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The econometric model with energy-saving effect of LSD and its application to industrial structure*

Xiaocui Song[2], Zhibin Wu[2], Jiuping Xu[1,2†]

[1] Low-carbon Technology and Economy Research Center, Sichuan University, Chengdu 610064, P. R. China
[2] Uncertainty Decision-Making Laboratory, Sichuan University, Chengdu 610064, P. R. China

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Abstract. Low carbon economy has been becoming a hot issue worldwide, and China is playing an important role in the development of low-carbon economy. Economic growth and energy demand are closely related, and energy-saving to industrial structure is significant in the low-carbon development. In order to analyze the economic structure of the system, forecast the trend of its economic development and energy demand, reducing carbon emissions, this paper uses econometric models combining historical data with present situation. LSD, the city we have chosen has been, is one of the most representative cities on the low carbon economy in China. A clear understanding of the relation between energy demand and economic structure would help planners to understand the implications of changes in the exogenous variables when the underlying relationships are fairly stable. Analyzing the application results, we deeply hope this can offer useful suggestions for other areas like LSD.

Keywords: structural analysis, economic forecasting, econometric model, energy-saving, energy demand

1 Introduction

To the end of this century the average global temperature will likely continue to rise by 1.8 degrees to 4 degrees[17]. Low carbon economy, as a development strategy to reduce global warming and an effective way of controlling greenhouse gas emissions, is gradually accepted by all countries, and evolved into a new development direction, which guides the human production and consumption patterns change[12].

Economic models are a simplified abstraction of a complex real world[20], which is an effective tool for studying regional economic development trends and analyzing economic structure. As changes and development of economic system structure are both results of the internal interaction of the productive force elements and the interaction between system and external environmental related factors, change and development is full of complexity and randomness. Energy end-use models are best suited for short-term energy forecast if the stock of appliances and their average energy consumption are readily available. Univariate time series analysis can also be used for energy analysis but they consider the energy consumption of the immediate past only. Mathematical programming methods are also used to forecast long-term energy requirements. These models, however, do not explicitly consider the macro economic parameters for analysis.

Rao and Parikh[14] mentioned that econometric models are effective in analyzing energy consumption pattern in developing countries. Econometric models are used for forecasting energy demand in many countries[11]. Examples of development of such models can be seen in [7, 16, 18, 19]. These models consider the impact of exogenous variable on energy requirement to forecast energy demand in gross terms for 5-10 years period. A lot of studies have been done on Chinas energy, including those conducted by [1, 2, 4]. There

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† Corresponding author. Tel.: +86 28 85418522. *E-mail address*: xujiuping@scu.edu.cn.

are few studies emphasizing on the relationships of economy and energy by modeling the components simultaneously. An integrated econometric model consisting of macroeconomic sub-model, energy sub-model and environment sub-model[7], sustainable energy strategies in China[8], renewable energy utilization[3], China's energy efficiency[5, 6], but there are few studies focusing on the relations of industrial structure and energy in regional areas.

The energy supply and demand pattern has a great impact on the possibility of attaining a sustainable energy scenario[13]. The energy-saving sub-block is classified into fuel equations and consumption sector equations. Commercial energy sources, such as electricity, petroleum products, natural gas and coal are generally considered for energy modeling studies due to their high market value and increasing and widespread use in economic activities. On one hand, energy situation depends on the historical pattern, whereas on the other hand, when the economic structure changes, it can also have a bearing on energy supply and demand situation. In order to achieve low-carbon economy, need to focus on energy-saving to industrial structure, reducing carbon emissions.

In order to analyze the economic structure, forecast the trend of the industrial structure and energy demand under low carbon economy, this paper uses econometric model with energy-saving effect in LSD. Energy and industrial structure analysis from the historical data generally provides a basis for forecasting short, medium and long-term energy demand projections till 2020.

2 Econometric model for energy-saving effect

It is necessary to understand the relation between different economic parameters and historical consumption record to understand the implications of the changing economic structure on the energy sector. The modeling follows the principle of macro, foreseeability and operational.

2.1 Model structure

According to the principles and objectives of modeling and model of the functional requirements, econometric system is divided into four parts, namely, production, investment, social spending and energy-saving. The model can be composed of five blocks, including the sub-block of social production, the sub-block of social construction, the sub-block of national income and consumption, the sub-block of human resources and the sub-block of energy-saving.

2.1.1 Definition of variables

Definition of variables in the econometric model for energy-saving can be seen in Appendix.

(1) Exogenous variable means a variable whose values are completely determined by the outside system under consideration, not immediately influenced by the mechanism described by the model, and they are treated as non-stochastic variables.
(2) Endogenous variable means a variable whose values are to be explained by the model and are immediately influenced by the mechanism described by the model. They are considered as stochastic variables and their values are determined by the model.

2.1.2 Explanation of variables

There are 57 variables in the model, and the following is the explanation of the mark (see Fig. 1).

A: The Scale of Primary Industry, B: The Scale of Secondary Industry, C: The Scale of Tertiary Industry, D: The Development of Science and Technology, E: Power of Gross Labor, F: Gross Population, G: Coefficient of Equations of Allocation of Resource; I: Social production, II: The Total Investment, III: Social construction, IV: National Income and Consumption, V: Energy Demand (Electricity, Coal, Petroleum and Natural gas), VI: Human Resources; (1) Scale of Farming, (2) Scale of Forestry, (3) Scale of Husbandry, (4) Scale of Fishery, (5) Scale of Industry, (6) Scale of Construction, (7) Scale of Wholesale and Retail Sale, (8) Scale of Real State, (9)

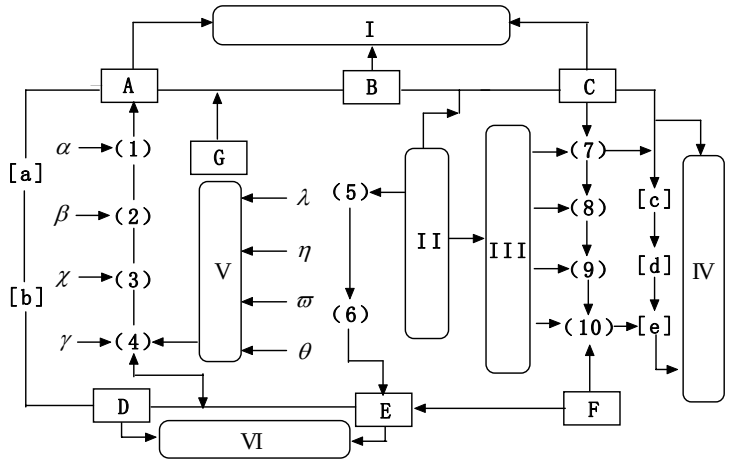

Fig. 1. Explanation of variables in econometric model for energy-saving effect

Scale of Finance and Insurance, (10) Scale of Catering Trade; [a] Primary Investment, [b] Primary Production Rate, [c] National Income, [d] Finance Expenditure, [f] Social Consume; α The Output of Farming, β The Output of Forestry, χ The Output of Animal Husbandry, γ The Output of Fishery; λ The Coal Demand, η The Electricity Demand, ϖ The Natural Gas Demand, θ The Petroleum Demand.

2.2 Equation system

Modeling mainly uses the least square method to identify the parameters of structural equation model, estimated parameters contain endogenous variables on the right side of the equation, if the actual sample values directly estimated, the result will be biased in inconsistent parameter estimates. The model tested from economic sense test, statistical test, and econometric analysis.

2.2.1 Social production sub-block

Combined with LSD, it is divided into primary industry: agriculture, forestry, husbandry and fisheries; the secondary industry is divided into industry and construction; the tertiary industry is divided into transportation, post and warehousing, wholesale and retail trade, catering, real estate, and financial sectors. Sub-block of social production is formed by Eqs. (1)∼(16):

(1) Gross domestic product

$$G = \text{Pri}_{\text{GDP}} + \text{Ind}_{\text{GDP}} + \text{Ter}_{\text{GDP}}. \tag{1}$$

(2) Gross domestic product of primary industry

$$GP_1 = GP_{11} + GP_{12} + GP_{13} + GP_{14}. \tag{2}$$

(3) Gross output value of farming

$$\begin{aligned} GP_{11} = &- 40920.285 + 0.425\text{food} + 1.762\text{fruit} \\ &(-2.737) \qquad (4.077) \qquad (6.446) \\ \text{Adjusted } R^2 = &0.856 \quad F = 20.803 \quad DW = 1.786. \end{aligned} \tag{3}$$

(4) Gross output value of forestry

$$\begin{aligned} GP_{12} = &- 2781.573 + 0.038\text{NJD} \\ &(-3.274) \qquad (7.654) \\ \text{Adjusted } R^2 = &0.856 \quad F = 20.803 \quad DW = 1.786. \end{aligned} \tag{4}$$

(5) Gross output value of husbandry

$$\begin{aligned} GP_{13} = &- 31133.415 + 2.119\text{pig} + 0.790\text{egg} \\ &(-1.781) \quad (2.356) \quad (1.285) \\ \text{Adjusted } R^2 = &0.986 \quad F = 180.089 \quad DW = 1.473. \end{aligned} \tag{5}$$

(6) Gross output value of fishery

$$\begin{aligned} GP_{14} = &- 322.946 + 0.918\text{fish} \\ &(-0.317) \quad (8.606) \\ \text{Adjusted } R^2 = &0.903 \quad F = 74.072 \quad DW = 1.450. \end{aligned} \tag{6}$$

(7) Value added of secondary industry

$$\text{Ind}_{\text{GDP}} = \text{GDP}_{21} + \text{GDP}_{22}. \tag{7}$$

(8) Value added of industry

$$\begin{aligned} \text{GDP}_{21} = &\text{EXP}(1.286)\text{SGZ}^{0.927} P_2^{-0.049} \\ &(2.758) \quad (23.689) \quad (-1.715) \\ \text{Adjusted } R^2 = &0.989 \quad F = 101.892 \quad DW = 2.212. \end{aligned} \tag{8}$$

(9) Value added of construction

$$\begin{aligned} \text{GDP}_{22} = &5529.244 + 0.099\text{SGZ} + 0.048P_2 \\ &(1.389) \quad (10.704) \quad (2.283) \\ \text{Adjusted } R^2 = &0.967 \quad F = 101.892 \quad DW = 2.212. \end{aligned} \tag{9}$$

(10) Value added of tertiary industry

$$\text{Ter}_{\text{GDP}} = \sum_{i=1}^{8} \text{GDP}_{3i}. \tag{10}$$

(11) Value added of transportation, post and telecommuniation

$$\begin{aligned} \text{GDP}_{31} = &6179.622 + 0.338\text{gtm} + 0.593\text{tpm} \\ &(186.572) \quad (13.793) \quad (5.199) \\ \text{Adjusted } R^2 = &0.967 \quad F = 66.143 \quad DW = 2.365. \end{aligned} \tag{11}$$

(12) Value added of wholesale and retail sale

$$\begin{aligned} \text{GDP}_{32} = &5529.244 + 0.099\text{SGZ} + 0.048P_2 \\ &(1.389) \quad (10.704) \quad (2.283) \\ \text{Adjusted } R^2 = &0.967 \quad F = 101.892 \quad DW = 2.212. \end{aligned} \tag{12}$$

(13) Value added of finance and insurance

$$\begin{aligned} \text{GDP}_{33} = &- 5572.977 + 435.158P + 0.006\text{GDP}(-1) \\ &(-8.371) \quad (12.152) \quad (6.518) \\ \text{Adjusted } R^2 = &0.989 \quad F = 1605.703 \quad DW = 2.392. \end{aligned} \tag{13}$$

(14) Value added of real estate

$$\begin{aligned} \text{GDP}_{34} =& -32107.125 + 0.967\text{csw} + 0.064\text{flr} \\ & (-7.460) \quad (0.900) \quad (8.454) \\ \text{Adjusted } R^2 =& 0.992 \quad F = 247.162 \quad DW = 1.507. \end{aligned} \tag{14}$$

(15) Value added of health and social security and welfare

$$\begin{aligned} \text{GDP}_{35} =& 826.014 + 0.015\text{FSR} \\ & (12.480) \quad (6.950) \\ \text{Adjusted } R^2 =& 0.945 \quad F = 48.506 \quad DW = 1.701. \end{aligned} \tag{15}$$

(16) Value added of catering trade

$$\begin{aligned} \text{GDP}_{37} =& 329.222 + 0.027PC_1 + 0.012\text{GDP}(-1) \\ & (7.287) \quad (4.761) \quad (4.005) \\ \text{Adjusted } R^2 =& 0.967 \quad F = 236.456 \quad DW = 2.357. \end{aligned} \tag{16}$$

2.2.2 Social construction sub-block

Regional economic development are inseparable from all aspects of the social construction, it is objective requirements of of expanding economic reproduction to increase elements investment and improve basic infrastructure development, as well as important means of achieving growth in social output. Main equations are as followed:

(1) Mechanical power in rural areas

$$\begin{aligned} \text{GDP}_{38} =& -57873.438 + 0.936\text{SXT} \\ & (-4.296) \quad (18.189) \\ \text{Adjusted } R^2 =& 0.976 \quad F = 300.822 \quad DW = 1.466. \end{aligned} \tag{17}$$

(2) Financial institution loans (year-end)

$$\begin{aligned} \text{FLR} =& 325630.276 + 15.241\text{GDP}_{34} \\ & (5.867) \quad (10.281) \\ \text{Adjusted } R^2 =& 0.955 \quad F = 105.695 \quad DW = 2.046. \end{aligned} \tag{18}$$

2.2.3 National income and consumption sub-block

Consumption is force of driving regional economic growth, full employment, mainly expressed by the total amount of consumer goods. This model includes national income, financial revenue, social goods consumption, financial institution deposits and so on, made up of the following equations.

(1) Per capita GDP

$$\text{GDP}_a = \frac{\text{GDP}}{P}. \tag{19}$$

(2) Total retail sales of social consumer goods

$$\begin{aligned} \text{SXT} =& -105846.997 + 0.663PW_3 + \text{GDP}_{32} \\ & (-2.941) \quad (1.301) \quad (18.844) \\ \text{Adjusted } R^2 =& 0.997 \quad F = 587.053 \quad DW = 1.598. \end{aligned} \tag{20}$$

(3) Local fiscal revenue

$$FI = -4682.272 + 0.66\text{SXT}$$
$$(-3.722) \quad (13.802)$$
$$\text{Adjusted } R^2 = 0.960 \quad F = 190.500 \quad DW = 1.895. \tag{21}$$

(4) Financial institution deposits (year-end)

$$\text{FSR} = -203685.435 + 70169.209\text{time} + 1.592\text{GDP}(-1)$$
$$(-2.941) \qquad (1.301) \qquad (18.844)$$
$$\text{Adjusted } R^2 = 0.997 \quad F = 587.053 \quad DW = 1.879. \tag{22}$$

(5) Local fiscal expenditure

$$FO = -\,7225.292 + 0.367\text{GDP}(-1)$$
$$(-7.150) \qquad (19.367)$$
$$\text{Adjusted } R^2 = 0.977 \quad F = 276.465 \quad DW = 2.364. \tag{23}$$

2.2.4 Energy-saving sub-block

The energy-saving sub-block is classified into fuel equations and consumption sector equations. As the economic value of coal, petroleum products, natural gas and electricity is significant, econometric models are developed for these fuels. The consumption sectors are developed for all major energy consuming sectors, and such sectors can highlight energy requirements in each sector and provide a more plausible method of forecasting energy demand related to economic and social factors. So the planners would be able to foresee the implication of forecasted changes in fuel requirements.

(1) Agriculture sector demand

$$\ln(\text{ASD}) = -\,4.239 + 1.290\ln(\text{Pri}_{\text{GDP}})$$
$$(-5.562) \qquad (11.675)$$
$$\text{Adjusted } R^2 = 0.955 \quad F = 136.317 \quad DW = 2.112. \tag{24}$$

(2) Industrial sector demand

$$\ln(\text{ISD}) = 6.525 - 0.407\ln(PC_1) + 0.701\ln(\text{Ind}_{\text{GDP}})$$
$$(22.514) \quad (-2.703) \qquad (5.729)$$
$$\text{Adjusted } R^2 = 0.986 \quad F = 205.68 \quad DW = 2.108. \tag{25}$$

(3) Service sector demand

$$\ln(\text{SSD}) = 0.501 + 0.668\ln(\text{Ter}_{\text{GDP}})$$
$$(2.706) \qquad (16.442)$$
$$\text{Adjusted } R^2 = 0.977 \quad F = 136.346 \quad DW = 1.813. \tag{26}$$

(4) Transportation sector demand

$$\ln(\text{TSD}) = -\,3.540 + 1.206\ln(TV) + 1.142\ln(PC_1)$$
$$(-7.994) \qquad (6.201) \qquad (9.089)$$
$$\text{Adjusted } R^2 = 0.981 \quad F = 270.346 \quad DW = 1.897. \tag{27}$$

(5) Residential sector demand

$$\begin{aligned}\ln(\text{RSD}) =& 51.573 + 0.849\ln(PC_1) - 4.206\ln(P_2) - 1.902\ln(P_1)\\ &(2.726) \quad (3.751) \quad (-3.023) \quad (-2.149)\\ &\text{Adjusted } R^2 = 0976 \quad F = 50.600 \quad DW = 2.064.\end{aligned} \tag{28}$$

(6) Total energy demand

$$\text{TED} = EC + CC + NSC + PC. \tag{29}$$

(7) Electricity demand

$$\begin{aligned}\ln(ED) =& -13.411 + 0.629\ln(\text{Ind}_{\text{GDP}}) + 0.196\ln(P_2) + 1.587\ln(P_1)\\ &(-85.408) \quad (411.595) \quad (48.474) \quad (91.753)\\ &\text{Adjusted } R^2 = 0.999 \quad F = 362.406 \quad DW = 1.732.\end{aligned} \tag{30}$$

(8) Coal demand

$$\begin{aligned}\ln(CD) =& -13.171 + 0.677\ln(\text{Ind}_{\text{GDP}}) + 1.694\ln(P_1)\\ &(-3.379) \quad (16.922) \quad (8.824)\\ &\text{Adjusted } R^2 = 0.999 \quad F = 462.413 \quad DW = 1.749.\end{aligned} \tag{31}$$

(9) Natural gas demand

$$\begin{aligned}\ln(\text{NSD}) =& -1.339 + 0.723\ln(\text{Ind}_{\text{GDP}})\\ &(-3.267) \quad (9.534)\\ &\text{Adjusted } R^2 = 0.984 \quad F = 90.905 \quad DW = 2.109.\end{aligned} \tag{32}$$

(10) Petroleum demand

$$\begin{aligned}\ln(PD) =& -0.272 + 0.661\ln(\text{Ind}_{\text{GDP}}) + 0.206\ln(\text{Pri}_{\text{GDP}})\\ &(-3.740) \quad (3.155) \quad (7.689)\\ &\text{Adjusted } R^2 = 0.986 \quad F = 139.608 \quad DW = 1.806.\end{aligned} \tag{33}$$

2.2.5 Human resources sub-block

This module analyzes the population and industry employment composition of LSD.

(1) Total population (year-end)

$$\begin{aligned}P =& -520385.324 + 4564.055\text{time} + 7851.039\text{GDP}_a\\ &(224.706) \quad (5.809) \quad (1.461)\\ &\text{Adjusted } R^2 = 0.984 \quad F = 213.407 \quad DW = 1.780.\end{aligned} \tag{34}$$

(2) Agriculture population (year-end)

$$\begin{aligned}P_1 =& -1.249 + 0.964P - 0.105\text{time}\\ &(-0.401) \quad (5.352) \quad (-261)\\ &\text{Adjusted } R^2 = 0.967 \quad F = 67.392 \quad DW = 2.201.\end{aligned} \tag{35}$$

(3) Number of employed persons

$$\begin{aligned}PW =& 278467.581 + 1293.581\text{time}\\ &(18.314) \quad (5.536)\\ &\text{Adjusted } R^2 = 0.937 \quad F = 60.649 \quad DW = 2.168.\end{aligned} \tag{36}$$

(4) Number of employed persons in primary industry

$$\begin{aligned} PW_1 =& 1471152.874 + 10.041PW \\ & (63.185) \qquad (6.223) \\ \text{Adjusted } R^2 = 0.917 \quad & F = 48.724 \quad DW = 1.873. \end{aligned} \tag{37}$$

(5) Number of employed persons in tertiary industry

$$\begin{aligned} PW_3 =& 61034.355 + 5234.355\text{time} \\ & (8.852) \qquad (5.024) \\ \text{Adjusted } R^2 = 0.923 \quad & F = 25.244 \quad DW = 2.209. \end{aligned} \tag{38}$$

2.3 Analysis of model structure

In the model equation system, a total of 38 equations, with 6 balance equation. Parameter estimation in model equations, selects time series samples of 10, all through t test, F test and the DW test. Based on forecast and comprehensive analysis, individual parameters having been further minor adjusted, make the accuracy of the model satisfactory and the reliability has reached the expected requirements. The structural equation system mainly has the following characteristics, including integrity and dynamism. Model can more fully reflect economic development and energy demand, and dynamic nature of the socio-economic system, to ensure stable development of model forward.

3 Empirical study

3.1 Date sources

Primary data are collected from "LSD Statistical Yearbook", "LSD Fixed Asset Investment Statistical Yearbook", "LSD Labor Statistical Yearbook", "LSD Environment Yearbook" and other official statistics. The uncertainty from the reliability of official LSD statistics could not be under-estimated. In the sample data, we use current prices to calculate. Many studies such as Maddison (1997) [9], Rouen (1996) [15] and Meng and Wang (2000) [10] found that the average annual GDP growth was overstated and cast doubt on official GDP statistics. In this study, the understatement of energy is taken into account for simulation analysis, but the overstatement of GDP growth. Through a careful analysis of established model equations, the characteristics of economic development and energy demand in the LSD can be reflected.

3.1.1 Structure analysis

Analysis in the model, the secondary and tertiary industries are the key. The key of leading low-carbon development in LSD is how to apply policy guidance and overall planning to regulate the amount of investment.

(1)Value added of primary industry can be explained by output value of farming, forestry, animal husbandry and fishery, and the results is consistent with the actual situation by testing. In agriculture, under the premise of maintaining the steady growth of grain output, LSD should actively explore the potential of a variety of economic crops such as fruit. In recent years, livestock development is very good, LSD can give priority to breeding pigs and cows, while maintain the natural growth of forestry and fishing industry over time basically.

(2) In the secondary industry, industry is dominant, and LSD has a good industrial base and technical power. The production of energy-intensive goods increased sharply, mainly driven by booming construction in infrastructure and real estate. Although the secondary industry consume energy mostly, its development promote the development of other industries such as transportation, service, finance. Therefore, to achieve a low carbon economy, the development of secondary industry must be properly, and the further development should increase investment in energy-saving technologies and improve the quality of employees.

(3) To achieve the rapid development of tertiary industry, should increase total government spending, improve the market economic mechanism, rich social goods, and efforts to improve urban and rural living. As the secondary industrial consume more energy, so LSD should support more on the tertiary sector, promote the low carbon economy development of LSD, which is rich in tourism. Tourism as a sunrise industry, after decades of rapid development, has become one of the society's most important industry. It is an indisputable fact that Leshan Giant Buddha, Ma Hao Tomb and other attractions are in the LSD officially, bring the invisible gravitational for the development of tourism in LSD. Therefore, tourism development in LSD still need to launch a publicity and marketing based on the influence of Leshan Giant Buddha, using the platform of Natural and Cultural Heritage to develop and design tourism product. LSD can further highlight the integration of tourism resources, and enhance overall competitiveness. The rapid development of tourism will lead the rapid development of tertiary industry, and the development of tourism contributes to low carbonization.
(4) According to energy consumption, coal is the major energy source in LSD, more than electricity and petroleum. The industry sector consumption is the main sector for energy consumption. Residential sector consumption is more than the agriculture, service and transportation sectors. For the energy-saving development, more comprehensive measures should be adopted, including improvements in energy efficiency, more rapid energy switching from coal to natural gas and renewable energy sources, imposing carbon tax, development of clean coal technology.

3.1.2 Development forecasting

The higher GDP growth rate in LSD is attributed to a increase in estimated investments. So in order to forecast energy demand and industrial structure based on the model, two new scenarios, are proposed here. Both scenarios are based on business as usual concept as they use trend analysis of explanatory variables for energy projections, and the current trends affecting energy demand will keep in place. Scenario 1 with a total estimated investments of 100 billion, and average growth in GDP at 11%. The Scenario 2 with a total estimated investments of 150 billion, and average growth in GDP at 13%.

Table 1. Forest of industry structure and energy demand in Scenario 1

Year	Investment	GDP	Pri_{GDP}	Ind_{GDP}	Ter_{GDP}	TED	ED	CD	NSD	PD
2011	732550	1249804	146214	560334	543256	1544194	160575	1122026	55108	206486
2012	762347	1431839	165456	580334	686049	1675512	183055	1200568	68885	223005
2013	792143	1564107	179548	600334	784225	1842114	210514	1308619	79906	243075
2014	851946	1674040	183250	640138	850652	2026076	246301	1413309	99084	267382
2015	950200	1860555	202350	705320	952885	2205651	280783	1512240	123855	288773
2016	1054603	1990096	210056	774560	1005480	2429676	322900	1648342	143671	314763
2017	1129813	2250989	220630	824533	1205826	2682394	377793	1780209	178152	346239
2018	1253308	2520576	239050	894508	1387018	2932137	430685	1904824	222691	373938
2019	1319955	2726179	268895	950695	1506589	3237459	495287	2076258	258321	407592
2020	1500509	3173385	295268	1070195	1807895	3590514	579486	2242359	320318	448352

The projected data for energy demand by fuel type and industrial development are given in Tabs. 1 and 2. For Scenario 1, the share of energy demand in other industries would rise, with largest increase in share in tertiary industry (14%); while the primary and secondary industries are at the growth rate of 8% and 9%. Compared with Scenario 1, investment growth has the most obvious effect on the secondary industry, with 14%, while the primary and tertiary industries are at the growth rate of 13% and 11% in Scenario 2.

Tabs. 1 and 2 also shows that for both scenarios, the energy demand would increase mainly because of increased estimated investments. The average growth of total energy demand is 10% in Scenario 1, much lower than Scenario 2, with growth of 15%. Compared with Scenario 1, energy demand in all fuels would be higher in Scenario 2. The forecast results show that coal would still be the major energy supplier in the projection

periods in both Scenarios. The growth rate of natural gas is the highest (23%), electricity demand increasing rapidly (16%) in Scenario 1. Coal consumption is expected to double between 2010 and 2020 under Scenario 1, however, the growth is more significant under Scenario 2. Although the share of coal in total energy demand would decrease in Scenario 1, there would not be such a remarkable adjustment in Scenario 2.

Table 2. Forest of industry structure and energy demand in Scenario 2

Year	Investment	GDP	Pri_{GDP}	Ind_{GDP}	Ter_{GDP}	TED	ED	CD	NSD	PD
2011	743887	1488803	167980	728993	591830	1620311	186184	1184361	56885	192881
2012	878996	1721244	197786	851724	671734	1855015	223421	1338328	73382	219884
2013	1025751	1974944	230656	985984	758303	2134708	254700	1539077	92461	248469
2014	1184150	2249901	266589	1131772	851540	2454277	303093	1754548	118351	278285
2015	1354195	2546116	305585	1289089	951442	2816269	363712	1982639	152672	317245
2016	1535884	2863590	347645	1457935	1058011	3245521	414632	2280035	192367	358487
2017	1729219	3202322	392767	1638308	1171246	3740387	493412	2599240	246230	401506
2018	1934198	3562312	440953	1830211	1291148	4304588	592094	2937141	317637	457716
2019	2150822	3943560	492202	2033642	1417716	4970141	674987	3377712	400222	517219
2020	2379091	4346066	546514	2248601	1550951	5745397	803235	3850592	512285	579286

Scenario 1 would represent an optimistic condition of low-carbon development, while Scenario 2 is the pessimistic condition. For the economic development with energy-saving, the Scenario 1 is more effective, as the tertiary industry develops better. Pursuit of "efficient investment", "efficient investment", "green investment", and investment in upgrading and optimization, play a significant role in the development of low-carbon economy. Scenario 1 does better in the planned energy objectives, such as development of renewable energy and nuclear power generation, energy saving, and the planned energy-related measures will be implemented. The government will take stronger action in energy conservation, switching from coal to non-fossil fuels and oil substituting, promoting structural adjustment in consumption sector.

4 Conclusion

It is hard to find a way to resolve the sustainability issues simultaneously and perfectly, as economic growth and energy demand are closely related. This paper apply econometric modeling to energy-saving of industrial structure in LSD, analyze and forecast the trend of the economic system and energy demand. For the low-carbon development, more comprehensive measures should be adopted, including improvements in energy efficiency, more rapid energy switching from coal to natural gas and renewable energy sources, imposing carbon tax, development of clean coal technology, establishment of strategic petroleum stockpiling, enforcement of air protection, etc. In future, we may do more research under the fuzzy state when forecasting the trend of energy-saving to industrial structure.

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Appendix

Variable type	Mark	Meaning	Unit
Endogenous variable	food	grain output	T
Endogenous variable	fruit	fruit output	T
Endogenous variable	pig	pig production	T
Endogenous variable	egg	egg production	T
Endogenous variable	fish	aquatic products	T
Endogenous variable	DJD	mechanical power in rural areas	kilowatt
Endogenous variable	gtm	cargo	10^4 T
Endogenous variable	ptm	passengers	10^4 RMB
Endogenous variable	fai	average annual income of farmers	RMB
Endogenous variable	csw	disposable income of urban residents	RMB
Endogenous variable	FI	local fiscal revenue	10^4 RMB
Endogenous variable	FSR	financial institution deposits (year-end)	10^4 RMB
Endogenous variable	FLR	financial institution loans (year-end)	10^4 RMB
Exogenous variable	FO	local fiscal expenditure	10^4 RMB
Exogenous variable	SGZ	total complete investment in fixed assets	10^4 RMB
Endogenous variable	TED	total energy demand	Tce
Endogenous variable	ASD	agriculture sector demand	Tce
Endogenous variable	ISD	industrial sector demand	Tce
Endogenous variable	SSD	service sector demand	Tce
Endogenous variable	TSD	transportation sector demand	Tce
Endogenous variable	RSD	residential sector demand	Tce
Exogenous variable	PC_1	private consumption	10^4 RMB
Endogenous variable	Ser_{GDP}	value added of service	10^4 RMB
Exogenous variable	TV	total vehicles	10^4V
Endogenous variable	ED	electricity demand	Tce
Endogenous variable	CD	coal demand	Tce
Endogenous variable	NSD	natural gas demand	Tce
Endogenous variable	PD	petroleum demand	Tce

Table 3. Variables and definitions

Variable type	Mark	Meaning	Unit
Endogenous variable	GDP	gross domestic product	10^4 RMB
Endogenous variable	Pri_{GDP}	value added of primary industry	10^4 RMB
Endogenous variable	Ind_{GDP}	value added of secondary industry	10^4 RMB
Endogenous variable	Ter_{GDP}	value added of tertiary industry	10^4 RMB
Endogenous variable	GP_1	gross output value of farming, forestry, animal husbandry and fishery	10^4 RMB
Endogenous variable	GDP_{11}	gross output value of farming	10^4 RMB
Endogenous variable	GDP_{12}	gross output value of forestry	10^4 RMB
Endogenous variable	GDP_{13}	gross output value of husbandry	10^4 RMB
Endogenous variable	GDP_{14}	gross output value of fishery	10^4 RMB
Endogenous variable	GDP_{21}	value added of industry	10^4 RMB
Endogenous variable	GDP_{22}	value added of construction	10^4 RMB
Endogenous variable	GDP_{31}	value added of transportation, post and telecommuniation	10^4 RMB
Endogenous variable	GDP_{32}	value added of wholesale and retail sale	10^4 RMB
Endogenous variable	GDP_{33}	value added of finance and insurance	10^4 RMB
Endogenous variable	GDP_{34}	value added of real estate	10^4 RMB
Endogenous variable	GDP_{35}	value added of health and social security and welfare	10^4 RMB
Endogenous variable	GDP_{36}	value added of public management and social organization	10^4 RMB
Endogenous variable	GDP_{37}	value added of catering trade	10^4 RMB
Endogenous variable	GDP_{38}	other value added services	10^4 RMB
Endogenous variable	P	total population (year-end)	person
Endogenous variable	P_1	agriculture population (year-end)	person
Endogenous variable	P_2	non-agriculture population (year-end)	person
Endogenous variable	GDP_a	per capita	RMB
Endogenous variable	PW	number of employed persons	person
Endogenous variable	PW_1	number of employed persons in primary industry	person
Endogenous variable	PW_2	number of employed persons in secondary industry	person
Endogenous variable	PW_3	number of employed persons in tertiary industry	person
Endogenous variable	SXT	total retail sales of social consumer goods	10^4 RMB
Endogenous variable	time	time variable	1999 year=1