Urban planning in the post-growth era: insights from World Bank indicators

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Abstract

In the current era of IPCC reports emphasising the urgency of shifting to a climate-resilient development paradigm, there is still a theoretical gap in understanding the interplay between economic growth and economic sustainability. This study proposes a new economic growth model based on an extensive analysis of 921 indicators from the World Bank database, which identifies two main categories of growth drivers: "economic model dynamics" accounting for 73.9% of influence, and "environmental forces for development" contributing the remaining 26.1% of influence. "Urban planning plays a key role in harnessing these drivers to adapt and optimise economic growth. We advocate an integrated approach that combines rigorous data analysis with visionary planning, aiming to promote an urban renaissance of sustainable and inclusive growth.

Keywords: urban planning, post-growth era , economic growth modelling, World Bank indicators, sustainable development

1 Introduction

On 20 March 2023, the United Nations Intergovernmental Panel on Climate Change (IPCC) released the Synthesis Report of the Sixth Assessment Report: Climate Change 2023, which highlights an era of urgency for a paradigm shift towards climate-resilient development. This is despite the notable attention the topic has received in contemporary policy discourse, particularly in relation to the use of large-scale data for strategic urban planning. However, there is still a theoretical gap in understanding the interplay between economic growth, climate change, social justice and economic sustainability .

Economic growth is the most intuitive embodiment of economic dynamics, since Adam Smith(Smith, 1776) has become the core topic of economic research; but from classical economics to modern economic growth theory, the source of wealth growth is attributed to the growth of specific material factors, although the theoretical construction paradigm is intuitively simple, but in the face of the economic growth process of different development backgrounds, a serious lack of theoretical explanation occurs. Although such a theoretical paradigm is intuitive and simple, it has serious theoretical inadequacies when facing the economic growth process in different development contexts. Therefore, this study will establish a theoretical framework for the growth-driving category of economic dynamics that is more in line with the objective reality of the world's development practice on the basis of the existing economic theory research, with the help of the complexity system science theory . Based on the research goal of analysing the category of economic growth drivers from the perspective of the complexity system, this study has the following three core questions: (1) What are the categories of economic growth drivers from the perspective of the complexity system? (2) What are the role characteristics of economic growth driver categories in generating economic dynamics? (3) What is the catalytic role of urban planning in driving these forces?

The development of economic theory reflects both the stage of development of human society and the progress of human cognitive ability. Although the theoretical system of modern economics is complex, it is still possible to find the theoretical starting point based on the research lineage. Based on Solow's growth model, the growth theory model Solow(Solow, 1956), which analyses the three elements of capital, population, and technology, has gradually been formed, data as well as information has become the ultimate development element(Wu Zhiqiang et al., 2021), and the element of economic dynamics identified based on the concepts of complexity systems science is a composite element, and the factor analysis method in the field of statistics is widely used in the study of various fields of the economy.

Throughout the research history of economic power elements, so far there is no unified conclusion, and with the development of science and technology, the connotation of power elements is also constantly expanding; to Solow model based on the creation of a series of economic growth model is also a continuous iterative process, but the Solow model is limited by the logic of economic development in the era of industrialisation, has obvious theoretical shortcomings; the economic system has a number of components and there is a complex relationship between the various parts of the role. The economic system has multiple components and complex interactions between them. Therefore, system dynamics cannot be

analysed according to simple causal logic and reductionism, and it is necessary to identify the operating characteristics of system dynamics from the perspective of system evolution and development on the basis of complex simulation of the dynamical environment.

The aim of this study is to use the most comprehensive and complete set of economic statistical indicators in the World Bank database as a data base, apply the theory of complexity systems science, and build a new economic growth model for extensive analysis with the help of advanced statistical techniques. This will unravel the complex network of impacts of these indicators on economic growth, identify the main growth drivers and account for the weight of impacts of each driver; construct a model of the role of urban planning that can be developed to exploit these drivers in order to adjust and optimise economic growth; and study the complex relationship between urban planning, economic growth and sustainability.

The rest of this study is organised as follows, with Part 2 examining the theoretical lineage and related work. Part 3 discusses the theoretical framework, extraction steps, and indicators for extracting the elements of economic dynamics under the complexity perspective. Part 4 describes the data sources involved. Part 5 experiments the results of extracting economic power elements. Part 6 discusses the economic dynamics characteristics around the economic dynamics elements. Finally, in Part 7, the interactions between urban planning and economic growth, climate change, social justice and economic sustainability are derived.

2 Literature review

2.1 Significance of the study

Since the birth of modern economics, economic theory has appeared in the vein of five analytical perspectives on economic dynamics: 1) the earliest two theoretical perspectives come from the founder of classical economic theory, Adam Smith, published in 1776 in the Wealth of Nations Adam Smith proposed that there are two ways to grow the economy, namely, "increase the amount of productive labor" and "improve labor efficiency"; 2) the third theoretical perspective focuses on the growth model and the role of innovation, the core issue was first raised by Malthus in 1798, but the theoretical breakthrough until Schumpeter in 1912. "and" improve the efficiency of labor "; 2) the third theoretical analysis focus on the role of the growth model and innovation, its core issues were first raised in 1798 by Malthus, but the theoretical breakthrough until 1912 Schumpeter's theory of economic development appeared in a breakthrough in the framework of neoclassical economics, Schumpeter founded a new economic development theory. On the basis of Schumpeter's creation of the concept of "disruptive innovation"; to the end of the 20th century, after more than 200 years of continuous discussion in the economics community to form a relatively consistent view that economic growth comes from three main lines, namely, productive resource inputs, resource efficiency improvements, and disruptive innovations and progress; (3) the fourth theoretical perspective has been widely accepted Until the beginning of the 21st century, with the 2002 Nobel Prize in Economics awarded three times to behavioural economists, the psychological motivation of people as the driving force of economic development has also gradually entered the field of mainstream economics research.

The cognition of the elements of economic power has gone through the process from physical resources, to abstract resources, and then to abstract elements, reflecting the deepening of the cognition of economic theories on the laws of economic operation, as well as the differences in the laws of economic operation of human societies at different stages of development.1) The era of agrarian civilization: classical economic theories take money, labor, and land as the core; 2) The era of industrial civilization: modern growth theories take capital , population, and technology as the core; 3) the era of information civilisation: the era of information civilisation is strengthening on data resources, and data as well as information has become the ultimate development element(Wu Zhiqiang et al., 2021); 4) the era of ecological civilisation: the theoretical system with complexity system science as the core The biggest difference between the theory and the theory of the previous eras lies in the cognitive difference of the methodology of scientific research, and it is a philosophical difference about the worldview from the reductionism to the philosophical conceptual shift of holism(Zhiqiang and Xin, 2016). The basic characteristics of complex systems are that they have many components, multiple relationships or interactions between components, and interactions that produce emergent phenomena. Therefore, the elements of economic dynamics identified based on the scientific concept of complexity systems are a kind of composite elements(Sterman, 2012); it can be classified into positive and negative feedback elements according to their role on the system(Meadows and Meadows, 2007); according to the way of participation in the dynamics of the physical dimension of the economic system can be divided into the role of providing material dynamics, the role of providing energy dynamics, and the role of providing information dynamics(Andersen *et al.*, 2012).

2.2 Research Basis

2.2.1 Economic models

Modern economic growth theory is based on the Solow model, whose theoretical logic is that there is a basic growth model for economic growth, and under the framework of the basic growth model, factor inputs will directly generate the power of economic growth. The Solow growth model is built around two equations: one is the production function equation; the other is the capital accumulation equation. 1) Production function equation: the Solow model divides inputs into capital K and labour L two categories, the total output is Y and specifies the exogenous variable1 as technology A (2) Capital accumulation equation: it considers that the change in capital stock per capita $\dot{k}$ is equal to the amount of investment per capita sy minus depreciation of capital per capita in the production process $(n + g + \delta)k$ where s is the savings rate, n is the population growth rate g is the rate of technological change、δ is the rate of depreciation. The production function equation is usually expressed in Cobb-Douglas form as:

$$Y = F(K, L, A) = A \cdot K^{\alpha} \cdot L^{1-\alpha} \quad (1)$$

The usual expression for the capital accumulation equation is:

$$\dot{k} = sy - (n + g + \delta)k \quad (2)$$

[1] An exogenous variable (exogenous variable) is a variable that is influenced by external factors in an economic mechanism and is not determined by factors internal to the economic system. It only acts as an explanatory variable in the model or system and therefore only affects other variables in the model and is not affected by other variables.

2.2.2 Dynamic environment

(1) Characteristics of the dynamics of development stages. Regarding the dynamic role of capital, population and technology, by analyzing economic data(Acemoglu *et al.*, 2001; Kaldor, 1961; Maddison, 2006) , found a number of typical development facts: 1) The basic growth model underpins the efficiency of factor inputs. The poorest countries have less than 5 per cent of the per capita income of the richest countries(Summers and Heston, 1991)， This illustrates the huge difference in factor benefits of labor. 2) Factor inputs are most beneficial in the early stages of the formation of the basic growth model. The growth of the four little dragons of Asia, the newly industrialized countries, came mainly from factor growth Young(Young, 1995) (3) Factor inputs are gradually driven together at the end of the formation of the basic growth model. Empirical studies have shown a gradual convergence of the role of resource accumulation in high-income countries, which may be caused by technology transfer(Coe and Helpman, 1993).4) Simple factor inputs do not lead to changes in economic growth rates. The ratio of the contribution of labor and capital to per capita generation is approximately constant at 7 to 3(Jones and Dietrich, 2013) .

(2) Characteristics of the dynamic role of natural endowments. Natural resource endowment has a relatively limited role in the formation of economic dynamics, which is specifically manifested in two two aspects: 1) natural resource scarcity on the economic dynamics of the limit gradually reduced. In Clark's analysis of the United Kingdom found that land rent in national income from 1750 accounted for 20% to 1850 accounted for 8%, and then only 0.1% in 2010(Clark, 2010) .2) Natural resources have a greater impact on lagging economies. According to Nordhaus' calculations, per capita income growth in the U.S. declines by roughly 0.3% per year due to natural resource constraints(Nordhaus, 1969) ; while the upper limit for natural resources as a proportion of all resources used for production is about 20-25 per cent for poor countries; the lower limit for rich countries is about 5 per cent(Gylfason and Zoega, 2010; Spengler and Joseph, 1962).

(3) The dynamic role of external resources. Three distinct views on foreign trade have also developed: 1) The first view began with the classical theory that foreign trade contributes to the formation of economic dynamics. This includes Ricardo (1847), Heckscher-Ohlin (1933), Baumol (1967), Chinnery (1969), and Yujiro Speedwater (2005); 2) The second view is that foreign trade has a completely opposite effect on the formation of economic dynamics in different economies. Including Harold Dormer model, Solow model, etc., it is argued that foreign trade pushes the accumulation of resources towards higher rates of return, and due to the role of trade resources are more inclined to accumulate in areas with higher rates of return through mobility.3) The third viewpoint is put forward by the New Structural Economics, advocated by Zhang Peigang, Lin Yifu, and others. While agreeing on the importance of differences endogenous to the structure of factor endowments, they emphasise that developing countries should seek a path of industrial upgrading and economic growth that is different from that of developed countries, and that should be rooted in comparative advantages endogenously determined by the structure of their factor endowments.

2.2.3 Ternary composition

Compared to the study of information elements in the field of economics, system science provides another way of thinking. The modern idea of systems science, recognised by the scientific community, was first put forward by the Austrian biologist Bertalanffy in 1932, and was gradually and widely accepted by the scientific community in the 1950s. Based on the idea of system science, Wiener, an American applied mathematician, proposed in his epoch-making work Cybernetics, published in 1948, that matter, energy and information are the three elements that constitute the real world.(Wiener, 1961) During the same period, Qian Xuesen, in his monograph "Engineering cybernetics" published in 1954 in the United States, also explicitly proposed that, as an open complex giant system, the core elements of the physical world can be reduced to three types of elements: matter, energy and information. This idea of system theory perceives the core elements of the physical world from a higher dimension . Therefore, the elements of the economic model in economic growth theory can be more clearly identified from the perspective of system theory and can effectively resolve the debate on the relationship and role of the elements among different theoretical lines in modern economic growth theory(Zhiqiang, 2016).

2.3 Technical means

Factor analysis is a statistical method designed to reveal underlying structures and relationships in observed data, and the formal method of factor analysis was first proposed by the British statistician Karl Pearson in 1901(PEARSON, 1905). Famous mathematical statisticians such as Harold Hotelling(Hotelling, 1933b)and Steffen S. Seifert(Seifert *et al.*, 2004) have made important contributions to the mathematical theory of factor analysis. Common factor models include principal component analysis (PCA) and constant factor analysis (CFA). The American mathematical statistician Hertling extended this method to the situation group of random vectors in 1933, and Stone (stone) extracted three new variables from 17 elements of variables reflecting national income and expenditures by using Principal Component Analysis in his 1947 study on the national economy.

3 Research methodology

3.1 Research ideas

In order to address the core question of "what are the driving categories of economic growth from the perspective of complex systems", combined with the study of existing theoretical foundations, this study puts forward the "complex system dynamics hypothesis". Complex system dynamics refers to "the economic system has the characteristics of complex system, the operating mechanism of system dynamics has a high degree of complexity, and the elements of system dynamics are composed of complex dynamics factors containing complex indicators" (Figure 1). 1) System dynamics has the characteristics of complexity. According to the assumption that the economic system has multiple components and the complexity of the role of the relationship between the various parts; therefore, the system dynamics can not be analysed in accordance with simple causal logic and reductionism, and it is necessary to identify the operating characteristics of the system dynamics from the point of view of the system's evolution and development on the basis of the complexity of the dynamics of the simulation of the environment. 2) The dynamics of the elements of the complex factor composition. According to the assumption that the dynamics of the economic system should be composed of

multiple dynamics factors; and the dynamics factors also have complexity characteristics represented by multiple economic indicators.

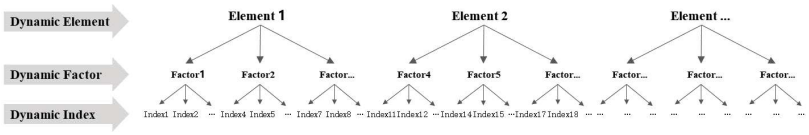


Figure 1 The way in which elements of the dynamics of the complexity economy are constituted (author's own drawing)

3.2 Data acquisition

Based on the theoretical ideas of complexity science and system dynamics, this study constructs multi-indicator constitutive factors as well as merges functional characteristic linkage factors to ultimately form the economic dynamics elements of physical dimensions that contain the characteristics of complex system dynamics. A total of 1,440 indicators in the World Bank database belong to 20 categories, including health, public sector, agriculture and rural development, urban development, infrastructure, external debt, gender, aid efficiency, education, climate change, environment, social protection and labour force, private sector, science and technology, economy and growth, energy and minerals, poverty, trade, financial sector and social development. Able to reflect the full range of socio-economic development.

3.3 Methods of analysis

Principal component analysis transforms random vectors whose components are correlated into random components whose components are uncorrelated with each other with the help of an orthogonal transformation, which geometrically manifests itself by transforming the original coordinate system into a new orthogonal coordinate system pointing in the n orthogonal directions with the widest dispersion of the sample points, and then downscaling the multidimensional variables. A few new variables with larger variance then combine the main information contained in the original multiple variables and also contain their own special meaning. The mathematical model is:

1) A coordinate transformation of the original variables gives:

$$F_1 = U_{11}X_1 + U_{12}X_2 + \cdots + U_{1n}X_n \quad (3)$$

$$F_2 = U_{21}X_1 + U_{22}X_2 + \cdots + U_{2n}X_n \quad (4)$$

$$\cdots$$

$$F_n = U_{n1}X_1 + U_{n2}X_2 + \cdots + U_{nn}X_n \quad (5)$$

2) Extract the principal components, which can be obtained:

$z_1$is called the first principal component, which satisfies the condition:

$$u_1'u_1 = 1 \quad (6)$$

$$\mathrm{var}(z_1) = \max \mathrm{var}(u'x') \quad (7)$$

$z_2$is called the second principal component, which satisfies the condition:

$$\mathrm{cov}(z_1, z_2) = 0 \quad (8)$$

$$u_2'u_2 = 1 \quad (9)$$

$$\mathrm{var}(z_2) = \max \mathrm{var}(u''x'') \tag{10}$$

The conditions satisfied by the remaining principal components are analogised one at a time.

4 Research data

4.1 Data sources

Data base construction. The steps include two processes, namely "data collection" and "data cleaning".1) Data collection. The world is regarded as a typical country in this study, and all 1440 indicators of the world in the World Bank's database and the statistical data from 1990 to 2018 are used as the data base of this study to ensure the comprehensiveness of the elements extracted.2) Data cleaning. The data were cleaned through data quality checking, and it was found that the number of indicators with valid data among the 1440 indicators was 921, that is, 519 indicators had the problem of missing data. Therefore, what was finally included in the subsequent data analysis was the 1990-2018 data of a total of 921 indicators with the world as the statistical calibre, which served as the data base for the study (Table 1).

Table 1 Classification of indicators in the World Bank database

Classification of economic indicators in the World Bank database[2]					
form	Number of indicators	Number of valid indicators	form	Number of indicators	Number of valid indicators
well-being	258	208	matrix	111	96
public sector	86	48	Social protection and the labour force	156	58
Agriculture and rural development	41	38	Private sector	161	123
urban development	18	16	science and technology	13	12
infrastructure	42	31	Economy and growth	239	132
external debt	69	18	Energy and minerals	48	42
distinguishing between the sexes	150	90	needy families	28	6
Aid effectiveness	58	52	(commercial) trade	119	110
educate	156	111	financial sector	64	35
climate change	74	65	social development	12	12

4.2 Data processing

4.2.1 Dynamic environment simulation

Steps of dynamic environment simulation through the economic development environment simulation to discover the economic dynamic environment with 871 indicators with complex system characteristics. The specific process is as follows: 1) System clustering. The data of 921 indicators with the world as the statistical calibre are subjected to "systematic

[2] World Bank database 873 indicators individually classified into a single category, 513 indicators classified into 2 or more categories, 52 indicators with no category, 2 indicators with incorrect information.

cluster analysis", forming 9 indicator clusters. 2) Cluster analysis. The first cluster group consists of 871 indicators, including economic development indicators, which constitutes the indicator system of this study to simulate the real economic dynamics environment. 3) Cluster exclusion. The 8 groups of clusters other than the first clusters mainly describe the indicators for the results of economic development, so they are not included in the power simulation environment.

From the simulation results (Fig. 2), 871 indicators related to economic development cover all 20 data categories, which fully demonstrates that: 1) the selection of indicators for simulating the environment of economic dynamics should not be limited to the 132 indicators in the category of "Economy and Growth", but should fully recognise that the formation of economic dynamics has a more complex and comprehensive mechanism; 2) the coverage of 20 data categories also indicates that this study has a more comprehensive feedback on economic dynamics based on the data, which has the basis for further research to address the Solow residual problem and endogenous growth. It should be fully recognised that the formation of economic dynamics has a more complex and comprehensive mechanism; 2) the coverage of 20 categories of data indicators also shows that this study has a more comprehensive feedback on economic dynamics on the basis of the data, and has the basis for solving the Solow residual problem and the endogenous growth problem in further research.

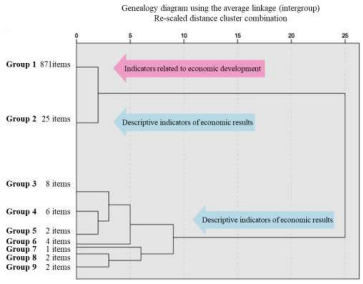


Figure 2 Tree diagram of the 921 indicators systematically clustered (author's own drawing)

4.2.2 Dynamic factor analysis

Through the economic power factor analysis, 19 economic power factors were obtained from 871 power environment simulation indicators, including 6 significant effect factors and 13 general effect factors. The steps of power factor analysis include two processes, namely "classification of effect characteristics" and "analysis of factor components". 1) Classification of effect characteristics. Bivariate correlation analysis is conducted between the 871 indicators generated by the dynamic environment simulation and the GDP, and three categories are obtained. Category 1 is "significant effect indicators", a total of 580 items, with significant positive correlation or significant inverse correlation with GDP; Category 2 is "double-edged effect indicators", a total of 265 items, which have insignificant correlation with GDP; Category 3 is unable to judge. (2) Factor component analysis. The main factors of "significant effect indicators" and "double-edged effect indicators" were extracted by the second factor analysis. From 580 items of "significant effect indicators", 6 significant effect principal factors were obtained, and according to the cumulative order of variance, F01 to F06 were used as the factor

codes (F is the first letter of the factor); from 265 items of "double-edged effect indicators", 13 double-edged effect principal factors were obtained, and according to the cumulative order of variance, F01 to F06 were used as the factor codes (F is the first letter of the factor). 13 double-edged effect main factors were obtained from the 265 "double-edged effect indicators", and C01 to C13 were used as the factor codes according to the cumulative order of variance (C is the initial letter of the common factor).

Table 2 Significant effect principal factor analysis

one-way factor analysis			quadratic factor analysis			factor nomenclature
Factor number	variance accumulation	Number of high-load indicators	Factor number	variance accumulation	Number of high-load indicators	
1	52.52 per cent	273 items	1	50.92 per cent	85 items	F01 Basic growth
			2	30.50 per cent	17 items	F02 Use of resources
2	23.36 per cent	65 items	3	33.42 per cent	20 items	F03 Public services
			4	25.11 per cent	7 items	F04 Outward Bound
			5	23.70 per cent	6 items	F05 Infrastructure
3	8.36 per cent	16 items	6	8.36 per cent	16 items	F06 Natural endowment

Table 3 Principal factor analysis of double-edged effects

one-way factor analysis			quadratic factor analysis			factor nomenclature
Factor number	variance accumulation	Number of high-load indicators	Factor number	variance accumulation	Number of high-load indicators	
1	14.88 per cent	24 items	1	59.21 per cent	14 items	C01 Public Policy
			2	35.42 per cent	5 items	C02 Private Environment
2	11.24 per cent	21 items	3	55.48	14 items	C03 Accidental death
			4	40.63 per cent	7 items	C04 Health expenditure
3	7.91 per cent	4 items	5	7.91 per cent	4 items	C05 Inefficient operations
4	7.56 per cent	9 items	6	7.56 per cent	9 items	C06 Level of Finance
5	7.43 per cent	13 items	7	7.43 per cent	13 items	C07 Foreign trade capacity
6	5.53 per cent	5 items	8	5.53 per cent	5 items	C08 Labour participation
7	4.32 per cent	5 items	9	4.32 per cent	5 items	C09 Public Education
8	3.68 per cent	5 items	10	3.68 per cent	5 items	C10 Environmental protection

9	3.65 per cent	6 items	11	3.65 per cent	6 items	C11 Land resources
10	3.57 per cent	2 items	12	3.57 per cent	2 items	C12 cost of funds
11	3.50 per cent	3 items	13	3.50 per cent	3 items	C13 Toughness Environment

5 Experimental results

5.1 Extraction results of dynamic elements

On the basis of 19 power factors, 9 economic power factors were found (Figure 3). The extraction of the power factors consists of two steps, namely: "factor independence calibration" and "power factor extraction".1) Factor independence calibration. Since the 19 power factors come from two groups of significant effect indicators and double-edged effect indicators, there may be correlation or covariance between the two groups of power factors, in order to test the independence of the factors, this study adopts two methods of "bivariate correlation analysis" and "multiple linear regression" to check. In order to test the independence of the factors, this study used "bivariate correlation analysis" and "multiple linear regression" to carry out calibration. It was found that there were significant correlation among 15 power factors and significant covariance among 14 power factors, so it was necessary to carry out "factor analysis" again for the 19 power factors. 2) Extraction of power factors. Nine independent dynamic factors were obtained, and the cumulative contribution rate of variance reached 84.42%. According to the cumulative order of variance, D1 to D9 were used as the codes of the factors (D is the initial letter of the dynamic element).

The naming of power factors and power elements follows three principles: 1) the principle of representativeness, i.e. the absolute value of the indicator loading coefficient representing the information contained in the main factor should be greater than 0.7, to reduce the interference of low loading indicators on the naming of the main factor. 2) the principle of comprehensiveness, i.e. a comprehensive analysis of the representative indicators selected through the principle of representativeness, and the naming based on the conclusions of theoretical basic research in the first section of this chapter. 3) the principle of directionality. That is, the naming of factors and elements seeks to highlight the direction of the role of power factors and elements in the formation of economic power, reflecting the power mechanism of power factors and elements. Through the classification of role characteristics as well as factor component analysis and naming principles, 6 significant effect factors, 13 double-edged effect factors and 9 economic power elements formed by the merger of power factors are finally identified.

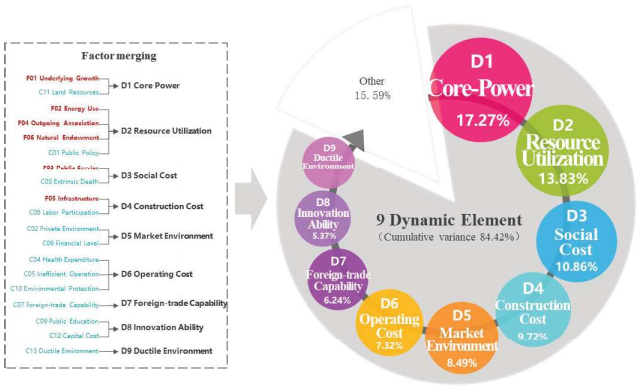


Figure 3 Compositional characteristics of the nine economic drivers (author's own drawing)

5.2 Characterisation of complex systems of dynamical elements

The nine economic drivers contain a total of 222 indicators covering 20 classifications in the World Bank database.The number of 222 indicators is very unevenly distributed among the 19 economic drivers (Figure 4). They can be broadly categorised into three levels according to the number of indicators: 1) over-indicator clustering: containing 73 indicators and only 1 factor (i.e. F01 Basic Growth); 2) more indicator clustering: containing 11 to 19 indicators and 5 factors; and 3) less indicator clustering: containing 3 to 8 indicators and 13 factors.

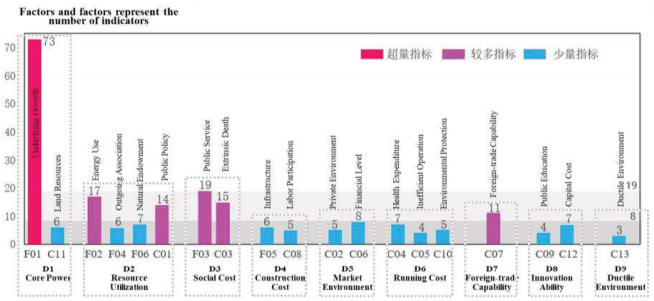


Figure 4 Complexity characteristics of the elements and factors containing indicators (authors' own drawing)

5.3 Characterisation of the economic dynamics of the power factor

(1) Factor D1: "Economic model". Reflects the dominant power model of economic growth; it consists of two power factors, F01 Basic Growth and C11 Land Resources. (1) F01 basic growth factor, as the main source of economic model contains 8 categories of economic indicators: education, population, land, labour, external resources, science and technology, health and infrastructure. (2) The "economic model" factor includes C11 land resources, which indicates that land resources are an important part of the "economic model", but its driving force plays a double-edged role.

(2) Factor D2: "Resource use". Reflects the use of various types of external resources; it consists of four driving factors: F02 energy use, F04 outward linkages, F06 natural endowments and C01 public policy. (1) Of the 17 statistical indicators represented by F02 Energy Use, 10 can be categorised as energy, including carbon dioxide emissions from electricity and heat production (as a percentage of total fuel combustion), etc.; one can be categorised as information technology, for fixed-line telephone subscriptions; one can be categorised as capital, for insurance and financial services (as a percentage of imports of business services); and five can be categorised as population, including insurance and financial services (as a percentage of imports of business services). indicators can be categorised as population, including children with HIV (0-14 years old), etc. (2) Two of the seven statistical indicators represented by the F04 outward linkages can be classified as capital, namely the unit value index of exports (2000=100) and the unit value index of imports (2000=100); three indicators can be classified as health, including domestic general government health expenditure (% of current health expenditure), etc.; and one indicator can be classified as information technology (IT). (2000=100); 1 indicator can be classified under the category of Information Technology (IT), which is Information and Communication Technology (ICT) product exports (% of total product exports); and 1 indicator can be classified under the category of Population, which is Low birth weight babies (% of births). (3) Four of the six statistical indicators represented by F06 Natural Endowments can be categorised as Energy, including Oil Rent (as a percentage of GDP), etc.; and two indicators can be categorised as Capital, Manufacturing Imports (as a percentage of Merchandise Imports) and International Tourism, Expenditures (as a percentage of Total Imports). (4) Eleven of the 14 statistical indicators represented by C01 Public Policy can be categorised as Public Policy, including the International Development Association (IDA) Resource Allocation Index (1=low, 6=high); and three can be categorised as Education, including Net Enrolment Ratio of First Year Students (as a percentage of the official school-age population), among others.

(3) Element D3: "Social costs". Reflects the maintenance costs of social development. It consists of two driving factors, F03 Public Services and C03 Accidental Deaths. (1) 19 of the 20 statistical indicators represented by F03 Public Services can be categorised as public services, including the rural population using safely managed drinking water services (% of rural population), etc.; and one indicator can be categorised as safety and health, which is the lifetime risk of maternal mortality (rates vary by country). (2) All 14 statistical indicators represented by C03 Unintentional deaths can be categorised as safety and health, including the female suicide mortality rate (per 100,000 female population).

(4) Factor D4: "Construction costs". Reflecting the costs of forming the basis for economic development, it consists of two driving factors, F05 Infrastructure and C08 Labour Participation. (1) Three of the six statistical indicators represented by F05 Infrastructure can be classified as infrastructure, including fixed broadband subscriptions), etc.; and three can be classified as safety and health, including antiretroviral treatment coverage (the proportion of people living with HIV)), etc. (2) All five statistical indicators represented by C08 Labour Participation can be classified under the Social Stability category, including Armed Forces Personnel, Total), etc.

(5) Factor D5: "Market environment". Reflects the role of marketisation level. It consists of two driving factors: C02 Private Environment and C06 Financial Level. (1) Six of the seven statistical indicators represented by C02 Private Environment can be categorised as Doing Business, including procedures for setting up warehouses (number), etc.; and one indicator can be categorised as Public Policy, with a rating of the National Policy and Institutions Assessment (CPIA) on Human Resource Development (1=low to 6=high). (2) All nine statistical indicators represented by the C06 financial level can be classified under the financial level category, including ownership of accounts in financial institutions or mobile money service providers (% of the population over 15 years of age that is female), etc.

(6) Element D6: "Running costs". Reflects the cost of normal operation of society. It consists of three driving factors: C04 Health Expenditure, C05 Inefficient Operation, and C10 Environmental Protection. (1) Of the seven statistical indicators represented by C04 Health Expenditure, six can be categorised as medical services, including the proportion of the population whose out-of-pocket medical expenditure results in the poverty line being below US$1.90 (2011 PPP) (%), etc.; and one can be categorised as education, which is the number of R&D researchers (per million people). (2) Of the 4 statistical indicators represented by C05 Inefficient Business, 2 indicators can be classified as Business Environment, including Enterprises Failing to File Full Tax Returns on Sales Revenues (% of Enterprises), etc.; 1 indicator can be classified as Health Care Services, as Causes of Death by Injury (% of total); and 1 indicator can be classified as Land, as Area of Rural Land (sq. km.). (3) One of the five statistical indicators represented by C10 Environmental protection can be categorised as environmental protection, as social contributions (% of income); one indicator can be categorised as education, as the percentage of male and female trained secondary school teachers (%); and three indicators can be categorised as land, including the area of terrestrial protected areas (% of the total area of land), etc.

(7) Factor D7: "Foreign trade capacity". Reflects the role of resources external to the economy. It consists of a power factor, C07 Foreign Trade Capacity. 10 of the 13 statistical indicators represented by C07 Foreign Trade Capacity can be categorised as International Trade, including Net Official Flows from United Nations Agencies, UNECE (in current US dollars), etc.; and 3 indicators can be categorised as Health and Safety, including Secure Internet Servers (per million people), etc.

(8) Element D8: "Innovative capacity". Reflects the conditions underlying the formation of innovation. It consists of two driving factors, C09 Public Education and C12 Capital Costs. (1) Four of the five statistical indicators represented by C09 Public Education can be categorised as education, including current expenditure on secondary education (% of total public institutional expenditure on secondary education), etc.; and one indicator can be categorised as money, which is commercial bank borrowers (per 100,000 adults). (2) All 2 statistical indicators represented by C12 cost of funds can be categorised as monetary, including interest payments (% of expenses) and interest payments (% of income).

(9) Element D9: "Resilient environment". Reflects an economy's confidence in its

development resilience. Consists of C13 Resilient Environment, a motivating factor.

One of the three statistical indicators represented by the C13 resilience environment is in the category of health services, the basic health services coverage index; two indicators can be classified as energy, including net energy imports (as a percentage of energy use)) and alternative and nuclear energy (as a percentage of total energy use), among others.

6 Analytical discussion

6.1 Validation of element extraction results

Through the extraction of economic drivers, this study obtained 19 economic drivers factors for 9 economic drivers and constituent elements. Following Owen et al. (2009) and others, the empirical model was tested using the regressions of the direct determinants of economic growth (Figure 5). The standard growth equation developed in this study is as follows:

$$GDP_i = \beta_1 \times D_1 + \cdots + \beta_i \times D_i + \varepsilon_i \quad (11)$$

where the dependent variableGDP is the gross domestic product (GDP).D_1 toD_i are the nine driving factors extracted from the factor analysis, theβ_1 toβ_i are the linear regression coefficients. The calculation results show that the regression test is superior, with a significance of 0.000, indicating that the nine economic power factors have good factor independence; the adjusted regression R-square of the model is 0.999, indicating that the model's explanatory ability is close to perfect.

Figure 5 Theoretical modelling of the core dynamical environment hypothesis (authors' own drawing)

6.2 The dominant role of economic models in economic growth

(1) Contributing about 3/4 of world economic growth. Analysing the characteristics of the contribution of the nine power elements to economic growth, it can be found that: (1) world economic growth is mainly determined by the contribution of the economic power elements of the D1 economic model, which contributes 73.9 per cent to world economic growth, i.e., basically determines the formation of three-quarters of the world's economic growth; and (2)

the contribution of the remaining eight economic power elements to world economic growth is 26.1 per cent in the aggregate (Figure 6).

(2) Explaining about 2/5 of the economic operating mechanism. Standardised coefficients are applied to the world economic growth equation to analyse the degree of explanation of the 9 types of economic power elements to the overall model . It can be found that: 1) the D1 economic model has the highest degree of explanation of the model among the 9 economic dynamics elements, at 37.8%; 2) the degree of explanation of the model of the D1 economic model is 2.5 times to 25 times higher than that of the other 8 elements, and the range of the degree of explanation of the rest of the 8 economic dynamics elements is 1.5%-14.7%, with the total degree of explanation of the 8 elements being 62.2%.

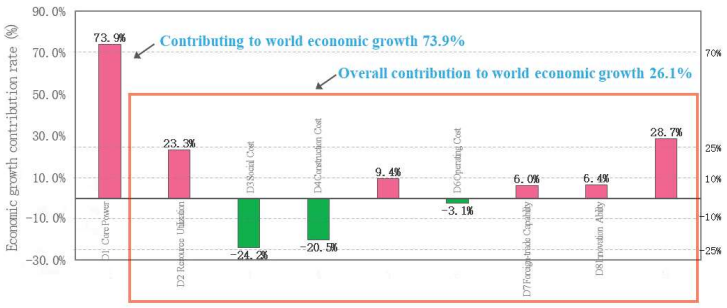


Figure 6 Contribution of the nine economic drivers to world economic growth (authors' own drawing)

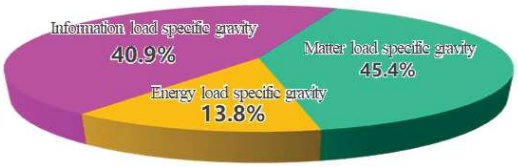
6.3 "Complexity" and "triadic character" of the economic model

The economic model element is an alternative upgrade to the Solow model. According to the world economic growth equation established in this study, the D1 economic model element contributes 73.9 per cent to economic growth and explains 37.8 per cent of the overall model; compared with the Solow model, which explains only 36.4 per cent-60.0 per cent of economic growth, the D1 economic model element has more theoretical and practical value. This is because the Solow model reduces the economic power mechanism to simple inputs of capital and labour under the total factor production constant, and this oversimplified treatment fully reflects the lack of knowledge of the complex economic growth mechanism, which is the product of a simple reductionist cognitive philosophy that lacks the concept of complexity system research.

(1) The complexity characteristics embodied in the eight types of indicators. In this section, we will analyse the driving mechanism of factor D1 from the perspective of complexity system theory, which consists of two factors, F01 basic growth and C11 land resources, and the 79 indicators belonging to it include eight new categories, namely, education, population, land, labour force, external resources, science and technology, health and sanitation, and infrastructure. The number of indicators of the eight categories is unevenly distributed, and can be classified into two levels according to the sum of the absolute values of the indicator loading coefficients. According to the absolute value of the indicator loading coefficients, the indicators

can be divided into two levels. (1) High-loading category: includes two categories, education and population, with loadings above 22 per cent; (2) Medium-loading category: includes two categories, labour force and external resources, with loadings between 10 and 20 per cent; and (3) Low-loading category: includes four categories, namely, land, science and technology, health and infrastructure, with loadings below 7 per cent.

(2) The triadic composition of matter-energy-information of the economic model. System science believes that matter, energy and information are the three elements of the physical world, which are composed of the ternary nature, and the same 79 indicators constituting the D1 elements can also be divided according to the three elements. The result of the division is that the total number of 32 indicators of information element, the absolute value of load 27.6; the total number of 36 indicators of material element, the absolute value of load 30.6; the total number of 11 indicators of energy element, the absolute value of load 9.3. By comparing the load value of material, information and energy elements, we get the proportion of the world's triad of nature, i.e., the proportion of matter: information: energy is 45.4%: 40.9%: 13.8%. From the ratio, we can get the following two conclusions: 1) matter and information are the main elements in the world's triad; 2) the weight of matter and information is close to each other, and slightly higher than that of information.



sFigure 7: Sum and proportion of world material information energy loads in years (author's own drawing)

6.4 Spatial relevance of land for economic modelling

The complementary role of land resources in the economic model. According to the composition of the D1 factor, the following correlation can be observed between the "F01 Basic growth" factor and the "C11 Land resources" factor.

(1) "F01 basic growth" is the driving core of the D1 factor. The F01 basic growth factor constituting the D1 factor consists of 73 indicators, with an absolute cumulative load factor of 91.9 per cent; while the C11 land resources factor consists of 6 indicators, with an absolute cumulative load factor of only 8.1 per cent.

(2) "C11 land resources" is a necessary component of the D1 factor. Firstly, the F01 basic growth factor and the C11 land resources factor are significantly positively correlated; secondly, the F01 basic growth factor and the C11 land resources factor are significantly covariant in the multiple linear regression; and lastly, the calculation result of the factor analysis method also combines the F01 basic growth factor and the C11 land resources factor into the D1 factor.

6.5 The "double-edged effect" of elements of the dynamic environment

The nine driving forces have a double-edged effect, and there is a wide variation in the direction of contribution of the nine driving forces to world economic growth, with six driving forces playing a positive role and three driving forces playing a negative role. Therefore, we set up economic growth equations with the nine driving forces as independent variables for each of the 84 case countries, and examine the direction of the contribution of the nine driving forces to economic growth. It can be found that there is a double-edged power effect of all nine factors.

7 Conclusion

7.1 Conclusions of the study

This study focuses on the discovery of categories of drivers of economic growth, understanding the interplay between economic growth, climate change, social justice and economic sustainability through the economic dynamics characterising the drivers, the key role of urban planning in harnessing these drivers in order to adjust and optimise the way in which economic growth occurs, quantifying the relative weights of these drivers and outlining intervention strategies.

7.2 Significance of the study

It provides ideas and research directions for the theoretical ideas of complexity science and system dynamics to study economic growth, explores the categories of economic growth drivers under big data analysis, discovers the interactive links between urban planning and the indicator system of economic growth drivers, and provides theoretical support for policy formulation and urban planning strategies.

7.3 Research limitations

The limitations of this study are as follows: (1) the limitations of data, some indicators in the World Bank database are more difficult to count, and the missing data cause 519 invalid indicators; (2) the limitations of time, although the current World Bank statistics began in 1960, the vast majority of indicators only began to be counted in 1990, which led to the time range of the data in this study from 1990 to 2018 years; (3) the complexity of the research field, as this study involves a number of fields such as urban planning, economic growth, sustainable development, etc., the study is complex and somewhat imperfect.

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Appendix

Figure 1 Table of basic information on indicators with significant effect factor loading coefficient of 0.7 or more in absolute value

F01 Basic growth factor (85 indicators)					
Indicator name	World Bank Sub-Group	Load value after rotation	Indicator name	World Bank Sub-Group	Load value after rotation
School enrolment, pre-primary, boys (per cent of total)	Education/ Gender	0.916	Women surviving to age 65 (% of cohort)	Health/Gender	0.835
School enrolment, pre-primary (per cent of total)	teach	0.914	Enrolment, secondary, boys (per cent of total)	Education/ Gender	0.834
School enrolment, pre-primary, girls (per cent of total)	Education/ Gender	0.913	Air traffic, registered carrier global departures	infrastructure	0.834
Enrolment, primary, private (% of total primary)	teach	0.909	Life expectancy at birth, women (years)	well-being	0.834
Intellectual property royalties, payments (balance of payments, current United States dollars)	Economy and growth/science and technology	0.909	Population aged 65 and over, male (per cent of male population)	well-being	0.831
Mobile cellular subscriptions (per 100 population)	infrastructure	0.908	GDP per capita (constant 2010 US$)	Economy and growth	0.831
Intellectual property royalties, receipts (balance of payments, current United States dollars)	Economy and growth/science and technology	0.905	Primary school completion rate for girls (percentage of relevant age group)	Education/ Gender	0.829
Labour remittances and employee compensation paid (in current United States dollars)	Economy and growth/financial sector	0.902	Life expectancy at birth, overall (years)	well-being	0.827
Air transport, passenger traffic	infrastructure	0.900	urban population	Urban development/climate change	0.827
Imports of services (BoP, in current dollars)	Economy and growth/trade	0.899	Urban population (% of total population)	Urban development/climate change	0.825
Imports of commercial services (current US$)	Trade/private sector	0.898	Life expectancy at birth, men (years)	Health/social development/gender	0.821

Exports of services (BoP, in current dollars)	Economy and growth/trade	0.894	Merchandise exports to developing economies in the region (per cent of total merchandise exports)	Trade/private sector	0.820
Exports of commercial services (current US$)	Trade/private sector	0.893	Men surviving to age 65 (% of cohort)	Health/Gender	0.820
Population aged 80 and over, female (per cent of female population)	well-being	0.893	Enrolment, secondary (per cent of total)	teach	0.819
Population aged 80 and over, male (per cent of male population)	well-being	0.892	Male employment in services (per cent of male employment)	Social protection and labour force/gender	0.819
Gross national income (GNI) per capita as measured by the Atlas method (current US$)	Economy and growth	0.879	Secondary education, teacher	teach	0.818
Merchandise imports from developing economies in the South Asia region (percentage of total merchandise imports)	Trade/private sector	0.878	Primary education, pupils (percentage of girls)	Education/ Gender	0.814
Net bilateral aid flows from DAC donors, UK (current US$)	Aid effectiveness	0.877	Trade in services (% of gross domestic product (GDP))	Economy and growth/trade/private sector	0.812
GDP per capita (current US$)	matrix	0.876	Net bilateral aid flows from DAC donors, EU institutions (current US$)	Aid effectiveness	0.809
GNI per capita, PPP (constant 2011 international dollars)	Economy and growth	0.875	Per capita final consumption expenditure per inhabitant (constant 2010 United States dollars)	Economy and growth	0.808
GDP per capita in purchasing power parity (PPP) (current international dollars)	Economy and growth	0.873	Enrolment, secondary, girls (per cent of total)	Education/ Gender	0.806
Gross national income (GNI) per capita at purchasing power parity (PPP) (current international dollars)	Economy and growth	0.873	Enrolment, primary (net per cent)	teach	0.803
Net adjusted national income per capita (current United States dollars)	Economy and growth	0.873	Secondary education, teacher, female	teach	0.802
Merchandise exports to developing economies in East Asia and the Pacific (percentage of	Trade/private sector	0.871	Merchandise imports from intraregional developing economies (per cent of total merchandise imports)	Trade/private sector/infrastructure	0.801

total merchandise exports)					
GDP per capita at purchasing power parity (PPP) (constant 2011 international dollars)	Economy and growth	0.868	Out-of-school children, male (% of male primary school age)	teach	-0.802
Agriculture, value added (constant 2010 United States dollars)	Economy and growth	0.866	Labour force participation rate, males (% of male population aged 15-64) (simulated ILO estimates)	Social protection and labour/social development	-0.803
Labour remittances received and compensation of employees (% of gross domestic product (GDP))	Economy and growth/financial sector	0.864	Mortality rate, under 5 years, female (per 1,000 live births)	well-being	-0.803
Enrolment, tertiary, female (% of total)	Education/ Gender	0.860	Employment rate of males aged 15-24 (percentage) (simulated ILO estimates)	Social protection and labour force/gender	-0.816
Merchandise exports to developing economies outside the region (per cent of total merchandise exports)	Trade/private sector	0.860	Labour force participation rate, males (% of male population aged 15+) (simulated ILO estimates)	Social protection and labour/social development/gender	-0.818
Female employed persons in services (per cent of female employment)	Social protection and labour force/gender	0.860	Labour force participation rate, males (% of male population aged 15-24) (simulated ILO estimates)	Social protection and labour/social development	-0.825
Enrolment, tertiary (% of total)	teach	0.858	Intentional homicide, female (per 100,000 females)	public sector	-0.825
Enrolment, tertiary, male (% of total)	Education/ Gender	0.856	Rural population (per cent of total population)	Agriculture and rural development	-0.825
Old-age dependency ratio (per cent of working-age population)	well-being	0.852	Ratio of total employed population aged 15 years and over (percentage) (simulated ILO estimates)	Social protection and the labour force	-0.832
Population aged 65 and over, female (per cent of female population)	well-being	0.848	Number of deaths among 15-19 year olds	teach	-0.840
Adjusted net national income per capita	Economy and growth	0.848	Merchandise imports from high-income economies (per	Trade/private sector	-0.846

(constant 2010 United States dollars)			cent of total merchandise exports)		
Total population aged 65 and over, women	well-being	0.843	Mortality rate, adult, male (per 1,000 males)	Health/Gender	-0.857
Total population aged 65 and over	well-being	0.841	Number of deaths among 10-14 year olds	well-being	-0.858
Overall primary school completion rate, (percentage of relevant age group)	Education/ aid effectiveness/climate change	0.840	Labour force participation rate, total (percentage of total population aged 15-64) (simulated ILO estimates)	Social protection and labour/social development	-0.860
Population aged 65 and over (per cent of total population)	well-being	0.840	Mortality rate, adult, female (per 1,000 adult females)	Health/Gender	-0.861
Population aged 65 and over, men	well-being	0.840	Contributing male domestic workers (per cent of male employment)	Social protection and labour force/gender	-0.865
Persons employed in services (per cent of total employment)	Social protection and the labour force	0.839	Probability of death among young people aged 20-24 (per 1,000)	well-being	-0.871
Primary education, teachers	teach	0.839	Labour force participation rate, total (% of total population aged 15+) (simulated ILO estimates)	Social protection and the labour force	-0.874
GNI per capita (constant 2010 US$)	Economy and growth	0.838	/	/	/
F02 Resource use factor 2 (17 indicators)					
Indicator name	World Bank Sub-Group	Load value after rotation	Indicator name	World Bank Sub-Group	Load value after rotation
Landline Subscription	infrastructure	0.916	Electricity generation from oil (as a proportion of total electricity generation)	Energy and minerals/infrastructure /climate change	-0.803
CO2 emissions from electricity and heat production (per cent of total fuel combustion)	matrix	0.882	Prevalence of anaemia among pregnant women (%)	well-being	-0.825
HIV-infected children (0-14 years)	well-being	0.870	Hydroelectricity generation (% of total electricity generation)	Energy and minerals/climate change/infrastructure	-0.838

Electricity generation from oil, gas and coal energy sources (as a proportion of total electricity generation)	Energy and minerals/environment	0.866	CO2 emissions from other sectors, excluding residential buildings and commercial and public services (percentage of total fuel combustion)	matrix	-0.841
Livestock production index (2004-2001 = 100)	Agriculture and rural development	0.840	Energy use per $1,000 GDP (constant 20011 PPP) (kg oil equivalent)	Energy and minerals/climate change	-0.855
Energy consumption per unit of GDP (constant 2011 PPP US$/kg oil equivalent)	Energy and minerals	0.831	Prevalence of anaemia in non-pregnant women (% of women aged 15-49)	well-being	-0.880
Electricity generation from natural gas (share of total electricity generation)	Energy and minerals/climate change/infrastructure	0.829	Prevalence of anaemia among women of childbearing age (% of women aged 15-49)	well-being	-0.882
Insurance and financial services (per cent of imports of business services)	Trade/private sector	0.821	Energy intensity level of primary energy sources (MJ/2011 PPP GDP)	Environment/energy and minerals	-0.899
Effective transition rate from primary to lower secondary general education for both sexes (%)	teach	0.800	/	/	/
F03 Public service factor (20 indicators)					
Indicator name	World Bank Sub-Group	Load value after rotation	Indicator name	World Bank Sub-Group	Load value after rotation
Rural population using safely managed drinking water services (per cent of rural population)	Health/Environment	0.775	Urban population using at least basic health services (per cent of urban population)	Health/Environment	0.730
People using safely managed drinking water services (per cent of the population)	Health/Environment	0.752	People using safely managed health services, urban population (% of urban population)	Health/Environment	0.729
Per capita out-of-pocket expenditures, purchasing power parity (current international dollars)	well-being	0.748	Rural population using at least basic health services (per cent of rural population)	Health/Environment	0.729
Domestic private health expenditure per capita, purchasing power parity (current international dollars)	well-being	0.747	Lifetime risk of maternal death (rates vary by country)	Health/Gender	0.723

Urban population using at least basic drinking water services (per cent of urban population)	Health/Environment	0.742	People using at least basic health services (per cent of the population)	Health/Environment	0.720
Current per capita health expenditure, PPP (current international dollars)	well-being	0.742	Rural population using at least basic drinking water services (per cent of rural population)	Health/Environment	0.717
Domestic per capita general government health expenditure, purchasing power parity (current international dollars)	well-being	0.738	People practising open defecation (% of population)	Health/Environment	-0.724
Rural population using safely managed health services (% of rural population)	Health/Environment	0.738	People practising open defecation in urban areas (% of urban population)	Health/Environment	-0.733
People using safely managed health services (per cent of population)	Health/Environment	0.732	Persons practising open defecation, rural (per cent of rural population)	Health/Environment	-0.737
Domestic general government health expenditure (% of GDP)	well-being	0.730	Urban population using safely managed drinking water services (% of urban population)	Health/Environment	-0.739
F04 Outward linkage factor (7 items)					
Indicator name	World Bank Sub-Group	Load value after rotation	Indicator name	World Bank Sub-Group	Load value after rotation
Export unit value index (2000=100)	/	0.859	Information and communications technology (ICT) product exports (per cent of total product exports)	Trade/infrastructure/private sector	-0.719759847
Domestic general government health expenditure (% of current health expenditure)	well-being	0.831	Low birth weight babies (per cent of births)	well-being	-0.792
Import unit value index (2000=100)	/	0.798	Domestic private health expenditure (% of current health expenditure)	well-being	-0.830
External health expenditure (% of current health expenditure)	well-being	0.763	/	/	/
F05 Infrastructure factor (6 indicators)					
Indicator name	World Bank Sub-Group	Load value after rotation	Indicator name	World Bank Sub-Group	Load value after rotation

Fixed Broadband Subscription	infrastructure	0.804	Antiretroviral treatment coverage (percentage of people living with HIV)	well-being	0.751
Rural electricity supply (% of rural population)	Energy and minerals/agriculture and rural development	0.798	Tuberculosis case detection rate (per cent, all forms)	well-being	0.711
Fixed broadband subscriptions (per 100 population)	infrastructure	0.796	Tuberculosis prevalence rate (per 100,000 population)	Health/aid effectiveness	-0.752
F06 Natural endowment factor (6 indicators)					
Indicator name	World Bank Sub-Group	Load value after rotation	Indicator name	World Bank Sub-Group	Load value after rotation
Oil rent (per cent of GDP)	Environment/energy and minerals/climate change	0.872	Adjusted savings: depletion of natural resources (percentage of GNI)	Economy and growth/energy and minerals	0.831
Gross natural resource rents (per cent of GDP)	Environment/energy and minerals	0.856	Manufacturing imports (per cent of merchandise imports)	Trade/social development	-0.859
Adjusted savings: energy losses (% of GNI)	Economy and growth/energy and minerals/environment	0.849	International tourism, expenditures (per cent of total imports)	Trade/private sector	-0.863

Figure 2 Information table for indicators with an absolute value of 0.7 or more for the main factor loading coefficient of the double-edged effect

C01 Public Policy Factor 7 (14 indicators)					
Indicator name	World Bank Sub-Group	Load value after rotation	Indicator name	World Bank Sub-Group	Load value after rotation
International Development Association (IDA) Resource Allocation Index (1=low, 6=high)	public sector	0.930	Country Policy and Institutional Assessment (CPIA) Social Security Rating (1=low to 6=high)	public sector	0.864

Country Policy and Institutional Assessment (CPIA) Fiscal Policy Rating (1=low to 6=high)	public sector	0.911	Country Policy and Institutional Assessment (CPIA) Financial Sector Rating (1=low to 6=high)	public sector	0.823
Country Policy and Institutional Assessment (CPIA) Public Management Quality Rating (1=low to 6=high)	public sector	0.894	Country Policy and Institutional Assessment (CPIA) Business Regulatory Environment Rating (1=low to 6=high)	public sector	0.818
Country Policy and Institutional Assessment (CPIA) Economic Management Cluster Mean (1=low to 6=high)	public sector	0.890	Country Policy and Institutional Assessment (CPIA) Macroeconomic Management Rating (1=low to 6=high)	public sector	0.804
Country Policy and Institutional Assessment (CPIA) Debt Policy Rating (1=low to 6=high)	public sector	0.883	Net enrolment rate of first-grade students (per cent of official school-age population)	teach	-0.816
Country Policy and Institutional Assessment (CPIA) Structural Policy Cluster Mean (1=low to 6=high)	public sector	0.882	Net enrolment rate in grade 1, girls (per cent of officially defined school-age population)	Education/Gender	-0.823
Country Policy and Institutional Assessment (CPIA) Gender Equality Rating (1=low to 6=high)	public sector	0.866	Net enrolment rate in grade 1, boys (per cent of officially defined school-age population)	Education/Gender	-0.859
C02 Private environmental factors (5 indicators)					
Indicator name	World Bank Sub-Group	Load value after rotation	Indicator name	World Bank Sub-Group	Load value after rotation

Procedures for establishing warehouses (number)	Private sector	0.900	Total tax rate (per cent of business profits)	Private/public sector	0.755
Property registration procedures (number)	Private sector	0.890	Country Policy and Institutional Assessment (CPIA) Human Resource Development Rating (1=low to 6=high)	public sector	-0.738
Time required for tax preparation (hours)	Public/private sector	0.871	/	/	/
C03 Accidental death factor (14 indicators)					
Indicator name	World Bank Sub-Group	Load value after rotation	Indicator name	World Bank Sub-Group	Load value after rotation
Female suicide mortality rate (per 100,000 female population)	well-being	0.887	Female smoking prevalence (percentage of all adults who smoke)	well-being	0.851
Suicide mortality rate (per 100,000 population)	well-being	0.880	Mortality rate from CVD, cancer, diabetes or CRD between the exact ages of 30 and 70, men (%)	well-being	0.847
Male suicide mortality rate (per 100,000 male population)	well-being	0.870	Mortality rate from accidental poisoning, males (per 100,000 male population)	Health/Environment	0.838
Prevalence of smoking among men (percentage of all adults who smoke)	Health/Gender	0.864	Mortality rate from accidental poisoning, female (per 100,000 female population)	Health/Environment	0.832
Mortality rate from CVD, cancer, diabetes or CRD between the exact ages of	well-being	0.862	Mortality rate from accidental poisoning (per 100,000 population)	Health/Environment	0.826

30 and 70, women (%)					
Total smoking prevalence (15+)	/	0.861	Causes of death due to infectious diseases, maternal, prenatal and nutritional conditions (% of total)	well-being	0.802
Mortality rate from CVD, cancer, diabetes or CRD between the exact ages of 30 and 70 years (%)	well-being	0.857	Cause of death, non-communicable diseases (% of total)	well-being	-0.809
C04 Health expenditure factor (7 indicators)					
Indicator name	World Bank Sub-Group	Load value after rotation	Indicator name	World Bank Sub-Group	Load value after rotation
Proportion of population with out-of-pocket medical expenditures resulting in a poverty line below $1.90 (2011 PPP) (%)	well-being	0.852	Proportion of population with out-of-pocket medical expenditure of more than 10 per cent of household consumption or income (%)	well-being	-0.874
Number of people with out-of-pocket medical expenditures resulting in a poverty line below $1.90 (2011 PPP)	well-being	0.831	Number of persons whose out-of-pocket medical expenditures account for more than 10 per cent of household consumption or income	well-being	-0.878
Proportion of population with out-of-pocket medical expenditure of more than 25 per cent of household	well-being	-0.867	Number of persons whose out-of-pocket medical expenditures account for more than 25 per cent of household	well-being	-0.880

consumption or income (%)			consumption or income		
R&D researchers (per million)	science and technology	-0.870			
C05 Inefficient operation factor (4 indicators)					
Indicator name	World Bank Sub-Group	Load value after rotation	Indicator name	World Bank Sub-Group	Load value after rotation
Enterprises failing to file full tax returns on sales revenue (per cent of enterprises)	Private sector	-0.800	Cause of death, by injury (% of total)	well-being	-0.856
Logistics performance index: frequency with which goods reach the consignee within a predetermined or expected time (1 = very low to 5 = very high)	Private sector/trade	-0.819	Rural land area (square kilometres)	Agriculture and rural development/environment	-0.899
C06 Financial level main factor (9 indicators)					
Indicator name	World Bank Sub-Group	Load value after rotation	Indicator name	World Bank Sub-Group	Load value after rotation
Ownership of accounts at financial institutions or mobile money service providers, females (% of population aged 15+)	/	0.967	Ownership of accounts at financial institutions or mobile money service providers, poorest 40 per cent (percentage of population aged 15+)	/	0.966
Ownership of accounts at financial institutions or mobile money service providers (% of population aged 15+)	/	0.967	Ownership of accounts at financial institutions or mobile money service providers, richest 60 per cent (percentage of population aged 15+)	/	0.965

Ownership of accounts at financial institutions or mobile money service providers, older persons (per cent of the population over 25 years of age)	/	0.967	Ownership of accounts at financial institutions or mobile money service providers, secondary education or higher (per cent of the population aged 15+)	/	0.963
Ownership of accounts at financial institutions or mobile money service providers, males (% of population aged 15+)	/	0.966	Ownership of accounts at financial institutions or mobile money service providers, young people (% of population aged 15-24)	/	0.956
Ownership of accounts at financial institutions or mobile money service providers, primary education or less (per cent of the population aged 15+)	/	0.966		/	
C07 Foreign trade capacity factor (13 indicators)					
Indicator name	World Bank Sub-Group	Load value after rotation	Indicator name	World Bank Sub-Group	Load value after rotation
Net official flows from United Nations agencies, UNECE (current US$)	external debt	0.956	Export costs, documentary compliance (United States dollars)	Private sector/trade	0.838
Import time, border compliance (hours)	Private sector/trade	0.953	Import costs, border compliance (United States dollars)		0.836

Export time, border compliance (hours)	Private sector/trade	0.925	Import time, document compliance (hours)	Private sector/trade	0.801
Communications, computers, etc. (per cent of services exports, BoP)	Economy and growth/trade	0.904	Secure Internet servers (per million people)	infrastructure	-0.820
Cost of exports, border compliance (United States dollars)	Private sector/trade	0.900	Distance to frontier score (0 = minimum performance to 100 = frontier)	Private sector	-0.830
Communications, computers, etc. (per cent of imports of services, BoP)	Economy and growth/trade	0.882	Prevalence of severe food insecurity among the population (per cent)	well-being	-0.900
Export time, document compliance (hours)	Private sector/trade	0.875	/	/	/
C08 Labour participation factor 15 (5 indicators)					
Indicator name	World Bank Sub-Group	Load value after rotation	Indicator name	World Bank Sub-Group	Load value after rotation
Armed forces personnel, total	(commercial) trade	0.841	Number of unemployed men (% of male labour force) (simulation of ILO estimates)	Social protection and labour/gender/education/social development	0.811
Female unemployment (% of female labour force) (simulation of ILO estimates)	Social protection and labour/gender/education/social development	0.840	Net official development assistance (ODA) received (per cent of GNI)	Aid effectiveness/economy and growth/external debt	-0.810
Total unemployment (% of total labour force) (simulation of ILO estimates)	Social protection and labour/education	0.833	/	/	/
C09 Public education factor (5 indicators)					
Indicator name	World Bank Sub-Group	Load value after rotation	Indicator name	World Bank Sub-Group	Load value after rotation

Current expenditure on secondary education (% of total expenditure on secondary public institutions)	teach	0.883	Expenditure on secondary education as a percentage of government expenditure on education (%)	teach	-0.870
Current expenditure on primary education (% of total expenditure on primary public institutions)	teach	0.817	Commercial bank borrowers (per 100,000 adults)	financial sector	-0.902
Expenditure per capita in secondary schools (per cent of GDP per capita)	teach	-0.817	/	/	/
C10 Environmental protection factors (5 indicators)					
Indicator name	World Bank Sub-Group	Load value after rotation	Indicator name	World Bank Sub-Group	Load value after rotation
Social contributions (% of income)	public sector	0.922	Area of terrestrial and marine protected areas (% of total territory)	Environment/climate change	0.820
Percentage of male and female secondary school teachers trained (%)	teach	0.897	Marine protected areas (per cent of occupied sea)	Environment/climate change	0.818
Area of terrestrial protected areas (% of total land area)	Climate change/environment	0.820	/	/	/
C11 Land resource factor (6 indicators)					
Indicator name	World Bank Sub-Group	Load value after rotation	Indicator name	World Bank Sub-Group	Load value after rotation
HIV prevalence, males (per cent of 15-24 year olds)	Health/social development/gender	0.959	Area of land below 5 metres above sea level	Climate change/environment	0.907

			(% of total land area)		
Urban land area below 5 metres above sea level (% of total land area)	Urban development/environment/climate change	0.908	Area of rural land below 5 metres above sea level (percentage of total land area)	Agriculture and rural development/climate change/environment	0.906
Urban population living below 5 metres above sea level (% of total population)	Urban development/environment/climate change	0.908	Rural population living below 5 metres above sea level (% of total population)	Agriculture and rural development/climate change/environment	-0.852
C12 cost of funds factor (2 indicators)					
Indicator name	World Bank Sub-Group	Load value after rotation	Indicator name	World Bank Sub-Group	Load value after rotation
Interest payments (percentage of costs)	public sector	-0.907	Interest payments (percentage of income)	public sector	-0.920
C13 Resilient Environment Factor (3 fingerprints)					
Indicator name	World Bank Sub-Group	Load value after rotation	Indicator name	World Bank Sub-Group	Load value after rotation
Basic health services coverage index	well-being	0.817	Alternative and nuclear energy (per cent of total energy use)	Energy and minerals	-0.798
Net energy imports (per cent of energy use)	Energy and minerals/trade	-0.784	/	/	/