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Evaluating the trends in CO2 emissions for manufacturing industries: Evidence from Germany, Sweden and Colombia

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1. INTRODUCTION

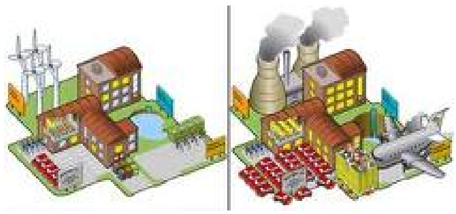
Population
Industrialization
Standard of living
Quality of life

Dependence on energy

Topics in global politics

- **Development of conventional energy resources**
- **Search for new or renewable energy sources**
- **Energy conservation (using less energy)**
- **Energy efficiency (having the same service or output with less energy usage)**
- **Decreasing CO_2 emissions**

1. INTRODUCTION



Energy use

Sustainable development

Environmental performance

Energy use
CO_2 emissions

Data
Indicators
Energy modelling

Policy decissions

An analysis and comparison of the trends in energy and CO_2 emissions in the manufacturing industries, it is fundamental to establish adequate strategies in the design of effective energy policy and to migrate to low carbon economy.

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1. INTRODUCTION

The overall aim of this research is to determine the effects of several variables, such as energy consumption, fuel substitution, investments and energy price on carbon dioxide emissions in German, Swedish and Colombian manufacturing industries between 1995 and 2008.

Specific goals are the following:

- **To study and compare the tendencies of CO_2 emissions in the German, Swedish and Colombian manufacturing industries by applying several indicators and econometric techniques.**
- **To determine the relationship between CO_2 emissions, production factors and energy sources in the manufacturing industries.**

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1. INTRODUCTION

Scope

I. German, Swedish and Colombian manufacturing industries

CO_2 emissions
Energy
Production factors
Fuel sources

The 2-digit level of disaggregation of the International Standard Industrial Classification (ISIC – Rev. 3.1) for the 19 manufacturing industries.

The establishment of adequate strategies in the design of effective energy policy.

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2. METHODS AND DATA

Empirical strategy

1. Panel unit root test → To determine that all of the variables are integrated to the same order. The test employed is the Im–Pesaran–Shin (2003)

$$y_{it} = \rho_i y_{it-1} + \Delta_i x_{it} + u_{it}$$

2. METHODS AND DATA

Empirical strategy

2. Cointegration techniques → To define if a long-run relationship exists among the variables is performed by applying the Pedroni (1999) heterogeneous panel cointegration test.

$$y_{it} = \alpha_i + \gamma_i t + \beta x_{it} + \varepsilon_{it}$$

2. METHODS AND DATA

Empirical strategy

3. DOLS estimators → **To estimate the long-run cointegration vector for non-stationary panels. These estimators allow for correction of the serial correlation and endogeneity of regressors that are normally present in a long-run relationship.**

$$CO_{it} = \alpha_i + \delta_t + \beta_i OV_{it} + \sum_{k=-K_i}^{K_i} \gamma_{ik} \Delta OV_{i,t-k} + v_{it}$$

$$\widehat{\beta}_{DOLS} = \left[\frac{1}{N} \sum_{i=1}^{N} \left(\sum_{t=1}^{T} z_{it} z'_{it} \right)^{-1} \left(\sum_{t=1}^{T} z_{it} \widetilde{CO}_{it} \right) \right]_1$$

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2. METHODS AND DATA

Model

Energy sources

$$LCO_{it} = \beta_0 - \beta_1 LFF_{it} + \beta_2 LELE_{it} + \beta_3 LOES_{it} + u_{it}$$

Output and production factors

$$LCO_{it} = \beta_0 + \beta_1 LVA_{it} + \beta_2 LE_{it} + \beta_3 LK_{it} + u_{it}$$

Energy price

$$LCO_{it} = \beta_0 + \beta_1 LEP_{it} + \beta_2 LE_{it} + u_{it}$$

Investment

$$LCO_{it} = \beta_0 + \beta_1 LINV_{it} + \beta_2 LOF_{it} + u_{it}$$

3. RESULTS AND DISCUSSION

Manufacturing industry: Trends and developments in Germany, Sweden and Colombia

- In the three countries, the manufacturing industry is one of the most important economic activities due to its contribution to the gross domestic product, employment, development and innovation.
- The trends of CO_2 emissions, energy, production value and value added in the manufacturing industries between 1995 and 2008 show that in Germany and Sweden, these indicators are similar: an increase in economic indicators and a decrease in energy and CO_2 emissions.
- The trends in Colombia show an increase in economic indicators and the decrease in CO_2 emissions and energy.
- In the three countries, the trend is to produce greater output with less pollution.

3. RESULTS AND DISCUSSION

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Results of panel unit root tests

Germany – Individual intercept and trend

Test		CO_2	Fossil fuels	Electri-city	Value added	Capital	Energy	Energy prices	Invest-ments	Capital-labour	Energy intensity
Im, Pesaran and Shin	Level	-3.949[a]	-2.258	-3.922[a]	-3.487[a]	-3.294[a]	-9.060[a]	-2.867[a]	-3.248[a]	-3.787[a]	-3.484[a]
	1st diffe-rence	-5.246[a]	-6.148[a]	-6.076[a]	-3.138[a]	-2.584[b]	-19.60[a]	-3.708[a]	-2.914[a]	-5.827[a]	-3.110[a]
	Decision	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)

Sweden – Individual intercept and trend

Test		CO_2	Fossil fuels	Value added	Capital	Invest-ments	Produ-ctivity	Energy taxes
Im, Pesaran and Shin	Level	-0.417	-0.585	3.007	-1.846	-3.006[a]	-1.865	-1.309
	1st diffe-rence	-3.939[a]	-4.008[a]	-7.439[a]	-2.839[a]	-2.571[b]	-10.483[a]	-3.686[a]
	Decision	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)

Colombia – Individual intercept and trend

Test		CO_2	Fossil fuels	Electri-city	Natural Gas	Value Added	Capital	Energy	Energy prices	Invest-ments
Im, Pesaran and Shin	Level	-2.867[a]	-3.006[a]	-3.084[a]	-2.912[a]	-2.997[a]	-2.636[b]	-2.981[a]	-6.547[a]	-3.519[a]
	1st diffe-rence	-5.468[a]	-5.339[a]	-5.870[a]	-5.963[a]	-4.633[a]	-3.970[a]	-5.430[a]	-9.756[a]	-5.432[a]
	Decision	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)

a denotes significance at the 1% level. b denotes significance at the 5% level.

3. RESULTS AND DISCUSSION

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Results of panel cointegration test

Pedroni Panel Cointegration Test		Sweden	Germany	Colombia	Sweden	Germany	Colombia	Sweden	Germany	Colombia	Sweden	Germany	Colombia
		(1)	(1)	(1)	(2)	(2)	(2)	(3)	(3)	(3)	(4)	(4)	(4)
		Energy sources			Output and production factors			Energy prices			Investments		
Panel Cointegration Test	Panel PP-Statistic	3.857	0.314	-45.58[a]	-3.608[a]	-26.14[a]	-3.987[a]	-22.87[a]	-21.10[a]	-3.776[a]	-23.81[a]	-25.68[a]	-2.901
	Panel ADF-Statistic	-5.966[a]	-3.601[a]	-16.86[a]	-3.602[a]	-8.094[a]	-4.425[a]	-16.11[a]	-5.263[a]	-9.588[a]	-14.25[a]	-6.586[a]	-4.037
Group Mean Cointegration Test	Group PP-Statistic	5.564	1.922	-49.75[a]	-2.788[a]	-28.00[a]	-3.212[a]	-24.55[a]	-22.56[a]	-2.977[a]	-25.74[a]	-27.72[a]	-1.997
	Group ADF-Statistic	-5.427[a]	-2.967[a]	-17.61[a]	-2.781[a]	-7.807[a]	-3.703[a]	-16.94[a]	-4.729[a]	-9.479[a]	-14.95[a]	-6.219[a]	-3.268

Note: a denotes significance at the 1% level.

3. RESULTS AND DISCUSSION

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Results of estimating the panel model using DOLS estimator

Model of energy sources

Parameter	Sweden	Germany	Colombia
	(1)	(1)	(1)
Fossil Fuels	1.153[a] (62.14)	0.722[a] (24.02)	0.932[a] (21.46)
Electricity	-0.061[a] (-4.52)	-0.108[a] (-4.78)	-1.156[a] (-11.18)
Bio-fuels	-0.037[a] (-14.97)		
Natural gas			-0.612[a] (-4.91)

Notes: the value in parentheses denotes the t-statistic.
a, b *and* c *denote the statistical significance at the 1%, 5% and 10% levels, respectively.*

For the three countries analysed, a decrease in fossil fuel consumption and an increase in electricity lead to lower CO_2 emissions, indicating that the substitution of fuels increases the use of fuels characterised to generate less greenhouse gas emissions, especially CO_2 emissions.

3. RESULTS AND DISCUSSION

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Results of estimating the panel model using DOLS estimator

Model of output and production factors

Parameter	Sweden	Germany	Colombia
	(2)	(2)	(2)
Value added	0.012[b] (2.49)	2.286[a] (3.61)	0.393[a] (3.26)
Capital	0.023 (1.05)	1.113[b] (2.28)	0.351[a] (3.29)
Energy	0.931[a] (16.59)	1.022[a] (18.16)	0.672[a] (11.79)

Notes: the value in parentheses denotes the t-statistic.
a, b *and* c *denote the statistical significance at the 1%, 5% and 10% levels, respectively.*

Higher energy consumption should generate greater economic activity and a higher level of CO_2 emissions

3. RESULTS AND DISCUSSION

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Results of estimating the panel model using DOLS estimator

Model of energy prices

Parameter	Sweden	Germany	Colombia
Energy prices	-1.359[a] (-21.58)	-0.368[a] (-3.57)	-0.792[a] (-11.21)
Energy	0.910[a] (15.30)	0.530[a] (5.10)	0.0009 (0.02)
Capital	0.047[b] (2.11)		
Energy taxes	-0.234[a] (-3.12)		
Investments		-0.332[a] (-4.38)	
Capital-labour		-0.063 (-0.58)	
Value added			0.734[a] (6.56)

Notes: the value in parentheses denotes the t-statistic.
a, b *and* c *denote the statistical significance at the 1%, 5% and 10% levels, respectively.*

3. RESULTS AND DISCUSSION

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Results of estimating the panel model using DOLS estimator

Model of investments

Parameter	Sweden	Germany	Colombia
Investments	-0.169[a] (-6.14)	-0.668[a] (-4.12)	-0.051 (-1.62)
Energy	1.243[a] (30.93)		0.004 (0.09)
Capital	0.080[a] (4.44)		
Energy taxes	-0.135[a] (-3.68)		
CO_2 taxes	-0.008[a] (-3.16)		
Energy prices		-0.591[a] (-30.64)	
Capital-labour		0.048 (0.26)	
Energy intensity		0.172[a] (7.37)	
Value added			0.423[a] (3.80)

Notes: the value in parentheses denotes the t-statistic.
a, b *and* c *denote the statistical significance at the 1%, 5% and 10% levels, respectively.*

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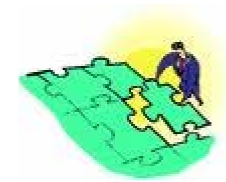
4. CONCLUSIONS AND POLICY IMPLICATIONS



- This paper evaluated and compared the trends in CO_2 emissions with their main determinants for the German, Swedish and Colombian manufacturing industries by employing annual data from 1995 through 2008.

- The empirical findings reported in the paper reveal, in general, that higher clean fuel consumption, energy prices, and investments decrease CO_2 emissions, while higher economic activity, energy consumption, fossil fuels and energy intensity increase CO_2 emissions.

- The model for energy sources indicates that a decline in fossil fuel consumption and an increase in electricity and natural gas usage generates lower CO_2 emissions.

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4. CONCLUSIONS AND POLICY IMPLICATIONS

- The model for output and production factors shows that higher energy consumption should generate greater economic activity and higher levels of CO_2 emissions.
- The model for energy prices indicates that higher energy prices generate lower CO_2 emissions, whereas higher energy consumption increases CO_2 emissions.
- The last model denominates investments and demonstrates that manufacturing sectors with higher levels of investments achieve a greater decrease in CO_2 emissions.

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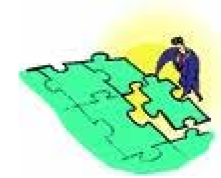

4. CONCLUSIONS AND POLICY IMPLICATIONS

- Germany and Sweden shows increases in economic indicators and decreases in energy and CO_2 emissions. These trends have been led by adequate policy instruments that have combined fiscal instruments, such as energy taxes and prices, technological changes through energy switching to lower carbon energy, investments in energy saving technologies and new production standards that lead to economic growth and sustainable development while simultaneously reducing greenhouse gas emissions.

- In Colombia, the results indicate that CO_2 emissions and energy use have not decreased to the same degree as they have in the developed country studied. This finding suggests the great potential for this country to become a low-carbon economy. Therefore, policy makers must develop adequate energy policies that combine technical and economic instruments to reduce CO_2 emissions through the application of new technologies and promotion of clean and environmentally friendly processes.

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Thank you very much for your attention

Any questions?

"Engineering consultants shoulder the responsibility to promote energy-efficient and eco-friendly technologies to meet the challenge of energy over-consumption and environmental deterioration"

Zeng Peyan