



**INTERNATIONAL WORKSHOP**  
BBVA Foundation – Ivie

**KNOWLEDGE, INNOVATION  
AND REGIONAL DEVELOPMENT:  
NEW EVIDENCE**

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ID VALÈNCIA



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# On the relative contributions of research and knowledge transfer to regional development in Spain: the role of universities' efficiency

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Knowledge, Innovation and  
Regional Development:  
New Evidence  
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WORK IN PROGRESS!!!!!!!

# Overview

- 1 Motivation
- 2 Measuring the efficiency of Spanish HEIs
  - Methodologies
  - What do HEIs do?
  - Other relevant issues: quality
  - Results on efficiency
- 3 The efficiency of the provincial university system
- 4 On HEIs' efficiency and its impact on provincial GDP
- 5 Conclusions

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# Introduction

- The role of **knowledge** and **innovation** and how they are transferred to the society—particularly via HEIs—has become an essential subject from **several points of view**:
  - Academic—as an **area of research**.
  - Political—since several growth strategies, at both regional and country levels, are based on **knowledge** and **education**.
  - Practitioner—**public institutions** and **agencies** are responsible for implementing the strategies.

# Introduction

- Some broadly analyzed issues are related to the **performance** and **impact** of HEIs, specifically:
  - Measurement of HEIs' **missions**, broadly understood (rankings).
  - Evaluation of **university-industry linkages**.
  - Measurement of HEIs' **performance/efficiency**.
  - Evaluation of the **contribution** to development—either **national, regional or local**.



# Introduction

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  - Measurement of HEIs' **missions**, broadly understood (rankings).
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  - **Measurement of HEIs' performance/efficiency.**
  - **Evaluation of the contribution to development—either national, regional or local.**

# Introduction

## Measuring the efficiency of universities

- Regarding the **measurement of HEIs' efficiency**, the available evidence is now remarkable.
- At the **international level** we should highlight relevant work by:
  - J Johnes.
  - G Johnes.
  - C Daraio.
  - A Bonaccorsi.
  - A Worthington.
  - T Agasisti... **and Alice Bertoletti!**
  - ...

# Introduction

## Measuring the efficiency of universities: the Spanish case

- It is much more limited when focusing on Spain:
  - A García-Aracil.
  - E M de la Torre.
  - C Pérez-Esparrells.
  - T Agasisti.
  - J Berbegal-Mirabent.
  - ...
- However, in terms of **number** of contributions, these are relatively low.
- Therefore, the **scope to contribute** is still **wide** (e.g., impact of the crisis, several specifications for inputs/outputs...).

# Introduction

## Evaluating the impact of universities

- The assumption that universities **contribute** to the **social, economic, and cultural** development of their **home regions** is **widely accepted**.
- The idea is that **HEIs interact** with key **stakeholders**—transferring **knowledge, innovation**, and **fostering competitiveness**.

# Introduction

## Evaluating the impact of universities: international studies

- Some authors argue the evidence in this regard is **limited**:
  - This is highlighted in the recent study by **Valero and Van Reenen (EoER, 2019)**—who evaluate the economic **impact of universities** from **across the globe**.
- Others **do not share** this view:
  - E.g., **Barra and Zotti (IRSR, 2017)**, who state that **the topic has existed** since the early 1970s.

# Introduction

## Evaluating the impact of universities: the case of Spain

- In this case, the **evidence focusing on Spain** is a bit more abundant, finding relevant work by:
  - **J M Pastor**, C Peraita.
  - D Urbano.
  - E Lafuente.
  - ...
- However, the **heterogeneity across studies** is high—studies also focus on related topics (entrepreneurship, regional innovation policies, smart cities,...).

# Introduction

## HEIs' performance and economic development

- Given the **role of HEIs** fostering their **home region's economic development**, it is **essential** that they operate **efficiently**. The arguments for this are **twofold**:
  - ① **Reputational effect**: if HEIs are deemed as **efficient**, **firms** and **local institutions** will be eager to **interact with universities**.
  - ② **Efficiency** is a **proxy** for the **quality of institutions**, which affects growth (Glaeser, La Porta, López-de-Silanes, J Ec Growth, 2004)...
  - ...and universities are important **institutions** in their regions.

# Introduction

## HEIs' performance and economic development

- However, the links between **HEIs' performance** and the **local/regional GDP** have been **barely examined**, only by:
  - Agasisti, Barra and Zotti (JRS, 2019).



# Introduction

## Aims of the study

- In this scenario, **our aims** will be **twofold**.

# Introduction

## Aims of the study

- ① To evaluate the performance (**efficiency**) of Spanish HEIs, considering:
  - Both crisis and post-crisis years (2009–2016).
  - Different measures for inputs and outputs.
  - Different concepts of efficiency—cost, technical, benefit of the doubt.
  - Efficiency and super-efficiency—implicitly accounting for outliers.

# Introduction

## Aims of the study

- 2 To analyze how **Spanish HEIs' performance** affect the provincial GDP per capita:
  - This requires constructing a measure of the **provincial university system's efficiency**.

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# Measuring the efficiency of Spanish HEIs

- When measuring the efficiency of HEIs, two decisions are critical:
  - 1 Which methodology shall we use to **estimate efficiency**?
  - 2 How do we **define** what universities do?

# Measuring the efficiency of Spanish HEIs

## Methodologies

- We focus on **DEA (Data Envelopment Analysis)**, a **frequently adopted method** for measuring HEIs' efficiency.
  - **New proposals** in the field: e.g., partial frontiers (order- $m$  and order- $\alpha$ ).
  - We partly contemplate these models controlling for **superefficiency** (Andersen and Petersen, 1993).

# Measuring the efficiency of Spanish HEIs

## Methodologies

- We consider an **output orientation**—universities are supposed to **maximize outputs**, rather than **minimize inputs**.
  - **Public institutions** are expected to **minimize**, but universities are different due to their specific **missions**.

# Measuring the efficiency of Spanish HEIs

## Defining inputs and outputs

- In this regard, there is a **broad consensus** on what universities do—i.e., their **missions**:
  - 1 Teaching (T).
  - 2 Research (R).
  - 3 Knowledge transfer (KT).



# Measuring the efficiency of Spanish HEIs

## Defining inputs and outputs

- Yet consensus is **lower** when it comes to choosing **inputs and outputs**
  - This is **partly explained** by **data availability**.
  - We deal with this issue by specifying **several models**.

# Measuring the efficiency of Spanish HEIs

## Defining inputs and outputs: models

- Previous contributions tend to **convolute** magnitudes expressed in **physical** and **monetary** terms.
  - We consider **budgetary items** as inputs—being in practical terms **cost efficiency** specifications.

# Measuring the efficiency of Spanish HEIs

## Defining inputs and outputs: cost efficiency, unrestricted model (T-R-KT)

Unrestricted model (T-R-KT)	
Outputs	Mission
Number of undergraduate students ( $y_1$ )	T
Number of graduate students ( $y_2$ )	T
PhD scholarships ("becas FPI" and "becas FPU", $y_3$ )	T-R
Post-doc contracts ("Ramón y Cajal" and "Juan de la Cierva" programs, $y_4$ )	R
Publications ( $y_5$ )	R
Research projects ("proyectos plan nacional" and "proyectos UE", $y_6$ )	R
Number of patents ( $y_7$ )	KT
Number of spin-offs ( $y_8$ )	KT
Input	
Total cost	

# Measuring the efficiency of Spanish HEIs

## Defining inputs and outputs: cost efficiency, restricted model-R

Restricted model-R (T-R)	
Outputs	Mission
Number of undergraduate students ( $y_1$ )	T
Number of graduate students ( $y_2$ )	T
PhD scholarships ("becas FPI" and "becas FPU", $y_3$ )	T-R
Post-doc contracts ("Ramón y Cajal" and "Juan de la Cierva" programs, $y_4$ )	R
Publications ( $y_5$ )	R
Research projects ("proyectos plan nacional" and "proyectos UE", $y_6$ )	R
Input	
Total cost	

# Measuring the efficiency of Spanish HEIs

## Defining inputs and outputs: cost efficiency, restricted model-KT

Restricted model-KT (T-KT)	
Outputs	Mission
Number of undergraduate students ( $y_1$ )	T
Number of graduate students ( $y_2$ )	T
PhD scholarships ("becas FPI" and "becas FPU", $y_3$ )	T-R
Number of patents ( $y_7$ )	KT
Number of spin-offs ( $y_8$ )	KT
Input	
Total cost	

# Measuring the efficiency of Spanish HEIs

## Defining inputs and outputs: alternative specifications

- These models differ with respect to the usual practice—our **inputs** are restricted to **budget items**.
- We therefore specify **alternative models**:
  - The first one is in line with the literature—**technical efficiency**.
  - The second one measures **effectiveness**—it is based on a **benefit-of-the-doubt** specification.

# Measuring the efficiency of Spanish HEIs

## Defining inputs and outputs: alternative specifications

Technical efficiency model	
Outputs	Mission
PhD scholarships ("becas FPI" and "becas FPU" $y_1$ )	T-R
Research projects ("proyectos plan nacional" and "proyectos UE" $y_2$ )	R
Publications ( $y_3$ )	R
Number of completed PhD dissertations ( $y_4$ )	R
Number of KT contracts ( $y_5$ )	KT
Patents ( $y_6$ )	KT
Number of spin-offs ( $y_7$ )	KT
Inputs	
Total number of academic staff ("PDI", $x_1$ )	
Total number of administration staff ("PAS", $x_2$ )	
Number of undergraduate students ( $x_3$ )	
Number of graduate students ( $x_4$ )	
Post-doctoral contracts ("Ramón y Cajal" and "Juan de la Cierva" programs, $x_5$ )	

# Measuring the efficiency of Spanish HEIs

## Defining inputs and outputs: BoD

- As for the **BoD model**, since it measures effectiveness, **input values** are replaced by 1.
  - In this model, the **weights are assigned endogenously**—as opposed to standard **composite indicators**.



# Measuring the efficiency of Spanish HEIs

## Defining inputs and outputs: data sources

Variable	Source
Scientific publications	IUNE (Web of Science)
Number of citations	IUNE (Web of Science)
Teaching/researcher staff	IUNE (Ministerio de Educación, Cultura y Deporte, Sistema Integrado de Información Universitaria – SIIU)
Administrative staff	IUNE (Ministerio de Educación, Cultura y Deporte, Sistema Integrado de Información Universitaria – SIIU)
FPI/FPU Contracts	IUNE (Ministerio de Economía, Industria y Competitividad)
Ramón y Cajal/Juan de la Cierva Contracts	IUNE (Ministerio de Economía, Industria y Competitividad)
National and UE projects	IUNE (Ministerio de Economía, Industria y Competitividad; CDTI)
Number of students	Ministerio de Ciencia, Innovación y Universidades (Sistema Integrado de Información Universitaria – SIIU)
Number of students per centre	Ministerio de Ciencia, Innovación y Universidades (Sistema Integrado de Información Universitaria – SIIU)
Spin-offs	IUNE (RedOTRI)
National/PCT patents	IUNE (RedOTRI)
Revenues per consulting	IUNE (RedOTRI)
Budgetary data	Ministerio de Ciencia, Innovación y Universidades (Sistema Integrado de Información Universitaria – SIIU)

# Measuring the efficiency of Spanish HEIs

## Sample

- 47 Spanish public universities.
- In continuous existence 2009–2016.
- Including previous years was problematic—no data availability for budgetary information.
- Several variables were also problematic for some years (graduates).

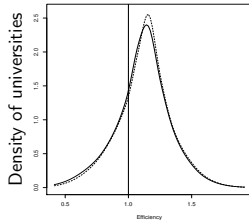
# Measuring the efficiency of Spanish HEIs

Results: selected years, cost efficiency models

Year	Statistic	Unrestricted model		Restricted model-R		Restricted model-KT	
		Efficiency	Super-efficiency	Efficiency	Super-efficiency	Efficiency	Super-efficiency
2009	Unweighted average	1.1635	1.1143	1.2330	1.2109	1.4337	1.4033
	Weighted average	1.1515	1.1137	1.2220	1.1978	1.4316	1.4166
2016	Unweighted average	1.1796	1.1283	1.3646	1.3383	1.9123	1.8898
	Weighted average	1.2274	1.1783	1.3999	1.3798	2.0423	2.0168

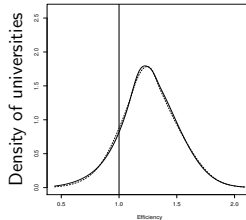
# Measuring the efficiency of Spanish HEIs

Results: kernel densities, cost super-efficiency models, weighted vs. unweighted



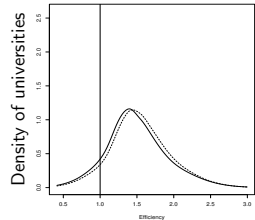
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Weighted - - - - -



Unweighted ———

Weighted - - - - -

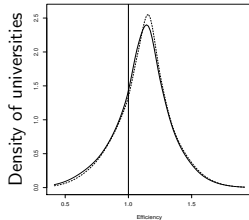


Unweighted ———

Weighted - - - - -

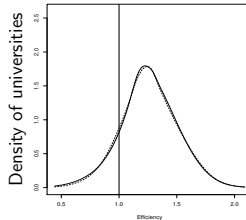
# Measuring the efficiency of Spanish HEIs

Results: kernel densities, cost super-efficiency models, crisis vs. post-crisis



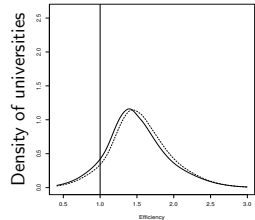
Unweighted ———

Weighted - - - - -



Unweighted ———

Weighted - - - - -

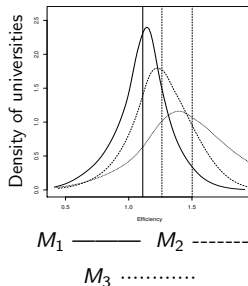


Unweighted ———

Weighted - - - - -

# Measuring the efficiency of Spanish HEIs

Results: kernel densities, cost super-efficiency models, model comparison



# Measuring the efficiency of Spanish HEIs

## Results: interpretations

- Recall: according to an **output orientation**, **higher values** imply **lower efficiency**.
- Interpretation: **potential output increase** in case we used the same inputs as the efficient universities.
- **Super-efficiency**: universities with values lower than 1 are those which, even producing less outputs, are still **efficient**.

# Measuring the efficiency of Spanish HEIs

## Results: initial screening (I)

- For the three models specified, average **inefficiency** has **increased**:
  - The economic crisis might have played a role—**inefficiency** increases remarkably.
  - A proper analysis of **dynamic** efficiency should be implemented.
  - Average inefficiency is particularly high for the **restricted models**.
  - The differences between **large** and **small** universities are not generalized.
  - **Super-efficiency** is always lower than efficiency—suggesting the presence of **outliers**.



# Measuring the efficiency of Spanish HEIs

Results: alternative specifications

Year	Statistic	Technical efficiency		BoD model	
		Efficiency	Super-efficiency	Efficiency	Super-efficiency
2009	Unweighted average	1.1048	0.9910	2.8363	2.8093
	Weighted average	1.0902	0.9985	1.9963	1.9314
2016	Unweighted average	1.1060	0.9788	2.7443	2.7044
	Weighted average	1.1040	0.9597	2.0893	1.9866

# Measuring the efficiency of Spanish HEIs

## Results: initial screening (II)

- Regarding the alternative models specified, results are not entirely coincidental:
  - The tendencies are less marked—efficiency more stable.
    - A proper analysis of *dynamic* efficiency should be implemented.
  - Average **effectiveness** is particularly **poor**.

# Measuring the efficiency of Spanish HEIs

## Results: individual universities

- We also report results for some specific universities.

# Measuring the efficiency of Spanish HEIs

Results: interpretations

WARNING: THIS IS NOT A RANKING

# Measuring the efficiency of Spanish HEIs

## Results: individual universities

Year	Unrestricted model		Restricted model-R		Restricted model-KT		Technical efficiency		BoD model	
	Efficiency	Super-efficiency	Efficiency	Super-efficiency	Efficiency	Super-efficiency	Efficiency	Super-efficiency	Efficiency	Super-efficiency
EHU	1.5089	1.5089	1.7163	1.7163	1.9296	1.9296	1.0905	1.0406	1.1812	1.1806
UAB	1.0000	0.9017	1.0032	0.9735	1.7998	1.7998	1.0000	0.7410	1.0202	0.9894
UBU	1.0228	0.9313	1.3570	1.3570	1.0407	0.9565	1.0000	0.6778	5.1635	5.1635
UIB	1.0158	0.9591	1.0493	1.0223	1.4003	1.4003	1.2662	1.2662	3.8808	3.8808
UPC	1.1166	1.0882	1.4622	1.4622	1.3627	1.3382	1.0069	0.8626	1.1205	1.0410
UPCT	1.1761	1.1471	1.5046	1.5046	1.4564	1.4273	1.0555	0.8657	6.5871	6.5871
UPM	1.0300	0.8410	1.5296	1.5296	1.1112	0.9509	1.0067	0.6328	1.0000	0.5145
UPV	1.3476	1.3476	1.5610	1.561	1.7281	1.7281	1.0209	0.8761	1.3260	1.3260
UV	1.1931	1.1931	1.2018	1.2018	1.8572	1.8572	1.1128	1.0682	1.1372	1.1372

# Measuring the efficiency of Spanish HEIs

## Results: individual universities

- Results show important tendencies to highlight:
  - Several universities perform very differently depending on whether we focus on efficiency or effectiveness.
    - Some of them much better under BoD: EHU.
    - Others much worse under BoD: UBU, UIB, UPCT.
    - Others show a more balanced behavior: UAB, UB, UPC, UPM, UPV, UV—i.e., particularly technological universities.

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# The efficiency of the provincial university system

- As indicated previously, we evaluate the **impact of universities** in their home region (**province**) indirectly—via **efficiency**.
  - Up to now, only Agasisti, Barra and Zotti (2019) have done this—for the Italian case.
- However, how do we measure the efficiency of **provinces'** university systems?



# The efficiency of the provincial university system

- Spain's territorial organization:
  - 17 regions.
  - 50 provinces.
  - More than 8,000 municipalities
- Regions are the level of government responsible for education—all levels.

# The efficiency of the provincial university system

- However, universities' home **provinces** have peculiarities:
  - Not all provinces have a university—but most of them have campuses.
  - Several provinces have several universities—particularly the larger ones.

# The efficiency of the provincial university system

- Therefore, we need to construct an **indicator** of **provincial university system's efficiency**. For this:
  - We compute the **share of students** in each province corresponding to **each university**.
  - For each province, we multiply the efficiency of each university by its **share of students**.

# The efficiency of the provincial university system

Efficiency of province  $i$ 's university system

$$EFF_i = \sum_{j=1}^J EFF_j \times \frac{STUD_{ij}}{\sum_{j=1}^J STUD_{ij}}$$

where:

$i$ : province indicator.

$j$ : university indicator.

$J$ : # of universities in each province.

$STUD_{ij}$ : # of students in province  $i$  enrolled in university  $j$ .

# The efficiency of the provincial university system

## Results for selected provinces

Year	Unrestricted model		Restricted model-R		Restricted model-KT		Technical efficiency		BoD model	
	Efficiency	Super-efficiency	Efficiency	Super-efficiency	Efficiency	Super-efficiency	Efficiency	Super-efficiency	Efficiency	Super-efficiency
Barcelona	1.0226	0.9243	1.0862	1.0158	1.6839	1.6795	1.0131	0.8413	1.2359	1.0967
Illes Balears	1.0158	0.9591	1.0493	1.0223	1.4003	1.4003	1.2662	1.2662	3.8808	3.8808
Las Palmas de Gran Canaria	1.5671	1.5671	1.6439	1.6439	1.6704	1.6704	1.2361	0.9908	3.5211	3.5211
Madrid	1.0844	0.9312	1.1961	1.0867	1.4615	1.3430	1.0783	0.9219	1.3807	1.1921
Ourense	1.0191	0.9548	1.1705	1.1705	1.2389	1.2101	1.0446	0.9503	1.9675	1.9675

# The efficiency of the provincial university system

Results for selected provinces: summary

- Some of the provinces with **more efficient HEIs systems** across specifications are **Barcelona, Madrid and Valencia**.
- In cases such as, for instance, Ourense there are higher heterogeneities.
- Results are worse across models for some specific provinces—e.g., Las Palmas de Gran Canaria.
- We have not explored (yet) results for **regions**.

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# On HEIs' efficiency and its impact on provincial GDP

- We test the relationship between **provincial university system's efficiency** and **provincial development**.
- We use a variety of efficiency measures and several estimation methods, including pooled regression, random and fixed effects models and System GMM.



# On HEIs' efficiency and its impact on provincial GDP

## Results

	System GMM. Dep. var.: GDP per capita (logs)		
	Model T-R-KT	Model T-R	Model T-KT
Lagged GDPpc	1.008*** (.0123)	1.009*** (.0230)	1.004*** (.0150)
Population growth	-.931*** (.285)	-.995*** (.293)	-.982*** (.305)
Efficiency	.0254* (.0139)	-.0247 (.0177)	.0196 (.0140)
<i>n</i>	350	350	350
FE	Yes	Yes	Yes
Time effects	Yes	Yes	Yes
AR2 test ( <i>p</i> -value)	0.417	0.421	0.423
Hansen test ( <i>p</i> -value)	0.944	0.633	0.912

Each column corresponds to a different specification of efficiency.  
 Constant included in all models but not reported.

# On HEIs' efficiency and its impact on provincial GDP

## Results: summary

- The impact of efficiency is **contrary to the expected** but, generally, **far from being significant**.
  - Therefore, results are **not** coincidental with Agasisti et al.'s (2019).

# On HEIs' efficiency and its impact on provincial GDP

## Results: summary

- **Explanations** for this may be **multiple**.
- However, given the **consistency** of the results—**robust** across **efficiency specifications** and **econometric models**, this should be made with care.
- Some possibilities:
  - **Quality** of output not accounted for (Berbegal-Mirabent and Ribeiro-Soriano, 2015).
  - **Characteristics** of the **staff** (teaching and administration).
  - Role of the **crisis**—some universities might be efficient just because they **undercut costs**.

# On HEIs' efficiency and its impact on provincial GDP

## Results: summary

- However, due to the consistency of results, we also looked for alternative explanations:

“Null results are interesting too”.

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## Conclusions (I)

- Researchers have tried to identify the **regional economic impact** of **HEIs** for some time now.
- There has been much discussion about whether the increase in a **region's economic activity** could be attributable to the presence of a university (Barra and Zotti, 2017).
- Some recent evidence has shown the **mechanism** could be **indirect**—via universities' efficiency (Agasisti et al., 2019).

## Conclusions (II)

- We have extended this (limited) previous evidence to the case of Spain, for several reasons:
  - Recent initiatives evaluating the **contribution of universities** to their **home region's development**.
  - The crisis affected quite strongly **public universities**.
  - The available evidence on **Spanish universities' efficiency** is relatively **limited**.

## Conclusions (III)

- In the **first stage** of the analysis we evaluated **universities' performance**.
- For this, we specified **several definitions** of **inputs and outputs**, and several methodologies.



## Conclusions (IV)

- Results could be exploited from **several perspectives**:
  - Several universities' **perform differently** depending on the **indicator**—some of them showed more **consistency**.
  - **Efficiency deteriorated** over the sample period, for most measures.
  - A fuller view would be provided by exploring the **determinants of performance**.

## Conclusions (V)

- In a second stage, we evaluated how **HEIs' efficiency** affected **provincial development**:
  - This implied constructing a **measure** for the **efficiency** of each **province's university system**.
  - Results, however, were **null**, and this was **robust across econometric specifications** and **efficiency models**.

## Conclusions (VI)

- Does this imply that the **hypothesis** should be **discarded**?
- Rather, we should contemplate **other possibilities**:
  - Considering **alternative definitions** of both **inputs and outputs**.
  - Alternative methodologies for efficiency.
  - Considering **conditional efficiency measures**—in order to **control implicitly** for **factors** that might affect efficiency.

THANK YOU!!!!!!!



**INTERNATIONAL WORKSHOP**  
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NEW EVIDENCE**

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