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ARTICLE

Is the Urban Shrinkage Inhibits the Improvement of Public Service Level?

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ABSTRACT

Public services provide convenient conditions for urban residents to study, work and live, and have important significance for improving the life quality of residents and improving the level of welfare. However, while China's spatial economic is heading towards agglomeration development, a large number of cities have shrunk, which has made unbalanced supply of public services between regions increasingly prominent. Based on the existing literature and the development reality, this paper analyzes the impact of urban shrinkage on the public service level from the public service supply mechanism, and discusses the heterogeneous effects of different labor shrinkage on public services. The results of the study show that urban shrinkage will inhibit the improvement of public service level, but inter-governmental competition makes the labor shrinkage of industry and service industry promote the improvement of public service level. In addition, this paper takes economic development level as a moderating variable to study the moderating effect of economic development level in the impact of urban shrinkage on public service levels. It is found that the reduction of economic development level will promote government competition and provide more public services.

1. Introduction

Since the reform and opening up, China's economic development has made remarkable achievements. With the rapid economic growth, the population size and urban land use in large cities have expanded rapidly. Especially in the spatial distribution of economic activities, a large number of people gradually gather in a few central cities with rich life, perfect public services and convenient working and living. Population concentration in central cities will inevitably lead to population reduction in small and medium-sized cities. Existing research shows that the local shrinkage of China's urban pattern is increasingly obvious under the overall growth environment [1]. Under such a background, the spatial pattern of population movement in China can be described as "ice and fire". On the one hand, the population is continuously flowing to the traditional first-tier big cities such as Beijing, Shanghai, Guangzhou and other first-tier cities, where housing prices are continuously pushed up, living pressure is increased, and urban roads are more crowded; On the other hand, second-and third-tier cities have joined in the "competition of attracting talent (people well educated) between cities" to make up for the lack of economic attraction of the cities themselves by lowering the household registration

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threshold and personal income tax. The spatial flow of population makes the unbalanced supply of urban public services in different regions more serious. Promoting the equalization of public services has become the basic focus of the government to improve people's livelihood and optimize the functions of the city as an important measure to coordinate regional development, improve the quality of life of residents and reform the public finance system. A large number of studies have confirmed that China's megacities, which are the places of population inflow, have the problem of insufficient supply of public services, resulting in "megacity disease", while relatively few studies have been conducted on the planning of small and medium-sized cities. However, the background of social and economic transformation has changed the focus of scholars from focusing only on the agglomeration effect brought by population inflow into large cities to starting to explore the benefits of "downsizing" cities. From the perspective of urban development, urban shrinkage is only a stage in the process of urbanization, which does not necessarily bring about economic recession, but also may bring new development opportunities to the shrinking cities [2]. Leipzig and Liverpool are both classic cases from urban shrinkage to economic re-growth. How planners apply the concept of streamlining planning to urban planning in shrinking areas is of great significance for shrinking cities to attract the return of population and revive the local economy [3].

Regarding the development trends of the shrinking area, although the streamlining strategy has been approved by some scholars, with the gradual deepening of research, scholars have found that the current concept of smart shrinkage is not flawless. The rational and streamlined planning concept has produced a series of new urban planning ideas. Promoting the redevelopment of shrinking areas has become the primary goal of the local government to restart economic vitality and move towards high-speed development. However, there are few discussions on what kind of reasonable smart shrinkage can conform to the current urban development law and effectively improve the level of regional economic development. The government will generally promote economic growth through infrastructure construction and high value-added economic activities [4], but the outflow of population from small and medium-sized cities and the construction of a large number of useless public services will aggravate the problems of resource space mismatch and resource waste. For a long time, China's urbanization based on the growth model has led to an aggressive development trend in a large number of small and medium-sized cities. Most cities have problems such as excessive construction of public services. Some scholars have proposed that there is a "shrinkage paradox" in many cities in China where the population size is declining, but the construction land is increasing instead [5].

Many small and medium-sized cities have built a large number of public services in order to optimize the investment environment and attract the re-concentration of capital and labor elements, resulting in serious waste of resources. In recent years, the phenomenon of "ghost cities" and "empty cities" in China has aroused great concern in academic circles and society. *The Key Task of New Urbanization Construction in 2019* issued by the National Development and Reform Commission proposes that small and medium-sized shrinking cities should "lose weight and strengthen their bodies", change the inertia of incremental planning thinking, strictly control the increment and revitalize the stock. Smart shrinkage must be combined with regional practice in order to better promote the development of theory [6]. To investigate what kind of development ideas can be suitable for the current development situation of our country's cities, we must think about this issue from the supply side of public services. This paper analyzes the motivation and influence mechanism of local governments to provide public services from the perspective of local government competition, which is commonly used in existing studies. It is found that urban shrinkage will inhibit the improvement of local government's public service level, but the impact of different types of labor shrinkage on the construction of public energy services is heterogeneous, and puts forward corresponding suggestions for the construction of public services in China.

2. Theoretical Analysis and Research Assumptions

2.1 Urban Shrinkage and Public Services

Research on the impact of population migration on public services generally believes that the provision of public services is dominated by government construction, with the satisfaction of local residents as the standard. Therefore, local governments will consider the size of local cities and the current situation of economic development when carrying out public service construction. The shrinkage of cities is generally manifested by the loss of urban population, which makes the government reduce the corresponding public service construction. This is particularly prominent in the field of education. Compulsory education for low-skilled labor in their hometown generates returns in the places where the population flows in, which makes

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the cities where the population flows out lack incentives to invest in education [7]. In addition, China's current urban shrinkage phenomenon usually occurs in economically underdeveloped areas. These cities generally have a relatively low level of urbanization, a relatively high proportion of rural population and relatively scattered residence, thus the economies of scale in the process of public service provision are limited by space and hard to accomplish. Moreover, the autonomy of choice enables the labor force with higher labor participation rate and education level to have higher initiative in the choice of living cities. Therefore, the loss of urban population has a negative impact on the quality of human capital in the shrinking areas while reducing the number of population in the areas. The decrease in population quality and technical level also further leads to the decrease in the efficiency of public service supply.

As mentioned above, the loss of population directly or indirectly reduces the local government's investment in the construction of public services and the construction efficiency of public services. Therefore, the level of public service construction closely related to people's lives will be reduced by the chain reaction of the shrinkage of the city. Based on the above analysis, this paper proposes assumption 1.

Assumption 1: Urban shrinkage inhibits the improvement of public service level, that is, the more serious the urban shrinkage, the lower the public service level.

2.2 Heterogeneity of Urban Shrinkage on Public Service Level

The traditional fiscal decentralization theory holds that the movement of population between regions will affect the competition of public service supply among local governments through the mechanism of "voting with feet". Therefore, local governments usually increase the supply of public services to attract the population to flow into the region and realize the supply of public products that are suitable for the residents' preferences in various regions [8]. However, China's existing "voting with feet" mechanism is not perfect, and the distortion of public resource allocation mechanism makes the ideal public service supply theory not fully applicable in explaining China's phenomenon.

Wages in modern economic sectors are usually higher than those in traditional agricultural sectors, thus the agricultural labor force is continuously flowing from traditional agriculture to modern industrial sectors [9]. Therefore, the decrease in the number of agricultural labor force in most cities in China is not the loss of agricultural labor force, but the transformation of agricultural labor force among various industries within the region. In short, the decrease in the agricultural labor force in each city is not that the farmers in this city move to other cities to continue to engage in agricultural production, but that the agricultural labor force enters the urban areas of the cities to which the household registration belongs and engages in industries with higher labor returns such as construction, industry and domestic economics. Therefore, the decrease in the agricultural labor force population will not stimulate the competition for public services among governments. In addition, since agricultural production relies less on public services than industry and service industry, the government, after reducing the agricultural labor force, focuses more on adopting policies such as agricultural subsidies and tax relief, rather than improving the level of public services to enhance the city's attractiveness to agricultural capital and labor and other factors.

The promotion mechanism using GDP as the main assessment indicator for local officials strengthens the existing competition among local governments [10]. Obviously, the shrinkage of industrial labor force can trigger the competition for public services of local governments. On the one hand, industry accounts for a relatively large proportion of the national economy, and the government is more willing to increase the level of public services to attract industrial enterprises, while more industrial enterprises can absorb more industrial labor force. On the other hand, due to the large amount of transportation and personnel exchanges required in the production process, industry is more dependent on the level of public services than other industries [11]. The fiscal competition launched by the government to attract enterprises to settle down usually includes tax competition and public service competition [12]. By providing better public goods and services, capital and labor factors can be attracted to flow into the local area, thus improving the local economic level. A large number of enterprises gathering in the region can better realize economies of scale and knowledge spillovers [13,14], with the development of information technology and many outsourcing agencies, the service industry is gradually gathering in urban areas, and the current flow of Chinese labor force between cities enables the selection mechanism of officials who "vote with their feet" to promote the construction of regional public services [15]. Based on the above analysis, this paper proposes assumption 2.

Assumption 2: The shrinkage of agricultural labor force inhibits the improvement of public service level, but the shrinkage of industrial and service labor force will promote the improvement of public service level.

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2.3 Moderating Effect of Economic Development Level

At present, China's population flow is mainly dominated by labor force flow. Population outflow not only reduces the per capita GDP of the outflow area, but also usually causes the manufacturing industry in the outflow area to shrink, making the outflow area gradually marginalized [16]. The decline of industries and the reduction of employment opportunities have led to the population flowing to regions with higher economic development level. As mentioned above, highly developed regions can provide better public services, job opportunities and living standards, thus labor force usually flows from backward regions to economically developed regions. For example, the collapse of a large number of state-owned economies in East Germany has led to the population flowing to West Germany regions with better employment conditions and better living conditions [17]. At the same time, cities with low levels of economic development are restricted by the reduction of population and the decline of the quality of human capital. They are in a more disadvantageous position in the competition with economically developed regions and further restrict the development prospects of economically backward regions. However, under the pressure of promotion, local government officials must optimize the local economic development environment. The existing literature holds that the government generally promotes the concentration of capital and labor in the local area by reducing taxes and providing more public services, thus promoting the economic development of the region.

Compared with economically developed regions, cities with lower levels of economic development may provide more public services to revive the local economy after shrank. The game of political promotion urges local officials to pay more attention to their relative position with competitors [18]. The government usually takes certain measures to attract industries to gather locally, and the agglomeration of industries in the region is based on the result of self-evolution of market mechanism. The government can only reduce the cost of agglomeration through public goods and policies to guide capital and labor elements to flow to the region. Due to the differences in geographical location and natural resources in different regions, the same policies will have different impacts on the economic development of different regions. In order to make up for the objective differences in development, the impact of public services is particularly important [19]; At the same time, China's large-scale land finance has enabled local governments to have abundant financial resources to support local financial expenditures. In areas with backward economic development, in order to attract the second return of labor force, local governments generally improve the attractiveness of cities to industries by providing better public services and lower tax rates. In the research on the relationship between intergovernmental competition and public service, most scholars believe that intergovernmental competition leads to excessive public service expenditure, which is manifested in the repeated construction of a large amount of infrastructure in cities with population outflow [20]. Therefore, when shrinkage occurs in regions with low economic development level, the local government will promote the concentration of capital and labor in the region by improving the level of public services, thus slowing down the inhibitory effect of urban shrinkage on the level of public services. On the contrary, when there is a phenomenon of urban shrinkage in regions with high economic development level, there is relatively little incentive to optimize the local business environment by improving the level of public services. Therefore, the more developed the urban economy is, the more obvious the inhibitory effect of urban shrinkage on public services will be. Based on the above analysis, this paper proposes assumption 3.

Assumption 3: The level of economic development plays an important moderating effect in the inhibition of urban shrinkage on the improvement of public service level. The inhibitory effect of urban shrinkage on public services increases as the level of urban economic development increases, vice versa.

3. Research Design

3.1 Variable Description

3.1.1 Explained Variables

This paper is based on the relevant research [21] and the availability of data, the measurement indicators of the selected public service level reflect as fully as possible the government guarantees the public services required by all citizens. These indicators can be divided into five categories with a total of 17 indicators: public healthcare and education are important factors to improve the basic living standards of residents; Environmental protection in the region affects the quality of life of residents. Basic cultural services provide a place for residents to relax and entertain. Infrastructure construction is the material basis for ensuring residents' travel and enterprises' production (Seen Table 1 for details).

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Table 1. Evaluation Index System of Public Service Level

Target layer	Criterion layer	Indicator layer	Weight
Public service level	Public education	Schools per 1,000 students	0.0797
		Expenditure on education per student	0.0482
		Number of full-time teachers per 1,000 pupils	0.0124
		Number of full-time teachers per 1,000 middle school students	0.0042
	Public healthcare	Number of beds per 1,000 medical institutions	0.0181
		Number of health institutions per 1,000 population	0.0362
		Number of health technicians per 1,000 population	0.0249
	Environmental protection	Industrial wastewater compliance rate	0.0844
		Comprehensive utilization rate of industrial solid waste	0.0842
		Road cleaning rate	0.0246
	Infrastructure	Post and telecommunications business per capita	0.0931
		Road density	0.1014
		Length of water supply pipeline	0.0986
		Park green space coverage	0.1131
	Basic cultural services	Number of theaters and theaters	0.0913
		Number of public libraries	0.0225
		Book collection per 100 people in public library	0.0632

Based on the above five categories and 17 indexes, this paper uses entropy method to determine the weight of each index and constructs a public service level index. It should be noted that in order to avoid negative values and zero being meaningless when taking logarithms, in the process of calculating weights by entropy method, this paper adds 1 after standardization to carry out non-negative treatment, and adopts the following formula:

$$X'_{tj} = \frac{X_{tj} - \min\left(X_j\right)}{\max\left(X_j\right) - \min\left(X_j\right)} + 1 \quad (1)$$

Where X'_{tj} represents the normalized variable and X_{tj} represents the original variable.

3.1.2 Explanatory Variables

This paper mainly discusses the impact of urban shrinkage and its heterogeneity on the level of regional public services. At present, scholars mainly measure urban shrinkage by using indicators such as population change, social economy and geographical space [22]. In this paper, referring to the study of Zhang et al. [23], cities with negative population growth rates during the fifth census and sixth census are defined as shrinking cities. In order to discuss the impact of heterogeneity of urban shrinkage on public service level, the reduction of labor force in agriculture, industry and service industry is used to express the heterogeneity of urban shrinkage.

3.1.3 Control Variables

In the empirical analysis of this paper, reference is made to the relevant domestic literature on the factors affecting the level of public services [24], introduce other variables that can affect the regional public service level into the model, including: labor productivity (lab_pro), degree of openness (open_lev), urbanization level (urb_lev), financial self-sufficiency rate (fin_self), technological innovation level (tec_inn), and resident consumption capacity (total_sal).

3.1.4 Moderating Variables

Based on the above theoretical analysis, this paper selects the level of economic development as the moderating variable. Many documents use different indicators to measure the level of economic development according to different research purposes, of which GDP per capita is used more frequently. The higher the GDP per capita, the higher the economic development level of the region, so the GDP per capita can be used to better measure the economic development level of the region.

Table 2. Description of Main Variables

Type	Variable	Symbol	Variable description
Interpreted variable	Public service level	pub_serv	Public service level index
Explanatory variable	The total population of the city is shrinking.	shrink	Virtual variables, shrinking city value is 1, non-shrinking city value is 0
	Agricultural labor shrinkage	lab_agri	
	Industrial labor shrinkage	lab_indu	
	Labor shrinkage in service industry	lab_serv	
moderating variable	Level of economic development	per_gdp	Per capita GDP
Control variable	Technological innovation level	tec_inn	Number of patent licenses per million people
	Degree of opening to the outside world	open_lev	Foreign direct investment in cities/national foreign direct investment
	Urbanization level	urb_lev	Non-agricultural population/total urban population
	Financial self-sufficiency rate	fin_self	Fiscal revenue/expenditure
	Labor productivity	lab_pro	Gross national product/labor force
	Residents' consumption ability	total_sal	Total retail sales of social consumer goods per capita

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3.2 Data Sources and Processing

The population data used in the paper are from the fifth and sixth censuses, the public service facilities and other data are from the 2001-2011 C*hina Urban Statistics Yearbook* and *China Urban Construction Statistics Yearbook*. In order to prevent the deviation that extreme values may bring to the regression results, this paper carries out 2.5% tail reduction processing, and at the same time carries out logarithmic processing on the data to remove the influence of different dimensions and heteroscedasticity. The descriptive statistical characteristics of variables are shown in Table 3. The average value of public service water is 0.2123 and the standard deviation is 0.0544, which indicates that the sample statistics are close to the values of the overall parameters and have certain representativeness. In addition, it can be seen that more than 26% of the cities in the sample selected in this paper have experienced shrinkage, of which more than 88.9% are cities with shrinking agricultural labor force and nearly 20% are cities with shrinking industrial and service labor force, indicating that the current problem of urban shrinkage in China is relatively serious (Seen Table 3 for details).

Table 3. Descriptive Statistics of Main Variables

Variable	Mean value	Standard deviation	Minimum value	Median	Maximum value
pub_serv	0.2123	0.0544	0.1016	0.2186	0.3161
shrink	0.2612	0.4394	0.0000	0.0000	1.0000
lab_agri	0.8892	0.3140	0.0000	1.0000	1.0000
lab_indu	0.1754	0.3804	0.0000	0.0000	1.0000
lab_serv	0.1934	0.3950	0.0000	0.0000	1.0000
per_gdp	0.9578	0.4743	0.3154	0.8433	2.2544
lab_pro	2.8879	0.5279	1.8019	2.9073	3.8955
open_lev	0.0009	0.0019	0.0000	0.0002	0.0088
urb_lev	0.2740	0.1648	0.0672	0.2301	0.6931
fin_self	1.1494	0.3144	0.6881	1.0987	1.9556
tec_inn	0.0601	0.1054	0.0007	0.0170	0.4988
total_sal	0.4428	0.2796	0.1097	0.3617	1.2720

3.3 Model Setting

In order to verify assumption 1, that is, urban shrinkage will inhibit the improvement of public service level; the basic econometric model set in this paper is shown as formula (2):

$$pub\_serv_{it} = \beta_0 + \beta_1 shrink_{it} + \beta X_{it} + \varepsilon_{it} \quad (2)$$

Where pub_serv represents public service level, shrink represents urban shrinkage, and X represents control variable.If β_1 in formula (2) is negative, assumption 1 is verified. In addition, considering that different labor shrinkage will have different impacts on the level of public services, the competition between local governments makes the shrinkage of labor in industry and service industry more conducive to the government's efforts to optimize the local business environment, thus promoting the improvement of the level of public services. The reduction of agricultural labor force will not stimulate the local government to strengthen the construction of public services. In order to test the impact of heterogeneous shrinkage on public service level and verify assumption 2, the following model is established in this paper:

$$pub\_serv_{it} = \beta_0 + \beta_1 lab\_agri_{it} + \beta X_{it} + \varepsilon_{it} \quad (3)$$

$$pub\_serv_{it} = \beta_0 + \beta_1 lab\_indu_{it} + \beta X_{it} + \varepsilon_{it} \quad (4)$$

$$pub\_serv_{it} = \beta_0 + \beta_1 lab\_serv_{it} + \beta X_{it} + \varepsilon_{it} \quad (5)$$

The level of economic development is an important factor that drives labor to flow across regions. In order to further discuss the moderating effect of economic development on urban shrinkage inhibiting the promotion of public services, thus testing assumption 3 and further studying the influence of economic development level on different shrinking cities, this paper introduces variables of "shrink*per_gdp", "lab_agri*per_ gdp", "lab_indu*per_ gdp", "lab_serv*per_ gdp" to verify the moderating effect of economic development level. The specific setting of the model is as follows:

$$pub\_serv_{it} = \beta_0 + \beta_1 shrink_{it} * per\_gdp_{it} + \beta X_{it} + \varepsilon_{it} \quad (6)$$

$$pub\_serv_{it} = \beta_0 + \beta_1 lab\_agr_{it} * per\_gdp_{it} + \beta X_{it} + \varepsilon_{it} \quad (7)$$

$$pub\_serv_{it} = \beta_0 + \beta_1 lab\_indu_{it} * per\_gdp_{it} + \beta X_{it} + \varepsilon_{it} \quad (8)$$

$$pub\_serv_{it} = \beta_0 + \beta_1 lab\_serv_{it} * per\_gdp_{it} + \beta X_{it} + \varepsilon_{it} \quad (9)$$

4. Empirical Analysis

4.1 Benchmark Regression Results

Table 4 reports the regression results for models 2-5. The regression results in column 1 show that the impact of urban shrinkage on public services is significantly negative at a 1% confidence level, indicating that urban shrinkage reduces the level of public services of local governments.

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After the shrinkage of cities, local governments have reduced non-economic public services such as education. At the same time, the declines in the quality of human capital and the loss of economies of scale in the supply of public services have also reduced the level of public services. Naturally, the level of public services will decrease with the decrease of population. At the same time, urban shrinkage will reduce the quality of local human capital and per capita income, and intergovernmental competition will make local governments pay more attention to regional economic growth while ignoring environmental protection and the improvement of residents' cultural life. On the whole, the shrinkage of the city inhibits the improvement of the public service level in the region, and assumption 1 is verified.

4.2 Heterogeneous Regression Results

Considering the impact of heterogeneity of urban shrinkage on the level of public services, the previous analysis shows that the local government's public service supply mechanism has certain differences in response to the three kinds of labor shrinkage. The shrinkage of agricultural labor force will not cause competition in the supply of public services by local governments, so the competition in the supply of public services will not increase with the shrinkage of agricultural labor force, but the lower the level of public service supply with the shrinkage of agricultural labor force (column 2). On the contrary, the promotion mechanism of local government officials, in which city residents "vote with their feet", urges the government to actively respond to the shrinkage of industrial labor force and service labor force. Existing research shows that the government usually optimizes the regional business environment by building public service facilities, especially economic infrastructure (including transportation infrastructure, etc.), thus increasing the attractiveness of the region to enterprises. The shrinkage of industrial labor force and service labor force has prompted the shrinking cities to compete for public services. The regression model in this paper also confirms the existence of competitive behaviors of public services among governments (columns 3 and columns 4).

Judging from other variables in Table 4, the sign of labor productivity coefficient is negative, but it has not passed the significance test, indicating that the improvement of labor productivity has no significant impact on the level of public service. The coefficient of the level of foreign direct investment is significantly positive, indicating that foreign direct investment has a significant "enhancing effect" on the level of public services in the region. An increase in the level of foreign direct investment will increase the investment in the construction of public services by local governments [25]. The coefficient of regional financial self-sufficiency rate is negative. The higher the financial self-sufficiency rate, the higher the economic development level of these regions, thus increases the regional tax revenue. According to the previous theoretical analysis, the improvement of economic development level can reduce the competition of public service supply. At the same time, the regression results show that the urbanization level and the level of opening to the outside world have a positive impact coefficient on the level of public services, and both pass the significance test, indicating that the improvement of the urbanization level and the level of opening to the outside world in each region has improved the level of public services in the region to a certain extent. Regional scientific and technological innovation is an important condition to promote the all-round development of the region, and also has a significant role in promoting the level of public services in the region. Areas with higher per capita social retail sales obviously have higher levels of economic development and more frequent production and transportation activities, so public services are significantly improved with the increase in per capita social retail sales.

Table 4. Regression Results of Impact of Urban Shrinkage and Its Heterogeneity on Public Service Level

Variable	Urban shrinkage	Agricultural labor shrinkage	Industrial labor shrinkage	Service industry labor shrinkage
shrink	-0.0079*** (-5.55)			
lab_pro	-0.0038 (-1.94)	-0.0040* (-2.05)	-0.0001 (-0.05)	-0.0037 (-1.87)
open_lev	1.4850*** (3.87)	1.4495*** (3.76)	1.5123*** (3.97)	1.4017*** (3.64)
urb_lev	0.0142** (3.03)	0.0140** (2.96)	0.0134** (2.88)	0.0176*** (3.73)
fin_self	-0.0070* (-2.52)	-0.0116*** (-4.24)	-0.0142*** (-5.22)	-0.0109*** (-4.02)
tec_inn	0.0163* (2.00)	0.0177* (2.16)	0.0263** (3.21)	0.0179* (2.19)
total_sal	0.0759*** (15.62)	0.0771*** (15.81)	0.0686*** (13.91)	0.0766*** (15.69)
lab_agri		-0.0063** (-3.26)		
lab_indu			0.0137*** (8.29)	
lab_serv				0.0043** (2.83)
_cons	0.1931*** (25.43)	0.2020*** (25.80)	0.1891*** (25.00)	0.1932*** (25.18)
N	2486	2486	2486	2486
R^2	0.4389	0.4344	0.4473	0.4338
F	275.8271	270.7531	285.3474	270.0911
p	0.0000	0.0000	0.0000	0.0000

Note: The values in brackets are T values, *, * * and * * * respectively indicate the significance levels of 10%, 5% and 1%, the same below.

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4.3 Moderating Effect

Table 5 reports the moderating effect of economic development level on the mechanism of urban shrinkage affecting public service level. The coefficient of interaction items in column 1 in table 5 is significantly positive at the 1% confidence level, indicating that the higher the level of economic development, the more obvious the inhibitory effect of urban shrinkage on the level of public services. According to the above analysis, in areas with high economic development level, the incentive for local governments to strengthen the construction of public services is relatively weak when urban shrank. Therefore, when the shrinkage occurs in cities with high economic development level, the decline in the level of public services will be more obvious, which shows that the inhibitory effect of urban shrinkage on public services will become more obvious with the improvement of economic level. The coefficient in column 2 is positive, which indicates that the degree of shrinkage of agricultural labor decreases with the increase of economic development level, thus weakening the supply competition of public goods by local governments.

Table 5. Moderating effect of Economic Development Level

Variable	Urban shrinkage	Agricultural labor shrinkage	Industrial labor shrinkage	Service industry labor shrinkage
shrink*per_gdp	0.0275*** (6.50)			
lab_pro	-0.0041* (-2.14)	-0.0099*** (-4.87)	0.0007 (0.34)	-0.0037 (-1.89)
open_lev	1.3557*** (3.57)	1.0476** (2.75)	1.4719*** (3.87)	1.4392*** (3.74)
urb_lev	0.0157*** (3.37)	0.0082 (1.73)	0.0145** (3.11)	0.0170*** (3.58)
fin_self	-0.0051 (-1.81)	-0.0066* (-2.38)	-0.0158*** (-5.73)	-0.0109*** (-3.96)
tec_inn	0.0244** (3.00)	0.0221** (2.74)	0.0234** (2.83)	0.0203* (2.45)
total_sal	0.0730*** (15.08)	0.0446*** (7.55)	0.0691*** (13.93)	0.0754*** (15.42)
lab_agri*per_gdp		0.0304*** (9.24)		
lab_indu*per_gdp			-0.0083* (-2.26)	
lab_serv*per_gdp				0.0084* (2.00)
_cons	0.1928*** (25.57)	0.2260*** (27.83)	0.1885*** (24.85)	0.1941*** (25.28)
N	2475	2475	2475	2475
R^2	0.4509	0.4555	0.4506	0.4368
F	252.0802	256.8319	251.7967	238.0805
p	0.0000	0.0000	0.0000	0.0000

The interaction item in the third column is negative, indicating that with the development of economy, the effect of industrial labor shrinkage on the promotion of regional public services has weakened. The higher the level of economic development, the less the shrinkage of industrial labor force and the less the competition for public service supply generated by local governments to attract the secondary return of industrial labor force. Therefore, economic development has a negative moderating effect on the improvement of public service level. The interaction item in column 4 is positive, which shows that with the improvement of economic development level, the effect of labor shrinkage in service industry on the improvement of regional public service level is enhanced. Areas with higher levels of economic development have attracted more labor in the service industry, which will transmit the improvement of human capital and new technologies to the downstream manufacturing industry [26], and the improvement of technology can significantly promote the supply efficiency of public services.

4.4 Robustness Test

4.4.1 Adjust the Regional Samples

After many years of research by many natural geography experts, China's territory has been divided into seven major natural geographical divisions based on the characteristics of geographical location and human geography. There are great differences in shrinkage phenomenon and public service supply among different regions. This paper selects four geographical regions with different economic development levels from all samples for robustness test. The test results are placed in Table 6 and the first two columns of Table 7.The regression results show that the urban shrinkage in all regions has a restraining effect on the improvement of public service level, and the urban shrinkage in central, northwest and southwest regions has the most obvious restraining effect on public service level. The level of economic development also has a positive moderating effect on this inhibition. Although the sign and significance of individual control variables have changed, the test results are basically consistent with the benchmark regression results, which show that the conclusion of this paper is robust.

4.4.2 Adjust the Time Samples

After 2008, in order to cope with the financial crisis, China has made a large amount of investment in infrastructure construction. In order to avoid the error of regression results caused by policy reasons; this paper selects samples from 2000 to 2007 for robustness test. As shown in the regression results in columns 3 and 4 of Table 7, urban

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shrinkage has a significant inhibitory effect on the level of public services at a 5% confidence level, and the moderating effect is significantly positive, thus avoiding the vigorous construction of the foundation due to government stimulus The impact of facilities on the regression results has verified the validity of the research conclusions of this paper.

4.5 Endogenous Test

According to the previous theoretical analysis, there may

Table 6. Robustness Test

Variable	East China		Central China		Northwest region	
	No moderating variable	Add moderating variable	No moderating variable	Add moderating variable	No moderating variable	Add moderating variable
shrink	-0.0065** (-3.03)		-0.0117*** (-4.95)		-0.0170* (-2.57)	
lab_pro	0.0170*** (-5.37)	0.0163*** (-5.17)	0.0041 (-0.78)	0.0035 (-0.66)	0.0309** (-3.31)	0.0219* (-2.22)
lnopen_lev1	2.9607*** (-6.33)	2.7405*** (-5.81)	3.1048*** (-3.75)	3.3553*** (-4.04)	0.9616 (-0.29)	1.3236 (-0.40)
lnurb_lev1	0.0202** (-2.86)	0.0209** (-2.97)	0.0226* (-2.23)	0.0263* (-2.57)	0.0499* (-2.56)	0.0393* (-2.02)
lnfin_self1	-0.0215*** (-3.47)	-0.0138* (-2.05)	-0.0137* (-2.19)	-0.0147* (-2.35)	-0.0108 (-1.23)	-0.0064 (-0.71)
lntec_inn1	0.0209 (-1.85)	0.0270* (-2.37)	0.0802*** (-3.34)	0.1025*** (-3.98)	-0.0449 (-0.96)	-0.0495 (-1.08)
lntotal_sal1	0.0553*** (-7.09)	0.0582*** (-7.44)	0.0118 (-0.76)	-0.0041 (-0.24)	0.0498** (-2.62)	0.0619** (-3.23)
shrink*per_gdp		0.0173** (-2.82)		0.0173* (-2.31)		0.0949** (-3.07)
_cons	0.1507*** (-11.89)	0.1436*** (-11.16)	0.1942*** (-9.90)	0.2008*** (-10.18)	0.1233*** (-3.77)	0.1412*** (-4.19)
N	746	746	420	420	197	193
R^2	0.6141	0.6183	0.4202	0.4278	0.4387	0.4663
F	165.4782	147.1779	41.6202	37.4754	19.9858	19.0011
p	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 7. Robustness Test and Endogenous Test

Variable	Southwest region		Adjusting time		Endogenous test	
	No moderating variable	Add moderating variable	No moderating variable	Add moderating variable	No moderating variable	Add moderating variable
shrink	-0.0103* (-2.35)		-0.0054** (-3.26)		-0.0293*** (-4.02)	
lnlab_pro1	0.0024 (-0.31)	0.0006 (-0.07)	-0.0084*** (-3.66)	-0.0083*** (-3.64)	-0.0019 (-0.88)	-0.0027 (-1.14)
lnopen_lev1	-6.1530 (-1.88)	-5.8165 (-1.76)	0.8600 (-1.79)	0.6608 (-1.40)	1.7398*** (-4.25)	1.4325** (-3.16)
lnurb_lev1	-0.0367 (-1.59)	-0.0368 (-1.58)	0.0072 (-1.26)	0.0101 (-1.80)	0.0084 (-1.60)	0.0097 (-1.72)
lnfin_self1	0.0020 (-0.25)	0.0019 (-0.23)	-0.0173*** (-5.22)	-0.0141*** (-4.17)	0.0026 (-0.61)	0.0146** (-2.94)
lntec_inn1	0.1090*** (-3.48)	0.1056*** (-3.34)	0.0137 (-1.17)	0.0251* (-2.17)	0.0164 (-1.93)	0.0424*** (-3.67)
lntotal_sal1	0.1255*** (-6.04)	0.1234*** (-5.86)	0.1021*** (-16.02)	0.0972*** (-15.43)	0.0720*** (-13.71)	0.0624*** (-10.52)
shrink*per_gdp		0.0159 (-1.16)		0.0482*** (-7.07)		0.0892*** (-3.62)
_cons	0.1555*** (-5.6)	0.1619*** (-5.7)	0.2014*** (-23.53)	0.1984*** (-23.41)	0.1852*** (-22.17)	0.1796*** (-20.02)
N	256	254	1763	1752	2486	2475
R^2	0.4544	0.4574	0.4954	0.5136		
F	28.313	24.7666	245.187	229.1628		
p	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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be some endogenous between the urban shrinkage and the level of public services. In order to avoid the endogenous problems affecting the unbiased and effective regression results, This paper uses the decline in birth rate and the rise in mortality during the fifth and sixth censuses as instrumental variables for explanatory variables. Birth rate and death rate in each city are usually related to regional culture, conception of fertility and regional health level, and generally do not directly affect the regional public service level. However, birth rate and death rate have certain correlation with the increase or decrease of urban population, thus theoretically meeting the erogeneity and correlation requirements of instrumental variables. In this paper, the two-stage least square method is used to estimate the tool variable equation. According to the regression results of the first stage, the statistics of model F is much larger than 10, which refuses the assumption of weak tool variable problem. As shown in the regression results of the second stage in columns 5 and 6 of table 7, the results of regression using tool variables are basically consistent with those of benchmark regression. Urban shrinkage still plays a restraining role on the level of public services, while the reduction of economic development level intensifies the restraining effect of urban shrinkage on public services, further proving the conclusion of this paper.

5. Conclusions

This paper analyzes the impact of urban shrinkage and its heterogeneity on public service levels, as well as analyzes the moderating effects of economic development based on the data from 268 prefecture-level cities 2000-2010. The conclusions are as follows: First, urban shrinkage has inhibited the improvement of public service levels. The reduction in the total population of the city directly or indirectly reduces the input and efficiency of local governments in building public services, and the number of government-allocated public services decreases. Second, the shrinkage of different labor forces has different effects on the level of public services. The shrinkage of agricultural labor has inhibited the level of regional public services. The shrinkage of industrial labor and service labor will prompt local governments to increase the supply of public services due to local competition. Third, economic development plays a positive moderating effect in urban shrinkage inhibiting the improvement of public service levels. That is, the lower the level of economic development, the more serious the shrinkage of the city. In order to attract the second return of the population, the local government's motivation to provide public services has increased, and the level of public services has been improved. The shrinkage of agricultural labor force will not cause competition for public services of local governments. Economic development plays a positive moderating effect in the shrinkage of agricultural labor force inhibiting the improvement of public service level. At the same time, the improvement of the level of economic development has alleviated the loss of industrial labor and has a negative moderating effect in industrial labor shrinkage promoting the level of public services. In addition, with the improvement of the economic level, the shrinkage of labor in the service industry has eased. The improvement of human capital and technology has made the supply of public services more efficient. Therefore, the level of economic development plays a positive moderating effect in service industry labor shrinkage promoting public services.

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ARTICLE

The Influence of Differential Leadership on Employees' Affective Commitment: A Perspective of the Insiders and Outsiders

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ABSTRACT

From the perspective of the insiders and outsiders, this study explores the influence of differential leadership on employees' affective commitment and the moderating effect of leader's self-enhancing humor and individual traditionality. The results show that the differential leadership has a positive impact on the organizational affective commitment of employees, the leader's self-enhancing humor and the employees' traditionality play a positive regulatory role respectively. Moreover, compared with the outsiders, the low traditionality has a stronger influence on the relationship between differential leadership and organizational affective commitment of the insiders. This paper enriches the research on the influence of leadership style on employee's affective commitment, proposes and verifies the moderation of leader's self-enhancing humor and employee's traditionality, which complements the boundary conditions for the effectiveness of differential leadership style.

1. Introduction

As a key work attitude, employees' organizational commitment level is related to many outcomes, such as task and situational performance, satisfaction, cognitive withdrawal and turnover [1]. Commitment research is still important in employee organization relationship literature. Although organizational commitment has three different dimensions, namely, affect, norm and persistence [2], this study focuses on affective commitment, because it can predict key organizational outcomes better than the other two (namely, persistent commitment and norm commitment) [3]. There are many factors influencing employees' affective commitment, such as organizational characteristics [4], organizational practice [5], leadership style [6], relationship factors [7], employees' personal characteristics [8], etc. Among them, on the relationship between leadership style and affective commitment, the existing literature rarely pays attention to the impact of local leadership style on organizational affective commitment.

In addition, commitment research is mainly carried out in the western context [4]. Therefore, transforming the commitment model of the western context into the eastern context does not provide an appropriate solution. Recently, with regard to the relationship between leadership

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style and affective commitment, domestic scholars have begun to pay attention to the impact of local leadership style such as benevolent leadership [9] on employees' organizational affective commitment. However, there are few studies on how the local leadership style such as the differential leadership style affects employees' organizational affective commitment.

Due to the characteristics of differential pattern in Chinese Society [10], differential leadership style is prevalent in Chinese organizations [11]. Different from the western leadership style which regards employees as equal individuals, as a kind of biased leadership style, how the differential leadership style affects employees' organizational affective commitment, and what factors regulate this influence need to be explored.

2. Theory and Hypothesis

2.1 Differential Leadership and Employees' Affective Commitment

With the development of leadership theory and the prosperity of Chinese dominated economic system, scholars began to pay attention to the local leadership style such as differential leadership style. In view of the phenomenon that Chinese leaders treat their subordinates in different order, scholars have interpreted the connotation of differential leadership style from the perspective of leadership cognitive structure [12] and employee cognition [13]. The existing research believes that the differential leadership has an impact on the individual level behavior (such as advice, innovation, pro organizational unethical behavior) and team level behavior (such as knowledge transfer performance, team creativity), but in general, the theoretical and empirical research results of the differential leadership still need to be rich.

Affective commitment means accepting and internalizing the other party's goals and values, being willing to work for the other party, and having strong emotional attachment to the other party [14]. Organizational affective commitment enables employees to stay in the organization because of organizational interests, rather than because staying in the organization may bring some benefits [15]. When employees are truly involved in the organization and connect with the organization by recognizing their identity value, organizational emotional commitment is formed [16]. Due to the loyalty and strong emotional connection to the organization, individuals are willing to do things in certain modes according to the views of the organization [17], and the sense of belonging will motivate everyone to do their best and improve performance. Employees with organizational emotional commitment think that they are part of the organization, so they will try their best to repay the organization [18]. Organizational affective commitment is considered to be an important predictor of organizational outcomes, such as performance, organizational citizenship behavior and employee turnover [3].

The biased behavior of differential leadership has different effects on the cognition and psychology of insiders and outsiders [11]. Therefore, this study analyzes the influence mechanism of differential leadership on employees' organizational emotional commitment from the perspectives of insiders and outsiders.

According to the theory of social exchange, the inner circle subordinates follow the norms of reciprocity, and "repay" the leader through work autonomy and behavior outside the role when the leader has a biased behavior towards the insiders in terms of communication and care, tolerance and trust, promotion and reward [13]. Moreover, the leader's biased behavior fully meets the insiders' psychological needs for respect, recognition and belonging, and the insiders' increased cognition of role status and organization related social identity improves employees' organizational affective commitment [5]. In addition, in the interactive contact with the leader as the agent of the organization, the insiders gradually show similar attitudes and behaviors with the leader, and to a certain extent, achieve the consistency of individual values and organizational values. Internalization [19] makes individuals produce affective commitment to the organization. The fit of individual values and organizational values explains the appropriate organizational strategy for creating employee commitment [20].

The leaders' biased treatment makes the outsiders tend to have a relative sense of separation, but the Confucian concept of justice and the mentality of "tolerance" may alleviate this adverse effect. The Confucian concept of justice abides by the cultural tradition of "respect" and the code of conduct of "kinship". The outsiders generally accept the leader's moderate and partial care for "their own people", and do not question the authority and fairness of the leader. In addition, in the face of adverse situations, the "tolerance" coping style may not only take into account the face of leaders, but also exchange the possibility and opportunity of positive interaction with leaders in the future. Because according to the view of power dependence, through the partial distribution of resources, differential leadership may make subordinates obey the requirements of leaders, and this obedience may have the characteristics of both compulsion and voluntariness[13,21]. From the perspective of social cognition, the outsiders will have the desire to enter the "circle" in order to obtain resources. In addition, with the continuous efforts of the outsiders to become leaders' own people, most leaders

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do not exclude the expansion of "own people" group in order to better achieve leadership effectiveness. In the process of the efforts of the outsiders to enter the "circle", their work autonomy and behaviors outside their roles are increasing, which are gradually similar to the attitudes and behaviors of leaders. According to the perspective of agent-oriented model, the outsiders also have affective commitment to the organization.

To sum up, although the biased behavior of differential leadership has different effects on the cognition and psychology of the insiders and outsiders, it may promote the employees' organizational affective commitment. Therefore, the hypothesis is put forward:

H1: There is a positive effect of differential leadership on employees' organizational emotional commitment.

In addition, although this study believes that differential leadership has a positive impact on employees' organizational affective commitment, there may be differences in the extent of its impact on the insiders and outsiders. At present, the research on this kind of difference is still lacking, which needs to be further explored. Therefore, the following question is raised:

Q1: The influence of differential leadership on employees' organizational emotional commitment may be different between the insiders and the outsiders.

2.2 The Moderating Effect of Leaders' Self-enhancing Humor

There are two perspectives of leadership humor: behavioral perspective and trait perspective, this study focuses on the perspective of behavioral view. Leadership humor as a communication strategy used by leaders [22], Martin et al.[23] divided leadership humor into four dimensions, in which leadership self-enhancing humor involves a universal humorous outlook on life, a tendency to be often amused by the disharmony of life, and a humorous perspective even in the face of pressure or adversity [24]. It is closely similar to the concept of humor coping [25], which is related to the use of humor as a mechanism of emotion regulation or coping [26]. It is most in line with Freud's definition of humor. In a narrow sense, humor is a healthy defense mechanism, which allows one to avoid negative emotions while maintaining a realistic view of potential aversion [27]. Self-enhancing humor focuses more on psychology than interpersonal, and focuses on regulating negative emotions through humor perspective [23]. It is found that leadership humor regulates the effect and process of leadership style, including transformational leadership, contingent reward leadership, laissez faire leadership, etc. [28].

This study considers that self-enhancing humor can moderate the effect of differential leadership style. Based on the implicit theory, followers evaluate leaders' behaviors according to leaders' prototypes and implicit expectations of leaders' behaviors related to these prototypes. Using humor to reduce tension or create a comfortable atmosphere in the team may be one of the typical or excellent leaders' behaviors expected by followers. Leaders who use self-enhancing humor will show less anxiety and depression at work, and produce more positive effects, so as to improve employees' psychological well-being [29]. In addition, a relaxed environment can lead to positive emotions (i.e. laugh heartily), which may lead to less rigid thinking and enhance the ability to connect and integrate different materials, so as to effectively manage work-related issues. Compared with the outsiders, because the leader contacts with the insiders more frequently, the positive emotion experienced by the leader when using self-enhancing humor will be more easily "transmitted" to the insiders. At the same time, for the insiders, the use of leadership humor is a kind of self-disclosure [30]. While facing the insiders, leaders use humor more frequently to share personal information, which gives followers an opportunity to "understand them in a deeper level" [31], which can help leaders establish close relationship with their subordinates and facilitate the exchange of ideas and information between superiors and subordinates, this kind of ideological exchange will help lower level to effectively manage issues related to work. Based on the similarity attraction paradigm, the use of leaders' self-enhancing humor helps to perceive similarity, shorten the social distance between superiors and subordinates, reduce the significance of hierarchy, and stimulate the positive emotional experience of the insiders [32], which is more likely to promote the insiders to internalize the experience of leaders in their work. Therefore, based on the view of agent-oriented model, the hypothesis is put forward:

H2: Leaders' self-enhancing humor positively moderates the influence of differential leadership on employees' organizational affective commitment, that is, the more self-enhancing humor is used, the stronger the positive relationship between differential leadership and employees' organizational affective commitment is, and vice versa.

In addition, although this study believes that leaders' self-enhancing humor positively moderates the influence of differential leadership on employees' organizational affective commitment, there may be differences in the extent of its moderating role for the insiders and the outsiders. At present, the research on this kind of difference is still lacking, which needs to be further explored. Therefore, the following question is raised:

Q2: The moderating effect of leaders' self-enhancing humor on the relationship between differential leadership

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and employees' organizational affectional commitment.

2.3 The Moderating Effect of Individual Traditionality of Employees

Traditionality refers to the influence of Chinese traditional culture on individual's cognitive attitude, ideology, value orientation, temperament and behavior will [33]. The traditional Chinese society is based on the five Lun relationship of Confucianism, which is constructed by the hierarchical model. When this hierarchical orientation is extended to the working environment, the traditional characteristics are mainly manifested in the hierarchical relationship of dignity and order [34]. Individuals with high traditionality choose to respect and obey their superiors, while individuals with low traditionality emphasize egalitarianism. Existing research shows that employees' response to leadership style is influenced by individual traditionality [35,36].

In this study, we think that individual traditionality can moderate the effect of differential leadership style. Higher traditional individuals are more in line with the hierarchical relationship of dignity and order, and believe that they have responsibilities and obligations to meet the expectations of their superiors, while lower traditional individuals are more egalitarian and follow the principle of incentive contribution balance in work and interpersonal communication [37]. The biased behavior of differential leadership has different effects on the cognition and psychology of the insiders and the outsiders. The insiders hold the psychology of "repaying", the higher traditional individuals abide by the role norms more, and strive to meet the leaders' expectations more. For the outsiders, the high traditional individuals will still perform the role obligations; while the outsiders with lower traditionality experience a stronger sense of separation in the face of the leaders' partial treatment. Therefore, based on the view of agent-oriented model, the hypothesis is put forward:

H3: Individual traditionality positively moderates the influence of differential leadership on employees' organizational affective commitment, that is, the more traditional the individual is, the stronger the positive relationship between the differential leadership and the employee's organizational affective commitment is, and vice versa.

In addition, although this study believes that individual traditionality positively moderates the influence of differential leadership on employees' organizational affective commitment, there may be differences in the extent of its moderating role for the insiders and the outsiders. At present, the research on this kind of difference is still lacking, which needs to be further explored. Therefore, the following question is raised:

Q3: The moderating effect of individual traditionality on the relationship between differential leadership and employees' organizational affectional commitment may be different between the insiders and the outsiders.

In conclusion, the research model is shown in Figure 1.

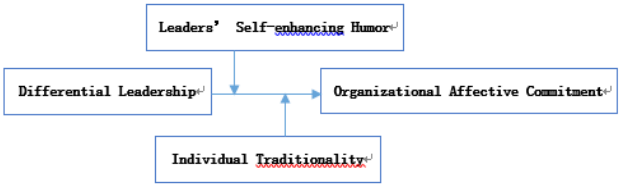

Figure 1. Research Model

3. Research Design

3.1 Sample and Data Collection

In this study, questionnaire survey was used to collect data in three times from May 2019 to September 2019. The first survey mainly collects the data of enterprise characteristics (such as enterprise scale, etc.), subject characteristics (gender, age, etc.), differential leadership, and individual traditionality of employees. The second survey (2 months later) collected data by pairing on the leaders' self-enhancing humor and identity recognition of insiders. The third survey (2 months later) collected data of organizational affective commitment by pairing. The survey samples are the employees of 18 enterprises in Jiangsu, Zhejiang and Shanghai, involving cultural, sports and entertainment, real estate, machinery manufacturing, software, finance and other industries. The data collection process is strictly confidential.

547 questionnaires were distributed in this survey. After the invalid questionnaires were eliminated, the final number of valid questionnaires was 449, and the effective recovery rate of the questionnaire was 82.05%. In terms of gender, men accounted for 50.79% and women 49.21%; in terms of age, 16.96% were under 25 years old, 35.25% were under 25-35 years old, 39.29% were under 36-45 years old, and 8.5% were over 45 years old; in terms of education, 6.61% were senior high school or below, 23.79% were junior college, 50.55% were undergraduate, 19.05% were postgraduate or above; in terms of positions, 35.18% were general employees, and 34.73% were first-line managers, 22.7% were the middle-level management, 7.39% were the top-level management; in terms of seniority, 13.5% are within one year, 43.5% are within one to five years, 25.14% are within six to 10 years, 9.82% are within 11 to 15 years, and 8.04% are over 16 years.

3.2 Variable Measurement

In this study, mature and authoritative scales at home and

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abroad were used to measure variables. Likert 7-grade scoring method was used in all scales. 1 was very disagree, 7 was very agree.

Differential leadership: using the differential leadership scale developed by Jiang and Zhang [13], there are 14 items in total. Before each item, state "when your leaders treat the insiders compared with the outsiders" [13]. The reliability coefficient of the scale is 0.861.

Leaders' self-enhancing humor: the scale of self-enhancing humor developed by Martin et al.[23] was used, with 8 items in total. The reliability coefficient of the scale is 0.847.

Individual traditionality: using the scale developed by Farh et al. [38], there are 5 items in total. The reliability coefficient of the scale is 0.791.

Affective commitment: using the "organizational affective commitment scale" compiled by Zhou [39], including 6 items. The reliability coefficient of the scale was 0.902.

Classification variables: for the classification of the insiders and the outsiders, the scale of perceptions of insider status [40] was used to measure, and then the mean score plus one standard deviation was used as the grouping standard to form inner circle and outer circle groups. The reliability coefficient of the scale was 0.894.

Control variables: take the common demographic variables as control variables.

4. Research Results

4.1 Homologous Error Test

The measurement of all variables from the subjects will cause homologous errors, which may affect the research results. Therefore, Harman single factor test method is used to check the homologous errors. The result of Harman single factor test shows that the first principal component obtained without rotation accounts for 31.298% (cumulative interpretation is 73.485%), which does not account for a large proportion. Therefore, the homology error exists but is not serious.

4.2 Confirmatory Factor Analysis

In this paper, amos21.0 is used to analyze the four constructs of differential leadership, organizational affective commitment, leaders' self-enhancing humor and individual traditionality (see Table 1). The results show that the four factor measurement model has the best fit (χ^2/DF=3.09, GFI=0.927, NFI=0.919, CFI=0.914, RMSEA=0.073), which is obviously superior to other models,

Table 1. Comparison of Measurement Models

Model	χ^2/df	GFI	NFI	CFI	RMSEA
Four factors: differential leadership/leaders' self-enhancing humor/ individual traditionality/ organizational affective commitment	3.09***	0.927	0.919	0.914	0.073
Three factors: differential leadership + leaders' self-enhancing humor/ individual traditionality/ organizational affective commitment	4.57***	0.882	0.870	0.867	0.104
Tow factors: differential leadership + leaders' self-enhancing humor/ individual traditionality + organizational affective commitment	9.42***	0.645	0.628	0.636	0.296
One factor: differential leadership + leaders' self-enhancing humor + individual traditionality + organizational affective commitment	13.18***	0.481	0.407	0.438	0.387

Notes: ***, **and * indicate that the significance level is less than 0.001, 0.01 and 0.05 respectively. The same as below. The significance level of χ^2 in each model in Table 1 is less than 0.001.

Table 2. Descriptive statistics and Correlation Coefficient

Variable	Mean Value	Standard Deviation	Gender	Age	Education	Position	Seniority	Differential Leadership	Self-enhancing Humor	Individual Traditionality
Gender	0.482	0.502								
Age	2.393	1.123	-0.374**							
Education	2.808	0.803	-0.311**	-0.299**						
Position	2.041	1.285	-0.104	0.234**	-0.093**					
Seniority	2.559	1.123	-0.031*	0.542**	-0.177	0.212*				
Differential Leadership	4.517	0.742	0.024	0.103	0.014	0.137	0.028			
Self-enhancing Humor	4.375	0.861	0.211*	0.240*	-0.236*	0.122	0.181	0.138		
Individual Traditionality	3.686	1.137	-0.206*	0.009	-0.117	0.156	0.099	0.305**	0.172	
Organizational Affective Commitment	5.063	0.850	0.197*	0.192*	-0.160	0.052	0.192*	0.229**	0.324**	0.245**

Notes: ***, **and * showed significant correlation at the levels of 0.001, 0.01, and 0.05 respectively. The same as below.

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indicating that the four constructs have good discrimination validity.

4.3 Descriptive Statistics and Correlation Analysis

Descriptive statistics of the variables studied are shown in Table 2. It can be seen from table 2 that there is a significant positive correlation between differential leadership and organizational affective commitment (r= 0.229, P $<$ 0.010), which preliminarily supports the theoretical model of this study.

4.4 Hypothesis Test

In this study, the hierarchical regression method was used to test the hypothesis of the total sample, the insiders sample and the outsiders sample. The total number of samples was 449, the insiders samples were 194 and the outsiders samples were 119. The mean value of the two moderating variables plus or minus one standard deviation is used as the grouping standard, which is divided into high and low groups, and the moderating effect graph based on the total sample is drawn.

4.4.1 Hypothesis Test Based on Total Sample

The results of the hierarchical regression method based on the main effect and moderating effect of the total sample are shown in Table 3. It can be seen from table 3 that the regression results of model 2 show that there is a significant positive effect of differential leadership on organizational affective commitment (β=0.219, P $<$ 0.001). Therefore, hypothesis 1 holds.

According to table 3, the results of model 4 and model 7 show that the interaction effect of differential leadership and leaders' self-enhancing humor has a significant positive impact on organizational affective commitment (β=0.069, p $<$ 0.01; β=0.051, p $<$ 0.01). The moderating effect of leaders' self-enhancing humor in the total sample is shown in Figure 2. The simple slope estimates of high and low leaders' self-enhancing humor groups are 0.311 (p $<$ 0.001) and 0.172 (p $<$ 0.01) respectively, and the difference between the high and low groups is 0.139 (p $<$ 0.001), 95% confidence interval was [0.110, 0.392], did not contain 0. Therefore, hypothesis 2 holds.

From table 3, the results of model 6 and model 7 show that the interaction effect of differential leadership and individual traditionality has a significant positive impact on organizational affective commitment (β=0.046, p $<$ 0.01; β=0.035, p $<$ 0.01). The moderating effect of individual traditionality in the total sample is shown in Figure 3. The simple slope estimates of high and low individual traditionality were 0.346 (P $<$ 0.001) and 0.165 (P $<$ 0.01) respectively, and the difference between the high and low groups was 0.181 (P $<$ 0.001), the 95% confidence interval was [0.216, 0.477], did not contain 0. Therefore, hypothesis 3 holds.

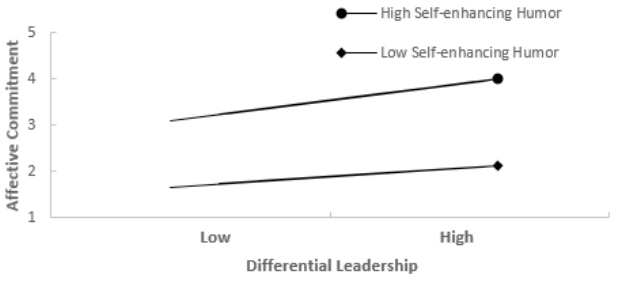

Figure 2. The Moderating Effect of Leaders' Self-enhancing Humor on the Relationship between Differential Leadership and Organizational Affective Commitment (Total Sample)

Table 3. Hierarchical Regression Results of Main Effect and Moderating Effect (Total Sample)

Variable	Organizational Affective Commitment						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Gender	0.180**	0.174**	0.060*	0.068**	0.082***	0.075***	0.053***
Age	0.082	0.070	0.047	0.011	0.063	0.071	0.025
Education	-0.171*	-0.19	-0.059	-0.047	-0.132	-0.139	-0.006
Position	0.167*	0.199*	0.142*	0.146*	0.158***	0.157***	0.139**
Seniority	0.149*	0.160*	0.127*	0.125*	0.110	0.108	0.110
Differential Leadership		0.219***	0.172**	0.100**	0.071**	0.048**	0.032**
Leaders' Self-enhancing Humor			0.355***	0.217**			0.141**
Individual Traditionality					0.271***	0.209	0.128
Differential Leadership * Leaders' Self-enhancing Humor				0.069**			0.051**
Differential Leadership * Individual Traditionality						0.046**	0.035**
R^2	0.094	0.145	0.318	0.327	0.212	0.215	0.359
ΔR^2		0.051***	0.173***	0.009***	0.067***	0.003***	

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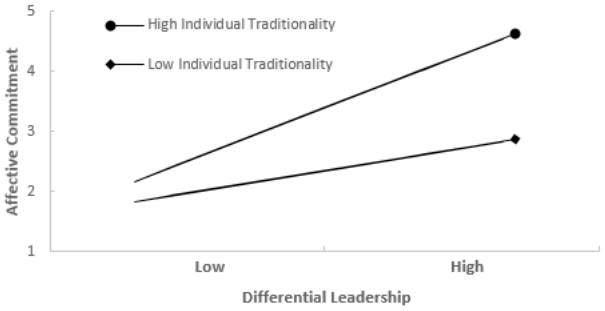

Figure 3. The Moderating Effect of Individual Traditionality on the Relationship between Differential Leadership and Organizational Affective Commitment (Total Sample)

4.4.2 Hypothesis Test Based On the Insiders Sample

This study further tests the hypothesis of the insiders and outsiders sample. See Table 4 for the hierarchical regression results based on the insides sample and table 5 for the hierarchical regression results based on the outsider sample.

According to table 4, regression results of model 9 show that differential leadership has a significant positive impact on organizational affective commitment of the insiders (β=0.285, $p < 0.001$). Therefore, hypothesis 1 holds.

From table 4, the results of model 11 and model 14 show that there is a significant positive effect of the interaction effect of differential leadership and leaders' self-enhancing humor on the organizational affective commitment of the insiders (β=0.074, $p < 0.01$; β=0.067, $p < 0.01$). As far as the moderating effect of leaders' self-enhancing humor of the insiders sample is concerned, the simple slope estimates of high and low leaders' self-enhancing humor are 0.333 ($p < 0.001$) and 0.221 ($p < 0.01$) respectively, and the difference between the high and low groups was 0.112 ($P < 0.001$), the 95% confidence interval was [0.126, 0.684], did not contain 0. Therefore, hypothesis 2 holds. The moderating effect chart of leaders' self-enhancing humor of the insiders sample is similar to that of leaders' self-enhancing humor of the total sample. Therefore, it is no longer shown in a schema, the same as below.

From table 4, the results of model 13 and model 14 show that the interaction between differential leadership and individual traditionality has a significant positive impact on the organizational affective commitment of the insiders (β=0.016, $p < 0.01$; β=0.010, $p < 0.01$). As far as the moderating effect of individual traditionality of the insiders sample is concerned, the simple slope estimates of high and low individual traditionality are 0.369 ($p < 0.001$) and 0.271 ($p < 0.01$) respectively, and the difference between the high and low groups was 0.098 ($p < 0.001$), the 95% confidence interval was [0.086, 0.470], did not contain 0. Therefore, hypothesis 3 holds.

4.4.3 Hypothesis Test Based On the Outsiders Sample

It can be seen from table 5 that the regression results of model 16 show that there is a significant positive effect of differential leadership on organizational affective commitment of outsiders (β=0.168, $p < 0.001$). Therefore,

Table 4. Hierarchical Regression Results of Main Effect and Moderating Effect (The Insiders Sample)

Variable	Organizational Affective Commitment						
	Model 8	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14
Gender	0.102**	0.095**	0.071*	0.079	0.098**	0.067**	0.038
Age	0.082	0.080	0.025	0.030	0.042	0.039	0.032
Education	-0.115	-0.164	-0.070	-0.065	-0.102	-0.178	-0.090
Position	0.266***	0.287***	0.196**	0.204**	0.200***	0.157***	0.220**
Seniority	0.076	0.047	0.113	0.112	0.082	0.080	0.082
Differential Leadership		0.285***	0.182***	0.108*	0.077**	0.069**	0.043**
Leaders' Self-enhancing Humor			0.447***	0.378**			0.293
Individual Traditionality					0.296**	0.202	0.125
Differential Leadership * Leaders' Self-enhancing Humor				0.074**			0.067**
Differential Leadership * Individual Traditionality						0.016**	0.010**
R^2	0.173	0.208	0.397	0.400	0.252	0.259	0.409
ΔR^2		0.035***	0.189***	0.003***	0.044***	0.007***	

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hypothesis 1 holds.

According to table 5, the results of model 18 and model 21 show that the interaction effect of differential leadership and leaders' self-enhancing humor has a significant positive impact on the organizational affective commitment of the outsiders (β=0.117, $p < 0.01$; β=0.074, $p < 0.01$). As far as the moderating effect of leaders' self-enhancing humor of the outsiders sample is concerned, the simple slope estimates of high and low leaders' self-enhancing humor are 0.264 ($p < 0.001$) and 0.102 ($p < 0.05$) respectively, and the difference between the high and low groups was 0.162 ($P < 0.001$), the 95% confidence interval was [0.116, 0.305], did not contain 0. Therefore, hypothesis 2 holds.

According to table 5, the results of model 20 and model 21 show that the interaction effect of differential leadership and individual traditionality has a significant positive impact on the organizational affective commitment of the outsiders (β=0.075, $p < 0.01$; β=0.021, $p < 0.01$). As far as the moderating effect of individual traditionality of the outsiders sample is concerned, the simple slope estimates of high and low individual traditionality are 0.260 ($p < 0.001$) and 0.089 ($p < 0.05$) respectively, and the difference between the high and low groups was 0.171 ($p < 0.001$), the 95% confidence interval was [0.214, 0.807], did not contain 0. Therefore, hypothesis 3 holds.

4.5 On the Difference of Influence Between the Insiders and the Outsiders

The bootstrap method is used to preliminarily test the influence of the insiders and the outsiders and the difference of moderating effect. See Table 6 for the test results of the difference of moderating effect.

The results show that there is no significant difference in the influence of differential leadership on employees' organizational affective commitment between the insiders and the outsiders (0.093, n.s.), the 95% confidence interval was [-0.104, 0.529], did contain 0. Therefore, Q1 does not hold.

There is no significant difference in the moderating effect of high leaders' self-enhancing humor on the relationship between differential leadership and employees' organizational affectional commitment of the insiders and the outsiders (0.069, n.s.), the 95% confidence interval was [-0.366, 0.129],did contain 0. There is no significant difference in the moderating effect of low leaders' self-enhancing humor on the relationship between differential leadership and employees' organizational affectional commitment of the insiders and the outsiders (0.119, n.s.), the 95% confidence interval was [-0.294, 0.305],did contain 0. Therefore, Q2 does not hold.

There is no significant difference in the moderating effect of high individual traditionality on the relationship between differential leadership and employees' organizational affectional commitment of the insiders and the outsiders (0.109, n.s.), the 95% confidence interval was [-0.259, 0.431],did contain 0. There is significant difference in the moderating effect of low individual traditionality on the relationship between differential leadership and employees' organizational affectional commitment of the insiders and the outsiders (0.182, $p < 0.001$), the 95% confidence interval was [0.116, 0.713],did not contain 0.

Table 5. Hierarchical Regression Results of Main Effect and Moderating Effect (The Outsiders Sample)

Variable	Organizational Affective Commitment						
	Model 15	Model 16	Model 17	Model 18	Model 19	Model 20	Model 21
Gender	0.052	0.057	0.064	0.072	0.068*	0.091*	0.062*
Age	0.073**	0.026*	0.051	0.048	0.057	0.083	0.083
Education	-0.075**	-0.082**	0.125	0.124	0.229	0.218	0.132
Position	0.130	0.158**	0.133	0.124	0.144	0.142	0.135
Seniority	0.075**	0.071***	0.058	0.081	0.067	0.091	0.052
Differential Leadership		0.168***	0.137**	0.091**	0.152***	0.103**	0.079**
Leaders' Self-enhancing Humor			0.327***	0.198**			0.124**
Individual Traditionality					0.243***	0.168*	0.113*
Differential Leadership * Leaders' Self-enhancing Humor				0.117**			0.074**
Differential Leadership * Individual Traditionality						0.075**	0.021**
R^2	0.106	0.138	0.385	0.390	0.236	0.247	0.414
ΔR^2		0.032***	0.247***	0.005***	0.098***	0.011***	

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Therefore, Q3 hold partly.

5. Conclusion

5.1 Research Results

Differential leadership has a positive impact on employees' organizational affective commitment, but there is no significant difference between the insiders and the outsiders, which may be related to the fact that most leaders in the organization are in the form of "leading group" [41]. The leaders'self-enhancing humor positively moderates the influence of the differential leadership on employees' organizational affective commitment, but there is no significant difference between the insiders and the outsiders. The individual traditionality of employees positively moderates the influence of differential leadership on their organizational affective commitment, and compared with the outsiders, low individual traditionality has a stronger impact on the relationship between differential leadership and organizational affective commitment of the insiders.

5.2 Theoretical Implications

First, to explore the impact of local leadership style on employees' affective commitment, enriching the research on the impact of leadership style on employees' affective commitment. At present, the study on the influence of leadership style on employee's affective commitment mainly uses western leadership theory to explain, and pays less attention to the influence of local leadership style. This study starts from the local leadership style, complements and enriches the local leadership theory.

Secondly, from the perspective of the insiders and outsiders, this paper empirically studies the influence of differential leadership on employees' emotional commitment, which provides an empirical basis for further understanding the cognition and attitude of the insiders and outsiders. There are few empirical studies on the influence of differential leadership on employees' cognition and attitude from the two paths of the insiders and outsiders. This study tests the total sample, the insiders sample and the outsiders sample respectively, which improves the accuracy and logicality of the research conclusion.

Thirdly, from the two aspects of leadership communication strategy and employee characteristics, this paper investigates the moderating role of self-enhancing humor and employee's individual traditionality in the process of leadership style, which complements and improves the boundary conditions for the effectiveness of leadership style. The current research examines the moderating effect of leadership humor on the effect and process of transformational leadership, contingent reward leadership and laissez faire leadership. However, there are few studies on the effect of leadership humor on the effect of local leadership style, and few studies on the effect of different leadership styles such as leadership self-enhancing humor on the effect of local leadership style. This study selects self-enhancing humor and individual traditionality as the moderating variables in the process of the influence of differential leadership on employee's affective commitment and adds the boundary conditions for the effectiveness of the differential leadership style.

5.3 Management Implications

The conclusion of this study is valuable to the practice of organizational management. First, the results show that differential leadership has a significant positive impact on employees' affective commitment, which shows that as a local leadership style, differential leadership

Table 6. Bootstrap Test Results of the Difference of Moderating effect

Moderating Variable	Group	Simple Slope Estimation	Standard Error	95% Confidence Interval	
				lower limit	Upper Limit
High Self-enhancing Humor	Insiders	0.333***	0.061	0.318	0.649
	Outsiders	0.264***	0.065	0.294	0.942
	Difference	0.069	0.070	-0.366	0.129
Low Self-enhancing Humor	Insiders	0.221**	0.072	0.079	0.364
	Outsiders	0.102*	0.080	0.107	0.316
	Difference	0.119	0.079	-0.294	0.305
High Individual Traditionality	Insiders	0.369***	0.066	0.460	0.819
	Outsiders	0.260***	0.089	0.392	0.815
	Difference	0.109	0.074	-0.259	0.431
Low Individual Traditionality	Insiders	0.271**	0.091	0.116	0.582
	Outsiders	0.089*	0.075	0.072	0.469
	Difference	0.182***	0.078	0.116	0.713

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has strong vitality and is an effective leadership style. At the same time, leaders should strive to create a united and fair working atmosphere, so as to improve the relationship between superiors and subordinates, and gradually transform the subordinates from outsiders to insiders, so as to give full play to their leadership effectiveness. Secondly, leaders should pay attention to the implementation of appropriate communication strategies that match the leadership style. Based on implicit theory, followers evaluate leader behavior according to leader prototypes and implicit expectations of leader behavior related to these prototypes. In the workplace, pressure, frustration, conflict and exclusion are inevitable. Leaders use self-enhancing humor which will show less anxiety and depression at work. At the same time, it can reduce the social distance between superiors and subordinates, which can stimulate the followers' positive emotional experience. In addition, a relaxed environment can lead to positive emotions (i.e. laugh heartily), which may lead to less rigid thinking and enhance the ability to connect and integrate different materials, so as to effectively manage work-related issues. Thirdly, leaders should distinguish the management of their subordinates. Individuals with different traditionality have different behavior patterns, perceive and response to leadership differently. As the post-90s and post-2000s gradually enter the workplace, there will be more and more employees with low traditionality [42], and for employees, their feelings for the organization mostly come from various performances of leaders. Therefore, leaders should strengthen the investigation of the psychology and behavior of the new generation of employees, strengthen their interpersonal interaction, establish high-quality interpersonal relationships, and stimulate employees' positive attitude and behavior towards leaders and organizations, and then improve leaders' leadership effectiveness.

5.4 Limitations and Future Research Directions

This study inevitably has some limitations. First of all, the questionnaire adopts self-report method. Although longitudinal sampling can reduce the problem of homologous error to a certain extent, this error is inevitable. Secondly, the division method of the insiders and outsiders in this study still needs to be discussed, because the statistical ability of analysis in each sub sample group is lower than that obtained from the whole sample [43]. In the future, the local "circle" scale can be developed for division and measurement. Thirdly, this study examined the moderating effect of leaders' self-enhancing humor on the effectiveness of differential leadership, and in the future, we can examine the moderating effect of other leadership humor styles, such as leaders' ironic humor. Again, this study only discusses the direct impact of differential leadership on employees' affective commitment, and whether there is intermediary effect in this impact is also worth thinking. Finally, this study investigates employee affective commitment as outcome variable, and makes some progress, but whether it can be extended to other outcome variables, such as job satisfaction, innovation behavior and organizational cynicism, remains to be studied.

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REVIEW

The International Mobility of Students Apprentices at the Heart of Building a Skills Economy: the Example of the Corsican Territory

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ABSTRACT

At a time of exacerbated globalization, education, and more generally training, is a key factor for our society, at the heart of territories challenged to renew themselves in the face of the emergence around the globe of new centers of economic and demographic gravity, with their own models. Training, and its link with working life, is a real challenge to face, in the near future, the technological, economic, political and environmental revolutions that we are already facing. Beyond what is called sandwich training or continuing vocational training in Higher Education, the current challenge is indeed around lifelong learning, old concept but whose forms always call for an actualization in modernity. At the heart of a small island territory like Corsica, this challenge is all the more crucial to take up as it foreshadows its attractiveness in a context of *glocalisation* [8] now durably anchored. In an ever-changing global environment, with moving landmarks, increasingly complex personal and professional lives, and where everything that seemed well compartmentalized yesterday faces increasing porosity, the purpose of this contribution is to explain that the international mobility of students apprentices, at the heart of the construction of a skills economy, is a major strategic issue for the development and structuring of a small territory such as Corsica.

1. Introduction

Training, and its link with working life, is a real challenge to face, in the coming decades, the technological, economic, political and environmental revolutions that we are already facing.

If it is already difficult to imagine, today, how an initial training could be enough for an individual for his 40 years of career to follow, the speed of evolution of our societies (ours, but also, even more importantly, those that surround us and thus constitute our environment, or even our ecosystem, at the global level), the digital and energy transitions underway, will only accentuate the obsolescence of this representation of training decoupled from later forms of learning.

The challenge for individuals, the economic world and ultimately the place of our country at the world level, is

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therefore that of the updating of knowledge, of the evolution of know-how, of the renewal of representations, of the understanding of the macroscopic stakes.

In a small island territory such as Corsica, populated by some 330,000 people and in search of structuring a skills economy beneficial to its sustainable development, this issue takes on an even more fundamental priority. After having demonstrated in previous works [10,11] how the sandwich training system in Higher Education in the Corsican region can be a strategic tool at the center of a territorial policy of human capital growth, today we reflect on the issue of the students apprentices' international mobility as a vector generating a skills economy profitable to the development and attractiveness of an island geographical space such as Corsica.

After recalling the importance of the concept of the students apprentices' international mobility in terms of the growth of skills relating to knowledge, know-how and skills to be, our analysis will show how a pedagogical policy of a CFA is likely to contribute to enhancing the professional integration and employability of the human resources that will structure local businesses.

2. The International Mobility of Students Apprentices: a Dual and Innovative Concept

The internationalization of Higher Education has grown significantly over the past 20 years. UNESCO counted 4.1 million international students in 2013 and estimates that this figure will reach 7.2 million by 2025. In Europe, the universities have included student mobility at the heart of their training programs, strongly supported by all the programs offered by the Erasmus Agency. The clearly stated objective is to contribute to the employability of their graduates *by equipping them with academic and non-academic skills, which immersion in an intercultural environment promotes* [3].

That being said, as of 2016, a report by the MEP Jean Arthuis had pointed to the obstacles to the students apprentices' international mobility. Indeed, the sandwich training is not harmonised in Europe, as it has been since 2010, with the Bologna process for the *European Higher Education Area*.

To implement this project, we must take into account the practices of 28 different countries. For each Ministry of Higher Education, the practical difficulties would be, in particular, to measure the professional sectors which, abroad, are applicants while simultaneously meeting the national teaching criteria.

In France, if the recent law for *the freedom to choose its professional future* of September 5, 2018 has lifted some legal obstacles to facilitate the students apprentices' international mobility [13], the focus set by the Minister of Labour, Muriel Penicaud, to reach 15,000 apprentices in Erasmus pro, may not be a sinecure.

2.1 *International mobility* Referents Named in the CFAs and an Exemption from Some Company's Obligations Provided for by Law

Until 2018, the few apprentices who benefited from European mobility came from particularly proactive training centers. In concrete terms, mobility is effective when there is a dedicated team. It is essential that mobility be structured around visible and identifiable mobility benchmarks by all stakeholders.

Decree No. 2019-1086 of 24 October 2019 laying down various provisions relating to the mobility abroad of apprentices and beneficiaries of professionalisation contracts specifies the procedures for implementing the mobility of students apprentices in or outside the European Union, in particular the content of the contractual relationships between the apprentice or the beneficiary of a professionalisation contract, the employer in France, the employer abroad, the training center in France and the training center abroad.

It also provides that the training organization or center in France shall replace the employer during the period of mobility, as regards the payment of contributions relating to accidents at work and occupational diseases, during the period of long mobility, exempting the company from part of its obligations.

The implementation of European and international mobility projects for students apprentices in CFAs requires the mobilisation of dedicated engineering. This engineering of international mobility, formerly often carried out informally by CFA teaching and/or administrative teams, has in recent years been largely professionalised in view of the specific skills required to carry out this type of project.

Considering this reality and in accordance with Article 24 of the law of 5 September 2018, the CFAs will have to acquire *mobility referents* whose main characteristics of the work performed cover a wide range of activities (administrative and financial management, organisation, construction and facilitation of partnerships, coordination and communication, etc.).

The involvement of management staff and the collective mobilization of teaching and educational teams is a primary condition for the development of students apprentices' long mobility. The organisation of mobility requires cross-competences of a legal, regulatory, pedagogical or organisational nature which must be fully deployed within the CFAs.

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In addition to a personal life experience that enhances future employability for the student apprentice, the international mobility scheme is also beneficial for its training host structure.

2.2 An International Experience as Beneficial to the Student Apprentice as to the Host Structure

Much research [1,4,14] has been carried out on the skills acquired by students during international mobility, whether in study semesters or internships in companies.

The bulk of these surveys are quantitative studies carried out with a large number of students who have completed questionnaires when they return from mobility or when thet graduate. Frequently carried out immediately, these *on the spot* assessments were also reinforced by analyses dealing with the medium and long term effects of international experience.

In this complementary perspective, Brassier-Rodrigues [2] surveyed students, graduates and professionals, about their experience of international mobility at least two years after its realization, to understand and analyse the skills they spontaneously associate with it.

Compétences relatives aux savoir et savoir-faire	Compétences relatives au savoir-être
1. Compétences linguistiques 2. Savoirs académiques 3. Connaissances techniques 4. Méthodes d'apprentissage 5. Méthodes de travail	***Compétences liées au développement personnel*** 6. Connaissance de sa propre culture 7. Connaissance de la culture d'accueil 8. Empathie, écoute, tolérance, patience 9. Curiosité, ouverture d'esprit 10. Organisation, débrouillardise, rigueur, sens des responsabilités 11. Adaptation 12. Gain de confiance, indépendance, ténacité, autonomie
	Compétences relationnelles 13. Communication interpersonnelle : compétences linguistiques et langagières 14. Intégration sociale : dans un groupe, constitution de réseaux de contacts, etc.

Source : Brassier- Rodrigues [2].

In the end, the answers provided by the respondents during the various studies confirm the range of skills acquired in intercultural communication: language, adaptation, empathy, interpersonal communication, social integration and knowledge of the host culture in addition to the adaptability and trust gained from international experience.

In the framework of the sandwich training's scheme, no study has so far demonstrated the potential benefit acquired by the student apprentices' host structure in the context of international mobility built-in integrating the competence frameworks specific to each training course followed. This is precisely the object of our exploratory reflection and its global prospective at the level of the economy of a small island territory similar to Corsica.

Indeed, since September 2018 and in coordination with the legislative evolution of 5 September 2018, the University CFA in the Corsican region has engaged in a proactive policy aimed at building international mobility pathways for some 400 students apprentices at the University of Corsica, in a dual perspective taking into account simultaneously the student aspirations and the expectations of complementary competences expressed by the host structures (companies, associations and local authorities).

With more than 2,200 entrepreneurial and institutional partners that have supported the training of nearly 3,500 students apprentices since its creation in 2009 [13], the CFA UNIV and its teaching teams have endeavoured to set up repositories of competences incorporating specific tasks relating to the international mobility of students apprentices.

3. Building a Skills Economy Through the International Mobility of Students Apprentices in Search of a Foundation

In Corsica, the promotion and development of sandwich training as well as the problem of University of Corsica students apprentices' quality of the professional integration, particularly in terms of awareness of entrepreneurship, revealed the strategic challenge of mastering managerial fundamentals at the heart of the development and structuring dynamics of the Corsican territory [12], thus reinforcing what other authors have demonstrated in a more theoretical framework [9] or global [5].

The local island economy is characterized by the absence of large multinational groups that lead and shape the global economy. There is also no mention of medium-sized enterprises, which in many other regions, such as Lombardy, are the spearhead of a dynamic economy. The Corsican economic fabric is mainly made up of very small enterprises, small farmers and producers, craftsmen and traders. The challenge of structuring a specific entrepreneurial ecosystem through an adapted lifelong learning regional policy is therefore of strategic importance with a view to building a sustainable local development plan.

3.1 Students Apprentices' International Mobility at the Center of a Lifelong Training Scheme Beneficial to the Structuring of a Small Island Economy

Corsica is also an example of a territory characterized by an ageing of its working population, which requires a medium-term adjustment of regional training strategies in response to this reality. As a major lever of territorial development and social regulation, the island training system must adapt its offer to the targeted perspective of the adequacy of the employment-training relationship. The sandwich training system, continuing vocational training and, more

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generally, the life long training thus constitute the two sides of the same gem at the service of a skill-building scheme, the qualifications and employability of the human resources available and active in a given territory.

In a small island territory characterized by an economic fabric composed of 95% of enterprises with fewer than 10 employees, the CFA UNIV's mission, both anchored and timeless, is to contribute to the promotion University of Corsica students apprentices' professional integration, through the development and adaptation of training strategies fundamental to the emergence and stimulation of qualified human resources' availability and the entrepreneurial logic based on innovative activities with potential high growth [9].

In this specific context, the structuring of the local economic fabric is largely impacted by the networking of the different actors (CFAs, Corsican region, companies, associations, local authorities, Skills Operators (OPCO), job houses, Consular Chambers) within the framework of a Regional Plan for the Development of Vocational Training and Guidance (CPRDFOP), which set, over the period 2018-2022, objectives clearly focused on responding to the needs of local actors in terms of securing pathways to employment and acquiring new skills proven through student mobility (inter-regional, national and international).

3.2 A Pragmatic and Exploratory Process Students Apprentices' International Mobility at the Initiative of CFA UNIV

In its 2018-2022 four-year establishment contract, the University of Corsica has placed at the heart of its strategic axes the deepening of the sandwich training system's development and the increased internationalization of its training offer. Nevertheless, the current reality reveals heterogeneous situations according to the pedagogical components: while the School of Management and Economy (IAE of Corsica) imposes the international mobility of students (internships) and students apprentices (as part of an apprenticeship and professionalization contract) to graduate from their Masters in Management Sciences (unless the international gap was made before enrollment in a proposed course), the other Institutes or Faculties (IUT, INSPE, Paoli Tech Engineering School, Faculties of Law, Arts and Sciences, Health Department) have opted to offer the opportunity to benefit from an international student mobility only on an optional basis.

This finding does not, for the time being at the University of Corsica, lead to the establishment of a homogeneous general policy on the international mobility of students, which led the CFA UNIV to propose a specific process, pragmatic and exploratory in the field of student apprenticeship.

Based on the mandatory nature of mobility and its variable duration (8 weeks to 6 months), the competency frameworks of the Master Manager Entrepreneur, Marketing and Human Resources have been redesigned with two objectives:

(1) add pedagogical and operational value to student missions as part of their international mobility;

(2) answer to the strategic perspectives identified by the host structures in international development.

For example, the *Union des Vignerons de l'Île de Beauté (UVIB)*, a cooperative winery that exports 75% of its production, wants to develop a new Terra Corsa brand, with a focus on international markets. With this in mind, it will propose to three students apprentices to set up a PMI.

The *Cuir Center* franchise, specialized in the sale of high-end sofas and furniture, wants to create a Mediterranean cluster and submits to two students apprentices international mobility at the European head office of the *Roche Bobois* group in Italy in order to decline this strategy by major HR issues, set general and specific objectives by site/population/department....

The extension of a pragmatic and exploratory international mobility process for students apprentices to enhance the professional integration and employability of human resources is now an essential prerogative of the CFA UNIV. The structuring, development and attractiveness of a small island territorial economy inherent to its development in particular, and more generally to those of training centers, are an underlying issue.

4. Conclusion

At a time when the economy of knowledge and skills is conveyed as THE solution to an endemic crisis, the CFAUNIV strives to contribute, in particular, to the construction of a consolidated and sustainable structure of the socio-economic fabric through the optimised management of a reinforced training/information system, supervision and individualized follow-up of the University of Corsica students apprentices' vocational guidance.

If the main issue of the law on *freedom to choose one's professional future* is the nature of the competences placed at the center of each citizen's individual training project, but also considered as the cornerstone of the appropriate response to the hiring needs of companies, there is no guarantee that the refocusing of the lifelong training system will ensure the bet of trust in the actors, companies, employees and social partners with a view to removing the obstacles to the hiring of companies and making the notion of skills a key issue at the heart of both individual and collective professional projects [13].

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Even though the national vocational branches will co-construct vocational training diplomas with the State in order to better meet the skills needs of enterprises, it remains that the links, until then concrete, between the regions and the CFAs will run the risk of distortion at the expense of developing the skills needed by local businesses.

From then on, it will belong to the regional CFAs, as developer agents of diploma and qualification courses in symbiosis with the expectations expressed by a local economic fabric, to develop a necessary capacity for innovation in the pedagogical engineering of the actions carried out allowing both the growth of the students' qualification and the conversion or conversion of the professional paths to the benefit of a small island territory in search of attractiveness.

This is the whole issue of the emergence of a new model of lifelong training system, a guarantee of the evolution and securing of professional paths, to which the CFA UNIV will seek to contribute by the evolution of its activity dynamics. There is no doubt that the operationality of the students apprentices' international mobility, which each participant in training calls for, will be the cornerstone, particularly in the context of a specific local economy and identity like Corsica.

Notes

i. In this case, the Corsica-region University-sponsored Placements & Apprenticeships Service [CFA UNIV]

ii. http://www.uis.unesco.org/education/

iii. *Erasmus pro: lifting the barriers to the mobility of apprentices in Europe, Report by Jean Arthuis, MEP*, Ministry of Labour, French Republic, January 2018.

iv. Erasmus +, an international springboard for apprentices:

https://www.letudiant.fr/educpros/actualite/erasmus-tremplin-international-apprentis.html

v. JORF n°0250 of 26 October 2019 text n° 13.

vi. JORF n°0026 of 31 January 2020 texts n° 34 et n° 35.

vii.

Knowledge and know-how skills	**Skills to be**
1. Language skills 2. Academic knowledge 3. Technical knowledge 4. Learning methods 5. Working methods	***Personal development skills*** 6.Knowledge of one's own culture 7. Knowledge of the host culture 8. Empathy, listening, tolerance, patience 9. Curiosity, open-mindedness 10. Organization, resourcefulness, rigour, accountabilities 11. Adaptation 12. Gain confidence, independence, tenacity, autonomy ***Relationship skills*** 13. Interpersonal communication: language and language skills 14. Social integration: in a group, networking of contacts..

viii. Cf. La circulaire n°2019-030 du 10 Avril 2019. (Circular no.2019-030 of 10 April 2019)

ix. International Marketing Plan . *Thanks to 2 months of international mobility in the Maghreb and 3 months in Southeast Asia* said Eric Pinelli, UVIB's Executive and Financial Director.

x. According to Jean Pierre Battistelli, Manager of the Cuir Center franchise in Corsica.

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ARTICLE

Optimization Processes of Tangible and Intangible Networks through the Laplace Problems for Regular Lattices with Multiple Obstacles along the Way

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transport systems
simulation
emergency

ABSTRACT

A systematic approach is proposed to the theme of safety, reliability and global quality of complex networks (material and immaterial) by means of special mathematical tools that allow an adequate geometric characterization and study of the operation, even in the presence of multiple obstacles along the path. To that end, applying the theory of graphs to the problem under study and using a special mathematical model based on stochastic geometry, in this article we consider some regular lattices in which it is possible to schematize the elements of the network, with the fundamental cell with six, eight or *2(n+2)* obstacles, calculating the probability of Laplace. In this way it is possible to measure the "degree of impedance" exerted by the anomalies along the network by the obstacles examined. The method can be extended to other regular and / or irregular geometric figures, whose union together constitutes the examined network, allowing to optimize the functioning of the complex system considered.

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1. The Representation of Complex Networks with Mathematical Models

Complex networks are networks whose structure is irregular, complex and which evolves over time and are used in various branches of science and technology, as in biochemistry, in the study of interactions in quantum field theory, in study of IT processes, topologies in geographical databases[1] and also on the web, in social networks such as Facebook and Linkedin and in the Google model.

The same term "complex" derives from the latin cum (together) - plexus (intertwined), "intertwined together": it highlights that a complex network system is composed of a set of parts connected together and "intertwined" in such a way that the final result (the effect produced) is different from the sum of the constituent parts. Therefore, the behavior of a complex system cannot be inferred by a simple analysis of the elements that compose it, but it is necessary a systematic examination of the interactions that are generated between them and the constraints that determine their operation must be carried out.

An appropriate methodological approach to the problem for the applied sciences can make use of particular discrete mathematical structures, called "graphs", which are represented by an *n-air* relationship on a finite set *S*, defined by the subsets of *S* with *n* elements which satisfy a property *P(1,..,n)*, which can be constructed in such way to be representative of the structure and the behavior of the main tangible and intangible networks, such as:

(1) WWW = *World Wide Web*;

(2) telematic or real communication networks (telephone networks, road, railway, port, logistics, airways, etc.);

(3) *networks describing ecological systems (food webs, etc.)*;

(4) biological networks (neural networks, genetic transcription networks, metabolic networks, protein networks, etc.);

(5) relationship networks (social networks, scientific collaboration networks, etc.);

(6) musical networks for composition (graphs based on notes and others on chords can be linked together by a relationship of duality to create the melody and harmony of a piece of music).

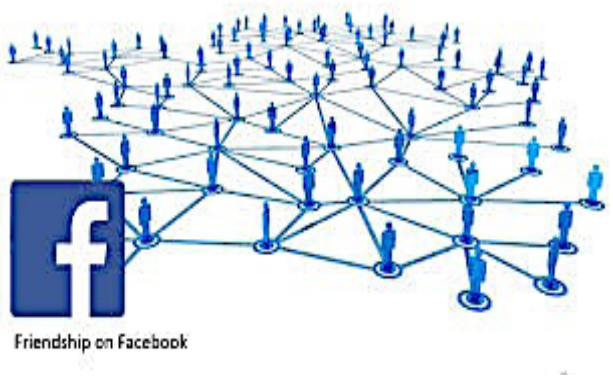

Figure 1.

From a geometric point of view, a graph is a data structure made up of a set of vertices (or nodes) which are related to each other through links, called arcs. In essence, a graph can be imagined as a set of points randomly arranged in the space R^n connected by "bridges" to the other points. So in a computer network, for example, the nodes are represented by all the devices connected to the network (such as a PC connected to the internet), while the arcs are represented by the communication channels that allow users to interact in the network. If the relationship between the elements of the represented set does not provide an order between them, there is a not oriented graph (see the following figure), while if it is foreseen, there is an oriented graph.

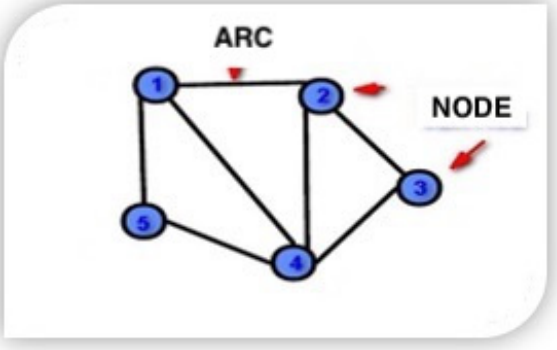

Figure 2.

An not oriented graph $G=(N,L)=G_{N,K}$ is algebraically definable through a pair of two sets N and L where the elements of are $N=\{n_1,n_2,...,n_K\}$ called nodes or vertices and the elements of $L=\{l_1,l_2,...,l_K\}$ are pairs of elements of N, called arcs or links. The number of elements of the set of vertices and arcs is respectively N and K. The graph is oriented if the elements of $L=\{l_1,l_2,...,l_K\}$ are ordered pairs of elements of N. In this case, l_{ij} indicates an arc that connects node i with node j.

Given a graph G with N nodes, the number K of arcs

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can vary from a minimum of 0 arcs to a maximum of *N(N-1)/2* and in this case all the nodes are adjacent (connected to each other by a arch)①; it is defined as connected if for each pair of distinct nodes *i* and *j*, there is a path *i→j*, otherwise it is disconnected, for the mathematical representation a special matrix is used, called adjacency, typically indicated as *A*, of dimension *NxN* and the degree of a node *i* is calculated through the number k_i of arcs adjacent to *i*②.

The numerical representations of a graph can be matrix or vector, the nodes of the set *N* are usually indicated with an integer. The representation of the graph most used in calculation programs is known as the outgoing star, or forward star, in which each node *i* is associated with the set of arcs it leaves, or the final nodes of these arcs, FWS (i). A similar representation of the graph called backward star (BWS) is obviously possible, which requires exactly the same amount of data. The choice between the representations depends on the algorithm for calculating the minimum paths that is adopted.

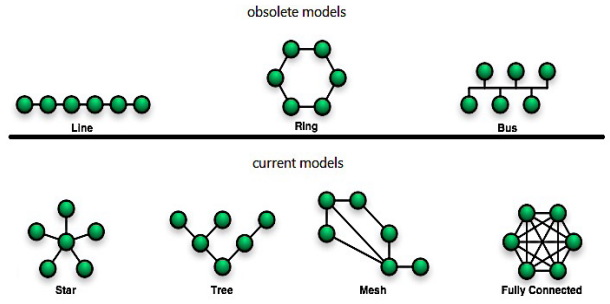

Figure 3.

A graph G(N,L) can be stored on a computer in multiple ways, the choice of which depends on the characteristics to be highlighted and the needs for use, as well as on its size and density (number of arcs compared to the number of nodes),

(1) connection matrix;

(2) incidence matrix;

(3) adjacency list.

Of these (see following diagrams), the first and the last are the most used③ but the incidence matrix, although less effective than the other two methods from the computational point of view, is however preferable in some optimization problems due to its relative ease of representation.

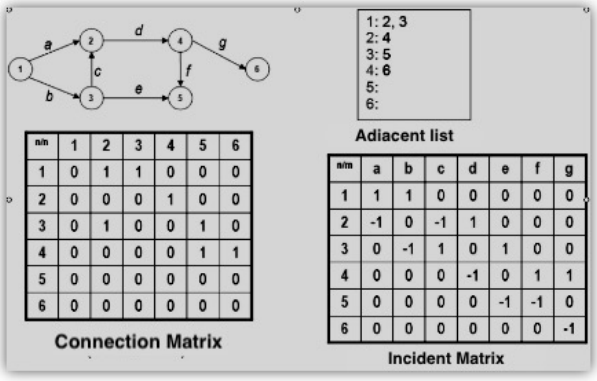

Figure 4.

The connection matrix as storage method is based on the use of a square matrix *nxn* (with *n* number of nodes in the graph), in which the generic element *(i,j)* assumes the value 1 if there is an arc that connects the node *i* with node *j*, while 0 in the other cases, so in the case of undirected graphs the matrix will be symmetric, since the element *(i,j)* is equal to the element *(j,i)*.

Furthermore, depending on the particular infrastructural network (material and / or immaterial) under examination, it is possible mathematically to "deposit" on the set of vertices or arcs (or both) some quantitative information of the arcs or vertices that represent specific "assessments" that characterize the problem and its constraints. It is possible to refer to specific models representative of the specific realities in the study, defining each time the set of variables, the objective function (or multi-objective) and the system of constraints, as in the case that we want to determine the cheapest way to transport a certain amount of an asset (for example, gas, oil, industrial or agricultural products, etc.) from one or more production nodes to one or more consumption points, through a certain transport network (hydraulic, distribution, road or railway, of the production chain, etc.)④. For such models of flow distribution at minimum cost, the network can be conveniently

① A graph is called complete if $K = \left(\frac{N}{2}\right) = N\cdot(N-1)/2$ it is denoted by K_N, while a walk G (i→j) is a sequence of nodes and arcs which begin from *i* to *j* and they can cross more times.

② For example, an infrastructural network of land mobility (road or rail) can be represented through an oriented and connected graph *G=(N,L)*, in a computerized way.

③ The connection matrix is preferable in the case of very dense graphs because, compared to the adjacency list, it allows greater efficiency and immediacy of the calculations, while the latter is useful in the case of scattered graphs (i.e. the number of arcs is small compared to the number of nodes).

④ The mathematical model of the problem is here of a general nature because it lends itself to representing cases that have nothing to do with the shipment of goods and, therefore, the more abstract notion of flow that can refer to each application will be used below.

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represented by means of an oriented graph, like the one in the figure below.

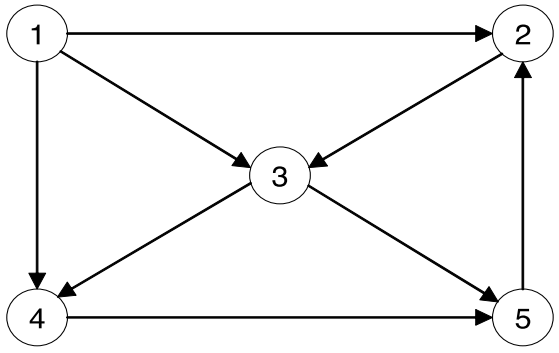

Figure 5.

In this simple explanation of the problem the 5 nodes of the oriented graph can be associated with the localities (intermodal centers, stations, depots, industrial plants, urban areas, etc.), and the 8 arcs with the communication routes which are supposed, for example, to one way (gas pipeline, road, railway branches, etc.) between the considered locations. In the real case of two-way streets, it will then be necessary, for each of them, to consider a pair of arcs directed in opposite directions between the two localities of reference. The network topology constitutes only a part of the problem data, to which must be added the demand for the goods, the availability of these in other locations, the transport costs from one location to another and the maximum capacity associated with each arc of the network (see example of integrated logistics network below [18]).

Figure 6.

To formulate this problem with graph theory (*m* variables and *n* constraints) we consider an oriented network *G=(N,L)*, associating to it for each arc $(i,j) \in L$ a cost C_{ij} (negative, positive or zero)①, a given capacity $C_{ij} \geq 0$ and a lower l_{ij} , with $0 \leq l_{ij} \leq C_{ij}$.

Suppose that each node *i* of *N* has an integer number *b(i)*, assuming that *b(i)* > 0 indicates the presence of an offer (*i* = origin, or "source") and that *b(i)* < 0 characterizes the presence of demand (*i* = destination, or "well"), while *b(i)* =0 indicates the absence of both supply and demand (*i*= transfer node).

In the following we will assume the hypothesis (of admissibility) for which the total offer equals the total demand, given by the equation:

$$\sum_{i \in N} b(i) = 0.$$

Then, the cost of a flow can be defined as the sum:

$$\sum_{(i \to j) \in L} c_{ij} \cdot x_{ij} \cdot$$

It should be noted that the classification of the nodes in the three mentioned types (origin, destination, transfer or transit) is completely independent of the structure of the network, but it is defined only by the numerical data on the availability of the asset and demand. So, for example, in the previous scheme, if there is a demand for 6 units at node 4, 8 at node 5, and an availability of 10 units at node 1, and 4 at node 2, then 4 and 5 they are well nodes, while 1 and 2 are source nodes, while the 3 is transit.

Assuming now that the availability of the asset corresponds to a negative demand, it is possible to associate each node *i=1,..,n* a variable equal to the demand b_i of the node (positive for the wells, negative for the sources and zero for the transit nodes). According to this approach, the application vector *b* will have *n* components, in which the *i-th* component will be b_i, definable by means of the expression:

$$b = \begin{pmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \\ b_5 \end{pmatrix} = \begin{pmatrix} -10 \\ -4 \\ 0 \\ 6 \\ 8 \end{pmatrix}.$$

Furthermore, for the calculation, we consider the hypothesis that the total availability of all the source nodes is equal to the total demand of all the well nodes which does not limit the applicability of the model to the practical problems concerning the transport of goods, because technically they can always be traced back to a form that satisfies this assumption. This, in fact, will be achieved by adding appropriate fictitious nodes and arcs in the network under study, with functions completely analogous to the waste variables used to bring the problems examined back to standard form.

① A unit of that property under study that is shipped from an "i" origin to a "j" destination must bear a cost equal to the sum of the unit transport costs of all the arcs of the network that must be crossed.

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In general, the problem of flow at minimum cost consists in to find an admissible flow distribution on the network $G=(N,L)$ such that the total cost is minimal. If we indicate the incidence matrix of the network with A_G with $b=[b(1),b(2),...,b(n)]^T$ the supply/demand vector, with R^m the cost vector and with $l \in (R^m)_+, u \in (R^m)_+$ the vectors whose components represent the lower limit and the capacity of the corresponding arc, the minimum cost flow problem can be analytically defined through the following system:

$$\begin{cases} \min c^T x \\ A_G x = b \\ l \le x \le u \end{cases}.$$

In the particular case of a non-capacitive network, that is when $l_{ij}=0$, $u_{ij}=\infty$, then the system assumes the following configuration:

$$\begin{cases} \min c^T x \\ A_G x = b \\ x \ge 0 \end{cases}$$

Finally, as regards, in general, for the resolution of any problem of optimization of the efficiency, quality, safety and reliability of a complex network[10, 11], the definition of the "objective function" (for the measurement of the value attributable to the set objective), this will depend on the number "n" of the choice variables $x_1,x_2,\ldots,x_n$, characterizing the case study (whose values must be established by the project manager, or by the multidisciplinary study team) and by a set of constraints that must be satisfied, expressed by equations or inequalities. These last can be "direct constraints", when they operate on the value of the variables of choice (for example, $1\le x_1\le 6$, "functional constraints", when they operate indirectly on them (for example $1\le x_1\le 6$ "functional constraints", when they operate indirectly on them (for example, $x_1+x_2\le 7$), or "non-negative constraints", when they impose on these variables to assume only non-negative values (for example, $x_3\ge 0$). If, we indicate the objective function by F, the maximum problem to be solved will be represented as follows:

$$\begin{cases} Max\{F(x_1,x_2,...x_n)\} \\ x_1,x_2,...x_n \\ g_1(x_1,x_2,...x_n) \le b_1 \\ g_2(x_1,x_2,...x_n) \le b_2 \\ ..... \\ g_m(x_1,x_2,...x_n) \le b_m \end{cases}$$

where $F(x_1, x_2, ..., x_n)$ it is the function to be minimized (for the search for the lowest cost route for an O-D relationship on a mobility network) or to be maximized (if you want, for example, to examine the revenue from the toll, etc.), the variables $x_1, x_2, ..., x_n$ are those on which the operator can intervene and the expression $g_j(x_1, x_2, ..., x_n) \le b_j$ represent the m constraints (con j=1, 2, ... , m), of the problem to be satisfied, which here, by way of example, have all been expressed in the form of inequalities of the type [≤], that is, with a weak inequalities.

However, the objective function F varies according to the cases and could be of the first degree (linear), or of the higher degree (nonlinear), of the deterministic type, or random (with the presence of random variables); moreover, the problem could refer to a single temporal phase ("static" case), or more successive and related phases ("sequential" or "dynamic" problems), etc., and therefore in practical applications it will be necessary to use the procedure of more appropriate resolution and referring to appropriate computer programs.

Finally, assigning the "optimal" values thus identified to the choice variables, we will obtain the best possible result among all the admissible ones, interpreting the reality in the studio as closely as possible, in order to be able to provide the decision maker with useful tools to operate successful choices.

2. The Contribution of Stochastic Geometry to the Analysis of Safety, Reliability and Quality in Operation of a Complex Network

Associating a representative set of a network with a suitable set of variables, it is possible to carry out the functional analysis of the "network-safety-reliability-quality" system, through particular stochastic $\mathcal{R}^n$ models that allow to calculate in the geometric space the interferences between the flow that crosses the branches of the network (vehicular flow, of fluids or gases, flow of information, relationships, etc.) and accidental obstacles placed along the path that can affect its normal operation, thus ensuring the best overall performance and system security.

The problem can therefore be addressed using a set of safety, reliability and quality indicators, $P_x^S(x), P_x^A(x), P_x^Q(x)$ which give rise to an indicator $P_x^G(x)$ of "global quality in operation" of the network, given by the expression:

$$P_x^G(x) = \sum \left[P_x^S(x)\right]^{-w_S} + \left[P_x^A(x)\right]^{-w_A} + \left[P_x^Q(x)\right]^{-w_Q},$$

where, case by case, the relative set of variables must be made explicit, including:

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(1) the overall costs[14, 15] of ris

$$C_r^R = \sum \left(C_{i \to j} \right)^{-w_{i \to j}}$$

for each arc $i \to j$ of the network (depending on the topology, peculiarities of the nodes and arcs, operating characteristics, level of tolerability of the risk for the user, emergency management, etc.);

(2) quality of the service, in terms of the generalized cost of transport, as the ratio between the minimum cost and the cost travel between the branches $i \to j$ of the network, which can be expressed with the ratio

$$Q = \sum \left(\frac{C_{min}^{i \to j}}{C_{eff}^{i \to j}} \right);$$

(3) the degree of interconnection of the *n* nodes

$$\beta = \sum \left(\beta_{i \to j}^{i=1,\ldots,n} \right)^{-w_{\beta_i}};$$

(4) the level of intrinsic security of the infrastructure

$$L_S = \sum \left(L_{i \to j}^{i=1,\ldots,n} \right)^{-w_{L_i}};$$

(5) reliability characteristics[10] in the useful life cycle of the technological devices in the network itineraries

$$T_{aff} = \sum \left(T_{i \to j}^{i=1,\ldots,n} \right)^{-w_{T_i}};$$

(6) associating the concept of vulnerability[9] with that of functionality and the loss of functionality of certain arcs, a characteristic indicator of the network

$$\eta = \frac{df}{dv},$$

where *f* is the functionality expressed in terms of efficiency and quality of the offer and *v* represents the extension of the malfunction (also as calculated risk) for the entire network;

(7) topological efficiency of the network, as an estimate of the probability that all nodes are reachable, which if d_i indicates the shortest path between *i* and *j* can be represented by the expression

$$E_{Top}(G) = \frac{1}{N-1} \sum_{i,j \in G} \frac{1}{d_{i \to j}};$$

(8) *index of resilience*① [17], understood as "service recovery capacity" also following a disaster recovery *disaster ricovery*②, as an indicator of the system's ability to adapt to conditions of use and to resist wear and tear so as to continue to guarantee the availability of services provided (network fragility index), definable with the expression

$$(I_R)^{\mathrm{G=(N,\,L)}} = \frac{\int_{t_1}^{t_2} \phi(t)\, dt}{(t_2 - t_1)} \cdot \theta \ ,$$

where the function

$$\theta = f\left(k_i^{i=1,\ldots,n}, E_{Top}, \beta \right),$$

depends on the variable E_{Top} and β defined above and on the total degree of each of the n nodes k_i of the network oriented graph, with

$$k_i = k_i^{out} + k_i^{in},$$

sum of the incoming and outgoing arches, being

$$k_i^{out} = \sum_{j \in N} a_{ij};\ k_i^{in} = \sum_{j \in N} a_{ji},$$

with a_{ji} the elements of the adjacency matrix. If the network is represented by a weighted graph, the term $k_i^{i=1,\ldots,n}$ will represent the "node strength", defined as the sum of all the weights of the arches connected to node i, extending the mathematical relationship is to the incident arches, both to their weight.

Furthermore, $\phi(t)$ is a characteristic function of the system service built through the service level in an undisturbed situation ϕ_{ind}, the one following the event examined ϕ_a , the variable which measures the speed of recovery of the system and $\Delta t=(t_2-t_1)$ the time interval considered. This function is given by the equation

$$\phi(t) = \phi_{ind} - (\phi_{ind} - \phi_o) \cdot e^{\varepsilon_r},$$

① The word resilience derives from the Latin verb "resilio", which means "to jump back, to return to a previous state". For a complex system we can distinguish the supply side resilience, or the functional resilience of the infrastructure, and the custumer side resilience, typical of the use of the network by its users. The issue of resilience takes on particular relevance, as it is mainly related to the "response" to unexpected events and sudden changes, such as in the case of accidental obstacles in the network.

② For computer networks, the term disaster recovery means the set of technological, logistical and organizational measures aimed at restoring data, systems and infrastructures necessary for the provision of business services to companies, associations or entities, in the face of serious emergencies that affect its regular activity.

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and $\phi(t)$ can take values between 0 and 1, with $\phi(t)=1$ corresponding to the full operation of the system and $\phi(t)=0$ in the case of total inoperability. In the case of a network of n interdependent infrastructures and assuming that R_i is the resilience of the generic infrastructure *i-esima*, (i=1,...,n) it is then possible to identify a function $R_{tete}=\omega(R_1,...,R_i,...,R_n)$ which describes the resilience of the entire network.

(9) impact indicator on the functioning of the system for the measurement of the probability of interference of the flows with any obstacles along the route, depending of the network topology P_{int}. The characteristics of the "traffic" l_i', and those of the obstacles (assumed overall in number of "k") defined by the size d_k of each,

$$P_{int.} = f\ (l_i, d_k)\,.$$

This last aspect, since it assume the particular importance for the systematic analysis of a network system, will be further developed through a special stochastic model based on a lattice obtained starting from a geometric figure called the "fundamental cell", at the top of which are represented some regular polygons equal to each other, called "obstacles", obtaining a "regular lattice with obstacles".

Considering that in a complex network it is possible the simultaneous presence of multiple obstacles along the constituent arches, due to events that affect quality, safety and functionality, the case of the presence of a generic number equal to $2(n+2)$ of obstacles.

The proposed model is, among other things, functional for the management of seismic and atmospheric emergencies for all physical transport networks and is also applicable to intangible ones.

In fact, in the studies of the infrastructures represented by graphs in $\Re^n$, the tool of geometric probabilities lends itself well to the analysis of interferences in operation of the relationship "network-obstacles-safety-system operation", assuming that the entire network is formed by a union union R of elementary geometric figures, constituting special lattices R_i, whereby $R=R_1,R_2,...,R_n$.

3. A Mathematical Model for Assessing the Probability of Interference of the Flow with Multiple Accidental Obstacles Along a Network System

Considering the graph $G=(N,L)$ representative of the considered network and constructed the sub-latticeolo R_i of the union set formed by it, by means of particular test bodies (mathematical models) representative of the means constituting the flow that passes through it, it is possible to study the relative motion in R_i(i=1,...,n) and any interferences generated by obstacles (of fixed shape and size) along each arc $i \rightarrow j$ of the network[12].

These test bodies can be taken as segments of suitable length l (to schematize, for example, in a road network a freight train with a large number of carriages, or an articulated lorry in the case of road transport), or consisting of rectangles of sides l_1 and l_2 (as in the case of a high-speed train, or a car along a road).

Furthermore, in order to research the mathematical solution of the problem, we will hypothesize that each side of the considered reticle offers the same resistance to the forward movement of the test body and that there are conditions of uniform motion.

We consider a lattice with the fundamental cell a rectangle (but it could be any other flat figure, even irregular, constituting the lattice) in which three different types of obstacles are inserted, in an equal number up to $2(n+2)$, formed by the following geometric figures: rhombuses, circular sectors and square.The degree of incidence of the disturbance produced by them on the regularity of the outflow in the network concerned varies from the maximum impact of the rhombuses to the minimum impact of the circular sectors, which have the least probability of interference between the test body (medium) and long obstacle path.

A reference scheme for the practical applications of the method is shown in the following table and refers both to the study of tangible and intangible networks, such as web networks, where for anomalies from accidental events, such as the occurrence of a "Bottleneck", one must evaluate, in analogy to the electrical circuits, the impedance①, that is the resistance opposed by the obstacle to the flow of information. The same approach can be considered in the case of a mobility or logistics system for the analysis of traffic safety and fluidity, or in emergency landslides for adverse weather situations, monitoring the problem of the probability of obstacle-vehicle interference (fall boulders, trees, etc. along the infrastructure network or its nodes).

① Impedance, in electrical engineering, is a physical quantity that represents the opposition force of a circuit to the passage of an alternating electric current, or, more generally, of a variable current.

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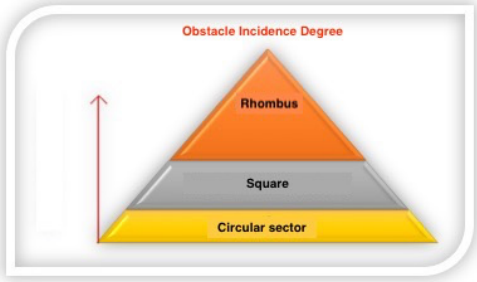


Figure 7.

Let $\mathfrak{R}(a,b,c)$ be the regular lattice with fundamental cell is as in Figure 8.

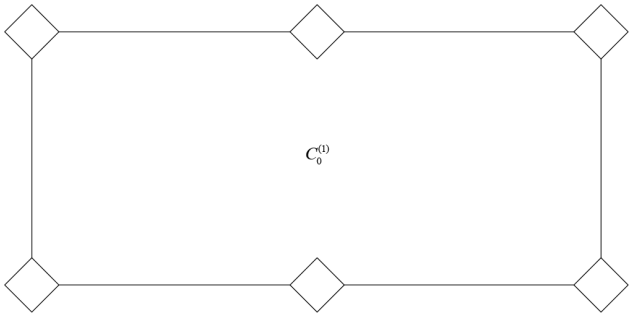


Figure 8.

Denoting with $C_0^{(1)}$ the fundamental cell, we have:

$$(1)\ area\, C_0^{(1)} = 2ab - c^2.$$

The cell $C_0^{(1)}$ have six obstacles that are squares with diagonal of length c with $c<min(a,b)$. Considering a segment s of random position and of length l with $c<l<min(a,b)$, we want compute the probability that this segment intersects a side of lattice. This probability is equal to probability $P_{\text{int}}^{(1)}$ that the segment s intersects the boundary of the fundamental cell. The position of the segment s is determined by the middle point p and by the angle φ that the segment form with the axis x. We consider the limit positions of the segment s that corresponds at angle φ and let $\hat{C}_0^{(1)}(\varphi)$ the determined figure from this position (see Figure 9):

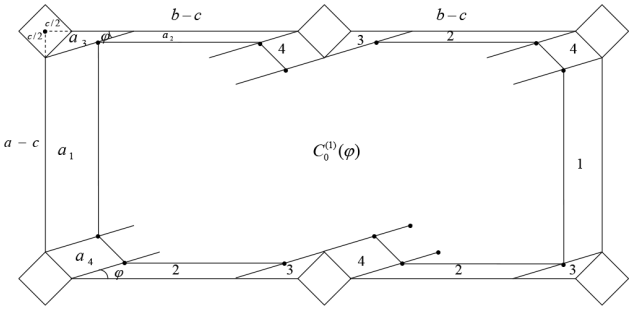


Figure 9.

Considering some results that we have obtained in a previous paper[1], and from Figure 9 follow that:

$$area\, a_1(\phi) = \frac{(a-c)}{2} l\cos\phi,$$

$$area\left[a_2(\phi) + a_3(\phi)\right] = \frac{(b-c)l^2}{2}\sin\phi,$$

$$area\, a_4(\phi) = \frac{cl}{4}(\sin\phi + 2\cos\phi) - \frac{l^2}{4}\sin 2\phi,$$

we have that:

$$area\, a_4(\phi) = \frac{cl}{4}\left(\sin\phi + \frac{3}{2}\cos\phi\right) - \frac{l^2}{8}\sin 2\phi.$$

With these results the relation (1) give us:

(2)

$$area\, \hat{C}_0^{(1)}(\phi) = 2ab - c^2$$
$$-\left[(a-c)l\cos\phi + 2(b-c)l\sin\phi + cl\left(\sin\phi + \frac{3}{2}\cos\phi\right) - \frac{l^2}{2}\sin 2\phi\right]$$
$$= 2ab - c^2 - \left[\left(a - \frac{c}{2}\right)l\cos\phi + (2b-c)l\sin\phi - \frac{l^2}{2}\sin 2\phi\right].$$

Denoting with M, the set of segments s whose the middle point are in $C_0^{(1)}$ and N, the set of segments s whose the middle point are in $C_0^{(1)}$, we have that:

$$(3)\ P_{\text{int}}^{(1)} = 1 - \frac{\mu(N_1)}{\mu(M_1)}$$

where μ is the Lebesgue measure in Euclidean plane[4]. In order to compute the measures $\mu(M,)$ and $\mu(N,)$ we use the Poincaré kinematic measure[3] $dK = dx \wedge dy \wedge d\phi$,

where x,y are the coordinates of p and φ the defined angle. Since $\varphi \in [0, (\pi/2)]$, we obtain that:

(4)

$$\mu(M_1) = \int_\alpha^{\frac{\pi}{2}} d\phi = \iint_{\{(x,y)\in C_0^{(1)}\}} dxdy = \frac{\pi}{2} area C_0^{(1)} = \frac{\pi}{2}\left(2ab - c^2\right),$$

and considering the (2)

(5)

$$\mu(N_1) = \int_\alpha^{\frac{\pi}{2}} d\phi = \iint_{\{(x,y)\in \hat{C}_0^{(1)}\}} dxdy = \int_\alpha^{\frac{\pi}{2}} \left[area\, C_0^{(1)}(\phi)\right] d\phi =$$

$$\frac{\pi}{2}\left(2ab-c^2\right)-\int_{\alpha}^{\frac{\pi}{2}}\left[\left(a+\frac{c}{2}\right)l\cos\phi+\left(2b-c\right)l\sin\phi-\frac{l^2}{2}\sin 2\phi\right]d\phi=$$

$$\frac{\pi}{2}\left(2ab-c^2\right)-\left[\left(a+2b-\frac{c}{2}\right)l-\frac{l^2}{2}\right].$$

Considering the (3), (4) and (5) we obtain the probability:

$$(6)\quad P_{\text{int}}^{(1)}=\frac{2\left(a+2b-\frac{c}{2}\right)l-l^2}{\pi\left(2ab-c^2\right)}.$$

When $c\to 0$, the obstacles becomes points and the fundamental cell becomes a rectangle with side a and $2b$. In this case the probability (6) becomes the Laplace probability:

$$P=\frac{2\left(a+2b\right)l-l^2}{2\pi ab}.$$

In the same way we can consider other different lattice configurations.

Example 1. Let $\mathcal{R}_2$(a,b,c) be the regular lattice with fundamental cell is as in Figure 10:

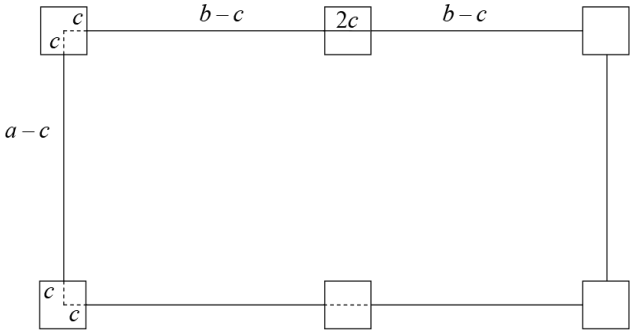


Figure 10.

The obstacles are squares with the side of length c. Considering a random segment whose length $l<min(a,b)$ we to want compute the probability that a segment intersects a side of the lattice. This probability is equal to the probability $P_{\text{int}}^{(2)}$ that a segment s intersect a side of the fundamental cell $C_0^{(2)}$ we have

$$area\,C_0^{(2)}=2ab-8\cdot\frac{c^2}{8}=2ab-c^2$$

Considering the position s of the segment with barycenter p and which forms an angle φ with axis x. We consider the limit positions of the segment s for a determined angle φ, and let $\widehat{C}_0^{(2)}(\varphi)$ the figure determined by these positions (see Figure 11):

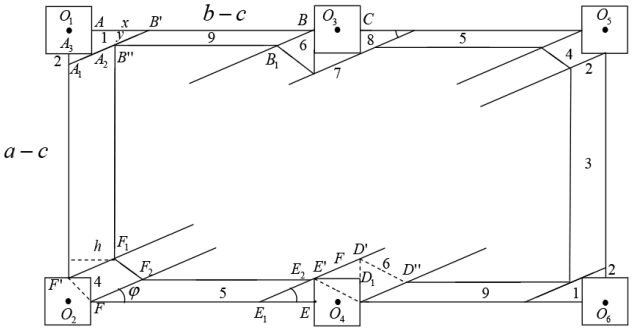


Figure 11.

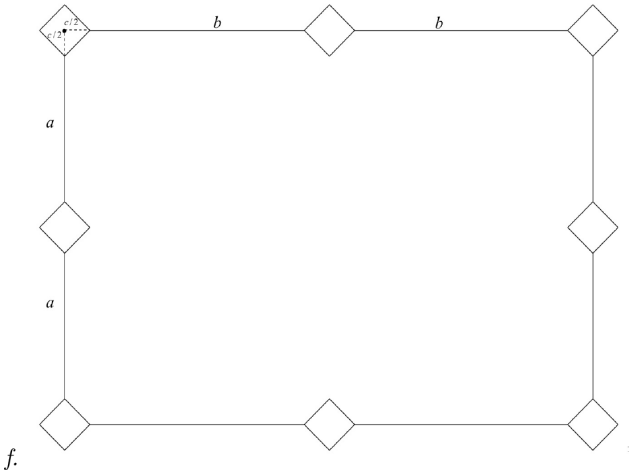
and we have that

$$P_{\text{int}}^{(2)}=\frac{l\left(a+2b-\frac{c}{4}\right)-\frac{l^2}{2}-\pi c^2}{\frac{\pi}{2}\left(2ab-c^2\right)}=\frac{2l\left(a+2b-\frac{c}{4}\right)-l^2-2\pi c^2}{\pi\left(2ab-c^2\right)}$$

When $c\to 0$ the fundamental cell $C_0^{(2)}$ becomes a rectangle with sides a and $2b$ and the obstacles become points and the probability $P_{\text{int}}^{(2)}$ becomes the Laplace probability:

$$P=\frac{2\left(a+2b\right)-l^2}{2\pi ab}$$

Example 2. Let $\mathcal{R}_2$(a,b,c) be the regular lattice with fundamental cell is as in Figure 12.



f.

Figure 12.

Denoting with $C_0^{(3)}$ the fundamental cell, we have:

$$area\,C_0^{(3)}=4ab-\frac{3c^2}{2}$$

The cell $C_0^{(3)}$ have eight obstacles that are squares with

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diagonal of length 2*c* with *c*<*min*(*a*,*b*). We have

$$(7)\ P_{\text{int}}^{(3)} = \frac{2\left(2a+2b-\frac{c}{2}\right)l-l^2}{\pi\left(4ab-\frac{3c^2}{2}\right)}$$

When $c\to 0$, the obstacles becomes points and the fundamental cell becomes a rectangle with side *2a* and *2b*. In this case the probability (7) becomes the Laplace probability:

$$P_{\text{int}}^{(3)} = \frac{2(2a+2b)l-l^2}{4\pi ab}$$

Example 3. Let $\mathfrak{R}_4(a,b,c;\alpha)$ be the regular lattice with fundamental cell $C_0^{(4)}$ is as in Figure 13.

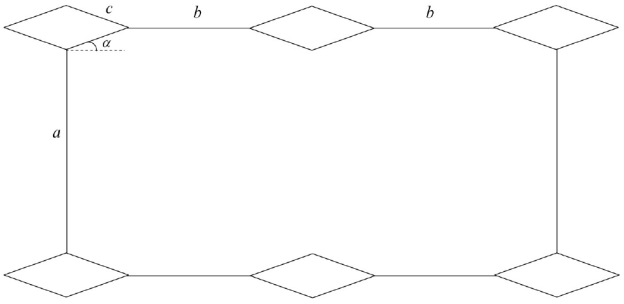

Figure 13.

where $\alpha \in [0, (\pi/2)]$ is an angle and *c*<*min(a,b)*. The $C_0^{(4)}$ have six obstacles that are rhombs with side *c* and with the diagonals $d_1=2c\sin\alpha$, $d_2=2c\cos\alpha$. We have that:

$$area\, C_0^{(4)} = 2ab+4c(\alpha\cos\alpha+b\sin\alpha)+4c^2\sin\alpha\cos\alpha$$

We have

$$(8)\ P_{\text{int}}^{(4)} = \frac{2(a+2b+4c\cos\alpha)l-l^2}{\pi\left[2ab+4c(a\cos\alpha+b\sin\alpha)+4c^2\sin\alpha\cos\alpha\right]}.$$

When $\alpha\to 0$, the obstacles becomes segments of length *2c* that go in the boundary of the lattice, the fundamental cell $C_0^{(4)}$ becomes a rectangle of side *a* and *2b+4c* and the (8) becomes the Laplace probability:

$$P = \frac{2(a+2b+4c)l-l^2}{\pi a(2b+4c)}.$$

Example 4. Let $\mathfrak{R}_5(a,b,c;n)$ be the regular lattice with fundamental cell $C_0^{(n)}$ a rectangle with sides (*n*+1) *a* and *b* with 2(*n*+2) obstacles that are four quarter of circle of radius (*c*/2) and 2n semicircle

with same radius (*c*/2) (Figure 14):

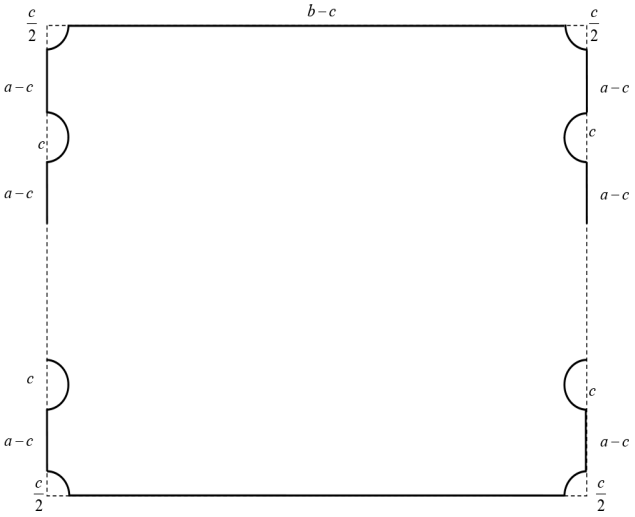

Figure 14.

We have that:

(9)

$$P_{\text{int}}^{(n)} = \frac{2\left[(n+1)a+b-c\right]l-l^2-\frac{\pi\left[(n+1)\pi-1\right]c^2}{4}}{\pi\left[(n+1)ab-\frac{(n+1)\pi c^2}{4}\right]}s.$$

When $c\to 0$, the fundamental cell $C_0^{(n)}$ becomes a rectangle of sides (*n*+1)a and b and the probability (9) becomes the Laplace probability:

$$P_{\text{int}}^{(n)} = \frac{2\left[(n+1)a+b\right]l-l^2}{\pi(n+1)ab}$$

4. Conclusion

In this work, a particular mathematical criterion has been proposed for the analysis of the performance characteristics and reliability in operation of the material and immaterial[20] networks in the presence of accidental obstacles, through the study of geometric probabilities and integral geometry. It covers a wide range of engineering, socio-economic and applied sciences applications, being able to deal with problems of Social Network Analysis, mobility and logistic systems(5), business, etc. In fact, the algorithm allows to evaluate, with an adequate degree of accuracy, the interferences of the "network - unexpected obstacles - interferences with the flow of traffic" system, representing the network with an appropriate regular grid formed by the union of equal regular polygons,

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generated by a "fundamental cell" and which have only segments of the relative "borders" in common.

For the development of the model, other equal regular polygons, called "obstacles", were positioned in the vertices of the fundamental cell, thus geometrically constructing a particular "regular grid with obstacles", capable of defining the ordinary operating conditions of the network and to calculate the probability of "flow-obstacles" interference for each O-D path (origin-destination).

In this way, it is possible to study the effects of an accidental "disturbing cause" on the circulation of the "vehicles" that make up the current of traffic and also to intervene to restore the functionality of the system. To fully define the problem, the "impacts" on the lattice of three different types of obstacles (square, circular sector and rhombus) were examined, considering a multiple number, up to 2(n+2). This, in order to appropriately represent the different degree of incidence of the disturbance on the network (min circular sector; max rhombus) according to the different unforeseen causes that can temporarily alter its regular performance characteristics and those of safety and reliability. For display simplicity, a rectangle has been assumed here as a "cell", obviously being able to extend the calculation (also with the aid of computerized processing) to any other flat, regular and / or irregular figure, constructing the representative grid of any case concrete through the effective articulation of arcs and nodes in the development of the network.

In this sense, by way of example, the configurations of both the internet network and the national road network ANAS complete with its TEN (Trans-European Networks) extensions are shown below.

Figure 15.

Figure 16.

In the case of complex networks such as those shown above, it is necessary to extend the results reported in the present work to the actual configurations in R^n, also considering the rotation of the test body formed by the segment s representative of the medium belonging to the traffic current flowing into the network (material or immaterial).

That is, it is necessary to take into account the particular geometric configuration of the lattice to be examined, considering in the calculation of the geometric probabilities developed above also the variable φ_0 given by the value assumed by the angle between the $0x$ axis and the straight support d of the aforementioned segment s .

If $P_m=(x,y)$ is the midpoint of s (of length l) and x and y represent its Cartesian coordinates, the problem can therefore be solved, in the general case, considering the elementary kinematic measure of Poincaré in the Euclidean plane [17]:

$$dk = dx \wedge dy \wedge d\varphi_0 .$$

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ARTICLE

Research on the Dynamic Relationships among Taiwan's Early Childhood Education and Its Stakeholders: The System Dynamics Perspective

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ABSTRACT

In Taiwan, the low birth rate has become one of the most critical problems faced by the government and educational institutions at all levels. The enrolling student number of kindergartens perhaps is the most directly affected by such trend. The purpose of this study aims at constructing a system dynamics model to depict the relationships between the preschool children and their stakeholders for deducing the evolutionary trends of, and the interactions of, governmental policies and the operations of the early childhood education institutions. Through the interpretation of policies and simulation analysis of the twenty-year growth trend related to the child population in Taiwan, this study found that governmental policies and the promotion of education and care services have a positive effect on the growth of all levels of kindergarten classes. Besides, the relationship between the education and care service staff and the kindergarten play a causal balancing role in our proposed model. We suggest that the system dynamics model proposed by this study can help to observe the dynamic relationships formed by the stakeholders in preschool education and care system based on the "joint responsibility" of Taiwan's early childhood education.

1. Introduction

In Taiwan, to enable young children to receive proper education and enjoy the right to be cared for, the government revised the "Early Childhood Education and Care Act" in 2018. It integrated the previous three types of institutions for child care, baby care, and young child care into "child care" expressly stipulating management rights and responsibilities as well as different management methods. The structure is divided as follows: The Ministry of Health and Welfare is in charge of "nursery centers," where licensed professional nursing staff are responsible for the care of young children under two years old; the Ministry of Education is in charge of "kindergartens" and "after-school care centers."

Kindergartens need to have qualified teachers as instructors to be responsible for young children over two years old and younger than six years old, providing educational services such as game learning, health education, life ethics education, etc. In after-school care centers, qualified personnel who have obtained training licenses from training institutions are responsible for after-school care and academic guidance for schoolchildren over six years old. In this way, an integrated system of early childhood education and care has been built to achieve the goal of young children's healthy physical

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and mental development.

Taiwan has become an aging society, and low birth rate has a significant impact on the operation of educational institutions. The government released a population estimation report (for 2018 to 2065) in August 2018, indicating that the birth rate will decrease year by year, and the school-age population will show a downward trend. This population estimation was made using the internationally adopted "Cohort Component Projection Method" [1]. In the current education scheme in Taiwan, young children must go through early childhood education before the primary school stage. Therefore, the issue of supply and demand of the preschool education population is an essential issue of concern to the government and education and care service institutions.

The purpose of this study is to use the system dynamics perspective to construct the systematical causal model of education and care services. In Taiwan, preschool education is mostly provided by various public and private kindergartens. The main service areas of the education and care service system include early childhood education, care, and community (tribe) mutual assistance; education and care services are encouraged to center on the children, upholding gender, ethnic, and cultural equality. Education and care service institutions and the government, society, families, and young children themselves form a common operating system.

The stakeholders (as mentioned above) influence each other as the complexity of the operation of social systems. In addition to the time-postpone characteristics of the interactions, they perform mostly nonlinear. Thus, the relationship among them is suitable for proceeding with the observation with the system dynamics perspective. In thinking so, in this study, we first started by constructing the theoretical model. We then ran the empirical simulation test using the database available from the Department of Household Registration of Ministry of the Interior, and simultaneously we conducted the consistency check on the relevant dynamic trends. Further, we implemented a system model test, verifying the reliability and validity of the proposed model structure, model sensitivity, and model behavior. In the final phase of the study, we proceeded with the policy simulation analysis.

2. Theoretical Backgrounds and Underpinnings

2.1 Low Birth Rate and Aged Society

According to a national profile published by the Ministry of the Interior in February 2020, Taiwan had a total population of 23.6 million by the end of 2019 and a population density of 652 people per square kilometer. Such statistics make Taiwan second worldwide in density (per 10 million people). As the population under 15 years of age continues to decline, the rate of the elderly population (over 65 years old) is increasing [2]. The population estimate (2018-2065) reports that the total population of Taiwan will reach its peak in 2021, after which it will show a downward trend [15].

Besides, according to the Ministry of the Interior's demographic data from 1958 to 2019, Taiwan has a year-on-year birth rate decline, calculated per 1,000 births per year with the average live births per 1,000 women of childbearing age (15-49 years old). The birth rate even dropped to 7.53% in 2019. In addition, Taiwan has a year-on-year upward death rate trend in terms of the number of deaths per thousand people per year, and simultaneously the death rate may exceed the fertility rate in the future (Figure 1).

Past research, whether it is a prediction with the ARIMA model or a natural population projection, suggests the coming shortage of the young-to-middle-aged population. As a result, the population aging index rises and affects the population structure. Policymaking is thus substantially needed to respond to the declining birth-rate and aging population structure [1]. At the same time, problems with the decreases in the supply of preschool young children will affect the demand for kindergartens [1,3,4,5]. That is, early childhood education will be limited by the reduction of the preschool children, which in turn leads to a reduction in the number of kindergarten classes, and consequently, makes it difficult for kindergarten to operate [6].

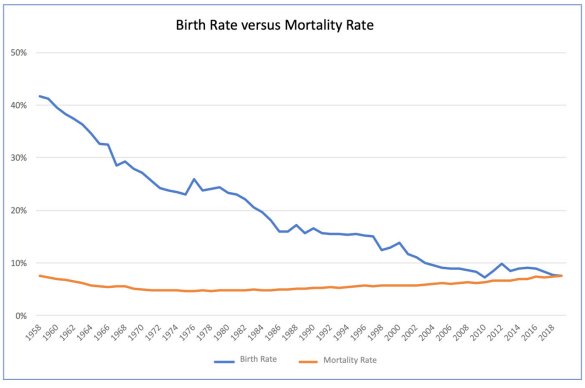

Figure 1. Comparison of birth rate and mortality rate (Source: the Department of Household Registration, Ministry of the Interior, Taiwan)

2.2 Early Childhood Education and Care System

Taiwan's early childhood education system was inherit-

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ed from China's early childhood education system and has been influenced by Western education, Japanese education, and Taiwan's early reform of early childhood education. This study refers to the classification of Duan[7] and Weng[8], and categorizes the development of Taiwan's early childhood education system into the following stages:

(1) Stage I (1911 to 1947): In 1904, the name "Meng Yang Yuan" was used to represent early childhood education. Later, the name "kindergarten" appeared in 1922. The services of nurseries were initially established for those families engaging in agriculture and farming in Taitung County. In this period, preschool education was considered as it is in the initial development.

(2) Stage II (1949 to 1981): In 1970, Taiwan's preschools were generally set up with the forms of primary schools with kindergarten classes, independent kindergartens, normal schools with kindergartens, and rural nurseries. The government promoted the Early Childhood Education Act in 1981 to build a preschool system. In this period, due to rapid population growth, a general shortage of public kindergartens resulted in the formation of many private kindergartens.

(3) Stage III (1981 to 2010): Due to the transformation of agricultural society and the development of industry and commerce, parents came to value preschool education under the age of 6 years, and policies were successively promoted including "Guidelines for Registration, Verification and Selection of Kindergarten Principals and Teachers," "Implementation Points for Evaluation of Taiwan Provincial Public and Private Kindergartens," and the "Kindergarten Equipment Standards." In 1987, the "10-year Development Plan for Early Childhood Education" was implemented to strengthen the evaluation of kindergartens. In 2010, the schooling of 5-year-old children was regarded as quasi-compulsory education, and the functions of kindergartens and nurseries were integrated into the larger education system. In 2006, a draft of the "Early Childhood Education and Care Act" was completed. The types of early childhood education services included childcare centers, kindergartens, home-based care services, after-school care centers, and community-based mutual help education and care services.

(4) Recently (after 2010): In order to enable young children to receive proper education and enjoy the right to be cared for, the government revised the "Early Childhood Education and Care Act" in 2018 to integrate the three original types of institutions - childcare, baby care, and young child care, gradually opening the "child care integration" model of early childhood education.

To improve the early childhood education and care system, the government passed the "Early Childhood Education and Care Act" and "Standards for Kindergartens and Classes, Basic Facilities and Equipment" in 2011 and 2019, respectively. By these acts, kindergartens and nursery schools were integrated into a single kindergarten education system (with young preschool children between the ages of 2 and 6 years old as the primary recruitment targets). According to the regulation "Kindergarten Evaluation Measures," all kindergartens are required to receive necessary evaluations for their education and care activities and courses, and safety management once every five years. This evaluation is to protect the young children's rights and interests in education and ensure that the kindergartens continue to comply with the relevant provisions of the law. According to the abovementioned decrees and referring to Chien [9], this study, categorizes Taiwan's early childhood education and care service institutions into four types, as follows:

(1) Public kindergartens: The kindergartens are established by the government and public schools. Public kindergartens are operated by public authorities and employ qualified education and care staff to implement multi-curricular education and care services.

(2) Private kindergartens: The kindergartens set up by private sectors or institutions use commercial (for-profit) management and hire qualified education and care staff to implement early childhood education and care services.

(3) Non-profit kindergartens: This type of kindergartens is approved and provided free venues by the governments to establish to support public welfare, such as supporting the disadvantaged and promoting the healthy growth of young children. These kindergartens are advantaged by non-profit-based charging standards and more flexible operation time than private kindergartens.

(4) Quasi-public kindergartens: In 2018, the government promoted the quasi-public education and care service policy to encourage private kindergartens to transform to the quasi-public kindergartens. The purpose of this policy is to provide affordable early childhood education and care services to the public, primarily by offering subsidies to the private kindergartens to ensure the salaries of teachers and caregivers.

The Taiwanese government also regulates the establishment of educational service agencies to a considerable extent. Education and care service agencies should have persons in charge and employ principals, teachers, caregivers, and assistant caregivers; implement class placement setting according to the age of young children and "Standards for Kindergartens and Classes, Basic

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Facilities and Equipment"; provide a healthy diet and health care safety education; focus on personality development and interpersonal interaction; cultivate essential living ability and habits; and promote learning and other services. Besides, education and care service personnel must meet the relevant qualifications according to the "Educational and Care Service Staff Regulations."

(1) Kindergarten principals: They are qualified as kindergarten teachers or caregivers and have served in the associated institutions for more than five years. They must have received and completed professional training early childhood education and care in a junior college or higher, or those educational institutions entrusted by the competent authorities of municipalities and counties (cities).

(2) Kindergarten teachers: They should be qualified through completing 26-credit professional courses for kindergarten teachers and a 6-month kindergarten internship course in universities. Besides, they must pass the qualification test hold by the Ministry of Education.

(3) Caregivers: They have received the diploma majored in kindergarten education and care professionals from a junior college or higher.

(4) Assistant caregivers: They need to receive a diploma majored in early childhood care from a domestic senior secondary school.

The Taiwanese government also clearly regulates the class placement mechanism of education and care service institutions. According to Article 18 of the "Education and Care Service Personnel Regulations," children over the age of 2 and under 3 years old constitute the toddler class, the number of children in a toddler class is limited to 16 children and these children must not be mixed with children of other ages. Each class of young children from 3 years old to school age (divided into the beginner class (K1), junior class (K2), and senior class (K3) in the order of age) is limited to 30 children. The K3 class is staffed with one kindergarten teacher; the K2 class is staffed with one caregiver (one more caregiver will be staffed if the number of children in a class exceeds nine); the K1 class is staffed with one caregiver (one more caregiver will be staffed if the number of children in a class exceeds sixteen); and the toddler class is staffed with one caregiver (one more caregiver will be staffed if the number of children in a class exceeds eight). Assistant caregivers must not exceed one-third of the school's caregiver staff.

3. Methodologies

3.1 System Dynamics

System dynamics defines a system as an entity that contains interconnected things or elements, such as parts, components, components, or sub-systems. Each element interacts with the others through specific behaviors, and the overall structure of the system should have the characteristics of being hierarchical and self-organized. When external forces impact the system, the operations of the system change, but then the system will further be getting stabilized. In practice, when system dynamics are applied for society or organizations, it can help policymakers or managers understand the dynamic trends of system changes [10].

Jay W. Forrester proposed the system dynamics perspective in the 1960s[11]. A system dynamics model is built through the causal relationship between system operations to form a circular feedback loop. The circular feedback loop can be converted into a series of systematical variables, such as product quantity, rate quantity, and relationship symbols. Researchers can thus test, through computer simulations, the system dynamics model and predict the system's changes for then long-term, periodical, nonlinear, dynamic, and complex issues [12].

This study focused on early childhood education, making the joint responsibility of various stakeholders as the structural basis of the proposed model. In promoting early childhood education and care services, kindergartens have formed complex and mutually-affecting stakeholder structures with the government, society, families, education and care service personnel, and even other education and care service organizations. In addition, the class placement of kindergartens has the characteristics of time lag for different ages of young children. Based on the above, this study holds that the use of system dynamics methods is appropriate and reflects the dynamic trends of practical operations on this topic.

3.2 Data Adopted

In this study, we collected the demographic data from the website of Taiwan's Department of Household Registration (DOHR), Ministry of the Interior (MOI). DOHR is mainly responsible for records of household registration, nationality, household, and population. The data that is open to the public to a certain extent is widely used by academics and other governmental institutions to explore related research on housing, education, low birth rate, and population forecasting.

The demographic data involved and used in the dynamic simulation analysis of this study include the national birth rate and estimated birth rate (1989-2019), the fertility rate of women of childbearing age in counties and cities (2007-2018), the number of townships, villages, neighborhoods, households, and people (1997-2019),

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the sex ratio in households (1997-2019), and the number of deaths (by gender and estimated mortality rate, 1994-2019). This study combined the data sets to calculate the total number of children born each year and the number of young children who can attend the toddler, K1, K2, and K3 classes in kindergartens.

3.3 Model Construction and Simulation Design

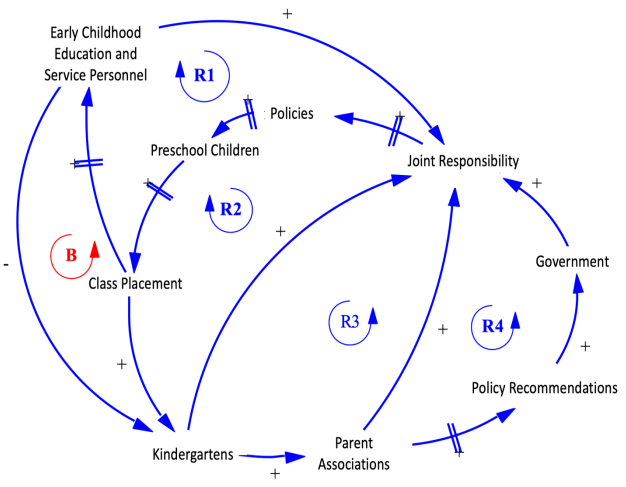

Figure 2. The System Dynamics Model of Taiwan's Early Childhood Education System

In this study, the relevant policies, regulations, and literature were incorporated to extend to the stakeholder structure to build the system dynamics model for early childhood education. Based on the core hypothesis of the empirical simulation of this study - "the growth of the number of young children enrolled in kindergartens increases the number of classes in kindergarten (preschool children → class placement (with time delay))" (Figure 2) - we presumed five major causal relationship loops: (1) the causal relationship loop between education and care service staff and joint responsibility; (2) the causal relationship loop between kindergartens and joint responsibility; (3) the causal relationship loop between parent associations and joint responsibility; (4) the causal relationship loop between the government and joint responsibility, and (5) the causal relationship between education and care service personnel and kindergartens. Among them, the former four causal relationship loops are considered as reinforcing (positive) feedback loops, marked as "R"; the last causal relationship loop is a balancing (negative) feedback loop, labeled as "B" (Figure 2). In addition, this study used Vensim DSS (simulation software) to conduct the empirical simulation test for these causal relationship loops. For the definitions of the elements (variables) involved in the proposed model and the relevant literature, please refer to Table 1.

Table 1. Variable Definitions

Variables and Definitions	Sources/Acts/Literature
Government: the competent unit of the education and care institution **Policies**: Education and care policy and the formulation **Joint responsibility**: the government provides care education together with the education and care institutions and families **Education and care service personnel**: the principal, teachers, caregivers and assistant caregivers who provide education and care services	Article 7 of the Early Childhood Education and Care Act
Preschool Children: Number of young children over 2 years old but under 6 years old. **Kindergartens**: provide early childhood education and care services	Article 3 of the Early Childhood Education and Care Act
Class Placement: the education and care service staff are equipped based on young children's age and number	1. Article 8 of the Early Childhood Education and Care Act 2. Standards for Kindergartens and Classes, Basic Facilities and Equipment
Parent Associations: the association built by the parents in each kindergarten	Article 30 of the Early Childhood Education and Care Act
Policy Recommendations: provide timely advice on improving education and care services	Article 31 of the Early Childhood Education and Care Act

The causal relationship loop between education and care service personnel and joint responsibility (labeled R1 in Figure 2) is built according to Article 7 of the "Early Childhood Education and Care Act." This article notes that the direction and promotion of education and care services development is the joint responsibility of education and care service personnel, involving principals, kindergarten teachers, caregivers, etc. They shall jointly promote the implementation of education and care policies.

Before entering kindergarten, children are placed in different age groups to distinguish between the toddler, K1, K2, and K3 classes. The number of students in each class affects the benchmarking of the education and care service personnel staffing (according to Article 16 of the same Act mentioned above). The maximum number of children of the toddler class is 16 at most, with one caregiver assigned to every eight young children. The number of children in each K1 class and K2 is 30 at most, and one caregiver is assigned to every 15 children. The number of children in each K3 class is 30 at most, and each class is staffed with one caregiver and one kindergarten teacher.

Based on the core hypothesis of the empirical simulation of this study "the growth of the number of young children enrolled in the kindergarten increases the number of classes in kindergartens (preschool children → class placement (positive and with time delay characteristics))," we presumed that the number of education and care service

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personnel needed would increase (class placement → education and care service personnel (with time delay)). Then, the "joint responsibility" that the education and care service personnel bear should increase accordingly (education and care service personnel → joint responsibility). Early childhood education "policy" suggestions and formulations, in response to the increase in joint responsibility, would gradually take shape (joint responsibility → policy). Further, the formulation of sound policies would have a positive impact on the growth of "preschool children" enrollment (policy → preschool children (with time delay characteristics)). In sum, this loop cycle forms a reinforcing causal relationship loop as the increasing joint responsibility of education and care service personnel (due to the increases of the education and care service personnel).

Like the R1 loop, the causal relationship loop between kindergartens and joint responsibility (labeled R2 in Figure 2) is built based on Article 7 of the Early Childhood Education and Care Act. Where it demonstrates that Kindergartens must bear joint responsibility for the promotion and implementation of early childhood education and services. In a general investigation on the management of kindergartens, more classes in a kindergarten represent the greater expansion of the scale of kindergarten operations. Such increases reflect the performance growth of a kindergarten.

Based on the core hypothesis (preschool children → placement (positive with time delay)), we presumed that an increase in the number of classes has a positive impact on a kindergarten's performance (class placement → kindergarten) when considering economic scale expansion. Because of such development, the "joint responsibility" that a kindergarten should bear would then be affected positively (kindergarten → joint responsibility). To sum up, this causal nexus shapes up a reinforcing causal relationship loop as the increases of joint responsibility of kindergartens (see R2 loop in Figure 2).

This study develops the causal relationship loop between parent associations and joint responsibility in the proposed model (labeled R3 in Figure 2) based on the "Child Care Education and Care Act." In this Act, Article 30 regulates that kindergartens need to set up a parent association. To explore the parents' or parent associations' responsibility, we referred to Article 11 of such Act. It clearly states that the parents (or the family) have considerable responsibilities in taking care of the child's physical and mental health[①]. Accordingly, the purpose of setting up the parent association in kindergartens is to supervise and require the government (for the improvement of education and care policies) and kindergartens (for implementing education and care services per regulations) to improve the quality of preschool education and care services. Therefore, when more kindergartens are set up (or the scale of kindergarten operations increases), the number of parent associations (or the size of the parent association) would increase. The parent associations' joint responsibility for early childhood education would also increase.

As far as the construction of the R3 loop is concerned, the R2 loop (increasing the number of kindergartens or the scale of operations) would be considered as the basis. When the scale of kindergartens is larger, the number or size of parent associations will increase immediately (kindergarten → parent association), and the joint responsibility of the parent associations would be higher (parent association → joint responsibility). The system further affects the change of the joint responsibility sharing structure of the stakeholders and affect the basis for the implementation of education and care policies (needs further improvement) (joint responsibility → education and care policy). Finally, the causal loop enters into the causal nexus with preschool children, class placement, and kindergartens. Overall, the R3 loop forms a reinforcing relationship loop in light of the increases in parent associations' joint responsibility for early childhood education.

This study identifies the causal relationship loop between the government and joint responsibility (labeled R4 in Figure 2) by referring to Article 7 of the "Early Childhood Education and Care Act." This article emphasizes that the government is responsible for formulating education and care policies and supervising early childhood education institutions to ensure that preschool children can be well educated and cared for.

To develop the R4 loop, the R3 loop is treated as the basic presumption. One of the functions of the kindergarten parent association is to make suggestions to the government on the governance of early childhood education (parent association → education and care policy recommendations). Recommendations can be about the diversity of education and care services, the practicality of education, and the richness of the curriculum. A parent association can also require the government to provide the kindergarten evaluation report, and promote and supervise the joint responsibility of the government. Therefore, the "joint responsibility" that the government should bear will increase accordingly (government → joint responsibility). Further, in response to the increase in joint responsibility, the government's effectiveness in improving early childhood education policy and governance will also gradually

① Such as developing good habits, life experience, and ethics; cultivating group habits; expanding aesthetic experiences; developing creative thinking; constructing cultural identity; and providing an enlightening, caring environment

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increase (joint responsibility → education and care policy (with time delay)). Just as it is in the development of the R3 loop, the R4 loop enters into the causal nexus of preschool children, class placement, and kindergartens. Overall, the R4 loop forms a reinforcing causal relationship loop according to the increases of the joint responsibility of the government.

The causal relationship loop between education and care service personnel and kindergartens (labeled B in Figure 2) is developed primarily based on Article 6 of the "Education and Care Service Personnel Regulations." In this article, the qualification of caregivers, teachers, and other staff are regulated. With such employment standards, the employment of education and care service personnel in terms of both quality and quantity, reflecting the operational cost, has a certain degree of pressure on kindergartens (i.e., costs in salary, personnel management and training, insurance for health and safety cover, and so on). That is, more preschool children enroll, the more education and care service staff are needed, and hence the more marginal cost generates in kindergartens. Therefore, the B loop demonstrates its feature of the balancing causality in the whole model that this study proposes.

With the core hypothesis in heart (as mentioned above: preschool children → class placement) for developing the B loop, this study presumes that the rise in the number of class placement has a positive impact on "education and care service personnel" in kindergartens (class placement → education and care service personnel (positive with time delay)), which in turn has a negative impact on kindergartens in operational performance (education and care service personnel → kindergarten). Finally, the B loop enters the causal paths of the joint responsibility of the kindergarten, the parent association, and the government. In sum, the B loop forms a balancing causal relationship loop for the whole proposed model in this study as considering the potentially negative impact of the education and care service personnel on kindergartens.

3.4 Simulation Reliability and Validity

In addition to constructing the model through the study of relevant early childhood education policies and literature, this study followed the testing and validation methods for system dynamics models proposed by Forrester[11,12], Barlas[13], and Sterman[14] for the tests of reliability and validity of the proposed model. This study arranged the test steps as follows:

First, the data that this study collected from the DOHR was used for the empirical simulations and consistency check with the historical trend. Second, tests for the model's structure, sensitivity, behavior, and reliability and validity were conducted. Finally, based on Taiwan's birth rate growth from 2015 to 2019 and the birth rate and the total population in 2019, this study carried out the policy simulation analysis for the next 20 years.

4. Results

4.1 The Tests of the Simulation Model

Table 2. Variable Parameters Used in Empirical Simulation Tests

Variable	Value (unit)	Definition	Sources/Acts/Literature
Birth rate	7.42% (2019)	Newborn population per 1,000 people (person/year)	Department of Household Registration
Total population	23,603,121 (2019)		Department of Household Registration
Toddlers		Toddlers who are younger than 2 years old	Department of Household Registration
Toddler enrolling age	2 (years)	Toddlers who are 2 years old	Article 16 of the Early Childhood Education and Care Act
K1 class enrolling age	1 (1 year)	Toddlers who are 3 years old	Article 16 of the Early Childhood Education and Care Act
K2 class enrolling age	1 year)	Toddlers who are 4 years old	Article 16 of the Early Childhood Education and Care Act
K3 class enrolling age	1 year)	Toddlers who are 5 years old	Article 16 of the Early Childhood Education and Care Act
Toddler enrollment	(Person/ year)	Total number of toddler class students	Article 16 of the Early Childhood Education and Care Act
K1 enrollment	(Person/ year)	Total number of K1 students	Article 16 of the Early Childhood Education and Care Act
K2 enrollment	(Person/ year)	Total number of K2 students	Article 16 of the Early Childhood Education and Care Act
K3 enrollment	(Person/ year)	Total number of K3 students	Article 16 of the Early Childhood Education and Care Act
Elementary enrollment	180,656	Number of births in 2018	Department of Household Registration
Toddler students	207,600	Number of births in 2018	Department of Household Registration
K1 students	213,093	Number of births in 2018	Department of Household Registration
K2 students	211,399	Number of births in 2018	Department of Household Registration
K3 students	194,939	Number of births in 2018	Department of Household Registration

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The simulation model was built based on the core hypothesis that the growth in the number of young children enrolled in kindergartens increases the number of classes in kindergartens. In designing the simulation model, this study used Taiwan's birth rate and population as the inputs, age as the rate, the student number of the toddler, K1, K2, and K3 classes as the levels, and enrolling student number to the primary school as the output (Figure 3).

The variables used in the simulation model with their definitions, test units, and references are listed in Table2. The settings of the simulation model that are based on the relevant literature reflect the real conditions in Taiwan's education and care service system. Besides, this study used Vensim DSS software to check the model logics. The results showed that the simulation model is validated with its structure and semantic equations.

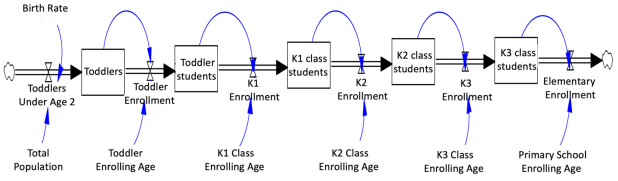

Figure 3. The System Dynamics Flow Diagram of the Early Childhood Education System

The model sensitivity evaluation is to test whether the simulation model's stability when the parameters involved in the model change. This study conducted 500 times of structural sensitivity test and actual parameter sensitivity test on the simulation model, respectively. The results that present a high degree of the convergence in both of the tests show that the simulation model designed in this study has high stability and is insensitive to the changes in parameters within the value ranges of the tests, hence confirming the model's simulation validity (Figure 4 for structural sensitivity test and Figure 5 for actual parameter sensitivity test).

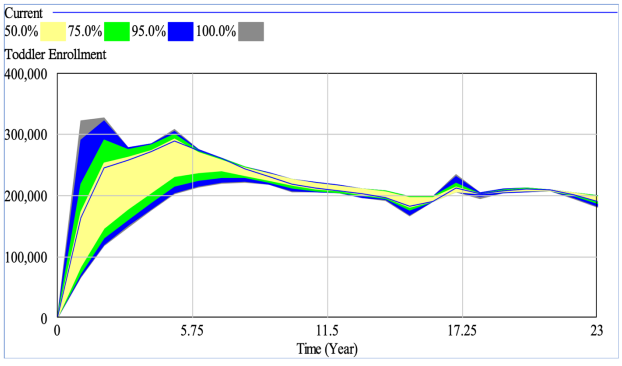

Figure 4. Model Structure Sensitivity Test (Vensim DSS)

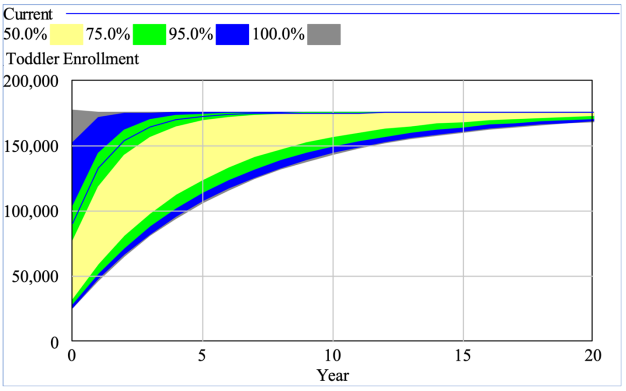

Figure 5. Model Structure Sensitivity Test with Actual Values (by Vensim DSS)

For the model behavior test, the data of the birth rate and total population (1992 to 2019) was used. This study conducted a comparison between the real behavior and the simulations for the student number of the K3 to toddler classes from 1992 to 2019. The results (Figure 6) show that the model presents a similar behavior trend with real and simulation data. Hence, the model can be used to forecast the potential trend of the enrollment of preschool students in Taiwan's kindergarten education system.

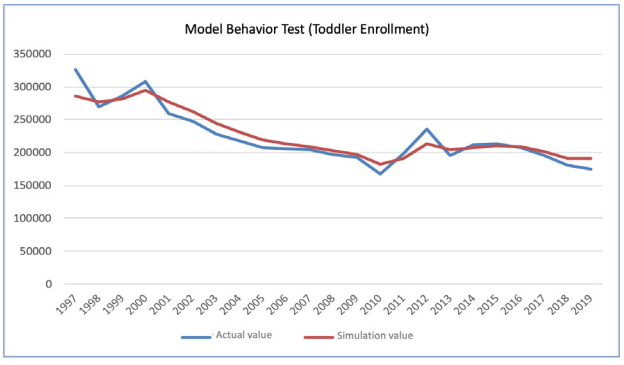

Figure 6. Model Behavior Test (by Vensim DSS)

4.2 Policy Simulation

The data for the implementation of the policy simulation in this study was the growth rate of Taiwan's total population in the past 22 years (1997 to 2019). The highest population growth rate was 0.8% in 1997 and 1999; the second highest was 0.4% with 6 occurrences in 2002, 2003, 2004, 2006, 2008, and 2011; the third-highest 0.2% happened 4 times in 2009, 2012, 2014, and 2015. Finally, the lowest of the population growth rate at 0.1% in 2016, 2017, and 2018.

Based on this historical information, this study designed the "policy1 simulation" proceeding with three growth rates of the population. These were high-growth at 0.4%, medium at 0.2% and low-growth at 0.1%. For

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the analytical settings of "policy simulation 2", this study referred to the population estimation for Taiwan within 2018 and 2065 [15]. Taking Taiwan's birth rate of 7.42% in 2019 as the basis, this study carried out the simulations with high-estimation (with a birth rate increase by 1.5%), mid-estimation (with a birth rate increase by 1.2%), and low-estimation (with a birth rate increase by 0.9%) for up to 20 years.

The policy1 simulation was to forecast the growth of the enrolling numbers of preschool children in the toddler, K1, K2, and K3 classes of kindergartens by assuming Taiwan's birth rate remaining unchanged as it in 2019. This study proceeded with the simulation analyses under the conditions that the total population of Taiwan increases by +0.4% (total increase = 94,412), +0.2% (total increase = 472,062) and +0.1% (total increase = 23,603), respectively. The simulation results (Figure 7) show that while the student numbers of each class almost have no significant change for up to 20 years, the changing trend of the student enrollment in each class has different and significant time lags as the limitation of the enrolling age for each class.

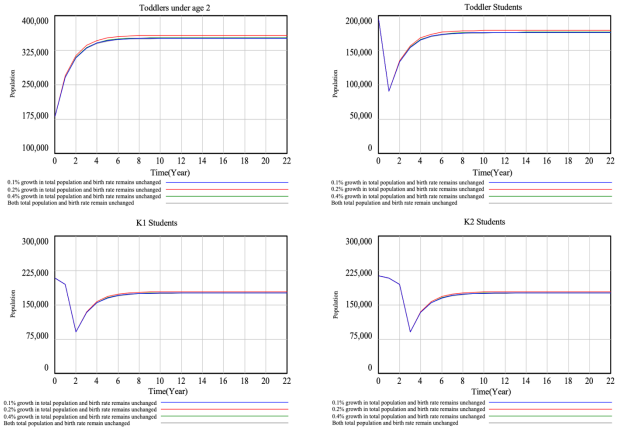

Figure 7. Policy1 Simulation

By assuming that Taiwan's total population remains unchanged, the policy2 simulation carried out for the prediction of the growth of the enrolling numbers of preschool children in the toddler, K1, K2, and K3 classes of kindergartens. With the simulation settings: the birth rate in high growth +1.5% (the birth rate = 8.92%), the medium growth +1.2% (the birth rate = 8.62%), and low growth +0.9% (the birth rate = 8.32%), this study proceeded with the simulations. The results show the number of young children in toddler, K1, and K2 classes will all increase to a significant extent in light of the growing trend of the birth rate (Figure 8).

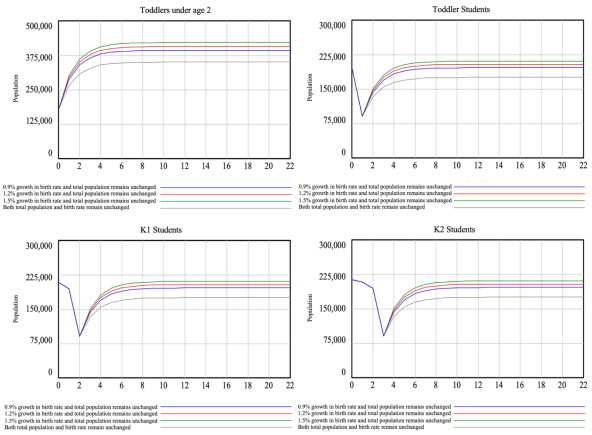

Figure 8. Policy2 Simulation

5. Discussions and Conclusions

With the heart in preschool children with the associated stakeholder structure, the research has developed the model to investigate the system dynamics of preschool education in Taiwan. We have identified five causal loops in this model, including (1) the causal loop linking the education-and-care-service staff and the joint responsibility; (2) the causal loop involving the kindergartens and the joint responsibility; (3) the causal loop connecting the parent councils and the joint responsibility; (4) the causal loop connecting the governments and the joint responsibility; and (5) the causal loop connecting the education-and-care-service staff and the kindergartens.

To examine this model, simultaneously, the research proceeded with the twenty-year-long (from 2019) empirical simulation test with a focus on how the population growth of young children influences the increases of kindergartens' class size in Taiwan. Under the premising condition that the birth rate remains unchanged, the test results showed that the trends of student numbers in either the toddler, K1, K2 or K3 class levels of kindergartens would be increasing. The class numbers would thus be rising while having a postponing effect due to the different enrolling ages for each level. Such simulation results support the hypothesized system dynamics model of the preschool education this study proposed.

Another important finding of this study is what we identified for stakeholders' joint responsibilities according to the preschool children. These stakeholders are the education-and-care service staff, kindergartens, parent councils, and governments. As presented in our proposed model, we have realized that one changing trend of the policies relating to the care services and preschool education for young children lies in how the changes and the interactions of the responsibilities for early childhood

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among these stakeholders. For example, in light of the birth rate decline, Taiwan's governments amended the "Early Childhood Education and Care Act" in 2010 and 2019, respectively. In addition to neutralizing the birth rate declination, the valid promotion of this act bursts the increases of the students in the preschool education system. Such influence, furthermore, benefits kindergartens' improvement in both education and care services, as well as the performance growth in business operations.

The system dynamics model and associated findings of this study are consistent with the recent amendment and promotion of the regulations or acts for promoting birth rate and early childhood education and care in Taiwan (since 2016). These include that for "the health and safety of young children," "the friendly environment for childbirth and care," "childcare allowance," "job retention for childcare," and "the quasi-public mechanism for early childhood education." Per our system dynamics model, these regulations would be understood as the changes resulted from the interactions of the responsibilities among the stakeholders according to early childhood education and care services.

Our initial view with the system dynamics approach to the nexus among early childhood education and the associated stakeholders has several implications. Our model provides a systematical understanding with a macro view for early childhood education. One contribution of this study thus falls on proposing the potential directions of policy innovation and making for Taiwan's early childhood education, namely the stakeholder structure and the changing trend of the joint responsibilities associated with this structure. Still, the research has only little efforts on the exploration of the micro insights with the associated system dynamics. Therefore, future research may benefit from the investigation of the micro-foundations and the related system dynamics for the interactions among the stakeholders according to early childhood affairs.

In addition, the causal balancing loop that connects the education-and-care service staff and the kindergartens has been identified. In practice, this causal loop presents that the education-and-care service staff is one critical cost constraint for kindergartens' operations. Education-and-care service staff is the major personnel marginal cost in kindergartens. Although the governments can assist kindergartens in improving the operational performance, the marginal cost incurred by the education-and-care service staff significantly limits the kindergarten's growth in economic scales. The present finding suggests that the managers of kindergartens (exceptionally private schools) should understand their best economies of scale (i.e., the number of classes opened, the quality of education and care service provided, and the personnel management), to obtain the optimized performance in the business activities.

For the policymakers, one part of the present findings, which were derived from the empirical simulations, relates to the importance of promoting the birth rate in Taiwan. As we proposed and tested, our model can work for the investigation on the system dynamics of Taiwan's early childhood education, only insofar as the birth rate remains in a positive trend. That is, the birth rate is the core for driving the development of childhood education. Consequently, our findings provide insights as to how policymakers can become keen concerned about the low birth rate and simultaneously remedy the situation. Furthermore, another implication for the governments relates to the stakeholders' joint responsibilities. This joint responsibility factor plays the hub role in connecting all of the stakeholders and forming up the reinforcing causal nexus in our proposed model. The changing trend of and the interactions among the stakeholders can be referred to as an antecedent to foresee the potential dynamics in early childhood educational affairs. In so doing, policymakers can timely and properly recalibrate or amend the relevant policies.

Finally, the proposed model was built especially for Taiwan's early childhood education and care services. Still, this study suggests that the model has strong potentials to be a reference for the countries or areas for their early childhood education, if they have similar education system with Taiwan and simultaneously they are facing to the threat of the low birth rate.

In conclusion, this study aims at developing a system dynamics model for Taiwan's early childhood education and care services. The proposed model explores the causal structure of the stakeholders according to the preschool children. In the meantime, we also elaborate on the joint responsibility factor for its central role in shaping the causal reinforcing loops among the associated stakeholders. This study proceeds a twenty-year-long simulation test. The evidence supports the expositions developed by this study.

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REVIEW

Research on the Application of Blockchain Technology in the Financial Field from the Perspective of The Belt and Road Initiative

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ABSTRACT

With the continuous deepening of The Belt and Road Initiative development strategy in China, blockchain technology has been more and more widely applied in the financial field. In recent years, the overall operation situation of China's financial sector is stable. However, with the reform of the economic system and the innovation of the financial sector, there are still many problems in China's financial sector that need to be improved. With its application advantages, blockchain technology has solved many problems in the financial field. This paper analyses and discusses the application of blockchain technology in the financial field from the perspective of "The Belt and Road Initiative".

1. Introduction

In recent years, the role of blockchain technology in the financial field has attracted more and more attention and has become a key topic in the international financial field. Countries have studied the application of blockchain technology in the financial field to better promote the development of the financial industry. Bitcoin is generally regarded as the first practical application of blockchain technology. Nowadays, both domestic and overseas are studying how to better apply various technical solutions of blockchain technology to the financial field, to improve the efficiency of financial transactions, standardize financial business transactions, reduce transaction risks, and ensure the security and reliability of data in the financial industry.

2. Existing Problems in China's Financial Sector and the Advantages of Applying Blockchain Technology

2.1 Current Problems in China's Financial Sector

Although in recent years, with the improvement of science and technology, China's financial industry has made great progress and development. However, compared with the financial service level of western developed countries, the development level of China's financial service industry is still at a relatively backward level in the world. Especially in the financial field of market competition and market development capacity, financial business infrastructure construction, and industry innovation capacity, there are still very big gaps [1]. On the

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whole, the problems existing in the current stage of China's financial sector are mainly reflected in the following aspects: first, China's financial service industry lacks market competitiveness and is unable to provide various financial service products that meet the needs of China's economic development. The transaction scale is small, the ratio of non-performing assets in Banks is high, and the debt situation of the securities industry is serious, resulting in serious losses in the securities industry in recent years. Secondly, the business innovation ability of China's financial sector is insufficient. Some foreign financial institutions have an absolute advantage in the business innovation of the financial sector. Compared with the financial instruments provided by China's financial sector, there are a variety of foreign financial instruments, which can meet the requirements of customers in various aspects of financial services. Besides, the ability to develop new financial products in China's financial sector lags far behind that of foreign financial institutions. This is mainly due to the low technical level of the development of new financial business in China, the low degree of electronicalization, and the relative shortage of professional talents, which leads to the low capacity of independent innovation. As a result, the variety of financial instruments in China's financial sector is relatively monotonous and it is unable to provide customers with more comprehensive and high-level financial services. Third, China's financial sector of the relevant infrastructure construction level is relatively low, industry regulatory capacity falls off [2]. To achieve long-term development of the financial sector, it is necessary to have modern communication technologies, computer network technologies and other infrastructure facilities to support it and to use scientific laws and regulations to provide institutional guarantee for new businesses and new tools of the financial sector. However, China's financial industry infrastructure construction capacity is insufficient, the relevant system construction is not standardized, the legislation lags behind serious problems, unable to carry out orderly supervision of the financial industry. Finally, the ability of Chinese financial institutions to carry out transnational business is relatively low. All but the highest-ranked Chinese Banks are in the early stages of expanding their overseas operations, and many foreign Banks already have branches around the world. China's banking financial business is still dominated by deposit and loan business, while foreign Banks have focused on some new financial derivatives. Therefore, financial innovation means can be better utilized to obtain greater economies of scale, and industry risks can be better avoided. Thus, it can be seen that the overall development level of China's financial sector is relatively low. Also, in recent years, the financial industry suffered serious losses, the growth rate of the whole industry was slow, and the development of the internal financial industry structure was very uncoordinated. Compared with some developed countries, the support rate of China's financial industry for China's overall economic growth is relatively low. It is precise because of the imbalance in the development of the internal structure of the financial industry (mainly reflected in China's financial sector dominated by the banking sector, while other securities and insurance financial services occupy a small proportion) that the development strength of China's financial industry is seriously insufficient and its competitiveness in the international financial market is insufficient [3]. Besides, the regional development of China's financial sector also presents an uncoordinated situation, and it is difficult for China's rural financial services to meet the needs of economic development in rural areas at this stage.

2.2 Advantages of Applying Blockchain Technology in the Financial Field

At present, blockchain technology is widely used in many industries, including the financial application of digital currency and other industries, and the application of blockchain in the financial field can be said to have its inherent advantages. Blockchain technology has many advantages such as decentralization, a high degree of security, strong traceability, and openness and transparency. Therefore, it can solve a variety of related problems in the financial field, such as credit investigation service, supervision level, and efficiency, as well as trade transactions [4]. The practice has proved that blockchain technology is an effective technology to solve many problems in the financial industry. Thus, the application of license technology in the financial field is conducive to the industry's innovation of service concepts and awareness, and makes the financial service industry closer to people's production and life, increasing the contribution of the financial industry to China's real economy. Under the general trend of China's economic restructuring, the application of blockchain technology can optimize the internal structure of China's financial sector, to establish a more perfect modern financial service system. Given the lack of legislation in the field of financial services in China, it is also conducive to the establishment of sound laws and regulations in the field of financial services and the continuous improvement of the regulatory system, to better cope with and prevent various financial risks and improve the security of China's financial industry.

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Finally, the application of blockchain technology in the financial industry can well solve the problem of unbalanced regional development of China's financial services industry and improve the level of China's rural financial services. Besides, it provides more new tools for China's financial industry to meet the requirements for further allocation of resources of the financial service industry under the requirements of the financial system reform, promotes the rational flow of China's financial resources, and improves the quality and efficiency of China's financial service industry. In the future, the financial sector will undergo further changes due to blockchain technology. This means that blockchain technology can well help the real financial economy to solve many coordination problems. For example, as far as the insurance industry is concerned, blockchain technology can well prevent insurance fraud, guarantee enterprise benefits, and improve customer experience [5]. The current situation is the application of blockchain technology in the financial field is still in the experimental stage, and the development heat of blockchain technology is obvious to all. However, it has not been applied in the financial field on a large scale. In order to make blockchain technology more widely used in the financial field in the future, it is necessary to further develop blockchain technology in terms of technology application and security performance. China must establish a strong regulatory means, improve relevant laws and regulations, and strengthen technical exchanges to avoid many risks in the financial industry, to provide a better application environment for blockchain technology.

3. Key Points of Blockchain Technology Application in the Financial Field from the Perspective of "The Belt and Road Initiative"

3.1 Scientifically Understand the Defects of Blockchain Technology

At present, the application of blockchain technology in the financial field is still in the experimental stage. Although it has provided new ideas and good technical support for financial reform and innovation, and it has improved the innovation and development capacity of China's financial industry and solved many existing problems in China's financial sector. However, due to the technical defects of blockchain technology itself and its application advantages as a new emerging thing, there are still many deficiencies. Therefore, the application of blockchain technology in the financial field from the perspective of The Belt and Road Initiative must first scientifically recognize the defects of blockchain technology and optimize and improve the deficiencies of blockchain technology through continuous exploration and practical application [6]. As for the defects in blockchain technology, financial institutions need to continuously optimize their application performance and improve the security of their application environment. Current status, the data processing capacity of blockchain cannot meet the scale requirements and growth speed of many financial transactions. Therefore, to improve the efficiency of resource allocation and transaction speed in the financial sector, we must constantly explore innovative technological means. Financial institutions also need to constantly improve the security of transactions to prevent the emergence of security holes. The reason is that the application advantages of blockchain technology include the performance of open sharing. If financial institutions do not strengthen security measures, it may lead to the risk of some data leakage, resulting in the loss of customer privacy security is not guaranteed, which will bringing unpredictable losses. At present, China's research on blockchain technology is still in its infancy, so there are still many problems in its application in the financial industry. However, the integrated development of blockchain technology and financial innovation is the general trend. China needs to make continuous innovations in the technology and system of the financial industry, and expand the application of blockchain technology in more areas of the financial industry. Nowadays, blockchain technology has already had successful practice cases in the application of virtual currency (bitcoin), while it is still in the exploratory stage of experimental research in the field of the financial industry. Therefore, it is necessary to have a scientific understanding of the defects of blockchain technology, keep the spirit of exploration, promote the continuous development and maturity of blockchain technology, and strengthen the innovative integration of blockchain technology and the financial field.

3.2 Application of Block link Technology by Bank Credit Information System

As the scale of transactions in the financial sector continues to expand, cross-border transactions are bound to occur. At present, many commercial Banks in China have started to carry out transnational credit business, and transnational now involves a more important issue is the credit problem. Credit verification must be ensured before cross-border credit operations can be carried out [7]. Only by clarifying the credit status of the lending entity can the smooth development of credit transactions be effectively guaranteed. However, each country's

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cross-border credit business is not the same, and there are many differences in the credit collection system on which cross-border credit depends, so it is necessary to carry out systematic analysis on it. On the other hand, the credit verification work of the transnational credit business is more complex, involving several work links. In the process of multi-layer approval, it is easy to have problems such as low efficiency of data use and incomplete information. In addition, the complex work will lead to the high cost of credit verification. As a result, some data will likely be leaked or tampered with [8]. Under the background of The Belt and Road Initiative Strategy, the new business of transnational financial transactions must be carried out on the premise of a good credit investigation. With the application of blockchain technology, the optimization and adjustment of information records in China can be made more efficient and scientific, and the storage and application of a huge amount of information can be completed. The application of blockchain technology can improve the difficulty of data tampering, reduce the possibility of data tampering, and realize the sharing of customer credit information records, thus making this work more open and transparent. Thus, it not only simplifies the work process of credit investigation and verification but also reduces the cost of credit investigation and verification. At the same time, the credit investigation and verification work of transnational credit businesses are more systematic [9]. Under the background of The Belt and Road Initiative Strategy, cross-border credit investigation cooperation must be strengthened to carry out financial cooperation. Countries should jointly establish credit rating standards and realize automatic recording and storage of credit information based on blockchain technology. This will effectively prevent information leakage, data tampering, and other credit risks.

3.3 Application of Financial Regulation to Blockchain Technology

Under the background of The Belt and Road Initiative Strategy, the financial regulation of various countries faces huge challenges. In China, there are some problems in the supervision of the financial industry, such as imperfect system and incomplete implementation, which lead to a relatively low level of supervision. Although The Belt and Road Initiative Strategy has promoted the development of China's foreign economy, it has also accelerated the outflow of capital and the inflow of foreign capital, thus increasing the relevant financial risks [10]. In particular, in recent years, the blind growth of shadow Banks, underground Banks and other improper financial trading institutions will lead to the excessive expansion of credit. Without timely and effective supervision, it is likely to trigger a financial crisis that is difficult to control, bring a very negative impact on the development of China's real economy, and increase the instability of China's international financial market. The application of blockchain technology in financial supervision can digitize customer information, to guarantee the reliability of user identity information, and realize the traceability of user-related data in real-time, which greatly reduces the possibility of abnormal transactions such as shadow banking and underground Banks. To strengthen the financial supervision in China, to ensure the orderly and normative development of financial business. From the current experimental situation, blockchain technology can well ensure the convenience and security of financial transactions, promote the establishment of a more secure and fair international financial transaction system, and strengthen the financial cooperation between countries.

4. Conclusion

To sum up, the author makes a comprehensive analysis of it in this paper, hoping to give readers some inspiration. The application of blockchain in the financial field has a very broad prospect. Although it is still in the experimental stage, it still needs to be improved in terms of technology and security. However, in the future, with the continuous improvement and development of blockchain technology, it will be able to be applied to a larger scale in the financial field. In order to ensure that blockchain technology can better promote the development and progress of the financial industry, it is necessary to ensure a good application environment for it, constantly improving the awareness of service innovation in the industry, strengthening relevant financial legislation, and enhancing the regulatory capacity of the government.

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