1984-2003).*

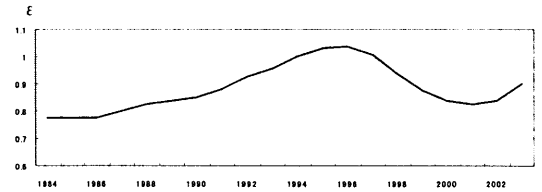

Figure 16. Trend in Entropy of Informatization to VEU *(1984-2003).*

Implication from productivity and entropy
(i) Productivity generally continued to increase.
(ii) Due to differences of the magnitude of impacts of Informatization on V.E.U depending on three periods, entropy changed from diversity (the first period) to convergence (the second period) and again slight diversity (the third period).
(iii) As a consequence of the divergence trend in the third period, productivity change to slight decrease in the end of the third period.

5. Co-evolution between Institutional Structure and Inter-firm Technology Spillover

Based on foregoing analysis, in order to analyze the co-evolution between institutional structure and inter-firm spillover, industries of PC, internet and mobile phone are taken as they developed dramatically in China. **Figure 17** demonstrates the quantitative analysis result of selected 20 firms. It can be found that product diversification is an obvious trend in China's ICT industry. More and more firms diversify theirs product line which expedite technology spillover within ICT industry. Due to the robust effect of informatization to VEU, there exist a co-evolution relationship between institution structure and inter-firm technology spillover.

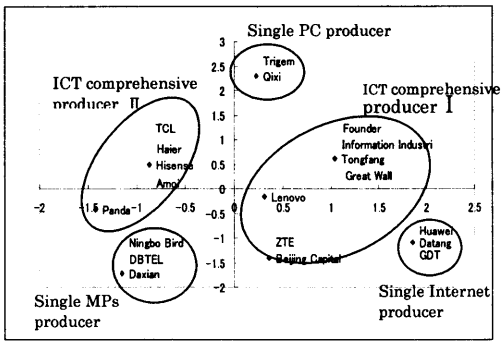

Figure 17. Technology Spillover between China's Major ICT Firms.

6. Conclusion

(i) China has been demonstrating a conspicuous economic growth.
(ii) This can be attributed to its unique institutional structure characterized by V.E.U structure.
(iii) Advancement of informatization accelerates the economic growth.
(iv) The contributing effect of informatization to VEU balances the development of triangle factors, slows down the fragile trend of institution to keep it not so convergence, though V.E.U development changed to slight fragile structure from 2000.
(v) There exist a co-evolution relationship between institution structure and inter-firm technology spillover.

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