An Empirical Test of the Correlation Between the Environmental Performance Index and GDP.

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December 1, 2023

ABSTRACT

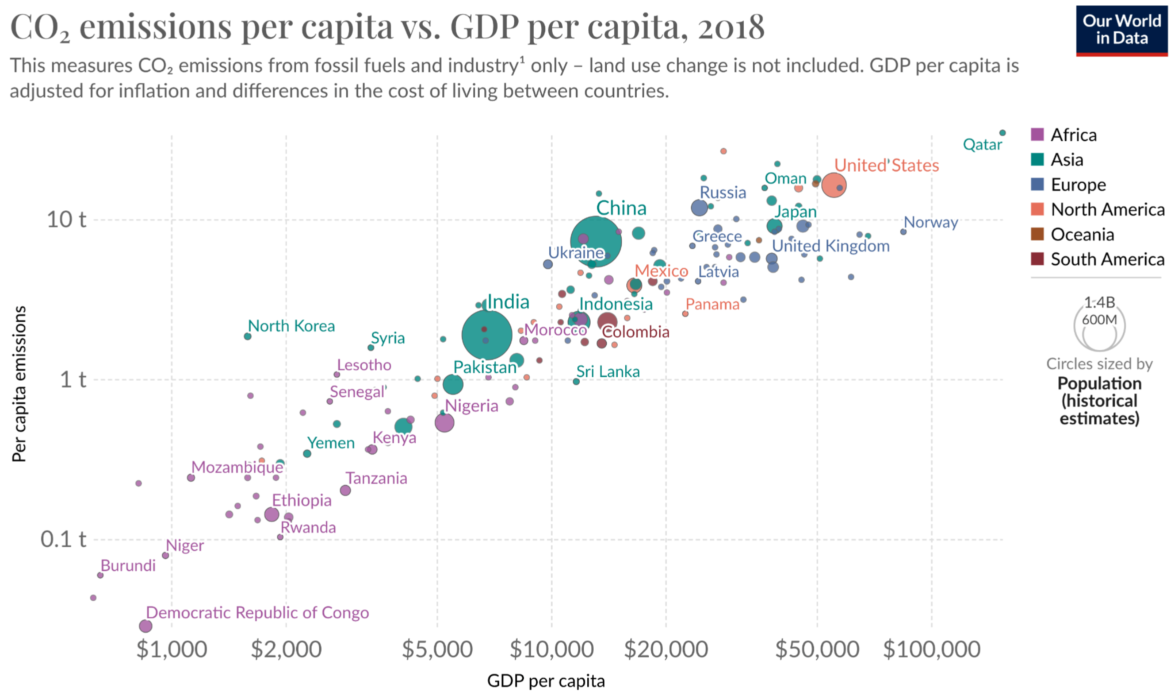
This study aims to determine whether there is a positive correlation between EPI and GDP. To investigate this topic, we used OLS estimation, performing a basic multivariable linear regression. We obtained data on GDP from the years 1990-2021, measured in 2017 dollars and data directly from the EPI. Then, we evaluated our data cross-sectionally and looked at the relationship between GDP per capita and EPI in the year 2018. To select our control variables from our candidate datasets, we analyzed the data in a multicollinearity matrix. Our regression suggests that there is a positive relationship between EPI and GDP in a cross-sectional analysis of the year 2018. Our results yielded a positive and significant result which supports the Porter Hypothesis.

Introduction

As the global community deals with the everlasting challenges of depleting resources and climate change, the delicate relationship between environmental conservation and economic prosperity has become a key issue. An understanding of the connection between a country's economic development and its preservation of the environment is instrumental for sustainable long-term policy making and overall efficiency. Economic growth has commonly been associated with the exploitation of the environment and the rapid depletion of its resources. The common political discourse surrounding environmental regulation is that it is too expensive, reduces economic growth, and hurts a country's international competitiveness.

Now, in the 21st century, regulating emissions and pollutants has become as important as ever due to industrial externalities. Discussions are more serious than ever about how a country can grow its economy and keep the environment clean simultaneously, setting itself up for green production in the future. Policies such as the cap-and-trade system aim to benefit both the economy and the environment but unfortunately aren't reaping the benefits that it is supposed to. There have been many incidents where environmental policies haven't been legislated because they will negatively affect the economy. The challenge lies in protecting the environment and growing the economy.

The following figure demonstrates how countries with larger GDP per capita tend to also have higher per capita emissions. This suggests that because particular countries have higher emissions, they must also allocate money into environmental sustainability.



Source: Our World in Data (2018)

This essay utilizes an empirical test of the correlation between the Environmental Performance Index (EPI) and Gross Domestic Product (GDP) to determine if policies that promote environmentally friendly procedures can actually be advantageous to GDP. This leads us directly to our research question: To what extent do environmental factors impact GDP and how effective are they?

The Environmental Performance Index (EPI)

The Environmental Performance Index (EPI) is a tool that is used to measure the environmental performance of countries all over the world. The Center for International Earth Science Information Network at Columbia University and the Yale Center for Environmental Law and Policy collaborate to provide a quantitative indication of each country's environmental policies and outcomes, focusing on specific issues as shown in the chart. The EPI provides a global comparison for all countries which allows for easy comparison and identification of those that are high performers and low performers.

Statistical Weightings Used for the 2016 EPI

EPI	Objective	Issue category	Indicator
EPI	Environmental health (50%)	Health impacts (33%)	Environmental risk exposure (100%)
		Air quality (33%)	Household air quality (30%)
			Air pollution - Average exposure to PM2.5 (30%)
			Air pollution - PM2.5 exceedance (30%)
			Air pollution - Average exposure to NO_2 (10%)
		Water and sanitation (33%)	Unsafe sanitation (50%)
			Drinking water quality (50%)
	Ecosystem vitality (50%)	Water resources (25%)	Wastewater treatment (100%)
		Agriculture (10%)	Nitrogen use efficiency (75%)
			Nitrogen balance (25%)
		Forests (10%)	Tree cover loss (100%)
		Fisheries (5%)	Fish stocks (100%)
		Biodiversity and habitat (25%)	Terrestrial protected areas (national biome weights) (20%)
			Terrestrial protected areas (global biome weights) (20%)
			Marine protected areas (20%)
			Species protection (national) (20%)
			Species protection (global) (20%)
		Climate and energy (25%)	Trend in carbon intensity (75%)
			Trend in CO_2 emissions per KWH (25%)

Source: Environmental Performance Index Report, 2016.

Starting from the 2022 publication of the EPI, climate change is being introduced as a coequal objective along with Environmental Health and Ecosystem vitality and assigns a 38% statistical weight towards climate change as a policy objective.[1]

LITERATURE REVIEW

There is a significant body of work that examines the relationship between the Environmental Performance Index (EPI) and GDP per capita. The 2022 EPI report published by the Yale Center for Environmental Law and Policy looks at the correlation between EPI and economic growth. They find that a higher GDP tends to result in better environmental policy and a higher EPI score. Economic growth allows for environmental policies to be made and executed effectively as there is a larger pool of funds for governments to access. Secondly, the report also acknowledges that the pursuit of economic growth tends to result in environmental degradation in terms of pollution through industrialization and urbanization. However, they find that countries don't necessarily have to sacrifice environmental health for the pursuit of economic growth and that both can be done sustainably as there are leaders and laggards in every income bracket of the countries.[1] This is what this paper tries to examine, in terms of looking at both the well-studied and documented effect that GDP has on EPI and the reverse causality of what effect EPI could have on the GDP.

Tektüfekçi, F. (2016) examines and corroborates this relationship. The study looks at 14 countries, split into developed and emerging categories. They find that the GDP and EPI of a country are strongly correlated and that the differences between the EPI ranks of countries can be largely explained by the GDP of the countries. When conducting a Spearman rank correlation, they found that there is a strong relationship between EPI scores and GDPs of the countries, but in the reverse direction.

Dkhili, H. (2019) looks at the relationship between the EPI and economic growth specifically in the Middle East and North African (MENA) region. They found an interesting result in that they managed to find a threshold effect for the relationship between EPI and GDP. They examined the effect of a change in EPI on the change in GDP and found that the effect is positive and significant only if a certain threshold of EPI value has been reached. Up until that point, the effect of EPI on GDP remains negative.[2] This set an interesting precedent which we examine further in our paper by exploring the use of a dummy variable to see if there is a material trend difference across our predetermined threshold.

Koukouritakis, Minoas. (2022) takes this a step further and examines the relationship between EPI and GDP across the G20 countries plus Spain and two smaller groups: the G7 countries plus Spain and the emerging BRICS countries. Their results hold largely true with the results produced in the research in the MENA region. This paper found that the impact of environmental performance and policy on GDP is negative below a specific threshold value after which it becomes positive, specifically for the group consisting of the G20 countries plus Spain. The results remain largely the same for the highly developed G7 countries plus Spain however, there was a larger persistence of a negative relationship in the BRICS countries because of their emerging economies being largely dependent on pollution-heavy production.

THEORETICAL FRAMEWORK

According to the Porter Hypothesis, the creation and enforcement of strict environmental regulations can encourage innovation and consequently induce efficiency in an economy which leads to an efficient allocation of resources, economic growth, and increased competitiveness. This hypothesis posits that such tight regulations will lead to the discovery, production, and implementation of cleaner and more efficient technologies. This largely counters the long-held and fairly substantiated belief that environmentally-friendly regulations and policies tend to work against a growing economy, where companies are rapidly industrializing and more regulations tend to force a higher degree of inefficiency in these companies.

In our analysis, we look at the possibility of the Porter Hypothesis having substantial statistical significance. We try to measure this by using the Environmental Performance Index (EPI) as a stand-in for the presence of environmentally friendly policies and regulations as well as how well a country is doing in terms of the preservation of the environment. We will try to establish a relationship between this index and a country's GDP per capita, and its economic growth (average change in GDP per capita across a time frame). To do this, we will be utilizing panel data. To achieve this and see if EPI can have an effect on the GDP, we will be using OLS estimation and performing a basic multivariable linear regression as outlined below:

$$\text{gdpPerCapita} = \beta_0 + \beta_1 \text{EPI} + \varepsilon$$

where, EPI stands for the Environment Performance Index and ε represents the error term.

To this basic regression model, we will be adding relevant control variables (as outlined next) in order to better isolate the effect of EPI on gdpPerCapita.

EMPIRICAL ANALYSIS

DATA

To analyze the impact of EPI on GDP, we needed to obtain data on both variables, as well as data on variables correlated with GDP to control for. For GDP, our data was obtained from Our World in Data, including GDP by country from the years 1990 through 2021, measured in 2017 US Dollars. EPI data was obtained through the Socioeconomic Data and Applications Center for the years 2006-2020, though EPI is only available on even years as it is released bi-annually. We evaluated our data cross-sectionally and looked at the relationship between GDP per capita and EPI in the year 2018. After collecting our data sets, organizing them, and cleaning up the data, we found that we were able to find panel data for 2014 - 2018.

CONTROL VARIABLES

For our control variables, we found a total of 7 different datasets for variables we expected to be correlated with GDP and could work as efficient controls. The potential control variables are: Education, Corruption, Account Balance, Energy Consumption, Government Spending, Press Freedom, and Unemployment Rate. We then used a multicollinearity matrix to find which variables had a high correlation with GDP and a relatively low correlation with EPI. We also calculated the Variance Inflation Factor (VIF) values for each of our potential control variables to ensure they were not heavily correlated with EPI.

Our education data is measured in the average year of schooling of persons older than 25. There were many datasets available for a longer age range, such as 15 or older, but we chose to focus on people over 25 because many people younger than 25 may still be in the schooling system and intending to take more classes, but most people over the age of 25 have likely finished their academic career. The dataset we chose was obtained from Our World in Data. Education presents a strong correlation with the GDP per capita as education tends to be positively correlated with income however, education is also positively correlated with the EPI as a more educated population is likely to be more aware of the harms they could be imposing on the environment.

For corruption, measured by the Corruption Perceptions Index (CPI), we found data from Transparency International. Transparency International releases CPI annually, and measures the perceived level of corruption in the public sector of a given country on a scale from 1 to 100, with a lower value being more corrupt. In our literature review, we have found multiple papers that cite that corruption tends to be heavily correlated with the EPI. This is corroborated by our multicollinearity matrix, as the lower the CPI score (more corruption) the worse the EPI performs (more corruption leading to more diversion of funds from environmental policy and programs).

Account balance is measured as the ratio between imports and exports plus the net primary and secondary income. This dataset was obtained from Our World in Data. The data supplied measured account balance as a percentage of GDP. The account balance can stand as a measure of the economic openness of the country and therefore how susceptible they are to global economic shocks, environmental disasters, and trend shifts. The degree of openness will also lead countries to be susceptible to policy influence from other countries, whether those policies are environmentally friendly or not.

Our data for energy consumption is from Kaggle, which compiled data from the US Energy Administration for ease of analysis. The sections from this dataset we chose to focus on are the values for energy consumption all_energy_types and renewables_and_other. all_energy_types_ measures energy consumption under the categories: coal, natural gas, petroleum and other liquids, nuclear, renewables, and other sources. We chose to focus on all_energy_types and renewables_and_other because renewable energy is accounted for in EPI, so our measurement of energy consumption is the difference between all energy consumption and renewable energy consumption. Looking at all forms of energy composition other than renewable energy consumption lets us isolate the effect of energy generation and consumption in a country that affects the GDP whilst avoiding correlation with EPI through the omission of renewable energy sources.

For government spending, we obtained data from Our World in Data, which measured government spending as a percentage of GDP by country. Our data on Press Freedom also came from Our World in Data. The data measured press freedom as an index of assessments observing violence against journalists. The index ranges from 0-100, where lower values equate to more press freedom. This measures the degree of repression in a country and affects not only the reliability of data but also the degree of government control exercised over things like the environment.

For the unemployment rate, we also sourced our data from Our World in Data, which measured the unemployment rate as the percentage of the population that is without work but willing and seeking to work. The unemployment rate stands as a measure of the labor participation rate.

To select our control variables from our candidate datasets, we analyzed the data in a multicollinearity matrix.

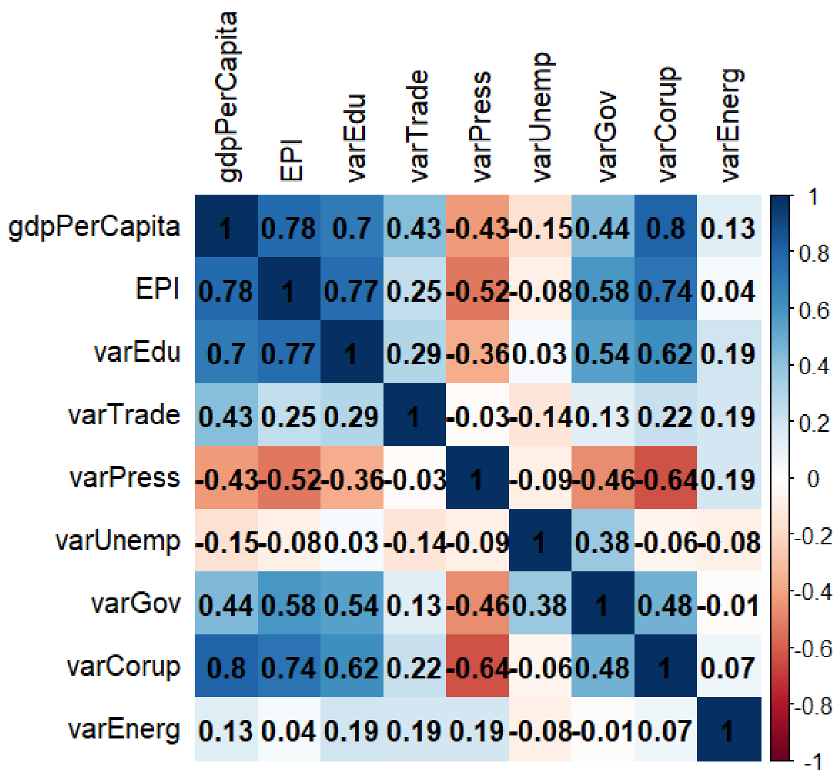


Figure 1: Multicollinearity matrix featuring gdpPerCapita, EPI, and potential control variables

We observed in this multicollinearity matrix that Account Balance (listed as varTrade) would be a good contender for a control variable because its correlation with gdpPerCapita is higher than that of EPI, and because it has a correlation of less than 0.7 with EPI. Corruption (varCorup) had to be ruled out because of its very high correlation with EPI and its known negative effect on EPI. Unemployment rate also demonstrated a higher correlation with GDP than with EPI, and maintained sub 0.7 values. To gain a better understanding of which variable to choose, we elected to analyze the Variance Inflation Factor (VIF) values of our potential control variables.

EPI	varEdu	varTrade	varPress	varUnemp	varGov	varCorup	varEnerg
3.070	2.955	1.240	2.028	1.524	2.386	2.728	1.160

Table 1: Variance Inflation Factors for EPI and potential control variables

All of the VIF values were less than 5, which is a common cutoff for deciding whether multicollinearity exists in a regression model. We chose values that were lower than 2 to ensure more accuracy in terms of collinearity.

For our control variables, we used varTrade, varPress, and varUnemp, for their low levels of collinearity and their explanatory quality of GDP. These variables are also the ones least correlated with EPI itself.

DATA SUMMARY

variable	N	Mean	St.Dev.	Min	Max
EPI	99	60.102121	13.572912	29.560	87.42
varPress	99	29.784141	13.175046	7.630	63.13
varTrade	99	-1.034141	6.769454	-24.350	22.61

REGRESSION

The regression by data with the three chosen control variables is in Appendix A. The multivariable final regression model we chose was:

$$gdpPerCapita = \beta_0 + \beta_1 EPI + \beta_2 varPress + \beta_3 varTrade + \beta_4 varUnemp + \varepsilon$$

DISCUSSION

In our regressions, we can find statistically significant results through the incremental additions of control variables. Our regression suggests that there is a positive relationship between EPI and GDP in a cross-sectional analysis of the year 2018. The results for EPI and its coefficient also show that it is statistically significant at the 5% level. This is suggestive of two things. In the inverse, it is indicative of the well-known fact that countries with high GDP are likely to have a high EPI score. However, our regression measures the impact of EPI on the GDP. The fact that the regression has yielded a positive and significant result lends support to the Porter Hypothesis.

The Porter Hypothesis argues that with stringent environmental policies, innovation and consequently economic growth and efficiency follow. It suggests that countries may not necessarily have to sacrifice economic growth in the name of sustainability and that with a higher EPI count, it is possible to maintain a high GDP per capita.

There are, however, a myriad of caveats to this interpretation. The first of them is that our regression focuses on a cross-sectional sample of data. The year of 2018 may not fully encompass the relationship that exists between EPI and its effect on GDP, especially across time. Our regression for our panel data, spanning from 2014 - 2018 rendered results that were not statistically significant and the model rendered an insufficient fit to the data. This is likely because the range of data (2014-2018) we could use was severely limited by our inclusion of varied data sets which also limited time ranges. The results of our panel regression are displayed in Appendix C. Although the results were insignificant, the relationship of a change in EPI also seems to be positive in relation to a change in GDP.

Secondly, we are working under a lot of assumptions, one of them being that the relationship between EPI and GDP can be expressed in a linear form. The effect of GDP on EPI however can be reasonably estimated through a linear form as seen in Appendix B. It is likely that the data could take on a non-linear form, especially a quadratic one with the slope of EPI being negative below a certain threshold then turning positive above a certain threshold. We tried to examine linearly if there was a cut-off where the slope was negative under it and positive above it. We did not find such a cutoff as other papers demonstrated; however, we do find that above the mean EPI, the coefficient of EPI is higher in the regression than it is below the mean value of the EPI.

CONCLUSIONS

We know that there is a well-established and well-studied relationship between GDP and EPI, in that there is a positive correlation between the effect GDP has on the EPI of a country. This paper sought to see if the Porter Hypothesis could be substantiated by regressing EPI on GDP and seeing if any material effect could be determined. Through a cross-sectional analysis, this paper found that there was a positive and statistically significant relationship between EPI and GDP however, the same could not be said for panel data. Multiple caveats such as data limitations, and the absence of non-linear relationship analysis hinders the final concluding statement that EPI can have a positive effect on GDP.

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APPENDIX A

	Dependent variable:			
	gdpPerCapita			
	(1)	(2)	(3)	(4)
EPI	1.245^{***}	1.219^{***}	1.085^{***}	1.070^{***}
	(0.102)	(0.120)	(0.116)	(0.116)
varPress		-0.051	-0.112	-0.130
		(0.124)	(0.115)	(0.116)
varTrade			0.828^{***}	0.805^{***}
			(0.198)	(0.198)
varUnemp				-0.295
				(0.260)
Constant	-49.404^{***}	-46.354^{***}	-35.629^{***}	-32.153^{***}
	(6.289)	(9.781)	(9.389)	(9.865)
Observations	99	99	99	99
R^2	0.605	0.606	0.667	0.672
Adjusted R^2	0.601	0.598	0.657	0.658
Residual Std. Error	13.717 (df = 97)	13.776 (df = 96)	12.723 (df = 95)	12.704 (df = 94)
F Statistic	148.759^{***} (df = 1; 97)	73.824^{***} (df = 2; 96)	63.553^{***} (df = 3; 95)	48.127^{***} (df = 4; 94)
Note:				*p<0.1;* ***p<0.05;*** p<0.01

gdpPerCapita measured in 000s USD (2017)

APPENDIX B

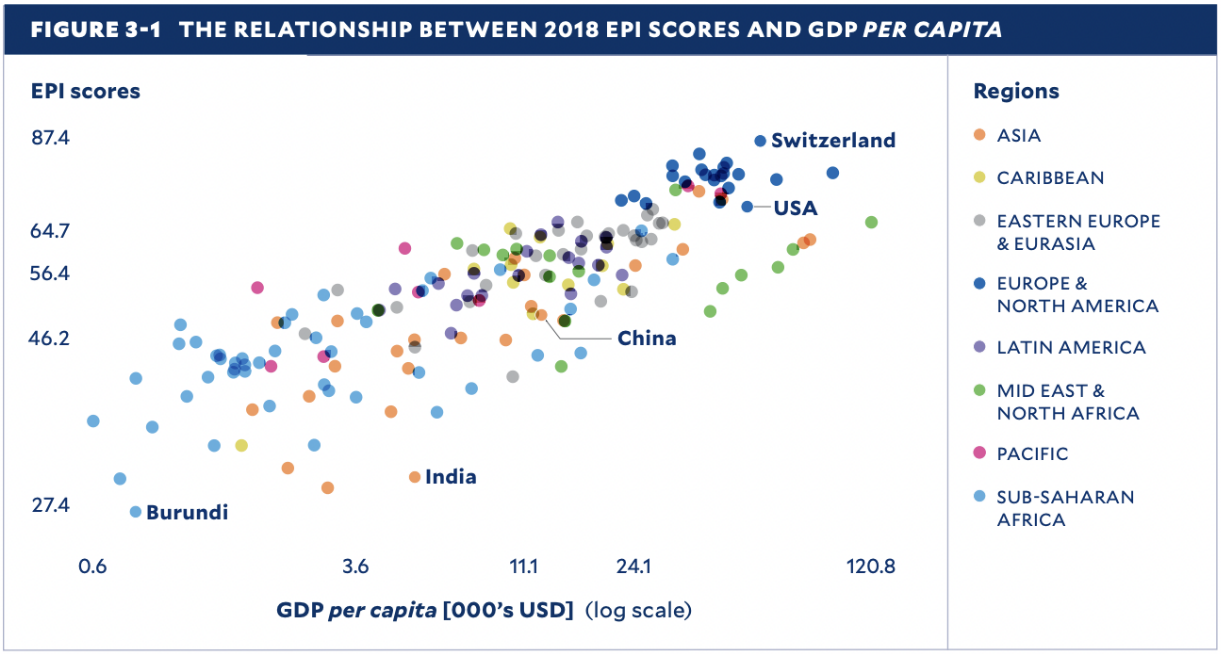

FIGURE 3-1 THE RELATIONSHIP BETWEEN 2018 EPI SCORES AND GDP PER CAPITA
EPI scores
87.4
64.7
56.4
46.2
27.4
Switzerland
USA
China
India
Burundi
0.6
3.6
11.1
24.1
120.8
GDP per capita [000's USD] (log scale)
Regions
ASIA
CARIBBEAN
EASTERN EUROPE & EURASIA
EUROPE & NORTH AMERICA
LATIN AMERICA
MID EAST & NORTH AFRICA
PACIFIC
SUB-SAHARAN AFRICA

APPENDIX C

	Dependent variable:			
	gdpMeanGrowth			
	(1)	(2)	(3)	(4)
epiMeanGrowth	-2.402	-2.702	1.300	5.050
	(4.427)	(4.422)	(4.957)	(4.988)
pressMeanGrowth		14.605	22.250^{*}	23.172^{*}
		(11.953)	(12.639)	(12.233)
tradeMeanGrowth			-21.727^{*}	-20.894^{*}
			(12.623)	(12.216)
unempMeanGrowth				-103.602^{***}
				(37.842)
Constant	0.083^{***}	0.081^{***}	0.081^{***}	0.077^{***}
	(0.009)	(0.009)	(0.009)	(0.009)
Observations	99	99	99	99
R^2	0.003	0.018	0.048	0.118
Adjusted R^2	-0.007	-0.002	0.018	0.081
Residual Std. Error	0.079 (df = 97)	0.079 (df = 96)	0.078 (df = 95)	0.075 (df = 94)
F Statistic	0.294 (df = 1; 97)	0.894 (df = 2; 96)	1.596 (df = 3; 95)	3.153^{**} (df = 4; 94)
Note:				*p<0.1;* **p<0.05;** p<0.01