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Research on the Prediction Model of Copper Consumption in China Based on Piecewise Curve-fitting Method

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1 Introduction

As an important non-ferrous metal, copper is widely used in manufacturing and living fields and the change of demand for copper is closely related to a country's industrialization process. The forecast analysis on the variation on copper demand has very important academic and practical significance. Now, scholars from home and abroad have carried out some research and exploration on the prediction of copper consumption, social accumulation, the relationship between copper consumption and economic development. These explorations include: comparative analysis of Sino-US copper consumption per unit of GDP, the relationship of economic growth and copper consumption during Chinese industrialization process (Yue and Lu, 2007), the relationship of copper consumption and GDP (Xu et al., 2010) and through the in-depth analysis on various elements of economic and social development in dozens of countries and regions which include earlier industrialized countries, new-pattern-industrialized countries and developing countries, building an S Law-Curve about per capita resource consumption and per capita GDP (Wang et al., 2010). On the basis of these studies, the article establishes the Chinese copper consumption forecast model choosing the per capita consumption of copper and the per capita GDP as core indexes, selecting copper consumption data samples during the past 23 years of China, setting up 3 prediction intervals of per capita GDP and using the piecewise curve-fitting method.

2 The Piecewise Curve-fitting Method

It is difficult for us to obtain the real curve $f(x)$, so we often replace it by fitting curve $\varphi(x)$. In curve fitting, we

often employ the least square method. when the formula

$$\sum_{i=1}^m [f(x_i) - \varphi(x_i)]^2$$

reaches its minimum and the $\varphi(x)$ is infinitely close to the $f(x)$, we can replace the real $f(x)$ by $\varphi(x)$ to do some predictions. To predict copper consumption for a short time, we can use the one-fitting method. However, long-term copper consumption of a country varies from its different developmental stages. We can learn that from the agricultural society to industrial society, and then post-industrial society, the per capita consumption of copper and per capita GDP present a full cycle of an S-Curve pattern, which means that per capita consumption of copper resources grows slowly in agrarian society, grows rapidly at the stage of industrialization development and shows a slow downward trend during the post-industrialization period (Chen et al., 2010). If we fit the whole cycle just once, the result is not ideal. Therefore, we can use the piecewise fitting method (Cai et al., 2007; Hou et al., 2011). Steps are as follows: firstly, according to the statistics of per capita consumption of copper and per capita GDP in a country during a period of time, we can fit a curve; secondly, according to the trend of the curve (i.e. The inertia of the copper consumption) and the industrialization process of a country, we set up two inflection points (i.e. the prediction interval is between the two inflection points); thirdly, we fit the prediction interval; fourthly, we repeat step 2 and step 3 until all the prediction intervals are fitted.

3 The Prediction Model of Copper Consumption of China

3.1 Data

In order to systematically analyze the change of Chinese copper demand, the article selects Chinese per capita copper consumption and per capita GDP from 1990 to 2003 as sample data. The per capita GDP is calculated in the price of 2008. We select the data sample about nearly a century of copper and the economic and social

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development of some countries having similar industrialization development model with China, such as Germany, Japan, Korea and Taiwan of China. The S Curve Law shows that in these industrialized countries and regions, the copper consumption takes off in the point of per capita GDP 3000 U.S dollars, the turning point is located at per capita GDP \$10000–\$12000, and the zero growth point is located at per capita GDP \$17000–\$20000 (Chen et al., 2010). According to this conclusion, we set up \$5000 to \$12000, \$10000 to \$18000 and \$17000 to \$20000 as three prediction intervals about per capita GDP.

3.2 Modeling

The first step: according to the sample data on Chinese per capita copper consumption and per capita GDP in the past 23 years, we fit a curve to establish a function of per capita copper consumption and per capita GDP.

The second step: we set up \$5000 to \$12000, \$10000 to \$18000 and \$17000 to \$20000 as three prediction intervals about per capita GDP; we work out the probability distribution of the sample data of Germany, Japan, Korea and Taiwan of China in these different prediction intervals, and by using the same probability distribution, we find the random points in different prediction intervals; according to the data from the former fitting curve and the random points in this part, we fit the curve step by step.

The third step: after getting curves of all the prediction intervals, we fit them again. In the end, we get the trend chart of China's per capita consumption of copper, as is shown in Fig. 1, “*” represents the scatter diagram of the sample data on Chinese per capita copper consumption and per capita GDP in the past 23 years. The equation of fitting curve is shown as the formula 1, and x represents the per capita GDP, y represents the per capita

consumption of copper.

$$77.5675x^2 + 33.609x - 1.2391 \quad (1)$$

4 Conclusions

(1) There is a strong positive correlation between per capita consumption of copper and per capita GDP in China.

(2) Chinese turning point on per capita consumption of copper is around \$8000 of per capita GDP. Before the turning point, per capita consumption of copper grows rapidly, while after the turning point, the growth of per capita copper consumption shows a slow growth trend. When per capita GDP at about \$17000, per capita copper consumption will peak, approaching 19Kg. After the peak, the copper consumption will decline.

(3) China is in the mid-industrialization period, enjoying a rapid growth of GDP, and we can learn that China will have a huge demand for copper in the future. It is important for us to care about the equipment of copper resources and the exploitation and utilization of secondary copper resources. We should actively look for alternative sources of copper to meet Chinese greater demand for copper in the future.

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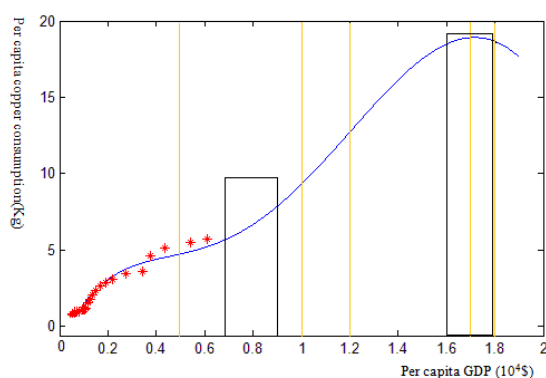


Fig. 1. Per capita copper consumption and per capita GDP.

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