Article

Relationship between Countries' Energy Indicators and the Indices of GVC Participation: The Case of APEC Member Economies

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Abstract: In the 21st century the importance of global value chains continues to grow. There is a scientific gap in the research on the relationship between countries' energy indicators and the GVC participation indices. Based on the analysis of the APEC member economies' GVC participation, the presence of quantifiable links between the countries' energy indicators and GVC participation indices was identified. APEC member countries have a higher index of forward GVC participation compared to a rather low index of backward participation. We have confirmed the following hypotheses. Countries with higher energy consumption and countries exporting fuel have higher forward GVC participation. Energy importing countries and countries with higher energy intensity have higher backward GVC participation. Countries with higher energy intensity have lower forward GVC participation than countries with lower energy intensity. It was concluded that concerted efforts of APEC member economies are needed to increase GVC sustainability and develop unified energy policy standards. Managerial implications of energy efficient and sustainable GVCs will include competitive advantages growth for all the countries and suppliers participating in a particular GVC.

Keywords: APEC; domestic value added; energy consumption; energy imports; energy intensity; foreign value added; fuel exports; global value chain; GVC participation index

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1. Introduction

Global value chains (hereinafter GVCs) are a substantial part of international trade, economic integration, and globalization. Amidst the liberalization of foreign economic activity and trade barriers reduction taking place in the 21st century, GVCs importance continues to increase. At the same time, companies operating in international markets, participating in the GVCs, tend to organize their production in those countries and regions where production costs may be lower [1].

In spite of the fact that there is a lot of research concerning the GVC participation indices and factors influencing GVCs, not many studies can be found devoted to the relationship between energy indicators and participation in GVCs.

The purpose of the study is to determine the relationship between countries' energy indicators and the GVC participation indices.

To conduct further research, the hypotheses should be formulated (Table 1).

Table 1. Hypotheses about the relationship between countries' energy indicators and the GVC participation indices.

Hypothesis Number	Formulation	Accepted/Rejected
Hypothesis 1 (H1)	Countries with higher GDP per unit of energy consumption (PPP USD per kg of oil equivalent) have higher forward GVC participation	Accepted
Hypothesis 2 (H2)	Countries with lower GDP per unit of energy consumption (PPP USD per kg of oil equivalent) have higher backward GVC participation	Rejected
Hypothesis 3 (H3)	Energy importing countries have higher backward GVC participation	Accepted
Hypothesis 4 (H4)	Countries exporting fuel have higher forward GVC participation	Accepted
Hypothesis 5 (H5)	Countries with higher energy intensity level of primary energy have lower forward GVC participation than countries with lower energy intensity level of primary energy	Accepted
Hypothesis 6 (H6)	Countries with higher energy intensity level of primary energy have higher backward GVC participation than countries with lower energy intensity level of primary energy	Accepted

Source: own elaboration.

The rest of this paper is as follows. Section 2 is a literature review. Section 3 provides the information base and research methods. Section 4 presents an analysis of APEC member economies' positions in the World Energy Trilemma Index, an assessment of APEC member economies participation in the GVCs, confirmation of the relationships between countries' energy indicators and the GVC participation indices, as well as research results discussion. Section 4 presents the conclusions, concerning the authors' opinion that it is necessary for APEC economies to make concerted efforts aimed at increasing the GVCs.

The main contribution of this study can be summarized as follows. It has been determined that there is a relationship between countries' energy indicators and the GVC participation indices.

2. Literature Review

Over the past almost 40 years, countries' participation in GVC has been deeply studied.

Michael Porter's fundamental work, "Competitive Advantage: Creating and Sustaining Superior Performance", first published in 1985, can be considered as a reference point in the GVC study. According to Porter (1985) [2,3], the GVC ultimate goal is to gain a competitive advantage over competitors in the market.

Firstly, there is a lot of research devoted to the GVC participation indices. Koopman et al. (2010) introduced the GVC participation index, particularizing that it is necessary to differentiate between backward and forward participation [4]. Johnson and Noguera (2012), and Stehrer et al. (2012) continued Koopman's research and suggested the measures of GVC participation and GVC position [5,6]. Backward and forward GVC participation analysis, studies of the GVCs determinant and peculiarities, as well as an estimation of particular countries participation in GVCs were conducted in the research by Kowalski et al. (2015) [7], Baldwin and Lopez-Gonzalez (2013) [8], and Sidorova (2018) [9]. In particular, Sidorova (2018) wrote that for successful integration of a country into the GVC, it is necessary to reconsider the priorities of state industrial and economic policy [9].

Secondly, there are a lot of research papers concerning various factors influencing GVCs, especially economic integration and preferential trade agreements. Van der Marel (2015) has researched the variables that have an influence on GVC participation, systemizing them in three groups: structural forces and endowments (market size, GDP, GDP per capita, etc.); traditional trade and regulatory barriers (trading across borders, doing business, trade barriers, etc.); and new issue areas (FDI restrictions, innovation climate, etc.) [10]. Van der Marel found the positive impact of GDP per capita and the negative impact of market size (population), FDI restrictions, and trading across borders on backward GVC

participation [10]. European Union integration and its GVCs particularities were studied by Amador, Cappariello, and Stehrer (2015) who found substantial heterogeneity between countries in the evolution of GVCs and made the conclusion that the high relevance of GVCs in the euro area is accompanied by their comparatively stronger resilience in the face of trade collapse [11]. Continuing the above-mentioned research, Amador and Cabral (2016) summarized general drivers of GVC participation, such as lowering the trade and investments costs, trade and investment liberalization, regional trade blocs (integration), EU enlargement, and technological development [12]. Another research paper for the EU-28 conducted by Kersan-Škabić (2019) showed that lack of GVC participation, GDP per capita, or GDP growth rate have a positive and significant impact on GVC participation; wages, and profit tax rates have a negative impact [13]. According to Casella, Bolwijn, Moran, and Kanemoto (2019), the relevance of GVC data for the analysis of globalization patterns, particularly at the intersection between trade, investment, and development, is obvious [14]. Some other research has discussed the relationship between preferential trade agreements and GVCs, in this case studies by Antras and Staiger (2012), Baldwin (2008, 2012) [15–17] should be mentioned. They explained the development of supply-chain trade and found it very regionalized, supported by a combination of deep regional trade agreements (RTAs), bilateral investment treaties (BITs), and unilateral reforms by developing countries, mostly accomplished outside the World Trade Organization (hereinafter WTO). Continuing the study of the relationship between preferential trade agreement and participation in GVCs, Osnago, Rocha, and Ruta (2015) found that the coefficient of the interaction term between depth of preferential trade agreement and participation in GVCs is consistently positive and significant across specifications, using different variables of depth and provisions. They concluded that deep preferential trade agreements have a larger impact on GVC-intensive sectors [18]. Moreover, Ruta (2017) introduced a trust dilemma that characterizes the relationship between preferential trade agreements and GVCs where countries can choose between four different strategies that go from a situation of no preferential trade agreement and no participation in GVCs (national production and no agreements) to GVCs and deep integration [19]. Lastly, Ignatenko, Raei, and Mircheva (2019) found that GVC-related trade, rather than conventional trade, has a positive impact on income per capita and productivity; however, there is large heterogeneity and the gains appear more significant for upper-middle and high-income countries [1].

Thirdly, several researches are focused on supply chain sustainability or resilience. At the international level, the standard ISO 28002:2011 “Security management systems for the supply chain—Development of resilience in the supply chain—Requirements with guidance for use” is accepted. In 2004, as a basis for the sustainability of supply chains, Lee proposed the Triple-A approach: Triple-A = Agility + Adaptability + Alignment. According to Lee (2004), the most successful, i.e., sustainable, are the companies whose supply chains have such characteristics as dynamism, adaptability, and alignment [20] (pp. 102–112). It should be mentioned that in 2003, the sustainability of the supply chain was defined as the ability to respond to unexpected failures and restore the normal operation of the supply chain [21] (pp. 22–30). Rice and Caniato (2003) considered that in today’s business environment, we need a supply network that has comprehensive security processes and procedures in place and is resilient enough to bounce back from any disruptions that do happen [21] (pp. 22–30). Another approach to GBC sustainability was suggested by Ponomarov and Holcomb (2009) who described sustainability as the adaptive ability of supply chains to prepare for unexpected events, respond to failures, and recover from them, maintaining the continuity of operations at the desired level of connectivity and control over structure and functions. According to Ponomarov and Holcomb, supply chain disruptions have adverse effects on both revenue and costs. Resilient supply chains incorporate event readiness, are capable of providing an efficient response, and often are capable of recovering to their original state or even better, post the disruptive event [22] (pp. 124–143). Day (2014) adheres to a similar interpretation, while including in it the need to predict risk and minimize its impact. A complex adaptive supply network (CASN)

lens was also suggested, which is used to frame what existing literature has uncovered regarding disaster relief efforts, showing how relief organizations, their interactions, and their environmental context help determine the level of resilience that supply networks experience following disasters. This CASN characterization is leveraged to help explain why traditional supply chain management practices lead to varied results in disaster relief [23] (pp. 1970–1988). Thus, due to Liao and Fan Ziyang (2020), supply chain visibility is crucial to understanding the impact of disruption [24]. According to Miroudot (2020), in times of a pandemic, it may be premature to call for the end of GVCs or to conclude that shorter supply chains would be less vulnerable. Thereby, the relationship between GVCs and resilience or robustness in the supply of inputs is more complicated than it looks. Thus, policies in the future should support business efforts to build more robust and resilient supply chains, and not add to health and other dangers a policy risk built on misconceptions about GVCs [25]. In our opinion, the concept of GVC resilience, or the strength of an economy or a regional grouping against systemic risks, introduced by Sangaraju and Bayhaqi (2020), is of particular importance. The GVC resilience is considered as the inverse value of risk: a range of factors determining the ability of an economy to respond to risks, limit their economic and social consequences, and restore the state of the value chain at the pre-crisis level [26].

Fourthly, there are several research studies concerning the role of energy indicators in sustainability and sustainable development. The role of energy indicators for tracking sustainability in developing countries was examined Kemmler and Spreng (2007) [27]. Furthermore, Taylor et al. (2017) particularized better energy indicators for sustainable development [28], and Perea-Moreno and Hernandez-Escobedo (2021) conducted analysis of advances in renewable energy and energy saving systems for the sustainable city [29]. Sustainability outlook of thermochemical-based second-generation biofuel production was presented by Meramo et al. (2021) [30]. Two more pieces of researches should be mentioned in this case. Haddad et al. (2021) identified a framework for assessing urban energy sustainability [31], and Aldhshan et al. (2021) discussed energy consumption and spatial assessment of renewable energy penetration and building energy efficiency [32].

Finally, there is a lack of research on the relationship between countries' energy indicators and their participation in GVCs. Nevertheless, several studies concerning energy sustainability and value chains are of particular interest. First of all, the Energy Trilemma Index suggested by Mastepanov and Chigarev (2020) is of great importance in assessing the sustainability of national energy policy and the development of safe, equally accessible, affordable, and environmentally sustainable energy [33]. Another interesting study was conducted by Palekhov and Palekhova (2018) who clarified the specific features of the modern concept of energy efficiency, which is based on three core dimensions—energy security, energy equity, and environmental sustainability. This concept was considered as the basis for further development of GVCs, as an approach for assessing energy efficiency of their links, and for planning appropriate joint actions [34]. Elemental concepts utilized in the Global Production Networks (GPNs) literature such as those used in global commodity chain, global value chain, and supply chain research were described by Van de Graaf et al. (2016). Three case studies related to energy and global production systems—solar photovoltaics, shale gas, and salmon aquaculture—were detailed [35]. Continuing GVCs researches, Bamber, Guinn, and Gereffi (2014) made use of the global value chain framework to unpack the multiple issues and constraints facing Burundi's electrical energy sector [36]. A GVC analytic framework to analyze the wind energy value chain in South Africa and its impact on localization of goods and services was utilized by Morris, Robbins, Hansen, and Nygard (2021) [37]. One more interesting model should be mentioned here. Sarkar Biswajit et al. (2021) suggested the multi-setup multi-delivery (MSMD) concept. The model's goal is to show bioenergy's effect to make a sustainable supply chain of biofuel and biogas [38]. Thus, supply chain management aims to integrate environmental thinking with efficient energy consumption into supply chain management. It includes a flexible manufacturing process, more product delivery to customers, optimum

energy consumption, and reduced waste. Vandana Singh et al. (2021) considered a two-echelon supply chain, particularizing a producer and supplier with two-level trade-credit policies (TLTCP) with the optimum consumption [39]. A suitable way of smart production was proposed by Bhuniya Shaktipada et al. (2020). They concluded that selling price and energy consumption-dependent demand should be considered for producer and customer benefit [40]. Another interesting model was proposed by Lim Byeongho et al. (2020). It is a quantitative approach using a computational general equilibrium (CGE) model to estimate the effects of the reverse GVC factors on the global economy, trade, and energy market [41]. A robust analysis of the global supply chain and manufacturing costs for components of Organic Rankine Cycle (ORC) turboexpanders and steam turbines used in geothermal power plants undertaken by Akar et al. (2018) [42] is of particular interest as well. Lastly, Wu et al. (2020) studied the causality between participation in GVCs and renewable energy consumption [43].

In Table 2 the contribution of different authors to the study of GVCs is given. Table 2 describes the different research gap mentioned in the literature review.

Table 2. Authors' contribution to the study of GVC management and sustainability and the relationship between Countries' Energy Indicators and the Indices of GVC Participation.

Researchers	GVC Participation Measurement	GVCs in Regional Trade Agreements and Organizations	GVC Sustainability or Resilience	Energy Indicators in Sustainability and Sustainable Development	GVC Energy Indicators	Energy Indicators and GVC Indices Relations
Koopman et al. (2010) [4], Johnson and Noguera (2012) [5], Stehrer et al. (2012) [6], Kowalski et al. (2015) [7], Baldwin and Lopez-Gonzalez (2013) [8], Sidorova (2018) [9], Van der Marel (2015) [10], Amador, Cappariello and Stehrer (2015) [11], Amador and Cabral (2016) [12], Casella et al. (2019) [14], Osnago, Rocha and Ruta (2015) [18], Ruta (2017) [19]	+					
Amador, Cappariello and Stehrer (2015) [11], Amador and Cabral (2016) [12], Kersan-Skabić (2019) [13], Antras and Staiger (2012) [15], Baldwin (2008) [16], Baldwin (2012) [17], Osnago, Rocha and Ruta (2015) [18], Ruta (2017) [19]		+				
Lee (2004) [20], Rice and Caniato (2003) [21], Ponomarov and Holcomb (2009) [22], Day (2014) [23], Liao and Fan Ziyang (2020) [24], Miroudot (2020) [25], Sangaraju and Bayhaqi (2020) [26]			+			
Kemmler and Spreng (2007) [27], Taylor et al. (2017) [28], Perea-Moreno and Hernandez-Escobedo (2021) [29], Meramo et al. (2021) [30], Haddad et al. (2021) [31], Aldhshan et al. (2021) [32]				+		
Casella et al. (2019) [14], Mastepanov and Chigarev (2020) [33], Palekhov and Palekhova; (2018) [34], Van de Graaf, Sovacool, Ghosh, Kern, Klare (Eds.) (2016) [35], Bamber et al. (2014) [36], Morris et al. (2021) [37], Sarkar Biswajit et al. (2021) [38], Vandana Singh et al. (2021) [39], Bhuniya Shaktipada et al. (2020) [40], Lim Byeongho et al. (2021) [41], Akar et al. (2018) [42], Wu et al. (2020) [43]					+	

Note: "+" means that the term is studied in the research. Source: own elaboration.

From Table 2, it is clear that research on a relationship between countries' energy indicators and the GVC participation indices has yet not been conducted. Moreover, Table 2 has helped us to highlight these research gaps.

3. Materials and Methods

Asia-Pacific Economic Cooperation (hereinafter APEC) member economies were used as an object of the study. APEC currently includes 21 member economies. They are as follows: Australia, Brunei Darussalam, Canada, Chile, China, Hong Kong SAR (China), Indonesia, Japan, the Republic of Korea, Malaysia, Mexico, New Zealand, Papua New Guinea, Peru, Philippines, the Russian Federation, Singapore, Chinese Taipei, Thailand, the United States of America, and Vietnam. APEC is one of the few international associations to which Taiwan has joined with the full approval of China (in our study it will be referred to as Chinese Taipei). Therefore, APEC adopted the term "member economy" instead of "member country" [44] (pp. 110–120).

The data of the World Bank (hereinafter World Bank), the World Trade Organization (hereinafter WTO), the World Economic Forum (hereinafter WEF), the International Monetary Fund (hereinafter IMF), the United Nations (hereinafter UN), the Organization for Economic Cooperation and Development (hereinafter OECD), the International Energy Agency (hereinafter IEA), etc., were used as the information base of the research.

Data from the international database TiVA (Trade in Value-Added) were used to assess the countries' participation in the GVCs [45]. TiVA is a joint product of the OECD and the WTO. The first version included information on 40 countries with a low degree of detail by economic sectors. There were only 18 economic sectors in total. The latest version of TiVA–2016 covers 64 countries with details on 34 industries. TiVA is based on the OECD Inter-Country Input–Output (ICIO) model, which allows a number of important indicators characterizing the process of value-added creation to be determined, including: foreign value added in domestic final demand, domestic value added in foreign final demand, value-added share of total final demand by country and industry, value-added share of consumption by country and industry, value-added share of gross fixed capital formation by country and industry, etc. TiVA dynamic series begin in 1995; data are published with a significant time lag of up to 5 years [9] (pp. 71–80).

In the course of the research, the methods of chronological average, economic and mathematical modeling, and econometric methods of analysis were used. The statistical time series TiVA for the eleven-year period 2005–2015 were used as an information base.

In our methodology, we develop an approach to evaluate each individual country's GVC participation, proposed by Sidorova [9] (pp. 71–80) and based on TiVA data for assessing countries' backward and forward GVC participation indices and total GVC participation index. Our methodology is a continuation of the approach suggested by Baldwin and Lopez-Gonzalez [8] (pp. 1682–1721), who conducted an analysis of supply-chain independence and assessed the contribution of natural resources in GVCs.

Research methodology is as follows.

Two following indices are traditionally used to assess the participation of countries and regions in the GVC:

1. The share of foreign value added in total exports, which characterizes the backward GVC participation. A high share of foreign value added in exports allows a country to import the necessary resources for the production of exported goods, components, or services [46] (pp. 589–606);
2. The share of a country's national (domestic) value added arising from its own exports (direct and indirect through the exports of other domestic industries) included in exports of other countries, i.e., the forward GVC participation. This is an indicator of the country's value added that is not consumed directly at the export destination, but is re-exported. A high level of the GVC participation means that the country exports more intermediate goods and services used for the export of other countries [46] (pp. 589–606).

The sum of these two indices gives the country's GVC participation index.

Four indicators were selected to confirm the hypotheses postulated in Introduction (Table 1):

1. GDP per unit of energy consumption (PPP USD per kg of oil equivalent). This indicator is the inverse of the GDP energy intensity;
2. Energy imports, net (% of energy use);
3. Fuel exports (% of merchandise exports);
4. Energy intensity level of primary energy (MJ/USD2011 PPP GDP).

Country's participation in GVC is assessed based on the following indices:

- Forward GVC participation index, %;
- Backward GVC participation index, %.

The chronological average for each indicator and index is calculated for each particular country. The calculations were made for the eleven-year period 2005–2015. As an information base, the statistical time series TiVA, OECD/IEA are used.

Then, taking into account the obtained values of the chronological averages within each indicator, the APEC member economies are divided into two groups according to the following criteria:

1. In terms of GDP per unit of energy consumption, the value of 10 PPP USD per kg of oil equivalent was chosen. Economies with the value of GDP per unit of energy consumption more than 10 PPP USD per kg of oil equivalent are classified as "the economies with higher GDP per unit of energy consumption". Economies with the value of GDP per unit of energy consumption less than 10 PPP USD per kg of oil equivalent are classified as "the economies with lower GDP per unit of energy consumption".
2. According to net energy imports, a positive value of the indicator was chosen as a criterion. In this case, the country is an energy importer. On the other side, the country is an energy exporter if a negative value of net energy imports is observed.
3. According to fuel exports, the value of 10% of fuel exports in merchandise exports was chosen as a criterion. Countries for which the share of fuel exports in total merchandise exports exceeds 10% are classified as fuel exporting countries. Countries for which the share of fuel exports in total merchandise exports is less than 10% are classified in the group with a low share of fuel exports in total merchandise exports.
4. According to the energy intensity level of primary energy, the value of 5 MJ per USD2011 PPP GDP was chosen as a criterion. The level of energy intensity of primary energy shows the ratio between energy supply and gross domestic product. This ratio is measured by purchasing power parity. Energy intensity shows how much energy is required to produce one unit of economic output. The lower this ratio, the less energy is used to produce one unit of production. Accordingly, such production or economy is less energy intensive. Countries for which the energy intensity level of primary energy is less than 5 MJ per USD2011 PPP GDP are classified in the group of countries with low energy intensity. Countries for which the energy intensity level of primary energy is higher than 5 MJ per USD2011 PPP GDP are classified in the group of countries with high energy intensity.

4. Results and Discussion

4.1. Analyzing APEC Member Economies Positions in the World Energy Trilemma Index

First, it seems important to analyze the positions of the APEC member economies in the ranking on the World Energy Trilemma Index for 2020–2021 (Table 3). There are 127 countries represented in the 2021 ranking. Data for 19 APEC member economies are available (with the exception of Chinese Taipei and Papua New Guinea).

Table 3. Positions of the APEC member economies in the ranking on the World Energy Trilemma Index.

APEC Member Economies	World Energy Trilemma Index, Ranking Place 2020	World Energy Trilemma Index, Ranking Place 2021
Australia	25	18
Brunei Darussalam	51	38
Canada	6	6
Indonesia	56	58
Japan	24	16
Republic of Korea	31	32
Malaysia	33	25
New Zealand	10	9
Philippines	76	70
Singapore	40	34
Thailand	64	53
USA	9	9
Chinese Taipei	NA	NA
Hong Kong SAR, China	34	35
China	55	51
Mexico	45	43
Papua New Guinea	NA	NA
Chile	37	37
Peru	42	44
Russia	29	28
Vietnam	65	61

Source: own elaboration on the basis of [47,48]. Used by permission of the World Energy Council.

Since 2010, the World Energy Trilemma Index has been providing an independent and objective assessment of a country's energy policy and its effectiveness, using proven global and country-specific data to assess governance on three main parameters: energy security, energy equity, and environmental sustainability.

Countries develop energy policies depending on their internal conditions due to various natural resources, geographical location, and socio-economic systems. This divergence of different systems and contexts means that there is no unified path for a successful energy transition. Each country needs to determine its own best way of energy policy instead, taking into account the national situation and priorities. This means that a direct comparison of countries' rankings and scores may be less informative, but at the same time it can help start a conversation. Countries can and should learn from each other, finding out which policies work and why such policies can be successful in some contexts and not in others. The Global Energy Trilemma Index can help countries and stakeholders in the energy sector to identify in a continuous dialogue which areas of energy policy need to be improved. Studying the examples of other countries can help determine the most suitable options.

When calculating the Global Energy Trilemma Index, 31 indicators of the national energy policy efficiency are taken into account. These indicators are grouped in three dimensions [47,48]:

1. Energy security;
2. Energy equality;
3. Environmental sustainability.

Energy security assesses a country's ability to meet current and future energy demand, and withstand and recover quickly from systemic shocks with minimal supply disruptions. This parameter takes into account the efficiency of internal and external energy sources management, as well as the reliability and sustainability of the energy infrastructure [33].

Energy equality makes it possible to assess a country's ability to provide universal access to reliable, fairly priced, and abundant energy resources for domestic and commercial use. This parameter takes into account basic access to electricity and environmentally friendly fuels and technologies for cooking, access to energy consumption that ensure prosperity, as well as the availability of electricity, gas, and fuel [33].

Environmental sustainability of energy systems shows the possible transition of the country's energy system to reduce and prevent potential environmental damage and the consequences of climate change. This parameter takes into account the productivity and efficiency of energy production, transmission and distribution, decarbonization, and atmospheric pollution [33].

In the 2021 ranking, 127 countries were ranked in 101 positions. In the 2020 ranking, 128 countries were represented, occupying 108 positions. Among the APEC member economies, Canada (6), the USA (9), and New Zealand (9) entered the top ten countries in terms of energy policy efficiency in 2021 (Figure 1). China (51), Thailand (53), Indonesia (58), and Vietnam (61) are in the second half of the ranking. Twelve APEC member economies improved their positions in the ranking over the year: Brunei Darussalam rose by 13 positions, Thailand—by 11 positions, Malaysia and Japan—by 8, Australia—by 7, the Philippines and Singapore—by 6, China and Vietnam—by 4, Mexico—by 2, Russia and New Zealand—by 1. The positions of Canada (6), the USA (9) and Chile (37) remained unchanged. The Republic of Korea, Hong Kong SAR (China), Peru, and Indonesia dropped slightly down in the ranking.

Figure 1. APEC member economies' places in the World Energy Trilemma Index for 2020–2021. Source: [47,48]. Used by permission of the World Energy Council.

Canada has been the leader of the ranking according to “Energy Security” for several years. This is facilitated not only by significant natural resources, but also by the consistent efforts of the Canada's Government of to diversify its energy system. The United States is also in the top 10 countries, in the seventh position.

According to “Energy Equality”, the USA became the best of the APEC member economies in 2021 (eighth position). All countries that achieved greater energy equality are implementing progressive energy strategies aimed at encouraging investment in sustainable energy and electricity infrastructure and increasing diversification of energy sources as countries try to balance changing demand with the availability of energy resources. The countries leading in the direction of energy equality are developed countries, as well as the countries of the Arabian Peninsula, OPEC members, with well-established, stable, and complex energy systems and infrastructure. For developing countries, the challenge is to improve access to and affordability of energy to meet the growing demand for energy to support fast-growing economies.

According to “Environmental Sustainability”, none of the APEC member economies entered the top ten. Despite ongoing efforts to decarbonize energy production, ensuring

continued progress in environmental sustainability remains a challenge. Countries that are improving their environmental sustainability are switching to renewable energy sources, such as wind and solar energy. APEC member economies, most of which are developing ones, are at different stages of industrialization. They continue to increase the use of mineral raw materials, fuels, and other non-renewable natural resources. Thus, the energy intensity of these economies continues to grow.

4.2. Indicators of APEC Member Economies' Participation in Global Value Chains

To assess the participation of APEC member economies in the GVCs, the TiVA dynamic series for 10 years (2005–2015) will be used [45].

The following APEC member economies are in the lead in terms of the backward GVC participation: Vietnam, Singapore, Malaysia, Mexico, Thailand, South Korea, and Chinese Taipei. In these countries, during the time period under review, the share of foreign value added in total exports exceeded 30%. It is very significant that the countries of Southeast Asia are mainly represented among the leaders (Table 4). Thus, it can be concluded that now the GVCs begin in Asian countries and stretch to European states. However, in the future, this trend may change, and the GVCs finish in Asian countries [49] (pp. 263–272).

Table 4. APEC member economies' backward GVC participation, %.

APEC Member Economies	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Australia	11.1	12.1	11.6	12.0	11.0	10.3	11.0	11.2	10.8	11.4	11.6
Brunei Darussalam	7.5	7.0	5.8	7.3	7.5	7.5	9.0	11.3	12.5	6.8	5.4
Canada	19.6	19.5	19.2	19.6	20.1	20.7	20.9	21.7	20.7	20.1	21.2
Indonesia	18.4	14.9	14.3	15.0	12.1	12.5	12.8	13.3	13.9	14.1	12.9
Japan	10.2	12.2	13.2	15.2	10.9	12.2	14.3	13.9	15.2	15.8	13.2
Republic of Korea	32.7	34.2	34.4	41.2	37.1	38.2	42.4	42.0	39.5	37.3	32.6
Malaysia	45.0	43.4	44.1	40.3	39.8	40.6	39.4	38.1	37.2	36.6	36.9
New Zealand	14.9	15.8	14.5	17.1	14.2	14.9	15.7	16.4	14.9	14.7	13.8
Philippines	26.3	31.7	24.2	24.8	21.9	23.9	23.5	23.9	21.0	20.4	22.0
Singapore	42.8	44.6	41.4	45.2	42.0	41.3	43.5	43.8	42.8	43.0	40.9
Thailand	38.4	37.1	36.1	39.0	34.4	36.0	38.8	38.4	37.5	36.7	33.6
USA	10.8	11.4	11.7	12.9	9.4	11.1	12.7	12.4	11.5	11.2	9.5
Chinese Taipei	37.1	39.3	40.6	43.7	36.3	41.5	42.1	41.2	39.5	38.3	32.4
Hong Kong SAR, China	27.7	29.5	30.6	32.7	29.1	31.6	32.4	31.9	31.0	29.2	26.6
China	26.3	25.9	24.8	23.0	19.5	21.1	21.7	20.8	20.3	19.5	17.3
Mexico	34.0	34.2	33.4	33.3	33.6	33.9	32.3	33.8	34.6	34.1	36.1
Papua New Guinea	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chile	17.7	15.2	16.1	19.4	15.4	13.8	15.8	15.5	14.9	15.0	15.1
Peru	13.3	13.6	13.3	15.0	12.4	12.3	12.1	12.7	12.4	12.3	10.3
Russia	9.9	9.3	9.3	10.4	10.5	9.7	9.4	8.7	8.9	9.4	10.8
Vietnam	36.1	38.1	40.8	41.5	37.2	40.5	41.8	40.8	41.7	42.4	44.5
APEC, total	7.0	7.3	7.5	8.7	7.0	7.7	8.5	8.5	8.2	7.8	6.5

Source: own elaboration on the basis of [45].

Concerning the forward GVC participation, over a ten-year period, the value of this index exceeded 30% on average in the five APEC member countries only. These are Brunei Darussalam, Russia, Peru, Chile, and Australia (Table 5). Figure 2 shows the dynamics of APEC's cumulative participation in the GVCs. The consequences of the global financial crisis of 2009 for the GVCs in the APEC region can be seen in Figure 2 as well.

Table 5. APEC member economies' forward GVC participation, %.

APEC Member Economies	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Australia	27.9	30.9	31.8	33.7	27.2	31.3	33.0	30.8	30.4	29.6	26.8
Brunei Darussalam	29.8	32.4	33.0	35.7	28.7	32.4	34.5	32.6	35.8	40.3	41.1
Canada	12.6	13.4	15.5	16.3	14.2	15.8	17.7	16.7	16.8	16.6	15.3
Indonesia	24.6	27.5	27.5	27.9	25.8	27.9	30.3	28.4	27.5	26.4	24.1
Japan	26.4	26.5	27.0	25.9	25.8	25.6	25.8	25.2	24.5	24.3	24.4
Republic of Korea	20.6	21.5	22.2	18.3	17.2	17.8	16.0	16.3	17.0	17.8	19.1
Malaysia	16.0	17.5	16.9	18.5	16.6	17.3	18.1	18.3	19.3	19.4	18.7
New Zealand	12.1	12.6	13.7	14.0	12.6	13.1	14.1	12.8	12.9	12.5	11.7
Philippines	20.1	22.4	23.1	24.0	22.2	23.0	22.5	21.5	23.0	22.8	22.4
Singapore	20.9	19.4	20.6	19.1	18.8	20.6	19.3	19.1	19.6	20.5	20.9
Thailand	15.4	15.6	16.0	15.0	14.4	14.9	14.1	13.9	13.5	13.6	13.8
USA	22.5	23.0	22.7	22.5	20.9	21.9	22.5	22.1	22.2	22.2	22.2
Chinese Taipei	22.8	23.7	23.8	21.6	21.8	20.5	20.5	21.0	21.9	22.1	24.4
Hong Kong SAR, China	17.6	18.1	18.1	17.4	15.4	15.8	15.4	15.0	14.6	15.9	15.7
China	15.6	16.1	16.5	17.5	16.0	16.2	16.6	16.2	16.3	16.8	17.5
Mexico	8.3	8.8	10.1	10.7	8.9	10.3	12.3	12.1	11.2	10.6	8.8
Papua New Guinea	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chile	31.9	37.0	37.5	33.7	30.4	35.0	34.2	32.3	31.0	30.7	28.9
Peru	31.7	37.5	39.2	36.5	34.3	39.1	41.1	37.0	34.0	30.7	29.4
Russia	33.5	35.5	36.1	35.7	29.3	33.8	36.0	35.3	34.4	33.7	30.5
Vietnam	14.5	13.8	14.0	13.8	13.5	12.5	12.7	12.4	12.3	11.9	11.1
APEC, total	22.7	23.1	23.0	22.8	19.5	21.1	22.2	21.8	21.6	21.3	21.1

Source: own elaboration on the basis of [45].

Figure 2. APEC member economies' GVC participation, 2005–2015. Source: own elaboration on the basis of [45].

4.3. Determining the Relationships between Countries' Energy Indicators and the GVC Participation Indices

This part of our research contains the hypotheses confirmation.

Hypothesis 1 (H1). *Countries with higher GDP per unit of energy consumption (PPP USD per kg of oil equivalent) have higher forward GVC participation.*

To confirm the hypothesis, dynamic data series were used. The initial data are presented in Table A1 and in Table 5. The final results of the calculations are given in Tables 6 and 7. APEC member economies with GDP per unit of energy consumption higher than 10 PPP USD per kg of oil equivalent (Table 6) have a forward GVC participation index equal to 23.2649629%. APEC member economies with GDP per unit of energy consumption less than 10 PPP USD per kg of oil equivalent (Table 7) have a forward GVC participation index equal to 21.3901517%.

Table 6. APEC member economies with higher GDP per unit of energy consumption.

APEC Member Economies	GDP per Unit of Energy Consumption (PPP USD per kg of Oil Equivalent), Chronological Average	Forward GVC Participation (%), Chronological Average
Japan	10.3979	25.582
Philippines	13.37724	22.45455
Singapore	15.64382	19.89091
Hong Kong SAR, China	25.53433	16.27273
Mexico	11.37353	10.19091
Chile	11.33236	32.96364
Peru	16.45766	35.5
Average	14.87383	23.2649629

Source: own elaboration on the basis of [45,50].

Table 7. APEC member economies with lower GDP per unit of energy consumption.

APEC Member Economies	GDP per Unit of Energy Consumption (PPP USD per kg of Oil Equivalent), Chronological Average	Forward GVC Participation (%), Chronological Average
Australia	7.988182	30.30909
Brunei Darussalam	8.264078	34.20909
Canada	5.716142	15.53636
Indonesia	9.795394	27.08182
Republic of Korea	6.918463	18.52727
Malaysia	7.622986	17.87273
New Zealand	9.156718	12.91818
Thailand	8.246268	14.56364
USA	7.699621	22.24545
China	4.528803	16.48182
Russia	4.977456	33.98182
Vietnam	8.178743	12.95455
Average	7.424405	21.3901517

Source: own elaboration on the basis of [45,50].

23.2649629% > 21.3901517%.
The hypothesis is accepted.

Hypothesis 2 (H2). *Countries with lower GDP per unit of energy consumption (PPP USD per kg of oil equivalent) have higher backward GVC participation.*

To confirm the hypothesis, dynamic data series were used. The initial data are presented in Table A1 and in Table 4. The final results of the calculations are given in Tables 8 and 9. APEC member economies with GDP per unit of energy consumption higher than 10 PPP USD per kg of oil equivalent (Table 8) have a backward GVC participation index equal to 24.6805186%. APEC member economies with GDP per unit of energy consumption less than 10 PPP USD per kg of oil equivalent (Table 9) have a backward GVC participation index equal to 22.1793285%.

Table 8. APEC member economies with higher GDP per unit of energy consumption.

APEC Member Economies	GDP per Unit of Energy Consumption (PPP USD per kg of Oil Equivalent), Chronological Average	Backward GVC Participation (%), Chronological Average
Japan	10.3979	13.3
Philippines	13.37724	23.96364
Singapore	15.64382	42.84545
Hong Kong SAR, China	25.53433	30.20909
Mexico	11.37353	33.93636
Chile	11.33236	15.80909
Peru	16.45766	12.7
Average	14.87383	24.6805186

Source: own elaboration on the basis of [45,50].

Table 9. APEC member economies with lower GDP per unit of energy consumption.

APEC Member Economies	GDP per Unit of Energy Consumption (PPP USD per kg of Oil Equivalent), Chronological Average	Backward GVC Participation (%), Chronological Average
Australia	7.988182	11.28182
Brunei Darussalam	8.264078	7.963636
Canada	5.716142	19.94286
Indonesia	9.795394	14.01818
Republic of Korea	6.918463	37.41818
Malaysia	7.622986	40.12727
New Zealand	9.156718	15.17273
Thailand	8.246268	36.90909
USA	7.699621	11.32727
China	4.528803	21.83636
Russia	4.977456	9.663636
Vietnam	8.178743	40.49091
Average	7.424405	22.1793285

Source: own elaboration on the basis of [45,50].

24.6805186% > 22.1793285%.
The hypothesis is rejected.

Hypothesis 3 (H3). *Energy importing countries have higher backward GVC participation.*

To confirm the hypothesis, dynamic data series were used. The initial data are presented in Table A2 and in Table 4. The final results of the calculations are given in Tables 10 and 11. APEC member economies—energy importers (Table 10) have a backward GVC participation index equal to 24.8790909%. APEC member economies—energy exporters (Table 11) have a backward GVC participation index equal to 21.16464646%.

Table 10. APEC member economies—energy importers.

APEC Member Economies	Net Energy Imports (% of Energy Use), Chronological Average	Backward GVC Participation (%), Chronological Average
Chile	66.7066835	15.80909091
China	10.8577044	21.83636364
Hong Kong SAR, China	99.3504955	30.2090909
Japan	86.4380592	13.3
Korea, Rep.	81.2646837	37.4181818
New Zealand	16.3163754	15.17272727
Philippines	42.8969538	23.96363636
Singapore	97.9018515	42.8454545
Thailand	41.5402161	36.9090909
United States	20.0480465	11.32727273
Average	56.33210696	24.8790909

Source: own elaboration on the basis of [45,50].

Table 11. APEC member economies—energy exporters.

APEC Member Economies	Net Energy Imports (% of Energy Use), Chronological Average	Backward GVC Participation (%), Chronological Average
Australia	−150.895474	11.28181818
Brunei Darussalam	−507.407213	7.963636364
Canada	−56.8210071	20.3
Indonesia	−85.7215069	14.01818182
Mexico	−23.4877831	33.9363636
Malaysia	−22.5730147	40.1272727
Peru	−0.95357117	12.7
Russian Federation	−82.918579	9.663636364
Vietnam	−27.092817	40.4909091
Average	−106.4301073	21.16464646

Source: own elaboration on the basis of [45,50].

$24.8790909\% > 21.16464646\%$.

The hypothesis is accepted.

Hypothesis 4 (H4). *Countries exporting fuel have higher forward GVC participation.*

To confirm the hypothesis, dynamic data series were used. The initial data are presented in Table A3 and in Table 5. The final results of the calculations are given in Tables 12 and 13.

Table 12. APEC member economies—fuel exporters.

APEC Member Economies	Fuel Exports (% of Merchandise Exports), Chronological Average	Forward GVC Participation (%), Chronological Average
Australia	27.014657	30.309
Brunei Darussalam	95.473216	34.209
Canada	24.76831	15.536
Malaysia	17.223968	17.873
Russian Federation	65.518602	33.982
Indonesia	28.943168	27.082
Singapore	15.6185	19.89091
Vietnam	14.07424	12.95455
Mexico	13.58184	10.19091
Average	33.57961128	22.447475

Source: own elaboration on the basis of [45,50].

Table 13. APEC member economies with low percentage of fuel exports in merchandise exports.

APEC Member Economies	Fuel Exports (% of Merchandise Exports), Chronological Average	Forward GVC Participation (%), Chronological Average
Chile	1.514769	32.964
China	1.718785	16.482
Hong Kong SAR, China	1.581702	16.273
Japan	1.725346	25.582
New Zealand	4.201364	12.918
Peru	9.696511	35.5
Philippines	2.512349	22.455
Thailand	5.257907	14.564
Korea, Rep.	7.857033	18.527
United States	7.293204	22.245
Average	4.335897	21.75091

Source: own elaboration on the basis of [45,50].

APEC member economies—fuel exporters (Table 12) have a forward GVC participation index equal to 22.447475%. APEC member economies with low percentage of fuel exports in merchandise exports (Table 13) have a forward GVC participation index equal to 21.75091%. $22.447475\% > 21.75091\%$.

The hypothesis is accepted.

Hypothesis 5 (H5). *Countries with higher energy intensity level of primary energy have lower forward GVC participation than countries with lower energy intensity level of primary energy.*

To confirm the hypothesis, dynamic data series were used. The initial data are presented in Table A4 and in Table 5. The final results of the calculations are given in Tables 14 and 15. APEC member economies with higher energy intensity level of primary energy (Table 14) have a forward GVC participation index equal to 19.539091%. APEC member economies with lower energy intensity level of primary energy (Table 15) have a forward GVC participation index equal to 24.90505222%.

Table 14. APEC member economies with higher energy intensity level of primary energy.

APEC Member Economies	Energy Intensity Level of Primary Energy (mJ/USD2011 PPP GDP), Chronological Average	Forward GVC Participation (%), Chronological Average
Australia	5.706151	30.30909
Canada	8.010616	15.53636
China	8.572967	16.48182
Malaysia	5.311621	17.87273
New Zealand	5.352883	12.91818
Korea, Rep.	6.841145	18.52727
Russian Federation	8.750783	33.98182
Thailand	5.422642	14.56364
Vietnam	5.893474	12.95455
United States	6.00242	22.24545
Average	6.5864702	19.539091

Source: own elaboration on the basis of [45,50].

Table 15. APEC member economies with lower energy intensity level of primary energy.

APEC Member Economies	Energy Intensity Level of Primary Energy (mJ/USD2011 PPP GDP), Chronological Average	Forward GVC Participation (%), Chronological Average
Brunei Darussalam	4.653082	34.20909
Chile	4.066956	32.96364
Hong Kong SAR, China	1.734539	16.27273
Indonesia	4.157324	27.08182
Japan	4.475695	25.58182
Mexico	4.125462	10.19091
Peru	2.587918	35.5
Philippines	3.325773	22.45455
Singapore	2.876856	19.89091
Average	3.555956111	24.90505222

Source: own elaboration on the basis of [45,50].

19.539091% < 24.90505222%.

The hypothesis is accepted.

Hypothesis 6 (H6). Countries with higher energy intensity level of primary energy have higher backward GVC participation than countries with lower energy intensity level of primary energy.

To confirm the hypothesis, dynamic data series were used. The initial data are presented in Table A4 and in Table 4. The final results of the calculations are given in Tables 16 and 17. APEC member economies with higher energy intensity level of primary energy (Table 16) have a backward GVC participation index equal to 24.417013%. APEC member economies with lower energy intensity level of primary energy (Table 17) have a backward GVC participation index equal to 21.6383829%.

Table 16. APEC member economies with higher energy intensity level of primary energy.

APEC Member Economies	Energy Intensity Level of Primary Energy (mJ/USD2011 PPP GDP), Chronological Average	Backward GVC Participation (%), Chronological Average
Australia	5.706151	11.28182
Canada	8.010616	19.94286
China	8.572967	21.83636
Malaysia	5.311621	40.12727
New Zealand	5.352883	15.17273
Korea, Rep.	6.841145	37.41818
Russian Federation	8.750783	9.663636
Thailand	5.422642	36.90909
Vietnam	5.893474	40.49091
United States	6.00242	11.32727
Average	6.5864702	24.417013

Source: own elaboration on the basis of [45,50].

Table 17. APEC member economies with lower energy intensity level of primary energy.

APEC Member Economies	Energy Intensity Level of Primary Energy (mJ/USD2011 PPP GDP), Chronological Average	Backward GVC Participation (%), Chronological Average
Brunei Darussalam	4.653082	7.963636
Chile	4.066956	15.80909
Hong Kong SAR, China	1.734539	30.20909
Indonesia	4.157324	14.01818
Japan	4.475695	13.3
Mexico	4.125462	33.93636
Peru	2.587918	12.7
Philippines	3.325773	23.96364
Singapore	2.876856	42.84545
Average	3.555956111	21.6383829

Source: own elaboration on the basis of [45,50].

24.417013% > 21.6383829%.

The hypothesis is accepted.

In the course of the research, the following five hypotheses have been confirmed:

- **Hypothesis 1 (H1).** Countries with higher GDP per unit of energy consumption have higher forward GVC participation;
- **Hypothesis 3 (H3).** Energy importing countries have higher backward GVC participation;
- **Hypothesis 4 (H4).** Countries exporting fuel have higher forward GVC participation;
- **Hypothesis 5 (H5).** Countries with higher energy intensity level of primary energy have lower forward GVC participation than countries with lower energy intensity;
- **Hypothesis 6 (H6).** Countries with higher energy intensity level of primary energy have higher backward GVC participation than countries with lower energy intensity.

Comparing the results obtained with the existing data, it should be noted that our conclusions are confirmed by similar data by Larionov and Andryushchenko (2016) [51] for South Korea, as well as Listopadov and Semenov (2019) [52] for the African region. Research conducted by Lim et al. (2021) [41] who used a computational general equilibrium (CGE) model to estimate the effects of the reverse GVC factors on the global economy,

trade, and energy market for ASEAN, paying particular attention to the influence of energy source, should be mentioned as well.

5. Conclusions

The current study proves the existence of a relationship between energy indicators and APEC member economies' GVC participation indices. The research shows that APEC member economies' have a higher index of forward GVC participation (21.1%), compared to a rather low index of backward GVC participation (6.1%). This means that APEC member economies export more intermediate goods and services used for the export of other countries.

According to the research results, the following conclusions can be made. Countries' energy indicators influence their GVC participation. Countries with higher GDP per unit of energy consumption, energy-importing countries, countries exporting fuel and countries with higher energy intensity level of primary energy have higher forward GVC participation. Countries with higher energy intensity level of primary energy have lower forward GVC participation than countries with lower energy intensity.

The following research will be devoted to the analyses of relationship between countries' positions in the Energy Trilemma Index and their GVC participation. We will assess the presence or absence of a correlation between the position of countries in the Energy Trilemma Index by three dimensions (energy security, energy equality, and environmental sustainability) and the indices of their participation in GVCs.

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Appendix A

Table A1. GDP per unit of energy consumption (PPP USD per kg of oil equivalent).

APEC Member Economies	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Australia	7.587	7.489	7.519	7.516	7.636	7.766	7.913	8.327	8.560	8.864	8.686
Brunei Darussalam	11.488	8.440	8.255	7.374	8.434	8.126	7.053	7.197	8.868	7.401	NA
Canada	4.992	5.261	5.587	5.595	5.643	5.759	5.791	5.964	6.031	6.022	6.227
Indonesia	8.433	8.692	9.287	9.655	9.345	9.448	10.413	10.642	10.947	11.088	NA
Japan	9.414	9.558	9.789	10.051	9.943	9.778	10.565	10.950	11.091	11.449	11.784
Korea, Rep.	6.562	6.796	6.915	6.971	6.96	6.816	6.783	6.868	7.076	7.178	7.172
Malaysia	7.079	7.434	7.216	7.237	7.501	7.894	7.971	8.262	7.670	7.959	NA
New Zealand	9.106	9.364	9.541	9.291	9.207	8.912	9.148	8.916	9.081	8.880	9.271
Philippines	11.229	11.913	12.665	12.734	13.568	13.766	14.202	14.274	14.713	14.703	NA
Singapore	13.276	13.470	15.855	14.061	16.343	15.638	16.085	16.967	17.566	17.173	NA
Thailand	8.129	8.368	8.465	8.382	8.355	8.210	8.289	8.291	7.916	8.051	NA
USA	6.927	7.192	7.201	7.381	7.567	7.584	7.789	8.088	8.140	8.219	8.603
Hong Kong SAR, China	23.686	24.038	23.823	24.816	22.995	26.384	25.619	26.963	28.413	28.601	NA
China	3.827	3.946	4.168	4.431	4.537	4.545	4.642	4.824	5.036	5.328	NA
Mexico	10.556	10.785	11.104	11.347	10.733	11.614	11.458	11.375	11.505	12.092	12.534
Chile	10.631	10.859	10.983	11.480	11.610	11.760	11.453	10.896	10.901	11.890	12.186
Peru	15.355	17.005	17.055	17.745	17.112	15.653	16.352	16.128	17.136	15.030	NA
Russia	4.413	4.640	5.020	5.160	5.062	4.972	4.9455	5.019	5.184	5.354	NA
Vietnam	7.990	8.341	8.304	8.206	7.927	7.599	8.077	8.353	8.806	NA	NA

Notes: Data on Papua New Guinea and Chinese Taipei are not available. The values of all indicators are rounded to three decimal places. Source: [50].

Table A2. Energy imports. net (% of energy use).

APEC Member Economies	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Australia	−133.666	−128.348	−134.10	−126.27	−132.23	−153.60	−143.73	−153.23	−172.43	−192.01	−190.190
Brunei Darussalam	−849.555	−608.136	−542.866	−495.880	−522.428	−473.190	−382.704	−383.542	−458.372	−357.394	NA
Canada	−48.953	−53.809	−53.291	−50.428	−50.197	−51.374	−52.962	−59.114	−64.443	−67.927	−72.528
Chile	67.082	67.412	69.405	67.934	65.461	70.146	70.612	64.990	61.288	64.201	65.236
China	6.0561	7.858	8.421	8.435	10.360	11.446	11.860	14.359	14.756	15.021	NA
Hong Kong SAR, China	99.595	99.515	99.546	99.532	99.556	99.300	99.226	99.320	99.231	98.680	NA
Indonesia	−55.914	−70.831	−74.094	−73.633	−74.395	−79.046	−106.70	−107.21	−112.28	−103.09	NA
Japan	80.924	80.715	82.645	82.345	80.361	80.144	88.936	93.827	93.918	93.981	93.019
Korea, Rep.	79.560	79.519	80.829	80.297	80.662	82.019	81.950	82.446	83.473	81.704	81.448
Mexico	−44.959	−42.219	−36.638	−26.918	−24.748	−22.697	−18.016	−13.981	−12.725	−10.793	−4.666
Malaysia	−45.396	−40.718	−28.354	−26.966	−24.720	−21.702	−14.737	−11.868	−5.7605	−5.505	NA
New Zealand	24.026	21.721	17.584	13.913	12.671	8.144	11.981	16.458	16.414	17.084	19.478
Peru	20.010	12.070	12.971	15.935	4.243	−3.737	−23.024	−14.186	−18.918	−14.899	NA
Philippines	44.931	44.537	42.713	42.719	38.541	41.708	40.923	41.801	45.324	45.768	NA
Russian Federation	−84.628	−82.950	−84.232	−82.133	−84.021	−85.847	−80.004	−77.856	−83.841	−83.670	NA
Singapore	98.172	98.302	98.128	98.246	97.932	97.688	97.701	97.608	97.555	97.682	NA
Thailand	44.257	43.201	42.521	39.407	39.998	40.106	41.653	40.214	42.473	41.568	NA
Vietnam	−47.289	−46.523	−38.839	−26.451	−25.235	−12.690	−15.965	−15.734	−15.105	NA	NA
United States	29.659	27.972	28.585	25.264	22.124	22.209	18.554	15.691	13.943	9.214	7.308

Note: Data on Papua New Guinea and Chinese Taipei are not available. The values of all indicators are rounded to three decimal places. Source: [50].

Table A3. Fuel exports (% of merchandise exports).

APEC Member Economies	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Australia	25.595	24.042	22.753	32.040	29.506	28.880	28.141	28.445	25.865	26.599	25.290
Brunei Darussalam	NA	96.325	96.145	97.815	96.062	95.150	95.442	95.747	96.524	92.539	92.979
Canada	21.403	21.137	22.114	29.135	24.420	25.324	27.432	25.624	26.361	28.893	20.603
Chile	2.808	2.433	1.852	2.379	1.461	0.937	1.117	0.990	0.995	0.919	0.763
China	2.312	1.833	1.711	2.220	1.696	1.690	1.700	1.513	1.529	1.470	1.227
Hong Kong SAR, China	1.336	1.266	1.517	1.899	1.940	1.974	2.047	1.083	1.083	1.441	1.806
Japan	0.7486	0.911	1.299	2.402	1.813	1.695	1.979	1.682	2.332	2.292	1.821
Mexico	14.885	15.456	15.671	17.223	13.278	13.768	15.945	14.056	12.812	10.412	5.890
Malaysia	13.406	13.731	14.394	18.349	14.763	15.846	17.738	20.407	22.272	22.089	16.463
New Zealand	2.519	2.810	4.557	7.112	5.006	4.944	5.488	4.930	3.719	3.229	1.895
Peru	9.324	8.002	8.579	9.142	7.735	9.342	10.534	11.569	12.966	12.299	7.165
Philippines	1.877	2.304	2.804	3.276	1.908	2.0532	2.920	2.428	3.766	2.972	1.320
Papua New Guinea	NA	NA	NA	NA	NA	NA	3.802	2.924	NA	NA	NA
Russian Federation	61.780	62.882	61.463	65.678	63.013	65.648	67.028	70.289	70.559	69.525	62.836
Singapore	12.154	13.040	13.704	18.318	15.171	16.058	19.452	18.182	16.998	16.531	12.190
Thailand	4.329	4.982	4.454	6.423	5.107	4.937	5.625	6.508	6.265	5.266	3.936
Vietnam	25.758	24.379	20.718	20.172	14.899	11.046	11.359	9.912	7.335	6.149	3.083
Korea, Rep.	5.523	6.428	6.630	9.112	6.543	6.985	9.561	10.494	9.669	9.190	6.288
United States	3.311	3.737	3.962	6.484	5.804	7.184	9.924	10.063	10.763	10.985	8.003
Indonesia	27.687	27.400	25.600	29.031	28.277	29.639	33.864	33.347	31.440	29.042	23.042

Note: Data on Chinese Taipei are not available. Data on Papua New Guinea are available since 2011. The values of all indicators are rounded to three decimal places. Source: [50].

Table A4. Energy intensity level of primary energy (MJ/USD2011 PPP GDP).

APEC Member Economies	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Australia	6.001	6.068	6.049	6.048	5.960	5.863	5.759	5.488	5.346	5.150	5.031
Brunei Darussalam	3.391	4.616	4.719	5.283	4.619	4.794	5.540	5.427	4.388	4.7499	3.652
Canada	8.694	8.373	8.257	8.245	8.176	8.012	7.968	7.738	7.661	7.647	7.341
Chile	4.279	4.266	4.208	4.034	3.968	3.921	4.036	4.237	4.238	3.768	3.776
China	10.281	9.974	9.446	8.888	8.693	8.679	8.502	8.190	7.851	7.104	6.690
Hong Kong SAR, China	1.887	1.859	1.876	1.801	1.943	1.694	1.744	1.657	1.573	1.553	1.488
Indonesia	4.864	4.719	4.416	4.248	4.389	4.341	3.939	3.854	3.747	3.683	3.525
Japan	5.015	4.924	4.775	4.642	4.683	4.735	4.403	4.233	4.206	3.871	3.742
Mexico	4.514	4.399	4.235	4.134	4.343	4.014	4.054	4.069	4.023	3.853	3.738
Malaysia	5.773	5.497	5.663	5.647	5.448	5.177	5.127	4.946	5.327	5.134	4.682
New Zealand	5.343	5.193	5.105	5.253	5.322	5.507	5.342	5.455	5.414	5.519	5.423
Peru	2.747	2.481	2.474	2.377	2.466	2.693	2.575	2.615	2.461	2.782	2.790
Philippines	3.945	3.721	3.497	3.484	3.280	3.224	3.131	3.121	3.019	3.034	3.122
Papua New Guinea	11.364	11.276	13.173	10.981	10.656	9.495	9.064	8.158	8.523	7.942	9.283
Korea, Rep.	7.160	6.920	6.822	6.780	6.796	6.959	6.993	6.915	6.729	6.625	6.548
Russian Federation	9.837	9.360	8.649	8.411	8.575	8.731	8.781	8.695	8.456	8.345	8.413
Singapore	3.420	3.375	2.865	3.233	2.802	2.910	2.833	2.706	2.618	2.484	2.394
Thailand	5.496	5.339	5.279	5.331	5.350	5.445	5.394	5.393	5.648	5.556	5.411
Vietnam	6.015	5.761	5.787	5.856	6.062	6.324	5.967	5.744	5.618	5.745	5.944
United States	6.601	6.369	6.367	6.222	6.084	6.072	5.909	5.692	5.676	5.621	5.408

Note: Data on Chinese Taipei are not available. The values of all indicators are rounded to three decimal places.
Source: [50].

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