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## Bottlenecks: causes and macroeconomic implications

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# Bottlenecks: causes and macroeconomic implications

*Key takeaways*

- *Bottlenecks in the supply of commodities, intermediate goods and freight transport have given rise to volatile prices and delivery delays.*
- *Bottlenecks started out as pandemic-related supply disruptions amid strong demand from the global economic recovery. But they have been aggravated by the attempts of supply chain participants to build buffers in already lean production networks – so-called bullwhip effects.*
- *Bottlenecks have been particularly severe in upstream industries – ie those that supply inputs used in many other products. These constraints have led to large international spillovers through global value chains.*
- *The direct inflationary effect of bottlenecks will likely be limited after relative prices have adjusted. However, sustained inflationary pressures could emerge if bottlenecks persist long enough to trigger an upward shift in wage growth and inflation expectations.*

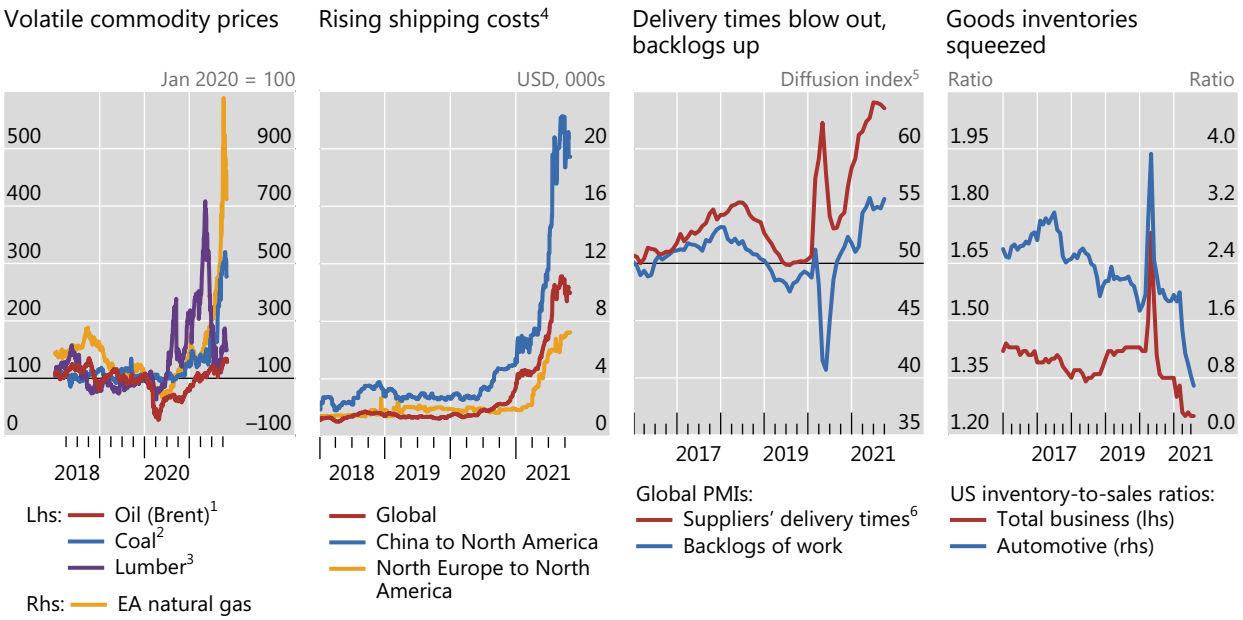
## Introduction

As the global recovery gains traction, demand for key raw materials, intermediate inputs and logistical services has outstripped available supply, leading to rising and volatile prices, and delivery delays. The resulting mismatches have put supply chains under pressure, causing bottlenecks that arise when the demand for an upstream production input suddenly and significantly exceeds the maximum amount that can be produced and delivered. Current bottlenecks have persisted longer than anticipated, weighed on output growth and helped to raise global inflation. This Bulletin outlines the sectors subject to bottlenecks, investigates their causes and assesses their macroeconomic implications.

## Where have bottlenecks emerged?

Recent bottlenecks have been most severe in raw materials, intermediate manufactured goods and freight transport. For raw materials, prices rose sharply as shortages emerged and firms scrambled to secure supplies, followed in several cases by sudden price declines as production ramped up or demand ebbed (Graph 1, first panel). In the manufacturing sector, prices have increased substantially for certain computer chips in high demand, forcing some customers to pause production and others to build precautionary stockpiles to maintain production. Meanwhile, shipping costs have shot up for trade between Asia and North America (second panel) and delivery times have lengthened. Ships have been forced to queue for days to access ports, clogging distribution across the supply chain. Truck and air freight prices have also soared, exacerbated by labour shortages.

Bottlenecks reflected in prices and quantities — Graph 1




[1] In US dollars/barrel. [2] Generic first futures price, coking coal on Dalian Commodity Exchange. [3] Generic first futures price, random length lumber. [4] Freightos Baltic daily containerised freight rate index. Seven-day moving average. [5] A value of 50 indicates that the number of firms reporting improvement is the same as the number reporting deterioration. [6] Delivery times displayed on an inverted scale.

Sources: Federal Reserve Bank of St. Louis, FRED; Bloomberg; Datastream; IHS Markit; BIS calculations.

These bottlenecks have had knock-on effects through production networks. Unable to secure inputs, firms slowed or stopped production, causing order backlogs and blowing out delivery times (Graph 1, third panel). At the retail level, goods inventories have sunk to historic lows, particularly for durable items such as cars and furniture with high transport costs (fourth panel). In several countries, energy inventories are also at record lows, leading to blackouts and rationing. These, in turn, have weighed on production of raw materials and manufactured goods, intensifying bottlenecks further.

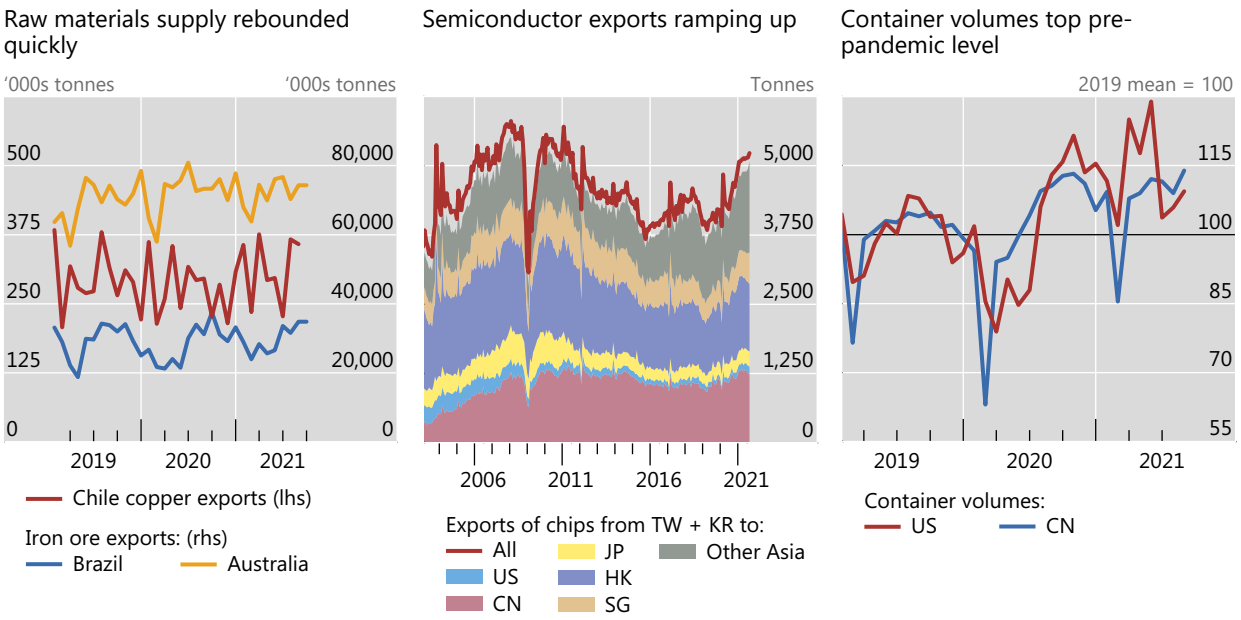
## Why have bottlenecks appeared and why are they so severe?

Pandemic-induced supply disruptions have clearly been a major cause of bottlenecks, especially in the early stages of the global recovery. Producers who had severed relationships with suppliers early in the pandemic found it hard to re-establish them when demand picked up. Asynchronous lockdowns disrupted shipping, while sporadic virus outbreaks led to further dislocations. But there are also other causes. Unexpected natural events have intensified supply pressures. A lack of investment in the years leading up to the pandemic left some industries with little spare capacity. The investment shortfall was particularly severe for oil and resource commodities, due in part to the transition away from fossil fuel energy.

At the same time, rising prices for some items went hand in hand with high volumes, suggesting an important role for demand. Prices for many resource commodities surged against a backdrop of stable supply – at least in aggregate – which was hardly affected by the pandemic (Graph 2, left-hand panel). And semiconductor exports from Asia considerably exceed the 2019 level (centre panel), in part reflecting trend increases in demand for IT and electronics goods. Meanwhile, ports in the United States and China have been processing a larger volume of shipping containers than pre-pandemic, albeit with considerable month-to-month volatility (right-hand panel).

## Supply struggling to keep pace with demand

Graph 2




Sources: CPT Single Window; Korea Customs Service; United States Department of Transportation; Bloomberg; CEIC; Refinitiv Eikon; BIS calculations.

Several factors have amplified the economic severity of bottlenecks. One is the shift in the composition of demand towards manufactured goods during the Covid recession and recovery. These goods are heavily reliant on inputs from other industries, leading to larger demand spillovers than from a services-led recovery (Graph 3, left-hand panel).[1] Manufactured goods (and their inputs) also tend to be relatively capital-intensive, making their short-run supply elasticity low as it takes time to expand productive capacity (centre panel). As a result, sudden increases in manufactured goods demand can translate quickly into bottlenecks, leading to higher inflation (right-hand panel).

A second factor is behavioural change on the part of supply chain participants. Anticipation of product shortages and precautionary hoarding at different stages of supply chain have aggravated initial shortages (the "bullwhip effect"), leading to further incentives to build buffers. These behavioural changes have the potential to lead to feedback effects that exacerbate bottlenecks. In this respect, there are parallels between supply chain disruptions and the liquidity stresses in financial markets.[2]

A third important background element is the lean structure of supply chains, which have prioritised efficiency over resilience in recent decades. These intricate networks of production and logistics were a virtue in normal times, but have become a shock propagator during the pandemic. Once dislocations emerged, the complexity of supply chains made them hard to repair, leading to persistent mismatches between demand and supply.

Nevertheless, persistent bottlenecks could also prompt corrective behavioural changes over time, eg by providing incentives for investment to expand capacity. Once bottlenecks begin to ease, the feedback loops could operate as a virtuous circle to mitigate the bullwhip effects. In this way, just as bottlenecks have persisted longer than initially expected, their resolution could also follow more swiftly than currently feared.

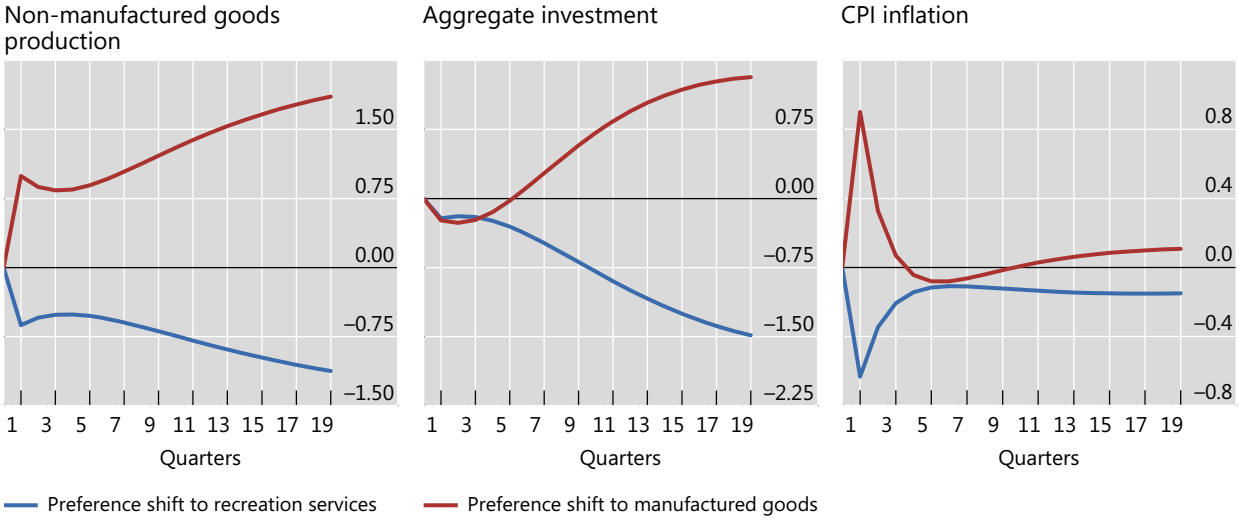
[1] For details of the modelling exercise underlying Graph 3, please see the Online Appendix accompanying this Bulletin.

[2] For a discussion, see Aramonte et al (2021).

Shift from services to goods demand has large positive spillovers[1]

In per cent

Graph 3




[1] See the Online Appendix accompanying this Bulletin for details of the model simulations underlying this graph.

Source: BIS calculations.

## Macroeconomic implications of bottlenecks

### Implications for economic activity

Bottlenecks reduce economic activity by constraining the inputs needed to produce goods and services along the value chain. The severity of these constraints depend partly on whether bottlenecks affect items that are upstream (ie at the start of production chains) or downstream (ie closer to final consumers).

One measure of "upstreamness" is the average number of times an item needs to be transformed before reaching final consumers. Using input-output tables, the left-hand panel of Graph 4 plots this measure for each of the 405 industries in the United States.[3] The production of primary commodities, such as oil, gas and metals, is concentrated at the start of production networks (purple bars). Supply bottlenecks for these goods affect the production of many others. Electrical components, such as semiconductors, appear around one third of the way down the chain, while freight transportation typically lies somewhat closer to final consumers.[4]

Bottlenecks in more upstream industries can have particularly large effects. Calculations based on a global input-output matrix indicate that the decline in output due to a constraint on the supply of energy commodities or semiconductors is on average 3.5 to 4.5 the size of the initial impact (Graph 4, centre panel).[5] Output multipliers for more downstream industries, such as accommodation services, are closer to 2. To put these numbers in perspective, they imply that, on average, a 10% contraction in world semiconductor production would reduce global GDP by about 0.2%. The effects could be larger due to the bullwhip effects arising from behavioural changes, and for economies that rely heavily on

[3] Input-output tables that cover multiple countries, contain a less granular industry breakdown and so cannot identify the specific industries affected by bottlenecks as clearly as those for individual countries.

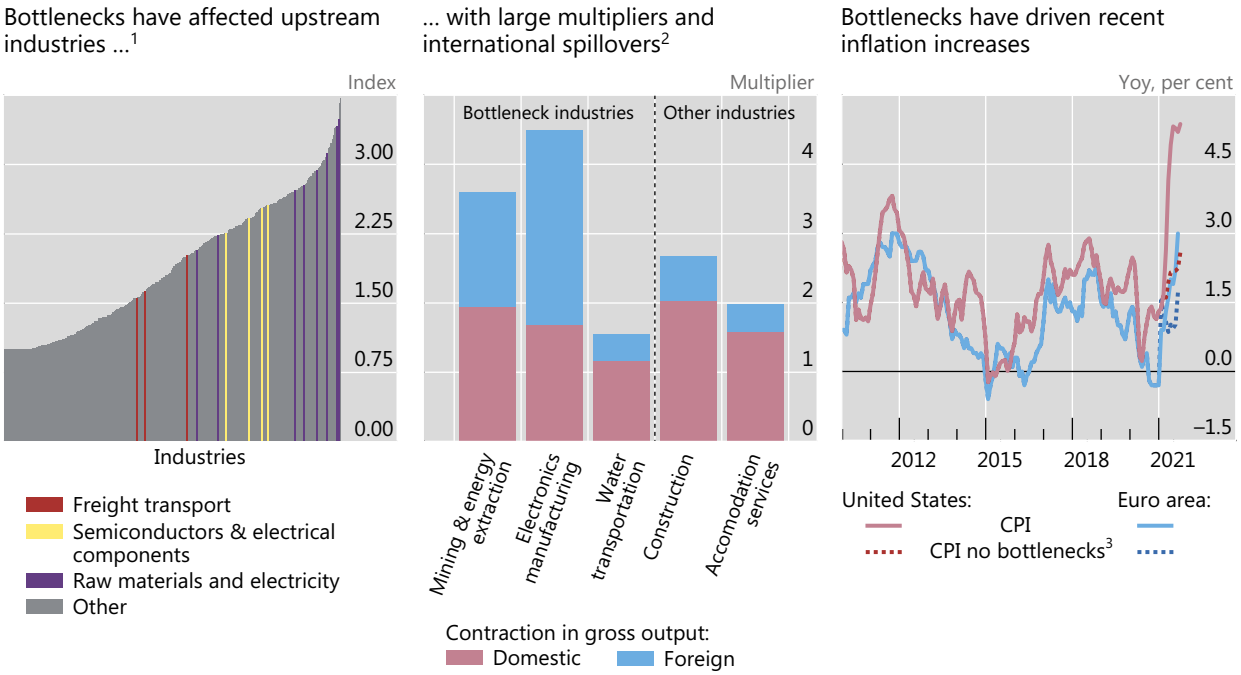
[4] The upstreamness of transportation services will vary across countries, depending on the position of their industries in global production networks. The estimates in the left-hand panel of Graph 4 likely understate the upstreamness of transportation in economies that specialise in the production of intermediate manufacturing inputs.

[5] The analysis uses the World Input-Output Tables (Timmer et al (2015)), which allows cross-border bottleneck effects to be accounted for, at the cost of a less granular industry breakdown

semiconductors. One analyst estimate suggests that chip shortages could cut car production in 2021 by 7.7 million units, all else equal (equivalent to 8% of pre-pandemic production).[6] For Germany, where the car industry accounts for 6% of GDP, this would be equivalent to 0.5% of GDP.

## Output and inflation implications

Graph 4




[1] The index shows the average number of stages taken for the output of an industry to reach end users. A value of 1 indicates that all of the output of an industry is sold directly to final users. The index is calculated based on US input-output tables, using the approach described in Antràs et al (2012). [2] Bars show the average total contraction in global gross output following a one unit constraint on the supply of the inputs listed on the x-axis, accounting for all input-output linkages down the supply chain to final demand. Average calculated based on supply constraints in 11 AEs and four EMEs. Domestic segment of the bars show the effect on gross output in the country that experiences the supply constraint. Foreign segment shows the effect on gross output summed across all other countries. [3] Excludes contributions from energy and vehicles.

Sources: IMF; Bureau of Economic Analysis; World Input-Output Database; BIS calculations.

Bottlenecks in tradeable industries – a feature of the current episode – also have international spillovers. On average, around half of the decline in output due to bottlenecks in energy commodities or semiconductors occurs outside the country of origin. By contrast, the bulk of the impact of bottlenecks in non-tradeable sectors, such as construction, does not spread abroad.

Adaptation could reduce the impact of bottlenecks. Substitutes for some bottleneck-affected items may be available. For example, rising natural gas prices have already seen some electricity firms increase coal power generation. This suggests that the economic impact of energy bottlenecks in Europe and China may not be so severe, and may actually provide income gains for producers of energy products when demand increases. Similarly, some firms have started to use air freight to circumvent shipping delays. Ports in the United States have lengthened their working hours to cope with higher demand. However, substitutes are no panacea, and may create their own bottlenecks (as in these examples for coal and air freight). And for some goods, like semiconductors, substitutes may not exist, indicating more persistent effects of bottlenecks for countries with large car industries.

[6] See AlixPartners (2021).

## Implications for inflation

The mechanical effect on CPI inflation from the price increases for bottleneck-affected items has been notable in recent months. If energy and motor vehicle prices in the United States and the euro area had grown since March 2021 at their average rate between 2010 and 2019, year-on-year inflation would have been 2.8 and 1.3 percentage points lower, respectively (Graph 4, right-hand panel). That said, once relative prices have adjusted sufficiently to align supply and demand, these effects should ease. Some price trends could even go into reverse as bottlenecks and precautionary hoarding behaviour wane. The mechanical effect on CPI could well turn disinflationary during this second phase.

The inflationary effect could be more persistent if wage-price spirals take hold. Workers may seek higher wages to compensate for the reduction in real wages. And they might get them, especially if ongoing labour shortages raise their bargaining power and reservation wages.[7] Meanwhile, a period of higher inflation could bolster firms' pricing power, strengthening the pass-through of costs into prices. And price competition could weaken if the rise in inflation is pervasive across countries, as has been the case, and if global value chains come under strain (see Auer et al (2019).

The chances of a wage-price spiral are higher if inflationary expectations become unmoored. Market- and survey-based inflation expectation measures have increased in recent months alongside tighter bottlenecks, albeit from very low levels in 2020. It is challenging to identify how much bottlenecks directly contribute to the recent increase in long-term inflation expectations, although the pass-through from short-run inflation expectations to its long-run counterpart has increased (see Boissay et al (2021)).

The inflation outlook lastly depends on any forthcoming investment required to address the dislocations. While higher investment boosts demand in the near term, it raises productive capacity only with a lag. This is a typical pattern observed in commodity-exporting small open economies during resource price booms. And if investment requires specialised equipment that is in short supply, eg in the case of semiconductor plants, it could lead to further bottlenecks upstream. Conversely, if needed investment does not occur, particularly in areas such as the energy sector that are undergoing a significant long-term transition, bottlenecks could become more common, leading to greater inflation volatility.

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[7] Indeed, wage growth has already picked up in several economies in recent months, see Economist (2021).

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