Measuring Industry Productivity Using DEA

An Input-Oriented Efficiency Analysis of 63 U.S. Industries (2006)

Tejasree Gottam

What This Project Is About

•Understanding how efficiently U.S. industries use their inputs.

•Comparing 63 industries using a data-driven benchmarking method.

•Identifying which sectors are performance leaders vs. laggards.

•Using DEA to uncover input waste, scale issues, and best-practice peers

Why Industry Productivity Matters

1. Productivity determines competitiveness and long-run growth.
2. Highly efficient industries attract more investment and create more value.
3. Policymakers use efficiency comparisons to guide resource allocation.
4. Businesses use such benchmarks for strategic planning and cost reduction.

What DEA Does

Compares each industry against **best performers** in the dataset.

Builds a data-based “efficiency frontier” from top industries.
Industries on the frontier = **efficient**
Industries below the frontier = **inefficient**
Efficiency score shows **how much inputs could be reduced** while keeping output constant.

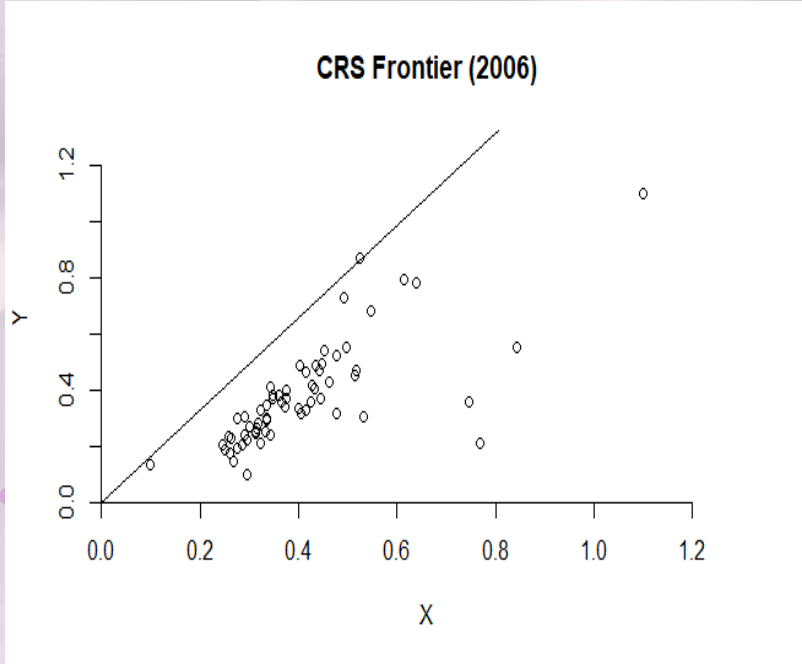
Technologies Used:

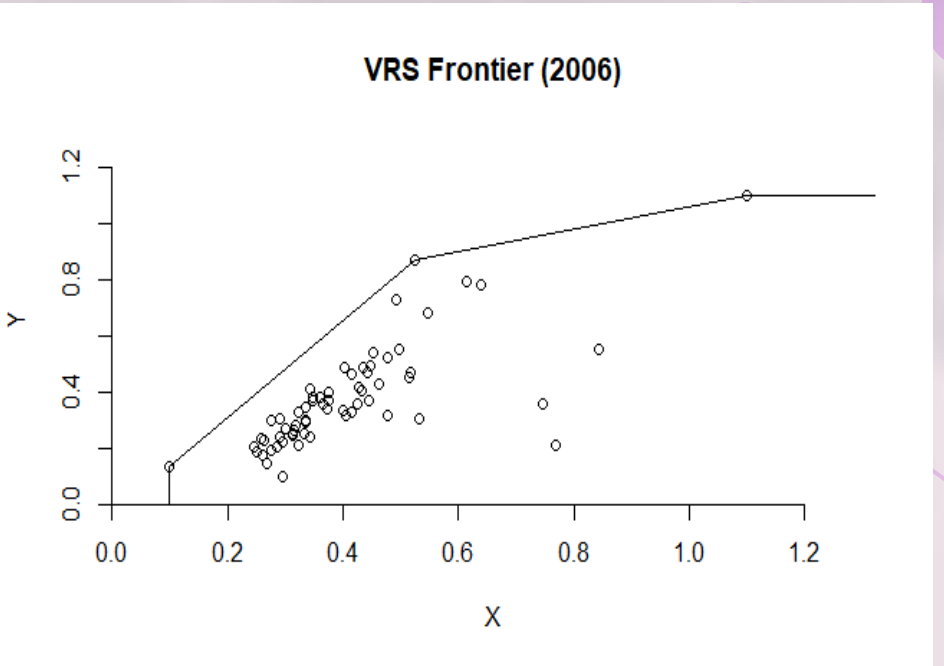
- •Constant returns (CRS)
- •Variable returns (VRS)
- •Increasing returns (IRS)
- •Decreasing returns (DRS)
- •FDH — non-convex frontier
- •ADD — slack-based model

Key Input Findings:

- Industries vary widely in how they use **intermediate inputs**, with many relying heavily on them.
- There is **large variation in capital intensity**, especially in IT, software, and R&D capital.
- **Labor composition** differs sharply across industries (college vs. non-college labor).
- These structural input differences influence how efficiently industries convert inputs into output.

Graphical Representation of CRS and VRS Efficiency Frontiers





What the CRS and VRS Frontiers Tell Us

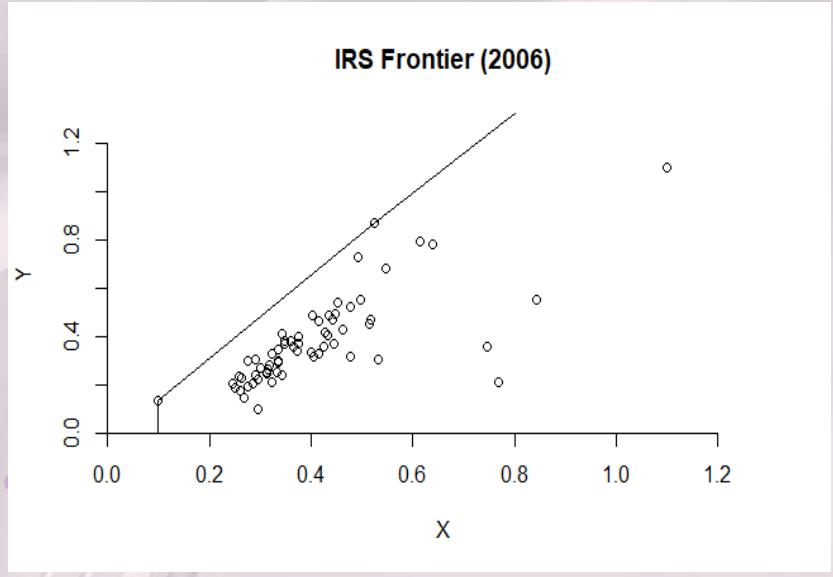
CRS Frontier

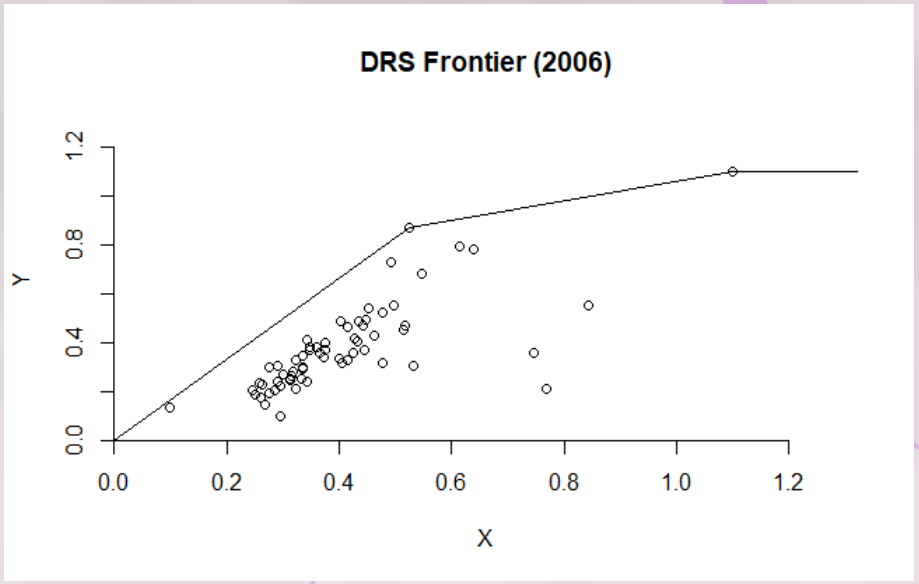
•**Only 9 industries** are fully efficient under CRS.
•Examples of CRS-efficient industries:
Support activities for mining, Wood products, Motor vehicles,
•**Major inefficiencies under CRS:**
•**Computer & electronic products – 0.5107**
•**Air transportation – 0.5942**
•**Retail trade – 0.6103**
•**Farms – 0.6163**
•**Federal Reserve & credit intermediation – 0.462**

.VRS Frontier

Efficient industries **increase from 9 → 31** under VRS.
•Many service sectors become fully efficient under VRS.
•**VRS reveals strong pure technical efficiency** even in industries that appear inefficient under CRS.
•**Examples of large improvements:**
•**Computer & electronic products: 0.5107 → 0.9933**
•**Broadcasting & telecommunications: 0.3983 → 0.9954**
•**Retail trade: 0.6103 → 0.9986**

Graphical Representation of IRS and DRS Efficiency Frontiers





What the IRS and DRS Frontiers Tell Us

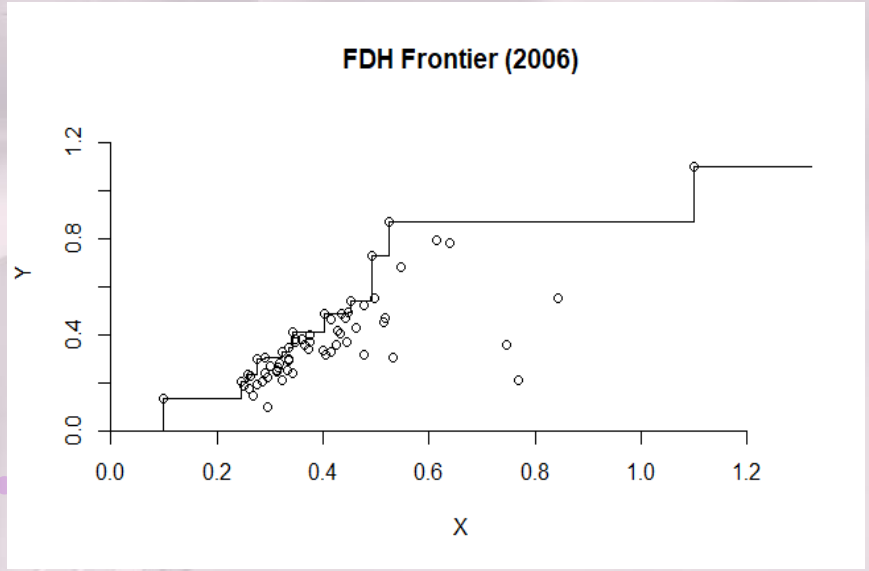
IRS Frontier

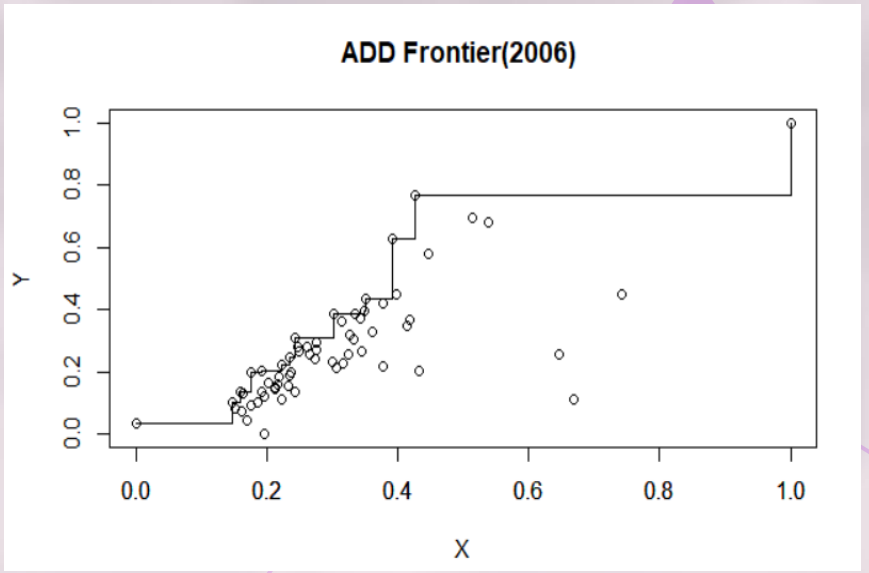
Industries showing **increasing returns to scale** include:
Oil & gas extraction – 1.000
Mining – 1.000
Utilities – 1.000
Plastics & rubber – 1.000
Rail transportation – 1.000
Water transportation – 1.000
Many service industries (Education, Healthcare, Management, Social assistance, etc.)

DRS Frontier

Industries with notable inefficiency under DRS:
Computer & electronics – 0.5107
Air transportation – 0.5942

Graphical Representation of FDH and ADD Efficiency Frontiers





What the FDH, and ADD Frontiers tell us

Under FDH:
Almost every industry becomes efficient (60 out of 63).
FDH is extremely permissive—it creates a “step frontier” that fits many DMUs exactly.
Remaining inefficiencies:
Broadcasting & telecom – 0.9962
Air transportation – 0.9969

ADD Frontier (Slack-based, Non-radial Efficiency)
All 63 industries score 1.000 under ADD.
ADD confirms the same pattern as FDH:
Inefficiencies under CRS/VRS come from scale or radial reductions, not from slacks.

Efficiency (CRS vs VRS)

CRS (Strict Model):
Only **9 industries** fully efficient.
Significant inefficiency appears due to **scale mismatch**.
Low performers:
Computer & electronics: **0.5107**
Air transportation: **0.5942**
Retail trade: **0.6103**
Paper products: **0.6625**
Primary metals: **0.8209**

VRS (flexible model):

- Many industries have good technology but operate at the wrong scale.
- High-performing industries include:
- **Support activities for mining**
- **Wood products**
- **Plastics & rubber products**
- **31 industries efficient**.
- **Water transportation**
- **Rail transportation**
- **Management of companies**
- **Social assistance**
- **Accommodation**

Industries Showing Strong Inefficiency

1. **Persistent Inefficiency Group**
2. **Computer & electronic products – 0.5107**
3. **Broadcasting & telecommunications – 0.3983**
4. **Federal Reserve & credit intermediation – 0.4623**
5. **Air transportation – 0.5942**
6. **Miscellaneous manufacturing – 0.5791**
7. **Food & beverage – 0.5597**

Peer Sets and λ-Weights

Top Peer Industries
Social Assistance
Warehousing & Storage
Management of Companies
Accommodation
Pipeline transportation
Support activities for mining

Practical Insights for Managers and Policymakers

- Study peer industries with high efficiency:
- Social Assistance → Labor optimization
- Warehousing & Storage → Cost control & logistics
- Management of Companies → Resource allocation discipline
- Use CRS–VRS gaps to pinpoint **scale inefficiency**.
- Use FDH and ADD to confirm whether **structural inefficiencies** exist.
- Computer & electronics
- Broadcasting & telecom
- Support industries trapped in **wrong-scale operations**, especially:
- Federal Reserve & credit intermediation
- Promote **best-practice diffusion** from high-performing service sectors.
- Encourage scaling adjustments (up or down) based on IRS/DRS signals.

Final Takeaways

•Overall, the DEA results show that a core group of industries—such as mining support, wood products, textiles, apparel, accommodation, and motor vehicles—consistently operate on the efficiency frontier across multiple models. Many industries appear inefficient under CRS but become efficient under VRS, indicating that most performance gaps arise from **scale inefficiencies rather than poor technology**. Service sectors like social assistance, warehousing, accommodation, and management of companies frequently serve as **peer benchmarks**, guiding improvement for manufacturing, finance, and transportation. A small set of industries—including computer & electronics, broadcasting & telecom, and air transportation—show persistent inefficiency and could reduce inputs by 10–30% to reach best-practice performance. Overall, the analysis highlights clear opportunities for better input allocation, cost control, and scale optimization across U.S. industries in 2006.

References:

Banker, R. D., Charnes, A., & Cooper, W. W. (1984). *Some models for estimating technical and scale inefficiencies in Data Envelopment Analysis*. **Management Science, 30(9)**, 1078–1092.

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). *Measuring the efficiency of decision-making units*. **European Journal of Operational Research, 2(6)**, 429–444.

Färe, R., & Grosskopf, S. (2000). *Theory and Application of Directional Distance Functions*. **Journal of Productivity Analysis, 13(2)**, 93–103.
U.S. KLEMS (2023). *U.S. KLEMS Growth and Productivity Accounts*. Retrieved from U.S. KLEMS official database.

Thank you!