STEEL INTENSITY AS A DYNAMIC FUNCTION OF ECONOMIC GROWTH

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Overview

Steel is the most widely used metal in modern society, a key material for industrialization and urbanization. This material plays a significant role in the energy sector, as about 10% of the world steel production is used in the energy sector, as in pipelines, reactors or wind-powered installations. Future choices for energy production will partly depend on steel prices, consequently on the steel demand. Conversely, the iron and steel sector is one of the most energy consuming industrial sector, consuming about 7% of the world energy, and more specifically 43% of the global coal production (Enerdata, 2015).

In the last decade, world steel production has soared to an annual growth rate of 7% per year, and more significantly to a growth rate of about 27% per year in China (WorldSteel Association, 2014). The steel consumption growth has very quickly exceeded many recent forecasts about the China's turning point for steel consumption. Difficulties to forecast the stabilized level of consumption will also probably be renewed for future large emergent regions, as India or Africa. Most long-term forecasts on steel consumption are based on a static Intensity-of-Use hypothesis. In this paper, a new dynamic formulation of this hypothesis is presented. The main assumption is that annual steel consumption in a country depends on the current GDP per capita level but also on its annual growth rate.

Methodology

The purpose of this paper is to study a new definition of the relationship between intensity of steel use and economic growth. Until now, many long-term published forecasts on global steel demand have been based on the traditional Intensity-of-Use hypothesis, directly relating national steel consumption divided by GDP, with the GDP per capita (Allwood et al., 2012; IEA, 2006; Van Vuuren et al., 1999). As this relationship doesn't depend on the rate of growth for a national economy, at a similar level of development, the intensity of steel use would be similar between a country with a low GDP annual growth, as for Western Europe countries, and a high GDP growth country, as China during the last decade.

We propose a new approach to this hypothesis by adding a dynamic dimension to the Intensity-of-Use relationship. First, we distinguish steel use for economic development and then steel for replacement of the in-use stock reaching end of life. In that sense, our hypothesis is close to the one used in dynamic material flow analysis (MFA) (Hatayama et al., 2010, Pauliuk et al., 2013). Then, we suppose that the inverse U-shaped curve describes the ***marginal*** relationship between intensity of steel use and GDP per capita. Therefore, the annual steel consumption for economic development is the integration of this marginal curve over the national GDP growth during one year. By this way, the hypothesis is that the amount of steel used for development up to a specific level is common across countries, but with different trajectories for annual consumption. The consumption flow is finally related to three factors: the level of economic development (GDP per capita), the economic growth rate (GDP growth per year) and to the discarded in-use stocks of steel (historic of the GDP growth).The advantage of this approach is to obtain a more robust modelization of the steel consumption flow in emerging countries compared to the traditional Intensity-of-Use hypothesis, which is based on old industrialized countries.

This new hypothesis is tested on historical steel use data for a panel of 43 countries, representing more than 97% of the world steel consumption, between 1974 and 2012. To this end, a simulation model is calibrated using an optimization process. Then, results are used to forecast long-term steel consumption up to 2050, with GDP and population projections from the OECD (OECD, 2015).

Results

Results of the model for steel consumption are compared to historical values. On the basis of only two external variables for each country, total population and GDP per capita, steel use historical trajectories are robustly matched by the model. Using the 1656 annual observations for steel use per capita in the 43 countries, the coefficient of determination (R^2) is close to 0.75. Aggregating all countries, figure 1 shows that long-term dynamics are effectively reproduced ($R^2 = 0.97$) as well as economic cycles (i.e. 2008), a behaviour that was not possible for a model using a traditional static inverse U-shaped curve. However, short-term volatility is not fully replicated, mostly because dynamics for steel prices are not reproduced currently in the model.

At the national level, results are also close to historical data. For old industrialised countries, as United States or France, the long-term trend for steel use is slowly decreasing, highlighting short-term economic upheaval. More interestingly, for new industrialised country as South Korea or China, results reproduce very well the dynamic of growth as well as the saturation effect in Korea. Results for long-term forecasts highlight quite different growth paths among countries, taking into account different national development dynamics or even demand decrease during economic crises.

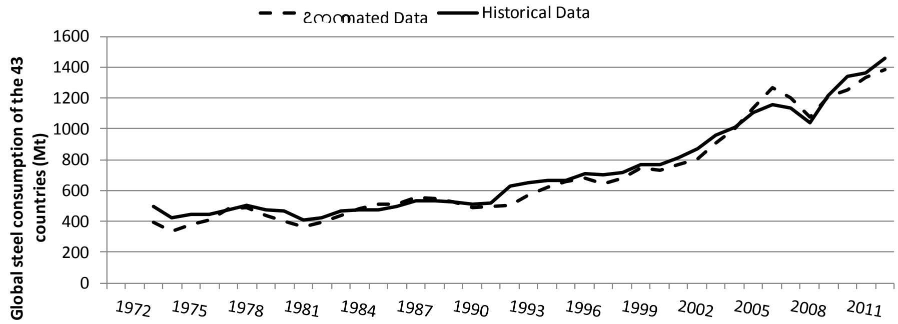

Figure 1 : World steel consumption: Actual and estimated historical data

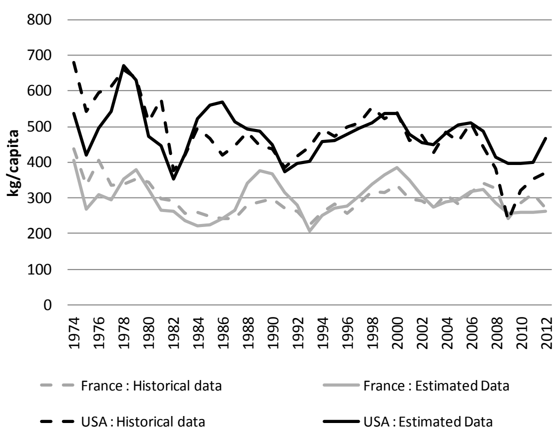

Figure 2 : Steel use per capita for USA and France

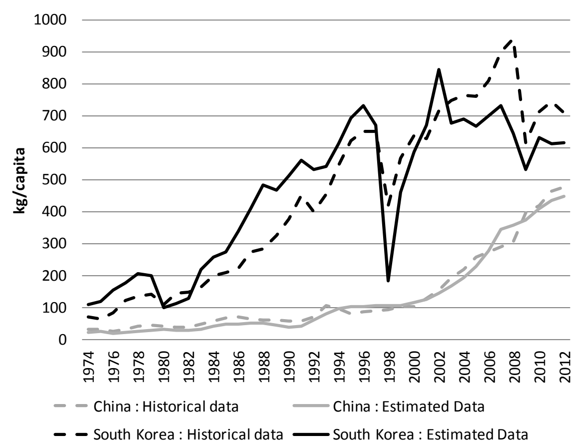

Figure 3: Steel use per capita for South Korea and China

Conclusions

In this study, a new approach to the Intensity-of-Use hypothesis is proposed and tested on the steel consumption across 43 countries, over 38 years. Introducing the dynamic of economic growth, in addition to the level of economic development, greatly improves estimations of steel needs of a country. This approach could also be developed for other products highly linked to economic development such as aluminium and cement. Development, energy and climate policies can thus be based on more realistic projections, especially for very rapidly growing countries.

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