

ECONOMIC COMMENTARY

Semiconductor Shortages and Vehicle Production and Prices

*Pawel M. Krolkowski and Kristoph N. Naggert**

Vehicle production has fallen since the beginning of the pandemic recession. We investigate reasons for this decline. Manufacturers in this industry cite insufficient materials, including a lack of semiconductors, as increasingly responsible. Demand seems to be less of an issue. In fact, demand has been strong, and together with accelerating prices and sharply declining inventories, it suggests an insufficient supply of new cars. Our best guess is that the materials shortages and their effects on new car prices will subside within the next six to nine months.

Recent inflation readings in the United States have been above the Federal Reserve's target, but these readings are largely driven by price increases that are likely transitory (Powell, 2021).¹ Large price increases have affected components with known supply issues (such as used cars, new cars, and household furniture) and components related to the reopening of the economy (such as hotel accommodation, airfares, and car rentals).² For example, the consumer price index (CPI) for used cars and trucks rose by almost 30 percent over the 12 months ending in May 2021 and accounted for about one-third of the overall monthly CPI increase.³ Because recent inflation readings are in part driven by these transitory factors, many forecasters anticipate that

they will abate after the economy normalizes and bottlenecks resolve (Survey of Professional Forecasters, 2021).

In this *Commentary* we study the impact of one bottleneck—semiconductor shortages—on vehicle production and new car prices and assess how transitory these effects might be. We find evidence that a global semiconductor shortage has constrained US vehicle production during the COVID-19 pandemic. At the same time, new car prices have accelerated and vehicle inventories have fallen, suggesting that the supply of new cars is insufficient to meet demand. Our best guess is that the materials shortages and their effects on new car prices will subside within the next six to nine months.

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Capacity Utilization in the US Semiconductor Industry

Recent reports have suggested that a semiconductor shortage is affecting producers of several goods (Dollar and Clark, 2021). We explore the extent of the shortage by assessing capacity utilization in the US semiconductor industry. Capacity utilization measures actual production relative to full capacity production, which is production capability with normal downtime, fully available inputs, and currently available machinery and equipment. The capacity utilization for an industry is the sum of all plants' market value of actual production in that industry divided by the sum of the market value of all plants' full capacity production in that industry.

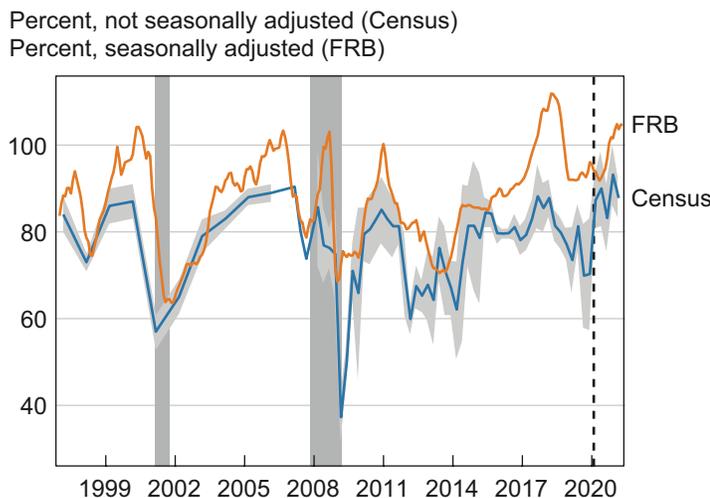
The United States is a small but nontrivial producer of semiconductors, with over 10 percent of global manufacturing capacity in 2019 (Platzner, Sargent, and Sutter, 2020; Semiconductor Industry Association, 2020). We focus on US capacity utilization because the data are accessible and because recent changes in US utilization rates likely reflect changes in global capacity utilization.

We use data from two sources to measure capacity utilization in the US semiconductor industry. First, we use the US Census Bureau's Quarterly Survey of Plant Capacity Utilization (QPC). The survey was conducted on an annual basis from 1997 to 2006 and has been conducted on a quarterly basis since 2007:Q1. Second,

we use the Federal Reserve Board's (FRB) estimates of capacity utilization. The data for the semiconductor industry begin in January 1972 and are published at the monthly frequency. Both data sources present disaggregated information for industries within manufacturing as well as manufacturing overall.

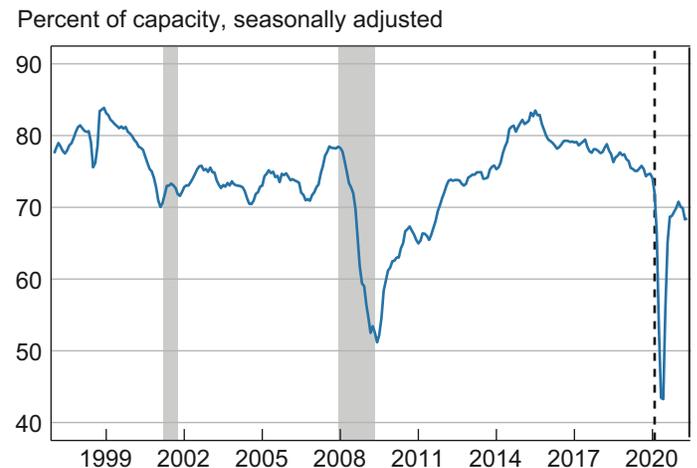
Data from both the Census and the FRB indicate that capacity utilization in the US semiconductor industry has risen to very high levels recently, as shown in figure 1. The Census measure was 93.2 percent in 2020:Q4, its highest level since the data began. The measure remains high in 2021:Q1 at 87.8 percent, similar to peak levels during the last three expansions. The FRB measure was 104.8 percent in May 2021, which is elevated relative to its historical average, but not above levels in 2018.⁴ Operating above full capacity means that plants are temporarily operating with increased overtime for workers and reduced maintenance time for equipment. This level of capacity utilization has only occurred several times since 1972. Compared to its average 2019 level, the Census measure rose by about 15 percentage points in 2021Q:1. The FRB measure has risen by about 10 percentage points from its average 2019 level. These high capacity utilization rates likely reflect a global shortage in semiconductors that is inducing domestic semiconductor producers to increase utilization to meet demand (Yinug, 2021; [spelling of author's name corrected 8/3/2021]).

Figure 1. Capacity Utilization: Semiconductor and Related Device Manufacturing



Notes: The figure depicts the capacity utilization rate in the semiconductor and related device manufacturing industry from the FRB and Census. The shaded areas surrounding the blue line represent 95 percent confidence intervals for the Census measure, which are not available from 2007:Q1 to 2007:Q4. Shaded bars indicate National Bureau of Economic Research (NBER) recessions. The vertical dashed line denotes the NBER's most recent peak. Last observation: 2021:Q1 (Census), April 2021 (FRB).
Sources: Census Bureau, Federal Reserve Board (nonpublic).

Figure 2. Capacity Utilization: Transportation Equipment Manufacturing



Notes: The figure depicts the three-month moving average of FRB capacity utilization in the transportation equipment manufacturing industry. Shaded bars indicate NBER recessions. The vertical dashed line denotes the NBER's most recent peak. Last observation: May 2021.
Source: Federal Reserve Board via Haver Analytics.

Capacity Utilization in Transportation Equipment Manufacturing

Modern cars cannot be manufactured without semiconductors, which are used in entertainment, driver’s assistance, and safety systems, among other applications. We find that vehicle producers’ capacity utilization is below pre-pandemic levels, consistent with the narrative that the semiconductor shortage has weighed on production.

FRB data suggest that capacity utilization in the transportation equipment manufacturing industry (relating to the transportation of people and goods) is below pre-pandemic levels, as shown in figure 2. The three-month moving average of capacity utilization in this industry was 68.5 percent in May 2021, up since the lows of the pandemic (43.3 percent in March 2020), but still 6.7 percentage points below its 2019 average level. In its June 2021 industrial production and capacity utilization release, the FRB notes that motor vehicle production “continue[s] to be hampered by shortages of semiconductors.”

Reasons for Producing below Capacity in Transportation Equipment Manufacturing

To confirm that semiconductor shortages are playing a role in the reduced capacity utilization among transportation equipment manufacturers, we use the Census QPC survey. That survey asks respondents to mark the primary reason(s) a plant’s actual production in the current quarter was less than full capacity production, as shown in figure 3. These “checkbox” data are available for all of manufacturing and by three-digit industry (for example, 336 is transportation equipment manufacturing). These data are annual before 2007, not available in 2007, and quarterly from 2008:Q1 through 2021:Q1.

We focus on two reasons. First, we suspect that a manufacturer facing semiconductor shortages would most likely cite “insufficient supply of materials” as the primary reason for producing below full capacity, although this reason could include other materials shortages. Second, we consider “insufficient orders” because this reason could also explain reduced production. Insufficient orders are a measure of product demand; that is, a decrease in the fraction of manufacturers citing insufficient orders as a reason for producing below full capacity suggests that product demand has risen.

Transportation equipment manufacturers are more likely to cite insufficient materials for reduced production than before the pandemic recession, and this is consistent with the narrative that semiconductor shortages have weighed on production in this industry. The fraction of respondents in the transportation equipment manufacturing industry citing insufficient supply of materials has risen sharply since 2020:Q1 to high levels in 2021:Q1, as shown in figure 4 panel A (blue line). In 2021:Q1, 27.3 percent of respondents cited this reason for producing below full capacity, which is well above any level since the start of the data in 1997.⁵

During the pandemic recession, lack of demand has become less important for transportation equipment manufacturers’ production. The fraction of respondents citing insufficient orders has fallen sharply since 2020:Q1 to low levels in 2021:Q1, as shown in figure 4 panel A (orange line). In 2021:Q1, 46.0 percent of respondents cited this reason for producing below full capacity, which is well below any level since the start of the data in 1997, except for 2020:Q4 (45.3 percent). This reduction during the current recession differs from the two previous recessions. During the

Figure 3. Reasons for Operating below Full Production Capability

B. ACTUAL OPERATIONS VS FULL PRODUCTION CAPABILITY

If this plant’s actual production in the current quarter was less than full production capability, mark (X) the primary reasons.

<input type="checkbox"/> Not most profitable to operate at full production capability	<input type="checkbox"/> Lack of sufficient fuel or electric energy	<input type="checkbox"/> Strike or work stoppage
<input type="checkbox"/> Insufficient supply of materials	<input type="checkbox"/> Equipment limitations	<input type="checkbox"/> Seasonal operations
<input type="checkbox"/> Insufficient orders	<input type="checkbox"/> Storage limitations	<input type="checkbox"/> Environmental restrictions
<input type="checkbox"/> Insufficient supply of local labor force/skills	<input type="checkbox"/> Logistics/transportation constraints	<input type="checkbox"/> Other – Specify
	<input type="checkbox"/> Sufficient inventory of finished goods on hand	<div style="border: 1px solid black; width: 150px; height: 30px; margin-top: 5px;"></div>

Notes: The figure depicts the section of the Quarterly Survey of Plant Capacity Utilization questionnaire that asks plants to provide the primary reasons for operating at less than full production capability in the current quarter.
Source: Census Bureau.

2008–2009 recession, and to a lesser extent during the 2001 recession, the fraction of respondents citing this reason moved up, suggesting a decrease in product demand.

Media reports have focused most on semiconductor shortages in vehicle manufacturing. However, these shortages are also likely adversely affecting production in other industries that use semiconductors extensively, such as computers and other electronic products (Semiconductor Industry Association, 2020).⁶ We present data that are consistent with this narrative. In particular, manufacturers of computers and other electronic products have cited insufficient supply of materials more frequently in 2021:Q1 than at any time since 1997, as shown in figure 4 panel B (blue line). For example, 29.3 percent of respondents in this industry cited this reason for production below full capacity in 2021:Q1, which was well above already-high levels in 2019 (14.8 percent). Capacity utilization in this industry (not shown) has moved above its pre-pandemic level (76.3 percent in May 2021 compared to 73.8 percent in February 2020)—in contrast to reductions in capacity utilization in transportation equipment manufacturing—but likely less than it would have if not for the semiconductor shortage.

New Car Prices and Inventories

Two pieces of evidence suggest that the recent production shortfalls, together with strong demand, have resulted in an insufficient supply of new cars. First, new car prices have accelerated since the middle of last year. Second, vehicle inventories have fallen during that time.

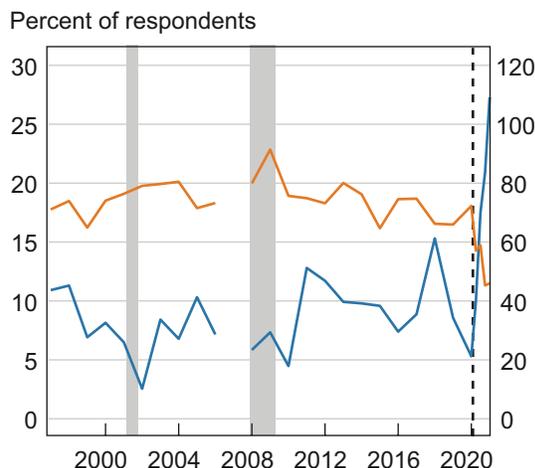
New car prices have accelerated recently. In particular, new car price changes, as measured by 12-month differences in the personal consumption expenditure (PCE) price index, have risen from –0.5 percent in April 2020 to 3.6 percent in May 2021, as shown in figure 5.⁷ This level of change in new car prices is the highest since the mid-1990s apart from two brief periods in 2009–2010 and 2011–2012.⁸ Accelerating prices are consistent with insufficient supply, which should put upward pressure on prices until supply meets demand.

Light-vehicle inventories have dropped since the start of the pandemic recession. In particular, inventories have fallen from 3.6 million units in February 2020 to 1.5 million in May 2021, as shown in figure 6 (orange line). The level of inventories in May is at its lowest since January 1985 when the data began, except for August 2009. The sharp declines in inventories in March, April, and May 2021 coincided with exceptionally high light-vehicle sales (figure 6, blue line). Light-vehicle sales in March, April, and May 2021 were 18.0, 18.8, and 17.0 million units (annualized rate), respectively, which were above their pre-pandemic level of 16.8 million in February 2020 and are consistent with strong demand. Declining inventories suggest that production is falling short of demand.

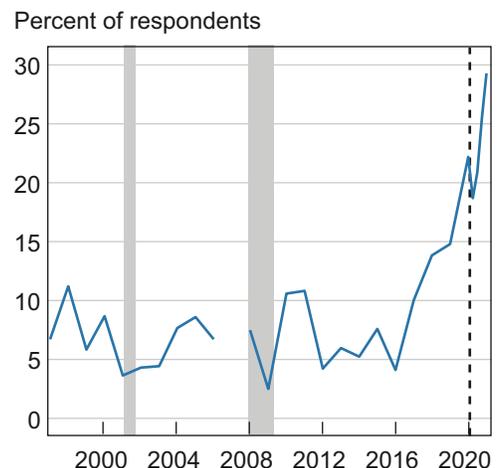
Based on comments by leaders in the semiconductor and automotive industries and analytic reports, 2021:Q2 was likely the peak of the semiconductor shortage. These shortages should recede in the next six to nine months so that vehicle production rebounds and acceleration in new car prices abates. At the beginning of May, Chairman Mark Liu of the Taiwan Semiconductor Manufacturing Company,

Figure 4. Reasons for Production below Full Capacity

Panel A. Transportation equipment manufacturers



Panel B. Computer and electronic product manufacturers



— Insufficient orders (right axis)
 — Insufficient supply of materials (left axis)

Notes: The figure depicts the percent of respondents who cited insufficient supply of materials and insufficient orders as the primary reason for production below full capacity. Data are annual from 1996 until 2019 and quarterly from 2020:Q1 to 2021:Q1. Data for 2007 are not available. Shaded bars indicate NBER recessions. The vertical dashed line denotes the NBER's most recent peak. Last observation: 2021:Q1.

Source: Census Bureau via Federal Reserve Board (nonpublic).

the world's largest contract chipmaker, said that he expects the shortages of car chips to last into early 2022 (Stahl, 2021). The chief executive of Ford Motor Company, Jim Farley, said that “the full recovery of the semiconductor supply chain for auto makers could stretch to 2022” but “our second quarter will be the trough for this year” (Boston, 2021). Several other automobile producers and suppliers have reported that they expect 2021:Q2 to be the peak of the supply shortages, with some tightness lasting into 2022 (St. John, 2021; Colias and Naughton, 2021; Ferraris et al., 2021).

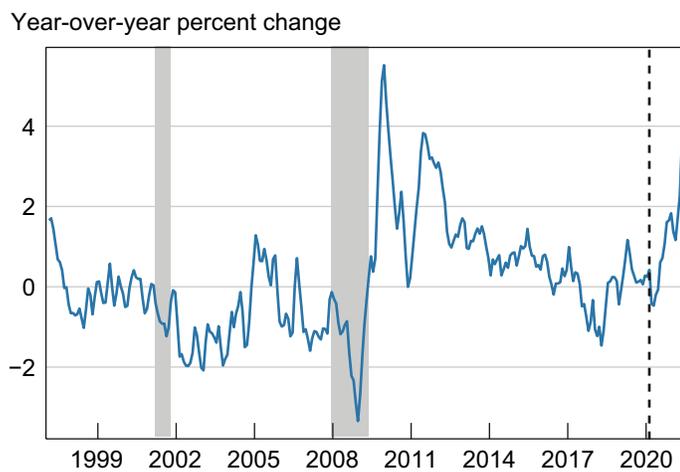
Reasons for Producing below Full Capacity in Manufacturing as a Whole

Although we focus on semiconductor shortages in vehicle production, reports suggest that materials shortages have affected many goods during the pandemic recession, including clothing, electronics, lumber, and plastics (Goodman and Chokshi, 2021). In this section we confirm these shortages in manufacturing as a whole with the Census checkbox data. We also document other reasons for reduced production. In summary, manufacturers are recently citing insufficient materials for reduced production more frequently than before the pandemic recession, and product demand seems to be less of an issue, as in transportation equipment manufacturing. Labor shortages and transportation constraints are also weighing on manufacturers' production, which is consistent with other incoming labor-market and international-shipment data.

Manufacturers have been more likely to cite insufficient materials during the pandemic recession than before it and less likely to cite insufficient orders for producing below full capacity. In particular, the fraction of manufacturers citing insufficient supply of materials has risen sharply from 2020:Q2 to 2021:Q1, from 9.4 percent to 21.6 percent, as shown in figure 7 (blue line). The level in 2021:Q1 is well above levels since the start of the data in 1997. The fraction of manufacturers citing insufficient orders has fallen sharply from 2020:Q1 to 2021:Q1, from 72.4 percent to 62.7 percent (orange line). The level in 2021:Q1 is well below levels since 1997.

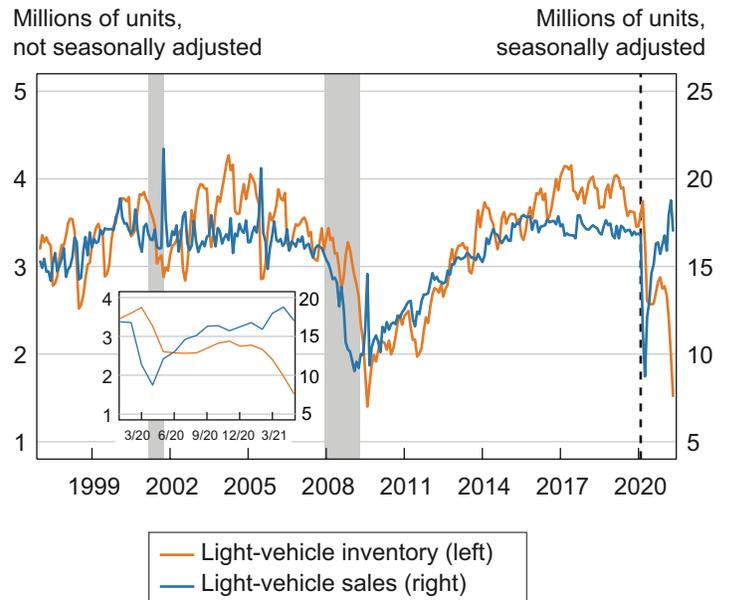
These data also suggest that labor shortages and transportation issues have been increasingly constraining manufacturers' production since the pandemic began. The fraction of manufacturers citing “insufficient supply of local labor force/skills” increased from 16.3 percent in 2019:Q4 to 28.0 percent in 2021:Q1 (green line). The fraction of respondents citing this reason in 2021:Q1 is well above levels since at least 1997.⁹ Manufacturers are also more likely to cite “logistics/transportation constraints” in 2021:Q1 than at any time before the pandemic recession, and this fraction has increased sharply since 2020:Q1 (red line). This increase in transportation constraints is consistent with reports about international shipment issues (Murray, 2021). Nevertheless, relative to other reasons, only a small fraction of manufacturers (5.6 percent) cite logistics or transportation constraints in 2021:Q1.

Figure 5. Personal Consumption Expenditures Price Index: New Motor Vehicles



Notes: The figure depicts the 12-month percent change in the PCE price index for new motor vehicles. Shaded bars indicate NBER recessions. The vertical dashed line denotes the NBER's most recent peak. Last observation: May 2021.
Source: Bureau of Economic Analysis via Haver Analytics.

Figure 6. US Light-Vehicle Inventory and Sales



Notes: The figure depicts light-vehicle sales at an annualized rate and inventory in the US. Shaded bars indicate NBER recessions. The vertical dashed line denotes the NBER's most recent peak. Last observation: May 2021.
Sources: Ward's Communication, Bureau of Economic Analysis via Haver Analytics.

Conclusion

Recent inflation readings in the United States have been high, but they have been driven in part by components with known supply issues and components related to the reopening of the economy. In this *Commentary* we study the impact of one bottleneck—semiconductor shortages—on vehicle production and new car prices. We find that capacity utilization in the US semiconductor industry has risen to very high levels recently, likely reflecting a global semiconductor shortage. Survey data show that vehicle manufacturers are more likely to report that insufficient materials, including a lack of semiconductors, are constraining production than before the pandemic recession. Demand seems to be less of an issue. These shortages have occurred simultaneously with an acceleration in new car prices and a sharp reduction in vehicle inventories, both of which suggest insufficient supply. Our best guess is that these shortages and their effects on new car prices will subside within the next six to nine months.

Footnotes

1. The persistence and magnitude of the transient inflation factors are, of course, actively debated.

2. Recent elevated inflation readings are also boosted by base effects from last year's low prices (Dapena and Santilli, 2021).

3. Despite large increases in official headline and core measures in recent months, alternative measures of core inflation moved up much more modestly because only a few expenditure components moved sharply. For example, median and trimmed-mean CPI were 2.1 percent and 2.6 percent, respectively, in May 2021, up from 2.0 percent and 2.1 percent in March (Federal Reserve Bank of Cleveland, 2021).

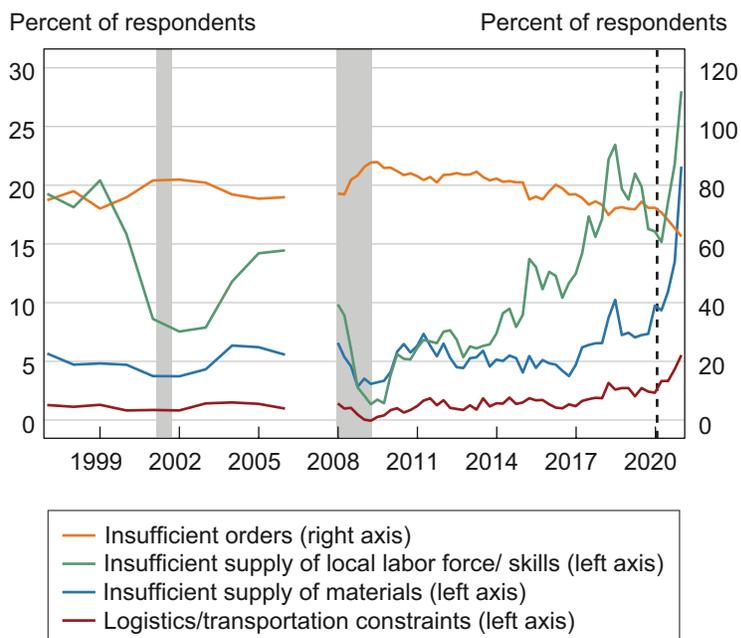
4. The high capacity utilization rates in 2018 were likely related to the US–China trade dispute and to tariffs levied on items used in semiconductor production.

5. This fraction also rose sharply in 2018. Reports from the Institute for Supply Management (ISM) during that time suggest that tariffs on steel and aluminum and the US–China trade dispute negatively affected the supply of materials to US manufacturers, including those in the transportation equipment manufacturing industry (ISM, June 2018).

6. This industry includes semiconductor manufacturers.

7. Some reports suggest that the shortage of new cars is boosting used-car and rental-car prices, which have also risen sharply in the last few months (Thomas, 2021).

Figure 7. Reasons for Production below Full Capacity: Manufacturing



Notes: The figure depicts the fraction of respondents citing insufficient orders, insufficient supply of local labor force/skills, insufficient supply of materials, and logistics/transportation constraints for producing below full capacity production for the manufacturing sector. Data are annual from 1996 until 2006 and quarterly from 2008:Q1 to 2021:Q1. Data for 2007 are not available. Shaded bars indicate NBER recessions. The vertical dashed line denotes the NBER's most recent peak. Last observation: 2021Q1.

Source: Census Bureau via Federal Reserve Board (nonpublic).

8. Annualized 24-month changes in the new car PCE index, a measure that avoids base effects, also suggest a recent acceleration in new car prices—from 0.3 percent in April 2020 to 1.7 percent in May 2021—but only to levels observed in 2013.

9. These recent high levels are noteworthy because the labor market is considered to have been particularly tight during the previous expansion and during the 1990s expansion. This signal that the labor market is recently tight is consistent with other measures about perceptions of labor market tightness, such as the percent of respondents who report that jobs are plentiful or hard to get from the Conference Board’s survey of consumers.

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[Editor’s note, August 3, 2021: The spelling of Falan Yinug’s name has been corrected.]