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INTERNATIONALIZATION OF THE CONSTRUCTION INDUSTRY IN THE GLOBAL VALUE CHAIN

Wentao NIU[1], Zhenzhen XU[1,2], Bin LIU[3*], Chunlu LIU[2#]

[1]*Zhengzhou University, Zhengzhou, Henan, China*
[2]*Deakin University, Geelong, Victoria, Australia*
[3]*Shandong University of Finance and Economics, Jinan, Shandong, China*

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Abstract. The construction sector plays a significant role in national economic development and accounts for a dominant portion of national economic growth. The international construction industry's development has been explored from the perspective of the economy. Internationalization improves awareness about participation in international trade activities. This paper aims to quantify the internationalization of the construction industry in the global value chain. The sectoral participation index and interaction index are conducted to evaluate the internationalized degree of the construction industries. In the results, the distribution of the backward participation indices shows nearly all countries' internationalization processes were still at the stage of benefiting from primary resources. The forward support index is easily influenced by the scale effect. The backward independence index accounts for a small percentage of national imports measured by value added. The main source of value-added supply was the local construction sector. This study proposes a comprehensive indicator to quantify the internationalization of the construction industries in the sight of national and global points. The references have a positive value for policymakers in the management of value-added flows in the international market and adjustment of the foreign trade environment.

Keywords: internationalization, construction industry, global value chain, value added.

JEL Classification: D57, F14, F63, L74.

Introduction

The exploration of internationalization processes has positive implications for the construction industry's development. Especially, the global value chain (GVC) has constructed a new economic framework based on worldwide internationalization. At the regional level, the distribution of export value added is unevenly disparity because of the geographical imbalance in global trade (Wang et al., 2020). The sectoral development towards forward and backward depends on the value added transfer in the GVC, while the formation of value

*Corresponding author. E-mail: *20208585@sdufe.edu.cn*
#Corresponding author. E-mail: *chunlu@deakin.edu.au*

added in a country does not necessarily lead to income (Bohn et al., 2021). The linkage between sustainable development and economic growth can be explained by value added (Fernández-Amador et al., 2020) and value added as the core of the GVC has an important impact on the sector's performance. Hence, the identified estimation of internationalization has its positive value and contributions to the improvement of the construction industries.

Internationalization can help enterprises to break through the institutional constraints of the domestic market (Yang et al., 2022), this principle is also valid for the development of the construction sector. The higher internationalization leads to complexity and uncertainties (Sakawa et al., 2022), so the construction sector needs a clear developing pathway towards the international market and quantifies its status based on the indicators. Internationalization is a process that requires more resource input to achieve the expected market position, the scope of internationalization affects the relationship between entrepreneurial orientation and innovation, a weakened influence appears in this relationship only when the scope states in a moderate condition (Wach et al., 2022). The contribution of the internationalization of innovation to firm performance has been proven as positive in the empirical study (Zhai & Ghosal, 2022). Wang et al. (2022) reported that the industry peers' international expansion positively promotes the speed of sectoral internationalization when the sector is in the condition of lack of experience and strongly sectoral competitive. Besides, internationalization requires specialization and expertise in specific areas to work, such as the impact of R&D on performance (Sommer & Bhandari, 2022). For example, from the perspective of information capture, digital internationalization was advanced in quickly achieving the opportunity (Ipsmiller et al., 2022). At the sectoral level, this means a type of competitive advantage for a specific country in the international market. In the study of Jankowska and Götz (2017), the measurement of internationalization is considered in dimensions of both breadth and depth at the enterprise level to indicate the internationalization intensity. For the developing trend of the construction sector, this indicator has been measured in the GVC (Liu et al., 2022), while the quantity, diversity and resources of the foreign market have been replaced by the indirect and foreign value added in this paper. The literature in relation to the participation index and interaction index has been reviewed as follows.

This paper aims to quantify the internationalization of the construction industry in the GVC. Both sectoral participation and interaction are explored. The indicators are conducted to realize the measurement of the internationalized degree of the construction industries in the GVC. This study proposes comprehensive indicators to quantify the internationalization of the construction industries in the sight of national and global points. The developing features reveal the degree of the participant and the relationships between the national construction sector and the international construction market in the GVC. A positive reference can be taken into account for the transformation and upgrade of sectoral structure in the quickly changing worldwide trade environment.

The studies in previous research mainly focused on exploring the property factors for the internationalization of multinational enterprises or domestic enterprises which intend to enter the international market. However, from the perspective of industry and country levels, the elements possessed by enterprises are not suitable for international measurement of the construction industries. Hence, the contributions of this paper in relation to the mea-

surement of internationalization included: a) Internationalization measurement based on added value presents an accurate description of foreign trade in the construction industry of each country and positions the degree of internationalization of the industry; b) The participation index shows the position of the national construction industry in the global value chain, which benefits the industry to find lower cost resources globally; c) Internationalization stimulates the industry development to actively engage in understanding the needs of the international market and to learn new technologies and management experience with a purpose of building core competitiveness.

1. Literature review

The GVC involvement has a close relationship with a specific sector and also a country's foreign trade. The trade patterns have deepened their influence on economic growth in recent decades, which has similarities with the influence of economic development on environmental sustainability. Low capital intensity may lead to a potential risk to the underlying factors behind gross value added, although high technology sectors present a driving force to economic growth (Șerban et al., 2022). An empirical study has also proved that the countries with a low degree of participation in GVC experienced a great many difficulties in the reduction of emissions in the short to medium term (Wang et al., 2019). An industrial environ-economic balance index can be adopted to estimate the situation of two countries in bilateral trade based on the value added and environmental indicators (Gao et al., 2022). A similar finding shows that the high degree of GVC participation facilitates the transfer of carbon emission within the trade and brings a negative influence on activities of carbon reduction (Zhong et al., 2021). Based on the linkage between GVC involvement and emissions, a negative effect on emissions from GVC participation was found in the study of Yang and Liu (2022). In contrast, Žarković et al. (2022) indicated that carbon emissions as a significant determinant had a positive correlation with economic growth in European Union countries. The linkage relationship leads to the improvement of value-added exports in the vertical international specialization. The forward and backward linkages presented opportunities for the local sectors to participate in GVC (Mehta, 2022). Moreover, the participation index also indicates the degree of dispersion of a specific sector in GVC among different locations (Kersan-Škabić, 2019).

In this paper, forward support and backward independence indices are developed to reveal the interaction effect at the sectoral level. The theoretical basis of these two indicators is the model of the diversification index. Both these two indicators explain the relationships between a single sector and the aggregation integrated by the rest of the relative sectors. Compared with the conventional position index, these two indicators have considered the performance and status at the sectoral level. Koopman et al. (2010) presented a position index to narrate the position of a country in GVC at the global level, the construction of this index relies on the intermediates in exports to determine the sectoral role as supplier or demanders within the upstream or downstream position. As the theoretical basis, Borin and Mancini (2019) presented a more precise decomposition of gross exports based on different destinations and trade patterns in value added, which improved the computation of

related value added in the position index. As an exploration, upstream positioning indicators are also used to measure country or industry-level positions in global value chains, such as applications in the agriculture and food industries (Montalbano & Nenci, 2022). Moreover, the breakdown of the gross exports was further developed by Koopman et al. (2014), and the constituents of gross exports were explicitly broken down with consideration of vertical specialization. From the perspective of theory, Kim et al. (2019) explored the criterion of selecting technology diversification indices based on the consideration of the validity of the index itself. In contrast, Bagci (2016) presented a within-diversification index to consider the impact of patterns and relative comparative advantages within industries on export diversification. An extended application of the diversification index is used to estimate the risks in the export and import activities of foreign trade. For example, the risk of international oil imports has been measured by the modified diversification index (Yang et al., 2014). The risk measurement in trade activities means better control and efficient strategy in exports and imports, which indicates steady support from upstream sectors and strong independence from downstream sectors in the international market. Besides, the energy diversification index has been developed based on the application of the Herfindahl–Hirschman index (Gozgor & Paramati, 2022), which indicates support and demand are the dominant forces in the processes of energy transfer. Namely, the detailed activities of these two forces are represented by the exports and imports.

2. Method and data processing

The hybrid method in this paper combines the participation index and the modified interaction index to realize the measurement of the internationalization of the construction industries in the GVC. First, the participation index origins from the research of Koopman et al. (2010) about the transfer of value added in the GVC. Then, the modified interaction index is developed based on the interaction effect (Dietz & Rosa, 1997) and the later extended study by Yang and Liu (2022). The modified interaction index contains two meanings which are forward support and backward independence. Hence, the application of this hybrid method realized the measurement of internationalization in the aspects of participation and interaction at the sectoral level. The participation degree of a sector in the international market indicates the internationalization processes, while the closeness between a specific sector and the international market has also been examined by the interaction linkage.

As the narrative of the detailed method, a multi-region input-output table includes m regions and n sectors. Then, the direct value-added coefficient has been expressed as the matrix as follows:

$$v = V \cdot \hat{X}^{-1}. \tag{1}$$

The letter v is used to denote the direct value-added coefficient with a dimension of $1 \times (m \times n)$. The element of matrix v means the value added per unit total input. The matrix V denotes value added which contains the sectoral value added in each region. X is a row matrix and is consisted of the total input of each sector. $\hat{X}^{-1}$ represents an inverse matrix of the diagonal matrix $\hat{X}$. Additionally, the construction of the Leontief inverse matrix $(I - A)^{-1}$ is shown to indicate the linkage of sector i and the other sectors (Leontief, 1986).

$$B = \left(I - A\right)^{-1} = \begin{pmatrix} B_{i,i} & B_{i,-i} \\ B_{-i,i} & B_{-i,-i} \end{pmatrix}. \tag{2}$$

B denotes the Leontief inverse matrix. According to the definition of the input coefficient in an input-output table, A represents the input coefficient matrix. The sector i represents the construction sector in a specific country, while $-i$ denotes the combination of the sectors excluded the sector i.

2.1. Forward and backward participation indices

The construction sector supplies the intermediate goods to the sectors in other countries and these goods are used to produce the exports. The indirect value added has been created in the production of exports. The export pathway of intermediate goods also includes many nodes such as the second country and the third country (Liu et al., 2019). From the perspective of bilateral trade, the decomposition of a country's total exports was developed by Borin and Mancini (2015) and the source-based and sink-based approaches contributed greatly to the improvement of the bilateral breakdown in the study of Borin and Mancini (2019). According to the developed theory, a matrix IV^r represents the indirect value added of country r. IV_i^r is an element of matrix IV^r. The indirect value added matrix IV^r is expressed as follows:

$$IV^r = v^r B^{rr} A^{rs} \left(I - A^{ss}\right)^{-1} \left[\sum_{t \neq r,s}^{m} Y^{st} + \sum_{t \neq r}^{m} A^{st} \sum_{l \neq r,s}^{m} \hat{B}_{-r}^{ts} Y^{sl} + \sum_{t \neq s}^{m} A^{st} \sum_{k \neq r,s}^{m} \hat{B}_{-r}^{tk} Y^{ks} + \sum_{t \neq s}^{m} A^{sj} \sum_{k \neq r,s,ll \neq r,s}^{m} \sum \hat{B}_{-r}^{tk} Y^{kl} \right]. \tag{3}$$

The results of the indirect value added of the international construction sectors have been calculated as the basic data support. v^r is a sub-matrix of matrix v and denotes the value-added ratio of region r. B^{rr} is a block matrix of region r in the Leontief inverse matrix. B^{rs} is a block matrix from region r to region s in the Leontief inverse matrix. A^{rs} is a block matrix from region r to region s, which denotes the input coefficient. A^{ss} is a block matrix of region s. The final demand is represented by Y^{st} which is produced in region s and consumed in region t. The Leontief inverse matrix $\hat{B}_{-r}^{tk}$ has excluded the input of other regions from region r. A^{sj} is the input coefficient matrix from region s to region j.

The foreign value added represents the value added embodied in the imported intermediates used in a country's production of exports and the results of the foreign value added of the international construction sectors have been calculated as the basic data support. In the study of Liu et al. (2020b), the foreign value added is a part of vertical specialization trade and is created in the production of exports which use the intermediate goods imported from other countries.

In this section, matrix FV^r is used to represent the foreign value added of country r. FV_i^r denotes the foreign value added of sector i in country r. Total exports EX^{s^*} means the country s exports goods to other countries around the world. The export of the construction sector EX_i^r can be calculated based on the input-output tables. The matrix FV^r of foreign value added has been displayed as follows:

$$FV^r = \sum_{s\neq r,t}^{m} v^r B^{tr} Y^{rs} + \sum_{t\neq s}^{m} v^t B^{tr} A^{rs} \left(I - A^{ss}\right)^{-1} Y^{ss} + \sum_{t\neq r}^{m} v^t B^{tr} A^{rs} \left(I - A^{ss}\right)^{-1} EX^{s^*}. \quad (4)$$

Koopman et al. (2010) proposed an index to revealing the sectoral degree of participation in the GVC. The index is reflected by the percentage of indirect or foreign value added to the total exports of a sector. Participation in the GVC is revealed by the bilateral trade in the international market, so participation can reveal the internationalized degree of a specific sector. The forward participation index has been shown as follows:

$$FP_i^r = \frac{IV_i^r}{EX_i^r}, \quad (5)$$

where EX_i^r is the gross exports of sector i in region r. The backward participation index is expressed as follows:

$$BP_i^r = \frac{FV_i^r}{EX_i^r}. \quad (6)$$

2.2. Interaction index

The interaction index is a measure of the degree of synergism or sub-additivity that occurs when two parts are present together (Tallarida, 2002), while the interaction effect is earlier started by the impact of population and affluence on carbon emissions (Dietz & Rosa, 1997) and later extended study, such as the effect of GVC involvement on the carbon emission by Yang and Liu (2022). Therefore, based on the interaction index, the modified indicators including forward support and backward independence indices have been adopted to reveal the interaction effect at the sectoral level. Both these two indicators explain the relationships between a single sector and the aggregation integrated by the rest of the relative sectors.

The forward support index denotes the ratio of sectoral exports to the total national exports from the perspective of value added. $Size_i^r$ denotes the share of the sector *i*'s exports in the sector's total production by value added and has been expressed as follows:

$$Size_i^r = \frac{v_i^r \times EX_i^r}{TP_i^r}, \quad (7)$$

where TP_i^r means the total production of sector i in country r. The matrix v_i^r denotes the value-added ratio of sector i in country r. EX_i^r represents the export of sector i in country r. Thus, from the perspective of production ability, a high value of $Size_i^r$ means a strong ability of a specific region in contributing to the international demand by value added.

In addition, the backward independence index shows the import of value added exports from the global market to satisfy the local final demand and indicates the participation degree and the connection closeness with other sectors from a perspective of import of intermediate in the construction sector. This index is represented by the sign $Demand_i^r$ and denotes the international demand rating which provides a means of evaluating the degree of dependence on the international market for the civil consumption of a country. So, the $Demand_i^r$ is expressed as follows:

$$Demand_i^r = \frac{TFD_i^r - F_i^r}{TFD_i^r} = \frac{\sum_{j\neq r}^{m} (v_i^j \times F_i^j) - v_i^r \times F_i^r}{\sum_{j}^{m} (v_i^j \times F_i^j)}. \quad (8)$$

TFD_i^r means the total final demand of the country r sourced from sector i of all over the worldwide countries. F_i^r is a part of final demand in country r from the supplier of sector i. Thus, for the local consumption of country i, a high value of $Demand_i^r$ means a high level of dependence on the international market.

2.3. Data sources and processing

Additionally, the data sources are derived from the World Input–Output Database (WIOD) (Timmer et al., 2015). The multi-regional input–output tables originate from the world input–output tables released in 2016. In a world input–output table of the 2016 version, there are 56 sectors in each country or region and there are 43 countries (regions) with an aggregation of the rest of the world (RoW). In some countries or regions, the export value in the construction sector is less than 0.001 million USD. The economy with this character contains France, Indonesia, Japan, Mexico, Taiwan and RoW. Therefore, Table 1 and Table 2 have neglected these economies.

Internationalization is a necessary path and natural attribute for industry development after economic globalization. The establishment of global value chains has expanded the market size for domestic competition and reduced the intensity and resource consumption of domestic competition. Based on historical data, this research quantifies the construction industry in various countries using value-added indicators, which has a positive contribution to objectively describing the scale development and direction of industry internationalization. Moreover, historical data can be result oriented and reflect on the problems that have arisen in the internationalization process of the industry, which has a certain reference value for correcting the development direction of the industry. Additionally, there is a limitation in the update of the WIOD database. So, the studying period from 2000 to 2014 includes 15 years of economic data in the version of 2016 released in WIOD, which is suitable for the research of sectoral internationalization in a stable international environment.

3. Empirical results and discussion

The participation index indicates that the local sector is not limited by the domestic market. The sectors in a country also have the developing demand to broaden their market. As a detailed exploration, the forward participation denotes the construction sector locates in the upstream sector of the GVC. In Table 1, the forward participation indices have been displayed for the international construction sectors over 2000–2014. According to the understanding of the forward participation index, the product of the construction sector normally controls advanced techniques and has a high value added to its products. From the perspective of market scale, the countries including Cyprus, Malta, Finland, Latvia and Bulgaria have chosen to develop the construction sector in indirect value added. Their average values of the forward participation indices were in the top five and indicated a high degree of participation in the international construction market. On the contrary, the small values of the forward participation indices have proved that the construction sectors in Belgium, Netherlands and China focused on the domestic market. The domestic market in China is large enough to digest the local intermediate goods, even the imported resources. For Belgium and

Netherlands, the construction sector's development in the local market has no competitive advantage compared with other domestic sectors. Besides, a small scale-market is usually hard to get the interest of foreign investment if the local government cannot pay attention to this industry. The countries in the top ten have forward participation indices large than 200, while the later countries have a better balance to maintain the sectoral development towards the international market.

Table 1. The forward participation indices of the international construction sectors from 2000 to 2014

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Means	Rank
Australia	152.91	174.66	153.72	144.22	142.50	128.56	128.60	113.80	112.49	103.59	96.78	90.40	74.61	71.39	74.31	117.50	16
Austria	30.29	28.08	31.18	30.30	39.95	47.50	45.86	43.17	41.55	43.38	52.82	51.85	55.11	54.11	62.67	43.86	24
Belgium	12.30	11.50	12.49	10.86	10.95	10.68	12.33	12.82	11.82	9.56	7.98	7.63	7.76	7.16	6.62	10.16	35
Bulgaria	1911.08	1335.39	1078.37	601.79	376.51	528.85	357.31	197.63	174.59	158.69	232.74	277.50	194.03	264.59	204.02	526.21	5
Brazil	18.97	32.60	34.57	47.04	60.05	41.18	31.52	19.45	20.57	18.74	18.86	15.89	15.64	16.75	17.62	27.30	30
Canada	19.86	19.44	19.47	18.22	16.48	16.14	16.48	15.56	19.90	23.03	17.09	18.54	16.80	19.01	19.56	18.37	31
Switzerland	165.88	171.23	160.90	158.60	156.30	167.18	187.38	183.27	189.30	172.42	188.20	169.47	173.36	170.08	173.72	172.49	11
China	6.01	5.36	4.63	3.00	1.74	1.76	1.51	0.94	1.06	1.17	1.20	1.05	0.99	0.83	1.07	2.15	38
Cyprus	1780.23	1345.05	1172.52	910.73	613.79	553.45	573.04	522.80	590.06	783.39	774.61	800.59	2039.13	620.49	876.61	930.43	1
Czech Republic	68.43	63.99	76.20	86.37	84.96	84.28	80.58	65.70	56.36	54.19	52.32	47.74	47.26	46.06	45.70	64.01	21
Germany	7.52	7.13	6.90	6.85	7.04	7.36	7.82	7.57	7.42	9.24	15.90	16.77	16.68	17.36	17.67	10.61	34
Denmark	16.28	14.46	14.33	13.74	16.10	19.07	19.36	15.86	13.40	14.95	18.20	19.10	21.66	20.11	19.27	17.06	32
Spain	122.08	113.50	90.61	81.03	84.08	82.72	86.65	87.41	110.03	38.01	25.37	22.20	20.13	15.02	13.67	66.17	20
Estonia	377.47	255.93	234.46	247.54	197.14	117.47	183.09	99.12	73.92	105.23	100.94	70.75	72.57	61.25	63.22	150.67	12
Finland	231.98	215.71	267.02	298.74	255.44	235.14	354.58	276.59	218.03	386.12	815.21	1172.99	1107.03	1198.58	1439.01	564.81	3
UK	42.95	34.40	38.48	34.43	32.30	27.41	30.01	31.02	31.03	25.72	27.43	31.75	30.55	26.38	34.23	31.87	27
Greece	38.24	67.82	76.35	70.28	66.59	52.85	80.01	56.28	44.78	42.74	42.29	45.55	77.97	60.21	54.21	58.41	23
Croatia	90.32	54.02	44.69	40.53	44.89	79.47	95.98	139.71	136.15	205.65	163.54	237.67	276.51	248.18	199.91	137.15	14
Hungary	25.67	27.37	27.89	27.11	33.88	45.64	35.69	26.98	25.23	25.95	32.61	31.85	31.19	23.72	33.09	30.26	28
India	63.34	98.32	77.00	59.96	48.18	61.41	48.72	30.74	57.26	41.50	41.95	61.14	70.37	79.97	88.90	61.92	22
Ireland	1239.51	713.72	567.53	463.68	446.17	377.32	375.81	386.35	608.78	676.80	351.59	305.18	261.32	190.05	215.68	478.63	6
Italy	23.30	21.46	23.30	24.55	26.91	27.55	30.84	28.40	37.18	38.30	40.88	33.83	26.23	25.36	25.15	28.88	29
Korea	71.59	64.36	44.84	41.25	37.17	32.49	33.61	27.37	28.29	30.09	31.40	30.70	30.78	34.19	37.50	38.38	25
Lithuania	856.46	657.16	451.34	525.89	411.30	331.03	318.10	252.15	223.56	178.46	238.28	199.71	163.90	134.23	136.99	338.57	7
Luxembourg	51.02	43.63	50.52	40.76	39.76	39.23	39.45	32.38	24.28	32.01	28.23	33.01	32.02	27.78	27.98	36.14	26
Latvia	1253.02	1191.06	1211.63	585.25	487.83	580.32	542.33	341.10	286.72	425.83	322.70	260.52	251.88	206.41	215.23	544.12	4
Malta	636.78	1076.56	774.86	1028.29	1017.15	1089.41	1029.37	638.18	591.56	598.17	591.82	1049.63	1018.58	874.75	860.22	858.35	2
Netherlands	3.24	6.65	8.05	9.90	11.06	11.29	13.09	11.96	10.04	8.58	8.32	8.96	8.36	1.15	1.46	8.14	36
Norway	108.45	107.54	126.87	114.99	110.10	101.19	132.43	126.82	131.03	142.69	139.35	148.14	90.09	146.36	168.83	126.33	15
Poland	25.99	22.98	21.06	16.31	16.61	20.42	18.00	14.21	13.81	12.94	13.44	11.79	10.65	9.66	9.44	15.82	33
Portugal	112.66	105.43	98.00	77.74	66.12	86.71	70.66	54.84	57.92	49.24	57.14	52.42	65.48	46.13	38.49	69.27	19
Romania	523.03	363.41	327.01	298.74	286.61	261.28	234.00	217.43	169.51	120.22	111.63	124.78	169.70	131.95	122.50	230.79	9
Russia	235.43	212.25	216.93	171.73	119.37	103.13	90.82	56.68	63.38	63.70	66.24	47.27	48.92	59.47	140.50	113.06	17
Slovak Republic	606.15	406.10	437.12	301.84	212.10	183.36	163.30	145.25	124.28	125.21	141.75	203.96	167.02	135.08	137.79	232.69	8
Slovenia	493.47	364.75	317.36	255.99	231.40	230.34	207.22	140.39	117.49	167.32	203.16	191.20	192.44	143.73	141.73	226.53	10
Sweden	102.39	105.53	103.69	98.71	89.44	89.31	85.24	82.63	84.85	86.74	95.01	88.72	94.92	92.96	85.62	92.38	18
Turkey	3.83	3.93	3.84	3.81	2.90	2.33	2.79	1.98	2.15	2.93	3.45	3.94	3.39	4.37	8.31	3.60	37
USA	83.26	86.85	83.97	94.13	106.35	116.91	150.93	195.22	218.05	171.99	157.57	186.66	184.78	178.62	195.28	147.37	13
Means	305.56	253.40	223.41	185.39	158.08	157.68	155.65	123.68	124.42	136.70	140.21	162.39	188.68	143.78	158.26		

In the aspect of backward participation, the nature of primary resources and cheap labour are two important determinants of the GVC specialization for the backward participation indices. In Table 2, the backward participation indices have been displayed for the international construction sectors over 2000–2014. The international construction sectors performed differently when compared with the performance in the forward participation. The construction sector in most countries has improved its backward participation, which indicates that the demand from local sectors dominated the international market and most construction sectors are located downstream of the GVC. Their internationalization processes were still at the stage of benefiting from primary resources, such as Luxembourg, Malta, Ireland, Estonia and Bulgaria. So, the smaller value of the backward participation indicates the higher position of the local sector in the GVC. For example, Brazil, the USA, Russia and the UK were 0.09, 0.09, 0.10 and 0.13. The remaining countries have their indices in a range of 0.15 and 0.30.

Table 2. The backward participation indices of the international construction sectors from 2000 to 2014

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Means	Rank
Australia	0.13	0.12	0.12	0.11	0.12	0.12	0.12	0.13	0.14	0.14	0.14	0.16	0.17	0.18	0.17	0.14	34
Austria	0.19	0.20	0.19	0.19	0.19	0.21	0.22	0.22	0.23	0.22	0.24	0.25	0.26	0.25	0.25	0.22	20
Belgium	0.28	0.28	0.27	0.27	0.27	0.28	0.28	0.28	0.29	0.29	0.35	0.36	0.36	0.36	0.38	0.31	7
Bulgaria	0.25	0.27	0.27	0.29	0.35	0.34	0.36	0.37	0.38	0.29	0.31	0.32	0.35	0.37	0.40	0.33	5
Brazil	0.08	0.09	0.09	0.09	0.09	0.08	0.08	0.09	0.10	0.08	0.09	0.09	0.09	0.10	0.10	0.09	38
Canada	0.24	0.23	0.23	0.22	0.23	0.23	0.22	0.21	0.22	0.21	0.23	0.23	0.23	0.23	0.23	0.22	17
Switzerland	0.20	0.20	0.18	0.19	0.20	0.21	0.22	0.22	0.22	0.20	0.20	0.20	0.21	0.21	0.20	0.20	24
China	0.13	0.12	0.14	0.16	0.17	0.17	0.17	0.17	0.16	0.14	0.16	0.16	0.15	0.15	0.13	0.15	31
Cyprus	0.18	0.18	0.18	0.18	0.19	0.19	0.19	0.20	0.22	0.21	0.23	0.24	0.25	0.31	0.32	0.22	21
Czech Republic	0.24	0.24	0.22	0.23	0.24	0.24	0.25	0.26	0.25	0.22	0.23	0.25	0.27	0.26	0.27	0.24	15
Germany	0.15	0.15	0.13	0.14	0.14	0.15	0.17	0.17	0.18	0.16	0.18	0.19	0.19	0.19	0.18	0.16	28
Denmark	0.26	0.27	0.27	0.26	0.27	0.29	0.28	0.31	0.31	0.30	0.31	0.31	0.33	0.33	0.32	0.29	8
Spain	0.14	0.14	0.14	0.14	0.14	0.15	0.16	0.16	0.15	0.11	0.12	0.13	0.14	0.13	0.14	0.14	33
Estonia	0.34	0.34	0.34	0.32	0.34	0.33	0.33	0.31	0.31	0.29	0.33	0.33	0.35	0.35	0.34	0.33	4
Finland	0.20	0.19	0.19	0.19	0.20	0.21	0.22	0.23	0.24	0.21	0.24	0.26	0.26	0.25	0.25	0.22	18
UK	0.11	0.12	0.11	0.11	0.12	0.12	0.12	0.12	0.13	0.14	0.15	0.15	0.15	0.15	0.14	0.13	35
Greece	0.19	0.19	0.17	0.16	0.16	0.17	0.17	0.20	0.22	0.19	0.18	0.20	0.19	0.19	0.20	0.19	27
Croatia	0.26	0.27	0.28	0.28	0.27	0.26	0.27	0.27	0.27	0.23	0.22	0.23	0.25	0.25	0.26	0.26	12
Hungary	0.32	0.31	0.29	0.30	0.30	0.30	0.33	0.33	0.33	0.33	0.34	0.35	0.35	0.36	0.37	0.33	6
India	0.13	0.13	0.13	0.12	0.14	0.16	0.17	0.17	0.17	0.15	0.16	0.17	0.19	0.17	0.16	0.15	29
Ireland	0.32	0.31	0.30	0.29	0.29	0.28	0.28	0.31	0.34	0.39	0.48	0.46	0.47	0.45	0.47	0.36	3
Italy	0.15	0.14	0.14	0.13	0.13	0.14	0.15	0.15	0.15	0.14	0.16	0.16	0.16	0.16	0.16	0.15	32
Korea	0.22	0.21	0.20	0.21	0.22	0.22	0.23	0.24	0.29	0.27	0.28	0.31	0.30	0.28	0.27	0.25	13
Lithuania	0.11	0.12	0.13	0.14	0.15	0.16	0.18	0.17	0.17	0.14	0.15	0.17	0.17	0.17	0.16	0.15	30
Luxembourg	0.36	0.37	0.37	0.38	0.40	0.41	0.43	0.43	0.47	0.46	0.45	0.44	0.47	0.46	0.45	0.42	1
Latvia	0.22	0.25	0.25	0.27	0.31	0.32	0.32	0.29	0.28	0.24	0.31	0.33	0.32	0.32	0.31	0.29	10
Malta	0.34	0.30	0.29	0.27	0.30	0.33	0.38	0.41	0.42	0.42	0.42	0.43	0.47	0.43	0.43	0.38	2
Netherlands	0.25	0.24	0.25	0.25	0.24	0.23	0.24	0.23	0.26	0.26	0.29	0.30	0.30	0.33	0.33	0.27	11
Norway	0.19	0.19	0.18	0.18	0.19	0.19	0.19	0.20	0.20	0.18	0.18	0.19	0.18	0.19	0.20	0.19	26
Poland	0.18	0.17	0.18	0.20	0.20	0.20	0.22	0.22	0.23	0.21	0.24	0.26	0.26	0.25	0.25	0.22	22
Portugal	0.23	0.22	0.22	0.21	0.22	0.22	0.23	0.22	0.23	0.21	0.23	0.23	0.22	0.21	0.22	0.22	19
Romania	0.22	0.23	0.22	0.23	0.24	0.23	0.22	0.21	0.20	0.19	0.25	0.28	0.28	0.27	0.26	0.23	16
Russia	0.10	0.09	0.10	0.11	0.10	0.10	0.10	0.09	0.10	0.08	0.08	0.09	0.09	0.10	0.11	0.10	36
Slovak Republic	0.24	0.28	0.25	0.25	0.27	0.30	0.29	0.27	0.24	0.23	0.24	0.22	0.18	0.22	0.20	0.25	14
Slovenia	0.26	0.26	0.26	0.26	0.28	0.29	0.30	0.31	0.30	0.28	0.31	0.31	0.30	0.31	0.30	0.29	9
Sweden	0.22	0.22	0.21	0.20	0.20	0.22	0.22	0.22	0.23	0.23	0.20	0.21	0.21	0.21	0.21	0.21	23
Turkey	0.14	0.16	0.18	0.18	0.20	0.20	0.22	0.22	0.22	0.19	0.20	0.22	0.21	0.24	0.22	0.20	25
USA	0.08	0.07	0.08	0.08	0.09	0.10	0.10	0.10	0.11	0.09	0.10	0.10	0.10	0.10	0.10	0.09	37
Means	0.21	0.21	0.20	0.20	0.21	0.22	0.23	0.23	0.24	0.22	0.24	0.25	0.25	0.25	0.25		

Some countries such as Spain, the UK, Italy, India, and China were followed at a secondary level, which shows their construction sectors had a balanced demand and dependency on the GVC. The construction sectors in these economies are developed by the natural resources and labour at the beginning, while they can develop rapidly based on the technology spill-over and the accumulated investment. The distribution of the backward participation indices shows the internationalization of the construction sector was mainly affected by the natural resources, sectoral techniques or cheap labour support, while the volume of the total exports and the scale of the domestic market al.o has an impact on the participation of the international market. For instance, the positive influence can be found in the countries of the USA and Russia, while the construction sectors in Luxembourg and Malta reveal a negative effect. Another important factor was the real estate boom of 2008, which improved the participation of the construction industries due to the concatenation of the global value chains.

The forward support represents the share of sectoral exports in the total national exports measured by the value added, so a higher index indicates the large ability to contribute to the international market in the GVC. For instance, this index of a specific country also reveals the importance of the construction sector in value added exports. Moreover, the index has a close relationship with export concentration and diversity. The forward support index has been shown in Table 3 for the international construction sectors. The statistical data in this table has a distinct sectoral character. The construction sector plays a significant role in the national economy and its commodity values normally account for a high percentage of national exports. This phenomenon was influenced by the scale effect. For example, the construction sectors in five countries, such as Luxembourg, Estonia, Portugal, Denmark and Belgium, had large support indices, which indicated that their construction sectors had high value added products and high proportions in value added exports. Despite of those performances, the supports index was hardly found in some countries with large sector scales. The USA, Japan, Russia, and France had their construction sectors maintained at a low level in export, although the quantity of value added exports was very large corresponding to the sectoral size. The forward support indices increased rapidly over 2006–2009 due to the contribution of the real estate boom of 2008. However, the indices decreased dramatically after the global economic crisis because the construction industry was first affected by the crisis and then spread to other related industries.

In contrast to the support, the measurement of independence for the construction sector's export needs to focus on the degree of the international construction sectors to satisfy the national final demand by value added export. It is a type of independence for the local market on the international market. The backward independence index has been displayed in Table 4 for the international construction sectors. In the construction sector, the value-added transfer embodied in final demand exports indicates the demand for products from the international construction market. This type of demand accounts for a small percentage of national imports measured by value added. The main source of value added supply was the national construction sector. The average values of the backward independence index are distributed in a range of 6.84E-05~2.98E-01. Before 2008, the backward independence indices in many countries or regions kept increasing, which indicated that the real estate boom of 2008 has reached its peak and the global fluid capital has converged into the construction industry.

Table 3. The forward support index of the international construction sectors from 2000 to 2014

Country/Region	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Means
Australia	6.26E-05	6.18E-05	6.75E-05	7.08E-05	6.94E-05	7.20E-05	8.31E-05	8.37E-05	9.06E-05	9.32E-05	9.34E-05	8.99E-05	1.04E-04	1.11E-04	1.31E-04	8.57E-05
Austria	1.25E-03	1.26E-03	1.11E-03	1.11E-03	8.77E-04	7.37E-04	7.89E-04	8.24E-04	8.30E-04	7.71E-04	6.98E-04	6.75E-04	6.65E-04	6.60E-04	6.10E-04	8.58E-04
Belgium	1.11E-03	1.11E-03	1.04E-03	1.11E-03	1.07E-03	1.07E-03	1.14E-03	1.06E-03	1.19E-03	1.40E-03	1.72E-03	1.70E-03	1.70E-03	1.79E-03	1.92E-03	1.34E-03
Bulgaria	3.50E-04	3.94E-04	3.76E-04	5.31E-04	6.36E-04	4.81E-04	7.07E-04	1.20E-03	1.27E-03	2.10E-03	1.44E-03	9.79E-04	1.21E-03	6.89E-04	7.10E-04	8.71E-04
Brazil	2.62E-04	1.74E-04	1.84E-04	1.24E-04	1.03E-04	1.22E-04	1.63E-04	2.17E-04	1.83E-04	1.81E-04	1.65E-04	1.73E-04	1.81E-04	1.66E-04	1.98E-04	1.73E-04
Canada	2.80E-04	2.94E-04	3.13E-04	3.22E-04	3.58E-04	3.54E-04	4.00E-04	3.91E-04	3.34E-04	2.85E-04	2.91E-04	2.89E-04	3.28E-04	2.78E-04	3.09E-04	3.22E-04
Switzerland	8.32E-05	8.10E-05	8.81E-05	9.26E-05	9.18E-05	9.19E-05	8.81E-05	8.49E-05	8.37E-05	8.85E-05	8.84E-05	8.62E-05	8.88E-05	8.89E-05	9.47E-05	8.81E-05
China	7.88E-05	7.11E-05	6.75E-05	8.28E-05	1.09E-04	9.45E-05	1.09E-04	1.29E-04	1.28E-04	1.04E-04	1.09E-04	1.17E-04	1.12E-04	1.28E-04	1.05E-04	1.03E-04
Cyprus	4.55E-04	6.39E-04	6.64E-04	9.10E-04	1.20E-03	1.38E-03	1.40E-03	1.52E-03	1.23E-03	7.80E-04	7.34E-04	6.97E-04	2.89E-04	5.13E-04	3.67E-04	8.52E-04
Czech Republic	6.22E-04	5.71E-04	4.39E-04	3.96E-04	4.16E-04	3.96E-04	3.81E-04	4.23E-04	4.63E-04	5.47E-04	6.62E-04	6.49E-04	6.47E-04	6.90E-04	7.18E-04	5.35E-04
Germany	2.99E-04	2.93E-04	3.04E-04	2.76E-04	2.65E-04	2.64E-04	2.68E-04	2.64E-04	2.80E-04	2.58E-04	1.95E-04	1.69E-04	1.84E-04	1.74E-04	1.84E-04	2.45E-04
Denmark	1.77E-03	1.73E-03	1.74E-03	1.84E-03	1.60E-03	1.42E-03	1.45E-03	1.66E-03	2.28E-03	2.06E-03	1.72E-03	1.58E-03	1.41E-03	1.44E-03	1.62E-03	1.69E-03
Spain	8.21E-05	8.85E-05	1.01E-04	9.72E-05	9.32E-05	9.59E-05	9.29E-05	8.28E-05	7.26E-05	2.45E-04	3.81E-04	3.88E-04	3.94E-04	4.64E-04	5.06E-04	2.12E-04
Estonia	7.41E-04	9.40E-04	8.77E-04	7.40E-04	9.92E-04	2.05E-03	1.49E-03	2.62E-03	3.85E-03	2.78E-03	2.39E-03	2.99E-03	3.03E-03	3.13E-03	3.16E-03	2.12E-03
Finland	1.01E-04	9.64E-05	7.41E-05	6.74E-05	8.09E-05	1.01E-04	7.96E-05	8.97E-05	1.18E-04	7.81E-05	4.31E-05	2.86E-05	3.38E-05	3.20E-05	2.91E-05	7.02E-05
France	7.55E-10	1.63E-09	0.00E+00	3.82E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.41E-10	1.53E-09	0.00E+00	4.01E-09	2.09E-10	2.20E-09	6.40E-10	1.04E-09
UK	1.03E-04	1.29E-04	1.26E-04	1.40E-04	1.46E-04	1.95E-04	1.95E-04	1.84E-04	1.97E-04	2.25E-04	2.24E-04	2.06E-04	2.00E-04	2.25E-04	1.78E-04	1.78E-04
Greece	8.72E-04	4.53E-04	3.88E-04	4.65E-04	5.71E-04	5.17E-04	6.22E-04	4.48E-04	3.41E-04	4.46E-04	6.61E-04	5.77E-04	4.83E-04	5.86E-04	7.61E-04	5.46E-04
Croatia	1.69E-03	2.13E-03	2.05E-03	2.05E-03	2.21E-03	1.47E-03	1.27E-03	7.91E-04	8.22E-04	8.83E-04	1.17E-03	7.64E-04	6.23E-04	7.41E-04	9.27E-04	1.31E-03
Hungary	1.37E-03	1.25E-03	1.14E-03	1.03E-03	7.75E-04	6.55E-04	8.43E-04	8.61E-04	9.58E-04	9.55E-04	7.15E-04	7.31E-04	7.82E-04	9.67E-04	8.09E-04	9.23E-04
Indonesia	0.00E+00	0.00E+00	0.00E+00	2.55E-10	0.00E+00	9.50E-10	0.00E+00	0.00E+00	3.61E-10	2.27E-09	1.27E-04	1.33E-04	1.06E-04	8.47E-05	6.06E-05	3.41E-05
India	1.85E-04	1.10E-04	1.39E-04	1.54E-04	2.10E-04	1.36E-04	1.75E-04	2.29E-04	1.43E-04	1.50E-04	1.35E-04	9.40E-05	8.12E-05	7.50E-05	6.72E-05	1.39E-04
Ireland	2.76E-05	4.21E-05	4.69E-05	5.22E-05	5.88E-05	7.70E-05	9.29E-05	7.48E-05	3.56E-05	1.41E-05	3.05E-05	4.19E-05	6.13E-05	1.07E-04	9.16E-05	5.70E-05
Italy	1.09E-04	1.24E-04	1.12E-04	1.09E-04	1.09E-04	1.17E-04	1.19E-04	1.25E-04	1.03E-04	1.01E-04	9.70E-05	1.23E-04	1.98E-04	2.02E-04	2.13E-04	1.31E-04
Japan	2.39E-08	2.71E-08	2.33E-08	2.37E-08	2.34E-08	2.31E-08	2.06E-08	2.49E-08	2.39E-08	2.32E-08	2.16E-08	2.30E-08	2.25E-08	2.93E-08	2.91E-08	2.42E-08
Korea	1.83E-05	2.17E-05	2.81E-05	3.60E-05	3.85E-05	4.03E-05	5.16E-05	5.74E-05	6.01E-05	5.63E-05	4.44E-05	3.76E-05	3.76E-05	3.50E-05	3.59E-05	3.99E-05
Lithuania	1.06E-03	1.10E-03	1.33E-03	9.04E-04	1.00E-03	1.11E-03	1.28E-03	1.30E-03	1.47E-03	2.36E-03	1.49E-03	1.42E-03	1.68E-03	1.99E-03	2.36E-03	1.46E-03
Luxembourg	2.79E-03	2.81E-03	2.88E-03	2.48E-03	2.68E-03	2.41E-03	2.19E-03	2.48E-03	2.94E-03	3.09E-03	3.12E-03	2.73E-03	2.69E-03	2.71E-03	2.57E-03	2.70E-03
Latvia	3.47E-04	2.37E-04	2.25E-04	3.80E-04	3.58E-04	2.71E-04	3.56E-04	5.15E-04	6.85E-04	6.32E-04	5.48E-04	6.27E-04	6.78E-04	8.74E-04	9.37E-04	5.11E-04
Mexico	0.00E+00	0.00E+00	1.03E-09	8.75E-10	9.99E-10	1.48E-09	2.25E-09	0.00E+00	0.00E+00	1.11E-09	3.31E-10	1.04E-09	6.68E-10	1.76E-09	7.13E-10	8.18E-10
Malta	1.22E-03	1.07E-03	1.79E-03	1.26E-03	1.28E-03	1.08E-03	9.07E-04	1.04E-03	1.02E-03	8.95E-04	9.39E-04	6.06E-04	6.02E-04	6.81E-04	6.75E-04	1.00E-03
Netherlands	2.32E-03	1.29E-03	9.85E-04	7.76E-04	7.85E-04	8.39E-04	7.88E-04	8.14E-04	8.99E-04	9.22E-04	9.18E-04	7.79E-04	8.33E-04	4.98E-03	4.33E-03	1.48E-03
Norway	1.87E-04	1.86E-04	1.62E-04	1.80E-04	1.93E-04	2.00E-04	1.80E-04	1.76E-04	1.76E-04	1.79E-04	1.90E-04	1.67E-04	2.72E-04	1.53E-04	1.44E-04	1.83E-04
Poland	1.55E-03	1.63E-03	1.69E-03	1.92E-03	1.79E-03	1.45E-03	1.63E-03	1.79E-03	1.65E-03	2.11E-03	2.07E-03	2.15E-03	2.27E-03	2.47E-03	2.39E-03	1.90E-03
Portugal	2.74E-04	2.90E-04	3.14E-04	3.80E-04	4.54E-04	3.73E-04	5.09E-04	6.43E-04	6.31E-04	7.01E-04	6.32E-04	7.15E-04	7.13E-04	9.55E-04	1.16E-03	5.83E-04
Romania	3.55E-04	4.87E-04	5.52E-04	5.43E-04	5.20E-04	5.45E-04	6.35E-04	5.34E-04	7.59E-04	1.56E-03	1.35E-03	1.02E-03	7.19E-04	8.94E-04	1.01E-03	7.65E-04
Russia	3.79E-05	3.86E-05	3.52E-05	3.95E-05	4.48E-05	4.32E-05	4.58E-05	5.49E-05	5.11E-05	4.45E-05	4.58E-05	5.36E-05	4.88E-05	4.45E-05	3.10E-05	4.39E-05
Slovak Republic	3.55E-04	3.67E-04	4.13E-04	4.24E-04	5.32E-04	5.68E-04	7.55E-04	7.76E-04	1.09E-03	1.22E-03	1.05E-03	9.42E-04	1.17E-03	1.10E-03	1.26E-03	8.01E-04
Slovenia	4.45E-04	5.47E-04	5.61E-04	6.24E-04	6.52E-04	7.39E-04	8.90E-04	1.28E-03	1.56E-03	1.32E-03	1.09E-03	1.17E-03	1.35E-03	1.52E-03	1.77E-03	1.03E-03
Sweden	1.87E-04	2.13E-04	2.22E-04	2.22E-04	2.60E-04	2.68E-04	3.24E-04	3.35E-04	3.21E-04	3.38E-04	3.26E-04	3.14E-04	2.85E-04	2.82E-04	3.56E-04	2.83E-04
Turkey	1.23E-03	1.66E-03	1.46E-03	1.27E-03	1.38E-03	1.46E-03	1.62E-03	1.84E-03	1.92E-03	1.42E-03	1.09E-03	8.57E-04	9.89E-04	7.42E-04	5.07E-04	1.30E-03
Taiwan	1.31E-07	1.32E-07	1.59E-07	1.73E-07	2.05E-07	1.91E-07	1.63E-07	1.86E-07	1.71E-07	2.18E-07	2.48E-07	2.70E-07	3.28E-07	3.35E-07	4.35E-07	2.23E-07
USA	2.81E-06	2.77E-06	2.82E-06	2.69E-06	2.46E-06	2.29E-06	2.26E-06	2.07E-06	2.00E-06	2.28E-06	2.44E-06	2.11E-06	2.10E-06	2.16E-06	2.14E-06	2.36E-06
RoW	4.42E-04	3.72E-04	3.35E-04	2.90E-04	2.78E-04	2.69E-04	2.66E-04	2.22E-04	2.10E-04	1.90E-04	1.68E-04	1.73E-04	2.12E-04	2.68E-04	2.49E-04	2.63E-04
Means	5.62E-04	5.53E-04	5.55E-04	5.34E-04	5.52E-04	5.36E-04	5.54E-04	6.18E-04	6.92E-04	7.18E-04	6.58E-04	6.14E-04	6.24E-04	7.51E-04	7.62E-04	

Table 4. The backward independence index of the international construction sectors from 2000 to 2014

Country/Region	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Means
Australia	5.86E-04	5.19E-04	4.13E-04	3.70E-04	4.60E-04	3.63E-04	4.44E-04	4.54E-04	6.23E-04	1.35E-03	2.49E-03	2.38E-04	2.58E-04	2.39E-04	1.40E-02	1.52E-03
Austria	5.04E-03	6.06E-03	6.04E-03	5.82E-03	5.14E-03	5.09E-03	5.13E-03	5.01E-03	5.73E-03	5.37E-03	4.57E-03	4.95E-03	5.54E-03	6.00E-03	5.72E-03	5.41E-03
Belgium	4.98E-03	4.57E-03	4.24E-03	3.99E-03	3.69E-03	3.39E-03	3.05E-03	2.75E-03	3.04E-03	3.36E-03	7.75E-03	8.48E-03	8.93E-03	1.12E-02	1.22E-02	5.71E-03
Bulgaria	3.03E-03	1.89E-02	3.06E-03	3.12E-03	3.00E-02	2.87E-03	2.81E-03	2.94E-03	6.64E-03	5.17E-03	6.53E-03	7.32E-03	7.77E-03	9.82E-03	1.12E-02	8.08E-03
Brazil	3.47E-04	4.16E-04	4.43E-04	3.92E-04	3.12E-04	3.06E-04	2.88E-04	3.01E-04	3.85E-04	3.40E-04	2.67E-04	2.58E-04	2.64E-04	2.69E-04	2.42E-04	3.22E-04
Canada	4.03E-04	3.55E-04	3.55E-04	3.43E-04	3.55E-04	3.81E-04	3.76E-04	4.68E-04	4.20E-04	3.96E-04	4.14E-04	4.05E-04	3.56E-04	3.23E-04	2.92E-04	3.76E-04
Switzerland	4.80E-03	4.67E-03	4.09E-03	3.57E-03	3.69E-03	3.98E-03	3.71E-03	3.88E-03	4.17E-03	3.77E-03	2.56E-03	3.01E-03	3.40E-03	3.45E-03	3.13E-03	3.73E-03
China	4.27E-04	5.20E-04	6.29E-04	1.24E-03	1.45E-03	1.29E-03	1.21E-03	1.24E-03	1.05E-03	8.39E-04	6.26E-04	5.96E-04	2.32E-04	2.03E-04	2.05E-04	7.84E-04
Cyprus	3.13E-03	2.69E-03	2.56E-03	2.54E-03	2.37E-03	2.60E-03	1.55E-03	5.59E-04	1.48E-03	2.15E-03	2.84E-03	3.34E-03	4.42E-03	7.13E-03	8.99E-03	3.22E-03
Czech Republic	9.25E-03	9.74E-03	6.90E-03	7.43E-03	5.79E-03	5.27E-03	5.38E-03	6.04E-03	6.35E-03	6.41E-03	6.20E-03	7.51E-03	8.21E-03	7.81E-03	8.18E-03	7.10E-03
Germany	1.01E-03	9.98E-04	1.01E-03	1.17E-03	1.23E-03	1.37E-03	1.64E-03	1.64E-03	1.67E-03	2.10E-03	2.24E-03	2.18E-03	1.97E-03	2.04E-03	1.95E-03	1.61E-03
Denmark	7.44E-03	7.57E-03	7.50E-03	6.92E-03	7.00E-03	8.90E-03	5.33E-02	9.69E-03	1.02E-02	1.16E-02	1.14E-02	8.92E-03	1.32E-02	1.22E-02	1.06E-02	1.24E-02
Spain	5.27E-04	6.04E-04	5.88E-04	5.27E-04	5.07E-04	5.15E-04	5.20E-04	5.53E-04	5.08E-04	5.70E-04	7.26E-04	7.42E-04	8.13E-04	9.83E-04	9.61E-04	6.43E-04
Estonia	3.31E-02	3.20E-02	3.10E-02	3.33E-02	3.22E-02	2.89E-02	2.39E-02	2.27E-02	2.27E-02	2.66E-02	3.14E-02	7.36E-02	7.22E-02	7.43E-02	7.40E-02	4.08E-02
Finland	1.88E-03	1.83E-03	2.22E-03	2.59E-03	2.13E-03	2.27E-03	2.04E-03	1.91E-03	1.63E-03	1.83E-03	1.28E-03	1.34E-03	1.33E-03	1.32E-03	1.34E-03	1.80E-03
France	1.12E-03	1.04E-03	1.04E-03	1.00E-03	1.02E-03	9.78E-04	9.79E-04	9.77E-04	1.05E-03	1.12E-03	1.16E-03	1.20E-03	1.19E-03	1.20E-03	1.25E-03	1.09E-03
UK	2.02E-03	1.90E-03	1.66E-03	1.59E-03	1.56E-03	1.50E-03	1.66E-03	1.34E-03	1.59E-03	2.25E-03	2.20E-03	1.93E-03	1.92E-03	2.05E-03	1.91E-03	1.81E-03
Greece	1.91E-03	1.52E-03	1.48E-03	1.11E-03	1.05E-03	1.58E-03	1.08E-03	1.59E-03	2.25E-03	2.19E-03	2.49E-03	3.22E-03	2.98E-03	3.97E-03	4.28E-03	2.18E-03
Croatia	2.01E-03	1.61E-03	1.89E-03	1.65E-03	1.48E-03	1.22E-03	1.23E-03	1.11E-03	1.12E-03	1.29E-03	1.18E-03	1.31E-03	1.44E-03	1.60E-03	1.81E-03	1.46E-03
Hungary	9.12E-03	7.98E-03	6.43E-03	6.70E-03	5.84E-03	5.05E-03	4.99E-03	5.85E-03	6.84E-03	6.76E-03	5.67E-03	5.73E-03	6.24E-03	7.21E-03	6.19E-03	6.44E-03
Indonesia	4.69E-04	5.32E-04	4.29E-04	2.94E-04	3.05E-04	3.20E-04	2.62E-04	2.38E-04	2.08E-04	1.68E-04	1.08E-04	1.04E-04	1.11E-04	8.74E-05	7.72E-05	2.48E-04
India	3.48E-04	2.57E-04	2.87E-04	2.82E-04	3.92E-04	4.53E-04	1.83E-03	3.65E-04	1.22E-03	1.69E-03	1.87E-03	1.50E-04	1.55E-04	1.35E-04	1.20E-04	6.37E-04
Ireland	6.27E-04	5.73E-04	6.63E-04	7.99E-04	5.56E-04	5.32E-04	5.61E-04	6.45E-04	8.95E-04	2.60E-03	3.98E-03	2.99E-03	2.24E-03	2.67E-03	2.27E-03	1.51E-03
Italy	2.71E-03	1.55E-03	1.58E-03	1.29E-03	1.20E-03	1.16E-03	1.23E-03	1.21E-03	1.26E-03	1.22E-03	1.48E-03	1.36E-03	1.51E-03	1.43E-03	1.50E-03	1.45E-03
Japan	5.72E-05	5.38E-05	5.80E-05	6.97E-05	7.66E-05	8.25E-05	8.94E-05	8.12E-05	7.85E-05	6.45E-05	5.57E-05	6.13E-05	6.31E-05	6.36E-05	7.13E-05	6.84E-05
Korea	3.45E-04	3.79E-04	3.80E-04	4.13E-04	4.99E-04	4.79E-04	4.94E-04	5.88E-04	7.77E-04	6.41E-04	6.06E-04	5.69E-04	9.79E-04	6.00E-04	5.52E-04	5.53E-04
Lithuania	2.97E-03	3.63E-03	3.85E-03	5.47E-03	3.05E-03	2.70E-03	1.96E-03	1.75E-03	1.83E-03	4.02E-03	4.25E-03	4.52E-03	5.05E-03	4.71E-03	4.36E-03	3.61E-03
Luxembourg	2.62E-03	2.62E-03	2.55E-03	2.60E-03	2.64E-03	2.47E-03	2.58E-03	2.63E-03	2.93E-03	2.61E-03	2.85E-03	2.67E-03	3.17E-03	2.85E-03	2.67E-03	2.70E-03
Latvia	3.66E-03	4.42E-03	4.73E-03	5.30E-03	5.70E-03	6.18E-03	5.78E-03	5.02E-03	4.95E-03	5.33E-03	9.05E-03	8.41E-03	6.93E-03	8.39E-03	8.08E-03	6.13E-03
Mexico	3.89E-04	3.87E-04	3.42E-04	3.56E-04	2.54E-04	2.65E-04	2.36E-04	2.31E-04	2.41E-04	2.74E-04	2.42E-04	2.44E-04	2.52E-04	2.17E-04	2.06E-04	2.76E-04
Malta	1.35E-02	1.14E-02	1.27E-03	7.11E-03	2.40E-03	8.80E-03	1.85E-03	2.18E-03	5.07E-03	1.47E-02	1.60E-02	1.59E-02	1.87E-02	1.58E-02	1.74E-02	1.01E-02
Netherlands	4.02E-01	4.31E-01	3.97E-01	4.03E-01	4.25E-01	4.70E-01	3.59E-01	6.37E-01	3.63E-01	4.90E-02	9.27E-02	9.96E-02	1.06E-01	1.17E-01	1.16E-01	2.98E-01
Norway	1.54E-02	1.48E-02	1.46E-02	1.80E-02	4.02E-03	3.50E-03	3.34E-03	3.36E-03	3.76E-03	3.23E-03	2.80E-03	2.99E-03	1.97E-03	2.23E-03	2.03E-03	6.40E-03
Poland	3.91E-03	3.77E-03	4.11E-03	5.11E-03	4.72E-03	3.14E-03	3.75E-03	3.54E-03	3.69E-03	3.39E-03	3.20E-03	2.80E-03	3.32E-03	3.59E-03	3.71E-03	3.72E-03
Portugal	1.97E-03	1.76E-03	1.71E-03	1.80E-03	1.96E-03	2.23E-03	2.21E-03	2.09E-03	2.13E-03	2.66E-03	3.02E-03	2.79E-03	2.71E-03	3.05E-03	3.09E-03	2.35E-03
Romania	5,53E-03	4.92E-03	4.44E-03	4.57E-03	4.70E-03	4.12E-03	3.71E-03	3.00E-03	2.37E-03	2.71E-03	3.34E-03	3.37E-03	3.36E-03	3.44E-03	3.03E-03	3.77E-03
Russia	5.36E-03	3.95E-03	4.18E-03	4.43E-03	4.72E-03	4.59E-03	4.67E-03	4.47E-03	4.17E-03	3.92E-03	2.94E-03	2.84E-03	3.01E-03	2.64E-03	2.03E-03	3.86E-03
Slovak Republic	8.69E-03	1.02E-02	8.31E-03	8.86E-03	1.01E-02	3.33E-03	2.81E-03	2.47E-03	2.29E-03	1.65E-03	1.66E-03	2.09E-03	2.62E-02	2.69E-03	2.68E-03	6.27E-03
Slovenia	5.65E-03	5.72E-03	5.36E-03	5.37E-03	5.50E-03	5.37E-03	5.24E-03	5.21E-03	5.10E-03	4.68E-03	5.36E-03	6.13E-03	6.16E-03	6.80E-03	6.39E-03	5.60E-03
Sweden	2.74E-03	2.25E-03	2.23E-03	2.23E-03	2.02E-03	2.14E-03	1.82E-03	1.81E-03	1.96E-03	2.16E-03	2.13E-03	2.10E-03	2.42E-03	2.13E-03	2.07E-03	2.15E-03
Turkey	6.62E-04	9.79E-04	1.36E-03	1.25E-03	1.01E-03	8.79E-04	8.20E-04	7.72E-04	7.46E-04	1.11E-03	8.11E-04	9.83E-04	9.03E-04	8.76E-04	8.00E-04	9.31E-04
Taiwan	2.66E-03	2.69E-03	2.57E-03	1.90E-03	2.12E-03	2.32E-03	2.09E-03	2.04E-03	2.23E-03	2.05E-03	1.44E-03	1.72E-03	3.55E-03	2.64E-03	3.51E-03	2.37E-03
USA	6.59E-04	6.22E-04	6.01E-04	6.32E-04	6.88E-04	6.91E-04	7.66E-04	7.11E-04	6.98E-04	5.91E-04	7.26E-04	8.34E-04	9.17E-04	7.69E-04	7.59E-04	7.11E-04
RoW	4.16E-03	4.08E-03	3.59E-03	3.84E-03	4.10E-03	3.48E-03	7.23E-03	3.17E-03	5.75E-03	5.22E-03	3.96E-03	2.56E-03	1.97E-03	2.17E-03	2.84E-03	3.88E-03
Means	1.32E-02	1.40E-02	1.25E-02	1.30E-02	1.35E-02	1.38E-02	1.20E-02	1.72E-02	1.13E-02	4.57E-03	5.88E-03	6.91E-03	7.82E-03	7.73E-03	8.06E-03	

The phenomenon was positive to the internationalization process of the construction industry. However, the subsequent outbreak of the financial crisis led to clearly decreased indices from 2009 to 2014, such as China and India. The construction sectors' structure in these countries has been improved and transformation in development directs under the policy guidance. In some European countries, the construction sectors maintained their indices at a steady level due to the mature industry structure, including Germany, France and the UK. The difference between the above two types of performances, the construction sectors in the USA and Spain kept increasing over the whole study period from 2000 to 2014. The final demand for value added exports almost continuously increased, which indicates the international construction market has become the destination of value-added export.

Foreign trade constructs a pathway to join in international trade activities for a specific economy. These foreign trade activities also facilitate the internationalization process and help the economies to form stable trade links. The forward support and backward independence indices indicate the abilities of a specific sector in exports and demand for imports of value added exports. These two indicators represent two parts of the outside loop and reveal the relationships between any two economies in GVCs. Figure 1 shows the value added flows of an economy in the outside and inner loops through an illustration of economy A. The figure also reveals the pathway of a segment of the GVC. Inside economy A, the inner loop contains the sectoral support from upstream sectors to downstream sectors and the demands in a reverse circular path. While observing in the sight of the global economic system, the relationship between economy A and the aggregation of the rest of the economies constructs the outside loop pathways. The exports from support represent the forward supports, which contain three trade patterns including value added exports, VS exports and VS1* exports (Liu et al., 2020a). Because the backward independence index indicates the imports of value added exports, the demand for imports is limited to final goods within domestic and foreign value added.

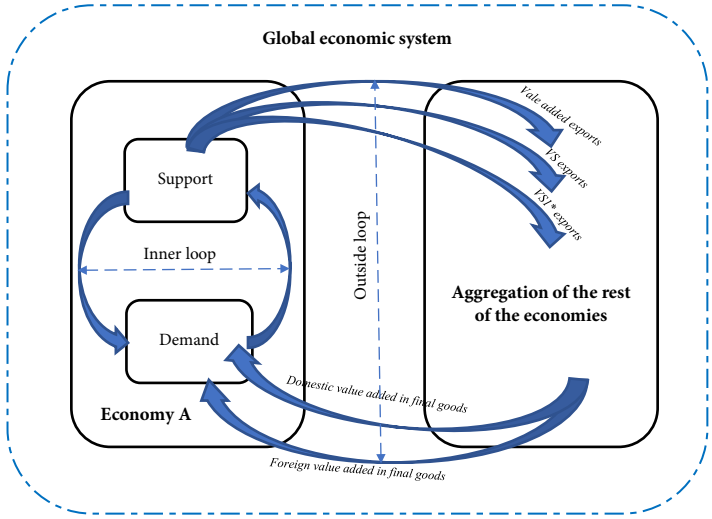

Figure 1. The value added flows of an economy in the outside and inner loops by an illustration of economy A

Additionally, the performance of the construction sectors can also be identified according to the narration in Figure 1. For example, an economy with a high forward support index indicates a favourable performance in the GVC, while the high backward independence index reveals that the economy's demand is satisfied by the imports and the independent ability is weak. Globalization has developed at a high level and this trend is also supported by many countries with a requirement for economic growth. Suggested strategies for countries with different forward support and backward independence indices can be found in Table 5.

Table 5. Suggested strategies for countries with different forward support and backward independence indices

Indices		Suggested strategies
Forward support index	*High*	– Favorable performance and beneficial position in GVC
	Low	– Develop both inner and outside loops; – Develop the sectoral techniques; – Adjust the sectoral structure; – Improve the level of products toward high value added products
Backward independence index	*High*	– Emphasize the development of inner loop; – Develop the sectoral techniques; – Extend the local market to enlarge the supply of intermediate goods
	Low	– Favorable performance and beneficial position in GVC

Conclusions

This paper focuses on the quantification of internationalization for the construction industries in the GVC. The indicators are conducted to realize the measurement of the development of the international construction industries in the GVC. The detailed conclusions have been depicted as follows:

The forward participation denotes the construction sector locates in the upstream sector of the GVC. The product of the construction sector normally controls advanced techniques and has a high value added to its products. The countries limited by market scale have chosen to develop the construction sector in indirect value added. In other words, a high degree of participation in the international construction market is an inevitable approach. The small values of the forward participation indices have proved the low degree of internationalization without the internal driving force of market competition, which indicates the weak competitive advantage and large domestic market. Besides, the demand from local sectors in most countries dominated the international construction market. In the construction sector, the backward participation indices' distribution shows that internationalization was mainly affected by natural resources, sectoral techniques or cheap labour support. The construction sectors in these economies can develop rapidly based on the technology spillover and the accumulated investment. Their internationalization processes were still at the stage of benefiting from primary resources.

The forward support index has a close relationship with export concentration and diversity. This index is also influenced by the scale effect. For example, some countries had large

support indices in the construction sector, which indicated that their construction sectors had high efficiency in value-added exports to support the international construction market. These countries are located at vantage points of the international construction market. The inner loop inside these countries also contains sectoral support from upstream sectors to downstream sectors. In addition, the backward independence index of the international construction sectors shows the transmission of value added embodied in the exports of final demand and the local demand for products from the international construction market. This type of demand accounts for a small percentage of national imports measured by value added. The main source of value added supply was the local construction sector because of the improved sectoral structure under the policy guidance.

This study proposes a comprehensive indicator to quantify the internationalization of the construction industries at the global level. The developing features reveal the degree of the participant and the relationships between a specific construction sector and the international market in the GVC. Considerable references can be taken into account for the local government, as well as the upgrade of sectoral structure in the quickly changing worldwide trade environment.

In this paper, the participation and interaction indicators can quantify the performance of the construction industry in the international market based on the transfer of value-added. However, the adaptability of the construction industry in different regions around the world limits further identification in distinguishing the development of sectoral internationalization. Thus, future studies focus on the research of regional adaptability indicators which lead to an important direction for measuring industry internationalization.

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