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IMPACT OF HUMAN DEVELOPMENT ON CO_2 EMISSIONS IN VIETNAM

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Abstract. This study aimed to examine how human development affects CO_2 emissions in Vietnam from 1990 to 2020. By utilizing data from the World Bank and CountryEconomy.com, the research results indicate no causal relationship between human development and CO_2 emissions in Vietnam. However, the study found that human development has a positive impact on reducing CO_2 emissions and, therefore, that it positively affects environmental protection. The result of this study is explained by the fact that more people need to live and invest in a cleaner environment to improve their health and well-being. This study contributes to enhancing knowledge about the relationship between human development and CO_2 emissions, which is significant for reducing environmental pollution in the future.

Keywords: human development, CO_2 emissions, Vietnam

1 Introduction

In recent years, climate change has become an interesting topic for researchers around the world [1]. CO_2 emissions are the main cause of climate change [2]. As a result of these emissions, many countries are grappling with the challenge of balancing economic growth with environmental responsibility [3]. Previous empirical studies suggest that human development may play an important role in this effort [4–14].

Vietnam is an emerging country that relies heavily on fossil fuels for economic activities, making environmental pollution a pressing issue for the government [15]. However, awareness of environmental protection among the population remains low in some areas, which greatly affects the quality of the environment. Furthermore, Vietnam is becoming increasingly integrated into the global economy and is committed to environmental protection, making the topic of environmental pollution important to domestic researchers. As shown in previous studies, CO_2 emissions in Vietnam are influenced by various factors such as economic restructuring [3], reforestation [1], energy consumption [16], economic development [17], foreign innovation activities [15], and external debt [18]. However, no prior research has investigated the role of human development on environmental quality in Vietnam. Therefore, this study aims to fill this gap by exploring whether human development has an impact on CO_2 emissions in Vietnam during the period of 1990–2020. The study uses a Vector Auto Regression model to analyze the relationship between human development and CO_2 emissions and finds that human development has a positive influence on environmental quality in Vietnam, which fills a critical gap in previous research.

This study makes three main contributions to the existing body of research on the relationship between human development and environmental quality in Vietnam. Additionally, this study confirms the relationship between human development and environmental pollution through the environmental Kuznets curve hypothesis. Finally, our findings suggest that prioritizing investments in human development could be an effective strategy for improving environmental quality in Vietnam, and should be considered by policymakers when making decisions about resource allocation.

2 Theoretical basis and empirical evidence, and research hypothesis

2.1 Theoretical basis

The environmental Kuznets curve hypothesis suggests a relationship between economic growth and the environment. Grossman and Krueger [19] posited that economic activities cause environmental pollution during a country's development phase. As income per capita stabilizes, people demand a better living environment [19]. Moreover, economic development contributes to human development by expanding access to knowledge, education, and community activities [20]. Better human development means an improved understanding of environmental pollution and how to tackle it by reducing CO_2 emissions [21]. Consequently, environmental protection activities have led to a reduction in environmental pollution.

2.2 Empirical evidence and research hypothesis

Previous studies have confirmed that human development affects CO_2 emissions. Wang et al. [6] explored the impact of the human capital index on CO_2 emissions in OECD countries during the period to 1990–2015. Their findings demonstrated a positive relationship between the human development index and environmental quality. Using data from 42 sub-Saharan African countries, Maji [13] analyzed the influence of inclusive development on the environment and found that inclusive human development negatively affects CO_2 emissions. Adekoya et al. [4] investigated the relationship between renewable energy consumption and CO_2 emissions in human development across 126 countries from to 2000–2016. Their results suggested that human development positively affects CO_2 emissions. Similarly, Dumor et al. [11] examined the correlation between CO_2 emissions and the human development index in the East African Community during the period 1980–2020. Their results highlight that human development has a positive impact on CO_2 emissions in the short term.

Various studies have demonstrated that CO_2 emissions affect human development. For example, Asongu [7] investigated the impact of CO_2 emissions on inclusive human development in 44 sub-Saharan African countries from 2000 to 2012 and found a negative relationship between CO_2 emissions and inclusive human development. Asongu and Odhiambo [8] explored the role of government quality in modifying the impact of inclusive human development on environmental pollution in a region during the same period. Their findings suggest that government quality can adjust for the negative relationship between CO_2 emissions and human growth. Conversely, Bedir and Yilmaz [9] examined the causal relationship between the human development index and CO_2 emissions in 33 countries from 1992 to 2011, revealing an inverted U-shaped relationship between environmental pollution and human development. Boonyasana and Chinnakum [10] studied the relationship between human growth and CO_2 emissions in Thailand from 1995 to 2018, and concluded a causal relationship between human development and CO_2 emissions. Similarly, Akbar et al. [5] investigated the two-way impact of CO_2 emissions on the human development index in 33 OECD countries over the period to 2006-2016 and found a causal relationship between human development and environmental pollution. In contrast, Hossain and Chen [12] examined the relationship between the human development index and environmental pollution in Bangladesh between 1990 and 2018 and found a weak decoupling correlation between CO_2 emissions and human development. Sezgin et al. [14] analyzed the influence of environmental policies and human development on CO_2 emissions in seven economic groups and BRICS countries from 1995 to 2015 and discovered causal relationships between human development and environmental pollution in Germany, Japan, the UK, and the United States. Based on the evidence presented, this study asserts that human development has a negative impact on CO_2 emissions for two reasons. Firstly, as income per capita increases, people desire better living conditions. Consequently, more people need to live and invest in a cleaner environment to improve their health and well-being indicators. The other reason is related to education and awareness. By improving education, people can better understand the impact of environmental pollution and take steps to reduce CO_2 emissions [20]. It may lead to more people using public transportation rather than private vehicles due to their increased environmental awareness. Thus, the author suggests the main hypotheses are as follows:

H_0: Human development negatively affects CO_2 emissions in Vietnam.

3 Research Methods

3.1 Research model

Following Nguyen and Do [15], Le et al. [1], and Nguyen et al. [3], the author has built the following model was developed:

$$CO_{2t} = \beta_0 + \beta_1 HDI_t + \beta_2 LGPP_t + \beta_3 URB_t + \mu_t \tag{1}$$

where i is the year, β is the regression coefficient of the independent variables and μ is the standard error.

CO_2: CO_2 emissions measured by CO_2 emissions per capita [3, 10, 15].

HDI: Human development measured by the human development index [6, 9, 11]. The Human Development Index (HDI) was developed by the United Nations in 1990. This index considers national economic and social development through three aspects: a long-lived and healthy life, the ability to educate, and the standard of living [22].

LGPP: Economic growth measured by the natural logarithm of GDP per capita [1].

URB: Urban population measured by urban population growth rate [23].

For time-series data analysis, the author employed vector autoregression estimation, which was suggested by Sims [25], for two primary reasons. First, vector autoregression is suitable for analyzing the impact of time-series data. Second, this method enables us to investigate causal effects in the research model. The vector autoregression model with n lags is as follows:

$$Y_t = C + \theta_1 Y_{t-1} + \theta_2 Y_{t-2} + \ldots + \theta_n Y_{t-n} + \mu_t \tag{2}$$

where Y_t is the vector of variables in the model $Y_t = (HDI_t, LGPP_t, URB_t)$, C is a vector of constants, θ_1 and θ_2 are coefficients of the variables in the matrix, and μ_t is a vector of errors.

3.2 Research data

The data in this study covers the period 1990–2020. The author collected data specifically for this period because Vietnam did not have complete data on the human development index before 1990. The data for GDP per capita and urban population (% population) were obtained from the World Bank [26], while data for CO2 emissions per capita and the human development index were collected from The Country Economy [27].

4 Empirical evidence

4.1 Descriptive statistics

The author of this study analyzed data from the World Bank and the country's economy to describe the variables in the research model, which include CO_2 (CO_2 emissions per capita), HDI (Human Development Index), GPP (GDP per capita – constant 2015 US$), and URB (urban population growth rate – annual %).

As shown in Table 1, the sample mean of CO_2 was 1.2983 tons per capita during 1990–2020. This value is higher than that reported by Nguyen *et al.* [3], whose CO_2 emissions per capita equaled 1.1899 between 1986 and 2020 in Vietnam. In addition, the average human development index is 0.615, the average GDP per capita is $1,722.029, and the sample mean of the URB variable is 3.2882 percent. It is clear that human development, economic growth, urban population, and CO_2 emissions tended to rise during the period 1990–2020 (Figure 1).

Table 1. Summary statistics

Variables	Observation	Mean	Standard Deviation	Min	Max
CO_2	31	1.2983	0.8331	0.3	3.24
HDI	31	0.6151	0.069	0.483	0.71
GPP	31	1,722.029	798.4118	673.3855	3,352.06
URB	31	3.2882	0.2891	2.8315	4.0084

Source: Analyzed by the author on Eview software

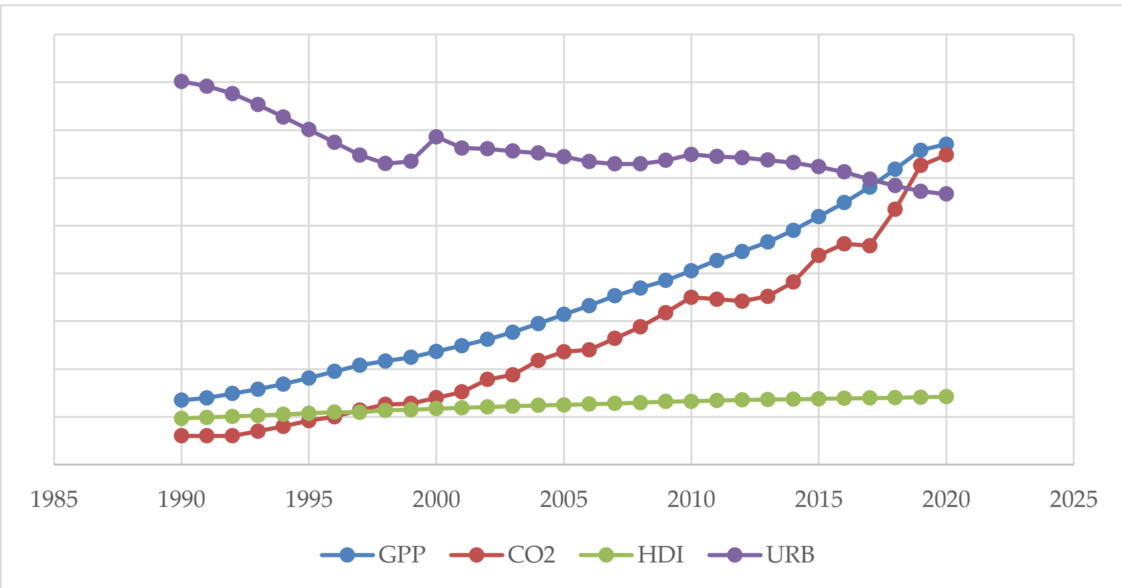

Fig. 1. Relationship between CO_2 emissions per capita, human development index, GDP per capita, and urban population growth rate in Vietnam during 1990–2020

Note: GPP: GDP per capita; CO2: CO_2 emissions per capita; HDI: Human development index; URB: Urban population growth rate

Source: Analyzed by the author on Eview software

4.2 Unit root test

We used two popular unit root tests for small sample sizes, the Augmented Dickey-Fuller and the Phillips-Perron test, to test the stationary time series. According to Table 2, the test for a unit root in the 1st difference of the CO2, HDI, LGPP, and URB variables showed significant results at the 10% level. These results indicate that these variables are stationary time series at the 1st difference, allowing the author to analyze the impact of human development on CO2 emissions in Vietnam in this study.

4.3 Test to optimate and suitable lags

Table 3 presents the results of suitable and optimal lags for the variables in the research model. The table indicates that a lag of two for each variable is sufficient to obtain optimal results based on the LR, FPE, AIC, and HQ criteria in the research model.

The next step is to investigate whether the model satisfies the stability condition of the VAR model. We used an AR test to check the stability of the research model with two lags. According

Table 2. Unit root test

Variables	ADF test		PP test	
	Level	**1st difference**	**Level**	**1st difference**
CO_2	1.2293^{ns}	-8.7044^{***}	-0.8376^{ns}	-6.8013^{***}
HDI	0.4976^{ns}	-9.9877^{***}	1.0937^{ns}	-14.4468^{***}
LGPP	-1.239^{ns}	-3.2687^{*}	-1.4385^{ns}	$-3,3026^{*}$
URB	-2.9092^{ns}	-3.297^{*}	-2.201^{ns}	-3.6275^{**}

Note: Significance levels of 10%, 5%, and 1% are denoted by *, **, and ***, respectively.

Source: Analyzed by the author on Eview software

Table 3. Optimate and suitable lags test

Lag	LogL	LR	FPE	AIC	SC	HQ
0	223.0681	NA	5.65e-13	-16.85139	-16.65784*	-16.79565
1	244.2330	34.18947	3.87e-13	-17.24869	-16.28093	-16.97001
2	269.9376	33.61372*	2.03e-13*	-17.99520*	-16.25322	-17.49357*
3	282.0209	12.08331	3.61e-13	-17.69392	-15.17772	-16.96934
4	292.1127	6.986604	1.07e-12	-17.23944	-13.94903	-16.29192

Note: * shows lag order selected by the criterion, LR: sequential modified LR test statistics; FPE: final prediction error; AIC: Akaike information criterion; SC: Schwarz information criterion; HQ: Hannan-Quinn information criterion

Source: Analyzed by the author on Eview software

to Figure 2, all values are within the circle, indicating that the estimated model is stable and ensures the reliability of the research results.

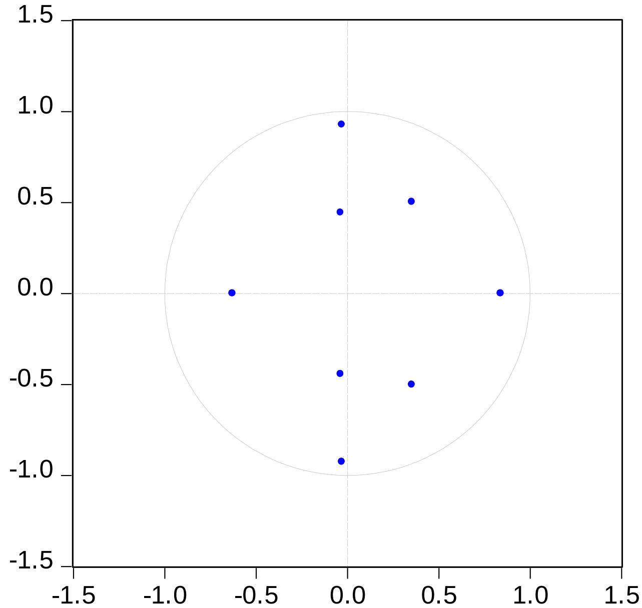

Fig. 2. Stable model test

Source: Analyzed by the author on Eview software

After selecting the optimal lags of the variables used in the research model, we estimate the vector autoregression model. Table 4 lists the results of the vector autoregression model.

Table 4. The results of vector autoregression model

Variable	**D(CO_2)**	**D(HDI)**	**D(LGPP)**	**D(URB)**
	(1)	(2)	(3)	(4)
D(CO_2(-1))	0.104399	-0.003845	-0.012411	0.066660
	[0.47242]	[-0.53096]	[-0.80510]	[0.61830]
D(CO_2(-2))	-0.844078***	-0.007306	-0.031390*	0.074548
	[-3.59396]	[-0.94941]	[-1.91594]	[0.65064]
D(HDI(-1))	-15.71819***	-0.160347	0.023211	1.026987
	[-2.34234]	[-0.72929]	[0.04958]	[0.31371]
D(HDI(-2))	-13.65425**	0.329605	0.361055	6.723902**
	[-1.95089]	[1.43731]	[0.73951]	[1.96923]
D(LGPP(-1))	-1.087958	-0.022417	0.678997***	-8.494657***
	[-0.33183]	[-0.20868]	[2.96876]	[-5.31079]

Variable	D(CO_2)	D(HDI)	D(LGPP)	D(URB)
D(LGPP(-2))	-1.940991	0.076535	-0.430858	0.958500
	[-0.49402]	[0.59453]	[-1.57203]	[0.50006]
D(URB(-1))	-0.201310	0.002299	-0.027334	0.170485
	[-0.54944]	[0.19153]	[-1.06948]	[0.95379]
D(URB(-2))	0.046457	-0.005659	-0.003618	-0.240303*
	[0.16005]	[-0.59504]	[-0.17869]	[-1.69701]
C	0.560931***	0.003959	0.040205***	0.304683***
	[2.34217]	[0.50448]	[2.40653]	[2.60776]
R^2	0.495014	0.294969	0.540725	0.687422
Adj. R^2	0.282388	-0.001887	0.347346	0.555810
F-statistic	2.328101	0.993644	2.796197	5.223092
Log likelihood	22.43546	118.1506	96.99160	42.53216
Akaike information criterion			-17.86438	
Schwarz criterion			-16.15155	
Number of coefficients			36	

Note: Significance levels of 10%, 5%, and 1% are denoted by *, **, and ***, respectively. The t-value is reported in bracket. D(CO_2); D(HDI); D(LGPP); D(URB) are the first difference of data series CO_2, HDI, LGPP, and URB.

Source: Analyzed by the author on Eview software

On the one hand, the author conducted tests to check the assumptions of the model, including the serial autocorrelation test and normal distribution test. Table 5 presents the test results. The LM test[1] shows that the p-value is greater than 10 percent, indicating sufficient evidence to conclude that the residual of the model has no autocorrelation. Similarly, the p-value of the Jarque-Bera test is higher than 10%, implying that the residuals of the model have a normal distribution (Table 5). Based on the results of these tests, the author argues that the research model is stable and well suited for investigating the relationship between human development and CO_2 emissions in Vietnam.

[1] LM test is a Lagrange multiplier test for autocorrelation in the residuals of VAR models.

Table 5. Tests after estimating VAR

Serial auto correlation	
Lags	2
p-value	0.7235
LM statistics value	12.2945
Normal distribution of the residual	
Jarque-Bera statistics value	12.1706
p-value	0.1437

Source: Analyzed by the author on Eview software

4.4 The results of Granger test

The author conducted a Granger test to examine the relationship between human development and CO_2 emissions in Vietnam from 1990 to 2020. Table 6 presents the results of the Granger test. The p-value of the HDI variable is significant at the 5% level, indicating that human development index is related to CO_2 emissions. On the other hand, the p-value of CO_2 and LGPP are significant at the 10% level, suggesting the causal relationship between CO_2 emissions and economic growth in Vietnam (Table 6).

Results in Table 4 show the coefficients of the variable HDI are statistically significant at the 5% level in Column (1), implying that human development has a negative impact on CO_2 emissions, thus supporting hypothesis 1. These findings are consistent with the results of previous studies by Wang et al. [6], Maji [13], and Adekoya et al. [4], suggesting that human growth has a greater influence on air pollution by reducing CO_2 emissions. These findings also support the viewpoint of environmental Kuznets curve theory for two major reasons.

First, as income per capita increases, people will require a better living environment. According to Chaabouni and Saidi [28] and Ozcan and Apergis [29], environmental degradation is a cause of the rising cost of high-quality healthcare. Consequently, an increasing number of people need to live in a better environment and improve their longevity by spending more on environmental protection.

The second reason is related to education and knowledge. Liu et al. [21] concluded that knowledge can help to create new technologies to reduce CO_2 emissions. Moreover, improving education [20] will help people better understand environmental pollution, leading them to act to reduce CO_2 emissions.

Table 4 presents that the coefficients of variable CO_2 are statistically significant at the 10% level, indicating that environmental pollution is associated with economic development, which is shown in Column (3). These findings are consistent with Olubusoye and Musa [30], who

Table 6. Granger causality test

Null Hypothesis	Chi-square	Prob.
D(HDI) does not Granger cause D(CO_2)	7.1653**	0.0278
D(CO_2) does not Granger cause D(LGPP)	5.6411*	0.0596
D(LGPP) does not Granger cause D(URB)	30.8788***	0.0000

Significance levels of 10%, 5%, and 1% are denoted by *, **, and ***, respectively.

Source: Analyzed by the author on Eview software

indicated a negative relationship between gross domestic product and CO_2 emissions in the short term. However, in some cases, this negative impact may only occur in the short term due to countries exporting wood through deforestation to generate revenue for their country [31]. In contrast, Asongu and Odhiambo [8] found that GDP positively affected CO_2 emissions.

On the one hand, the p-value of LGPP is significant at the 1% level, suggesting that economic development has a negative impact on the urban population growth rate in Column (4) (refer to Table 4). These findings are consistent with those of Nguyen and Nguyen [17], who argued that GDP per capita affects urban growth rates in some ASEAN countries. Similarly, Lewis [32] concluded that urban growth negatively affects economic growth in Indonesia.

4.5 Impulse responses and variance decomposition

The author employs the impulse response function to examine the relationship between human development and environmental pollution using the Cholesky approach. This approach reveals that when one unit of standard deviation is added, the impulse response function estimations generate interesting impacts on other variables. The results of the impulse response function are presented in Figure 3, which demonstrates that the impact of the human development index shock on CO_2 emissions decreases after the fourth period. The graph also indicates that the response propensity of the human development index to CO_2 emissions becomes stronger after the 10^{th} period.

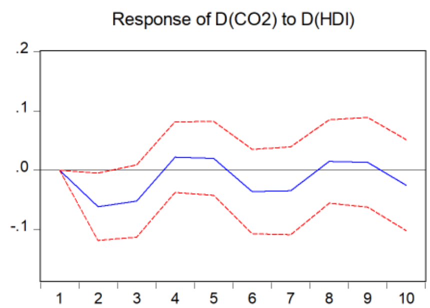

Fig. 3. Impulse response function

Source: Analyzed by the author on Eview software

On the other hand, Table 7 displays the variance decomposition analysis of endogenous variables to function shocks in vector autoregression. The table reveals that the CO_2 emissions in the first year are explained 100% by the preceding period. After the second year, the introduction of the human development index explained 16.97% of the changes in CO_2 emissions. By the end of the tenth year, the change in CO_2 emissions was explained by human development, accounting for 20.368%.

5 Conclusion

The importance and attention that human development and CO_2 emissions have been enjoying in the past few decades served as motivation for this study. This study examined the influence of human development on CO_2 emissions in Vietnam. Using data from Vietnam between 1990 and 2020, empirical evidence has indicated that human growth is positively associated with environmental protection. This implies that better human development leads to an improved understanding of environmental pollution and how to tackle it by reducing CO_2 emissions. These findings also show that CO_2 emissions are associated with economic development. On the one hand, economic growth negatively affects urban population growth rates.

Based on these findings, we suggest policies that focus on improving environmental pollution through human development. These policies include (1) Encourage people to invest in renewable energy: Switching to renewable energy (e.g., solar power, wind power) can help reduce the amount of pollution generated by fossil fuels; (2) Promote sustainable transportation: Encourage people to the use of public transport, and promote the development of clean

Table 7. Forecast error variance decomposition

Period	S.E.	D(CO_2)	D(HDI)	D(LGPP)	D(URBG)
1	0.131819	100.0000	0.000000	0.000000	0.000000
2	0.149798	81.84193	16.97282	0.476065	0.709185
3	0.179944	78.94248	20.11913	0.444090	0.494300
4	0.182242	77.02186	21.07249	0.435367	1.470276
5	0.203605	79.90793	17.83040	0.964853	1.296818
6	0.208439	76.52930	20.00763	1.966875	1.496200
7	0.219792	76.37285	20.50459	1.776455	1.346105
8	0.220881	75.70980	20.74990	1.878264	1.662030
9	0.229838	77.14009	19.49373	1.820506	1.545668
10	0.231783	75.85432	20.36800	2.112397	1.665276

Source: Analyzed by the author on Eview software.

transportation alternatives such as electric vehicles, bicycles, and walking; (3) Sustainable agriculture practices: Encourage people to the adoption of sustainable agriculture practices that reduce the use of pesticides and fertilizers, conserve water, and promote soil health; (4) Waste management: Encourage people to the adoption of sustainable waste management practices such as recycling & composting to minimize the amount of waste that ends up in landfills; (5) Promote awareness: Promote awareness of the negative impacts of pollution on the environment, and educate people on ways they can reduce their own environmental footprint; (6) Encourage people green technologies: Encourage the development and adoption of "green" technologies, such as energy-efficient buildings and appliances; (7) Advocate for policies that protect the environment, such as regulations that limit pollutants in the air and water.

These results provide empirical evidence that supports the theory of the impact of human development on environmental pollution. However, it is important to note that this study only covers a relatively short period, which is a limitation. Therefore, the author suggests that future studies should consider a longer time frame to improve the efficiency of statistical estimation.

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