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# Rethinking Supply Constraints

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## Rethinking Supply Constraints

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**ABSTRACT:** In macroeconomic policy discussions, the supply side of the economy is usually represented as a level of potential output, reflecting the real resources available for production. It is often assumed that aggregate demand and potential output evolve independently, and that the task of macroeconomic policy is to keep demand-determined output close to the level corresponding to the economy's productive potential. A number of developments have made this representation of supply constraints less satisfactory. The failure of output and employment to return to its previous trend following the financial crisis of 2007-2009 suggests that demand-induced changes in output can have permanent effects. On the other hand, it has become clear that supply constraints come into play in response not only to increases in aggregate expenditure, but also to changes in its composition. We argue that these developments call for a reconceptualization of supply constraints. Rather than limiting the level of output, we should think of them as limiting the rate of change of output, both in the aggregate and in its composition. Substantively, we should think of supply constraints in modern economies as fundamentally reflecting limited capacity for coordination by markets.

**Keywords:** inflation, supply constraints, hysteresis, increasing returns, coordination, distributional conflict, adjustment costs

**JEL codes:** E12, E23, E31

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## 1. Introduction

In capitalist economies, production is organized and directed by flows of money payments. In the short run, production takes place for sale, not for use; goods that are not purchased are not produced. In the longer run, expansions to the capacity for production are made in the expectation of greater money income.

But while an increase in payments calls forth increased production in both the short and longer run, it does not necessarily call forth a proportionate increase. Limits exist to the extent to which additional expenditure can mobilize additional production. For both individual commodities and for aggregate output, the most obvious sign of these limits is a rise in prices. Indeed, the idea that prices reflect the obstacles to increased production is central to their function in a market system. In addition to rising prices, a rapid increase in spending (or disruption to the production process) may result in longer delivery times, difficulty in obtaining certain products, queuing in various forms, reports by business of capacity limits and input shortages and, in the limit, an absolute ceiling on production. These phenomena are what we describe as supply constraints. In practice, discussion of supply constraints is typically associated with periods of high inflation, as over 2021-2022.

The supply side of the economy is often conceptualized as a level of *potential output*. This concept is supposed to describe a level of output consistent with target unemployment and target inflation; that makes full use of society's real resources; that describes the long-run trend followed by observed output and employment; that depends only on supply-side factors and not on current, demand-determined output; and that can be understood as corresponding with the optimal growth path or intertemporal equilibrium described by macroeconomic theory.

In this paper, we suggest that the historical development of macroeconomic aggregates can be better understood if supply constraints are instead thought of as limits on the speed at which production can change, rather than as limits on the absolute level of production. A "speed limit" view of supply constraints makes sense of a number of empirical patterns which are anomalies from the potential-output perspective. An adjustment-speed approach is also consistent with what we substantively know about real economies – that production involves organized human activity within specialized firms, rather than the combination of abstract "labor" and "capital" through arms-length market exchanges. In our view, the fundamental economic problem reflected in supply constraints is not the need to allocate scarce resources among competing ends, but the open-ended problem of how to better organize the collective activity of production.

We believe this approach can be used in most practical settings in which potential output is currently employed. In this paper, we do not try to develop a specific alternative measure. Rather, we seek to make the case for this general approach to the supply side, on the grounds both that it is more consistent with a range of important macroeconomic facts, and that it is more consistent with a realistic substantive view of economic activity.

The remainder of the paper is organized as follows. In Section [2](#) we briefly describe the conventional approach to supply constraints, formalized as potential output. In Section [3](#), we lay out five broad macroeconomic developments or patterns that, we argue, are inconsistent with the conventional potential-output approach, but are consistent with an adjustment-costs view. Section [4](#) discusses implications of our view of the supply side for macroeconomic policy debates. Section [5](#) concludes by linking the adjustment-costs view with a broader vision of economic life.

## 2. The Potential-Output Approach to Supply Constraints

In policy contexts, supply constraints are normally formalized as a level of potential output. This level is supposed to increase steadily over time at a rate that depends on “real” factors – the demographically-determined growth of the labor force, technological progress and the increase of the capital stock through investment, with the latter depending on the cost of capital. Importantly, potential output is invariant to the changes in aggregate expenditure, or demand, which determine the level of output in the short run.

This exogenous level-path conception of the supply side of the economy allows the policy problem to be neatly divided into short-run, demand side policy to minimize deviations of actual output from potential; and long-run supply-side policy to raise the path of potential output. Positive deviations of actual output from potential show up mainly as high or rising inflation, negative deviations as unemployment along with low or falling inflation. Whatever the sources of these deviations, they operate mainly or exclusively at the level of aggregate expenditure, without affecting its composition.

Ball (2014) concisely summarizes this feature of mainstream models:

A fall in aggregate demand causes a recession in which output drops below potential output – the normal level of production given the economy’s resources and technology. This effect is temporary, however. A recession is followed by a recovery period in which output returns to potential, and potential itself is not affected significantly by the recession.

The primary use of potential output is to guide macroeconomic policy. The goal is understood to be minimizing deviations of actual from potential output, avoiding positive

output gaps that create inflation and negative output gaps that create excessive unemployment.

In practice, as Palumbo (2015) describes, measures of potential output build on three principles, or a combination of them. First, it may be simply estimated as trend output using a univariate filter. Second, the non-accelerating inflation rate of unemployment (NAIRU) may be estimated from inflation data, with deviations of inflation from its target level being treated as signs that unemployment is above or below its full-employment level. The size of the output gap is then derived from unemployment, through some form of Okun's law. Third, by assuming that potential output is purely driven by supply considerations, statisticians can derive potential output from a production function approach.

There are important differences between these three approaches; the first is a purely statistical approach, while the latter two incorporate economic theory. But all derive potential from historical trends. While each approach bases its estimates on a different set of series over a decade or so of recent data, they do not, by construction, allow potential output to deviate persistently from actual output.

For example, the production function approach must assume a particular aggregate production form (Cobb-Douglas or CES) and then back out the implied underlying input use. But empirical estimates of, for example, potential labor force, are always derived from some sort of filtering of actual employment. Furthermore, the multiple free, unobservable parameters in these models means that they can only be calibrated to match the actual path of output. Anderton et al. (2014) are unequivocal: "applied researchers ... proxy the trend components of the various inputs by means of statistical filters. For this reason, the production function approach is sometimes criticized as being a method which shifts the inherent problems of HP filtering (of output) to the level of sub-components of the production function (capital, labour and TFP)."

The fundamental conceptual problem, from our point of view, is the conflation of three possible meanings of potential: the highest level of activity that we would forecast based on the recent past; the levels of activity that, under current conditions, would be associated with a positive or negative output gap; and an absolute limit on production based on "real" resources. The question of what would happen to wages and the price level if expenditure rose by 10 percent over the next year', or what path of output and employment is plausible over the next decade, refer to observable aggregates. They may be difficult, but are in principle answerable. The questions, "how much is our economy capable of producing?" or "what is the maximum number of people who can be employed?" are not answerable even in principle. They rely on a sharp line between exogenously given real resources, on the

one hand, and actual activity, on the other, which is neither logically coherent nor empirically sustainable.

### **3. Challenges to the Potential Output Approach**

The conceptual problems with defining and measuring potential output might be ignored if it gave a reasonable description of observable developments. One could imagine a world where aggregate measures of output and employment grew at steady rates which were consistent with the growth of observable factors of production; where changes in aggregate spending were associated with only temporary deviations from this trend, while changes in the trend itself were associated with independently-observed changes in the economy's productive capacity; and where inflation and other measures of tighter or looser supply constraints were consistently associated with the gap between this trend and actual output.

Our world, however, does not look like this. In this section, we discuss five groups of observable developments that create challenges for the potential-output approach. Our examples are drawn mainly from the recent history of the United States, but similar arguments could be made on the basis of evidence from other contexts.

#### **3. 1 Deviations in output and employment are persistent.**

If short-run variation in output and employment are driven by demand, while long-run trends depends on the causally independent growth of potential output, then we would expect business-cycle fluctuations to be transitory. Short-run change in output and employment should not affect our longer-run forecasts for these variables. Since at least Campbell and Mankiw (1989), however, econometric studies of a variety of advanced countries have repeatedly found that fluctuations in output are persistent rather than transitory. In many of these studies, output appears to follow a random walk with drift, so that business cycle fluctuations should change long-run forecasts one for one.

For much of the postwar period, the permanent character of output fluctuations was not obvious in the US because of their relatively modest scale. But since the worldwide financial crisis following 2007, the persistence of fluctuations has been unmistakable. Measured as inflation-adjusted GDP per capita, output in the US fell about to about 11 percent below the previous trend by the official end of the recession in mid-2009. This gap did not close at all during the subsequent recovery. At the start of the pandemic in 2020, real per-capita GDP was about 14 percent below the level predicted by the earlier trend. While the CBO's estimate of the output gap shrank to zero during this period, this was entirely due to downward revisions to estimated potential output.

Similar patterns were found among most other OECD countries in this period, with no return to prior trends during the post crisis recoveries. The falls in output during the recession eventually reduced estimated potential one for one. (Ball 2014)

In the years immediately after the crisis, it was possible to argue that these developments reflected the exceptionally large output gap following 2007, rather than a problem with the concept of potential output itself. In this view, potential had continued to grow at its old rate after 2007 but output and employment remained persistently below it. But by the start of the pandemic, most obvious symptoms of a large negative output gap – below-target inflation, an elevated unemployment rate, and so on – had disappeared, despite the failure of output to return to its earlier trend. This suggests that potential output had adjusted over time to the path of actual output. Under the name of hysteresis, this idea was attracting increasing interest by the end of the decade. (Fatás and Summers 2018; Ball and Onken 2021)

The same patterns are present if we look at employment rather than output. If employment fluctuates around (or below) a supply-determined labor force or level of full employment, falls in employment in recession should be associated with faster growth afterward, as employment returns to its long run trend. But as Fatás (2021) shows, employment grows remarkably steadily during business-cycle expansions, regardless of how much it fell in the previous recession. There is no sign of slower employment growth as the previous trend is approached, or when unemployment is low compared to when it is high. This means that either full employment is not a relevant concept for modern economies, or that it has not been reached during any recent business cycle. Ball (2009) similarly documents that in Europe, deviations of unemployment rates from the estimates NAIRU or full-employment level consistently lead to adjustment of the NAIRU toward the actual unemployment rate, rather than a convergence of unemployment to the old NAIRU.

While it is not normally framed this way, accepting that hysteresis is real and important necessarily implies rejection of the conventional potential-output view of supply constraints in favor of something like an adjustment-cost view. Logically, if potential output changes as a result of demand gaps, then it cannot reflect real resources that are prior to actual production. Supply constraints, in this case, reflect not the long-run potential of the economy but rather the frictions or adjustment costs of moving from one growth path to another. This point is sometimes recognized in the Keynesian literature on hysteresis – for example, by Fazzari, Ferri, and Variato (2020) – but less often in mainstream work.

We can see this more clearly if we formalize hysteresis in the straightforward way followed by most of the literature on the topic.

$$Y_{t+1}^* = (1 + g) \left( Y_t^* + \alpha(Y_t - Y_t^*) \right)$$

Here  $Y$  and  $Y^*$  are actual and potential output respectively,  $\alpha$  is the degree of hysteresis, or fraction of demand-driven variation in output that is passed through to potential, and  $g$  is an exogenously given growth rate presumably reflecting the usual technological and demographic factors.

This formalization captures the intuition that potential output gradually adjusts to actual output. But it's important to see that any degree of hysteresis in this sense is equivalent to supply constraints limiting the transition from a lower to a higher level of activity, rather than the level of activity itself.

With  $\alpha = 0$  we have the conventional case of an exogenous level-path of potential output. With  $\alpha = 1$  we have a pure constraint on growth rates, with a positive output gap when  $Y$  increases at a rate above  $g$  and a negative output gap when it increases more slowly. But for any intermediate value, output gaps will also be transitory, in the sense that a permanent exogenous change in  $Y$  will result in an output gap that diminishes over time as potential output converges to a new higher or lower path.

Similarly, for any  $\alpha > 0$ , a permanent shift in growth of demand from  $g$  to  $g + \Delta g$  leads to permanent but finite output gap converging to  $\frac{\Delta g}{\alpha}$ .

Put another way, in the presence of hysteresis, "potential" cannot be thought of as a limit on the level of output, but only on changes in it. Any level of output growing at rate  $g$  is consistent with a zero output gap. It is the transition between paths that will be associated with output gaps, the larger the more rapid the transition between paths. So insofar as we think that real economies are usefully described in terms of hysteresis, we should think of supply constraints as operating on transition or adjustment speeds and not on the level of output as such.

This has far-reaching implications which the empirical literature on hysteresis has not generally engaged with. For example, we would expect increases in demand to have temporary costs in higher inflation, but permanent benefits in higher output and inflation. This is the opposite of the conventional view.

On the other hand, we can also see that the two approaches to supply constraints are locally equivalent. Let us say that, given the current state of the economy, we believe that a given percent increase in expenditure over the coming year will be associated with a certain unemployment rate and inflation rate. In the short run, we may make the same predictions whether we think of potential as a constraint on levels or on adjustment speeds. It is only in the case of sustained shifts in demand that the two diverge.



### 3.2 The size of the labor force varies with current employment.

In the potential-output paradigm, the size of the labor force – the number of people available for employment – is exogenous to current employment. It evolves mainly based on changes in the size and age distribution of the population, plus structural factors – rates of disability, norms around wage labor versus non-market activities – that change only slowly, and independently of labor market conditions. A well-defined state of full employment is reached when a sufficient fraction of this labor force is employed.

While this conception of the labor force and of full employment seems reasonable at first glance, it has problems as a description of real employment dynamics. First, changes in employment rates over time do not straightforwardly follow changes in the age distribution. Second, there are large differences in employment rates across other demographic categories that don't plausibly reflect any fundamental differences in willingness or capacity to engage in paid work. Third, there is micro level evidence that labor market conditions have lasting effects on employment rates – an important form of hysteresis. Fourth, even “structural” factors are not exogenous to current employment.

The most important demographic factor affecting employment rates is age. Young children do not engage in wage labor, and teenagers and the elderly do so at lower rates. So we would expect changes in the fraction of the population in these age groups to lead to changes in employment rates. At first glance, this seems to explain a large part of changes in employment. If we take employment rates by age in the year 2000 (the peak year for the US employment-population ratio) as fixed and then apply those rates to the 2020 age distribution, we predict a fall in the employment rate not far from what actually occurred.

This apparent correspondence, however, conceals very large changes in employment rates *within* age groups – a large rise among those over 55, and a fall among younger people and especially in the youngest groups. In this period, these happened to more or less offset it each other, but the gross shifts were larger than the effects of changing population shares and cast doubt on whether the distribution of employment by age can reasonably be treated as exogenously fixed. Indeed, over this period the fall in employment-population ratio for the under-55 group was as large as that for the entire population, even though aging within this subgroup played no role in the fall. (Mason, Konczal, and Melodia 2021)

In addition, there are large differences in employment rates across demographic groups that, unlike with age, cannot plausibly be ascribed to differences in willingness or ability to engage in paid work. In the US, employment rates for the Black population are consistently 5 to 10 percentage points lower than for similarly-aged white people. Women, people without college degrees, and people with criminal records are also consistently less likely to be employed. These differences in employment rates tend to be widest when measured

unemployment is high, and narrow when the overall unemployment rate falls, suggesting that they reflect employer preferences rather than different capacities to work. (Mason, Konczal, and Melodia 2021) In both the Great Recession of 2007-2009 and the pandemic recession of 2020, job loss was concentrated among Black workers and those with less formal education. (Fazzari and Needler 2021) Employment gaps between native and immigrant workers in Europe show similar variation over the business cycle. (Diop-Christensen and Pavlopoulos 2016)

These patterns suggest that much of the difference in employment rates across demographic groups reflects employer preferences unrelated to capacity to perform the required work, which are easier to act on in conditions of abundant labor than relative labor scarcity. This in turn implies that the number of people who are in principle available for work is much larger than the measured labor force. These conclusions are supported by micro-level evidence, such as the finding that employers will list the same job as requiring a college degree in a slack labor market but not requiring one in a tight labor market. (Modestino, Shoag, and Ballance 2020)

Hysteresis in labor markets is well-supported empirically. In the US, it shows up mostly as changes in labor force participation rates, since the unemployment rate is basically stationary. In Europe, there are also lasting changes in estimates of full-employment rates of unemployment, which follow the actual rates close to one for one. (Stockhammer and Jump 2022) At the individual level, there is evidence for long-run differences in employment outcomes as a result of shifts in labor market conditions. In the US, exposure to job loss during the 2007-2009 recession has large and seemingly permanent effects on subsequent employment rates and wages. (Yagan 2019) In a number of European countries, the employment rates of young people are sensitive to the level of unemployment at the time they entered the labor force, even many years later, reflecting the “scarring” effects of labor market disruptions. (Causa, Luu, and Abendschein 2021)

Finally, even demographics are not necessarily independent of labor market conditions. Net migration is influenced by labor-market conditions in both source and destination countries. Over the longer run, natural population growth may also be endogenous to employment conditions. This idea, emphasized by the early classical economists, fell out of favor for understandable reasons. But there is a plausible case that increased economic insecurity facing prospective parents has contributed to the fall in birthrates over the past generation. (Brown 2019)

In this view, rather than thinking of labor supply as a fixed quantity, we should imagine a gradient of proximity to employment. The short-term unemployed are the closest, followed by the longer-term unemployed, employed people seeking additional work, discouraged workers, workers disfavored by employers due to ethnicity, credentials, etc. Beyond this

are people whose claim on the social product is not normally exercised by paid labour – retired people, the disabled, full-time caregivers – but might come to be if labour market conditions were sufficiently favorable. Even further out, migration (both inward and outward) is also responsive to labour market conditions. There is no place within this gradient to draw a line around “the labor force”.

The labor supply question, from this point of view, is, can the additional labor required for increased production be acquired without any changes to current employment practices and norms? Can a decision to hire more labor be carried out without any change in existing hiring standards, recruitment, training and so on, and from people who already expect to be engaged in (that kind of) paid work? Or does it require some shift in the expectations of employers and/or prospective workers? Might it require, for example, a change in the credentials demanded by employers for a particular job, or a decision by households to relocate for better job prospects? Limits on labor supply should be understood fundamentally as the cost of making these changes.

### **3. 3 Labor market conditions influence the composition as well as the level of employment.**

The conventional view is that shifts in demand may affect the level of employment, but do not have important effects on its composition. This is important for two reasons. From one side, it means that the level of employment can be taken as a measure of the extent to which people’s capacity for labor is being utilized. From the other, it is consistent with the idea that competitive labor markets deliver something like an optimal mix of employment, in the sense that people are normally engaged in the most productive, and therefore highest paying, activity that they are capable of.

This view was accepted by Keynes, at least for the sake of argument.<sup>1</sup> But at least since Robinson (1936), it has been recognized that there may also be an important category of “disguised unemployment,” in the form of activity where marginal output per worker is extremely low but where employment is relatively unconstrained. These activities will absorb workers who cannot find jobs elsewhere.

The obvious example of this, which is still important in some developing-country contexts, is traditional agriculture. Other family businesses, commission-based work, and self-

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<sup>1</sup> For example, in Chapter 27 of *The General Theory*: “When 9,000,000 men are employed out of 10,000,000 willing and able to work, there is no evidence that the labour of these 9,000,000 men is misdirected. ... It is in determining the volume, not the direction, of actual employment that the existing system has broken down.”

employment in various forms also fit this model. Pollin (1998) recalls a Bolivian official explaining that the country had no unemployment, in the sense that the whole adult population was engaged in some form of income-generating market activity regardless of macroeconomic conditions. But this of course did not mean that their capacity for useful work was being fully utilized.

More broadly, this concept applies whenever an increase in aggregate expenditure and output leads to shifts in employment from lower-productivity to higher-productivity activities. As Kaldor (1972) observes, to the extent that this is the case, we must reject “the sharp distinction made by Keynes between a ‘full employment’ situation ... and an unemployment situation... No valid distinction can be made between an increase in the effective labor supply due to a rise in numbers employed and that due to ... a re-deployment of labor.”

Eatwell (1997) suggests that the persistent differences in productivity across industries are a sign of pervasive disguised unemployment in Robinson’s sense. Historical accounts of economic growth often emphasize the role of rising wages in allowing newer, higher productivity firms and industries to hire workers away from existing activities. (Armstrong et al. 1991) It is a well-established fact that there are large differences in wages across industries and firms, even for observationally similar workers. (Card et al. 2018) These can be interpreted as evidence for pervasive disguised unemployment.

A somewhat more direct piece of evidence for this view is the large, strongly cyclical differential wage gains for workers who switch jobs. As of November 2022, the year-over-year growth in nominal wages for US workers who switched jobs was 7.7 percent, compared with 5.5 percent for workers who remained in their current jobs, according to the Federal Reserve Bank of Atlanta’s Wage Growth Tracker. Similar job-switching wage premia existed in previous periods of tight labor markets and low measured unemployment, including the late 1990s and the period immediately before the pandemic. During cyclical downturns and periods of high measured unemployment, on the other hand, this premium disappears. A natural way to interpret this pattern is that many workers are engaged in lower-pay (and presumably lower-productivity) work than they are in principle capable of, but are kept at their current employer due to search costs and other frictions. It takes an exceptionally strong labor market to overcome these frictions.

The critical point, from our point of view, is that in a world where workers enjoy large wage gains when switching jobs, and the frequency of such switches varies with labor-market conditions, one cannot assume that workers are already in the highest-earning position their skills, credentials and other characteristics will allow them to occupy. Assuming there is some relationship between wages and productivity, we should similarly conclude that workers normally are doing lower-productivity work than they could be. It

follows that some part of the inflation and other costs associated with “overtight” labor markets may be seen as the costs of transition from lower-value to higher-value employment.

### 3.4 Increasing returns and learning by doing are ubiquitous in modern economies.

The potential-output view assumes that production technology can be treated as existing prior to the actual pattern of production, and improves at an exogenously determined rate. This assumption, and the closely related one of diminishing returns (or increasing costs) in any given activity, is also essential if we imagine investment in terms of an economy-wide stock of capital being allocated to its best use by returns at the margin. Keynesian economists have long suggested that there is an important link from output growth to productivity, summarized as the Kaldor-Verdoorn law. (See Chandra and Sandilands (2021) for an overview of the debates around this term, and Jeon and Vernengo (2008) for an empirical investigation using US data.) But the implications for macroeconomics have not always been foregrounded.

The idea that unit costs fall with the scale of output is so universally accepted outside of economic theory that it is often hard for people with business or policy backgrounds to believe that it is controversial among economists. A recent popular history of building technology, for example, straightforwardly glosses “supply and demand” as the tendency of production costs to *fall* as demand rises, giving as an example the improvements in steel technology that followed its widespread adoption as a structural material. (Winkless 2016) The prevalence of increasing returns was also widely accepted in the economics profession by the early 20th century. The return to models based on decreasing returns was not based on any new empirical evidence but on the incompatibility of increasing returns with economists’ preferred models of competitive markets. (Jennings 2015)

There are many reasons for unit costs to fall as the scale of production rises. One is simply that where the efficient scale of the productive unit is small, it can be duplicated, but where it is large, it cannot be subdivided. (Largely for this reason, Pigou (1927) believed that outside of primary products, “cases of increasing costs ... do not occur”.) Another is the more extensive division of labor possible with larger scale production, as famously discussed by Adam Smith. A third is the increasing possibilities for investment in specialized capital equipment and technology as the scale of production rises. As Allyn Young memorably observed, no one would make a hammer in order to pound a single nail.(quoted in Kaldor 1972)

A related but distinct phenomenon, emphasized by Alchian (1959), is the fall in costs as production is extended over time. The possibilities for human labor to transform the

material world are not knowable *ex ante*; much of the technical knowledge for doing so is acquired only in the course of production. Unit costs in many manufacturing processes fall over time, independently of any investment or other observable technical improvements. In one famous example, the Horndal steelworks in Sweden showed a steady 2 percent annual productivity growth over a 15 year period in which no new investments of any kind were made. (Lazonick and Brush 1985) Even in the course of construction of a single high-rise building, later floors typically take less time to build than earlier ones. (Pellegrino et al. 2012)

Evidence for the ubiquity of increasing returns and learning by doing is found in the structure of the economy all around us, from the organization of production in long-lived, specialized firms, to the geographic clustering of particular industries. The importance of increasing returns to making sense of observed patterns of international trade was the central insight of the New Trade Theory. As Krugman (1981) acknowledges, this vision of path-dependent specialization is shared with an older radical literature on imperialism and underdevelopment.

The path dependency implied by increasing returns has long been recognized within the Keynesian tradition (Kaldor 1972) Early entrants, whether firms, regions, or countries, will tend to maintain their advantage. A process or standard, once established, will tend to remain in place, whether or not it has any advantages over alternatives. In general, we can think of increasing returns as creating a rugged or uneven efficiency landscape. Rather than one unique equilibrium that will be reached from any starting position, there may be many locally stable equilibria, so that where markets converge depends on the starting point.

In the present context, the importance of increasing returns and learning-by-doing is that production technology cannot be treated as independent of actual production. A new product or process will typically have higher costs when it is first introduced, which will then fall as it is more widely adopted. The period of high-cost production can be thought of as a friction in the transition from existing forms of production to new ones.

An important recent example of this phenomenon is the fall in renewable energy costs. Between 2010 and 2021, the levelized costs of photovoltaic solar power fell by nearly 90 percent, while the levelized costs of wind power fell by about two-thirds. (IRENA 2022) While there are multiple reasons for this dramatic fall in costs, it is clear that it followed, rather than led, the rapid expansion in the use of these technologies. Early growth was driven by regulatory mandates and subsidies, which were needed to overcome a substantial initial cost disadvantage. Only once they were already in wide use did their costs fall below established power sources.

Not all new technologies will experience the same kinds of steeply falling costs as wind and solar energy have. But there is good reason to think the phenomenon is widespread. The

mobilization for World War II, for example, saw very rapid productivity gains in many sectors related to war production. (Bossie and Mason 2020)

Historically, booms are not just periods of faster growth, but of widespread adoption of new forms of production. Insofar as investment embodies new technologies rather than simply reproduces existing techniques on a larger scale, we might expect to see the same phenomenon at the aggregate level, where faster growth involves a short-term slowdown in productivity and a longer term rise.

All these considerations point to the conclusion that current costs are not necessarily a good guide to long run tradeoffs, especially in situations where there has been a rapid acceleration of growth of output or, as discussed in the next subsection, rapid changes in its composition.

### **3.5 Supply constraints appear in response to changes in the composition of output as well as increases in its level.**

Potential output is understood as a limit on the achievable quantity of aggregate output, reflecting the limited quantity of labor, capital, and other real resources available at a given moment. Various imperfections and constraints may distort the allocation of these resources, but this is unrelated to supply constraints as such. For inflation and other macroeconomic outcomes, what matters is aggregate output and employment.

In recent years, there have been major shifts in both demand, as consumers shifted from purchases of in-person services to goods, and supply, as the pandemic and then the Russia-Ukraine war disrupted specific categories of production. In the potential-output view, these shifts should have at most second-order effects on aggregate outcomes, as symmetrical impacts across sectors largely offset each other. But, while the causes of the worldwide inflation of 2021-2022 remain controversial, it appears that much of it, along with broader signs of binding supply constraints, is associated precisely with these sectoral shifts.

A straightforward explanation of inflation in terms of excessive aggregate demand faces the problem that the acceleration in prices does not have any direct relationship with above-trend expenditure or a positive output gap as conventionally measured. In the US, for example, inflation rose sharply from the second quarter of 2021, even though it was not until the last quarter of 2021 that real GDP significantly exceeded its pre-pandemic trend. Variation in inflation across countries does not show any correlation with either the growth of output or the scale of fiscal stimulus. (Stiglitz and Remni 2022)

On the other hand, the pandemic has provided clear evidence that shifts in demand have strong effects on the aggregate price level. Here are two examples from the US experience. At the start of 2020, consumer spending on food at home and bars and restaurants were

roughly equal, at about \$60 billion per month. During the early months of the pandemic, bar and restaurant spending fell by over 50%, to about \$30 billion, while monthly spending on food at home rose by about \$20 billion. The former remained significantly depressed, and the latter elevated, until mid-2021. During this period, unsurprisingly, prices accelerated sharply for food at home, from an annual increase of less than 1 percent prior to the pandemic to over 5 percent. But there was no deceleration in prices for food away from home, which continued to rise at roughly the pre-pandemic rate.<sup>2</sup>

A second example is the price of new and used vehicles. During the initial rise in inflation during 2021, these two categories accounted for a large majority of the acceleration of the price level, despite accounting for only about 7 percent of the consumption basket.<sup>3</sup> The reason for the sharp rise in vehicle prices is not a mystery: Output was tightly constrained in the short run (used vehicles by definition, new vehicles by the lack of imported components, particularly chips.) The rise in prices for a good in inelastic supply facing a sudden rise in demand is not surprising. What is noteworthy is that there was no offsetting fall in prices elsewhere. In the conventional view, substitution should dampen the effect of sector-specific shocks on the aggregate price level.

In reality, it seems clear that disruptions to shipping and energy were amplified rather than dampened, with higher costs fully passed on to downstream sectors. This is a problem for an understanding of supply in terms of a level of aggregate output, since it suggests that reduced production in one area will not be made up by increased production elsewhere, at least for certain strategic sectors. (Weber et al. 2022) As with the asymmetric impact of demand shifts, this points toward a microeconomic rather than macroeconomic understanding of inflation and the supply side generally. The relevant constraint is not (only) on aggregate output, but on production of particular goods.

If supply constraints reflect mainly or entirely the frictions of changing activity, rather than absolute resource constraints, then it is natural that we would see them in response to changes in the composition as well as the level of real activity. One important reason for this is that production units are specialized. Rather than renting generic capital services in a spot market, as in a production function, firms invest in the capacity to produce particular output via particular processes.

Over time, there is certainly substitution between capital and labor, in the sense that businesses carry out investment with the intent and effect of raising output per worker. But

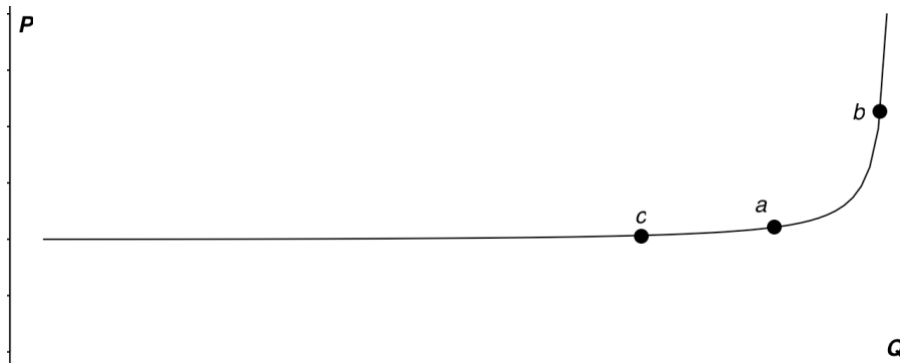
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<sup>2</sup> Authors' analysis of data from the Federal Reserve Bank of St. Louis' FRED database.

<sup>3</sup> Authors' analysis of data from the Bureau of Labor Statistics' Consumer Price Index databases.



in the short run, capital equipment and production technology is specialized for a particular process as well as particular output. This means that a demand-induced reduction in output and employment does not raise output per worker, but simply leaves part of the capital stock unutilized. Conversely, the specialization of capital means a firm that faces a rapid increase in demand cannot simply rent more capital services. Firms normally maintain some excess capacity, based on expectations of a normal growth rate and variability of demand, but output beyond this faces steeply rising marginal costs or is simply unachievable in the short run.



*Typical short-term cost curve*

We can summarize this by saying that cost curves are strongly convex. As shown in Figure 1, we can think of them as having something like a backwards-L shape, with marginal costs constant over the normal utilization range and rising vertically somewhere above it. This picture of strongly convex cost curves gets support from recent empirical work.<sup>4</sup> (Boehm and Pandalai-Nayar 2022)

Formalizing specialized production units in this way helps explain why changes in the composition of output lead to a rise in the overall price level. Normally, production is at a point like *a* in the figure; capitalists will invest to the point where capacity is a bit greater than expected levels of output. As long as production is taking place within the normal level of utilization, marginal costs are constant. But once normal capacity is exceeded by more than some reasonable margin, costs rise rapidly. A rapid change in the composition of demand would shift some firms to *c* and others to *b*. The former would see lower output at their old prices, while the latter would see little increase in output but a large rise in prices.

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<sup>4</sup> It is common, as in the cited article, to refer to convex supply curves. But since the conventional definition of supply curve does not apply in the absence of increasing marginal costs, we prefer to refer to cost curves.

It is sometimes argued that the reason that shifts in the composition of output lead to rises in the overall price level is because of price rigidity, and in particular that prices and wages are sticky downward. This argument, while arriving at the right conclusion, has the logic backward. The reason that shifts in the composition of demand are inflationary is not that prices are slow to adjust. The problem is that prices can adjust much *faster* than the organization of production can.

Over time, if the new pattern of demand is sustained, (dis)investment will cause the cost curves to shift to bring the level of activity back to the normal utilization range. In other words, for many sectors, supply curves may be close to vertical in the short run, and horizontal in the long run. Or as discussed in the previous section, long-run cost curves may be downward sloping. This is a further reason why, in contrast to the orthodox view, it cannot be assumed that short run price responses are informative about longer run production possibilities.

#### 4. Implications for Policy

The productive capacity of the economy cannot, of course, be captured by any single value. But the considerations discussed in the previous section suggest that, if we need a simple, tractable representation of the limits to production, we would do better to represent this as a maximum rate of change rather than a maximum level of output and/or employment – a speed limit, not a ceiling. An adjustment-speed conception of supply constraints has important implications for macroeconomic policy.

First, on the negative side, rising prices and other signs of supply constraints cannot be taken as evidence for the long-run limits on the economy's productive potential. Current prices do not necessarily reflect long-run tradeoffs, particularly in a situation in which one or both sides of the market are experiencing rapid changes. This suggests that, insofar as inflation is the result of an excess of desired spending over (current) productive capacities, patience is called for. An increase in demand, in the aggregate or in an individual sector, may lead to rising prices in the short run, while over the long run the cost of production will be the same or lower. Rising prices and other signs of supply constraints need not reflect scarcity of real resources in any absolute sense, but rather the fact that spending flows can change much more quickly than the organization of production can adjust.

More broadly, this view should make us skeptical of suggestions that recent rises in the prices of energy, food and other essential commodities reflect the “end of abundance” – a sign of a world where pervasive material scarcity means that Keynesian policy prescriptions are no longer suitable. (See Aboobaker and Michell (2022) for a version of this argument from a broadly Keynesian perspective.) This view could already be be

challenged on the grounds that recent price hikes are a symptom of the short-term distortions of pandemic and war, and that these commodities have often been subject to large speculative price swings in the past. (Between 2005 and 2008, a number of energy and agricultural commodities saw price rises comparable to what they experienced over 2020-2022.) But from the perspective being presented here, even if the rise in prices was entirely a result of strong demand, we should not interpret it as a sign of permanent scarcity.

On the positive side, if we think of the supply constraint facing the economy in terms of adjustment rather than real resources, that suggests a different form of “supply side” policies to enable more rapid growth or redirection of economic activity. What is fundamentally needed are measures to overcome the coordination and information problems and other frictions that limit rapid changes in productive activity. The analysis here suggests a focus on the limits to market coordination – rapid shifts in demand will generate large price changes faster than real activity can respond. These price changes, if large enough, can interfere with the routing functioning of economic units, lead to counterproductive adaptations (such as speculation and hoarding of scarce inputs) and entail large redistributions of income that will be disruptive both economically and politically. In many cases, the distributional consequences of more rapid growth may be *the* binding constraint, rather than productive capacity as such.

It follows that more rapid growth – as well as rapid redirection of economic activity as required by decarbonization or events like the pandemic – will require an increased role for non-market forms of allocation, to ensure that capacity increases in a coordinated way and short-term scarcities are managed without disruptive price spikes. This implies planning of some sort, though not necessarily central planning in the traditional sense. This is a point emphasized in much of the classic literature on industrialization, such as Gerschenkron (1963). It is also one of the central lessons of the economic mobilization for World War II, where very rapid growth in output entailed a much more direct role for the state in directing credit and key inputs than in other periods. (Bossie and Mason 2020a)

Another implication is that price regulation may play an important role during a period in which capacity is adjusting to rapid shifts in demand or disruptions to production. While price signals play a central role in market coordination, large, rapid price changes can be disruptive. As discussed above, in the presence of specialized capital goods and increasing returns, current prices may not be a good guide to long-run opportunity costs. This is especially likely when expenditure and output are changing rapidly. Rapid changes in prices also create uncertainty about future prices. Finally, as price changes get larger, income effects become more salient. At the same time, these price changes may have limited value as incentives. For firms facing constant or declining marginal costs over longer horizons, an increase in sales at the current price should be sufficient inducement to

raise capacity, assuming it is expected to persist. Conversely a large shift in demand relative to current capacity that is believed to be temporary may generate large price changes that have little effect on investment, but simply generate windfall gains and losses for buyers and sellers.

These points are widely recognized in the wake of natural disasters, when sharp price increases for essential goods would serve little value as signals while causing undesirable income effects. But we suggest it applies more widely. If, for example, demand for housing in a particular location rises rapidly, market rents are likely to increase faster than new housing can be added. This implies a redistribution of income from tenants to property owners, and may even undermine the otherwise-positive developments that led to increased demand in the first place. In general, policies to moderate price changes may be called for whenever there is reason to think that adjustments to productive capacity are lagging behind demand, so that current prices do not reflect long-run costs.

The central policy implication of this perspective is that the appearance of rising prices and other signs of binding supply constraints does *not* mean that efforts to maintain strong demand should be abandoned or scaled back. Rather, it means that those efforts must be combined with other measures to improve the coordination capacity of markets, and to limit disruptive price movements in the short run.

## 5. Conclusions: Toward a New Paradigm for the Supply Side

The disruptions to production and trade during the COVID-19 pandemic and the ensuing worldwide rise in inflation over 2021-22 refocused the attention of economists and policymakers on the supply side of the economy. After a long period in which the focus in macroeconomics was on stabilizing the aggregate flow of spending in the economy, and in the possibility of disruptive developments within the financial system, there has been renewed interest in the constraints imposed by the limits to labor and other real resources, and by productive capacity more generally. It is to be hoped that this renewed interest does not merely involve a reassertion of old ideas about scarcity, but leads to a critical rethinking of how we imagine the supply side of the economy.

We have argued that a number of important macroeconomic developments are inconsistent with a conception of supply constraints as limits on the absolute level of production, based on the availability of labor and other real resources. They are more consistent with a conception of supply constraints as binding the speed at which productive activity can adjust to changes in money flows, based on the limited coordination capacity of markets. But the appeal of this perspective is not simply that it better fits

observable developments. It is also more consistent with what we know substantively about the concrete organization of production.

The adjustment-costs view reflects a number of fundamental features of real economic activity, which the potential-output approach ignores or abstracts from.

1. *Employment and other economic relations are embedded in larger social arrangements.* Economic decisions are not made in a vacuum. Decisions about employment in particular, are deeply connected with the reproduction of the household as a social unit. People's choices about forming new households, where to live, when to have children, and other central choices in their lifecourse are closely bound up with beliefs about who is expected to engage in paid work, and what kind. Nor are employers' expectations and preferences for hiring limited to technical ability to perform certain tasks. For example, recent work has confirmed the commonsense view that people are significantly more likely to be hired, and on more favorable terms, at firms where a parent already works. (Staiger 2021) Over time, changing labor-market conditions can shift norms around employment, and lead people to move to new areas and reorganize their lives in other ways; but because these choices involve are central to people's lives, they won't happen quickly, or be easily reversed. While labor markets are probably unique in the extent to which they are integrated into other social relations, few markets are purely one-off commercial transactions. Established relations of trust and preexisting social ties are important to the smooth functioning of almost any kind of economic activity.
2. *Production technology is embodied in long-lived, specialized capital goods and organizations.* One of the most visible facts about the economies in which we live is that production is organized through specialized, long-lived firms, typically corporations with distinct legal identities. Almost all decisions about production are not made directly by households or the notional owners of capital, but through the administrative hierarchies of these firms. Yet the existence of long-lived, specialized enterprises is largely ignored in macroeconomic theory, which imagines the economy in terms of the combination of homogeneous labor and "capital," whose services are rented period by period like any other input. Economists, presumably, are as aware that iPhones are manufactured exclusively by the Apple corporation and its subcontractors, using specialized inputs and equipment, according to a plan deliberately chosen by its management, not by anyone who can buy the requisite quantities of labor and capital in the open market. But conventional macroeconomic models assume that this is an institutional detail that can safely be abstracted from. When it comes to rapid changes in production – the situations where supply

constraints are most relevant – the fact that capital goods, technology and the activity of production exist within specialized, hierarchical organizations cannot be ignored.

3. *Large-scale changes in activity pose coordination problems.* Market coordination depends on the ability of individual actors to take decisions on the basis of current prices, while taking other actors' choices as given. This is reasonable when choices involve small changes from the previous period. But the greater the changes being contemplated, the less reliable this assumption will be, especially when production choices must be made in large, indivisible units, are irreversible, entail substantial lags, require specialized linkages with other producers, or involve networks. For example, the decision to expand electricity generation may involve construction of a new plant with a very large minimum size, a construction time of several years and an expected service life of decades. A decision like this cannot be made solely on the basis of current costs and prices, but requires a long-term commitment from a utility or other major purchaser as well as the development of appropriate transmission facilities. In such cases the model of economic actors as individually small price takers breaks down, and some form of explicit coordination is required.
4. *Real-world markets characterized by limited information and pervasive frictions.* The idea that the economy is normally, or even occasionally, close to the absolute limit of its productive capacity implies that workers are aware of all the alternative forms of employment open to them, and business owners and managers are aware of all the possible uses their facilities can be put toward, and that all of these alternatives are accessible regardless of what is currently being engaged in. As soon as we step back from the world of theory to the concrete world around us, it is obvious how unreasonable these assumptions are. Businesses can hire easily from only a limited pool of labor and must make increasingly costly efforts at recruitment and training as they move beyond it, as the newer models of search frictions and monopsony have emphasized. (Manning 2013) Consumers don't choose among all possible products, but those which they are familiar with – this is why businesses value market share. Ongoing organizations have capabilities that cannot be easily reproduced by new entrants. Specialization – whether at the level of the firm or the region – is ubiquitous and persistent. This means that while small changes to the current pattern of activity can be made easily, larger changes become increasingly difficult and costly.

Our suggestion is that models that represent supply constraints as a limit on the rate of growth of aggregate output, or particular subsets of it, are more consistent with this

understanding of real economies, while retaining the simplicity and tractability of the familiar potential-output approach.

Such an approach does not force us to reject the concept of supply constraints in general, or ignore the real ways in which increases in the flow of expenditure run up against the limits of current productive capacity. Given the existing pattern of spending, production and employment, an increase in spending may lead to inflation, shortages, longer delivery times, and so on. But we should not imagine that this tells us anything about the level of production or employment that the economy is capable of in principle.

This view of supply constraints has implications for macroeconomic theory. Supply constraints as adjustment costs rule out any fundamentals-determined long run, and hence any model of behavior based on lifetime income or similar long run values. While it is true that decisions about current production take productive capacity as given, there is no sense in which there is a stock of capital, labor and technology that exists prior to production. There is no preexisting capital stock to be allocated among different firms and industries, only the existing machines, structures, and techniques associated with the current pattern of production. Nor is there a strong hierarchy of adjustment speeds such that we can treat factors of production as exogenous in practice. In particular, we cannot assume that employment adjusts to the size of the labor force faster than the labor force adjusts to current employment.

All this suggests that an adjustment-speed perspective on the supply side will be easier to reconcile with some kinds of theoretical approaches than others. It fits better with a view of macroeconomics as fundamentally aimed at accounting for concrete historical developments in particular economies, as opposed to one aimed at developing a model of “the economy” in general. (See Jayadev and Mason (forthcoming) for more on this distinction.) It fits, in other words, with the use of partial-equilibrium models for particular questions rather than an overarching general equilibrium model. (Indeed, in the absence of sharply defined endogenous and exogenous variables, it is not clear what “general equilibrium” would mean.) In particular, a view of supply constraints that incorporates hysteresis and other forms of path dependence is not compatible with long-run growth models.

On the positive side, the adjustment-costs perspective fits well with approaches that make distributional conflict a central element of the macroeconomics of inflation, and of supply constraints more generally. It is consistent with accounts of the labor market that emphasize search costs and other frictions. It is consistent with models of product markets that incorporate market power and increasing returns. It could be said that what we are proposing here, is simply a way of conceptualizing supply constraints that is consistent with what we already believe in these other domains. Or, from the other side, it can be seen

as a generalization of arguments that have been made in the context of the pandemic for seeing shifts in demand and specific disruptions to production as the source of high inflation and other signs of binding supply constraints. Our suggestion is that we should not treat the pandemic period as a unique event, but as an important laboratory for improving our understanding causal links that may be harder to see in normal times.

It is conventional to end papers with a call for further research. But in this case, we do so out of more than convention. Our goal in this paper has been neither to develop an alternative quantitative measure of supply constraints, nor to put forward a coherent way of formalizing them within macroeconomic models. Rather, it has been to sketch out an alternative “pre-analytic vision,” in Schumpeter’s well-known phrase, of the supply side of the economy, to encourage both economic theory and policy-oriented empirical work to move away from the conventional potential-output approach in what we hope will be a more fruitful direction.

Inflation as such is a symptom, rather than a distinct phenomenon in its own right. It may reflect a breakdown of the tax and banking systems (as in historical hyperinflations), a depreciation of a country’s currency, or simple measurement issues, rather than a macroeconomic problem of excessive aggregate demand relative to supply. But insofar as inflation is a macroeconomic phenomenon, we suggest, the fundamental problem it reflects is not scarcity of real resources, but the limits to market coordination. Large changes in demand generate large price and income changes before output can adjust. These price changes may be sufficiently disruptive as to prevent the shift in demand from being sustained long enough to call forth increases in capacity. Distributional conflicts are a central dimension of the resulting supply constraints. Overcoming them requires more extensive non-market coordination.

Most if not all of these claims should, we believe, be congenial to economists working in the Keynesian tradition. Our hope in posing the questions that we do in this paper is to help formalize supply constraints in a manner more consistent with the workings of the world we see.

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