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ANALYSIS OF THE GVC EXPANSION EFFECT ON MEKONG RIVER ECONOMIES THROUGH ODA UNDER THE EKC MODEL AND THE UN SDGS ACHIEVEMENT

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Abstract

The COVID-19 pandemic poses risks for Korea due to its export dependence and involvement in the global value chain (GVC), as it deepens the vulnerabilities of the global supply chain (GSC) and the GVC crises. Therefore, Korea should respond through supply chain diversification and near-shoring to address the GVC reorganization trend. The Mekong economies are suitable cooperative partners as emerging markets, global production bases, and geographical neighbors. Given the Korea's ODA-based cooperation project, there is complementarity between Korea's GVC expansion and Mekong economic development.

This study analyzed panel data from 1995 to 2018 in the five Mekong countries to examine the relationship between Mekong economic ODA, GVC expansion, and CO_2 emissions using the environmental Kuznets curve (EKC) model. The results showed a significant positive correlation between ODA and GVC, and an inverse U-curve relationship between GVC and CO_2 emissions, conforming to the EKC pattern. Simulations indicated that Thailand reduced CO_2 emissions above the GVC threshold, while the remaining four countries had increased emissions below the threshold. Expanding GVC through ODA in the Korea-Mekong cooperative relationship is necessary while addressing potential environmental issues from increased CO_2 emissions.

The ASEAN Smart City Network (ASCN), part of the Korea-Mekong cooperation project, can promote economic growth in the water resources sector. ASCN in the water resource sector creates a favorable environment for economic growth, addressing climate change, reducing CO_2 emissions, and expanding GVC and diversification. This establishes a long-term reciprocal relationship between Korea and Mekong. Based on this, a K-Smart City strategy for the Mekong economic zone was presented, including the establishment of basic and advanced water infrastructure models. Support projects such as K-drain, sewage treatment technology, K-smart water management, and K-smart energy technology were proposed for each model. Korea-Mekong cooperation through ASCN can contribute to global development by aligning with the Sustainable Development Goals (SDGs) and the ASEAN Sustainable Urbanization Strategy (ASUS).

Keywords: GSC, ODA, CO2, EKC, ASCN-water resource, K-smart city, UN SDGs

1. Introduction

The COVID-19 pandemic has significantly impacted global supply chains, causing disruptions in major countries such as China, Italy, the United States, and Germany. These disruptions have halted production and logistics, imposed trade restrictions, and decreased international trade, indirectly affecting emerging countries. Global Value Chains (GVC) have played a crucial role in economic growth, with the division of labor across countries creating value (Choi, M. J. et al., 2020). The GVC reorganization trend, triggered by the U.S.-China trade dispute and de-Sinicization after the 2008 global financial crisis, has highlighted the vulnerability of GVC due to the pandemic-induced bottlenecks in production bases like Vietnam and Thailand. In response, Korea, heavily reliant on exports and deeply involved in GVC, must adapt to this trend through supply chain diversification and near-shoring.

The Mekong economies (Vietnam, Thailand, Cambodia, Myanmar, Laos) are regarded as the last "blue oceans" in Asia, with abundant resources and high economic growth. Geopolitically positioned to connect China-ASEAN-India, they serve as a gateway to a consumer market encompassing half the world's population. Capitalizing on these advantages, the Mekong economy is rapidly becoming an attractive emerging market and global production base, attracting substantial Official Development Assistance (ODA) from countries worldwide, including the United States and China.

Previous studies have shown that ODA from donor countries generally influences recipient countries' GDP or GVC (Lee, H. S. et al., 2018). In the case of the Mekong economy, ODA can contribute to GVC expansion, which will be empirically analyzed using a multiple regression model estimated through the Ordinary Least Squares (OLS) method. Additionally, as developing countries like the Mekong economic zone anticipate CO2 emission issues resulting from GVC expansion due to rapid industrial development, the study aims to analyze the relationship between economic growth, environmental pollution, and CO2 emissions by applying the environmental Kuznets curve (EKC) model. The goal is to develop a plan to address both GVC and environmental concerns in the Mekong economy.

The establishment of the ASEAN Smart City Network (ASCN) cooperation system through ODA linkage is expected to provide an effective solution for GVC expansion and environmental problems by reducing CO2 emissions (Shin, K. W., 2020) and promoting K-Smart City participation in the water resource sector. Moreover, ASCN cooperation support can enhance Korea's economic growth through increased participation in GVC, value-added activities, and diversification (Lee, J. M., 2020). Accordingly, based on ASCN's pilot project, individual demands of Mekong countries will be assessed to develop a tailored K-Smart City strategy for each nation. Additionally, considering the strategic connection between ASCN and the United Nations Sustainable Development Goals (UN SDGs) (Bang, S. A., 2020), the study will explore the alignment of ASCN achievements with the UN SDGs.

2. Literature Review and Theoretical Framework

2.1. COVID-19 and Global Supply Chain (GSC) Risk

2.1.1. Economic Impact of the Mekong River and GSC Vulnerability

The Mekong economy has been hit by the recent COVID-19 pandemic and has shed light on global supply chain risks caused by disruptions in the production bases of domestic companies and multinational companies. In the case of Vietnam, as part of strong quarantine measures against COVID-19, lockdown measures such as restrictions on operations at workplaces and factories have been implemented, and global supply chain damage is inevitable along with production disruptions by global companies operating in Vietnam (KOTRA, 2022). Thailand, the largest automobile producer in ASEAN, also saw its car production an 11.2% decrease in automobile production as of September 2021 from a year earlier due to the COVID-19 infection and a global shortage of semiconductor supplies. This problem of production disruption can act as a factor that increases global inflation pressure in conjunction with other global supply bottlenecks (Bank of Korea, 2021).

The need for additional supply chain diversification has been raised in Vietnam and Thailand, beneficiaries of the GVC reorganization trend due to the prolonged U.S.-China trade dispute and de-China. Korea also needs to reduce supply chain risks by linking ODA strategies concentrated in Vietnam with GVC expansion, as in the case of the "Thailand Plus One" strategy in which Japan, which had been investing intensively in Thailand, has recently diversified its investments to neighboring countries such as Cambodia, Laos, and Myanmar.

2.1.2. The Impact of Korea's GVC Vulnerability and the Need to Expand GSC in the Mekong River Economy

In the case of the Korean economy, which has higher trade dependence (about 80%), manufacturing share (about 40%)[1], and GVC's backward participation than major countries in the world, supply chain problems such as export regulations and pandemics of trading countries can be hurt hard.[2] (See Figure 1-1 and Figure 1-2) According to a survey by the Korea Chamber of Commerce and Industry in January 2022, 67% of the 300 Korean companies that procure raw materials and parts from abroad were damaged by global supply chain instability. In addition, due to the global supply bottleneck and rising raw material prices, the producer price index (PPI), the leading index of the Consumer Price Index (CPI) in December 2021, rose 9% year-on-year, and the domestic supply price index considering import prices (based on raw materials, intermediate goods, and final goods) also rose 15.2% year-on-year. This increase in production costs affects

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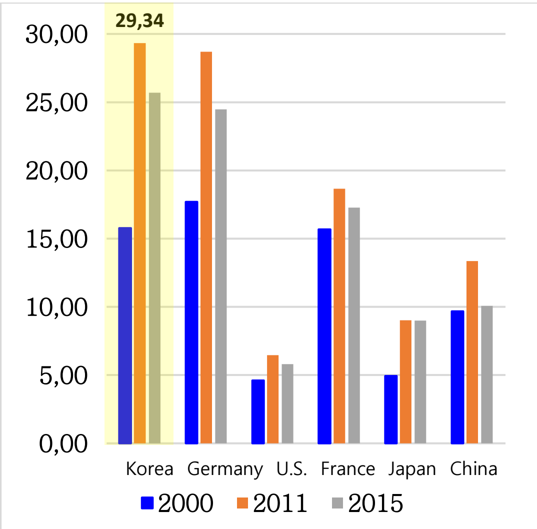
[1]) GVC forward participation means to participate in GVC by producing and exporting raw materials and intermediate goods, and backward participation means to participate in GVC by importing intermediate materials and assembling and processing raw materials (Choi, M.J. et al., 2020). In Korea, the proportion of imported intermediate goods is higher than in other countries, and the 13 major items such as petrochemicals, petroleum products, semiconductors, steel, and automobile parts are intermediate goods, so both front and rear participation is high (Jo, G. K. et el,. 2021).

[2]) Korea has a high proportion of exports of technology-intensive intermediate goods, which means that it is highly dependent on GVC and has a high degree of integration (Koo, Y.M., 2020).

a company's profitability or product price competitiveness, and in the long run, it can affect all economic players through overall inflation (Kim, B. W., 2021). Therefore, in order to prepare for such a supply chain shock, it is necessary to respond to the GVC reorganization flow and monitor the GVC trend. Furthermore, it is necessary to create high-added value by utilizing and systematically managing suitable GVCs through this (Jo, G.K. et al, 2021). Vietnam and other Mekong economies are major considerations of GVC reorganization and diversification, given that the purpose of GVC participation is considered as important factors, including labor cost reduction, access to consumers, and natural resources. This is because it is adjacent to Korea and can increase the efficiency of procuring intermediate goods such as parts by constructing and expanding a near-field supply chain, and it is possible to produce near-consumption areas for ASEAN countries, which are considered emerging markets. In addition, it is judged that Korea's GVC expansion, diversification, and development cooperation in the Mekong economy can be complemented in terms of expanding East Asian economic integration in ASEAN[3] and greatly expanding development demand for regional development gaps and growth bases.

Figure 1.1. Participation in GVC in Developed countries

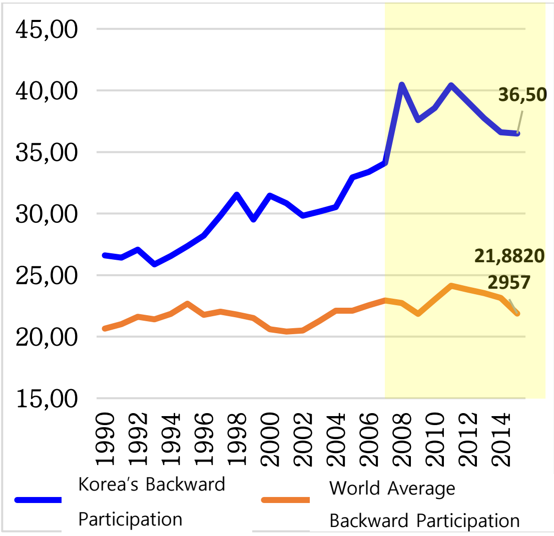
(%)



Note: 1) Written by the author with EORA I/O data presented by the World Bank. 2) GVC participation is measured on a production basis.

Figure 1.2. Korea's Backward GVC Participation

(%)



Note: 1) Written by the author with EORA I/O data presented by the World Bank. 2) The world average is a simple average of 189 EORA indicators.

2.1.3. The necessity of expanding GVC in the Mekong River economy at the ODA level

Six out of ten ASEAN countries subject to the New Southern Policy are ODA-

[3]) ASEAN is actively promoting a development gap mitigation program linked to regional integration policies, focusing on narrowing the regional development gap between existing and new member CLMVs (Cambodia, Laos, Myanmar, and Vietnam) with the aim of establishing a community in 2015 (Kwon, Y. et al., 2012).

focused partners.[4] Given that four of them belong to the Mekong economic zone, ODA linkage for GVC construction can play a pivotal role in improving and industrializing the business environment of the Mekong economic zone in the future (Jeong Oh, 2020). On the other hand, many environmental problems can arise due to the establishment and operation of infrastructure and manufacturing-related industrial facilities for such GVC expansion. As of 2019, Vietnam's greenhouse gas emissions were 3.1 tons, ranking 21st in the world. As can be seen in the recent case of the Vietnamese government's announcement of a "long-term low-carbon power generation strategy (LEDS)" or the Thai government's introduction of a BCG (BIO-Circular-Green) economic model throughout the industry, ODA linkage measures to minimize environmental impact will also be required as sustainable growth and ESG awareness spread in the Mekong economy. Therefore, this paper intends to empirically analyze and verify the possibility of GVC expansion through ODA at the national level and the environmental impact (CO2) and propose an effective action plan for ODA as a solution.

3. An Empirical Analysis of the GVC Extension Effect of ODA and the Environmental Kuznets Curve (EKC)

3.1. Research data and methodology

ODA can contribute to the expansion effect of GVC in the Mekong economy (Lee, H.S. et al., 2018), and to analyze the environmental impact, it attempted to empirically analyze the threshold by substituting GVC and CO2 emissions in the existing environmental Kuznets curve (EKC) model (Bae, Y.J. et al., 2021). The variables and sources used in the study are as shown in **Table 1**, and the panel data of the five Mekong countries from 1995 to 2018 were analyzed, and the Dummy variable was used in consideration of the significant changes in the international economic environment before and after the 2008 financial crisis. As a quantitative analysis tool, 'Stata/BE 17.0' was used to analyze through a multiple regression model estimated by the OLS (Ordinary least squares) method for intuitive understanding.

In this paper, in order to analyze the effect of expanding GVC in the Mekong economy at the level of ODA policy, the ODA policy is The degree of contribution to the expansion effect of GVC in the Mekong economy (Lee Hong-sik et al., 2018), and the environmental impact accordingly For analysis, the threshold is determined by substituting GVC and CO2 emissions into the existing EKC model (Bae Yoo-jin et al., 2021) It was intended to be an empirical analysis.

In addition, the EKC basic model and expansion model presented in previous studies The expansion model in the middle shows relatively high accuracy, but the difference between the main variables is for simplicity and convenience of analysis, the EKC basics in this study are not significant It was analyzed using the model. The GVC data used in

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[4]) KOICA, Korea's free aid agency, established the "Korea-ASEAN Future Community ODA Strategy Implementation Plan" after the announcement of the New Southern Policy, and confirmed the government's willingness to support the 5 KOICA New Southern Policy through ODA in 2021 in the 35th International Development Cooperation Committee resolution.

the EKC model is FVA (Foreign) of OECD Tiva data at the national level Value Added) UNCTAD-Eora GVC data that is highly correlated with the share Used (Bruno Casella et al., 2019). GVC data provided by UNCTAD is available from other international organizations and GVC data provided by the organization, and key across a wide variety of value-added databases It was judged that the variable reliability was high in that the index was studied.

Furthermore, It was decided to select and analyze GVC data provided by UNCTAD. 5 The variables and sources used in other studies are shown Table 1 and from 1995 to 2018 in the five Mekong countries Panel data by year were analyzed, and the international economic environment changed significantly before and after the 2008 financial crisis The Dummy variable was used in consideration. Use 'Stata/BE 17.0' as a quantitative analysis tool to create an intuitive Multiple regression models estimated by OLS (Original Last Squares) method for understanding.

Table 1. Description of key variables

Variable name	Explanation	Reference
Function Model Common Variables		
GVC_t	Production Value Added Index of the Global Value Chain (US$)	UNCTAD
ODA_{t-1}	Official Development Assistance (US$)	OECD CRS
GVC function model variable with ODA as the explanatory variable		
$GDP_{per,t}$	GDP per capita (US$)	World Bank
CPI_t	Consumer Price Index (2010 = 100)	
$Tarriff_t$	Tariff Rate Weighted Average (%) for All Goods	
$Labor_t$	Annual Labor Productivity Indicators (US$)	ILO
$Demo_t$	Democratic Indicators (0-10)	EIU
$Dummy$	Variables before and after the 2008 financial crisis (before = 0, after = 1)	Self-setting
EKC function model variable with GVC as the explanatory variable		
$Co2_t$	Greenhouse gas emissions per person (ton)	Global Carbon Project
$Energy_{per,t}$	Energy consumption per person (kg)	World Bank
$Agri_t$	Ratio of primary industries (agriculture, forestry, and fisheries) to GDP (%)	
$Manu_t$	Secondary industry (manufacturing) ratio to GDP (%)	
Ele_fossil_t	Percentage of electricity production from fossil fuels (oil, gas, coal) to total electricity production	

3.2. Correlation Analysis between ODA and GVC

3.2.1. Setting up a GVC function model with ODA as an explanatory variable

First, to analyze the effect of ODA on GVC, the natural log of GVC was set as a target variable. The reason for taking a natural logarithm of variables with large units, such as GVC and ODA, is to reduce the estimation error by units. In addition, we tried to minimize the omitted variable bias by including per capita GDP and CPI, which greatly influence GVC, as control variables. The specific multiple regression model established based on this is as follows.

$$ln(GVC_t) = \beta_0 + \beta_1 ln(ODA_{t-1}) + \beta_2 ln(GDP_{per,t}) + \beta_3 ln(CPI_t)$$
$$+\beta_4 ln(Tarriff_t) + \beta_5 ln(labor_t) + \beta_6 ln(Demo_t) + \beta_7 Dummy$$

3.2.2. Analysis of Estimation Results through OLS Model

As a result of estimating the regression coefficient by the OLS method, it was found that the coefficient of $ln(ODA_{t-1})$was 1.1303, which had a significant positive influence. In addition, GDP, CPI, and Demo are also shown as positive coefficients, and the higher the level of democracy, the more positive it is for GVC. In addition, it is judged that Tariff is not positive or statistically significant.

Figure 2.1. ODA and GVC correlation

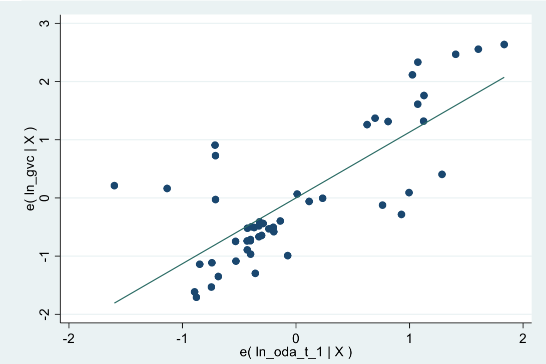
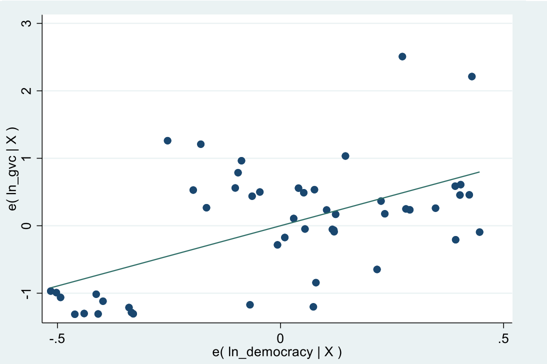


Figure 2.2. GVC and Democracy correlation



Note: 1) ln_gvc: $ln(GVC_t)$, ln_oda_t_1: $ln(ODA_{t-1})$, ln_democracy: $ln(Demo_t)$

Table 2. OLS Model Between ODA and GVC

Source	SS	df	MS
Model	**140.71628**	**7**	**20.1023258**
Residual	**26.9510963**	**42**	**.641692768**
Total	**167.667377**	**49**	**3.4217832**

Number of obs	=	**50**
F(6, 43)	=	**31.33**
Prob > F	=	**0.0000**
R-squared	=	**0.8393**
Adj R-squared	=	**0.8125**
Root MSE	=	**.80106**

$ln(GVC_t)$	Coefficient	Std. err.	t	P>|t|	[95% conf. interval]	
$ln(ODA_{t-1})$	**1.130311*** **	**.1429897**	**7.90**	**0.000**	**.8417455**	**1.418876**
$ln(GDP_{per,t})$	.6120202***	.1279417	4.78	0.000	.3538234	.8702169
$ln(CPI_t)$	-1.391678	1.00561	-1.38	0.174	-3.42108	.6377245

$ln(Tariff_t)$	.2831882	.2181302	1.30	0.201	-.1570165	.7233928
$ln(labor_t)$	.0002372***	.0000221	10.73	0.000	.0001926	.0002819
$ln(Demo_t)$	1.786305***	.3995698	4.47	0.000	.9799403	2.592669

Note: 1) The above subscripts *, **, and *** indicate significance levels of 10%, 5%, and 1%, respectively.

3.3. Analysis of GVC Expansion Effect of ODA and CO2 under EKC Model

3.3.1. Setting up an EKC function model with GVC as an explanatory variable

In order to analyze the effect of GVC on CO2 emissions, the natural log of CO2 was set as a target variable. Next, to confirm the threshold of GVC, the natural log of GVC and its square number were set as explanatory variables. In addition, we tried to minimize the omitted variable bias by including control variables such as per capita energy consumption and primary and secondary industries relative to GDP, which greatly affect CO2. The specific multiple regression model established based on this is as follows.

$$ln(Co2_t) = \delta_0 + \delta_1\, ln\, ln\, (GVC_t) + \delta_2 ln(GVC_t)^2 + \delta_3\, ln\, ln\, (ODA_{t-1}) + \delta_4 ln(Energy_{per,t}) + \delta_5 ln(Agri_t) + \delta_6 ln(Manu_t) + \delta_7 ln(Ele\_fossil_t)$$

3.3.2. Analysis of Estimation Results through OLS Model

The same estimation showed that the coefficient of $ln(GVC_t)$was 2.034879, which had a significant positive effect, and the inverse U-curve relationship between GVC and CO2 emissions was identified by the coefficient of $ln(GVC_t)^2$being -0.590181. In other words, it was confirmed that a positive relationship between GVC and CO2 emission appeared in a range below the threshold of GVC, and a negative relationship appeared in an excess range. In addition, Energy, Agri, Manu, and Ele fossil are also positive coefficients, indicating that most energy consumption and industrial activity increase CO2 emissions. On the other hand, reliability was verified through F-test for the overall model and T-test for individual variables.

Table 3. OLS Model between CO2 for GVC Expansion Effect of ODA under EKC Model

Source	**SS**	**df**	**MS**			
Model	**57.656244**	**7**	**8.2366063**	**Number**	**=**	**57**
	5		**6**	**of obs**	**=**	**548.**
				F(7, 49)	**=**	**66**
Residual	**.73559865**	**49**	**.01501221**	**Prob > F**	**=**	**0.00**
	1		**7**	**R-**	**=**	**00**
Total	**58.391843**	**56**	**1.0427114**	**squared**	**=**	**0.98**
	2		**9**	**Adj R-**		**74**
				squared		**0.98**
				Root		**56**
				MSE		**.122**
						52

$ln(Co2_t)$	**Coefficient**	**Std. err.**	**t**	**P>|t|**	**[95% conf. interval]**	
$ln(GVC_t)$	**2.034879*****	**.4544418**	**4.48**	**0.000**	**1.121644**	**2.948114**
$ln(GVC_t)^2$	**-.0590181*****	**.0158745**	**-3.72**	**0.001**	**-.0909192**	**-.0271171**
$ln(ODA_{t-1})$	.0240929	.0293994	0.82	0.416	-.0349874	.0831732
$ln(Energy_{per,i}$	1.046919***	.1681784	6.23	0.000	.7089516	1.384886
$ln(Agri_t)$	.1691129	.1271106	1.33	0.190	-.0863255	.4245513
$ln(Manu_t)$	.0206863**	.0088779	2.33	0.024	.0028455	.0385272
$ln(Ele\_fossil_t$	.3892665***	.0665783	5.85	0.000	.2554723	.5230608

Note: 1) The above subscripts *, **, and *** indicate significance levels of 10%, 5%, and 1%, respectively.

3.3.3. Derivation of Environmental Kuznets Curve (EKC) and Analysis of CO2 Emission Threshold

Therefore, under the assumption that other variables are the same, the model was simplified to confirm the threshold of GVC expansion.

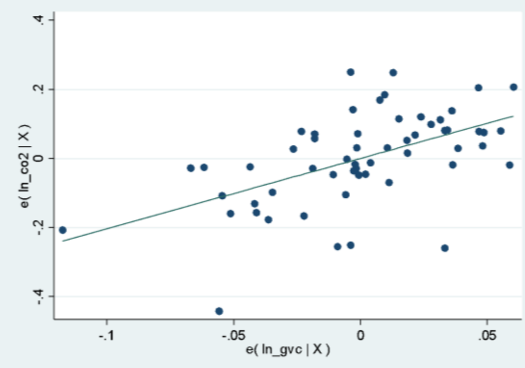
$$l(Co2_t) = 2.03\ ln\ ln\ (GVC_t) - 0.06ln(GVC_t)^2$$

3.3.4. Analysis of CO2 emission estimation results through GVC expansion simulation by Mekong River country

As a result of calculating through the estimation equation, the threshold for GVC expansion was about 22,297,831$, and as shown in **Figure 3.2**, it was possible to grasp the change in CO2 emissions per person before and after the threshold. In Thailand, CO2 emissions have been decreasing since 2013, and in Vietnam, CO2 emissions are expected to increase for the time being below the GVC threshold.[5]

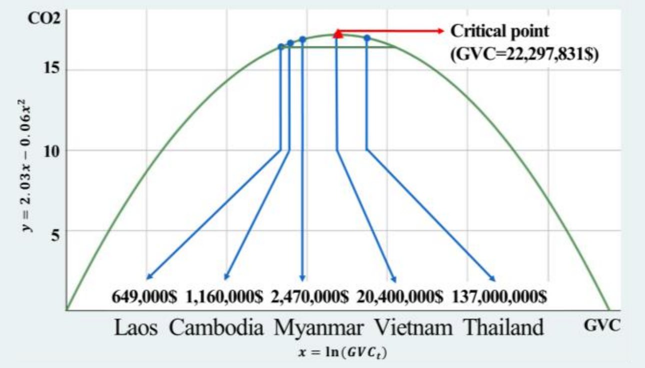
[5]) In the case of Thailand, CO2 emissions per capita are on the decline to 2013 (287,597,656t) → 2020 (257,765,782t), and in the case of Vietnam, they continued to increase, but in 2020, they decreased by 2.3% year-on-year.

Figure 3.1. Correlation between GVC and CO2



Note: 1) ln_gvc : $ln(GVC_t)$, ln_co2 : $ln(Co2_t)$

Figure 3.2. Simulation of EKC in the Mekong Economy



Note: 1) The horizontal axis is the natural log value converted into GVC ($)

Therefore, it was confirmed that there was a positive correlation between ODA and GVC expansion in the Mekong economy, and CO2 emissions also increased as GVC expanded. This suggests that it is necessary to systematically respond to environmental problems that may arise from increased CO2 emissions while promoting GVC expansion through ODA in the future Korea-Mekong cooperative relationship. In addition, as shown in **Figure 3.2**, it is necessary to devise a strategy for environmental problems by dividing the model into 'emission progressing countries (Laos, Cambodia, Myanmar)' and 'emission reduction countries (Vietnam, Thailand)'.

4. ASEAN Smart City Network (ASCN)

4.1. ASCN in the Water Resources Sector for GVC Reorganization and Economic Growth in Korea-Mekong Countries

Establishing an ASCN cooperation system through ODA linkage is a promising solution for GVC expansion and environmental challenges. It is crucial to meet the development demands of Mekong economic countries and establish long-term partnerships for GVC expansion through ASCN cooperation in sustainable infrastructure development, including logistics, water and sewage, and transportation. ASEAN countries, particularly the Mekong River economic zone, aim to expand their economic growth base by promoting infrastructure development to enhance internal and external connectivity. This has attracted increasing interest and investment from neighboring countries in the infrastructure development market.

ASEAN's emphasis on infrastructure development is evident in its joint development strategy, MPAC 2025, and the establishment of ASUS as a framework for sustainable infrastructure goals. ASCN, established in 2018, serves as a platform for developing smart cities in ASEAN. Previous studies have shown that utilizing ODA for improving economic infrastructure, such as logistics and transportation, contributes to GVC expansion by enhancing production bases' comparative advantage. Enhancing infrastructure and international transportation is crucial for strengthening trade and export capabilities, enabling active participation in GVC for the Mekong River economy.

Preemptive ASCN cooperation in the water resources sector, including water and sewage, is essential before the development of other economic-related infrastructure. Water resource infrastructure is a fundamental urban infrastructure that is interconnected with transportation and roads. Given Vietnam's vulnerability to climate change and the expectation of more severe floods in the Mekong economies, ensuring the availability of qualitative water resources becomes crucial. ASCN cooperation in the water resources sector plays a vital role in establishing a long-term reciprocal relationship between Korea and the Mekong region. It addresses the effects of climate change and their direct and indirect impact on residents' lives, health, and industries.

4.1.1. A Study on the Expected Effects of Economic Growth in Mekong River Countries through ASCN in Water Resources Sector

ASCN in the water resources sector can be a sustainable development plan for Mekong countries because it uses eco-friendly smart technologies in flood and drainage, sewage treatment, water circulation, waterfront green area creation, and wetland restoration (Shin, K.W., 2020).

Bringing the climate Radar Network Technology Improvements in Flooding with ASCN[6] enables early warnings and corresponding measures against floods, it is possible to prevent road flooding caused by floods and reduce logistics and transportation costs, thereby enhancing the comparative advantage of production bases in the Mekong economy (Lee, H.S. et al., 2018).

Improvements in the drainage sector can reduce the use of power and fossil fuels used for drainage in urban plants through the implementation of rainwater and runoff groundwater reuse activation system (Yoo, Y.J. et al., 2013), thereby preventing CO2 emissions reduction and carbon regulation in the industry (Han, H.J. et al., 2021).[7] Improvements in the sewage treatment sector can reduce CO2 generated from sewage treatment by recovering carbon dioxide (CO2) and methane (CH4) in the sewage treatment process[8] through the implementation of a carbon-neutral sewage treatment system (Kim, W.J.,2021). These results can ensure the free participation of the industry in GVC, as they reduce CO2 generated during the sewage treatment process of factories in the city.

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[6]) The climate radar network is based on a technology that can predict rainfall more accurately, enabling early warning and corresponding action promotion for sudden flooding by predicting the flow of water using rainfall prediction, weather models, and weather radar networks (K-water, 2019).

[7]) In the past, ASEAN's urban expansion centered on manufacturing-based cities, and recently, it has been formed around industrial complexes created as special economic zones outside or on the border (Kim, I.H. et al., 2020).

[8]) Unlike existing sewage treatment systems, carbon-neutral sewage treatment systems contribute to reducing CO2 emissions by achieving goals such as water treatment efficiency, eco-friendliness, cost reduction, energy efficiency improvement, nutrient recovery, and energy recovery (Kim, Y.J., 2020).

The improvement in the water circulation sector can reduce CO_2 emissions from factories in the city by supplying electricity produced by hydrothermal energy and water photovoltaic technology to residential facilities and factories through thermal power generation used in heating and cooling processes (Ki, J.Y.,2020). This increases the participation of the industry in GVC by allowing factories in the city to emit less CO_2 than before when using the power required for the production process. On the other hand, the reduction in the use of thermal power generation due to the use of water-related renewable energy may reduce the level of air pollution by reducing fine dust (Kim, Y.J., 2020). A decrease in air pollution reduces the health risk and death risk of surrounding urban residents, which can lead to a quantitative increase in the national labor force (Seo, B.S. et al., 2019).

The implementation of the waterfront green area and wetland restoration project sector can generate a new type of GVC consisting of only services by reducing CO_2 in the Mekong country as well as expanding tourism business (Lee, J.M.,2020). As such, improvements in the water resource sector through ASCN can lead to GVC expansion and economic growth in terms of improving the comparative advantage of production bases, breaking away from carbon regulations in urban industries, quantitative increase of labor, and generation of new types of GVCs (World Bank, 2020). Therefore, ASCN is a way to support the sustainable development of the Mekong economic zone in that it can have a positive impact on the expansion of GVC and economic growth in Mekong countries.

4.1.2. A Study on the Expected Effects of Korea's Economic Growth through ASCN in the Water Resources Sector

First, as renewable energy companies and government ministries in the water resources sector enter the Mekong economy, Korea can participate in the localized GVC, or ASCN. In the current situation where GVC is blocked by region and it is becoming difficult for countries outside the region to enter, smart cities have become effective countermeasures against climate change and urban problems, and related global markets are gradually expanding from $308 billion in 2018 to $617.2 billion in 2023 (Ministry of Land, Infrastructure and Transport, 2019). ASEAN is requesting technology and investment support for smart cities through ASCN, and in the case of Kota Kinabalu, Malaysia, it also requested the Korean government for water-related cooperation projects apart from the smart city project announced by ASCN (K-water, 2019). This can be expected to have a long-term economic growth effect in that Korea, a country outside the region, can access the GVC that is localized and enhance Korea's participation in GVC based on the establishment of cooperative relations.

Next, through the development of smart and eco-friendly technologies essential for ASCN[9], Korea can enter high value-added GVC (Lee, J.M., 2020). The AI flood

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[9]) The artificial intelligence flood management system is an AI system that analyzes precipitation in real time to predict and respond to floods, and the flood damage prediction and warning system is a flood damage prediction and warning system based on weather models and big data (Shin, K.W., 2020).

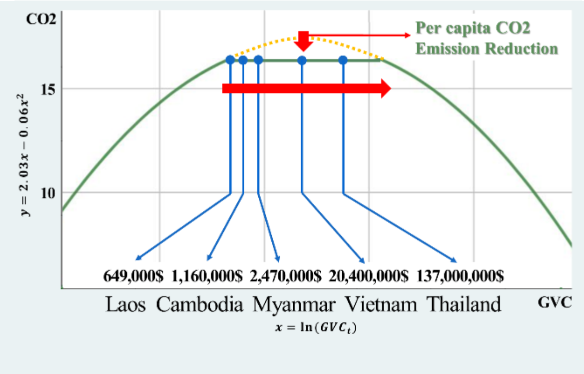
management system and flood damage prediction and warning system enable the advancement of GVC by creating added value through SW innovation in the water resource sector using AI and big data technologies.

Finally, by exporting eco-friendly parts used in the smart city development process, such as water quality and air pollution sensors, Korea can establish a crisis response system through diversification of export items. Procurement of intermediate goods in the eco-friendly sector to the Mekong economy can reduce the damage to the GVC reorganization crisis by diversifying Korea's participation in GVC, and furthermore, this type of export will improve economic growth (Choi, M.J. et al., 2021). Therefore, it is believed that Korea's participation and support for ASCN cooperation in the water resource sector can be a way to promote Korea's economic growth in the current situation where GVC is being reorganized.

4.2. ASCN Water Resources Sector's Entry into the K-Smart City Mekong Economy

4.2.1. Review of EKC analysis results and development demand for effective entry into K-Smart City

Figure 4. EKC Simulation via ASCN



Note: 1) The horizontal axis is the natural log value converted into GVC ($)

As seen from the EKC simulation results of the Mekong economy, CO2 emissions vary depending on the degree of GVC development, so a tailored strategy for ASCN in the water resource sector is needed to minimize environmental impact. As a result, as shown in **Figure 4**, each country in the Mekong economy should be able to maintain or reduce the current CO2 emissions while promoting GVC expansion. In addition, these tailored strategies will be able to effectively address problems in various environmental sectors facing the Mekong economy and positively improve the quality of life of citizens considering the development needs of individual national cities.

Therefore, in order to understand the development demand of individual countries, ASCN pilot projects that reflect national priorities were reviewed first. Among them, the smart city project for the environment and water resources sector was surveyed as a total of 7 countries, 10 cities, and 11 projects (Shin, K.W., 2020). In the case of Mekong countries, Cambodia and Myanmar want to implement smart city projects in waste and sewage treatment, Laos installs drainage facilities, Vietnam manage water resources, and

Thailand build waste power generation facilities (Shin, K.W., 2020). Accordingly, the five Mekong countries could be classified into two models based on the demand for smart city development in the water resource sector. Laos, Cambodia, and Myanmar set the above three countries as "Basic Water Infrastructure Construction Model" in that they requested technical support and investment support for sewage and drainage, and Vietnam and Thailand set the two countries as "Advanced Water Infrastructure Implementation Model". This model classification was derived based on the development demand of Mekong countries and is the same as the EKC simulation model classification presented earlier based on the environmental conditions of CO_2 emissions.

Table 4. Classification of ASCN Development Demand Model in Mekong National Water Resources Sector Based on EKC

Model of Basic Water Resources Infrastructure	Model of Advanced Water Resources Infrastructure
(Laos) (Cambodia)  (Myanmar)	(Vietnam)  (Thailand)

Note: self-made table resources

4.2.2. Presenting a K-smart city strategy tailored to the Mekong economy

Previously, we would like to present a customized 'K-Smart City Strategy' for the two models set based on CO_2 emissions and demand for infrastructure development in the water resource sector.

First, countries in the <Basic Water Resources Infrastructure Construction Model> support 'K-drain and sewage treatment technology' to reduce CO_2 emissions and create infrastructure in the water resources sector of the country.[10] Laos, Cambodia, and Myanmar, which are countries of the above model, do not even have the necessary infrastructure to introduce smart technologies, so Korea's drainage and sewage treatment technologies can be supported to lay the foundation for future smart technologies such as smart sensors. Meanwhile, in the case of Vientiane City in Laos, which is requesting cooperation projects with Korea, despite the first and second stages of the existing Korean EDCF project, the drainage system to prepare for the rainy season that lasts for about five months has not been developed enough. Therefore, prior to the introduction of new facilities and technologies, the size, level, and performance of the existing business should also be considered.

[10]) K-drain technology has eco-friendly drainage construction technology that operates rainwater and runoff groundwater reuse activation system (Yoo Y.J. et al., 2013), and K-sewage treatment technology has sewage management facility construction technology that has eco-friendly sewage treatment technology to recover biogas such as CO_2 and CH_4 (Kim, W.J., 2021).

Figure 5.1.
Basic water infrastructure Construction Model: Integrated Management System for Urban Water Disaster

Note: 1) K-water(2019)

Figure 5.2.
Advanced water resources infrastructure Introduction Model: Low Impact Development (LID) Technology

Note: 1) K-water(2019)

Next, countries in the **<Advanced Water Resources Infrastructure Introduction Model>** support 'K-Smart Water Management Technology' and 'K-Smart Energy Technology' to create a smart city. "Smart Waterworks" and [11] Water reuse and 'Low Impact Development (LID) Technology' [12] It can cooperate with the water resource management sector through transfer and help the construction of renewable energy-based waste generation facilities through transfer of hydrothermal energy and water solar renewable energy technologies (Shin, K.W., 2020). In the case of Danang, Vietnam, it is necessary to introduce operational technologies such as Korea's water supply network management, data management, and "SCADA system" in terms of improving water quality due to rapid urbanization and population growth. In addition, Korea's waterfront green technology, based on the experience of the Cheonggyecheon restoration project, will be able to create tourism resources and improve drainage by restoring rivers in cities with high social and cultural values, such as Luangprabang in Laos.

ASCN cooperation in the water resource sector using Korea's smart and eco-friendly technologies can not only lay the foundation for economic growth in the Mekong economy in the future, but also contribute to Korea-Mekong co-prosperity and prosperity in the long run as a necessary condition for GVC expansion. Furthermore, it is expected to improve the quality of life of residents in the Mekong economy and contribute to the Korea-Mekong partnership as partners through the effect of reducing complex CO2

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[11]) Smart water supply technology includes real-time water quality and water monitoring technology for water supply sources, and water leakage sensor technology that prevents water pipe leakage and damage using a water leakage sensor attached to each water pipe joint (Shin, K.W., 2020).

[12]) Low Impact Development (LID) means developing with minimal impact on the water cycle of nature. It can effectively control and manage problems such as rainfall outflow and pollution load caused by impermeable sleep by providing functions such as storage, penetration, filtration, and evaporative acid (Ministry of Environment, 2013).

emissions and effective water resource management in response to disasters such as floods caused by climate change.

4.3. ASCN to achieve the national goal of UN SDGs

Based on ASUS, ASCN is carrying out urban development projects in 10 ASEAN countries, including 5 Mekong countries. The main area of ASUS has been found to have strategic links with the Sustainable Development Goals (UN SDGs) (Bang, S.A., 2020), and it is believed that the implementation of ASCN projects can help achieve UN SDGs.

Table 5. Structure of UN SDGs

Objectives for each field	Social development people	Economic development Prosperity	Environment development Planet
	1-6 Goals	6-12 Goals	13-15 Goals

Note: 1) Lee Sung hun (2017)

4.3.1. Review of the UN SDGs at the economic development level achieved through ASCN

Table 6. ASCN's relationship between ASUS and UN SDGs

ASUS	UN SDGs
Infrastructure	
Industry Innovation	
Environment development	
Civil society	
Health wellbeing	

Note: 1) Bang Seol ah(2020)

The ASUS items have areas of infrastructure construction and industry and innovation, and the introduction of ASCN's smart flood management system for improvement in those areas can achieve UNSDGs at the economic development level. First, in terms of infrastructure construction, the introduction of a smart flood management system achieves the sustainable urban goal (Goal 11) by enhancing the city's flood prevention capacity and mitigating flood damage (Bang, S.A., 2020). In addition, the creation of a smart technology training camp, such as flood management technology, leads to skilled manpower emissions and innovation in the flood management sector industry, achieving jobs and economic growth (Goal 9) (Bang, S.A., 2020).

4.3.2. Review of the UN SDGs at the environmental development level achieved through ASCN

In the area of environmental improvement, the environmental UN SDGs can be achieved through cooperation in the water quality improvement sector of ASCN (Bang, S.A., 2020). In terms of environmental improvement areas, smart technology transfer, such as solar floating waste collection ship technology, achieves the conservation of marine resources and sustainable utilization goals (Goal 14) by reducing water pollution and improving the surrounding water environment.

4.3.3. Review of the UN SDGs at the social development level achieved through ASCN

In civil and social and health and well-being areas, the creation of ASCN's waterfront green areas can achieve UNSDGs at the social development level. First of all, in terms of civil and social areas, the creation of waterfront green areas leads to the expansion of tourism projects, enabling inclusive growth of ASEAN cities with severe urban poverty (Kim, N.J., 2014), achieving the poverty eradication goal (Goal 1). In addition, the implementation of the waterfront green area development project achieves the health and well-being goals (Goal 3) by improving the residential environment of citizens by providing green space to ASEAN cities (Bang, S.A., 2020).

5. Conclusion

Amid the global supply chain (GSC) risks and vulnerabilities to the global value chain (GVC) crisis, it is necessary to reorganize and diversify Korea's GVC. In this context, the Mekong economy has emerged as a new global production hub due to its favorable geopolitical location, natural resources, and potential as an emerging market. The development of the Mekong economic zone within ASEAN and Korea's GVC reorganization and diversification can complement each other. ODA can serve as an effective means to expand GVC, especially considering that most Mekong countries are ODA-focused partners.

To explore this further, this study analyzed panel data from 1995 to 2018 in the five Mekong countries and empirically examined the relationship between Mekong economic ODA, GVC, and CO2 emissions using the environmental Kuznets curve (EKC) empirical model and the OLS method. The analysis revealed a significant positive influence of ODA on GVC and CO2 emissions. It also confirmed an inverse U-shaped relationship, known as the EKC model, between GVC and CO2 emissions. The estimated GVC threshold was approximately $22,297,831, and in the case of Thailand, CO2 emission reduction was observed above the GVC threshold. While the remaining four countries are projected to experience increased CO2 emissions in the short term, Vietnam exhibited a decrease in CO2 emissions in 2020 and was close to the GVC threshold. This indicates the need to expand GVC through ODA in the future Korea-Mekong cooperative relationship, while addressing potential environmental issues arising from increased emissions. Considering that the impact of GVC expansion on CO2 emissions varies across countries, a strategy for environmental issues should be tailored to each country, distinguishing between "CO2 emission progressing countries" (Laos, Cambodia, Myanmar) and "CO2 emission reduction countries" (Vietnam, Thailand).

ASEAN, as part of the Mekong economy, expresses its commitment to developing infrastructure for expanding its economic growth base through the ASEAN Linkage Master Plan (MPAC) 2025. Such infrastructure development is expected to enhance the comparative advantage index of production bases, creating a favorable environment for Korea's GVC expansion and diversification. In this regard, cooperation through ODA in the ASEAN Smart City Network (ASCN) is considered effective for establishing long-term reciprocal relations between Korea and the Mekong region.

Proactive infrastructure development in the water resource sector, through ASCN cooperation, is crucial to prepare for abnormal weather conditions such as climate change and floods, which directly or indirectly impact the Mekong economy. Specific measures include the introduction of climate radar network technology to prevent flood problems, the implementation of rainwater and runoff groundwater reuse activation systems to address drainage issues, and the adoption of carbon-neutral sewage systems to reduce CO2 emissions in the sewage treatment sector. Moreover, the utilization of hydrothermal energy and water solar technology in the water circulation sector can contribute to CO2 reduction and help address the issue of fine dust pollution. Additionally, the creation of waterfront green areas and wetland restoration can boost the service sector and tourism industry while reducing CO2 emissions in Mekong countries.

In conclusion, through ASCN cooperation in the water resources sector, it is anticipated that Korea and the Mekong region can achieve long-term growth and prosperity. The proposed K-Smart City strategy for Mekong countries presents an effective cooperation method. Priority projects for each country should be classified based on the "Basic Water Infrastructure Construction Model" and "Advanced Water Infrastructure Introduction Model," considering development demand and CO2 emissions. Basic water infrastructure countries such as Laos, Cambodia, and Myanmar should receive support in establishing foundations for future smart technology through the introduction of "K-drain treatment and sewage treatment technology." Advanced water resource infrastructure countries like Vietnam and Thailand should focus on solving urban challenges caused by rapid industrial development and reducing CO2 emissions effectively with support in "K-Smart Water Management Technology" and "K-Smart Energy Technology." Implementing the K-Smart City strategy in the Mekong economic zone will improve residents' quality of life, contribute to the co-prosperity of Korea and the Mekong region, and align with the UN Sustainable Development Goals (SDGs) and the ASEAN Sustainable Urbanization Strategy (ASUS), enabling participation in global-level development.

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