Regional Synergy: Congenital Dilemma and Acquired Intervention

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Abstract. Regional synergy would face a congenital “prisoner's dilemma” in the absence of external intervention. And it might be necessary to establish an intervention of subsidy intervention model, punishment intervention model or “subsidy + punishment” dual intervention model to make the region’s behavior return to the optimal strategic goal of {synergy, synergy} rather than falling into “non- synergy” dilemma. Research three intervention model intervention goals agreed conditions, draw corresponding intervention variable scope. Based on the intervention model, gross synergistic effect was calculated. From the perspective of gross synergistic effect, the region prefers the subsidy + punishment dual intervention, while the society has no obvious preference for intervention. And then it could be expected to design a regional synergy model without compulsory intervention for reducing the impact of endorsement mechanism on synergies.

Keywords: Regional synergy; Congenital dilemma; Acquired intervention

1 Introduction

Synergetics was first proposed by German physicist Haken[1]in 1969, and Zhang Shouwen [2]believed that regional synergetics required all regions to achieve common development goals in a cooperative way. Yin Zhi [3]pointed out that regional cooperation is a regional economy designed to reduce the gap between regions and realize the complementary development of advantages between regions. Chen Hao and Luo Lifei [4]believe that regional cooperation has three meanings: coordination, synchronization and competition and cooperation. Saunavaara[5]believed that regional coordination was to solve the problem of unbalanced and inadequate regional development with the help of policy planning. Randolph[6]proposed that regional cooperation should incorporate external ideas to coordinate the development of the first-mover and late-mover regions. Tang Yalin [7] reviewed the history of the expansion of regional governance space in the Yangtze River Delta and found the competition mode of geographical adjacency and industrial homogenization. Xing Haifeng [8]found that regional cooperation in Northwest Xinjiang still has "bleeding competition" in which various regions compete to lower land prices in order to attract investment. Fang Xingming et al. [9] believe that the intensification of homogeneous competition will expand the negative effects of competition and eventually form a dilemma. It is pointed out that regional disordered competition is mainly manifested in repeated construction, industrial homogenization, vicious competition in attracting investment and so on. Mao Yong and Lv Kangyin [10]proposed that regional disordered competition is mainly manifested in repeated construction, industrial homogenization, vicious competition in attracting investment

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and so on.

The increasingly severe problem of uncoordinated and unbalanced regional development urgently calls for regional coordinated development. In the absence of external intervention, due to competition, trust, culture, history and many other reasons, regions tend to choose non- synergy poor strategies. From the perspective of non- synergy game, regional synergy is faced with a serious congenital dilemma.

In order to break the congenital dilemma of non- synergy, the introduction of acquired intervention becomes a necessary option to promote regional synergy. The specific ways of acquired intervention include adequate subsidies for synergy behavior, adequate penalties for non- synergy behavior, or a combination of the two approaches. Through sufficient intensity of acquired intervention, regional behavior can be pulled back to the synergistic strategy, so as to avoid the non- synergy congenital dilemma.

Therefore, it is necessary to conduct a precise quantitative evaluation of the synergistic effect of acquired intervention, so as to determine the acceptable intensity of acquired intervention, so as to obtain as large regional synergy effect as possible at the cost of as small as possible.

2 Regional synergy model design

2.1 Congenital dilemma model

(1) Construction of congenital dilemma model. Regional synergy is faced with a congenital dilemma, that is, regional synergy eventually falls into the trap of "non-synergy " inferior strategy due to many negative influences such as homogeneous comparison, continuation of historical grudges and cultural conflicts. It is assumed that the subjects are region A and region B respectively, and the innate dilemma model of regional synergy is constructed, as shown in Table 1.

Table 1. Congenital dilemma model of regional cooperation

		region B	
		synergy	non-synergy
region A	synergy	R_1, P_1	R_3, P_3
	non-synergy	R_2, P_2	R_4, P_4

(2) Income variable. R_1, P_1, R_2, P_2, R_3, P_3, R_4, P_4 are the corresponding regional benefits under different regional decisions.

(3) Congenital dilemma: {non-synergy, non-synergy}. According to the model in Table 1, if there is no external intervention, region A and region B will fall into a congenital dilemma of both choosing " non-synergy " strategies.

2.2 Subsidy intervention model

(1) Construction of subsidy intervention model. The first way of external intervention is to give a certain amount of subsidies to the region that chooses the " synergy " strategy. The construction

of the subsidy intervention model is shown in Table 2.

Table 2. Subsidy intervention model of regional synergy

		region B	
		synergy	non-synergy
region A	synergy	$R_1 + \alpha M_1$， $P_1 + (1-\alpha)M_1$	$R_3 + M_1$， P_3
	non-synergy	R_2， $P_2 + M_1$	R_4， P_4

(2) subsidy variable. M_1 is the subsidy amount of the " synergy " strategy imposed by the society on the region; α（$\alpha \in (0,1)$） refers to subsidy allocation ratio when both sides of the region choose the "synergy" strategy.

(3) Subsidy endorsement mechanism. The society deposits the subsidy amount M_1 into a special account as a subsidy commitment for the game players to choose the " synergy " strategy. Once the game subject chooses the " synergy " strategy, the special account pays the subsidy amount to the " synergy " strategy subject according to the game rules in Table 2.

(4) Subsidy intervention target: {synergy, synergy}. Through the "subsidy" intervention in Table 2, the {synergy, synergy} optimal strategy goal is achieved.

2.3 Punishment intervention model

(1) Construction of punishment intervention model. The second way is to choose the strategy of "synergy" area to give a certain amount of punishment, to deter players choose "synergy" strategy, punish intervention model structure as shown in table 3.

Table 3. Punishment intervention model of regional synergy

		region B	
		synergy	non-synergy
region A	synergy	R_1， P_1	R_3， $P_3 - M_2$
	non-synergy	$R_2 - M_2$， P_2	$R_4 - \beta M_2$， $P_4 - (1-\beta)M_2$

(2) penalty variable. M_2 is the penalty limit of "non- synergy " strategy paid by the game subject, and β（$\beta \in (0,1)$） is the penalty sharing ratio when both sides of the region choose "non- synergy " strategy.

(3) Punishment endorsement mechanism. Before the start of the game, both sides of the game deposit the penalty amount M_2 into a special account respectively. Once the game player chooses the "non- synergy " strategy, the special account will collect the penalty amount from the "non- synergy " strategy player according to the game rules in Table 3.

(4) Punishment intervention target: {synergy, synergy}. Through the "punishment" intervention in Table 3, the {synergy, synergy} optimal strategic goal is achieved.

2.4 Subsidy + punishment dual intervention model

(1) Construction of dual intervention model. The third way of external intervention is to introduce both subsidy and penalty intervention mechanisms, while using subsidies to encourage "synergy" and penalties to deter "non-synergy". The construction of subsidy + punishment intervention model is shown in Table 4.

Table 4. Subsidy + punishment dual intervention model of regional synergy

		region B	
		synergy	non-synergy
region A	synergy	$R_1 + \alpha M_3$，$P_1 +$ （$1-\alpha$） M_3	$R_3 + M_3$，$P_3 - M_3$
	non-synergy	$R_2 - M_3$，$P_2 + M_3$	$R_4 - \beta M_3$，$P_4 -$ （$1-\beta$） M_3

(2) Double intervention variables. M_3 is not only the " synergy " strategy subsidy amount imposed by the society, but also the "non- synergy " strategy penalty amount paid by the game subject.

(3) double-intervention endorsement mechanism. According to the quota M_3, the subsidy commitment and penalty commitment should be implemented simultaneously.

(4) Double intervention goal: {synergy, synergy}. Through the "subsidy + punishment" intervention in Table 4, the {synergy, synergy} optimal strategy goal is achieved.

3 Conditions for achieving intervention objectives

3.1 Constraints on the relationship between income variables

(1) Non-synergy equilibrium condition. In the model shown in Table 1, non- synergy equilibrium {non- synergy, non- synergy} must satisfy the conditions of non-cooperative equilibrium shown in Equation (1).

$$\begin{cases} R_2 \geq R_1 \\ R_4 \geq R_3 \end{cases} \text{ and } \begin{cases} P_3 \geq P_1 \\ P_4 \geq P_2 \end{cases} \tag{1}$$

(2) Conditions of synergistic effect. In view of the synergy effect in theory, the relationship between income variables should also satisfy the synergy effect condition shown in Equation (2).

$$\begin{cases} R_1 \geq R_4 \\ P_1 \geq P_4 \end{cases} \tag{2}$$

(3) Joint qualification relation. By combining equations (1) and (2), the joint limiting relation (3) can be obtained.

$$\begin{cases} R_2 \geq R_1 \geq R_4 \geq R_3 \\ P_3 \geq P_1 \geq P_4 \geq P_2 \end{cases} \tag{3}$$

3.2 Conditions for achieving the target of subsidy intervention

For the subsidy intervention model shown in Table 2, the achievement of its target {synergy, synergy} strategy must satisfy the conditions shown in Equation (4).

$$\begin{cases} R_1 + \alpha M_1 \geq R_2 \\ R_3 + M_1 \geq R_4 \end{cases} \text{ and } \begin{cases} P_1 + (1-\alpha) M_1 \geq P_3 \\ P_2 + M_1 \geq P_4 \end{cases} \tag{4}$$

The value condition of subsidy variable M_1 can be obtained from equation (4), as shown in Equation (5).

$$M_1 \geq \max\left\{ \frac{R_2 - R_1}{\alpha};\ (R_4 - R_3);\ \frac{P_3 - P_1}{1-\alpha};\ (P_4 - P_2) \right\} \tag{5}$$

That is, when the subsidy amount M_1 satisfies the condition of Formula (5), the subsidy intervention is effective. At this time, both region A and region B will choose the "synergy" strategy, and the target {synergy, synergy} strategy can be realized.

3.3 Conditions for achieving the target of punishment intervention

For the punishment intervention model shown in Table 3, the achievement of its intervention target {synergy, synergy} strategy must satisfy Equation (6).

$$\begin{cases} R_1 \geq R_2 - M_2 \\ R_3 \geq R_4 - \beta M_2 \end{cases} \text{ and } \begin{cases} P_1 \geq P_3 - M_2 \\ P_2 \geq P_4 - (1-\beta) M_2 \end{cases} \tag{6}$$

The value condition of penalty variable M_2 can be obtained from equation (6), as shown in Equation (7).

$$M_2 \geq \max\left\{ (R_2 - R_1);\ \frac{R_4 - R_3}{\beta};\ (P_3 - P_1);\ \frac{P_4 - P_2}{1-\beta} \right\} \tag{7}$$

That is, when penalty limit M_2 satisfies the condition of Formula (7), penalty intervention is effective. At this time, both region A and region B will choose the "synergy" strategy, and the intervention target {synergy, synergy} strategy can be realized.

3.4 Conditions for achieving the target of subsidy + punishment dual intervention

For the subsidy + punishment dual intervention model shown in Table 4, the achievement of its target {synergy, synergy} strategy must satisfy Equation (8).

$$\begin{cases} R_1 + \alpha M_3 \geq R_2 - M_3 \\ R_3 + M_3 \geq R_4 - \beta M_3 \end{cases} \text{ and } \begin{cases} P_1 + (1-\alpha) M_3 \geq P_3 - M_3 \\ P_2 + M_3 \geq P_4 - (1-\beta) M_3 \end{cases} \tag{8}$$

The value condition of the dual intervention variable M_3 can be obtained from equation (8), as shown in Equation (9).

$$M_3 \geq \max\left\{ \frac{R_2 - R_1}{1+\alpha};\ \frac{R_4 - R_3}{1+\beta};\ \frac{P_3 - P_1}{2-\alpha};\ \frac{P_4 - P_2}{2-\beta} \right\} \tag{9}$$

That is, when the dual intervention limit M_3 satisfies the conditions of Formula (9), the double intervention of subsidy and punishment is effective. At this time, both region A and region B will choose the "synergy" strategy, and the intervention target {synergy, synergy} strategy can be realized.

4 Gross synergistic effect after the intervention target is achieved

4.1 Concept of gross synergy effect

Synergistic effect refers to the excess returns that exceed {non- synergy, non- synergy } bad strategies obtained by both parties in the game by simultaneously choosing " synergy " strategies. The synergy effect thus obtained is called gross synergy effect because no deduction of intervention cost is taken into account.

4.2 Calculation and calculation of gross synergistic effect

Calculation formula of gross synergistic effect. Based on the concept of gross synergistic effect, the calculation formula of gross synergistic effect can be defined as follows:

$$\text{regional gross synergy} = \{\text{synergy}, \text{synergy}\}\ \text{regional revenue} - \{\text{non} - \text{synergy}, \text{non} - \text{synergy}\}\ \text{regional revenue} \quad (10)$$

$$\text{Social gross synergy effect} = \text{regional gross synergy effect} - \text{subsidy and penalty limit} \quad (11)$$

(2) Calculation of gross synergistic effect. For the intervention models in Table 2, 3 and 4, gross synergistic effects of the three intervention models were calculated respectively according to equations (10) and (11). The calculated results are listed in Table 5.

Table 5. Gross synergy effect obtained by acquired intervention

Intervention mechanism	{synergy, synergy} regional income	{non-synergy, non-synergy} regional income	Regional gross synergy effect	Social gross synergy effect
subsidy	$R_1 + P_1 + M_1$	$R_4 + P_4$	$R_1 + P_1 - R_4 - P_4 + M_1$	$R_1 + P_1 - R_4 - P_4$
punishment	$R_1 + P_1$	$R_4 + P_4 - M_2$	$R_1 + P_1 - R_4 - P_4 + M_2$	
Subsidy + punishment	$R_1 + P_1 + M_3$	$R_4 + P_4 - M_3$	$R_1 + P_1 - R_4 - P_4 + 2M_3$	

As can be seen from Table 5, regional gross synergy is related to subsidy penalty limit. For comparison, $M_1 = M_2 = M_3 = M$, then the maximum regional gross synergy effect of subsidy + punishment dual intervention model is $(R_1 + P_1 - R_4 - P_4 + 2M)$. The regional gross synergies of subsidy intervention model and punishment intervention model are the same, which are $(R_1 + P_1 - R_4 - P_4 + M)$. As for the social gross synergy effect , the three intervention models are the same, and they are all $(R_1 + P_1 - R_4 - P_4)$.

5 Examples

5.1 Parameter Assignment

Take A synergy between two cities as an example, in which Rong Shu is region A and Yu Ba is region B. According to the relation of earning variables shown in equation (3), the income variables of region A R_1、R_2、R_3、R_4 are assigned values of 0.5, 1, -1 and 0 respectively. The yield variables P_1、P_2、P_3、$P_4$of region B are assigned values of 0.5, -1, 1 and 0. Based on the consideration of fairness, the subsidy distribution coefficient α and penalty sharing coefficient β are both assigned 0.5. The intervention intensity was uniformly taken as $M_1 = M_2 = M_3 = 2$ according to the acceptability condition. The above parameter assignments are summarized in Table 6.

Table 6. Parameter assignment summary

R_1	R_2	R_3	R_4	P_1	P_2	P_3	P_4	α	β	M
0.5	1	-1	0	0.5	-1	1	0	0.5	0.5	2

5.2 Calculation Examples

(1) Examples of gross synergistic effect. The parameters in Table 6 were assigned and substituted into Table 5 to calculate the gross synergy effect, and the calculated results were shown in Table 7.

Table 7. Examples of gross synergy effect obtained by acquired intervention

Intervention mechanism	{synergy, synergy} regional income	{non-synergy, non-synergy} regional income	Regional gross synergy effect	Social gross synergy effect
subsidy	3	0	3	1
punishment	1	-2	3	
Subsidy + punishment	3	-2	5	

It can be seen from Table 7 that the regional gross synergy effect is maximum in the subsidy + punishment dual intervention model, which is 5. The subsidy intervention model is the same as the punishment intervention model, and the value is 3. The three intervention models had the same social gross synergy effect, which is 1.

Therefore, from the perspective of synergy effect, the region prefers the subsidy + punishment dual intervention mode.

6 Conclusion

Based on the innate dilemma of regional coordination, three acquired intervention models including subsidy, punishment and "subsidy + punishment" are constructed, and the conditions for reaching intervention targets and their gross synergy effects are analyzed. The main conclusions are as follows:

(1) Without external intervention, regional cooperation will face a congenital dilemma similar to "Prisoner's dilemma". Due to many negative influences such as homogeneous comparison, continuation of historical enmity and cultural conflict between regions, it is difficult to establish an effective trust relationship between regions, and eventually they often fall into the trap of "non-synergy " bad strategy which is neither beneficial to the two parties nor to the society.

(2) In order to avoid the congenital dilemma of "non-synergy", it is necessary to introduce the acquired intervention, establish the subsidy intervention model, penalty intervention model or "subsidy + punishment" dual intervention, pull the regional behavior back to the strategic space of mutual cooperation, achieve the optimal strategic goal of {synergy, synergy}, and then obtain certain synergistic effect.

(3) Under the interventions, the social gross synergistic effect is the same, that is, the three interventions have the same impact on the society. From the regional perspective, the subsidy + punishment dual intervention is the best choice. Therefore, under the compulsory intervention, the dual intervention mechanism is the common choice of the region and the society.

Of course, it is expected that further studies in the future can design a regional synergy model of non- synergy intervention, so as to avoid "non- synergy " congenital difficulties and achieve regional synergy.

REFERENCES

[1] Haken H. (1989) Synergetics: an overview[J]. Reports on Progress in Physics, 52(5): 515. DOI 10.1088/0034-4885/52/5/001.

[2] Zhang Shouwen. (2021) Analysis and promotion of economic law for regional coordinated development [J]. Contemporary Law, 35(05): 99-109. https://kns.cnki.net/kcms2/article/abstract?v=3uoqIhG8C44YLTlOAiTRKibYlV5Vjs7iy_Rpms2pqwbFRRUtoUIm-HaaErQX585NHBN2pHESK4Nfbt0jyYoG5vARi3Y0uhV28&uniplatform=NZKPT.

[3] Yin Zhi, Lu Qingqiang.(2022) China's new urbanization enters the stage of regional coordinated development [J]. Academic Frontiers, People's Forum, 2022(22):29-36. DOI：10.16619/j.cnki.rmltxsqy.2022.22.003

[4] Chen Hao, Luo Lifei. (2023) The impact of regional coordinated development Policy on factor flow and allocation: A case study of Beijing-Tianjin-Hebei [J/OL]. Reform: 1-19 [2023-03-24]. HTTP: / / http://kns.cnki.net/kcms/detail/50.1012.F.20221019.1630.002.html.

[5] Saunavaara J. (2017) The role of international development strategies in making regional development policies: Hokkaido as a case study[J]. Urbani izziv, 28(2): 122-135.DOI：10.5379/urbani-izziv-en-2017-28-02-004.

[6] Randolph R. (2019) Regional development policies and the challenge to reduce spatial inequalities in Brazil[J]. Area Development and Policy, 4(3): 271-283.DOI：

10.1080/23792949.2019.1570824.
[7] Tang Yalin. (2014) From homogeneous competition to Diversified complementarity and Co-prosperity: Theory and Practice of regional Governance in the Pan-Yangtze River Delta Era [J]. Academic Circles, 2014(05): 71-83+309. https://kns.cnki.net/kcms2/article/abstract?v=3uoqIhG8C44YLTlOAiTRKgchrJ08w1e7M8Tu7YZds8_KgaxZHEHkkVMC-eZgUaJAOFHcEomwDzowRklIEcGE4Zw-hZ2MbTaE&uniplatform=NZKPT.
[8] Xing Haifeng. (2015) Construction of Local cooperation Mechanism in Regional Coordinated Development: A Case study of Regional Cooperation in Northwest Xinjiang [J]. Urban Development Research, 22(03): 33-38.DOI：10.3969/j.issn.1006-3862.2015.03.005.
[9] Fang Xingming, Xu Chendi, Yang Jirui. (2022) Chengdu-chongqing homogeneous competition and resolution[J]. Reform of Economic System, 2022(02): 73-78. https://kns.cnki.net/kcms2/article/abstract?v=3uoqIhG8C44YLTlOAiTRKibYlV5Vjs7iJTKGjg9uTdeTsOI_ra5_XdFVn8lYnxeRaYmFmbzwh6xSyLii9xXZkr-wW6-J6fVL&uniplatform=NZKPT.
[10] Mao Yong, LV Kangyin. (2013) Economic analysis and cultural causes of regional disordered competition [J]. East China Economic Management, 27(11): 73-77.DOI： 10.3969/j.issn.1007-5097.2013.11.015.