



Vertical specialisation measurement of energy embodied in international trade of the construction industry

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ABSTRACT

Due to the conflict between economic development and environmental preservation, energy consumption in the construction industry has become an urgent concern. This research aims to measure the interaction between imports and exports in relation to the embodied energy that accompanies international trade from the perspective of vertical specialisation. The energy embodied in the imports and exports of the construction industry is measured and the net embodied energy use is used to identify the level of dependence of the construction industry on international trade. For the construction industries in the selected countries, the share of imported energy embodied in exports is used to show the degree of participation in the global production chain. The construction industries had greater degrees of participation in the international trade of embodied energy from the demand perspective, than from the supply perspective. The findings of this research help to identify the role and position of national construction industries and are beneficial to the design of strategies for the international market. References are also provided to assist policymakers in adjusting natural resource consumption and production structures in the international trade of construction goods and services.

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1. Introduction

Important challenges are posed by the rising world population and rapidly flourishing economies in relation to maintaining sufficient energy to meet the growing global consumption [1]. In particular, the issue of energy consumption in the construction industry has become an urgent concern which has been studied in the last decade due to the conflict between economic development and environmental preservation. The energy consumption of the construction industry is continuing to rise due to the high demand for construction around the world caused by the requirements of economic development. The energy-related emissions induced by human activities account for over 80% of global greenhouse gases [2]. As one bottleneck of economic development, the high level of energy consumption has resulted in huge environmental pressures and the problem of climate change. In order to promote the sustainable development of the construction industry, optimal energy conservation must be considered as an important objective.

Therefore, improving energy efficiency is seen as an important path towards energy reduction in production processes, and a previous study considered the impact of efficiency on the energy consumption of the construction industry in China [3].

The efficiency of energy consumption in the construction industry is determined by several factors, including industrial economic output, labour input, capital investment and other traditional elements [4]. With the rapid spread of globalisation, the comparative advantages of some countries are prominent in cross-border trade costs and infrastructure, technology and labour costs. A significant feature of current international trade is domination by vertical specialisation [5]. Similar to the definition of vertical specialisation, Krugman et al. (1995) [6] indicated that the global value chain was divided up by producers and the production processes were separated into many steps located in different places. Feenstra (1998) [7] described vertical specialisation as the fragmentation of production processes in the context of the growing integration of world trade. Hummels et al. (2001) [8] explained vertical specialisation as the specialisation of a country in a specific phase of the production processes involved in vertical trading chains distributed across many countries, and they utilised the proportion of imported goods used in the production of exported goods to express this type of vertical linkage. The development of

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individual industries has also changed from horizontal integration within a country to vertical specialisation among multiple countries.

Furthermore, this specialisation has facilitated the rapid growth of national industries due to their positive participation in the mechanism of the global value chain [9]. The trade patterns of vertical specialisation strengthen the connection between national industries and encourage many countries to join the global production chains. The vertical specialisation caused by economic globalisation is increasing its influence on international trade, so the proportion of imported content of export goods can be used as an effective indicator to measure the degree of participation of a country in the global value chain [10]. Within an economy, the production of goods and services is connected directly or indirectly to energy consumption, and at the same time the energy consumption is affected by international trade, which is a vital factor in the industrial structure of a country [11].

The purpose of this study is to measure the degree of participation of 40 world regions in relation to the embodied energy that accompanies the international trade of the construction industry from the perspective of vertical specialisation. The quantities of embodied energy in international trade have been calculated at the sectoral and global levels, and the net balances of embodied energy use between imports and exports have been applied to identifying the levels of dependence of the national construction industries on international trade. In addition, vertical specialisation as an important indicator has been examined based on multi-regional input–output tables from both demand and supply perspectives.

2. Literature review

2.1. Economic impacts of vertical specialisation

The differences in trade costs due to differing production techniques and management styles increase the specialisation of specific goods in the global value chain. Since vertical specialisation provides opportunities for developing countries to participate in the global production chain, vertical trade patterns provide an effective channel for the transfer of advanced techniques and management styles between different countries. Vertical specialisation has been described as a consequence of exported and imported intermediate inputs following sequential supply chains, while the fragmentation of production is caused by the decreasing costs of service connections between the fragments [12]. For instance, a framework including raw materials, intermediate goods and final goods has been proposed in order to analyse the vertical specialisation of trade and this has emphasised that the declining trade costs of manufactured parts has driven the rapid development of manufacturing and the vertical specialisation of trade [13]. The roles of delivery, logistics, infrastructure and governance have also been analysed in relation to the international trade of the clothing and electronic sectors from the perspective of vertical specialisation [14].

Vertical specialisation facilitates industrial productivity due to variations in demand for intermediate goods. An empirical analysis measured the influence of vertical specialisation on productivity and the results indicated that the average productivity of the global economy had increased due to improvements in the participation levels of countries in the global value chain [15]. Although the traditional viewpoint recognises that specialised production tends towards the countries with inexpensive labour costs, such production might face the risk of high trade costs in transportation and communications, which would reduce the competitive advantage of low wages. The low labour costs might affect the energy expenditures of both working employees and capital products, which would diminish the sectoral competitiveness in vertical

specialisation trade [16]. A study showed that most of the vertical specialisation in production processes happened in developed countries and the advantages of a country in ownership, location and internationalisation facilitated the decomposition of production processes due to the variety of specific final demands for intermediate goods [17].

Vertical specialisation affects the transactions in the global value chain, as well as the trade at the sectoral level. A study showed that the linkage of vertical specialisation in bilateral trade between host and home countries was a significant factor in the measurement of international trade integration [18]. The degree of vertical specialisation depends on trade barriers in some extent and the influence of vertical specialisation has been explored in relation to the connection between business cycle synchronisation and trade across different countries [19]. The influence of vertical specialisation on intra-industry trade between the USA and its partners was examined based on three indicators: total imports, non-dutiable trade share and dutiable trade share of items related to offshore assembly, and these indicators showed that domestic advantage played a significant role in national production processes [20]. Based on national input–output tables and the method proposed by Hummels et al. (2001) [8], Duan et al. (2018) [21] developed a new method to decompose the vertical specialisation shares and then analysed the decrease of China's vertical specialisation shares over 2005–2012 from a perspective of energy consumption structure.

2.2. Assessment of vertical specialisation based on input–output tables

Input–output tables offer an advantage in measuring vertical specialisation at national and sectoral levels. Hummels et al. (1998) [22] first established a vertical specialisation indicator by measuring the import content of exports in order to study the degrees of participation by different countries based on the application of input–output tables. These contain the necessary information for the calculation of vertical specialisation, such as imports and exports, the value added and total outputs. Thus the imported intermediate inputs embodied in the production of exports can be measured based on the input–output tables [23]. For example, the Organisation for Economic Co-operation and Development (OECD) input–output tables were adopted to measure the international trade of the USA in a specific period in relation to intermediate commodities, exports by transnational enterprises and connections between service exports and manufacturing exports [24]. In order to identify the potential of the manufacturing industry in facilitating economic growth in Malaysia, the vertical specialisation index and backward linkage index were combined based on the input–output table [25]. In addition, the information from the input–output table along with international trade data complemented the typical measurement of vertical specialisation based on a specific input–output table with import coefficients, while a general input–output matrix was used to identify the original inputs of different goods for a specific production chain [26]. With further analysis of the allocation of imported intermediate inputs across sectors, a split input–output table was applied in the vertical specialisation analysis of Chinese exports [27]. Similarly, another study chose Chinese processing trade as a case to measure the vertical specialisation in exports based on the national input–output tables, and a weighted average method was proposed to correct the measurement biases of the national vertical specialisation in exports [28].

However, national input–output tables lack description of the interdependence between sectors in different countries. The multi-regional input–output table is a useful tool in examining the degree of participation of a sector in global production and the

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