Analysis of the Driving Forces of Influence Factors on China’s Steel Output

Cheng-kang GAO, You-xuan WEI*, Zhou YE and Meng-hui ZHANG
SEPA Key Laboratory on Eco-industry, Northeastern University, Shenyang, Liaoning, China
*Corresponding author

Keywords: Steel output forecast, Influence factor, Driving forces, Industry ecology.

Abstract. The paper aims at analyzing the steel output and consumption in China from 2016 to 2020 and to demonstrating the main driving forces that influence our country’s steel output. The value of $H$ was used as a key link in steel forecast; the steel in use was calculated by the value of GDP and $H$, then steel output was obtained, at last we got steel consumption by the quantitative relationship of steel consumption and output. Results showed that the value of GDP, $H$ and $\Delta \tau$ are all influence factors on steel output. Steel output grew when the value of GDP was increased and their growth rates were positive correlated, steel output declined when $H$ and $\Delta \tau$ were increased, but the main influence factor was GDP. The way to minimize steel output is to decrease GDP increase rate, grow the value of $H$ and raise average service life of steel at the same time.

Introduction

The forecasts of China’s steel output are the important basis for making decisions and policies on Iron and Steel industry. While the main forecast methods at present are the forecast based on artificial neural networks[1] and time series analysis[1~5]. Meanwhile, there is other method such as input-output analysis, a scholar at Tsinghua University made the forecast that whether the steel output in China will become disintegrated before 2050 on industry life cycle method [6]. Wu Xinchun used Verhulst model build the relationship of steel consumption and time then predicted that the steel consumption in China will arrive peak value in 2015[7] while Xing Yin et al. who used the forecast model (similar to stock model) stated it will be 2025[8].

The method presented in this paper is different from all the models mentioned above. We forecasted the steel output in three steps and illustrated driving forces of different factors, finally proposed the countermeasures that help steel industry in China developing sustainable.

Theoretical Method

Basic Concepts[9]

(1) $\Delta \tau$: average service life of steel, the unit is year. It refers to weighted average value of the steel products towards various industries.

\[
\Delta \tau = \sum_{i=1}^{n} \frac{C_i}{C} \sum_{j=1}^{k} \frac{C_{ij} \Delta \tau_{ij}}{C_{ij}}
\]

(1)

$C_i$ is steel consumption from industry $i$; $C$ is total steel consumption of the corresponding year; $\Delta \tau_{ij}$ is lifetime of steel product from the $j$ category in $i$ industry.

(2) $S$: steel in service. It refers to the total amount of steel from all sorts of iron and steel products (e.g. buildings, infrastructure, vehicles, articles, etc). So the way to calculate $S$ of the $\tau$ year is the sum of steel output from the $\tau - \Delta \tau$ year to the $\tau$ year.
\[ S_\tau = P_\tau + P_{\tau-1} + P_{\tau-2} + \ldots + P_{\tau-2n+1} = S_\tau = \sum_{i=\tau}^{r-3n+1} P_i. \] 

(2)

\( P_\tau \) refers to steel output of the \( \tau \) year.

(3) \( H \): GDP engendered by unit steel in service, it is the ratio of GDP and \( S_\tau \).

\[ H = \frac{G_\tau}{S_\tau}. \] 

(3)

**Forecasting Procedures of Steel Output**

\[ S_\tau = \frac{G_\tau}{H} \]

\[ P_\tau = S_\tau - S_{\tau-1} + P_{\tau-\Delta \tau} \]

\[ Y_\tau = f(P_\tau) \]

Figure 1. Forecasting procedures.

The first step is figure out \( S_\tau \) by GDP and the value of \( H \) over the years. Then the steel output of corresponding year can be calculated by formula (2). Bring the value of steel output into the fitting formula will get the value of steel consumption.

**Steel Output Forecasting of Different Scenarios**

**Service Life of Steel Products and the Value of \( H \)**

![Graph](image)

Figure 2. The average service life of steel and the value of \( H \) over the years.

Since the data collection for the actual service life of steel products was fussy and was quite different to deal with, we calculated \( \Delta \tau \) based on depreciable lives of some fixed assets that can be found in Enterprise Income Tax Law of PRC. So \( \Delta \tau \) of each year can be got from formula (1) based on downstream outputs and depreciable lives.

It can be seen in Figure 2 that service life increased dramatically from 2000 to 2005 which mainly due to the sharp increase of the new construction area in China. Because the expected life of new constructions is much higher than that of other steel consumed industries, so this some extent
made the increase of life expectancy. After 2005 the service life decreased sharply, the reason is the large amount of dismantlement and moving work during these years, many buildings were demolished when their working lives were still far less than expected.

**Effect of Every Parameter on Steel Output**

The cases were all evolved from basal scenario \((g=0.07, \ H=9.45 \times 10^3 \text{yuan/t}, \ \Delta \tau =15 \text{ years})\), and the values of basal scenario were determined from development trend in Figure 2. First case indicated that steel output will increase when GDP increases. While \(g\) is 0.13, 0.07 and 0.01 respectively, China’s steel output in 2020 reaches \(19.69 \times 10^8 \text{t}, 10.17 \times 10^8 \text{t} \) and \(4.27 \times 10^8 \text{t}\) respectively, the growth is 32%, 55% and 73% respectively. The second case indicated that steel output will increase when the value of \(H\) reduces. While \(H\) is \(10 \times 10^3, 9.45 \times 10^3\) and \(8 \times 10^3 \text{yuan per t}\), China’s steel output reaches \(9.8 \times 10^8 \text{t}, 10.17 \times 10^8 \text{t} \) and \(11.37 \times 10^8 \text{t}\) in 2020. The way to increase \(H\) is adjusting the structure of industries and product, improving the technological and managerial level. The third case indicated that the raise of \(\Delta \tau\) can lessen steel output. While \(\Delta \tau\) is 10 years, 15 years and 20 years respectively, steel output will be \(13.00 \times 10^8 \text{t}, 10.17 \times 10^8 \text{t}\) and \(7.90 \times 10^8 \text{t}\) in 2020, the growth is 30%, 55% and 40% respectively. The steel output can be decreased 20% with 20 years more in \(\Delta \tau\), while the same effect can be achieved by reducing \(g\) by 0.06, therefore the driving force of GDP is bigger than \(\Delta \tau\).

**Determination of the Four Scenarios**

We designed the following four scenarios based on factor variation trends from Figure 3.

![Figure 3. Effect of different parameters on steel output.](image)

- **Figure 3a.** \(g\) was changed, **Figure 3b.** \(H\) was changed, **Figure 3c.** \(\Delta \tau\) was changed.

We set \(\Delta \tau\) from 2016 to 2020 15, 16, 17, 20, 20 respectively.

<table>
<thead>
<tr>
<th>Controlling Parameters</th>
<th>Scenario A</th>
<th>Scenario B</th>
<th>Scenario C</th>
<th>Recommended Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\Delta \tau) [years]</td>
<td>15</td>
<td>15</td>
<td>20</td>
<td>We set (\Delta \tau) from 2016 to 2020 15, 16, 17, 20, 20 respectively</td>
</tr>
<tr>
<td>(H) [yuan/ton]</td>
<td>(9.45 \times 10^3)</td>
<td>(9.45 \times 10^3)</td>
<td>(9.45 \times 10^3)</td>
<td>Made (H) unchanged from 2016 to 2018 but 0.7% and 1.62% in 2019, 2020</td>
</tr>
<tr>
<td>(g)</td>
<td>0.07</td>
<td>0.10</td>
<td>0.07</td>
<td>(g) is 7%, 7%, 6.8%, 6.7% from 2016 to 2020</td>
</tr>
</tbody>
</table>

The determination of \(g\) was based on Nation Plan, which planed GDP per capita doubled in 2020 than that of 2010. To achieve the goal, \(g\) needs to be no more than 7.1% by our calculation.

Scenario B is a condition that \(\Delta \tau\) isn’t increased but the growth of GDP increases, it means in next five years, the problem of large numbers of moving works, “ephemeral” buildings is still exist and there is no improvement in the quality of steel products.

Scenario C is a condition that \(g\) stays unchanged but \(\Delta \tau\) is increased. This scenario means that
China remains the economic developing trend and the issue of “ephemeral” buildings rarely happens, technical level of steel industry and the quality of steel products is increased.

Recommend Scenario we carried out aims to make China steel industry a sustainable development. From the 13th Five-Year Plan, we got that the five years are during the period of slowly global recovery, steel output will no longer increases year by year. In addition, results of some forecasts point that the trend of steel output will increase at the first and then decrease when meet the peak value. Took those factors into account, the recommend scenario was gotten.

**Forecasting Analysis of the Four Scenarios**

Forecasted the steel output by the steps we mentioned, the results can be seen in Table 2.

<table>
<thead>
<tr>
<th>Year</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario A</td>
<td>6.56</td>
<td>7.22</td>
<td>8.00</td>
<td>8.91</td>
<td>10.17</td>
</tr>
<tr>
<td>Scenario B</td>
<td>8.72</td>
<td>9.75</td>
<td>10.94</td>
<td>12.32</td>
<td>14.11</td>
</tr>
<tr>
<td>Scenario C</td>
<td>6.06</td>
<td>6.49</td>
<td>6.92</td>
<td>7.42</td>
<td>7.90</td>
</tr>
<tr>
<td>Recommended Scenario</td>
<td>6.56</td>
<td>7.22</td>
<td>8.00</td>
<td>6.59</td>
<td>5.97</td>
</tr>
</tbody>
</table>

It can be seen in the Table that the steel output in Scenario B is largest among four scenarios, and its driving force is GDP. That means the influenced effect of GDP growth rate is much higher than that of steel life to steel output. High-speed of the economic development, higher value of $H$, lower life expectancy of steel products will all make steel output increase, but it can be noticed in Table 3 that the number in Scenario A is always higher than that in Scenario C and the gap between them is bigger and bigger. Therefore the main reason of overlarge steel output is constantly building and demolitions.

Following measures are recommended to achieve sustainable development: a. Take rigid control on the GDP growth rate to prevent excess demand of steel products. b. Decline the demolitions of buildings, improve the quality of steel products. c. Lessen the number of unused steel, such as vacant houses. d. Make full use of iron and steel scraps.

**Summary**

(1) GDP growth rate increases, steel output increases and the growth rate of it also increases. As long as the growth rate of GDP is a positive value, steel output will increase theoretically. Raise $H$, steel output will decrease, on the contrary, it will increase. The improvement of average service life of steel products will depress steel output.

(2) Influence of GDP on steel output is much stronger than that of service life. The influence of increasing service life longer by 20 years has the same effect of increasing $g$ by 0.06, steel output will increase 20% after 5 years. Therefore, when the steel life is improved, steel output will also increase, but the increasing rate will decline.

(3) GDP growth rate and steel products service life are all direct acting factors to $H$. So increasing $H$ to decline steel output doesn’t mean increase $g$ or decrease $\Delta \tau$ only, but increase $g$ and $\Delta \tau$ at same time, the combined action of three factors makes steel output decrease. It’s the situation with lower steel output, less environment load and higher GDP.
The Recommend Scenario can be a reference for the goal that $6 \times 10^8$ t steel output in 2020. This situation needs to improve the steel life, increase $H$ (Adjust the industrial structure, improve technology and management skills), control GDP growth rate strictly (decline it a little year by year conforming to the National Plan).

Acknowledgement

This research was financially supported by the National Natural Science Foundation of China (41301643, 71373003, 41401636).

References


