Measuring the industrial sector at the Federal Reserve Board

Blended data before it was cool

Presented by Ryan Decker

Federal Reserve Board

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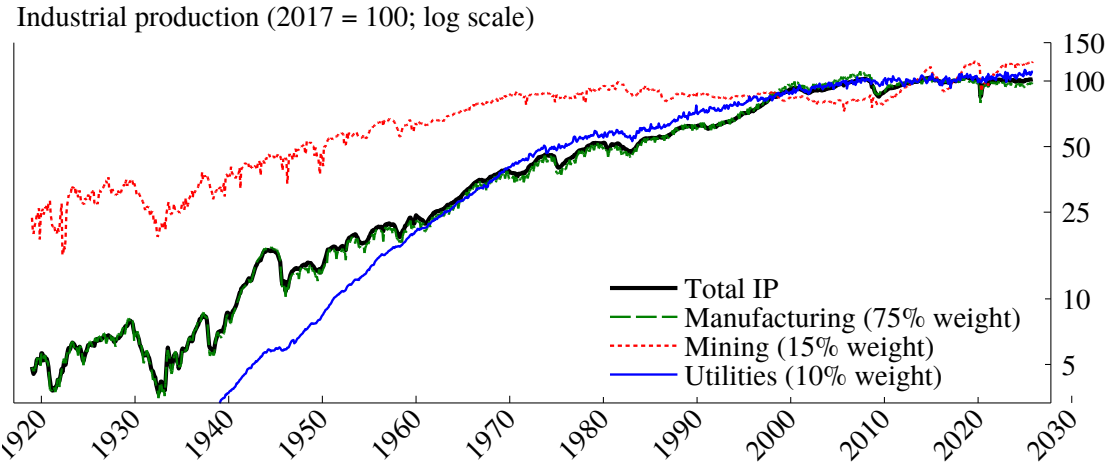
The analysis and conclusions set forth are those of the authors and do not indicate concurrence by other members of the research staff or the Board of Governors of the Federal Reserve System.

The industrial sector: Manufacturing, mining, utilities

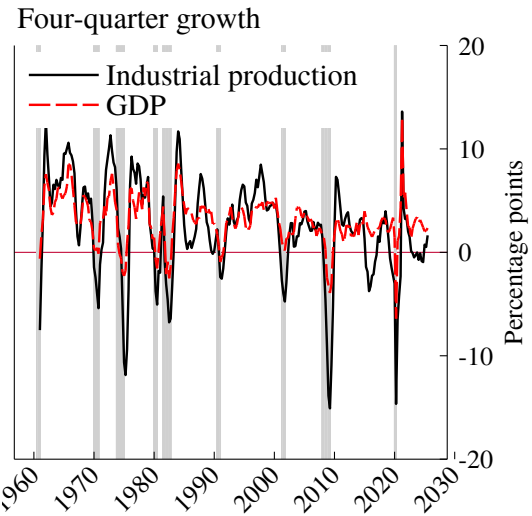


Source: Federal Reserve Board.

Overview

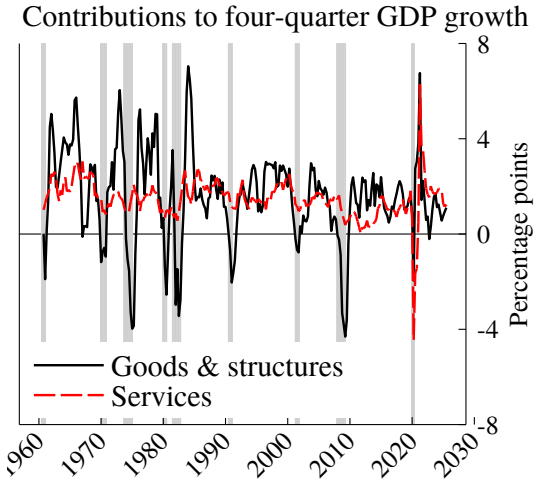
Why the industrial sector matters

Industrial production is "high beta"

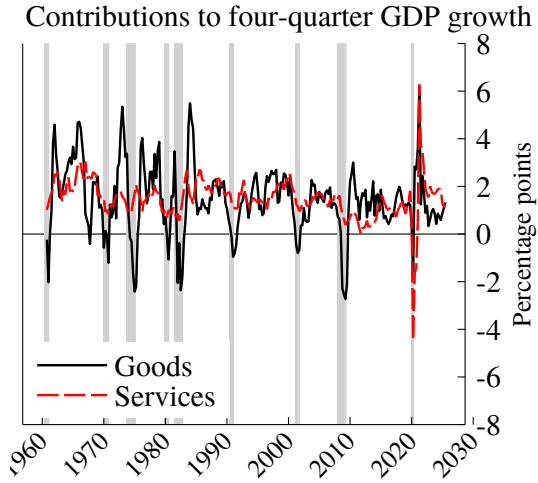


- Industrial production is more "cyclical" than GDP
  - IP swings wildly with broader boom and bust...
  - ... and is one of the NBER's "business cycle" indicators
- More broadly, recessions are a goods economy phenomenon

Recessions are a goods phenomenon



Source: Bureau of Economic Analysis.



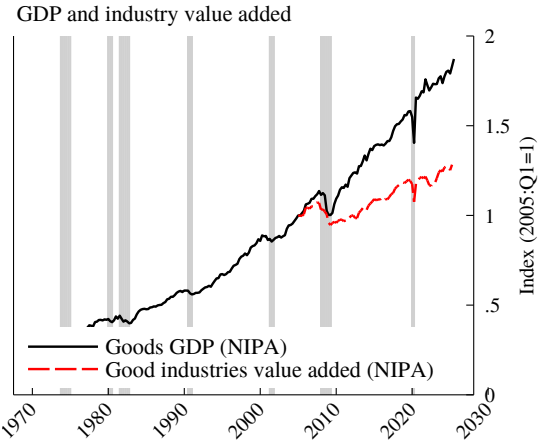
Source: Bureau of Economic Analysis.

The industrial sector is a focal point for broader issues

- Key driver of productivity growth More
- Drives inflation fluctuations More
- High relevance for national security More
- Jobs:
  - Manufacturing jobs have historically commanded a wage premium... since diminished [Bayard et al., 2024]
  - Industrial investment has long-lasting labor market spillovers [Garin and Rothbaum, 2024]; negative industrial sector shocks are costly for workers [Blonz et al., 2023], [Pierce and Schott, 2020]
- AI infrastructure requires enormous quantities of industrial inputs (chips, computers, structures, power)
- Inventory investment swings, supply chain congestion, trade policy, etc.

Comparing measures of goods output

NIPA goods output measures

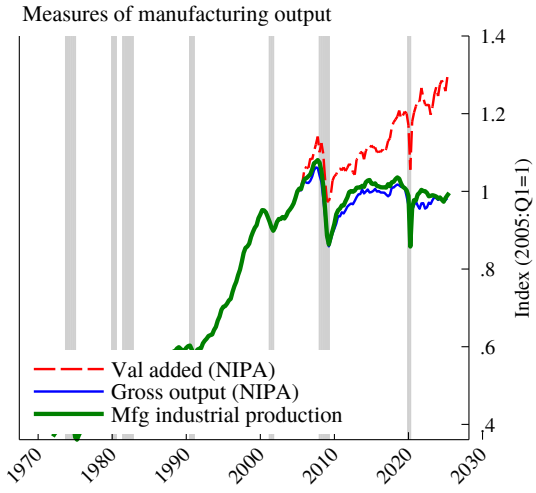


Note: BEA goods GDP less intellectual property products. Goods value added includes natural resources, mining, construction, and manufacturing.

- **Goods GDP**: A subset of GDP based on *final purchases and values*
- **Value added**: Goods output *net of intermediate inputs*, and *valued at the factory gate*
- GDP vs. value added growth gap suggests increased "services content" of goods
  - Input-output tables confirm higher services inputs for goods (see also [Tito, 2024])
  - Value can be added by transportation networks, wholesalers, others (e.g., R&D, see [Ding et al., 2022])

Deflators

Value added versus gross output (manufacturing)



Note: NAICS manufacturing.

- **Value added** nets out intermediate inputs
- **Gross output (IP)** measures total value of sector output (also valued at factory gate)
  - Growth gap vs. VA implies intermediates' share of gross output declining.
  - Different measures for different things, but gross output is a view of the whole business supply chain [Skousen, 2024], may be more relevant for "mobilization" consideration.

Deflators

G.17 Release on Industrial Production and Capacity Utilization:

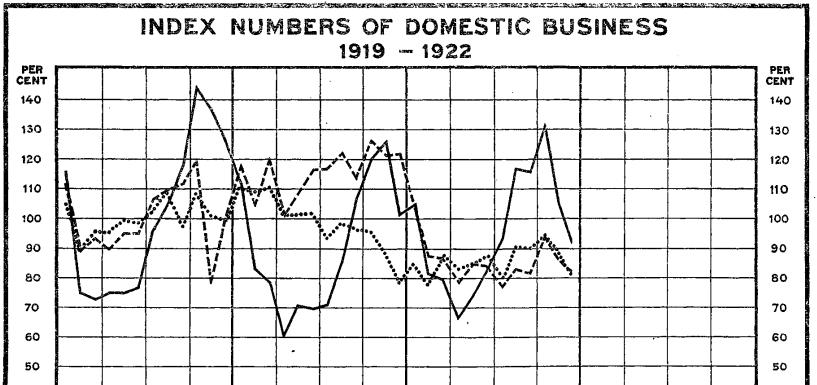
"Rapid changes are now going on in every department of industry in consequence of the reorganization necessary for war and in preparation for future development of trade.... There is thus an increasing need for the development of some method of measuring in an authoritative way changes in business conditions.... 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: $CU = 100 \times IP \,/\, CAP$

IP 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" including large annual Census Bureau surveys (ASM/AIES), semi-decadal Economic Censuses, various other sources
  - Monthly/quarterly "indicator"-based estimates combined with annual "benchmark" is very common for business statistics (e.g., payroll survey, retail trade survey, etc.)

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; e.g., *primary metal manufacturing*
- **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 IP/CU

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

Benchmarking IP

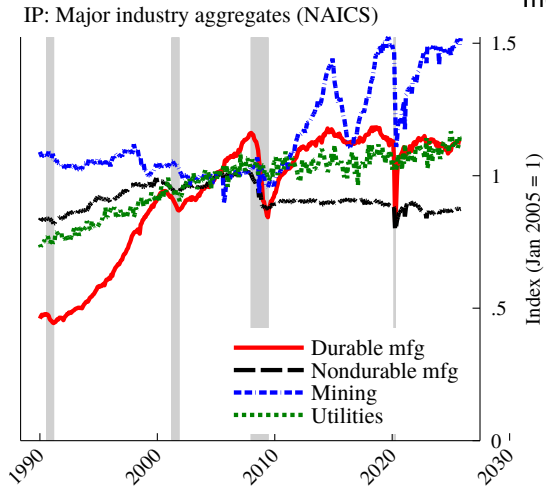
Each year, IP (and capacity) indexes are benchmarked to:

- Incorporate new and revised annual data on output, prices, and value-added proportions
  - Gross output, value added from Census Bureau's annual manufacturing surveys (ASM/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.

IP Charts

IP: Industry structure

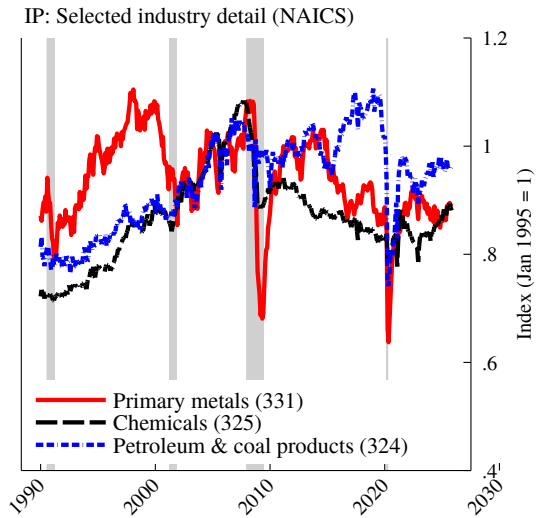


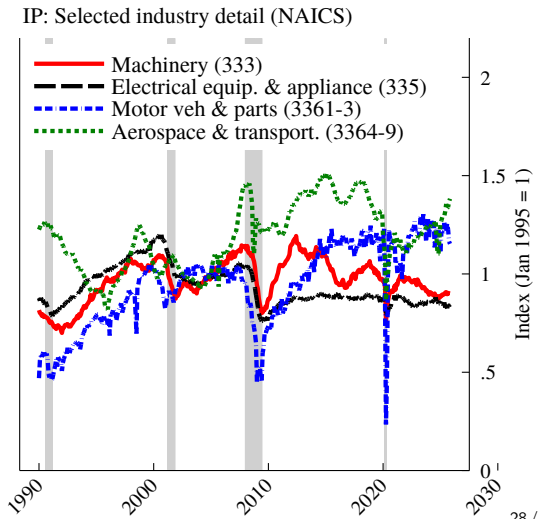
Note: Omits other manufacturing (NAICS 1133, 5111).

Industries categorized on NAICS basis.

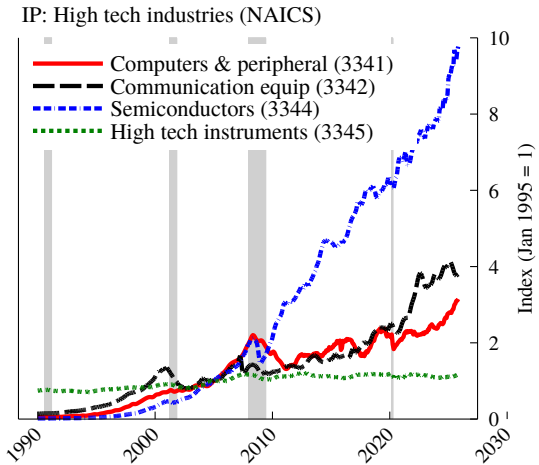
- **Durable manufacturing** close to pre-GFC peak, but quite soft recently (40% of IP).
- No post-GFC recovery in **nondurable manufacturing** (35%).
- In **mining**, growth of oil and gas production offsets gradual decline of other mining and downtrend in support activities (15%).
- **Utilities** composed of electricity generation and natural gas distribution (10%).

IP: Some industry examples (manufacturing)





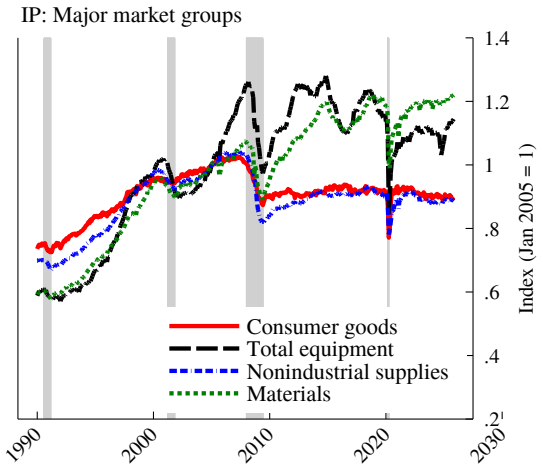
IP: High tech industries



Note: Instruments include navigational, measuring, medical, electromedical, control.

The U.S. manufacturing sector has increasingly focused on "special-purpose" equipment [Byrne, 2015] (computing, medical, military)

IP: Market group structure

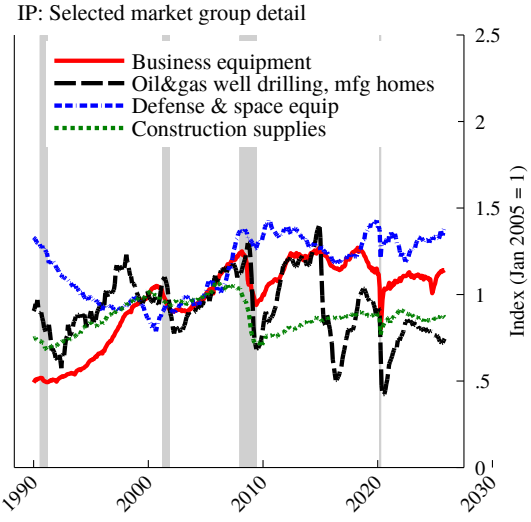


Note: Final products composed of consumer goods, total equipment, and nonindustrial supplies.

Market groups classify output based on its uses:

- **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%.

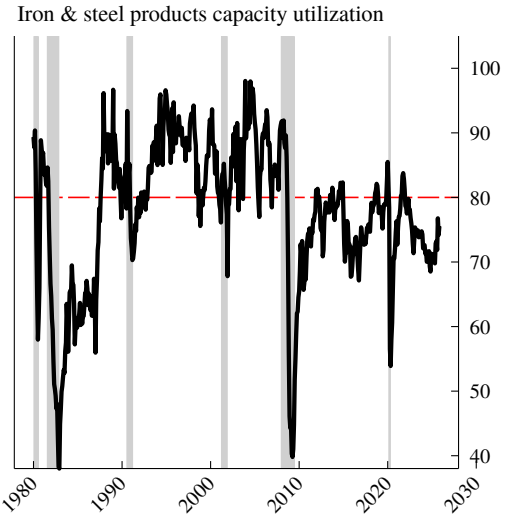
IP: Some market group examples



- **Business equipment**, e.g., motor vehicles, aircraft, railroad stock, ships, computers, machinery, machine tools, electrical equip, etc. 9% of IP.
- **Oil & gas drilling and manufactured homes**: 2%.
- **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 data

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, fit a statistical (regression) model (simplied):

$$ICAP_t = K_t + A_t + u_t$$

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 explanatory variables also provide means for projecting/imputing capacity outside range of ICAP estimates.

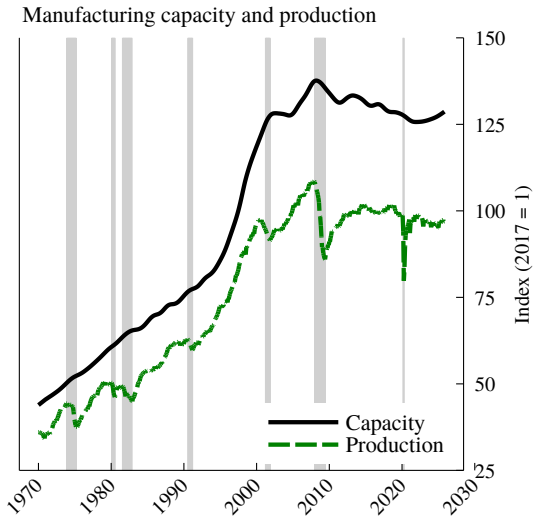
Final capacity steps and utilization

- 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 divided by capacity.

One other thing: Investment and capital stocks

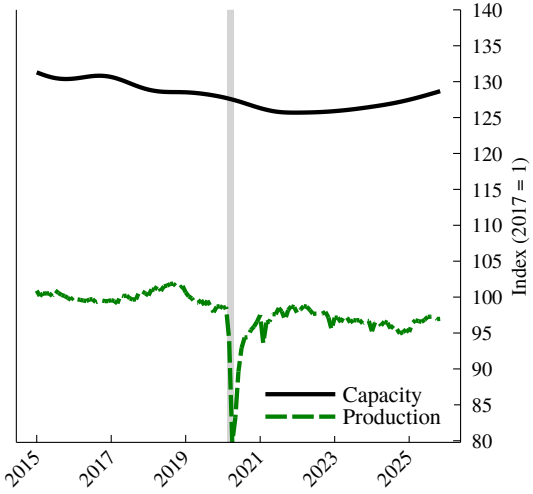
- An important component of capacity estimation is a measure of the flow of services derived from an industry's net stocks of physical assets; see [Kurz and Morin, 2016].
  - Industry-level investment data from large surveys (Census Bureau's ASM/AIES, CM)
  - Asset-level investment data (BEA)
  - Perpetual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

The results (manufacturing)

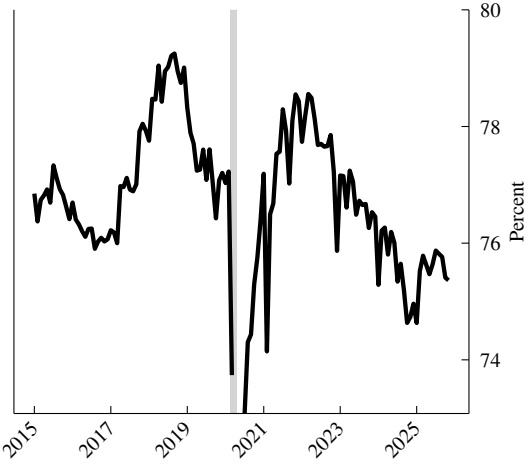


More recent capacity & utilization trends

Manufacturing capacity and production

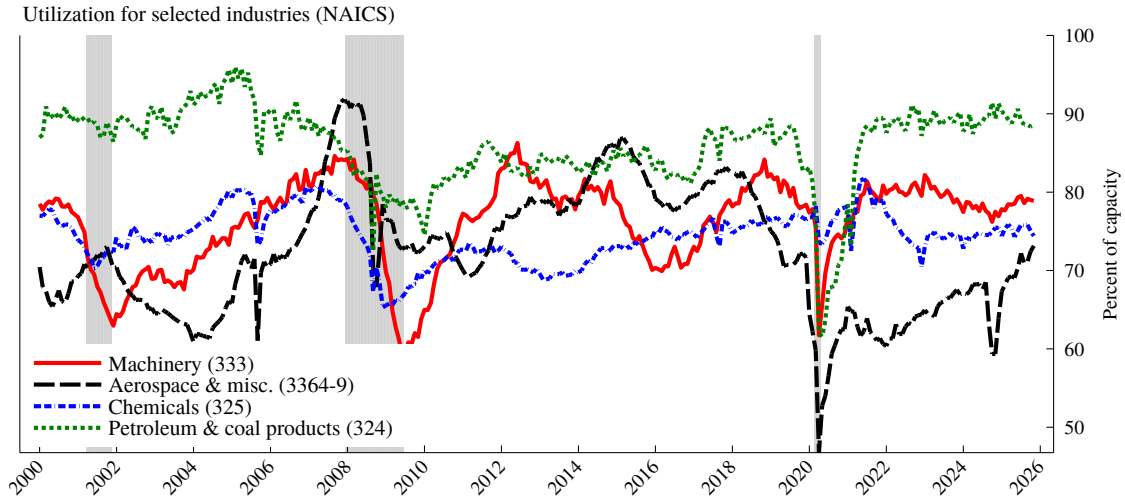


Manufacturing capacity utilization



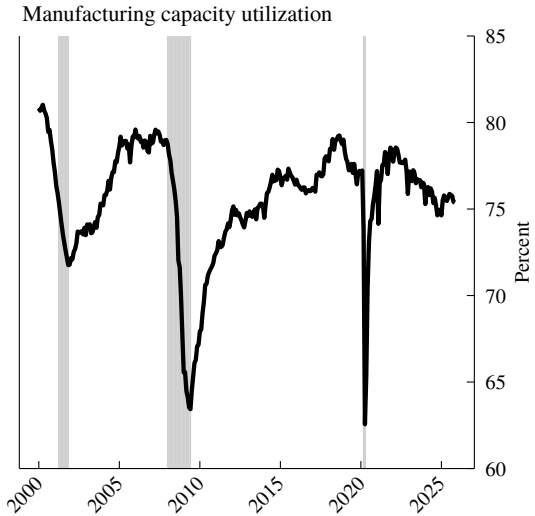
Note: April-June of 2020 omitted.

Utilization in selected industries



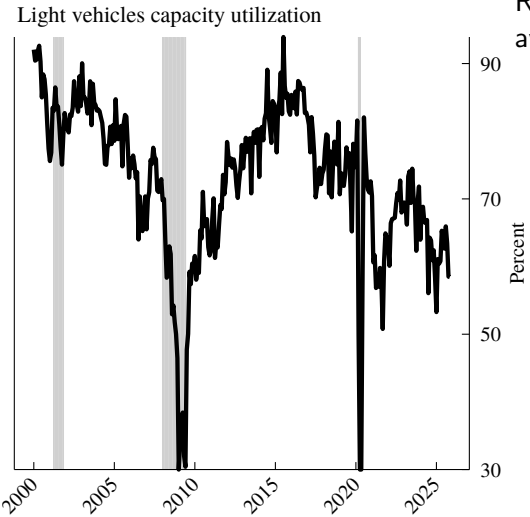
A couple puzzles in recent utilization patterns

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.

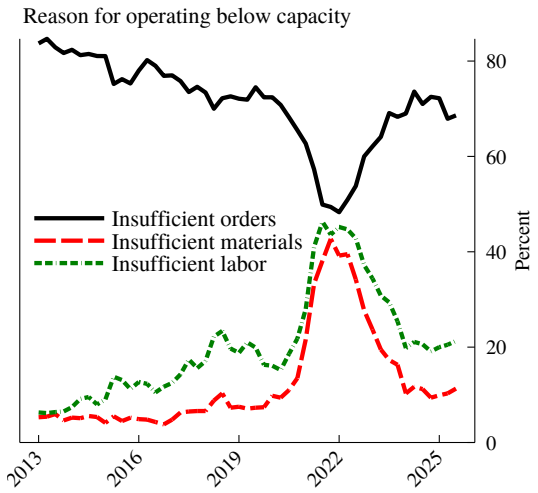
How supply conditions held down utilization



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!

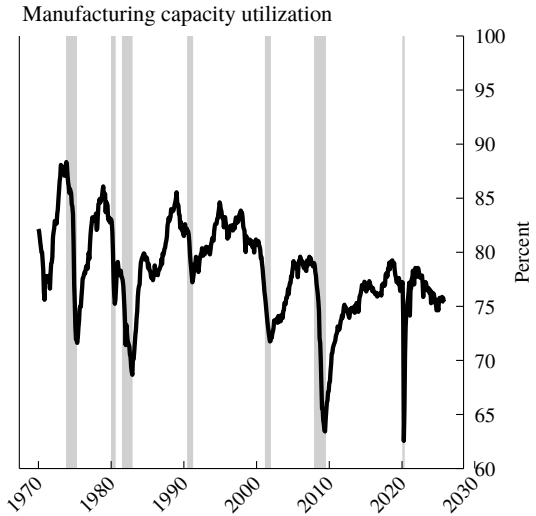
From the QSPC: Specific reasons for low utilization



- 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? Capacity is an *estimated* object

Concluding thoughts

Concluding thoughts

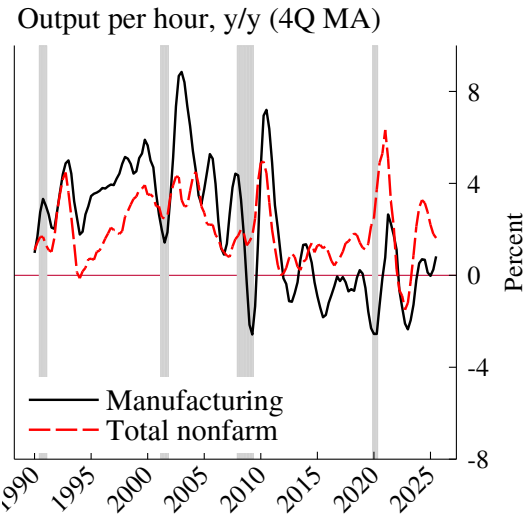
- The industrial sector is as important as ever despite lower share of activity
- The IPCU system provides a rich view into industrial activity.
  - Industry detail
  - End use/market group categorizations
  - Integrated output, capacity, and utilization data
  - Long time series with consistent industries
- At the same time, recent data suggest the need for a broad view of goods production
  - The manufacturing process isn't the only contributor to goods value; R&D, software (AI!), professional services, etc. contribute to goods value
  - Recent experience highlights importance of transportation networks, logistical planning, inventory management

Thanks!

Extra slides

Industrial sector as focal point: Productivity

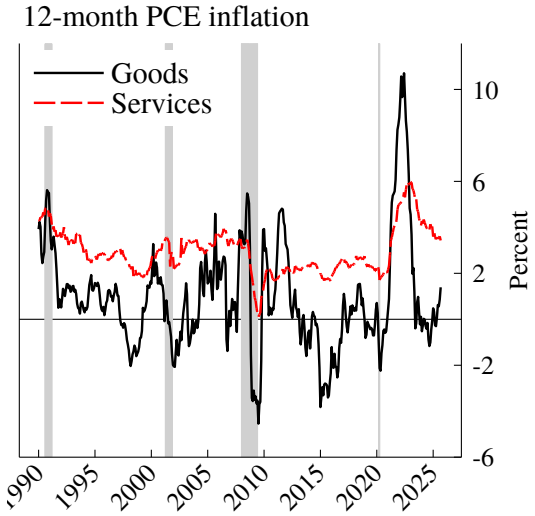
Back



- 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]

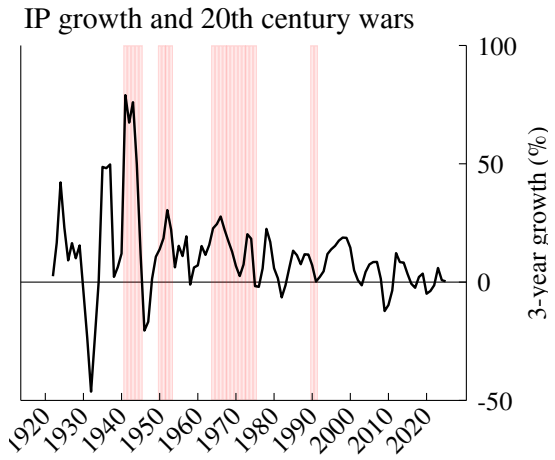
Industrial sector as focal point: Inflation

Back



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

Industrial sector as focal point: National security



Note: Red shading indicates WWII, Korean War, Vietnam War, Desert Shield/Storm.

- National security often linked with the "defense industrial base" [Dunne, 1995]
- Rapid IP growth occurred in major 20th c. mobilizations
- The IP system tracks output for use in defense and space applications
- Capacity and utilization helpful for thinking about mobilization readiness...

Industrial sector as focal point: National security (cont'd)

Back

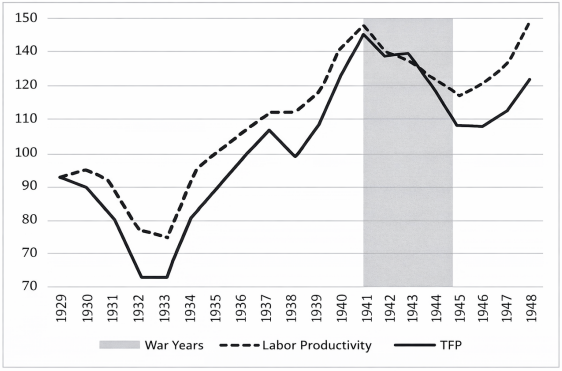


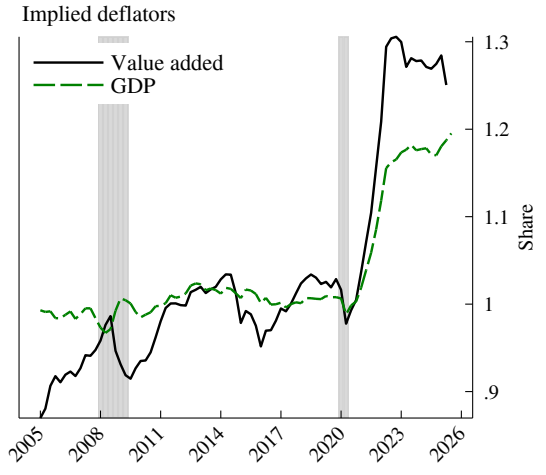
Figure 2.1. Indexes of labor productivity and TFP, U.S. manufacturing, 1929–48; 1929 = 100.0.
Source: Table 2.3.

Figure: [Field, 2022]

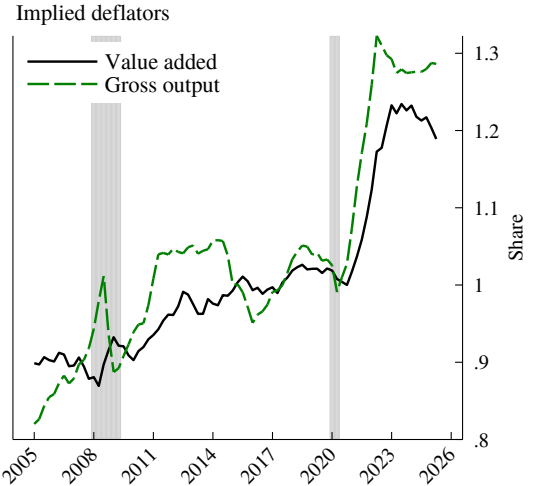
- ... but WWII suggests converting consumer-facing capacity to defense production is complicated:
  - Much wartime production required new (often gov-funded) capacity [Higgs, 2004, Gordon, 1969]
  - New capacity takes time; producing new things requires "learning by doing" [Herman, 2012]
  - Some existing capacity unuseable (approx 8% of manufacturing capacity was "unable to participate in war production" [Field, 2022]
  - Rapid output growth likely requires massive provision of additional inputs
- Maybe capacity for inputs (e.g., machinery, steel) is more flexible

Implied deflators in NIPA goods output measures

Back



Note: NIPA data. Goods GDP ex. IPP.
Goods VA is natural resources, MIN, CON, MFG.



Note: NIPA data. NAICS manufacturing.

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