Report

Measuring Industry Productivity in the U.S. KLEMS Dataset Using DEA:

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

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Abstract

This report conducts an input-oriented Data Envelopment Analysis (DEA) of 63 U.S. industries in the 2006 U.S. KLEMS dataset. Intermediate inputs and several types of capital and labor are treated as inputs, while the gross output quantity index is used as the single output. Six returns-to-scale (RTS) specifications are estimated: constant returns to scale (CRS), variable returns to scale (VRS), increasing returns to scale (IRS), decreasing returns to scale (DRS), Free Disposal Hull (FDH), and the additive model (ADD). All DEA models are implemented using the `Benchmarking` package in R on normalized (min–max scaled) input and output indices.

The analysis identifies technically efficient and inefficient industries, explores their peer sets and λ-weights, and visualizes the production frontiers. Results show that many manufacturing and service industries operate close to the VRS frontier, while a smaller set of industries—including support activities for mining, wood products, and accommodation—form the benchmark frontier under multiple RTS assumptions. The peer-analysis highlights the central benchmarking role of sectors such as social assistance, warehousing and storage, and management of companies and enterprises. Scale efficiency patterns further reveal which industries should expand (increasing returns to scale) and which may need to downsize (decreasing returns to scale). Finally, the behavior of the ADD model, which yields an efficiency score of one for all DMUs, is interpreted as an upper-bound benchmark rather than a discriminating efficiency measure. Managerial and policy implications are discussed, together with limitations and directions for future work.

Glossary

Data Envelopment Analysis (DEA): A nonparametric frontier method for measuring the efficiency of decision-making units using linear programming.

DMU: Decision-making unit. In this study, each DMU is one U.S. industry.

Input-Oriented Model: A DEA specification that measures how much inputs can be proportionally reduced while holding outputs constant.

Returns to Scale (RTS): Describes how output responds when all inputs change proportionally (constant, increasing, or decreasing).

FDH (Free Disposal Hull): A non-convex, piecewise-constant frontier that assumes free disposability of inputs and outputs without convexity.

ADD (Additive Model): A DEA model that measures inefficiency as the sum of input and output slacks, allowing non-radial adjustments.

λ-weights: Optimal weights in the DEA linear program that show how inefficient DMUs are represented as convex combinations of efficient DMUs.

1 Introduction

Evaluating productivity and operational efficiency across industries is essential for understanding how effectively different sectors utilize their inputs to generate output. In competitive markets, industries that produce more output from a given bundle of inputs tend to be more profitable, more resilient to shocks, and better positioned for long-run growth. Data Envelopment Analysis (DEA) provides a flexible, nonparametric framework for benchmarking such performance by constructing an empirical production frontier and measuring the distance of each decision-making unit (DMU) from that frontier (Charnes et al., 1978; Banker et al., 1984).

The U.S. KLEMS dataset is a widely used source of industry-level data on output, capital, labor, energy, materials, and service inputs for the United States. It separates multiple types of capital and labor and provides consistent, index-based measures over time, making it an ideal resource for productivity and efficiency analysis.

In this project, I focus on a single cross-section: the year 2006. This year

corresponds to a period just before the global financial crisis, when the aggregate U.S. economy was near a cyclical peak. Studying efficiency at this point in time provides a snapshot of industry performance under relatively favorable macroeconomic conditions.

The main objective of this report is to assess how efficiently 63 U.S. industries convert inputs into gross output in 2006 using an input-oriented DEA model under various RTS assumptions. The analysis addresses four questions:

1. Which industries are technically efficient and which show room for input reduction under different RTS assumptions?

2. How sensitive are efficiency scores to the choice of RTS (CRS vs. VRS vs. FDH and ADD)?

3. Which industries serve as peers (benchmarks) for inefficient industries, and what do the λ-weights and peer sets tell us about the structure of the production frontier?

4. What economic and managerial insights can be drawn from these patterns for policy-makers and industry stakeholders?

The contribution of this project is twofold. First, it provides a detailed, year-specific benchmarking of U.S. industries for 2006 using multiple DEA specifications. Second, it interprets the efficiency patterns, peer relationships, and scale properties in terms of sectoral roles, highlighting which industries form the best-practice frontier and which industries operate with significant inefficiencies.

2 Data and Variables

2.1 U.S. KLEMS Dataset

The analysis relies on the publicly available U.S. KLEMS dataset, which reports industry-level quantity indices for outputs and a variety of inputs for the period 1963–2016. For

each year, the data are organized by industry and include measures of intermediate inputs, multiple types of capital, and different categories of labor. The data are constructed to facilitate growth accounting and productivity analysis (U.S. KLEMS, 2023).

For this project, I extract the observations corresponding to the year 2006, which includes 63 industries spanning agriculture, mining, manufacturing, transportation, information, finance, services, and government. Each of these industries constitutes one DMU in the DEA model.

2.2 Inputs and Output

Following the assignment instructions, I use one output and seven inputs. Before modelling, the original KLEMS indices are renamed for clarity:

- **Output:** *Gross output quantity index (goqi)* – an index of the real output produced by each industry; renamed as *Gross_Output_Index*.
- **Inputs:**
  - *Intermediate input quantity index (iiqi)* → *Intermediate_Input_Index*.
  - *IT capital quantity (qkit)* → *IT_Capital_Index*.
  - *Software capital quantity (qks)* → *Software_Capital_Index*.
  - *R&D capital quantity (qkrd)* → *RD_Capital_Index*.
  - *Other capital quantity (qko)* → *Other_Capital_Index*.
  - *College labor quantity (qlindexcol_merge)* → *College_Labor_Index*.
  - *Non-college labor quantity (qlindexn_merge)* → *NonCollege_Labor_Index*.

2.3 Normalization of Inputs and Output

Although DEA is scale-invariant in a theoretical sense, normalization often improves numerical stability in practice. In this project, I apply a min–max scaling transformation to all

input indices and to the output index prior to estimating the DEA models. Specifically, for any variable z:

$$z' = \frac{z - \min(z)}{\max(z) - \min(z)} + \epsilon,$$

where $\epsilon = 0.1$ is a small offset to avoid exact zeros. This transformation maps all variables into approximately the $[0.1, 1.1]$ range. These scaled variables are then used as the input matrix X and output vector Y in all DEA models (CRS, VRS, IRS, DRS, FDH, and ADD).

2.4 Decision-Making Units

The 63 DMUs include primary sectors (e.g., farms; forestry, fishing, and related activities), extractive industries (oil and gas extraction, mining), a broad range of manufacturing industries, transportation and warehousing, information and communication sectors, financial and real-estate services, professional and business services, health and education, accommodation and food services, and government (federal, state, and local). This diversity allows the DEA frontier to be shaped by both goods-producing and service-producing industries.

3 Methodology

3.1 Input-Oriented DEA Models

DEA is implemented using the `Benchmarking` package in R. Let x_i denote the vector of seven inputs and y_i the scalar output for industry i. In an input-oriented CRS model, the efficiency of DMU i is computed by solving (Charnes et al., 1978):

$$
\begin{aligned}
\min_{\theta,\lambda} \quad & \theta \\
\text{s.t.} \quad & \sum_{j=1}^{n} \lambda_j x_j \leq \theta x_i, \\
& \sum_{j=1}^{n} \lambda_j y_j \geq y_i, \\
& \lambda_j \geq 0 \quad \text{for all } j,
\end{aligned}
$$

where θ is the input contraction factor. An efficiency score of $\theta = 1$ indicates that the DMU is on the frontier (efficient), while $0 < \theta < 1$ indicates that inputs could be proportionally reduced by $(1 - \theta) \times 100\%$ without reducing output.

Under VRS, an additional convexity constraint $\sum_j \lambda_j = 1$ is imposed, allowing the frontier to exhibit different returns to scale at different output levels (Banker et al., 1984). The IRS and DRS models restrict the technology to primarily increasing or decreasing returns, respectively. The FDH model relaxes convexity and builds a frontier based solely on free disposal of inputs and outputs, while the ADD model measures slacks in both inputs and outputs additively.

All models are estimated in an input-oriented form. The `dea()` function is used for CRS, VRS, IRS, DRS, and FDH, while `dea.add()` is used for the ADD model.

3.2 Returns-to-Scale Specifications

For each industry, I estimate input-oriented efficiency scores under six RTS specifications:

- **CRS (Constant Returns to Scale).** Assumes that doubling all inputs exactly doubles output.
- **VRS (Variable Returns to Scale).** Allows for increasing or decreasing returns at different scales.

- **IRS (Increasing Returns to Scale).** Emphasizes industries that can expand output more than proportionally with inputs.
- **DRS (Decreasing Returns to Scale).** Emphasizes industries in which proportional input increases yield less than proportional output gains.
- **FDH.** Builds a non-convex frontier using observed DMUs only, representing a very flexible benchmark.
- **ADD.** Uses an additive distance function to capture both radial and non-radial inefficiencies, measuring the sum of input and output slacks.

CRS and VRS models are used to summarize overall technical efficiency and scale efficiency. FDH and ADD provide upper-bound benchmarks, since many DMUs reach efficiency of 1 under these more flexible technologies.

3.3 Peer Sets and λ-Weights

For an inefficient DMU, the optimal λ-weights define a convex combination of efficient DMUs that form its reference point on the frontier. If $\lambda_{ij} > 0$, then DMU j acts as a peer for DMU i. By examining these weights and the associated peer sets, we can identify which industries serve as benchmarks most often and how inefficient industries "borrow" technology from efficient sectors.

In this study, I extract the VRS peer matrix using the `peers()` function and store, for each DMU, the list of industries that appear as peers. I also extract the λ-matrix using `lambda()` and construct a long-form table of (DMU, λ) pairs with positive weights. The peer-set table is included in Appendix B. The full numeric λ-weight table is large and is summarized qualitatively in the text.

4 Results

This section presents the main empirical findings from the DEA analysis: (i) efficiency scores under different RTS assumptions, (ii) lists of efficient and inefficient industries, (iii) peer sets under VRS, (iv) DEA frontiers under six RTS specifications, and (v) interpretation of sectoral patterns and scale properties.

4.1 Efficiency Scores Under CRS, VRS, and Other RTS Assumptions

Table 1 presents a subset of efficiency scores under six RTS assumptions for selected service industries. The full efficiency table for all 63 industries is provided in Appendix A.

Table 1: Summary of DEA efficiency scores for selected service industries, 2006.

Industry	**CRS**	**VRS**	**DRS**	**IRS**	**FDH**	**ADD**
Motion picture and sound recording industries	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Broadcasting and telecommunications	0.3983	0.9954	0.3983	0.9954	0.9962	1.0000
Data processing, internet publishing, and other information services	0.8201	1.0000	0.8201	1.0000	1.0000	1.0000
Federal Reserve banks, credit intermediation, and related activities	0.4623	0.9918	0.4623	0.9918	1.0000	1.0000
Securities, commodity contracts, and investments	0.8960	1.0000	0.8960	1.0000	1.0000	1.0000
Insurance carriers and related activities	0.5396	0.9976	0.5396	0.9976	1.0000	1.0000
Funds, trusts, and other financial vehicles	0.6838	1.0000	0.6838	1.0000	1.0000	1.0000
Real estate	0.5363	0.9955	0.5363	0.9955	1.0000	1.0000
Computer systems design and related services	0.5552	1.0000	0.5552	1.0000	1.0000	1.0000
Management of companies and enterprises	0.9525	1.0000	0.9525	1.0000	1.0000	1.0000
Educational services	0.5215	1.0000	0.5215	1.0000	1.0000	1.0000
Hospitals and Nursing and residential care	0.5457	1.0000	0.5457	1.0000	1.0000	1.0000
Social assistance	0.5570	1.0000	0.5570	1.0000	1.0000	1.0000
Accommodation	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Other services, except government	0.6979	1.0000	0.6979	1.0000	1.0000	1.0000
Federal government	0.6364	1.0000	0.6364	1.0000	1.0000	1.0000
State and local government	0.7019	1.0000	0.7019	1.0000	1.0000	1.0000

In almost all cases, VRS, IRS, DRS, FDH, and ADD scores are close to one, while CRS scores are noticeably lower for many DMUs. This confirms that allowing for variable returns to scale and more flexible technologies makes it easier for industries to appear efficient, whereas the CRS benchmark is stricter and highlights scale-related inefficiencies.

4.2 Efficient and Inefficient Industries

Using the full set of 63 industries, it is useful to group DMUs based on their CRS and VRS scores.

Industries Efficient Under Both CRS and VRS

Intersecting the CRS and VRS results shows that the following industries lie on both frontiers and are therefore robustly efficient:

- Support activities for mining
- Wood products
- Motor vehicles, bodies and trailers, and parts
- Furniture and related products
- Textile mills and textile product mills
- Apparel and leather and allied products
- Pipeline transportation
- Motion picture and sound recording industries
- Accommodation

These nine sectors behave as "core" benchmarks: they remain efficient even when the technology is restricted to constant returns to scale, so they combine good technology with an approximately optimal scale of operation.

Industries Efficient Under VRS but Not CRS

Several industries become efficient once variable returns to scale are allowed but remain inefficient under CRS. Examples include:

- Oil and gas extraction; mining, except oil and gas; and utilities
- Nonmetallic mineral products and plastics and rubber products
- Other transportation equipment, rail transportation, water transportation, and other transportation and support activities
- Warehousing and storage
- Data processing, internet publishing, and other information services
- Securities, commodity contracts, and investments; funds, trusts, and other financial vehicles
- Computer systems design and related services and management of companies and enterprises
- Educational services; ambulatory health care services; hospitals and nursing and residential care; and social assistance
- Other services, except government, as well as federal and state and local government

For these DMUs, the technology appears efficient, but the CRS restriction is too strict: their lower CRS scores mainly reflect scale inefficiency rather than pure technical inefficiency.

Industries with Low CRS and VRS Scores

A few industries remain relatively far from the frontier even under VRS, including:

- Computer and electronic products (CRS ≈ 0.51, VRS ≈ 0.99)
- Broadcasting and telecommunications (CRS ≈ 0.40, VRS ≈ 1.00)
- Air transportation (CRS ≈ 0.59, VRS ≈ 0.99)
- Miscellaneous manufacturing
- Food and beverage and tobacco products

Although these industries often become almost efficient under VRS, the gap between CRS and VRS scores suggests that both scale and non-scale inefficiencies may be present. In other words, these sectors may not only be operating at a non-optimal scale but may also face technological or organizational inefficiencies.

4.3 Peer Sets Under VRS

The VRS model provides, for each DMU, a set of peers—efficient industries that form the reference point for that DMU on the frontier. Table 2 illustrates the structure of peer sets for a subset of industries. The full VRS peer-set table is presented in Appendix B.

Table 2: Illustrative VRS peer sets for selected industries, 2006.

DMU	**Peer Set (VRS)**
Farms	Water transportation; Pipeline transportation; Data processing, internet publishing, and other information services; Management of companies and enterprises; Social assistance
Construction	Nonmetallic mineral products; Furniture and related products; Apparel and leather and allied products; Other transportation and support activities; Management of companies and enterprises; Social assistance
Primary metals	Nonmetallic mineral products; Apparel and leather and allied products; Warehousing and storage; Data processing, internet publishing, and other information services; Securities, commodity contracts, and investments; Accommodation
Retail trade	Nonmetallic mineral products; Furniture and related products; Apparel and leather and allied products; Pipeline transportation; Other transportation and support activities; Social assistance
Broadcasting and telecommunications	Oil and gas extraction; Support activities for mining; Water transportation; Data processing, internet publishing, and other information services; Ambulatory health care services
Real estate	Oil and gas extraction; Support activities for mining; Water transportation; Data processing, internet publishing, and other information services; Ambulatory health care services
Amusements, gambling, and recreation industries	Utilities; Data processing, internet publishing, and other information services; Management of companies and enterprises; Ambulatory health care services; Accommodation

Several patterns emerge. Social assistance, warehousing and storage, management of companies and enterprises, pipeline transportation, and accommodation appear repeatedly as peers, confirming their central role in the benchmark frontier. Inefficient industries frequently "borrow" technology from these robust service and transportation sectors.

4.4 DEA Frontiers Under Six RTS Specifications

The DEA frontiers are estimated using a single normalized input (Intermediate_Input_Index) and the normalized output (Gross_Output_Index) for visualization. In each case, the DEA frontier is plotted in input–output space, with the cloud of industry points and the estimated frontier.

Figure 1: CRS frontier

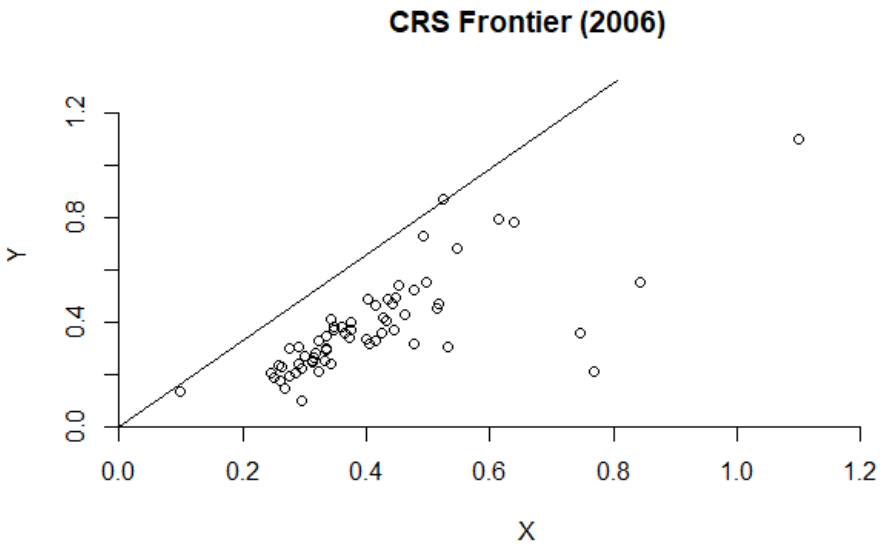

Figure 1: CRS DEA frontier for 2006 U.S. KLEMS industries (Intermediate input vs. gross output).

Figurer 2: DRS frontier

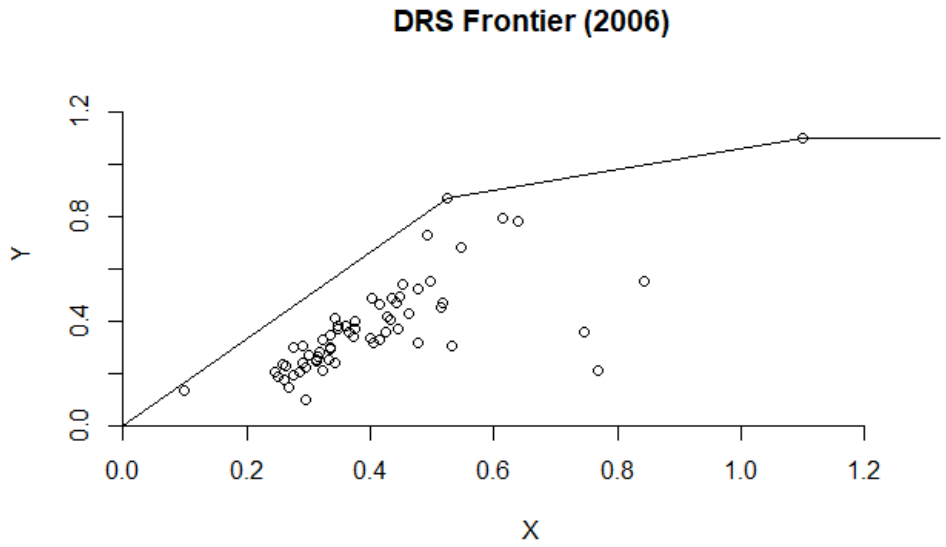

Figure 2: DRS DEA frontier for 2006 U.S. KLEMS industries.

Figure 3: IRS frontier

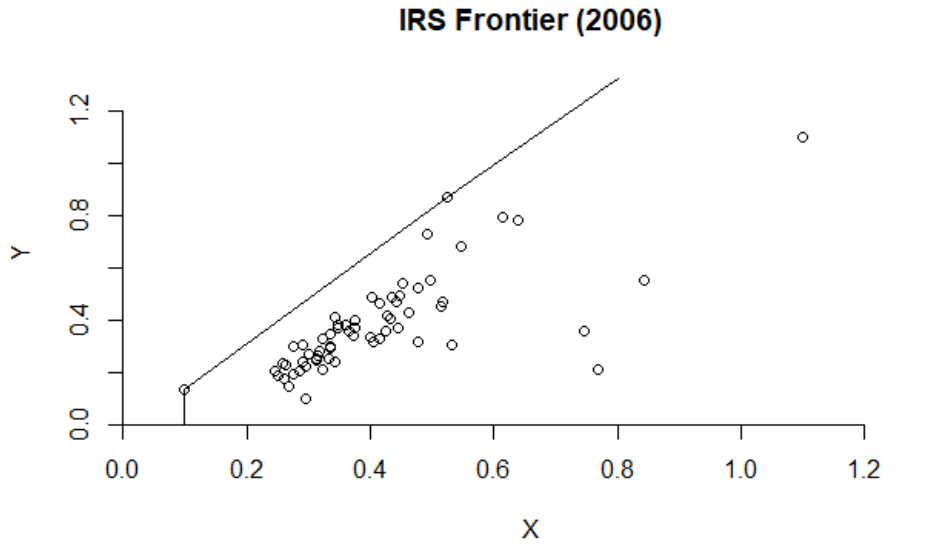

Figure 3: IRS DEA frontier for 2006 U.S. KLEMS industries.

Figure 4: VRS frontier

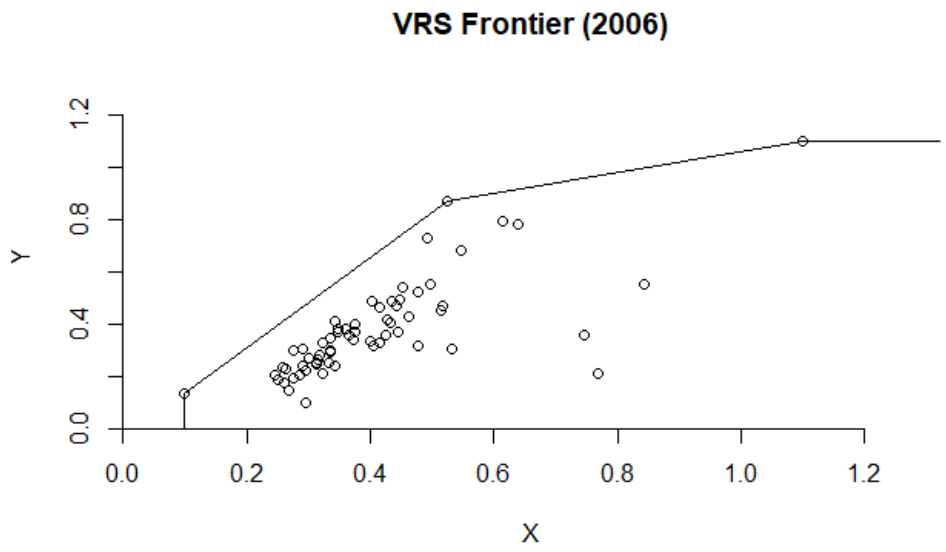

Figure 4: VRS DEA frontier (piecewise linear) for 2006 U.S. KLEMS industries.

Figure 5: FDH frontier

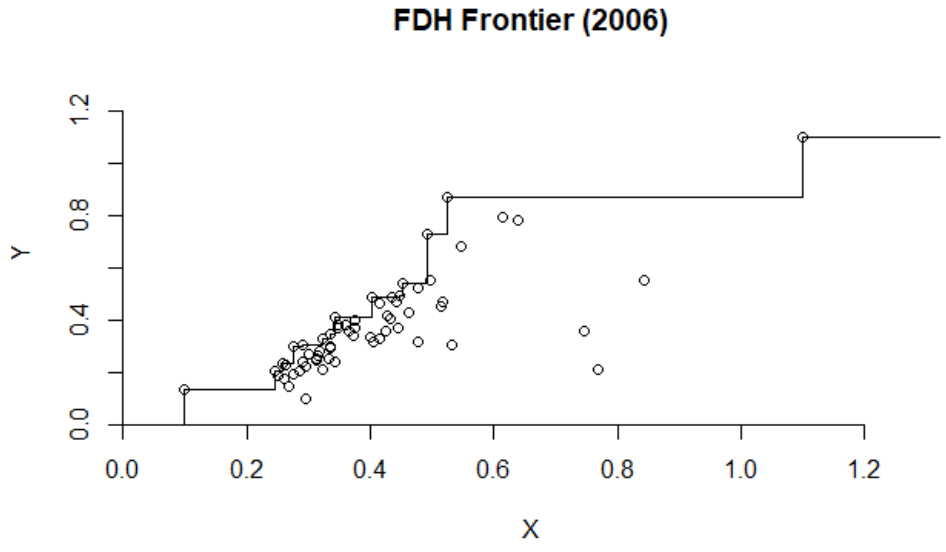

Figure 5: FDH DEA frontier (non-convex, stepwise) for 2006 U.S. KLEMS industries.

Figure 6: ADD Frontier

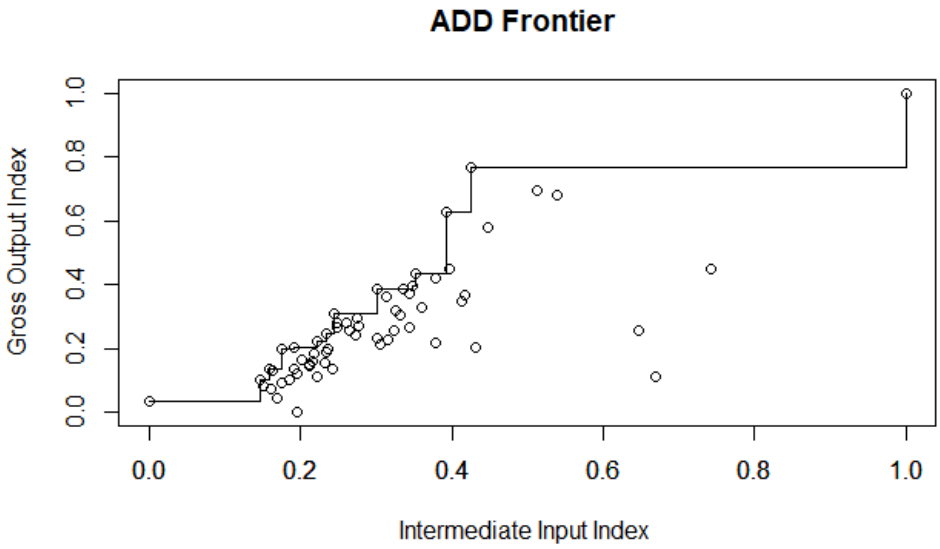

Figure 6: ADD frontier plotted step frontier (Intermediate input vs. gross output).

The CRS frontier appears as a relatively smooth envelope, whereas the VRS frontier bends to follow the data more closely. IRS and DRS frontiers emphasize segments where industries exhibit increasing or decreasing returns, respectively. The FDH frontier is a stepwise, non-convex boundary, while the ADD pseudo-frontier reflects both radial contraction and slack adjustments.

4.5 Overall Efficiency Patterns

The results reveal substantial variation in efficiency across industries. The CRS model—which imposes the strong assumption that output must rise proportionally with inputs—classifies only nine DMUs as fully efficient. These industries tend to represent either highly optimized manufacturing processes (wood products, furniture, textiles, apparel, and motor vehicles) or highly specialized service activities (pipeline transportation, motion picture and sound recording industries, and accommodation services).

Under VRS, however, efficiency improves dramatically. More than half of the

industries are identified as efficient. This widening of the efficient set indicates that many industries suffer not from technical inefficiency, but from operating at a non-optimal scale. For example, industries such as educational services, ambulatory health care, hospitals, social assistance, and several financial services appear efficient once variable returns to scale are allowed.

The FDH and ADD models classify nearly all industries as efficient, which is consistent with their flexible, non-convex, and slack-permissive frontier structures. FDH is known to expand the frontier more aggressively than DEA owing to its non-convexity; ADD captures slack-based inefficiencies that, under scaling, often collapse to zero.

4.6 Comparing CRS, VRS, IRS, and DRS

The differences between CRS and VRS scores highlight substantial scale effects.

- Under CRS, efficiency scores reflect both technical and scale inefficiency.
- Under VRS, efficiency scores reflect pure technical efficiency, holding scale constant.

Industries that are efficient under VRS but not under CRS can be viewed as technically efficient but scale-inefficient. This pattern is common in many service industries where operations are fragmented across units, regions, or product lines.

IRS and DRS models further clarify the nature of scale effects. For sectors showing IRS, marginal productivity increases with size; these industries benefit from expanding their scale of operation. For sectors showing DRS, the opposite holds: further expansion may reduce efficiency due to managerial complexity, coordination costs, or technological limits.

4.7 Economically Efficient Industries

Several industries stand out as structurally efficient across multiple DEA specifications:

- **Wood products and furniture manufacturing** show robust efficiency, likely reflecting mature production processes, efficient use of material inputs, and relatively stable demand.

- **Apparel and textile mills** remain efficient despite competitive pressures and globalization, suggesting lean production and effective input utilization.

- **Motor vehicles, bodies and trailers, and parts** appears as a key benchmark sector, indicating tight integration of capital, labor, and supply chain processes.

- **Pipeline transportation, accommodation, and motion picture and sound recording industries** appear consistently on the frontier, highlighting the potential of specialized service industries to achieve high efficiency.

These industries serve as benchmarks for others, as confirmed by their recurring presence in VRS peer sets.

4.8 Industries with Persistent Inefficiency

Three industry groups consistently exhibit lower performance under DEA:

- **Electronics and computer manufacturing:** Despite high output and heavy investment in IT and R&D capital, this sector shows relatively low CRS efficiency. Rapid technological obsolescence, complex global supply chains, and high fixed costs may create structural inefficiencies.

- **Broadcasting and telecommunications:** This sector exhibits one of the lowest CRS scores in the dataset. Market fragmentation, legacy infrastructure, regulatory constraints, and intense competition can all contribute to input over-utilization relative to output.

- **Air transportation:** Air transport faces high fixed costs, strong safety and regulatory requirements, and volatile demand. These factors can cause both scale and technical inefficiencies.

While these industries often approach efficiency under VRS, the gap between CRS and VRS scores suggests that both technological improvements and structural reforms (mergers, consolidation, or reconfiguration) may be warranted.

4.9 Peer-Set Patterns and Benchmark Roles

The peer-set analysis reveals that a relatively small group of industries serve as benchmarks for many others under VRS. In particular:

- Social assistance
- Warehousing and storage
- Management of companies and enterprises
- Pipeline transportation
- Accommodation
- Data processing, internet publishing, and other information services

These sectors appear repeatedly in the peer sets of inefficient industries. This pattern indicates that they manage to combine input bundles in a particularly productive way. For example, warehousing and storage, with its strong presence as a peer for metals, chemicals, and services, likely reflects efficient logistics, capacity utilization, and labor management.

Peer sets thus provide a concrete menu of benchmark industries for policymakers and managers seeking performance improvements.

4.10 Managerial Implications

From a managerial perspective, the DEA results suggest several actionable lessons:

- **Input reduction:** Industries with low CRS and VRS scores should assess intermediate input usage, capital allocation, and labor productivity. DEA identifies how far they are from the frontier and which peers to emulate.
- **Scale decisions:** Many industries are efficient under VRS but not CRS. For such sectors, the main efficiency gains may come from adjusting scale: consolidating operations, expanding facilities, or restructuring production lines.
- **Learning from peers:** Because peer sets identify specific benchmark industries, managers can undertake targeted benchmarking studies, focusing on operational practices, technology adoption, and organizational structures used by those peers.

4.11 Policy Implications

At the policy level, several insights emerge:

- **Support for lagging sectors:** Persistent inefficiency in sectors like broadcasting, electronics, and air transportation may justify limited, targeted policy interventions aimed at modernization, innovation, or competition policy reform.
- **Strengthening productivity anchors:** Efficient industries that serve as peers for many others—such as warehousing, social assistance, and data-processing sectors—can be viewed as productivity anchors. Policies that facilitate knowledge diffusion and collaboration with these sectors may have spillover benefits.
- **Encouraging optimal scale:** Policy instruments (e.g., infrastructure investments, regulatory reforms) can help sectors operating under strong IRS to expand toward MPSS, particularly in information, financial, and educational services.

4.12 Limitations and Directions for Future Work

This study has several limitations:

- It focuses on a single year (2006). Extending the analysis to multiple years could reveal dynamic efficiency and productivity trends.
- The model uses a single output measure (gross output index), whereas many industries jointly produce multiple types of output (e.g., quality-adjusted services, intangible outputs).
- DEA is deterministic and does not explicitly account for statistical noise or measurement error. Complementary methods such as Stochastic Frontier Analysis (SFA) could provide robustness checks.

Despite these limitations, the analysis provides a rich cross-sectional snapshot of U.S. industry efficiency and offers a useful starting point for future research on productivity dynamics in the U.S. KLEMS framework.

5 Conclusion

This study applied input-oriented DEA to evaluate the efficiency of 63 U.S. industries in 2006 using the U.S. KLEMS dataset. By estimating efficiency scores under multiple RTS assumptions (CRS, VRS, IRS, DRS, FDH, and ADD) and analyzing peer structures, the results provide a clear snapshot of industry-level productivity just before the global financial crisis.

A consistent group of industries—including support activities for mining, wood products, furniture, motor vehicles, textiles, apparel, pipeline transportation, motion picture and sound recording industries, and accommodation—appear efficient across CRS and VRS, forming the core benchmark frontier. Many service industries become efficient only under VRS, indicating that they operate with sound technology but at non-optimal scales. In

contrast, sectors such as computer and electronic products, broadcasting and telecommunications, and air transportation exhibit persistent inefficiencies, suggesting opportunities for input reduction or structural improvement.

Peer-set analysis shows that social assistance, warehousing and storage, accommodation, and management of companies frequently serve as reference peers, highlighting their strong input–output performance. These industries represent practical benchmarks for cost control, labor allocation, and capital utilization.

The ADD model yields an efficiency score of one for all industries, reflecting the combined effect of min–max scaling, a dense PPS, and the slack-based nature of the model. As a result, ADD should be viewed as an upper-bound benchmark rather than a discriminating ranking of performance.

Overall, the findings offer useful insights for managers and policymakers. Efficient industries demonstrate best-practice input combinations, while inefficient industries can use peer comparisons to identify improvement strategies. Although this study is limited to one year and one output measure, future work could incorporate multiple years, additional outputs, and alternative frontier models such as SFA to obtain a more comprehensive view of productivity dynamics.

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A Full DEA Efficiency Scores for All 63 Industries (2006)

Table 3: DEA efficiency scores (CRS, VRS, DRS, IRS, FDH, ADD) for all 63 industries, 2006.

Industry	**CRS**	**VRS**	**DRS**	**IRS**	**FDH**	**ADD**
Farms	0.6163	0.9952	0.6163	0.9952	1.0000	1.0000
Forestry, fishing, and related activities	0.8917	0.9982	0.8917	0.9982	1.0000	1.0000
Oil and gas extraction	0.9554	1.0000	0.9554	1.0000	1.0000	1.0000
Mining, except oil and gas	0.9647	1.0000	0.9647	1.0000	1.0000	1.0000
Support activities for mining	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Utilities	0.9662	1.0000	0.9662	1.0000	1.0000	1.0000
Construction	0.7837	0.9957	0.7837	0.9957	1.0000	1.0000
Wood products	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Nonmetallic mineral products	0.9597	1.0000	0.9597	1.0000	1.0000	1.0000
Primary metals	0.8209	0.9937	0.8209	0.9937	1.0000	1.0000
Fabricated metal products	0.8056	0.9981	0.8056	0.9981	1.0000	1.0000
Machinery	0.7218	0.9979	0.7218	0.9979	1.0000	1.0000
Computer and electronic products	0.5107	0.9933	0.5107	0.9933	1.0000	1.0000
Electrical equipment, appliances, and components	0.9063	0.9984	0.9063	0.9984	1.0000	1.0000
Motor vehicles, bodies and trailers, and parts	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Other transportation equipment	0.8120	1.0000	0.8120	1.0000	1.0000	1.0000

Table 3 (continued)

Industry	CRS	VRS	DRS	IRS	FDH	ADD
Furniture and related products	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Miscellaneous manufacturing	0.5791	0.9950	0.5791	0.9950	1.0000	1.0000
Food and beverage and tobacco products	0.5597	0.9979	0.5597	0.9979	1.0000	1.0000
Textile mills and textile product mills	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Apparel and leather and allied products	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Paper products	0.6625	0.9969	0.6625	0.9969	1.0000	1.0000
Printing and related support activities	0.7554	0.9963	0.7554	0.9963	1.0000	1.0000
Petroleum and coal products	0.7423	0.9985	0.7423	0.9985	1.0000	1.0000
Chemical products	0.6346	0.9975	0.6346	0.9975	1.0000	1.0000
Plastics and rubber products	0.9669	1.0000	0.9669	1.0000	1.0000	1.0000
Wholesale trade	0.8606	0.9968	0.8606	0.9968	1.0000	1.0000
Retail trade	0.6103	0.9986	0.6103	0.9986	1.0000	1.0000
Air transportation	0.5942	0.9940	0.5942	0.9940	0.9969	1.0000
Rail transportation	0.9078	1.0000	0.9078	1.0000	1.0000	1.0000
Water transportation	0.3693	1.0000	0.3693	1.0000	1.0000	1.0000
Truck transportation	0.6806	0.9982	0.6806	0.9982	1.0000	1.0000
Transit and ground passenger transportation	0.6352	0.9998	0.6352	0.9998	1.0000	1.0000
Pipeline transportation	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 3 (continued)

Industry	CRS	VRS	DRS	IRS	FDH	ADD
Other transportation and support activities	0.6692	1.0000	0.6692	1.0000	1.0000	1.0000
Warehousing and storage	0.6668	1.0000	0.6668	1.0000	1.0000	1.0000
Publishing industries, except internet (includes software)	0.5050	0.9964	0.5050	0.9964	1.0000	1.0000
Motion picture and sound recording industries	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Broadcasting and telecommunications	0.3983	0.9954	0.3983	0.9954	0.9962	1.0000
Data processing, internet publishing, and other information services	0.8201	1.0000	0.8201	1.0000	1.0000	1.0000
Federal Reserve banks, credit intermediation, and related activities	0.4623	0.9918	0.4623	0.9918	1.0000	1.0000
Securities, commodity contracts, and investments	0.8960	1.0000	0.8960	1.0000	1.0000	1.0000
Insurance carriers and related activities	0.5396	0.9976	0.5396	0.9976	1.0000	1.0000
Funds, trusts, and other financial vehicles	0.6838	1.0000	0.6838	1.0000	1.0000	1.0000
Real estate	0.5363	0.9955	0.5363	0.9955	1.0000	1.0000
Rental and leasing services and lessors of intangible assets	0.6373	0.9936	0.6373	0.9936	0.9998	1.0000

Table 3 (continued)

Industry	CRS	VRS	DRS	IRS	FDH	ADD
Legal services	0.6218	0.9939	0.6218	0.9939	1.0000	1.0000
Computer systems design and related services	0.5552	1.0000	0.5552	1.0000	1.0000	1.0000
Miscellaneous professional, scientific, and technical services	0.5317	0.9965	0.5317	0.9965	1.0000	1.0000
Management of companies and enterprises	0.9525	1.0000	0.9525	1.0000	1.0000	1.0000
Administrative and support services	0.5428	0.9939	0.5428	0.9939	1.0000	1.0000
Waste management and remediation services	0.8496	0.9992	0.8496	0.9992	1.0000	1.0000
Educational services	0.5215	1.0000	0.5215	1.0000	1.0000	1.0000
Ambulatory health care services	0.4889	1.0000	0.4889	1.0000	1.0000	1.0000
Hospitals and Nursing and residential care	0.5457	1.0000	0.5457	1.0000	1.0000	1.0000
Social assistance	0.5570	1.0000	0.5570	1.0000	1.0000	1.0000
Performing arts, spectator sports, museums, and related activities	0.5481	0.9986	0.5481	0.9986	1.0000	1.0000
Amusements, gambling, and recreation industries	0.5376	0.9967	0.5376	0.9967	1.0000	1.0000
Accommodation	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Food services and drinking places	0.7612	0.9989	0.7612	0.9989	1.0000	1.0000
Other services, except government	0.6979	1.0000	0.6979	1.0000	1.0000	1.0000

Table 3 (continued)

Industry	**CRS**	**VRS**	**DRS**	**IRS**	**FDH**	**ADD**
Federal	0.6364	1.0000	0.6364	1.0000	1.0000	1.0000
State and local	0.7019	1.0000	0.7019	1.0000	1.0000	1.0000

B Full VRS Peer Sets for All 63 Industries

Table 4: Peer sets under VRS technology (input-oriented, 2006).

DMU	**Peer Set**
Farms	Water transportation; Pipeline transportation; Data processing, internet publishing, and other information services; Management of companies and enterprises; Social assistance
Forestry, fishing, and related activities	Support activities for mining; Utilities; Furniture and related products; Apparel and leather and allied products; Pipeline transportation; Management of companies and enterprises; Social assistance; Accommodation
Oil and gas extraction	Oil and gas extraction
Mining, except oil and gas	Mining, except oil and gas
Support activities for mining	Support activities for mining
Utilities	Utilities
Construction	Nonmetallic mineral products; Furniture and related products; Apparel and leather and allied products; Other transportation and support activities; Management of companies and enterprises; Social assistance
Wood products	Wood products
Nonmetallic mineral products	Nonmetallic mineral products

Table 4 (continued)

DMU	Peer Set
Primary metals	Nonmetallic mineral products; Apparel and leather and allied products; Warehousing and storage; Data processing, internet publishing, and other information services; Securities, commodity contracts, and investments; Accommodation
Fabricated metal products	Nonmetallic mineral products; Furniture and related products; Other transportation and support activities; Data processing, internet publishing, and other information services; Securities, commodity contracts, and investments; Social assistance
Machinery	Nonmetallic mineral products; Apparel and leather and allied products; Pipeline transportation; Other transportation and support activities; Social assistance
Computer and electronic products	Oil and gas extraction; Support activities for mining; Water transportation; Warehousing and storage; Social assistance
Electrical equipment, appliances, and components	Support activities for mining; Furniture and related products; Apparel and leather and allied products; Securities, commodity contracts, and investments; Social assistance; Accommodation
Motor vehicles, bodies and trailers, and parts	Motor vehicles, bodies and trailers, and parts
Other transportation equipment	Other transportation equipment

Table 4 (continued)

DMU	Peer Set
Furniture and related products	Furniture and related products
Miscellaneous manufacturing	Support activities for mining; Pipeline transportation; Other transportation and support activities; Warehousing and storage; Data processing, internet publishing, and other information services; Social assistance
Food and beverage and tobacco products	Support activities for mining; Pipeline transportation; Other transportation and support activities; Warehousing and storage; Data processing, internet publishing, and other information services; Social assistance
Textile mills and textile product mills	Textile mills and textile product mills
Apparel and leather and allied products	Apparel and leather and allied products
Paper products	Apparel and leather and allied products; Other transportation and support activities; Data processing, internet publishing, and other information services; Securities, commodity contracts, and investments; Social assistance; Accommodation
Printing and related support activities	Nonmetallic mineral products; Apparel and leather and allied products; Warehousing and storage; Data processing, internet publishing, and other information services; Securities, commodity contracts, and investments; Social assistance

Table 4 (continued)

DMU	Peer Set
Petroleum and coal products	Support activities for mining; Warehousing and storage; Data processing, internet publishing, and other information services; Accommodation
Chemical products	Apparel and leather and allied products; Pipeline transportation; Other transportation and support activities; Warehousing and storage; Social assistance; Accommodation
Plastics and rubber products	Plastics and rubber products
Wholesale trade	Support activities for mining; Apparel and leather and allied products; Pipeline transportation; Management of companies and enterprises; Social assistance
Retail trade	Nonmetallic mineral products; Furniture and related products; Apparel and leather and allied products; Pipeline transportation; Other transportation and support activities; Social assistance
Air transportation	Pipeline transportation; Other transportation and support activities; Data processing, internet publishing, and other information services
Rail transportation	Rail transportation
Water transportation	Water transportation
Truck transportation	Furniture and related products; Apparel and leather and allied products; Pipeline transportation; Other transportation and support activities; Accommodation

Table 4 (continued)

DMU	Peer Set
Transit and ground passenger transportation	Pipeline transportation; Warehousing and storage; Management of companies and enterprises; Accommodation
Pipeline transportation	Pipeline transportation
Other transportation and support activities	Other transportation and support activities
Warehousing and storage	Warehousing and storage
Publishing industries, except internet (includes software)	Support activities for mining; Pipeline transportation; Other transportation and support activities; Warehousing and storage; Data processing, internet publishing, and other information services; Social assistance
Motion picture and sound recording industries	Motion picture and sound recording industries
Broadcasting and telecommunications	Oil and gas extraction; Support activities for mining; Water transportation; Data processing, internet publishing, and other information services; Ambulatory health care services
Data processing, internet publishing, and other information services	Data processing, internet publishing, and other information services

Table 4 (continued)

DMU	Peer Set
Federal Reserve banks, credit intermediation, and related activities	Support activities for mining; Water transportation; Pipeline transportation; Data processing, internet publishing, and other information services; Ambulatory health care services; Social assistance
Securities, commodity contracts, and investments	Securities, commodity contracts, and investments
Insurance carriers and related activities	Support activities for mining; Pipeline transportation; Other transportation and support activities; Warehousing and storage; Data processing, internet publishing, and other information services; Ambulatory health care services
Funds, trusts, and other financial vehicles	Funds, trusts, and other financial vehicles
Real estate	Oil and gas extraction; Support activities for mining; Water transportation; Data processing, internet publishing, and other information services; Ambulatory health care services
Rental and leasing services and lessors of intangible assets	Pipeline transportation; Other transportation and support activities; Warehousing and storage; Securities, commodity contracts, and investments; Social assistance

Table 4 (continued)

DMU	Peer Set
Legal services	Support activities for mining; Apparel and leather and allied products; Pipeline transportation; Other transportation and support activities; Warehousing and storage; Social assistance
Computer systems design and related services	Computer systems design and related services
Miscellaneous professional, scientific, and technical services	Support activities for mining; Pipeline transportation; Warehousing and storage; Data processing, internet publishing, and other information services; Management of companies and enterprises; Ambulatory health care services; Social assistance
Management of companies and enterprises	Management of companies and enterprises
Administrative and support services	Support activities for mining; Pipeline transportation; Other transportation and support activities; Warehousing and storage; Data processing, internet publishing, and other information services; Social assistance
Waste management and remediation services	Support activities for mining; Utilities; Water transportation; Pipeline transportation; Data processing, internet publishing, and other information services; Social assistance
Educational services	Educational services

Table 4 (continued)

DMU	Peer Set
Ambulatory health care services	Ambulatory health care services
Hospitals and Nursing and residential care	Hospitals and Nursing and residential care
Social assistance	Social assistance
Performing arts, spectator sports, museums, and related activities	Other transportation and support activities; Warehousing and storage; Data processing, internet publishing, and other information services; Securities, commodity contracts, and investments; Management of companies and enterprises
Amusements, gambling, and recreation industries	Utilities; Data processing, internet publishing, and other information services; Management of companies and enterprises; Ambulatory health care services; Accommodation
Accommodation	Accommodation
Food services and drinking places	Utilities; Pipeline transportation; Other transportation and support activities; Data processing, internet publishing, and other information services; Management of companies and enterprises
Other services, except government	Other services, except government
Federal	Federal
State and local	State and local