Resources Policy 45 (2015) 239–246

Contents lists available at ScienceDirect

Resources Policy

journal homepage: www.elsevier.com/locate/resourpol

Explaining variation in steel consumption in the OECD

Paul Crompton

Business School, University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia

ARTICLE INFO

Article history:
Received 19 May 2015
Received in revised form
23 June 2015
Accepted 23 June 2015
Available online 1 July 2015

Keywords:
Steel consumption
Intensity of use
Leapfrogging

ABSTRACT

This paper examines the main drivers of intertemporal and cross-country variation in steel consumption using a fixed-effects panel model of 26 OECD countries over the period 1970–2012. The results indicate that per capita GDP is the main driver of steel consumption, however, investment spending, and the rates of industrialisation and urbanisation are also important determinants. Per capita steel consumption is found to be concave with respect to per capita GDP, suggesting that the growth rate in steel consumption slows as a country's level of economic development advances. Through the inclusion of a set of time dummy variables, there is evidence of the leapfrogging effect of Hwang and Tilton, 1990. *Resour. Policy*. 16 (3), pp. 210–224, in which improvements in the efficiency of material use and material substitution reduced per capita steel consumption by around 1% per annum over the sample period, albeit mainly in the 1970s and 1980s. Finally, there is evidence of substantial cross-country variation in income elasticities, ranging from 0.01 for Norway to 4.05 for Greece, and these elasticities are related negatively to the countries' level of economic development.

1. Introduction

Global consumption of crude steel increased from 595 million tonnes (MT) in 1970 to 1648 MT in 2013. Within these aggregate global figures, however, are significant geographical differences in the changes in steel consumption over this period. In Western Europe, consumption was 155 MT in 1970, decreased to 147 MT in 1990, climbed to 219 MT just prior to the Global Financial Crisis in 2007, before falling to 153 MT in 2013. Consumption in North America followed a similar pattern of low growth. Starting at 138 MT in 1970, consumption increased to 166 MT in 1990, before falling to 149 MT in 2013. In contrast, consumption in Asia, increased from 110 MT in 1970 to 258 MT in 1990 and 1087 MT in 2013. Of the growth in consumption in Asia between 1990 and 2013, 85% occurred within the booming Chinese economy, which consumed 772 MT of steel in 2013.

At the same time, this global growth in consumption has had profound effects on iron ore and coking coal exporting countries such as Australia, Brazil, India, Canada and South Africa. In Australia, for example, primary commodity producers have struggled to keep pace with raw-materials demand over this period, creating strong wage inflation in the mining and mining-services sectors, as well as non-mining sectors because of strong competition for skilled labour. In addition, the inflow of new workers into the mining and mining-services sectors has placed significant upward pressure on house prices and consumer prices, particularly in Perth and Brisbane, which act as the main fly-in-fly-out bases for Australia's iron ore and coking coal producing regions. To the extent that the benefits of this mining boom have been distributed unevenly, it has also caused a degree of social and financial stress in various communities throughout Australia.

Given the scale and importance of the global steel industry, understanding the main drivers of steel consumption is important for both the mining industry and policymakers. Previous studies have analysed various aspects of steel consumption, most of which have used single-country analyses. Among these studies, the majority have used the intensity-of-use technique, in which changes in both intensity-of-use and GDP are used to explain changes in metals consumption over time (see Crompton (2000) for crude steel for Japan, Rebiasz (2006) for Poland and McKay et al. (2010) for China, and for other metals see Roberts (1996) and Guzman et al. (2005)). Other studies have focused on the presence of co-integrating relationships between steel consumption and GDP (see Labson and Crompton (1993), Evans (2011) and Huh (2011)). A third stream of literature has used panel data to investigate the existence of inverted U-shaped intensity-of-use curves with respect to per capita GDP (see Wårell (2014) for steel, and Canas et al. (2003) and Jaunky (2012) for other metals).

This paper extends the existing literature by estimating a fixed-effects panel model of per capita steel consumption using a sample of 26 OECD countries over the period 1970–2012 to explain variation in per capita steel consumption using per capita GDP, as well

E-mail address: Paul.Crompton@uwa.edu.au

http://dx.doi.org/10.1016/j.resourpol.2015.06.005
0301-4207/

as other macroeconomic variables and a series of dummy variables that measure the effects of time and cross-country differences on the relation between steel consumption and GDP. The main aims of this paper are as follows. First, we seek to identify the main drivers of both intertemporal and cross-country variation in per capita steel consumption. Second, we search for the presence of the leapfrogging effect of Hwang and Tilton (1990), in which later developing countries achieve a lower steel intensity of domestic production than earlier developing countries by leapfrogging older production technologies and materials in favour of more modern alternatives. Third, we examine cross-country variation in the sensitivity of steel consumption to changes in GDP as measured by the income elasticity of steel consumption. Based on the existing literature on metals consumption, it is anticipated that a large part of the variation in steel consumption will be explained by variation in GDP, due primarily to the derived nature of steel consumption. However, the incorporation of other key drivers of steel consumption in a panel model of OECD countries and the empirical investigation of the presence of the leapfrogging effect are important extensions to the literature.

The paper proceeds as follows. In the next section, we use the intensity-of-use model to describe the main determinants of steel consumption. The econometric methodology is then outlined and the estimation results presented. The final section provides concluding comments.

2. Determinants of steel consumption

The intensity-of-use model of Roberts (1990, 1996) provides a convenient conceptual framework with which to decompose changes in steel consumption into changes in GDP and changes in the intensity-of-use for steel. Intensity of use can further be decomposed into measures of (i) the steel content of domestically produced goods in steel consuming industries and (ii) the size of steel consuming industries relative to GDP. To illustrate this approach, the aggregate quantity of steel consumed across n steel consuming industries, S_t, in a particular country can be decomposed as follows:

$$S_t = \sum_{i=1}^{n} \left(\frac{S_{it}}{P_{it}} \times \frac{P_{it}}{GDP_t} \times GDP_t \right) \quad (1)$$

where S_{it} is the quantity of steel consumed by industry i in period t, P_{it} is the value of production in industry i and GDP_t. is gross domestic product. Eq. (1) can be written alternately as:

$$S_t = \sum_{i=1}^{n} (MCP_{it} \times PCI_{it} \times GDPI_t) \quad (2)$$

$$S_t = \sum_{i=1}^{n} (IU_{it} \times GDP_t) \quad (3)$$

where MCP_{it} is the material composition of product of industry i (or $\frac{S_{it}}{P_{it}}$), PCI_{it} is the product composition of income (or $\frac{P_{it}}{GDP_t}$) and IU_{it} is the intensity of use for steel (or $\frac{S_{it}}{P_{it}}\frac{P_{it}}{GDP_t}$). The MCP measures tonnes of steel consumed per unit of production in steel-consuming industries. For a mature metal such as steel, it is reasonable to expect that the MCP will decline over time (the MCP for steel in Japan was found to be declining since 1980 in the steel-consuming industries of construction, transport equipment, machinery, electrical machinery and equipment, other manufacturing and fabricated metal products in Crompton (2000)) through the implementation of new production processes and/or technologies that allow more effient use of steel or through the substitution of new or alternate materials for steel. The PCI meares the proportion of GDP accounted for by production in steel-consuming industries, and hencelects the composition of a country's GDP, which in turn depends on the stage of a country's economic development. In particular, during the early stages of economic development, growth in production in the steel consuming industries is likely to outpace the growth in GDP as the majority of this developing country's economic growth is concentrated in these industries, leading to a rising PCI. More mature economies, however, are likely to experience growth that is concentrated in industries such as services and high-technology, resulting in a slower rate of growth in steel consumption and a declining PCI.

Eq. (3) shows that the relationship between steel consumption and GDP, rather than being stable over time, may change because of changes in the intensity of use, which can be measured at either the industry level or economy-wide level. Changes in the intensity of use, in turn, are driven by changes in the MCP and PCI. The changing nature of the relationship between steel consumption and GDP is summarised partly by the hypothesized inverted U-shaped relationship between steel intensity and per capita GDP as illustrated in intensity-of-use curve T_1 in panel (a) of Fig. 1, where the subscript indicates the time period. The shape of this curve is driven solely by changes in the PCI over time as described in the previous paragraph.

As mentioned above, the inverted-U shape of the intensity-of-use curve in panel (a) of Fig. 1 is driven by changes in the PCI over time, however, in addition to this, a separate dynamic affects intensity of use. As indicated by Eq. (2), IU is also affected by changes

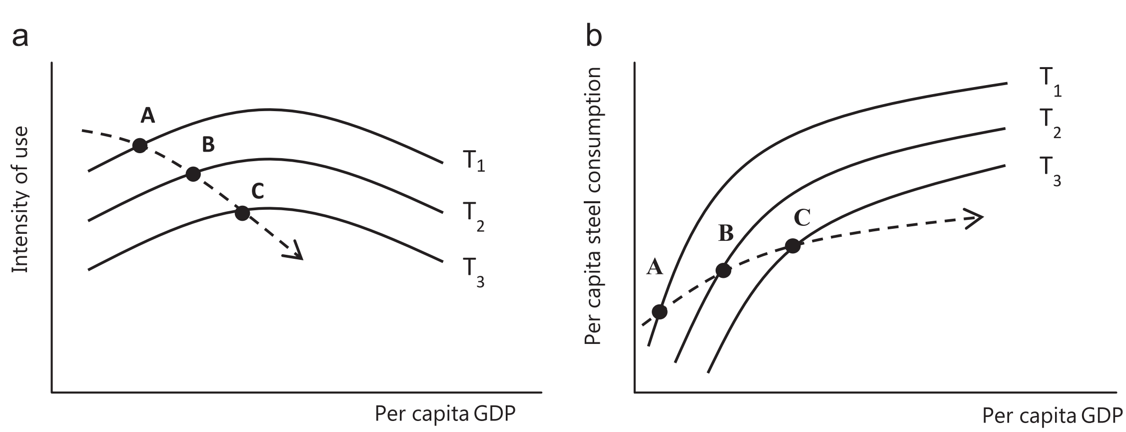

Fig. 1. Steel consumption and GDP.