ENERGY USE AND CO2 EMISSIONS IN SERVICE INDUSTRIES: EVIDENCE FROM SWEDEN

ROYAL INSTITUTE OF TECHNOLOGY
UNIVERSIDAD DE LA SALLE
"Educar para Pensar, Decir y Servir"

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2012

CONTENTS

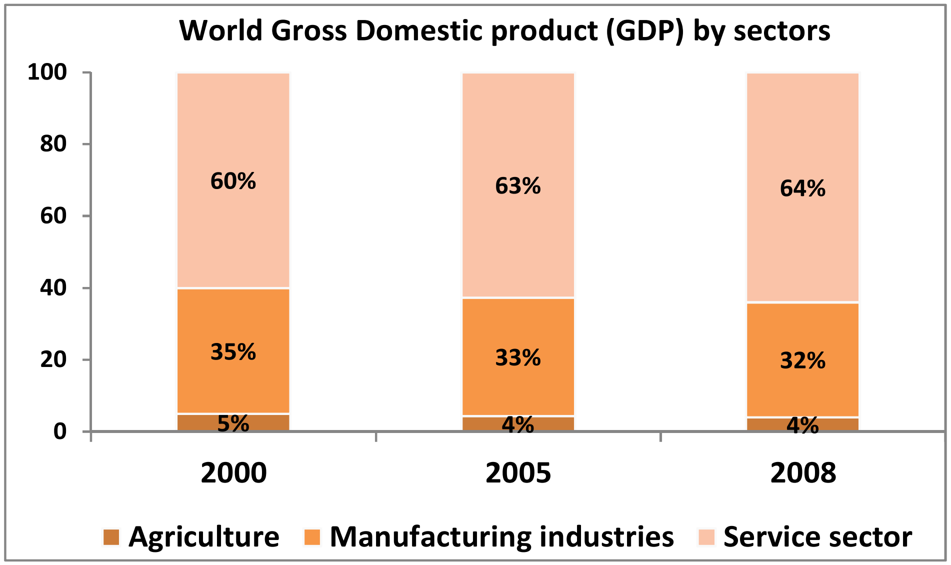
1. INTRODUCTION

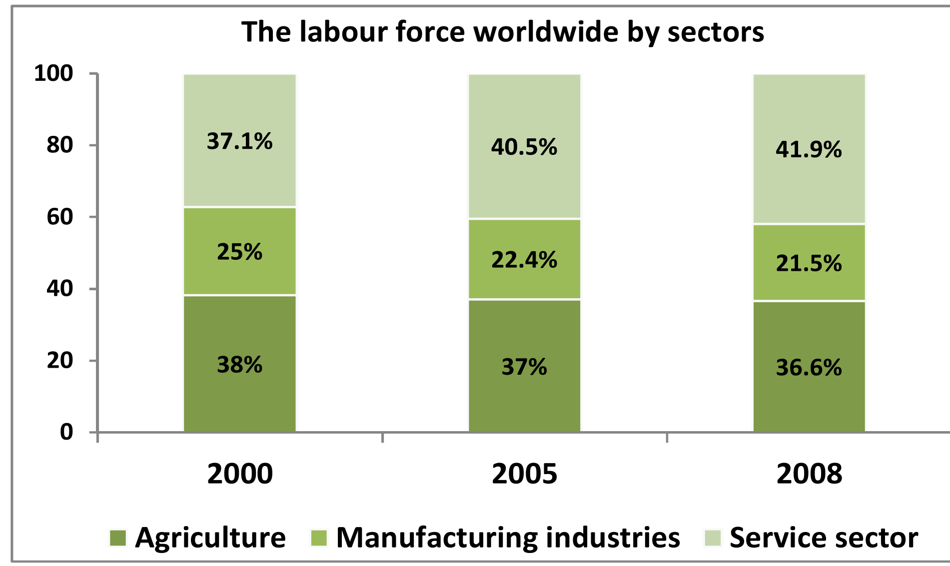
Energy efficiency

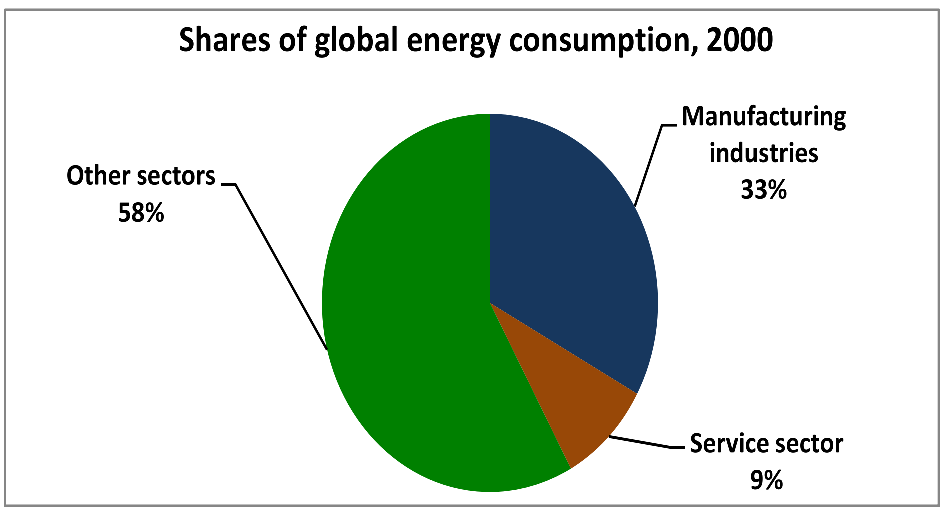
- **Economic growth**
- **International competitiveness**
- **Environmental protection**

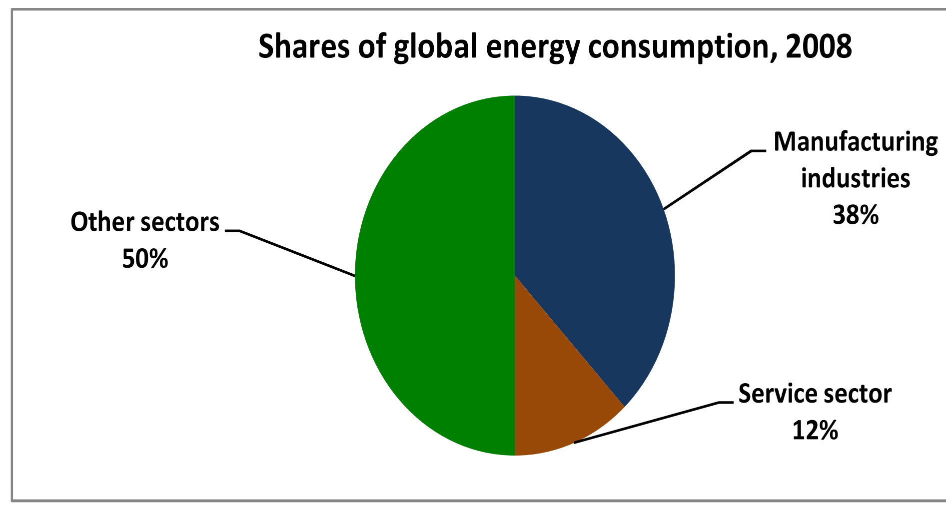
This research is supported by the importance that is placed on improvements in energy use and the reduction of greenhouse emissions within an energy system and because energy efficiency has become a crucial strategy for sustainable economic development and climate stabilization today and in the near future.

1. INTRODUCTION



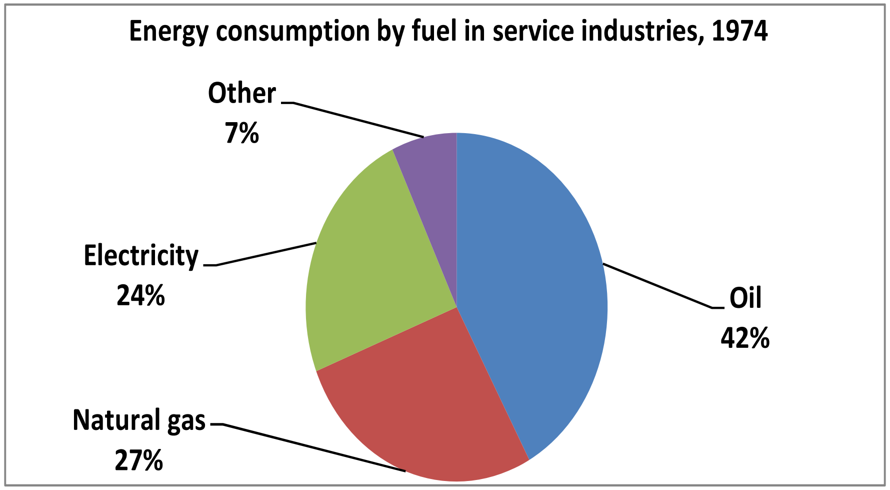


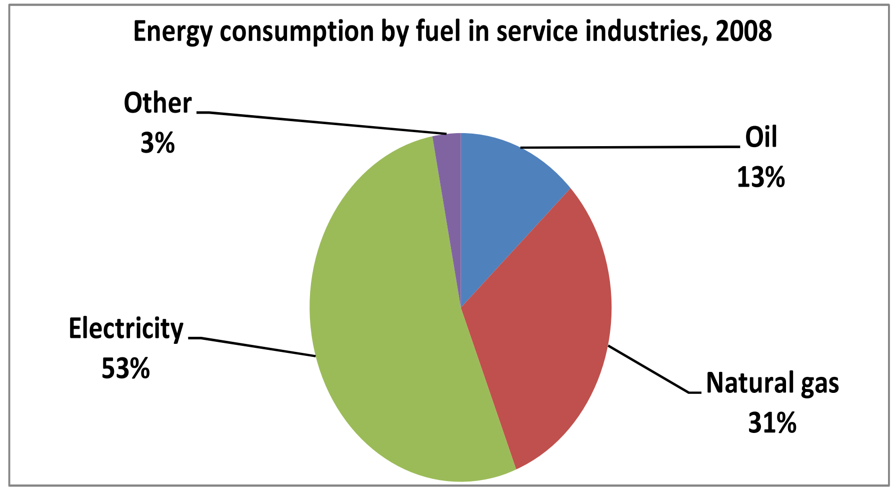


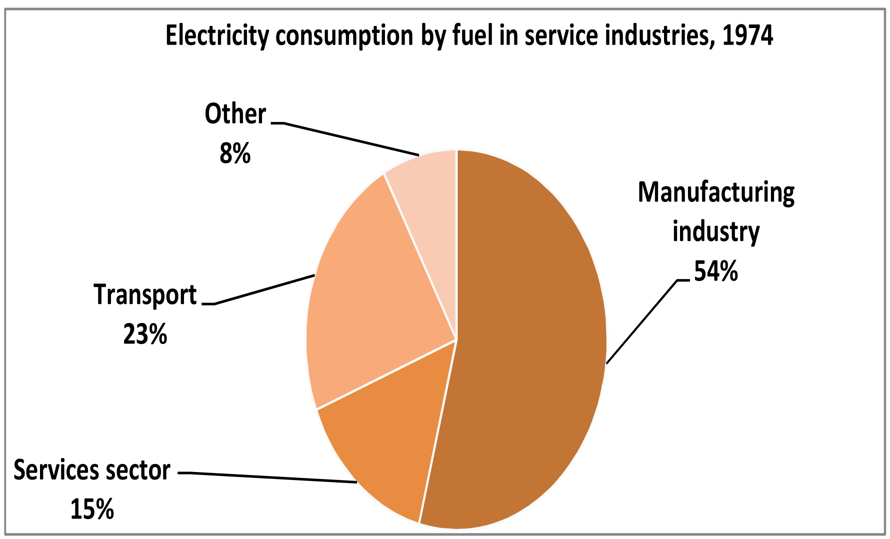


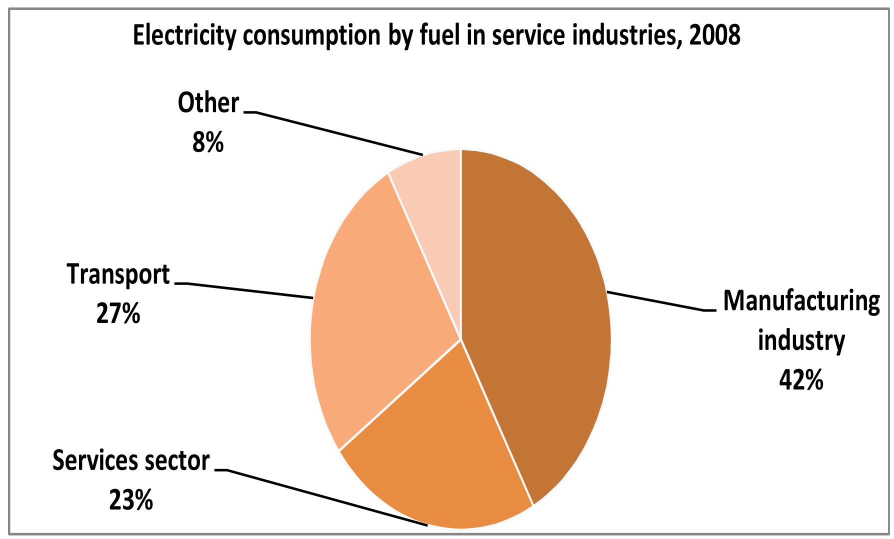
Sources: IEA, 2009 and CIA, 2011

1. INTRODUCTION









Sources: IEA, 2009 and CIA, 2011

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1. INTRODUCTION

Notwithstanding these trends showing that the fastest growth in energy consumption is in the service industries. This sector has been neglected in energy analysis and the application of energy policies and programmes by the following:

- **The heterogeneity of the segment.**
- **The complexity of its statistical valuation (which requires detailed and disaggregated information).**
- **The sector's low energy intensity relative to manufacturing.**

1. INTRODUCTION

The overall aim of this research is to analyse the development of energy efficiency and CO_2 emissions in Swedish service industries.

Specific goals are the following:

- **To study the trends of energy consumption, energy efficiency and CO_2 emissions from different approach in Swedish service sector.**

- **To increase the knowledge about energy use and CO_2 emission trends in the Swedish service industries.**

1. INTRODUCTION

Swedish service industries → **Energy consumption**
CO_2 emissions
Energy efficiency
Value of production
Fuel sources

The time period 1993-2008

2. DATA

The service industries (excluding electricity, gas and water supply and transportation services), involve activities that take place in buildings used outside of manufacturing, agriculture and households, which comprise offices, banking, education activities, hospitals, retail trade, hotels, restaurants, computer and data processing services, and numerous others

A dataset for Swedish service industries at 2-digit level of aggregation was collected from Swedish statics offices and International Standard Industrial Classification (ISIC Rev. 3.1) for the period 1993-2008.

All monetary variables are deflated to 2005 euro values.

3. METHODOLOGY

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The most common definition of energy efficiency is energy intensity, defined as the quantity of energy required per unit of output or activity.

$$EI = \frac{Energy\ (E)}{Production\ or\ output\ (Y)}$$

Energy efficiency indicators measure 'how well' energy is used in the production of output.

CO_2 emission intensity

$$COI = \frac{CO_2}{Y}$$

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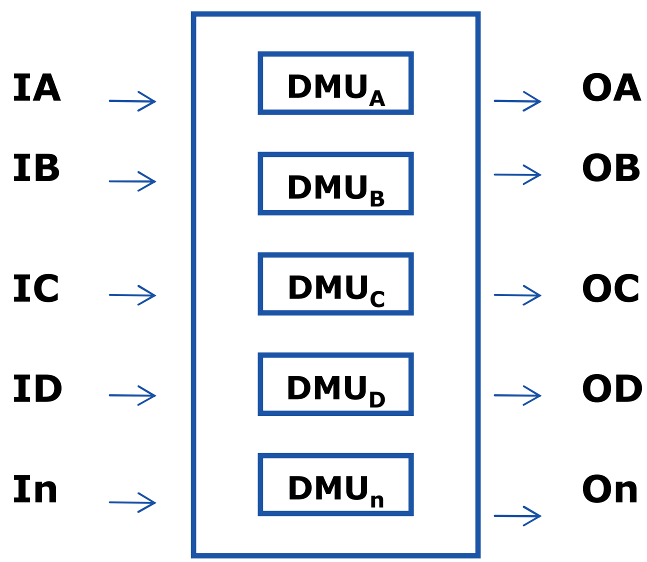
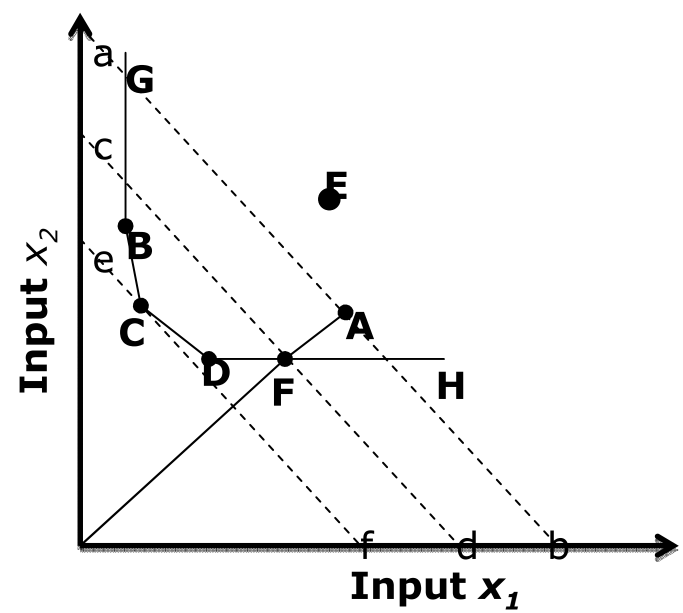
3. METHODOLOGY

a. Data Envelope Analysis (DEA)

DEA allows for the measurement of relative efficiency for a group of <u>decision making units (DMUs)</u> that use resources (inputs) to produce products (outputs). This methodology involves the use of linear programming methods to build a <u>non-parametric piecewise frontier</u> over data, so as to be able to calculate efficiencies relative to this frontier.





3. METHODOLOGY

a. Data Envelope Analysis (DEA)

This model evaluates energy efficiency performance within a joint production framework, in which both desirable (gross production) and undesirable (CO_2 emissions) outputs are considered simultaneously.

$$\phi^* = max\,\phi \qquad (1)$$

subject to

$$\sum_{j=1}^{n} x_{mj}\lambda_j \le x_{m0}\,(m = capital,\ labour, materials\ and\ energy) \qquad (2)$$

$$\sum_{j=1}^{n} y_{pj}\lambda_j \le \phi x_{p0}\,(p = desirable\ output\ and\ undesirable\ output) \qquad (3)$$

$$\lambda_j \ge 0, j = 1, 2, \dots, n \qquad (4)$$

ϕ: *total outputs*

3. METHODOLOGY

b. Panel data model

$$EEM_{i,t} = \alpha_0 + \alpha_1 ET_{i,t} + \alpha_2 ES_{i,t} + \alpha_3 INV_{i,t} + \alpha_4 PR_{i,t} + \alpha_5 KL_{i,t} + \varepsilon_{i,t}$$

The hypothesis that drives the analysis implies that higher energy taxes, electricity consumption, investments and productivity generate higher energy efficiency, whereas higher fossil fuel consumption reduces energy efficiency and increases CO_2 emissions.

3. METHODOLOGY

b. Panel data model

$$EEM_{i,t} = \alpha_0 + \alpha_1 ET_{i,t} + \alpha_2 ES_{i,t} + \alpha_3 INV_{i,t} + \alpha_4 PR_{i,t} + \alpha_5 KL_{i,t} + \varepsilon_{i,t}$$

What data panel model?

F-test:
OLS vs. Fixed effects

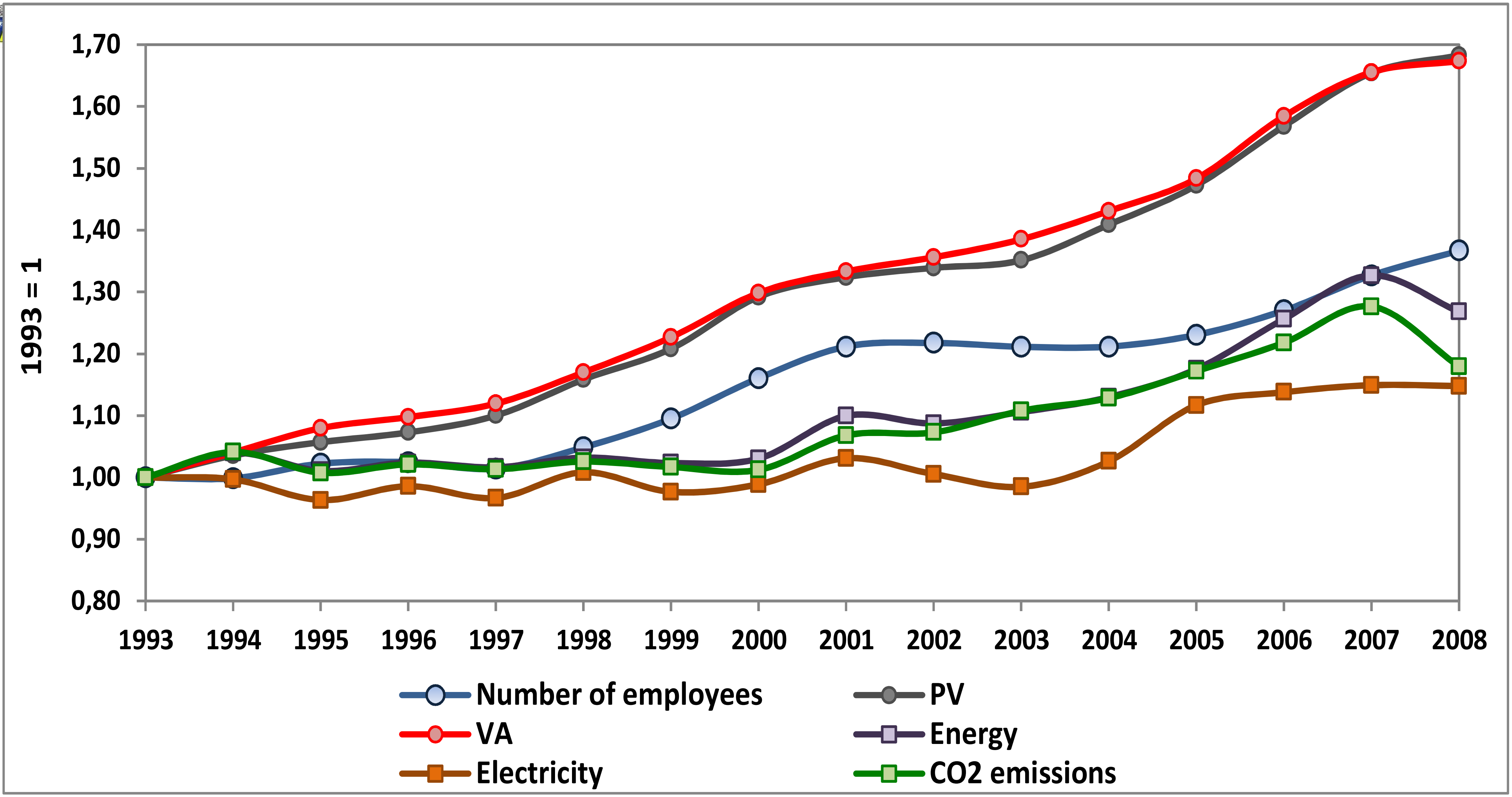
Breusch and Pagan test:
OLS vs. Random effect

Hausman test: Fixed effects vs. Random effect

- **The Pesaran cross sectional dependence test.**
- **Testing for heteroskedasticity.**
- **The Wooldridge test for serial autocorrelation.**

5. RESULTS AND DISCUSSION

Energy consumption, CO_2 emissions and economic variables in Swedish service industries, 1993-2008



Source: SCB (Statistics Sweden)

5. RESULTS AND DISCUSSION

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Energy efficiency in Swedish service industries (Energy intensity and DEA)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Ave.
EA M2 (ϕ)	0.69	0.681	0.732	0.727	0.711	0.694	0.745	0.747	0.733	0.745	0.695	0.718	0.752	0.728	0.691	0.760	**0.72**
/VA (TJ/M€)	2.84	2.274	1.773	1.716	1.589	1.658	1.600	1.889	2.058	1.812	1.634	1.768	1.806	1.903	1.784	1.403	**1.84**
/100 mployees	8,38	8,841	8,451	8,709	8,432	9,196	9,015	9,075	9,429	8,815	8,537	9,193	9,376	10,17	10,42	9,911	**9,12**
O_2 / VA (Ton M€)	123,4	98,09	75,75	74,45	70,06	72,12	68,91	75,38	80,97	73,44	72,69	78,62	79,82	77,49	75,47	54,67	**78,2**
O_2/ Employees	3,441	3,675	3,545	3,761	3,695	3,950	3,863	3,704	3,807	3,717	4,182	4,516	4,558	4,370	4,660	3,842	**3,95**

This result indicates that the Swedish services industries have excellent potential to increase energy efficiency and reduce CO_2 emissions.

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5. RESULTS AND DISCUSSION

Energy efficiency in Swedish service industries (Energy intensity and DEA)

- **The results of DEA model are consistent with the energy baseline in the 2030 scenario developed by European Commission (2008), which estimated that final energy demand of the service industries is projected to decrease between 30% and 60% in 2030.**
- **The findings of the DEA models indicate that several service industries have increased energy efficiencies while decreasing CO_2 emissions.**
- **Results regarding efficiency in energy use and reduce in CO_2 emissions have varied across years and services industries, but they show similar trends with respect to energy intensity and CO_2 emission intensity.**

5. RESULTS AND DISCUSSION

Panel data model for explaining energy efficiency in Swedish service sector

Dependent variable	EE DEAϕ		EI (Energy/ value added)		EI (Energy/ employee)	
Variables	Random effects	MLE	Random effects	MLE	Random effects	MLE
Constant	-0.212 (0.232)	-0.217 (0.233)	-5.504*** (0.456)	-5.562*** (0.479)	-1.570*** (0.416)	-1.577*** (0.421)
Energy Taxes	0.056*** (0.015)	0.057*** (0.015)	-0.023 (0.025)	-0.021 (0.025)	-0.164*** (0.017)	-0.164*** (0.017)
Fossil fuel consumption	-0.086*** (0.028)	-0.085*** (0.028)	0.677*** (0.037)	0.681*** (0.038)	0.813*** (0.035)	0.813*** (0.035)
Electricity consumption			-0.094** (0.037)	-0.092** (0.037)	-0.106*** (0.033)	-0.106*** (0.033)
Investments	0.010 (0.007)	0.010 (0.006)	-0.110*** (0.024)	-0.109*** (0.024)	-0.093*** (0.019)	-0.093*** (0.019)
Labour productivity	0.115*** (0.021)	0.114*** (0.021)	-0.963*** (0.031)	-0.964*** (0.031)		
Capital-labour Ratio	-0.144*** (0.021)	-0.143*** (0.021)	0.171*** (0.027)	0.170*** (0.027)	0.217*** (0.021)	0.217*** (0.021)
F-test statistic	$F(18, 280) = 127.60$ 0.000 Reject OLS		$F(18, 279) = 180.92$ 0.000 Reject OLS		$F(18, 280) = 258.43$ 0.000 Reject OLS	
LM test Prob > chibar^2	chibar^2(01) = 1448.08 0.000 Reject OLS		chibar^2(01) = 1542.58 0.000 Reject OLS		chibar^2(01) = 1780.87 0.000 Reject OLS	
Hausman test Prob>chi^2	chi^2(5) = 8.19 0.1461 Reject FE		chi^2(6) = 10.97 0.089 Reject FE		chi^2(5) = 6.79 0.236 Reject FE	
Test for heteroscedasticity [a] Prob > chi^2	LR chi^2(18) = 328.48 0.000		LR chi^2(18) = 320.18 0.000		LR chi^2(18) = 287.13 0.000	
Wooldridge test for autocorrelation[b] Prob > F	$F(1, 18) = 16.744$ 0.000		$F(1, 18) = 51.427$ 0.000		$F(1, 18) = 46.40$ 0.000	
No. Obs	304	304	304	304	304	304

6. CONCLUSIONS

- **The results of the DEA analysis indicate that energy efficiency and CO_2 emission intensity varied across years and service industries.**

- **Several service industries have increased eco-efficiency by increasing energy efficiency and decreasing CO_2 emissions, especially in recent years.**

- **This sector has the potential to further improve energy efficiency and decrease CO_2 emissions.**

- **The results of the panel data techniques suggest that increased energy taxes, investments and productivity generate higher eco-efficiency, while higher fossil fuel consumption generates lower eco-efficiency. The capital-labour ratio shows a complementary relationship with energy.**

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6. CONCLUSIONS

- **The tests used in the different techniques applied in this study demonstrate that the methods are adequate to generate consistent, robust and reliable estimates in the analysis of energy efficiency and CO_2 emissions from DEA.**

- **All of the findings in this study are important for designing suitable energy policies to increase energy efficiency and decrease CO_2 emissions in the service industries.**

- **The design and application of various strategies and policy instruments are important because energy consumption have grown the quickest in this sector and have driven the increase in total energy consumption and CO_2 emissions for the whole Swedish industrial sector.**

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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