

Sustainable Growth: A Trinity or Trilemma of Growth, Equality, and Environment¹⁾

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Abstract

Choi, Han, and Ko (2019) empirically investigate the link between the Kuznets curve and the environmental Kuznets curve. In particular, they examine whether a country can simultaneously obtain the following three goals: economic growth, income equality, and environmental quality. They find that there exists the trilemma between three objectives. In this paper, we revisit the link between three goals using alternative data and show the robustness of the between three objective variables. Furthermore, we discuss policy insight into what an optimal policy combination of the national policy goals can be.

Keywords: Kuznets curve; environmental Kuznets curve; economic development; income equality; environmental quality; CO₂; SO₂; trade openness; industry structure; international finance trilemma

JEL classification: F18; F43; F63

1) This work is supported by a research grant from the Institute of Economic Research, Aoyama Gakuin University.

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1. Introduction

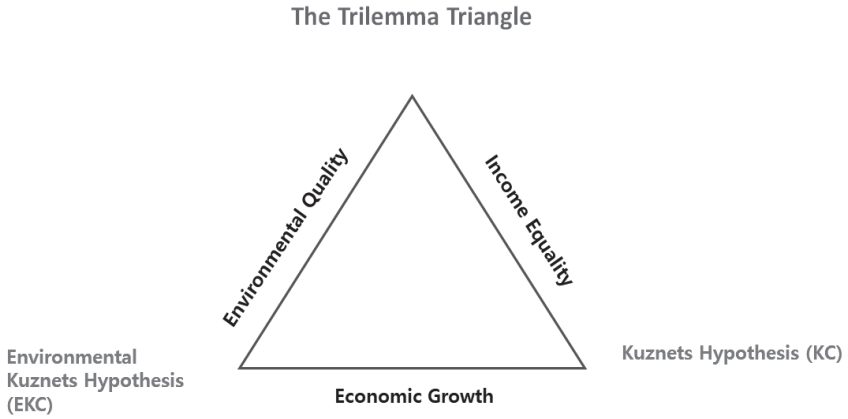
In the 21st century, human beings face more frequently global challenges and threats such as climate change, energy depletion, competition, poverty, food problems, water shortages, pollution, biodiversity crises, widening gaps between developed and underdeveloped countries, finance crises, etc. These threats are challenges to sustainable growth and, more fundamentally, threats to our present and future. To overcome these threats and challenges, a new concept of sustainable growth must be considered, rather than the unsustainable growth methods that have been carried out so far. The reflection on unsustainable growth that has caused environmental deterioration has led to a situation in which today's people must ask fundamental and imperative questions.

According to UN estimates, the world's population will be 9.7 billion by 2050, and global GDP will grow by 130% by 2030. This means that, even with technological progress, some 50% of natural resources will be more extracted. Economic growth has been important in the past and will be important in the future because it determines the wealth of a nation. Especially in poor countries, economic growth is still the only hope of getting out of poverty. Our experience has led us to think about two big issues: environmental degradation and income inequality as negative externalities that arise in the early stage of economic growth. Therefore, the relationships between environmental degradation, income inequality, and economic growth have received academic attention for a long time.

Numerous studies have attempted to find and explore the relationship between two variables combined among the three variables (environmental quality, economic growth, income inequality). Especially, the literature²⁾ on the KC and EKC hypotheses has paid attention to a dilemma (trade-off) relationship that may exist between policy objectives (e.g. environmental quality and economic growth / economic growth and income equality). Some studies³⁾ have focused on association between income equality and environmental quality. While the results of these analyses are inconclusive, these studies

2) Deininger and Squire (1996, 1998), Barro (2008), Atkinson and Brandolini (2003), Gallup (2012), Ravallion et al. (2000), Heerink et al. (2001), Borghersi (2006).

3) Torras and Boyce (1998), Ravallion et al. (2000), Heerink et al. (2001), Hao et al. (2016).



indicate that a country may face a dilemma in pursuing these policy objectives simultaneously.

This study reviews the methodology of Choi, Han, and Ko (2019), which extends and integrates the mechanism of the existing KC and EKC literature⁴⁾, and pays attention to the interrelationship between three policy variables, and examines whether the three policy objectives have trade-off relationships and fall under a trilemma constrained by the policy space of a country.

The most prominent study of interrelationship of three variables is the open economy policy trilemma theorized in the Mundell–Fleming model (Mundell 1963; Fleming 1962). These authors have stressed that it is not possible to have simultaneously: fixed exchange rates, independent monetary policy and free capital mobility. Therefore, policy makers are forced to drop one of these objectives and fulfill only two of them. Alternatively, they can choose a combination of the three policy objectives in which none of them is fully achieved.

To explore our trilemma variables, we adopt the analytic framework provided by the Mundell–Fleming trilemma literature (Aizenman and Reuven, 2009; Aizenman et al., 2010, 2013; Aizenman, 2011; Steiner, 2017) that test the validity of the trilemma constraints of the Mundell–Fleming model. We investigate whether the indexes of the three policy variables have linear rela-

4) Kuznets (1955), Grossman and Krueger (1991, 1994).

tionship. If the estimated coefficients of the three variables have different signs, the three goals are supplementary to one another. It means that a country can achieve all three policy objectives at the same time. By contrast, if the coefficients share the same sign, (e.g. all positive) a country cannot jointly achieve the three policy objectives (Aizenman et al., 2013).

Based on panel data on 1980-2010 for 149 countries, we find the existence of trilemma relationship between the policy goals for sub-sample despite the trinity relationship for pooled sample. However, sub-group sample results show different results across income and region. Except for high income countries, middle- and low-income countries have a trilemma relationship between the three policy objectives. Regions other than Europe and Central Asia and North America, have trilemma or dilemma relationship. Considering macro-economic effects, trade openness and changes of industrial structure have eased tensions in high-income countries, Europe and Central Asia, and the Sub-Sahara regions. On the other hand, tensions have been strengthened in middle- and low-income countries and elsewhere. In North America, in particular, the trinity relationship has turned into a dilemma after considering macro-economic effects.

This paper is organized as follows. Following the explanations of the trilemma indexes, the methodology, empirical results, and final remarks are concluded.

2. Trilemma Indexes

2.1. Economic Growth (EG)

The index for economic growth is defined as:

$$EG_{i,t} = \frac{Y_{i,t} - Y_{min}}{Y_{max} - Y_{min}} \quad (1)$$

where EG and Y denote the indexes of economic growth and real GDP per capita, respectively. i and t refer to country and time, respectively. Y_{max} and Y_{min} denote the maximum and minimum values of output (value of real GDP per capita: $0 \leq EG \leq 1$), respectively. Ideally, there is no maximum or minimum level of output, and hence we take them from the actual data. Country i with

$EG_i = 1$ achieves the maximum level of economic growth during the sample period, whereas $EG_i = 0$ implies that country i has the lowest economic growth. Hence, the values are relative normalized economic growth. Real GDP per capita data are taken from the WDI database.

2.2. Income Equality (IE)

The Gini coefficient is widely used for measuring income inequality. Hence, we construct our income inequality index using the Gini coefficient as follows:

$$IE_{i,t} = 1 - GINI_{i,t} \quad (2)$$

where IE and $GINI$ denote the indexes of income equality and the Gini coefficient, respectively. If IE_i equals 1, all workers in country i earn an equal income. By contrast, if IE_i is 0, the top earner takes all the income of country i . The Gini coefficient data are obtained from the WDI database.

2.3. Environmental Quality (EQ)

Sulphur Dioxide (SO_2) is widely used to measure environmental quality. SO_2 is one of the main contributors to human death and disease from air pollution. The burning of fossil fuels such as coal, oil, and gas most used in industry activities is the largest source of emissions of SO_2 resulting in disastrous air pollution and premature deaths. Hence, we construct the environmental quality index using SO_2 as follows:

$$EQ_{i,t} = 1 - \frac{SO_{2,i,t} - SO_{2,min}}{SO_{2,max} - SO_{2,min}} \quad (3)$$

where EQ and SO_2 denote the indexes of environmental quality and per capita SO_2 emissions, respectively. We take $SO_{2,min}$ and $SO_{2,max}$ from the actual data during the sample period because we only consider the degree to which the objective of the variable can be achieved. The data on SO_2 emissions per capita (kg) are from the UNEP GEO database (Edgar.v4.2).

2.4. Trade Openness (TO)

We consider other macroeconomic variable, which may change the trilemma

relationships of the three policy variables. For example, trade liberalization is an important factor in economic development. Thus, the impact of trade openness on economic growth and income inequality has been investigated by many researchers. Furthermore, trade openness has been included as a factor affecting the environment in many EKC empirical studies. Hence, the normalized index of trade openness (TO) is defined as:

$$TO_{i,t} = \frac{TG_{i,t} - TG_{min}}{TG_{max} - TG_{min}} \quad (4)$$

where TO and TG denote the indexes of trade openness and the trade-to-GDP ratio, respectively. The trade openness data are also from the WDI database.

2.5. Industrial Structure (IS)

We also consider another critical variable to consider is changes in industrial structure. Economic growth is accompanied by changes in industrial structure. Economic growth and industrial restructuring also result in changes in social and environmental aspects. Structural change in industry may thus be a factor changing the trilemma relationships among the three policy variables. Therefore, the index of industry share (IS) is as follows:

$$IS_{i,t} = \frac{IG}{100} \quad (5)$$

where IS and IG denote industrial structure and the industry share-to-GDP ratio (value added), respectively. The industry share-to-GDP ratio are taken from the WDI database. In particular, industry (value added) corresponds to ISIC divisions 10–45 and includes manufacturing (ISIC divisions 15–37). This comprises value added in mining, manufacturing, construction, electricity, water, and gas. The service industry (ISIC divisions 50–95) is excluded from the industry data.

3. Methodology and Data

3.1. Methodology

We adopt the linear trilemma regression model developed by Choi, Han, and Ko (2019). Choi, Han, and Ko (2019) extends Aizenman and Reuven (2009), Aizenman et al. (2013), Steiner (2017), and Canale et al. (2018), which tests the constraint on the three variables to investigate the Mundell-Fleming trilemma. Our trilemma indexes are constructed based on Canale et al. (2018) using the relative normalized index. Our trilemma variables are economic growth, income equality, and environmental quality, which are normalized to values between 0 and 1. Higher index values imply greater closeness to the goal of the policy. Our trilemma equation is as follow:

$$I = \alpha_1 EG_{i,t} + \alpha_2 IE_{i,t} + \alpha_3 EQ_{i,t} + e_{i,t}, \quad (6)$$

where EG is the measure of economic growth, IE accounts for income equality, and EQ is the measure of environmental quality. As discussed by Aizenman and Reuven (2009), Aizenman et al. (2013), and Steiner (2017), if the estimated coefficients of the three variables are significantly positive, there exists a trade-off (trilemma) among these three variables. If the estimated coefficients of the three variables are mixed (i.e., they have different signs), the three policy goals supplement one another. In other words, a country can achieve all three goals simultaneously. To consider other macroeconomic factors and test the robustness of the trilemma relationship, we also extend this trilemma equation by including additional indicators such as trade openness and industrial structure (quintilemma):

$$I = \beta_1 EG_{i,t} + \beta_2 IE_{i,t} + \beta_3 EQ_{i,t} + \beta_4 TO_{i,t} + \beta_5 IS_{i,t} + \mu_{i,t} \quad (7)$$

3.2. Data

We employ global panel data composed of 149 countries for 1980–2010 to test the trilemma or trinity relationship among economic growth, income equality, and environmental quality. Table 1 describes the variables used in the study. The main difference from Choi, Han, and Ko (2019) is that we use SO2

Table 1. Variables

Variable	Description	Source
1	Constant	
EG	Real GDP per capita	WDI
IE	1-Gini index	WDI
EQ	SO ₂ emissions per capita (kg)	UNEP

Table 2. Country Classification (by World Bank Classification 2014)

Income	Region
High Income Countries (H)	East Asia and Pacific (EAP)
Middle Income Countries (M)	Europe and Central Asia (ECA)
Upper Middle Countries (UM)	Latin America and the Caribbean (LAC)
Lower Middle Countries (LM)	Middle East and North Africa (MNA)
Low Income Countries (L)	North America (NA)
	South Asia (SA)
	Sub-Saharan Africa (SSA)

emissions to measure the environmental quality, whereas they use CO₂.

4. Empirical Results and Discussion

Table 3 is our benchmark model. Our main finding is there is a trilemma relationship between economic growth, income equality, and environmental quality at the sub-group level. The analyses of income groups show that, with the exception of high-income countries, middle- and low-income countries have a trilemma relationship among the three policies. This suggests that, for middle- and low-income countries, enhancing two policy goals will result in lower level of the other one policy goal. For high-income countries, the three policies are irrelevant and do not have a trilemma relationship. Table 4, which shows the analyses of regional groups, indicate that countries in Europe and Central Asia (ECA), and North America (NA) have a trinity relationship between the three policy goals. On the other hand, countries in South Asia (SA) and Sub-Saharan Africa (SSA) have a dilemma relationship between economic growth and environmental quality. Table 4 and Table 5, considering the

Table 3. Estimation Results by Income (Benchmark Model)

VARIABLES	Total const	H const	M Const	UM const	LM const	L const
EG	-0.1068*** (0.023)	0.0210 (0.022)	1.6044*** (0.127)	1.3699*** (0.199)	2.8316*** (0.417)	4.9134*** (0.792)
IE	0.9048*** (0.023)	1.4040*** (0.029)	0.7763*** (0.027)	0.9151*** (0.033)	0.2715*** (0.030)	0.0306* (0.015)
EQ	0.5332*** (0.015)	0.0280 (0.027)	0.5634*** (0.017)	0.4921*** (0.022)	0.8476*** (0.019)	0.9803*** (0.010)
Observations	946	230	618	379	239	97
R-squared	0.9888	0.9963	0.9912	0.9894	0.9976	0.9998

Notes: *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are reported in the brackets. EG, IE, and EQ denote economic growth, income equality, and environmental quality, respectively.

Table 4. Estimation Results by Region

VARIABLES	Total const	EAP const	ECA Const	LAC const	MNA const	NA const	SA const	SSA const
EG	-0.1068*** (0.023)	0.2566*** (0.083)	-0.0857*** (0.017)	0.3610** (0.155)	0.5507*** (0.125)	1.2568*** (0.154)	2.2741*** (0.485)	3.8534*** (0.265)
IE	0.9048*** (0.023)	0.8618*** (0.091)	1.2776*** (0.021)	1.0313*** (0.055)	1.0119*** (0.112)	1.1552*** (0.061)	0.1104 (0.161)	0.0511 (0.056)
EQ	0.5332*** (0.015)	0.5270*** (0.058)	0.1752*** (0.017)	0.5361*** (0.027)	0.4001*** (0.077)	-0.3671*** (0.067)	0.9392*** (0.111)	0.9628*** (0.032)
Observations	946	73	377	274	44	18	30	130
R-squared	0.9888	0.9969	0.9955	0.9955	0.9970	0.9994	0.9989	0.9979

Notes: *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are reported in the brackets. EG, IE, and EQ denote economic growth, income equality, and environmental quality, respectively.

macroeconomic variables such as trade openness and changes of industrial structure, report the relationship between the three policy variables. Table 5 and Table 6 show that trade openness and industrial structure relax the tension of the three policy variables in high-income countries at the income level, European and Central Asian countries, and Sub-Saharan African countries at the regional level. However, for middle- and low-income countries, these macroeconomic variables tighten the tension of the policy variables. Interestingly,

Table 5. Estimation Results by Income (TO, SC)

VARIABLES	Total const	H Const	M const	UM const	LM const	L const
EG	-0.0678*** (0.022)	-0.0045 (0.022)	1.4842*** (0.131)	1.2848*** (0.206)	2.3780*** (0.419)	3.8759*** (0.917)
IE	0.7135*** (0.026)	1.5173*** (0.051)	0.6592*** (0.031)	0.7826*** (0.045)	0.2601*** (0.030)	0.0113 (0.017)
EQ	0.5357*** (0.015)	0.0417 (0.033)	0.5339*** (0.016)	0.4616*** (0.022)	0.8050*** (0.019)	0.9857*** (0.009)
TO	0.0272 (0.027)	-0.1146*** (0.025)	0.1768*** (0.036)	0.0973* (0.051)	0.1701*** (0.033)	0.0349*** (0.011)
SC	0.3505*** (0.028)	-0.1946*** (0.060)	0.1973*** (0.033)	0.2583*** (0.050)	0.0627** (0.027)	0.0280 (0.020)
Observations	894	203	598	369	229	93
R-squared	0.9911	0.9972	0.9919	0.9900	0.9980	0.9999

Notes: *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are reported in the brackets. EG, IE, and EQ denote economic growth, income equality, and environmental quality, respectively.

Table 6. Estimation Results by Region (TO, SC)

VARIABLES	Total const	EAP const	ECA Const	LAC const	MNA const	NA const	SA const	SSA const
EG	-0.0678*** (0.022)	0.2570*** (0.066)	-0.0877*** (0.018)	0.5245*** (0.169)	0.5708*** (0.132)	1.1157* (0.260)	1.8772** (0.857)	4.4010*** (0.331)
IE	0.7135*** (0.026)	0.7542*** (0.077)	1.3365*** (0.037)	0.9163*** (0.059)	0.8145*** (0.165)	1.6069*** (0.134)	0.2202 (0.129)	0.0620 (0.064)
EQ	0.5357*** (0.015)	0.4798*** (0.052)	0.1576*** (0.019)	0.5118*** (0.027)	0.4996*** (0.100)	-0.4021 (0.138)	0.7981*** (0.091)	0.9776*** (0.038)
TO	0.0272 (0.027)	0.0857 (0.052)	-0.0629** (0.028)	0.2246*** (0.041)	0.0772 (0.112)	-0.2693 (0.315)	0.0887 (0.122)	-0.0900** (0.044)
SC	0.3505*** (0.028)	0.2380*** (0.049)	-0.0210 (0.043)	0.1153** (0.050)	0.0571 (0.081)	-0.7357 (0.416)	0.2458*** (0.068)	-0.0449 (0.032)
Observations	894	69	361	268	42	7	29	118
R-squared	0.9911	0.9982	0.9958	0.9960	0.9972	1.0000	0.9995	0.9979

Notes: *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are reported in the brackets. EG, IE, and EQ denote economic growth, income equality, and environmental quality, respectively.

for countries in North America, the relationship of the three policy variables change from a trinity in the absence of macroeconomic variables to the dilemma in the presence of macroeconomic variables.

The process of economic development transitioning from agriculture to manufacturing and services is related to the U curve relationships between economic growth and income equality, and between economic growth and environmental quality, which are derived from the KC and EKC hypotheses, respectively. Furthermore, trade openness, an important factor affecting economic development and environmental quality, is considered in many EKC studies. According to the KC and EKC hypotheses, the three policy objectives (economic growth, income equality, and environmental quality) are expected to show positive interplay in rich countries and negative interplay in poor countries, respectively. Our results are largely to support our expectations by identifying the trinity relationship of the three policies in high-income, and European countries, and the trilemma relationship in middle- and low-income countries, and non-European countries. To sum up, our results present that high-income countries and European countries have policy harmonization mechanism (regulation, system, industrial structure, trade, etc.) to achieve the trinity relationship. However, such mechanism is insufficient in middle- and low-income, and non-European countries.

5. Final Remarks

This study reviews Choi, Han, and Ko (2019) that examine whether the three policies of economic growth, income equality, and environmental quality, which are preconditions for sustainable growth, are in a trilemma. Using alternative data, our results confirm that there are trilemma or trinity relationships depending on the heterogeneity (different stage of economic development) of the country, which generally supports the existing KC and EKC hypotheses. According to our results, policy makers in middle- and low-income countries are forced to drop one of the three policy objectives and fulfill only two of them. Alternatively, they can choose a combination of the three policy objectives in which none of them is fully achieved. Our results, on the other hand, imply that high-income countries have a favorable mechanism for achieving

these three policy goals.

As our empirical results indicate, developing countries are in a dilemma situation to sacrifice environmental quality to achieve economic growth, or lower the weighted sum of income equality and environmental quality. These results imply that many developing countries are still at limits of the unsustainable development whereas developed countries are likely to achieve sustainable development. Furthermore, the findings suggest that we should make a whole new discourse about the sustainable growth of new concepts. After fully understanding the interrelationships (Trinity and Trilemma) of policy objectives, policy makers must try to identify them and then intentionally develop the win-win relationships of policy objectives. This study contributes to provide new insights into sustainable growth, as a country can pay more attention to which policy combinations are optimal when it comes to achieving its policy goals for sustainable growth simultaneously.

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