Measuring the industrial sector at the Federal Reserve Board

"Blended" data before it was cool

Industrial Output Section / presented by Ryan Decker

Federal Reserve Board

February 20, 2025

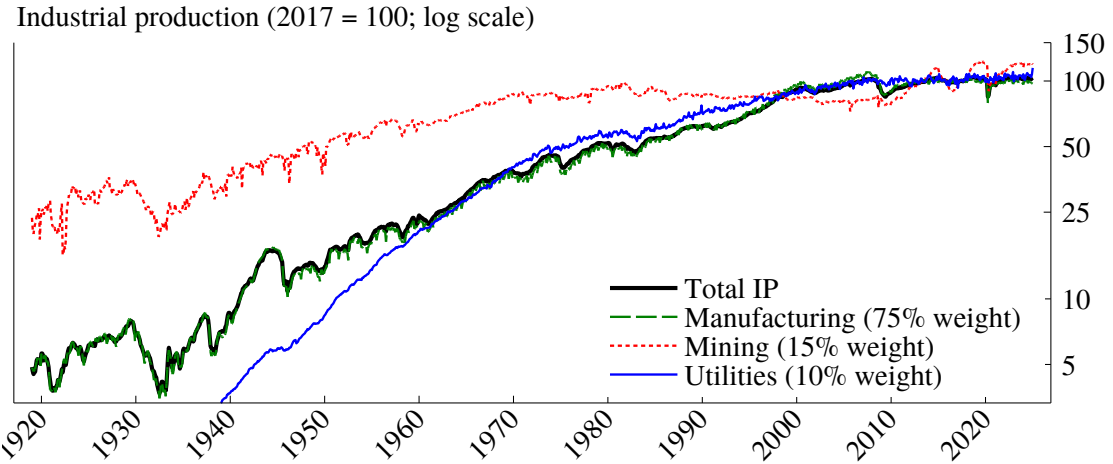
The analysis and conclusions set forth are those of the authors and do not indicate concurrence by other members of the research staff or the Board of Governors of the Federal Reserve System.

First: An overview of the Industrial Output section

The Industrial Output section at the Federal Reserve Board

- Heavy focus on measurement; many Census data users
- Three areas of focus:
  - Produce the monthly G.17 Industrial Production and Capacity Utilization statistic *(Group manager: Robert Kurtzman)*
  - Contribute to Board staff analysis and forecasting of the industrial sector *(Group manager: Maria Tito)*
  - The Board's Expanded Measurement Agenda: Evaluate "nontraditional" data and build products (all sectors!) for improving economic analysis and forecasts *(Group manager: Tomaz Cajner)*

The industrial sector: Manufacturing, mining, utilities

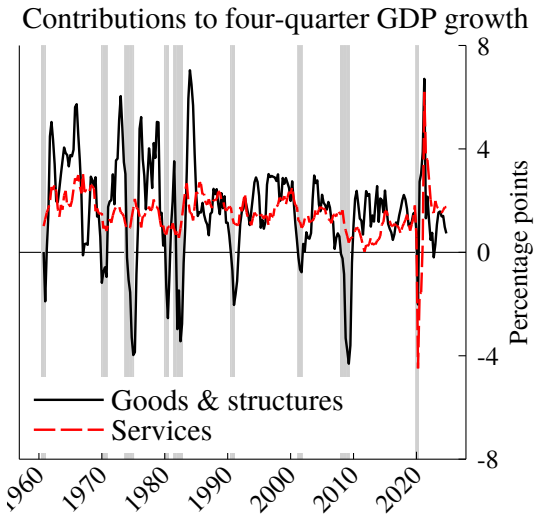


Source: Federal Reserve Board.

Overview

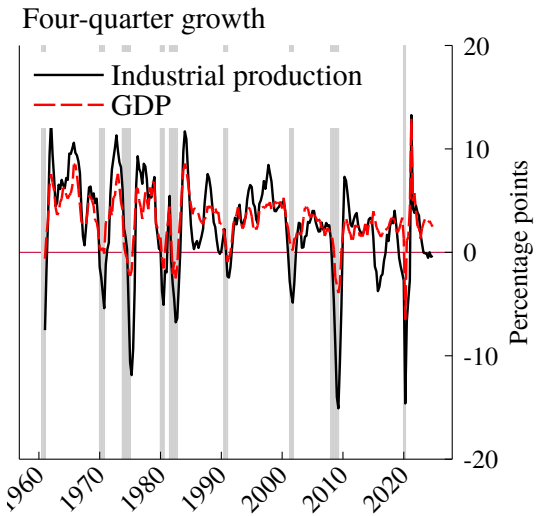
Why the industrial sector matters

The industrial sector is volatile and cyclical



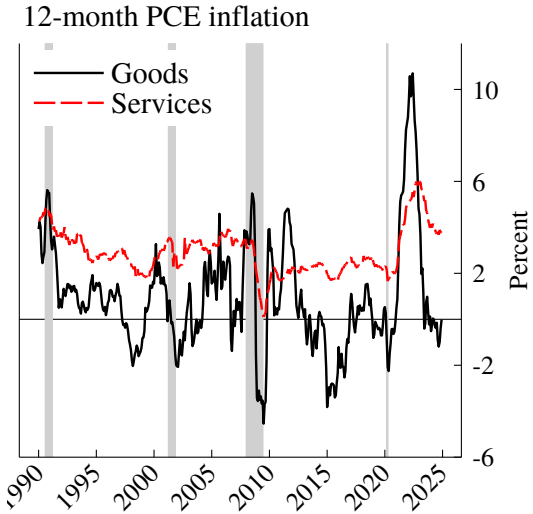
- Outside of goods production, real output is relatively stable. *Recessions are physical goods phenomena!*

Industrial production is "high beta"



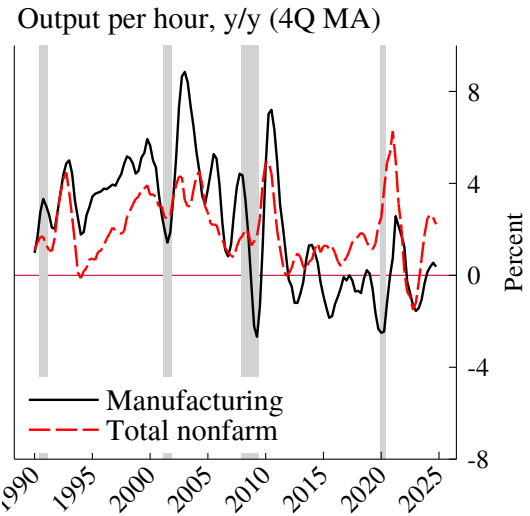
- Industrial production is more cyclical than GDP; total IP is used by the NBER for business cycle dating.
- The goods economy is a focal point for broader phenomena:
  - Inventory investment swings, supply chain congestion, national security debates, trade policy, etc.

Industrial sector as focal point: Inflation



- Goods inflation is volatile; services is boring.
- Pandemic inflation from goods supply shocks [Braun et al., 2024] and supply chain congestion [Soto, 2023]

Industrial sector as focal point: Productivity



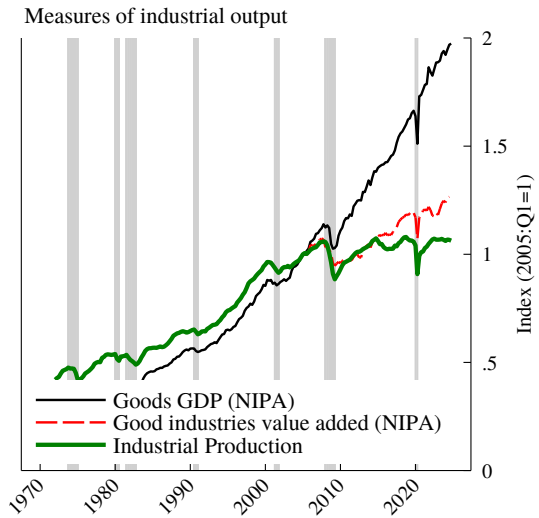
- Manufacturing was important for the last productivity boom (esp. durables)... and slowdown
  - Manufacturing productivity relative to rest of economy peaked just before the Great Recession
- Manufacturing features disproportionate share of aggregate R&D. "The sector is a core source of technological progress" [Syverson, 2016]
- (Some parts of) manufacturing may be rapidly adopting AI [Soto, 2025]. And they have robots [Zolas et al., 2020]

Industrial sector as focal point: Other considerations

- Jobs: Manufacturing jobs have historically commanded a wage premium... since diminished [Bayard et al., 2024]; negative industrial sector shocks are costly for workers [Blonz et al., 2023], [Pierce and Schott, 2020].
- Industrial sector features rich data and is focus of enormous literature, e.g.,
  - Industrial production used in large-scale time series nowcasting work [Giannone et al., 2008], GDPNow, etc.
  - Most work on productivity microdata, e.g., [Blackwood et al., 2021]; of course there is great retail trade work too!
  - energy, externality regulation, etc, e.g. [Curtis and Lee, 2019].

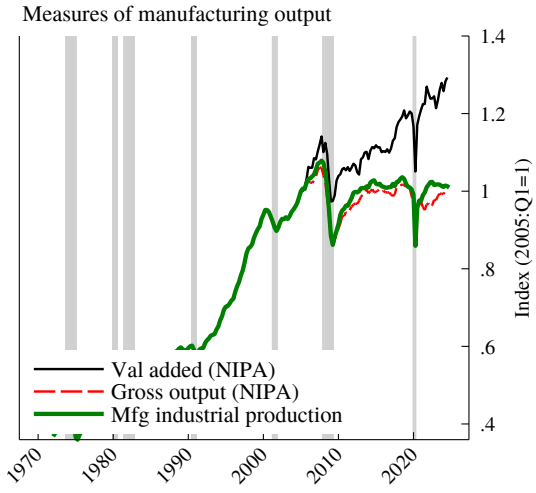
Comparing measures of goods output

Goods GDP and industrial production



- Goods industries' VA and IP have flat/modest growth since GFC, while goods GDP goes up and up
- Goods GDP based on *final purchase* measurement; VA and IP more like *factory gate*
- Increased "services content" embedded in goods value?
  - Gap is concentrated in consumer markets [Tito, 2024]
  - Retail service inputs rose, 2005-2023 (per KLEMS, I-O tables)

Still a value added vs. gross output gap: Manufacturing example



Note: NAICS manufacturing.

- Post GFC: NIPA value added rising while IP and NIPA gross output are both flat...
  - ...implies intermediates' share of gross output declining.
  - Note: Both NIPAs and IP are benchmarked to ASM through 2021.
  - Different measures for different things, but gross output is a view of the whole business supply chain [Skousen, 2024].

G.17 Release on Industrial Production and Capacity Utilization:

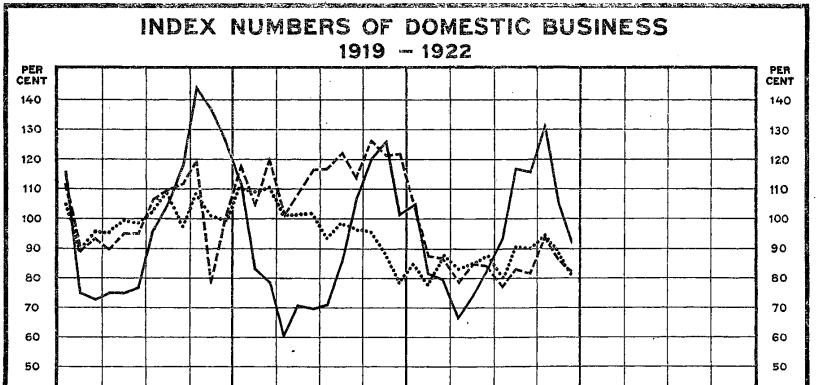
"Rapid changes are now going on in every department of industry in consequence of the reorganization necessary for war and in preparation for future development of trade.... There is thus an increasing need for the development of some method of measuring in an authoritative way changes in business conditions.... It is desired that these indexes be as nearly scientific and authoritative as they can be made."

Federal Reserve Bulletin, 1918, vol. 4

As there is a fundamental difference in these systems of measurement, as well as in the factors measured, no attempt was made to combine these three main groups of commodities.

After each commodity series had been converted into relatives on a base of average monthly activity in 1919 it seemed advisable to summarize the results of the study by grouping together all closely related products (e. g., manufactured foods) and finally to obtain a combined measure for each of the three main groups (e. g., manufactures). Experiments were made with three methods of than the geometric method of averaging. Furthermore, in the averaging of actual figures of production, which on the whole are quite inclusive, there seems no justification for minimizing increases over the base (which would result from the use of the geometric average).

The system of weights was next considered. As the commodities are measured in varying units the best system of determining their relative importance seemed to be their value. Two methods of determining relative value are the use of census statistics of value and the use of market prices. As the census statistics for 1919 have not yet been published in final



What is the industrial production and capacity utilization (IP/CU) system?

- A detailed and integrated system of output, maximum sustainable output, and resource utilization for the industrial sector.
- Industrial production
  - Estimates started in the 1920s with data back to 1919
  - Based on roughly 300 individual industries
  - Since 1972, aggregate series are chain-weighted based on value-added weights to avoid double counting.
- Capacity and capacity utilization
  - Estimates for selected products started in the 1950s; current estimates have data back to 1948.
  - Based on roughly 90 individual industries

What does the IPCU system measure?

- **IP**: A monthly **production index** that represents the level of **real output** in some part of the industrial sector. Output is measured relative to its level in a base year.
- **CAP**: A **capacity index** that represents the level of sustainable maximum production in some part of the industrial sector.
- **CU**: A **capacity utilization rate** that measures the share of capacity used in current production: $CU = 100 \times IP \,/\, CAP$

Publication details

- When: Around the 15th of the month, at 9:15 a.m.
- What: Full-month activity in the month just ended, with updated/revised estimates for the five previous months
- Release consists of:
  - Release text providing a summary of the month's data along with special details of use to data users; e.g., "In January, gains in the output of aircraft and parts contributed 0.2 percentage point to total IP growth following the earlier resolution of a work stoppage at a major aircraft manufacturer."
  - Variety of tables on IP by market and industry group, capacity utilization, and capacity
  - Related material on unit motor vehicle assemblies (table 3), IP diffusion indexes (table 6), gross value of IP (tables 9, 10)
- Revised annually to available benchmarks (ASM/AIES, Economic Censuses, various other sources)

The industry structure of IP/CU

A supply-oriented classification—output is classified by the industry of the producer.

- **Manufacturing industries** (75% of total industry): The mechanical or chemical transformation of materials or substances into new products.
- **Mining industries** (15% of total industry): The extraction of oil, gas, and metals and quarrying.
- **Electric and gas utilities** (10% of total industry): The production and distribution of electricity and the distribution of natural gas.

This is an intuitive classification and is how we receive most of the underlying data.

A different point of view: the market structure of the G.17

A demand-oriented classification–output is classified by the purchaser and how the output is used (think NIPA expenditure categories)

- **Final products and nonindustrial supplies**: Goods that leave the industrial sector
  - **Final products**: Goods absorbed for consumption or investment
    - Consumer goods
    - Business equipment
    - Oil and gas well drilling and manufactured homes (can you guess why this is a group?)
    - Defense and space equipment
  - **Nonindustrial supplies**: Goods used as intermediates outside the industrial sector
    - Construction supplies
    - Business supplies
- **Materials** Intermediates used by the industrial sector
  - Non-energy materials
  - Energy materials

Building an IP index

It is useful to think of an individual IP series at the most detailed industry level as a *monthly index of real output* that combines:

- information from *high-frequency indicators* of production
- *annual benchmark information* on production from Census data (and other data).

Three parts of a monthly IP index

- A **monthly indicator** of activity based on:
  - A "physical product" measure (monthly, sometimes quarterly), **OR**
  - *Output* estimated from a measure of *input*: Production worker hours
- A **correction factor** to align the monthly data to the annual benchmarks. This factor is projected forward past the latest benchmark.
  - Many business statistics products feature such adjustments (CES, MRTS, etc.)
  - For hours-based series, this adjustment takes on some of the contour of the utilization rates in the Quarterly Survey of Plant Capacity (QSPC or QPC), if QSPC data are helpful for forecasting annual revisions. QSPC data available a month after quarter end.
- A **seasonal factor** to remove the predictable seasonal variation
- Sometimes: **Special adjustments** for natural disasters [Bayard et al., 2017], strikes, pandemics (see, e.g., April & May 2020 releases), etc.

Physical product data from all kinds of sources

Physical product data come in all shapes and sizes

- Weekly, monthly, quarterly
- In time for current month estimate, or with a delay of a month, 2 months, etc.
- Dollars (deflated), tons, barrels, kWh, board feet, square yards, cubic feet, units (transistors, bricks, vehicles, tractors, boilers, engines, chips, etc.)

Blending public and private data sources: Source data examples

- ACT Research
- **Alcohol & Tobacco Tax & Trade Bureau**
- American Bearing Manufacturers Assn
- American Bureau of Metal Statistics
- American Chemistry Council
- American Forest & Paper Assn
- American Fuel & Petrochemical Mfgrs
- American Gear Manufacturers Assn
- American Iron & Steel Inst
- Association of American Publishers
- Association of American Railroads
- Association of Home Appliance Mfgrs
- Aviation Week
- Baker Hughes
- Brick Industry Association
- **Bureau of Labor Statistics**
- Can Manufacturers Inst
- Carpet & Rug Inst
- **Census Bureau**
- The Chlorine Inst
- Composite Panel Assn
- Corn Refiners Assn
- Cottonseed Products Assn
- **Department of Agriculture**
- **Department of Energy**

Even more data blending!

- The Engineered Wood Assn
- Fibre Box Assn
- Glass Packaging Institute
- IHS Automotive
- Intl Aluminum Inst
- Intl Sleep Products Assn
- IQVIA
- Manufactured Housing Inst
- The Maple Flooring Mfgrs Assn
- National Marine Mfgrs Assn
- National Oilseed Processors Assn
- Pulp & Paper Products Council
- Recreation Vehicle Industry Assn
- Rubber Mfgrs Assn
- Semiconductor Equip & Materials Intl
- Semiconductor Industry Asson
- **U.S. Geological Survey**
- Ward's Communication

Data flow

Availability of monthly IP data in publication window

Percent of value added (2023)

	month 1	month 2	month 3	month 4	month 5	month 6
Physical product	33	41	51	54	55	55
Hours	44	44	44	44	44	44
Data received	77	85	94	98	99	99
Data estimated	23	15	6	2	1	1

Benchmarking IP

Each year, IP (and capacity) indexes are benchmarked to:

- Incorporate new and revised annual data on output, prices, and value-added proportions
  - Gross output, value added from Census Bureau's ASM (soon AIES). Other sources include Census Bureau's SAS and data from USGS, EIA, and others.
  - Prices from BEA, BLS, FRB.
- Incorporate new monthly or quarterly data that were revised or that arrived too late to be included in the 6-month estimation window
- Update seasonal adjustment factors
- Update the methods used to construct the indexes
- Introduce changes to the industry- or market-group structure of the indexes based on changes to underlying data sources

Consistent industry time series are maintained throughout.

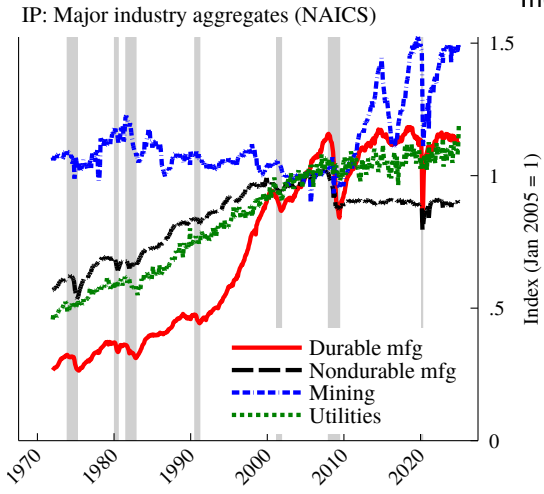
The 2025 benchmark: Unique challenges

This year we will benchmark IP to the 2022 Economic Census and other data. This will require:

- Conversion to 2022 NAICS:
  - In addition to updating benchmark series, the conversaion may require changes to IP industry structure.
  - One challenge in 2022 NAICS is the combination of 511 (publishing except internet), which is an industrial industry, with 51913 (internet publishing), which is not.
- Incorporation of 2017 benchmark input-output tables (used for mapping industries to market groups)
- Incorporation of new data from the 2023 AIES, replacing ASM: changes to format, data availability and time series consistency?

IP Charts!

IP: Industry structure

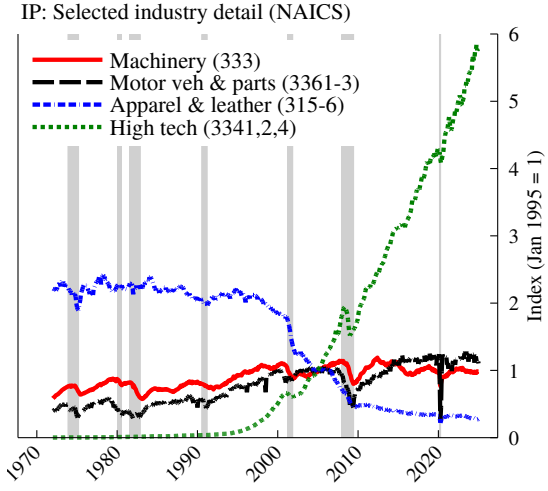


Note: Omits other manufacturing (NAICS 1133, 5111).

Industries categorized on NAICS basis.

- **Durable manufacturing** close to pre-GFC peak, but quite soft recently (35% of IP).
- No post-GFC recovery in **nondurable manufacturing** (35%).
- In **mining**, growth of oil and gas production offsets gradual decline of other mining and downtrend in support activities (15%).
- **Utilities** composed of electricity generation and natural gas distribution (10%).

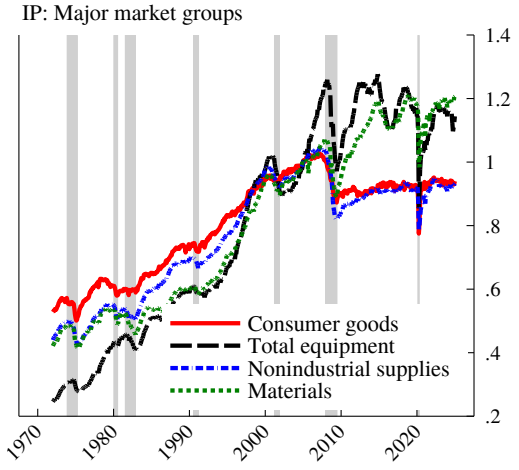
IP: Some industry examples (manufacturing)



Note: High tech is computers, comm. equip., and semicond

- **Machinery**: steady 5-6% of IP since 1990 from 1970s peak above 8%.
- **Motor vehicles and parts**: 5-6% of IP of late; was lower in GFC era and higher in early 2000s.
- **Apparel and leather goods**: close to 0% of IP, down from 4% in early 1970s.
- **High tech**: recent 2% of IP vs. 2000 peak above 8%.

IP: Market group structure

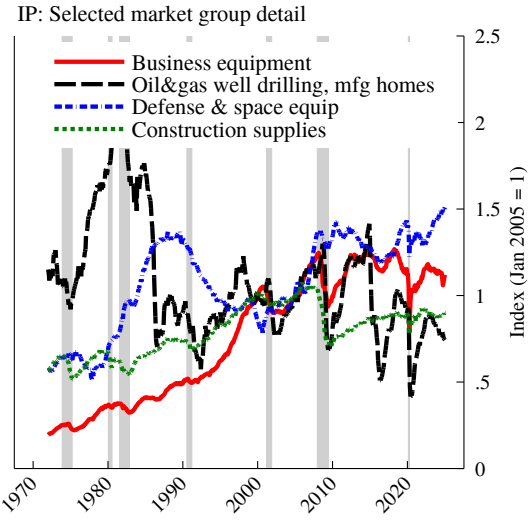


Note: Final products composed of consumer goods, total equipment, and nonindustrial supplies.

Market groups:

- **Final products**
  - **Consumer goods**: 30% of IP.
  - **Total equipment**: 10%
  - **Nonindustrial supplies**: Supplies that exit the industrial sector; 15%.
- **Materials**: Supplies used in the industrial sector; 45%.

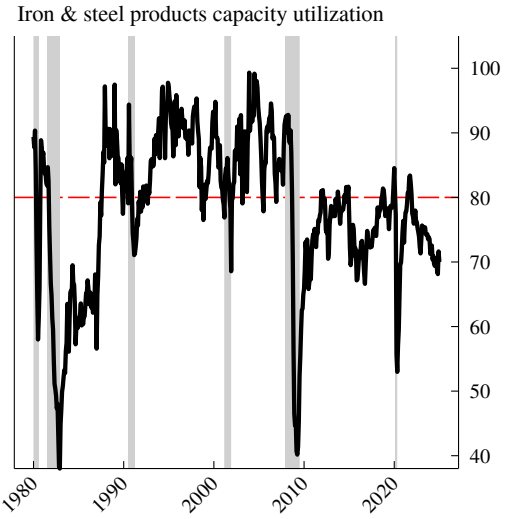
IP: Some market group examples



- **Business equipment**, e.g., motor vehicles, aircraft, railroad stock, ships, computers, machinery, machine tools, electrical equip, etc. 8% of IP.
- **Oil & gas drilling and manufactured homes**: Classic. 1%.
- **Defense & space equipment**, e.g., missiles, military aircraft, ships, small arms, etc. 2%.
- **Construction supplies**, e.g., stone, gravel, lumber, brick, glass, cement, gypsum, steel, etc. 5%.

G.17 Release on Industrial Production and Capacity Utilization: The capacity part

Who cares about capacity utilization? An example



Policymakers care (among others):

- Iron & steel products utilization depressed since the GFC
- The White House as identified steel utilization of 80% as a key target for national security considerations and related trade policy.

Purpose of capacity and capacity utilization measurement

- **Capacity:** Sustainable maximum output—the greatest level of output a plant can maintain within the framework of a realistic work schedule after factoring in normal downtime and assuming sufficient availability of inputs to operate the capital in place.
  - The concept itself generally conforms to that of a full-input point on a production function, with the qualification that capacity represents a *sustainable* maximum.
  - May be different from engineering-based concept of capacity and may be below maximum emergency possibilities
  - Possible to exceed 100% for brief periods
- **Utilization:** Current output relative to capacity
  - A measure of economic slack generally, with historic (but attenuating!) relationship with inflation
  - An indicator of industry-level price pressures and bottlenecks
  - National security implications

We already have our measure of production (IP). To estimate utilization, we need to estimate capacity.

Estimating capacity: Step 1

Obtaining an estimate of "implied capacity" (methodology described in [Gilbert et al., 2000])

- Base on physical units (e.g., mining, steel, motor vehicle assemblies)—about 20% of total
- Base on survey and other data—about 75% of total
  - Obtain end-year self-reported *utilization* rates from the Census Bureau's Quarterly Survey of Plant Capacity (QSPC). Capacity is production (IP) divided by utilization.
- Remaining 5% estimated based on trends through production peaks

Result: end-of-year implied capacity (ICAP), expressed relative to base-year IP.

Estimating capacity: Step 2

Improve ICAP estimates using other indicators of capacity; this can reduce sources of error in the ICAPs. By industry, regress (simplified):

$$ICAP_t = K_t + A_t + u_t$$

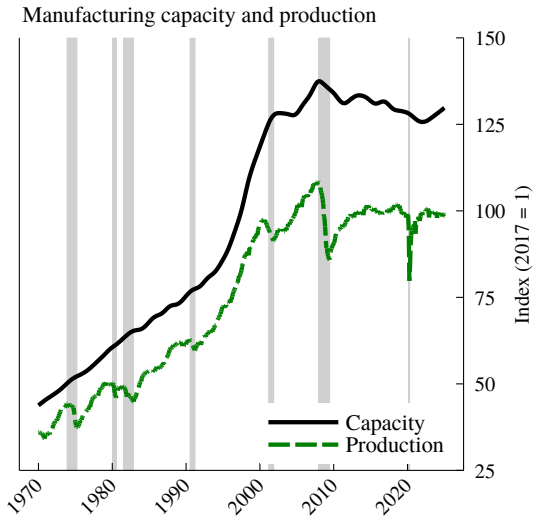
where K_t is an estimate of industry capital services (more on this later) and A_t captures the age profile of the capital stock, all variables in logs. The model is also enhanced with time trends and flexibility for trend breaks or discrete events.

Fitted values from the regression serve as baseline capacity estimates. These RHS variables also provide means for projecting/imputing capacity outside range of ICAP estimates.

Final capacity steps and utilization

- With end-year capacity estimates in hand, construct monthly time series with interpolation (and, for current year, projection).
- Adjust capacity to be consistent with pre-1972 estimates (based on McGraw-Hill/DRI survey), and other housekeeping.
- Create aggregates from industry-level series.
- Calculate utilization as production over capacity.

The results (manufacturing)

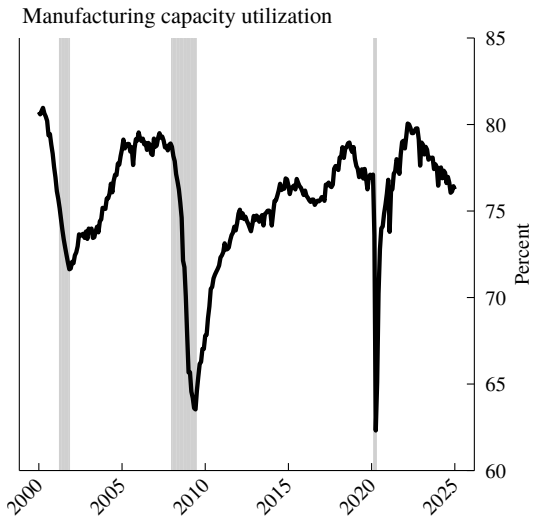


One other thing: Investment and capital stocks

- An important component of capacity estimation is a measure of the flow of services derived from an industry's net stocks of physical assets; see [Kurz and Morin, 2016].
  - Industry-level investment data (ASM, CM)
  - Asset-level investment data (BEA)
  - Perpetual inventory method
- These are made available publicly for the NBER-CES Manufacturing Industry Database [Becker et al., 2013].

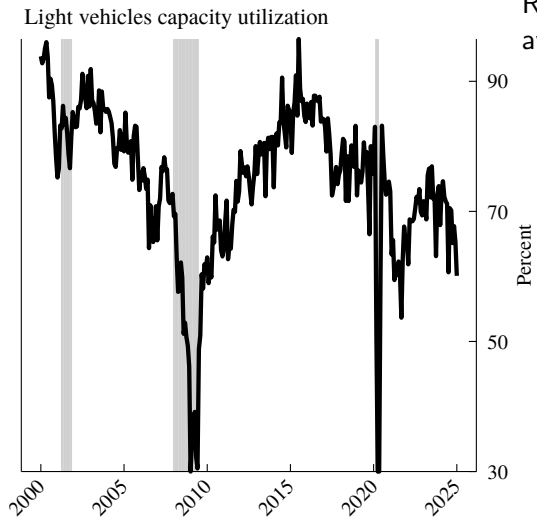
A couple puzzles in recent utilization patterns

Puzzle 1: Why wasn't utilization higher recently?



- Utilization was elevated (relative to recent history) during the post-pandemic supply crisis...
- ... but perhaps not as elevated as one might expect given inflation patterns.
- Considerations:
  - Cross-industry utilization does help make sense of cross-industry inflation.
  - Utilization is not the only slack measure struggling to predict inflation of late (have you heard of the "flat Phillips Curve"?).
  - Utilization is ultimately a *within-plant* object; recent events featured *between-plant* congestion.

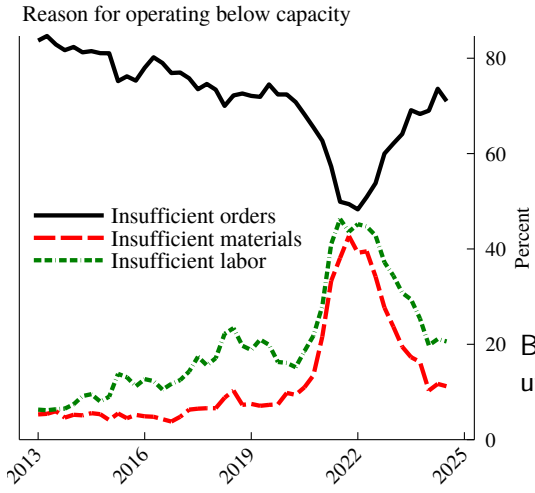
How supply conditions held down utilization



Recall: Capacity estimates assume availability of inputs!

- In the wake of the pandemic, many domestic industries suffered from shortages of key inputs (production is Leontief!... at least in the short run).
- Vehicle production, in particular, suffered from shortages of chips (and other inputs)...
- ... holding down utilization in this industry.
- Shortages of inputs can depress utilization in downstream industries!

From the QSPC: Specific reasons for low utilization

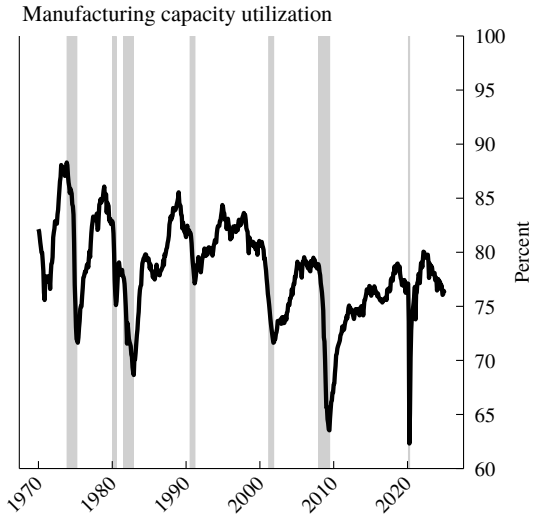


Source: Quarterly Survey of Plant Capacity

- Usually, managers blame weak demand for depressed utilization...
- But during the post-pandemic supply problems, they blamed input shortages.
- Input shortages also help predict price increases [Braun et al., 2024]

But this does complicate the use of capacity utilization for Phillips Curve-style inference!

Puzzle 2: The downtrend in manufacturing utilization



- Secular downtrend is evident...
  - ...with downsteps in recessions.
  - Not shown: Also downtrending in utilities (post-2000) but not mining
- Appears to be happening even within continuing plants (i.e., not an entry/exit phenomenon) and within industries [Pierce and Wisniewski, 2018]

Puzzle 2: Possibilities

Why the trend decline in utilization?

- Tight supply of inputs?
- Capacity distribution, mismatch, stranded assets?
- Lower relative price of capital (vs. holding inventories)? [Bansak et al., 2007]
- Measurement issues (e.g., is capacity increasingly overstated?)

Concluding thoughts

Blended data

- Key concerns about nontraditional and "blended" data
  - **Hold-up problems: what if the data provider stops providing?**
    - This happens to us all the time.
    - It makes us sad. We prefer physical product data—more direct measurement, often full-month measures—but we can always fall back on hours-based estimates.
  - **What are these weird data even measuring?**
    - Our system of benchmarking and, in the meantime, adjusting with QSPC keeps the private sector data on track.
    - Performance in predicting benchmarks helps us decide whether to keep a data source.
- How to do blended data:
  - Embed nontraditional data *in a framework of official data*
  - Have a method for dealing with hold-up problems and data quality issues

Since 1920!

This is my last slide

- The industrial sector continues to matter even as its share of activity has declined.
- The IPCU system provides a rich view into industrial activity.
  - Industry detail
  - End use/market group categorizations
  - Integrated output, capacity, and utilization data
  - Long time series with consistent industries (longer than the LBD! Take that Teresa!)
- Opportunities... and challenges:
  - The IPCU system is "blended data" in action! Perhaps an example for future products across stat agencies.
  - But the system is heavily dependent on specific public and private data sources whose outlook can be, at times, uncertain.
  - Open questions about recent patterns in the data. Services content of goods, changing role for intermediates, trends in utilization, etc.

Thanks!

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