The Supply-Shock Explanation of the Great Stagflation Revisited*

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ABSTRACT

U.S. inflation data exhibit two notable spikes into the double-digit range in 1973-1974 and again in 1978-1980. The well-known "supply-shock" explanation attributes both spikes to large food and energy shocks plus, in the case of 1973-1974, the removal of price controls. Yet critics of this explanation have (a) attributed the surges in inflation to monetary policy and (b) pointed to the far smaller impacts of more recent oil shocks as evidence against the supply-shock explanation. This paper reexamines the impacts of the supply shocks of the 1970s in the light of the new data, new events, new theories, and new econometric studies that have accumulated over the past quarter century. We find that the classic supply-shock explanation holds up very well; in particular, neither data revisions nor updated econometric estimates substantially change the evaluations of the 1972-1983 period that were made 25 years (or more) ago. We also rebut several variants of the claim that monetary policy, rather than supply shocks, was really to blame for the inflation spikes. Finally, we examine several changes in the economy that may explain why the impacts of oil shocks are so much smaller now than they were in the 1970s.

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"Everything should be made as simple as possible, but not simpler."
Albert Einstein

1. Preamble

Between, say, the first OPEC shock and the early 1980s, economists developed what has been called "the supply-shock explanation" of what this conference calls "the Great Inflation," that is, the period of high inflation seen in the United States (and elsewhere) between 1973 and 1982.[1] At the conceptual level, the supply-shock explanation can be succinctly summarized by four main propositions:

1. At any given moment, there is an underlying (or "core") inflation rate toward which the actual (or "headline") inflation rate tends to converge. This rate is determined by the fundamentals of aggregate demand and aggregate supply growth.

2. Many factors, including but not limited to monetary and fiscal policy, influence the growth rate of aggregate demand. On the supply side, the fundamental driving factor in the long run is the growth rate of productivity, but occasional abrupt restrictions in aggregate supply ("supply shocks") can dominate over short periods.

3. For empirical purposes, the core rate of inflation can be proxied by the rate of change of prices for all items other than food and energy.

4. The headline inflation rate can deviate markedly from the core rate over short periods. Rapid increases (or decreases) in food or energy prices, which are largely exogenous, can push inflation above (or below) the core rate for a while. There may be other special one-shot factors as well, such as the 1971-1974 Nixon wage-price controls.

This model, if you want to call it such, was applied by a number of scholars to explain the history of the Great Inflation with six additional propositions:[2]

5. The dramatic rise in inflation between 1972 and 1974 can be attributed to three major supply shocks—rising food prices, rising energy prices, and the end of the Nixon wage-price controls program—each of which can be conceptualized as requiring rapid adjustments of some *relative* prices. (Thus nominal rigidities play a central role in the story.)

6. The equally dramatic decline in inflation between 1974 and 1976 can be traced to

[1] For a short but comprehensive summary in an earlier NBER volume, see Blinder (1982, pp. 262-264).
[2] Among the many who could be listed, see Gordon (1975), Phelps (1978), and Blinder (1979, 1982). The specific six points listed here follow Blinder (1982).

the simple fact that the three above-named factors came to an end. In other words, double-digit inflation went away "by itself."

7. The state of aggregate demand thus had little to do with either the rise or fall of inflation between 1972 and 1976. This is not to say that aggregate-demand management (e.g., monetary policy) was irrelevant to the behavior of inflation over this period, but only that its effects were dwarfed by the effect of the supply shocks.

8. Specifically, while the rate of headline CPI inflation rose about eight percentage points between 1977 and early 1980, the core rate may have risen by as little as three percentage points. The rest of the inflationary acceleration came from "special factors."

9. The initial impetus for rising inflation in 1978 came mainly from the food sector, with some help from mortgage interest rates.[3] The further increase into the double-digit range in 1979 mainly reflected soaring energy prices and, once again, rising mortgage rates. Finally, mortgage interest carried the ball almost by itself in early 1980.

10. The 1970s really were a break from recent history. Energy shocks appeared to be a product of the brave, new post-OPEC world.[4] Food shocks were not new. We had experienced them in the 1940s, but somehow managed to get away without any in the 1950s and 1960s.

These ten numbered points can be said to constitute the supply-shock explanation—or, more correctly, the special-factors explanation—of the Great Inflation. But before proceeding to analyze this explanation, two important preliminary points must be made.

First, the Great Inflation was in fact *two* distinct episodes, as Figure 1—which plots headline and core inflation as measured by both the CPI (using current methodology) and the PCE price index—clearly shows.[5] There were sharp increases in inflation in 1973-1975 and then again in 1978-1980, but each was followed by a sharp *disinflation*. (And for later reference, it is worth noting that, in both episodes and by both measures, core inflation rose and fell *later* and *by smaller amounts* than headline inflation.) Any

[3] At the time, the mortgage interest rate was a direct component of the CPI. More on this in Section 3.1.4.
[4] However, Hamilton's (1983) subsequent work showed that this was not quite so.
[5] At the time of the conference, the core PCE price index was defined to exclude food, beverages, and energy goods and services. (The core CPI excludes food and energy only.) In the 2009 comprehensive revision to the national accounts, the Bureau of Economic Analysis modified the definition of core PCE prices so that food away from home was no longer excluded. This paper uses the pre-revision definition of core PCE throughout. (Appendix 1 gives definitions and sources for all series used in this paper.)

coherent explanation of the inflation of the 1970s must explain *both* the ups *and* the downs.

In addition, however, Figure 1 displays a clear upward drift in core inflation, from under 2 percent in 1964, to around 4 percent by 1970, and then to about 6 percent by 1976—before it falls back to 4 percent or so after 1983. This upward drift, which is presumably explainable by the fundamental factors listed in point 2 above, constitutes an interesting and important macroeconomic episode in itself—and one that has certainly not gone unnoticed! [6] But it is *not* the subject of this paper. Had the upward drift in inflation from 2 percent to 6 percent (and then back down to 4 percent) been all that happened, no one would have dreamed of calling this episode the "Great Inflation." Hence we focus squarely on the two big "inflation hills" that are so evident in the figure.

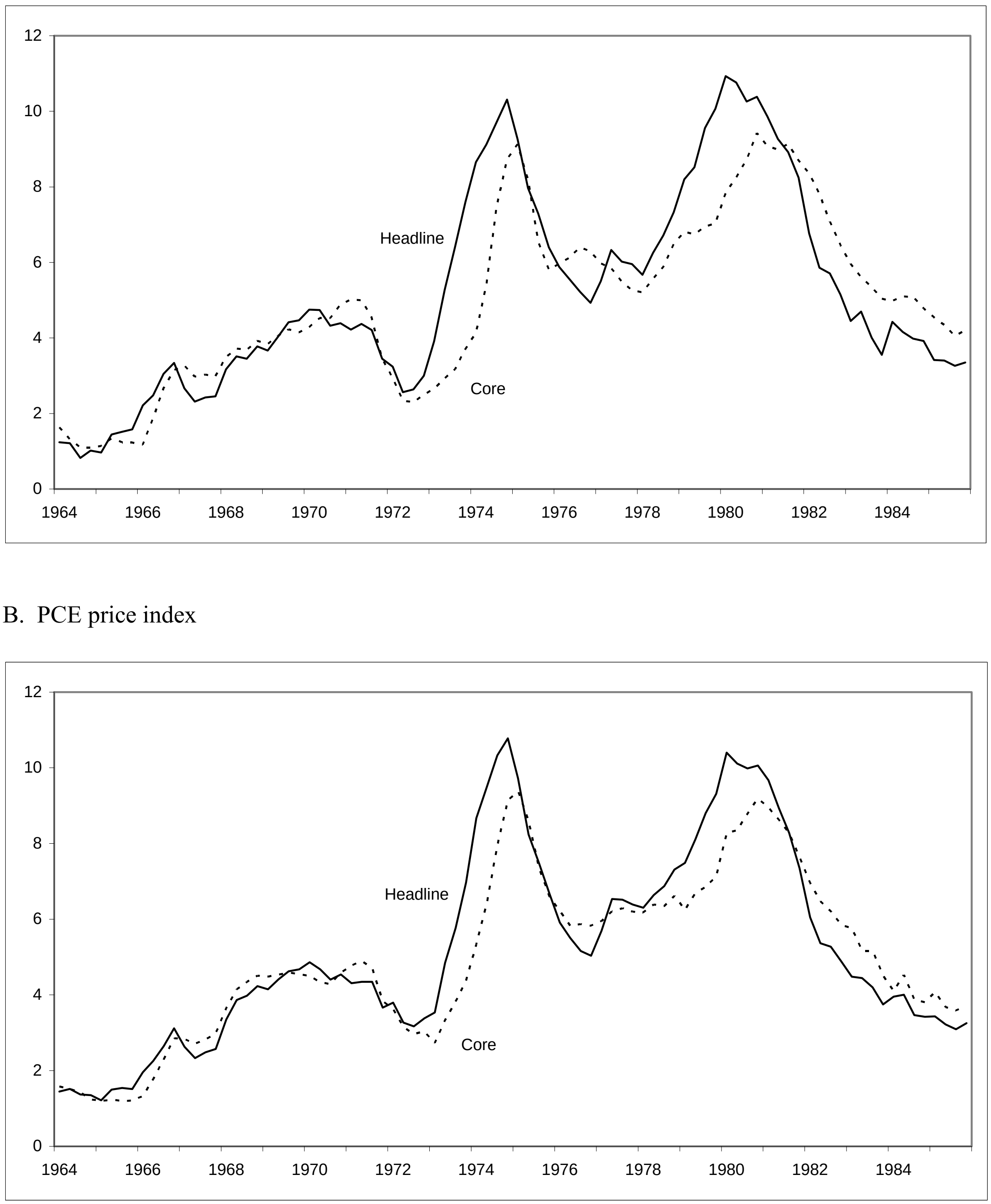
Second, the Great Inflation was really the Great *Stagflation*. Any coherent explanation must also explain the contemporaneous deep recessions. In particular, the economy did not merely experience *real output* declines over these two periods. *Unemployment* also rose sharply, implying that what was going on in each case was more than just a neoclassical drop in output in response, say, to the rise in the relative price of energy.

[6] Among these fundamental factors, we would count Vietnam War spending in the late 1960s, over-expansionary monetary policy, and the post-1973 productivity slowdown. According to CBO estimates, the unemployment rate was below the NAIRU in every year from 1964 through 1974.

Figure 1
Consumer price inflation, 1964-1985

A. Current-methods CPI

B. PCE price index



Note: Four-quarter log differences.

Why revisit this ancient explanation now? There are several reasons. First, all the data have been revised, and we have experienced nearly thirty additional years of macroeconomic history, including several more oil shocks. Some of this history looks quite different from the 1970s, which already provides sufficient reason to reexamine the supply-shock story. Second, both macroeconomic theory and the theory of stabilization policy have gone through several upheavals since 1980, during which (among other things) the canonical macro model has changed multiple times. Third, an extensive empirical and theoretical literature on supply shocks, partly spurred by Hamilton's (1983) important paper, has developed. Some of this literature disputes the supply-shock explanation. The purpose of this paper is to reexamine the supply-shock explanation of the Great Stagflation in the light of these new facts, new models, and new econometric findings. Our central questions are: Do we need to rewrite the economic history of this period—and if so, how?

The analysis proceeds in four main steps. Section 2 outlines and slightly modernizes the basic conceptual framework (points 1 to 4 above) and reexamines it in the light of much new theory and many new empirical findings. Section 3 takes a fresh look at the evidence on the Great Inflation in the United States (points 5 to 10 above)—once again making use of new data, new theory, and new econometric findings. Section 4 then deals with a series of objections to the supply-shock explanation, some of which were raised before 1982, but most of which surfaced later. Finally, Section 5 looks beyond the narrow historical confines of the 1972-1982 period, considering (albeit briefly) supply shocks both prior to and after the Great Stagflation. The main focus here is on why recent oil shocks seem to have had so little impact on either inflation or output.

Section 6 draws some conclusions. But we can end the suspense right now by stating that, at least in our judgment, the "old fashioned" supply-shock explanation holds up quite well.

2. What is the supply-shock explanation of the Great Stagflation?

First we must define what we mean by a "supply shock." We begin, as is now conventional (but was not in 1973), by dividing the various influences on output and prices into two categories: factors that influence *aggregate supply* ("supply shocks") and factors that influence *aggregate demand* ("demand shocks"). Their respective hallmarks can be described in either of two ways.

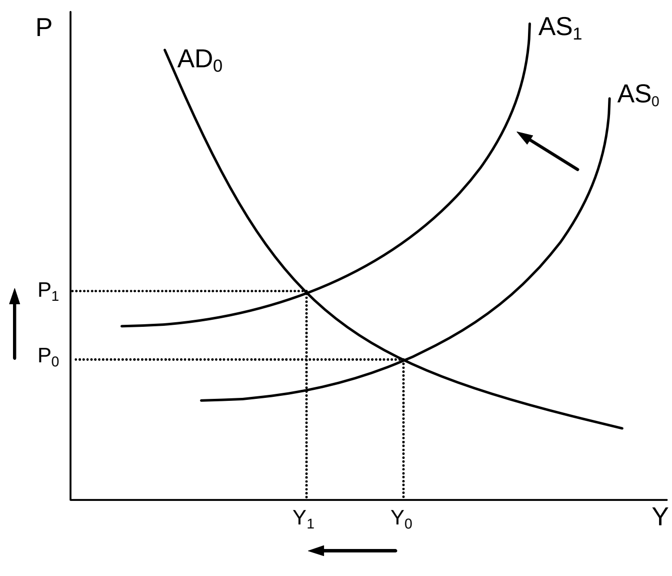
1. Supply shocks affect the ability of firms to *produce* the gross domestic product, which means that they *directly* affect either the prices or quantities of factor inputs or the production technology. The resulting changes in output can be thought of as basically neoclassical in nature. On the other hand, demand shocks affect spending by the households, businesses, and governments that *purchase* the GDP. Naturally, any demand shock will have short-run Keynesian effects (*e.g.*, result in changes in real output) if the economy has Keynesian properties—which it does.[7]
2. Supply shocks are events that, on impact, move the price level and real output in *opposite* directions (*e.g.*, an adverse shock causes prices to go up and output to go down). Demand shocks are events that, on impact, move the price level and real

[7] For this purpose, we define "Keynesian properties" as the presence of nominal rigidities plus some inertia in wage and price setting (whether from expectations or not) that makes this behavior at least somewhat backward looking. We exclude purely forward-looking models with rational expectations. As is well-known, models in this latter class carry starkly different—and generally counterfactual—implications.

output in the *same* direction (*e.g.*, an expansionary demand shock pushes up both prices and output).

The second definition is exemplified by the standard aggregate supply and demand diagram (shown in Figure 2) in which an upward-sloping aggregate supply curve shifts inward along a fixed aggregate demand curve, thereby simultaneously raising the price level and reducing output—a stagflationary outcome. The non-vertical aggregate supply curves AS_0 and AS_1, of course, embody some sort of nominal wage-price stickiness.

Figure 2
Supply shocks in the AS/AD framework



Either of the two definitions will suffice for our purposes. But it is important to note that some shocks have *both* supply-side *and* demand-side elements. A shock to the price of imported oil is, of course, the most prominent example. We will show later that neoclassical supply-side considerations alone cannot come close to explaining the magnitudes of the two recessions that occurred during the Great Stagflation. Rather, to explain these episodes, the two big oil shocks must be viewed as having affected both aggregate supply and aggregate demand—with the aggregate demand effects notably larger.[8]

2.1 Three types of supply shocks

To interpret the history of the 1970s and 1980s through the lens of the supply-shock model, it is important to distinguish among three different *types* of supply shocks, with the typology determined by the shocks' nature and timing. These three stylized types are not just theoretical constructs. Each has a clear historical counterpart in Figure 3, which depicts the history of the *real* price of oil (in panel A) and the closely-related *real* consumer price of energy (in panel B) since 1965.

The first type of shock is *a transitory price spike* that gets reversed, leaving no permanent level effect—as exemplified in Figure 3 by the behavior of real oil and energy prices following the second OPEC shock in 1979. Conceptually, we expect such a spike to cause a corresponding (but greatly muted) jump in headline inflation, which then reverses as the *inflationary* shock turns into a *deflationary* shock. If there is some pass-through from oil prices into core inflation, as there should be, then the latter should display a lagged, and even more muted, hump-shaped pattern.[9]

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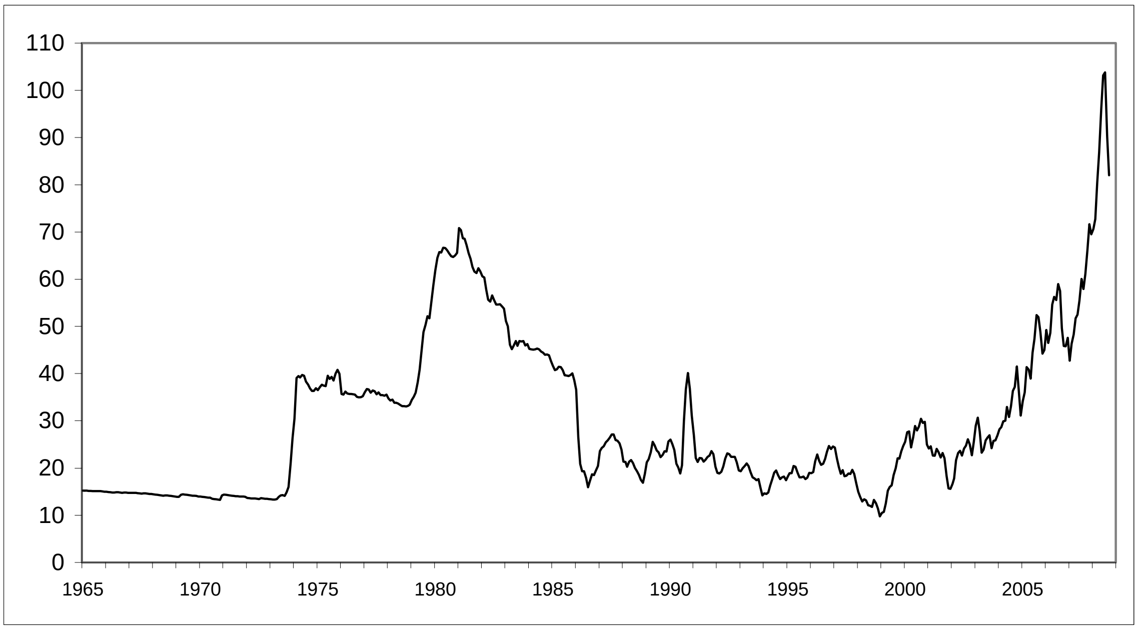
[8] As detailed later in Section 2.3, some demand-side influences amount to *shifts* of the AD curve, while others pertain to its *slope* (that is, to why demand is lower at a higher price level).

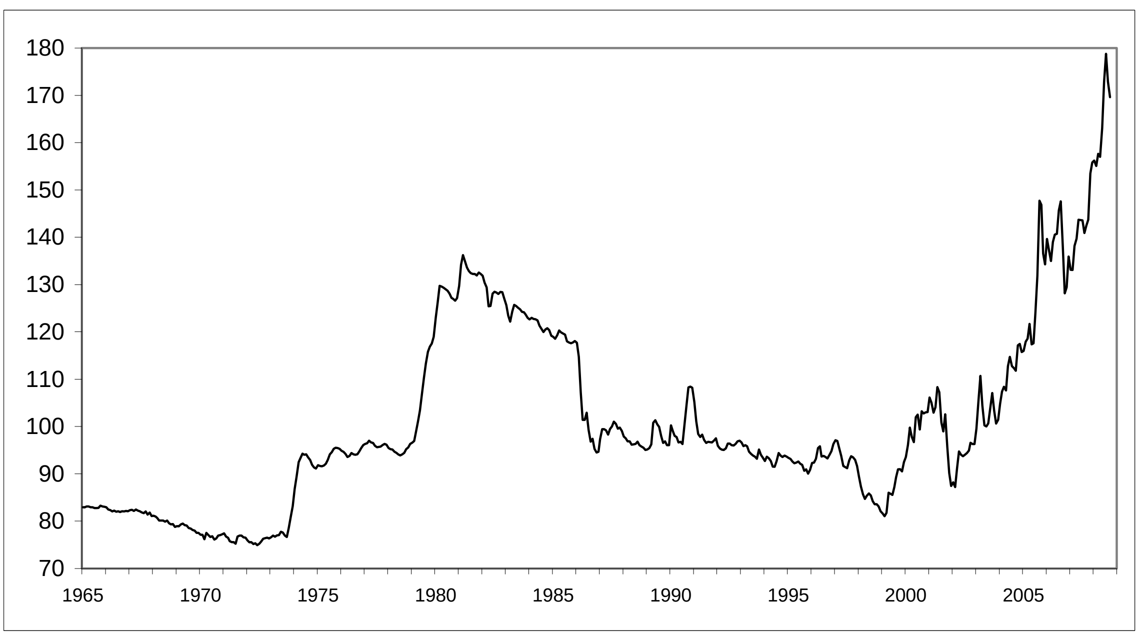
[9] The proportionate effect of an oil shock on consumer energy prices is much smaller than the percentage rise in oil prices, as can be seen from the two panels of Figure 3. (For example, crude oil accounts for only a portion of the production and distribution costs of gasoline and heating oil.) The impact on headline inflation is further damped because energy accounts for a relatively small share of total consumption.

Figure 3
Real Oil and Energy Prices, 1965-2008

A. Real oil price (2000 dollars)



B. Real consumer price of energy (PCE-based, 2000=100)



Note: Series deflated by headline PCE price index; see Appendix for data definitions. Last observation is Sept. 2008.

Figure 4 gives these qualitative points a quantitative dimension. To study pass-through empirically, we estimated a relatively standard *backward-looking* price-price Phillips curve model of U.S. inflation on monthly data from January 1961 to December 1984. The basic specification takes the form

$$\pi_t = \alpha_0 + A(L)\pi_{t-1} + B(L)x_{t-1} + G(L)\zeta_{t-1} + \varepsilon_t,$$

where π_t is the inflation rate; x is the detrended unemployment rate, used here as a measure of slack; ζ is a supply-shock term; and ε is a stochastic error.[10] The supply-shock variable in our baseline specification (we tried several variants) is a weighted average change in relative food and energy prices, using smoothed PCE shares as weights.[11] We take a six-month moving average of this weighted relative price change variable, and use its first lag in the model (additional lags did not enter).

For this exercise, we treated the relative price of energy as exogenous, with panel A of Figure 4 plotting the precise path of energy we assumed: Relative energy prices rise by 35 percent (30 log points) over a period of 12 months and then return to where they started over the next 12 months.[12] Panel B of the figure shows the simulated inflation results, which are just as expected. Headline inflation rises quickly and sharply by about

[10] The number of monthly inflation lags used in the model was determined with the Akaike criterion, with twelve lags used as the default. Note, however, that we did not impose the "accelerationist" restriction $A(1) = 1$. The estimated model also includes additional terms to capture the impact of the Nixon wage-price controls—see Section 3.1.3 for a discussion. (Appendix 2 provides more details on this and other empirical specifications employed in the paper; the calculations that underpin Figures 4 through 6 are described more fully in Appendix 3.)

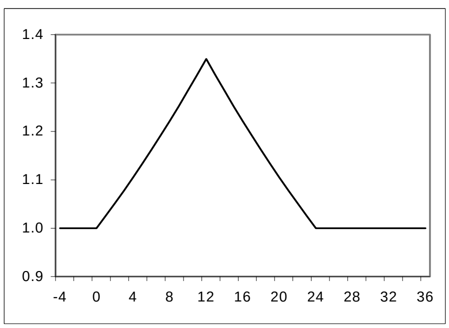
[11] Ideally, a CPI-based model would use CPI relative importance weights rather than PCE shares. Unfortunately, there are significant breaks in the relative importance weight series over time—notably in 1978, when the CPI moved from measuring prices faced by wage earners to prices faced by all urban consumers, and again after owner-occupied housing costs moved to a rental equivalence basis. In any event, whether weighting is used turns out to make little difference to the results.

[12] The actual OPEC II peak was spread out over a longer period: Oil and (especially) energy prices did not return to their pre-shock levels until the collapse in oil prices in 1986. Note that this and the other two simulations assume a 30 log-point increase in relative *energy* (not oil) prices. Following OPEC I, real energy prices rose about 20 log points; the corresponding increase after OPEC II was 35 points, and the five-year net increase after the end of 2002 was around 45 points—so a 30 point increase is (in round terms) close to the average increase in log real energy prices over these three episodes.

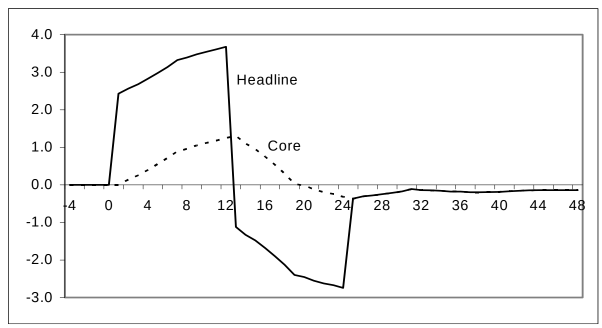
3½ percentage points within a year, but then falls abruptly to *below* its pre-shock level (and below core inflation) as energy prices decline, before returning to normal. Core inflation moves less, more gradually, and with a lag, with a negligible impact on the core beyond 18 months.

Figure 4
Effect of a temporary spike in energy prices

A. Level of real energy price



B. Path of headline and core inflation (monthly change at AR)



In terms of our supply-shock story, then, OPEC II should have first pushed headline inflation *above* core inflation, and then *below* it. For core inflation, the shock should have created a smaller rise in inflation that then "naturally" petered out, as in panel B of Figure 4. The long-run effects on both headline and core should have been negligible. Thus, in this example, headline inflation first diverges from but then converges back to core inflation—a pattern that is evident in the real-world data shown in Figure 1. Furthermore, core inflation itself should converge back to its pre-shock level, other things equal.[13]

The second type of supply shock, exemplified in Figure 3 by OPEC I (1973-1974), is an *increase to a permanently higher relative price level*. Panel A of Figure 5 shows

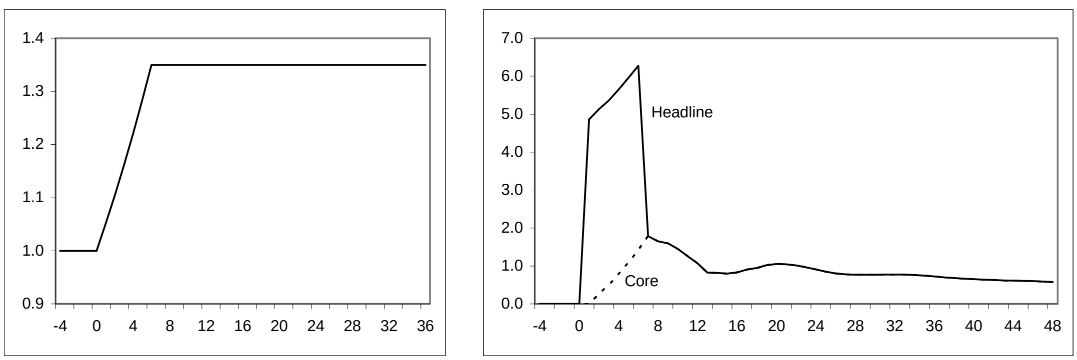
[13] Some of the "other things" that were not equal over this period include the back-to-back recessions of 1980-82, which pushed core inflation down, and the large swing in food price inflation.

how we entered this type of energy-price shock into our econometric model: The energy price is assumed to jump by 30 log points (35 percent) over two quarters and then to remain there forever. The speed of this simulated shock is not too different from what actually happened in 1973-74: While the rise in oil prices took place over a period of about four months, the bulk of the pass-through to retail energy prices occurred over an eight-month period.

Figure 5
Effect of a permanent jump in energy prices

A. Level of real energy price

B. Path of headline and core inflation (monthly change at AR)



Panel B of Figure 5 shows the simulated impact of the shock on headline and core inflation. Headline inflation leaps quickly and dramatically (by about 6 percentage points), but then recedes just as quickly. After six months, the direct contribution of energy prices to headline inflation is zero. Core inflation moves up much more slowly and by much less. But the effects on core and headline inflation are essentially identical as soon as energy prices have finished moving up to their new higher level—and they both die out very slowly. So, in terms of the basic supply-shock story, a permanent increase in the *level* of energy prices should cause a quick burst of inflation which mostly, but not quite (because of pass-through to the core), disappears of its own accord.

Once again, headline inflation quickly converges to core, but now core inflation remains persistently higher than it was before the shock. As is evident in Figure 1, a similar pattern can be seen in actual U.S. inflation during and after OPEC I.[14]

Writing in the 1980s or 1990s, our typology might have stopped there. But this decade has taught us that we should perhaps consider a third type of supply shock; namely, a long-lasting *rise in the rate of energy price inflation,* as exemplified by the stunning run-up in the real prices of oil and energy from 2002 until mid-2008 (see Figure 3). We entered this third type of shock into our model as a *permanent* rise from a zero rate of *relative* energy price increase to a rate of 6 percent per year, which cumulates to a 35 percent increase in the *level* of real energy prices over five years. (Panel A of Figure 6 shows the first three years of the assumed real energy price path.) This hypothetical history is qualitatively similar to what actually occurred between 2002 and mid-2008, although the actual increase in real oil prices was, of course, followed by a spectacular decline.

Panel B of Figure 6 shows the model simulation results. Headline inflation starts rising right away and continues to rise very gradually. Core inflation does the same, though with a short lag and to a smaller degree. But notice that inflation keeps on rising as long as the higher energy inflation persists. Headline inflation now does *not* converge to core until real energy prices stop rising. Nor does the impact on core inflation fade away until that happens.[15]

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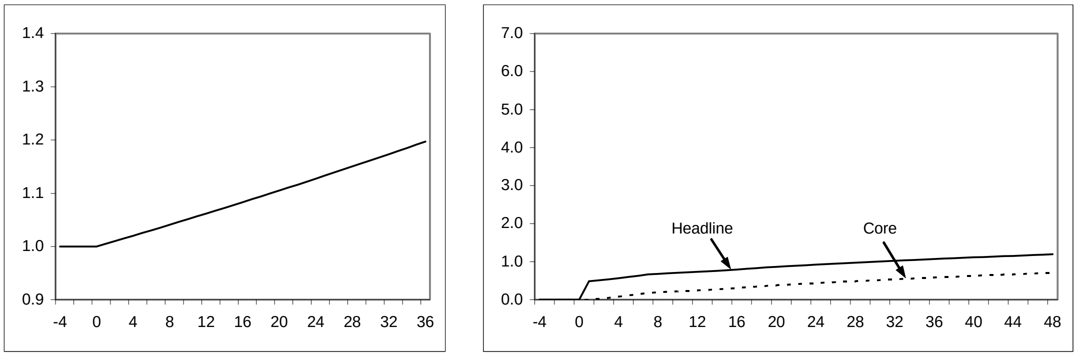
[14] It would be even more evident were it not for the effects that price controls had on the core. We discuss these in Section 3.1.3.

[15] The estimated effect on core inflation from this third simulation is almost certainly higher than current reality. As we discuss in Section 5, the pass-through of energy price shocks to core inflation appears to be much smaller now than in the 1970s and early 1980s, but the model used to generate these simulations is estimated through 1984.

Figure 6
Effect of a steady rise in energy prices

A. Level of real energy price

B. Path of headline and core inflation (monthly change at AR)



2.2 Why do we need the demand-shock piece?

The strictly neoclassical (that is, non-Keynesian) analysis of supply shocks is easy to explain—and even to calibrate. Consider a three-factor, constant-returns-to-scale production function for *gross* output, $Q = Q(K,L,E)$. Here, E denotes energy input, whose nominal price is P_E and whose *relative* price is $\rho = P_E/P$. Assume for the moment that energy is entirely imported, and that we are interested in real gross *domestic* product $Y = Q - \rho E$. As Bruno and Sachs (1985, pp. 42-43) showed decades ago, optimal use of E implies a value-added production function of the form $Y = F(K,L;\rho)$, which is linearly homogeneous in K and L, in which the marginal products of K and L are the same as in $Q(.)$, and in which $F_\rho = -E$. Thus, a rise in the relative price of energy acts as a shift term akin to an adverse technology shock, and whose magnitude can be measured by the volume of energy use.

What does this framework imply about the size of the supply-side effects of the OPEC I and OPEC II shocks? Bruno and Sachs show that the elasticity of Y with respect to the real energy price, ρ, is $-s/(1-s)$, where s is the energy share in *gross* output Q.

Using national accounts data to compute the effects of higher prices of imported petroleum and products on real GDP, we find that the 1973-74 oil shock implies a cumulative reduction in real GDP of 1.1 percent through the first quarter of 1975. Similarly, the OPEC II shock implies a real GDP reduction of 1.7 percent through the second quarter of 1980. (Details of these calculations are provided in Appendix 3.)

But the actual decline in real GDP in the United States (relative to trend) was much larger in each case. For example, real GDP fell a little more than 3 percent between its 1973:4 peak and its 1975:1 trough, a five-quarter period during which normal (pre-1973) trend growth would have called for an increase of around 4.5 percent. Thus, in round numbers, we lost nearly 8 percent of GDP relative to trend.[16]

The period of the two oil shocks also saw large increases in the prices of other imported materials (in addition to oil). It is straightforward to extend the Bruno-Sachs framework to incorporate multiple imported inputs and to compute the real GDP effects of their price increases. Even with this extension, however, the impacts of the supply shocks are far smaller than the observed GDP declines. For 1973-75, the supply-side reduction in real output from both higher oil and nonoil material prices cumulates to 1.6 percent, while the corresponding estimate for the OPEC II period is 1.9 percent. (See Appendix 3 for details.)

In addition, the pure neoclassical view does not provide any particular reason to think that *unemployment* should rise following an oil shock. In that framework, real wages and the rate of profit fall by enough to keep labor and capital fully employed. Put differently, a purely neoclassical oil shock reduces both actual and potential output

[16] We obtain almost identical estimates of the cumulative GDP shortfall by using CBO's (*ex post*) measure of potential output.

equally, leading to no GDP gap (if the gap is measured correctly). In fact, however, the U.S. unemployment rate soared from 4.8 percent in the second half of 1973 to almost 9 percent in the second quarter of 1975.

Both of these calculations suggest that something else was going on—probably something Keynesian on the demand side.[17]

2.3 The "oil tax"

That something is often called "the oil tax." The idea is simple: If imported energy—which mainly means imported oil—becomes more expensive, the real incomes of Americans decline, just as if they were being taxed by a foreign entity. The "tax" hits harder the less elastic is the demand for energy, and we know that the short-run price elasticity is low. Using OPEC I as an example, the nominal import bill for petroleum rose by $21.4 billion through the end of 1974, which represented about 1.5 percent of 1973's GDP. If the marginal propensity to consume (MPC) was 0.9, this "tax" would have reduced non-oil consumption by almost 1.4 percent of GDP. If standard multiplier-accelerator effects created a peak multiplier of 1.5, the maximal hit to GDP would have been about 2 percent, or almost twice as large as the neoclassical supply-side effect.[18] Adding the two together would bring the total reduction in GDP to a touch above 3 percent, which is still far less than actually occurred.

These calculations encompass only *imported* oil. But there was also an *internal* redistribution within the United States, as purchasing power was transferred from energy

[17] Or, possibly, something "new-Keynesian" on the supply side (cf. Rotemberg and Woodford, 1996).
[18] By comparison, Blinder (1979, pp. 84-85) cited two econometric studies—by Perry (1975) and Pierce and Enzler (1974)—that used an early version of the MPS model to attribute approximately a 3 percent decline in real GDP to OPEC I. We are aware of the continuing controversy over the size of the multiplier (see, for example, Hall, 2009). Naturally, using a smaller multiplier would make these effects smaller as well.

users to energy producers. To the extent that the latter group—*e.g.*, oil companies and their shareholders—had lower MPCs than the average consumer, aggregate demand would be reduced further. And there are yet more demand-side effects from an oil shock. For example:

i. In an unindexed tax system, which we had in 1973-1974, an upward shock to the price level leads to bracket creep, which amounts to a fiscal tightening. Inflation also raises the tax rates on capital since nominal interest rates and capital gains are taxed, and depreciation allowances are imputed on an historic-cost (nominal) basis.
ii. To the extent that the Federal Reserve targets the nominal money supply, an upward shock to the price level reduces real balances, thereby inducing a monetary tightening. This channel was more relevant in 1973 than it is today, since the Fed now targets the federal funds rate.
iii. A higher price level induces a negative wealth effect on consumer spending as both equity values and the real values of other financial assets decline.
iv. The large change in relative input prices renders part of the capital stock obsolete, resulting in accelerated scrappage (see Baily, 1981).[19]
v. The huge uncertainty induced by the oil shock (and subsequent recession) may lead investors and purchasers of consumer durables to "pause" while the uncertainty gets resolved (Bernanke, 1983). In addition, until new, energy-efficient capital becomes available, firms may postpone their investment spending (Sims, 1981).
vi. Increased uncertainty may also induce consumers to increase precautionary saving (Kilian, 2007a).

[19] This is, strictly speaking, a supply-side effect. But it can also reduce demand by lowering equity values.

Point (ii) above raises an important issue that we will return to several times in this paper: The impact of a supply shock on real output and inflation depends critically on how the monetary authorities react. Monetary accommodation to mitigate the incipient recession will produce larger effects on inflation and smaller effects on output and employment. Monetary tightening to mitigate the increase in inflation will produce just the opposite. This is one, though not the only, reason why responses to oil shocks vary both across countries and across time.

2.4 "Second-round" effects

Another important issue, related of course to monetary policy, is how much "second-round" inflation is induced by the "first-round" price-level effects of supply shocks—as, for example, higher energy costs creep into the prices of other goods and services and into wages.

Regarding the price channel, Nordhaus (2007, p. 223) recently used an input-output model to estimate that the long-run pass-through of energy costs into other *consumer* prices (which include airfares, apartment rents, and so on) is 80 percent as large as the direct effect of energy prices on the index. However, this estimate overstates the short-to- medium run effects of an energy-price shock. For example, airfares will react quickly to higher fuel costs, but the higher cost of the energy used to manufacture airplanes will probably not show up in airfares for years.[20] That said, there is still significant scope for sizable second-round price effects. Indeed, as might be expected, energy-intensive

[20] Moreover, it matters whether an estimate of this sort is based on crude or finished energy. Using the 1992 input-output accounts, we estimate that finished energy costs accounted for 3.4 percent of non-energy PCE, while *crude* energy costs only accounted for 1.5 percent (these estimates include an imputation for the energy costs incurred in transporting and distributing consumption goods). For core PCE, the estimates are a little smaller (3 percent and 1.3 percent, respectively). That said, this still appears to be a reasonably large indirect effect given that the direct effect of finished energy on PCE prices (measured as the nominal share of energy goods and services in total consumption) was 5½ percent in that year, and also given that crude energy price changes tend to be much larger than changes in finished energy prices.

consumption goods and services posted relatively larger price increases following the first two oil shocks.[21] As evidence, the first two columns of Table 1 report rank correlations between energy intensity and three-year price changes for various groupings of individual PCE components following OPEC I and OPEC II.[22] These correlations are similar whether one looks at total, core, non-energy, or non-transportation components of PCE. (As is evident from the rightmost column of the table, however, similar correlations cannot be found during the most recent run-up in oil prices—a point to which we will return in Section 5.)

Table 1. Rank Correlations between Energy Intensity and Price Change

	Correlation with change in price from		
	1972 to 1975	1978 to 1981	2002 to 2007
1. All PCE components	0.308**	0.343**	0.048
2. Nonenergy PCE	0.256**	0.283**	−0.025
3. Nonenergy ex. transportation	0.270**	0.150[a]	−0.057
4. Core components	0.267**	0.326**	−0.036
5. Core ex. transportation	0.275**	0.193*	−0.072

Note: **/*/[a] denotes significant at 1/5/10 percent level, respectively.

One simple way to study the pass-through question is to examine the impacts of supply shocks on measures of *core* inflation, which by definition remove the mechanical impacts of energy and food prices on headline inflation. We did this earlier in Figures 4 through 6, which showed the results of passing three different types of stylized supply

[21] In a more specialized context, Weinhagen (2006) finds evidence of significant pass-through of crude petroleum prices into the PPIs for plastics and organic chemicals over the period 1974-2003.

[22] The rank correlation measure that we use is Kendall's "tau-b," which is more robust to the presence of ties across rankings. Energy intensities are estimated using data on total crude energy requirements from the 1972 and 1977 input-output tables. Price changes are December-over-December increases computed over the relevant periods.

shocks through a reduced-form price-price Phillips curve.[23] In this model, the effect of a sustained increase in relative energy prices yields, after one year, an indirect effect on core inflation roughly half as large as the direct effect on headline inflation. It is important to note that, in generating Figures 4 through 6, the path of the unemployment rate was held constant. Hence, each simulation tacitly gives the second-round effects on core inflation *with an accommodating monetary policy* that prevents the supply shock from causing a slump. (More on this shortly.)

Figure 4 showed that the second-round effects of a temporary energy-price spike on core inflation, while notable, are entirely transitory—disappearing after about 18 months. Thus core inflation displays a “blip” that vanishes by itself, without any need for the central bank to tighten—which can be thought of as justifying the policy decision to accommodate.

Figure 5, in which energy prices rise to a permanently higher plateau, shows another such blip, but one that does *not* disappear entirely of its own accord because of the presence of second-round effects. In this case, a central bank that does not want to see a persistent rise in core inflation would have to tighten.

Finally, Figure 6 shows that persistently higher energy-price inflation will lead to persistently higher core inflation as well—although the magnitudes are small. (In the example, a 6 percentage point increase in energy-price inflation induces less than a

[23] No doubt, some of the effect of a supply shock in our price-price Phillips curves reflects the wage-price spiral—indeed, the textbook way to derive a price-price equation is by substituting a wage-price Phillips curve into a markup equation. In the case of food price pass-through, this channel is probably the main one at work. But, as suggested by the input-output analysis above, energy is also an important intermediate input into consumer goods production. Hence, both channels are likely being captured by the coefficients on relative energy prices in our price-price models.

1 percentage point increase in core inflation after five years.) In this case, a monetary response may be appropriate.

A second pass-through mechanism comes via expected inflation and wages. To illustrate the likely magnitudes and timing, we again consider a stylized supply shock—the 35 percent one-time jump in real energy prices shown in Figure 5—in the context of an estimated wage-price model. The model consists of two equations, estimated on quarterly data from 1960:Q1 to 1985:Q4. The wage-price Phillips curve relates wage inflation (hourly compensation growth) to lagged *headline* CPI inflation, unemployment, and a long (40-quarter) moving average of trend productivity growth. The markup equation relates *core* CPI inflation to trend unit labor costs, unemployment, and several price-control terms explained later.

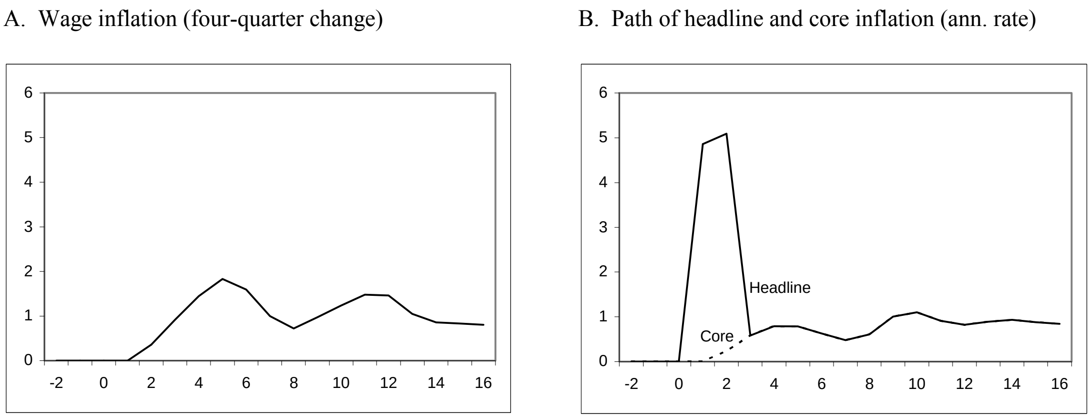
In contrast to the price-price Phillips curve discussed earlier, these models impose an accelerationist restriction: The coefficients on trend unit labor costs and lagged inflation in the markup equation are constrained to sum to one, and the coefficients in the wage equation are constrained so as to make the real consumption wage rise with trend productivity growth in a steady state. As a result, the implied pass-through of higher food and energy prices into core inflation is larger and more persistent than in the corresponding price-price model. (For more details, see Appendix 2.)

The response of this system to a jump in energy prices is shown in Figure 7.[24] Qualitatively, the paths of headline and core inflation following the shock are similar to those from the earlier exercise: Headline inflation spikes immediately but quickly recedes toward a core inflation rate that is persistently higher. Neither the magnitudes nor the exact dynamics are exactly the same, of course, because the mechanisms at work

[24] Note that the time scale here is in quarters, in contrast to the monthly scale used in Figures 4 through 6.

are different. In the wage-price system, higher energy prices raise headline inflation, which feeds into wage inflation. Rising wages, in turn, raise firms' costs, thus putting upward pressure on core inflation. By the end of the simulation period, real wages are rising at the same rate as before the energy price shock because, as noted above, the model constrains real wages to move in line with productivity. But nominal wage growth and consumer price inflation are persistently higher.

Figure 7
Effect of a permanent jump in energy prices (quarterly wage-price system)



Finally, there is a countervailing force that offsets some of the "second-round" effects we have just estimated: Each of the two oil shocks of the 1970s was associated with a deep recession. For example, the unemployment rate rose more than four percentage points in the recession that followed OPEC I. Such an increase in labor- and product-market slack puts significant *downward* pressure on core inflation. How much? In the simple pass-through model used for Figure 5, each point-year of higher unemployment reduces core inflation by about ½ percentage point (on average) over the first year and by about ¼ percentage point (on average) over the second year. Using this estimate, which is broadly consistent with many Phillips curves estimated by

Gordon (1977, 1982, and others), the four-point run-up in unemployment would have been more than sufficient to offset the impact of OPEC I on core inflation.[25]

Of course, not all of the rise in unemployment that resulted from the 1973-75 recession can be attributed to higher oil prices. Other supply shocks also hit the economy during this period, and there were significant swings in fiscal and monetary policy as well. Using a VAR model, Blanchard and Gali (2007) estimate that exogenous oil-price shocks were responsible for only about a third of the swing in real GDP.[26] If we impute one-third of the observed rise in unemployment to the oil shock, and feed this estimate into our model, we find very little offset from slack in the year following the shock, about a 50 percent offset in the second year, and a virtually complete offset by the end of the third year.

2.5 Lagging perceptions of productivity growth

Almost everything we have discussed up to now was already on economists' radar screens by the late 1970s. But there is an additional inflationary channel that few people were talking about back then: the impact of lagging perceptions of productivity growth on inflation.

In principle, there is no reason why inflation and productivity growth should be systematically linked. According to simple economic theory, the trend growth rate of *real* wages should equal the trend growth rate of productivity (g), making the trend growth rate of *nominal* wages (w) equal to g plus the rate of inflation, π. If $w = g + \pi$,

[25] However, virtually all of the first-year effect on core inflation would have remained because the unemployment rate rose relatively slowly at first.

[26] Blanchard and Gali find that the shock accounts for roughly half of the reduction in *employment*. However, this overstates the effect of the shock on the *unemployment* rate, because Blanchard and Gali define employment as hours worked. In addition, our calculation is actually based on historical movements in an estimate of the unemployment *gap*, not the unemployment rate, to capture the fact that the rate of unemployment consistent with stable inflation (the NAIRU) was likely rising over this period. (See Section 2.5.)

workers receive a constant share of national income *regardless of the inflation rate*. And in this frictionless and rational world, any decline in g would show up immediately as a decline in the growth rate of real wages, with no particular implications for inflation.

In practice, however, there are at least two *perceptual* channels through which a decline in productivity growth might boost inflation. The first stems from the possibility that a drop in the productivity growth rate is not promptly and fully reflected in real wage gains. If workers and firms are slow to recognize that the productivity growth rate has fallen, they may agree on real wage increases that are too high relative to actual increases in productivity. That would put upward pressure on unit labor costs, and hence on inflation. High real wages would also reduce employment demand and, therefore, tend to raise the level of unemployment consistent with stable inflation—the NAIRU.[27]

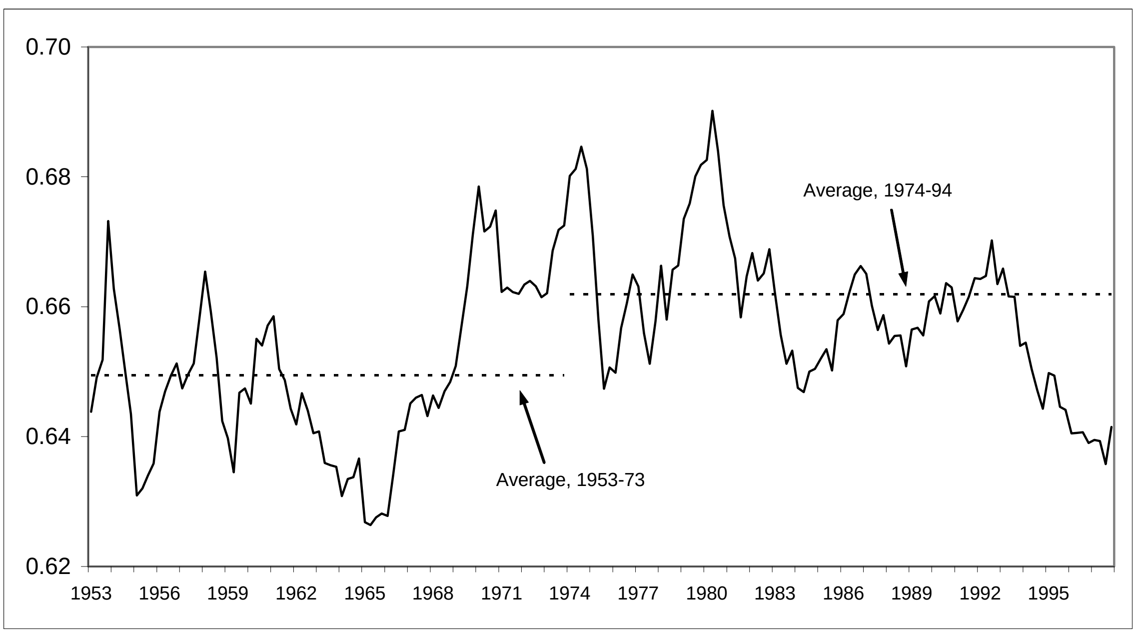
The second channel through which a productivity slowdown can raise inflation arises if *policymakers* fail to recognize it in time. If the central bank overestimates the growth rate of potential output—that is, if it fails to recognize that g has fallen—it will target a rate of aggregate demand growth that is too high, leading to increasing inflation. Furthermore, since the abovementioned mistakes by workers and firms will raise the NAIRU, policymakers may aim for a level of labor market slack that results in accelerating prices.

Arguably, both of these channels were at work during the Great Stagflation, especially the first episode. Productivity growth actually began to slow in the late 1960s as the expansion of the preceding decade came to an end. By the time of OPEC I, trend

[27] In our empirical work, we control for changes in the NAIRU by detrending the unemployment rate with a band-pass filter. Staiger, Stock, and Watson (2001) argue that such a measure yields an unemployment gap that captures essentially all of the variation in labor-market slack that is relevant for inflation dynamics in a Phillips curve. In addition, they show that the resulting trend is suggestively (and negatively) correlated with low-frequency movements in U.S. productivity growth.

productivity growth had moved about a percentage point below the rate that had prevailed over the preceding twenty years. The failure of real wage growth to adjust downward can be seen in the behavior of labor's share of income over this period (Figure 8). Labor's share started to move higher in the late 1960s and spiked during the 1969-70 recession—a pattern typically seen during an economic downturn. But rather than moving back down, labor's share remained high over the 1970s and even appears to have trended upward slightly, since each successive cyclical peak was higher than the preceding one.

Figure 8
Labor's share of income (nonfinancial corporate sector), 1953-1997



Note: Total compensation, nonfinancial corporate sector, divided by nominal nonfinancial corporate output.

Regarding policy errors over the period, Orphanides (2003) has argued persuasively that contemporaneous estimates of the output gap (and, by extension, of the NAIRU) were far too optimistic. In addition, the natural rate of unemployment was itself drifting upward over the period, partly as a result of the increased entry of young baby boomers and women into the labor force. These demographic developments also appear to have eluded policymakers at the time. Besides resulting in an inflationary monetary policy, these mis-estimates of the output gap may have raised the perceived cost of bringing inflation under control. If policymakers see little reduction in inflation despite what they perceive to be a large margin of slack, they may erroneously conclude that the sacrifice ratio is higher than it really is.

In brief, when *actual* productivity decelerated in the early 1970s, sluggish adjustment of *beliefs* about productivity growth probably became a source of stagflation in its own right.

Blinder and Yellen (2001) and Ball and Moffitt (2001) turned this argument on its head to suggest that the opposite happened after the *speedup* in productivity growth in the mid-1990s—and that a surprising *disinflation* ensued. In support of this notion, Figure 8 shows that labor's share fell to a 30-year low over this period as real wage gains lagged far behind productivity growth.[28] In contrast to the experience of the 1970s, however, policymakers (specifically, Alan Greenspan) recognized the productivity acceleration early enough to prevent the Fed from running an inappropriately tight monetary policy.[29]

3. Reexamining the evidence on the Great Inflation

The supply-shock "story" of the Great Inflation, which was summarized in points 5 through 10 of Section 1, emphasizes four salient empirical observations:

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[28] Unfortunately, labor's share becomes harder to read after the late 1990s because of the surge in stock option exercises that occurred around that time.
[29] See Blinder and Yellen (2001) and Meyer (2004).

1. The Great Inflation was actually *two* episodes of sharply higher inflation, *each of which was followed quickly by a disinflation*—a fact we emphasized in discussing Figure 1. That inflation receded notably and quickly in the 1975-1977 period, and then again after 1980, is an important part of the story—one that is too often ignored.[30]
2. Blinder (1979, 1982) emphasized the strong *symmetry* apparent in the two inflation "hills" of Figure 1. In each case, the graph provides circumstantial evidence that something—to wit, the supply shocks—"came and went."
3. Core inflation rose and fell, but by less than headline inflation in each direction. That observation is also consistent with the notion that each episode was dominated by food and/or energy shocks that then disappeared.[31]
4. Ignoring the two inflation "hills," core inflation rises from about four percent in the late 1960s and early 1970s to around six percent in the mid-to-late 1970s, but then ends up back at four percent in the mid-to-late 1980s.[32]

Let us now examine this story in more detail.

3.1 The initial shocks

The near-symmetry point (number 2 above) is an important part of the supply-shock story. Table 2 displays three measures of consumer price inflation over the years 1972-1982: the current-methods CPI, the published PCE deflator, and the deflator for

[30] For example, models generating "inflation bias" became popular in the 1980s. But they can explain only why inflation is too high, not the ups, and certainly not the downs. For an attempt, see Ireland (1999).
[31] This is not meant to deny that the deep recessions that followed OPEC I and OPEC II brought both core and headline inflation down further. They did, just as strong aggregate demand pushed inflation a bit higher in 1977 and 1978.
[32] From 1985 through 1990, core PCE inflation averaged 3.9 percent per year.

market-based PCE.[33] For each price measure, the table gives both headline and core inflation rates. The near symmetry of the rise and fall of inflation in the two episodes is apparent. In fact, these numbers correspond very closely to a similar table constructed by Blinder (1982, Table 12.2, p. 265) from the data available then to make the same point.[34] Thus, our first conclusion is that *historical data revisions have not changed the basic story* of two nearly symmetrical episodes of rising and then falling inflation.[35]

Table 2
Inflation Rates in the United States, 1972-1982

	Headline measures			Core measures		
	CPI	**PCE**	**MPCE**	**CPI**	**PCE**	**MPCE**
1972	3.0	3.4	3.0	2.6	3.1	2.5
1973	8.3	7.2	7.0	3.8	4.5	3.8
1974	10.9	11.4	11.2	9.4	9.6	8.9
1975	6.4	6.9	6.9	5.9	6.8	6.8
1976	4.9	5.2	5.5	6.4	6.0	6.6
1977	6.3	6.6	6.4	5.5	6.4	6.0
1978	7.8	7.6	7.1	6.8	6.8	6.1
1979	10.8	9.8	9.9	7.4	7.4	7.2
1980	10.9	10.6	10.5	10.0	9.6	9.3
1981	8.2	7.6	7.9	8.8	7.9	8.4
1982	5.1	5.0	4.8	6.6	6.0	5.9

Note: Inflation rates computed as percent changes. The CPI data are expressed on a methodologically consistent basis, December over December. MPCE is a measure of market-based PCE prices (see Appendix 1 for details). PCE and MPCE inflation rates are Q4-over-Q4 changes.

Simply eyeballing these data suggests that one or more shocks pushed inflation up *and then disappeared*. In the first episode, the headline inflation rate jumped from about

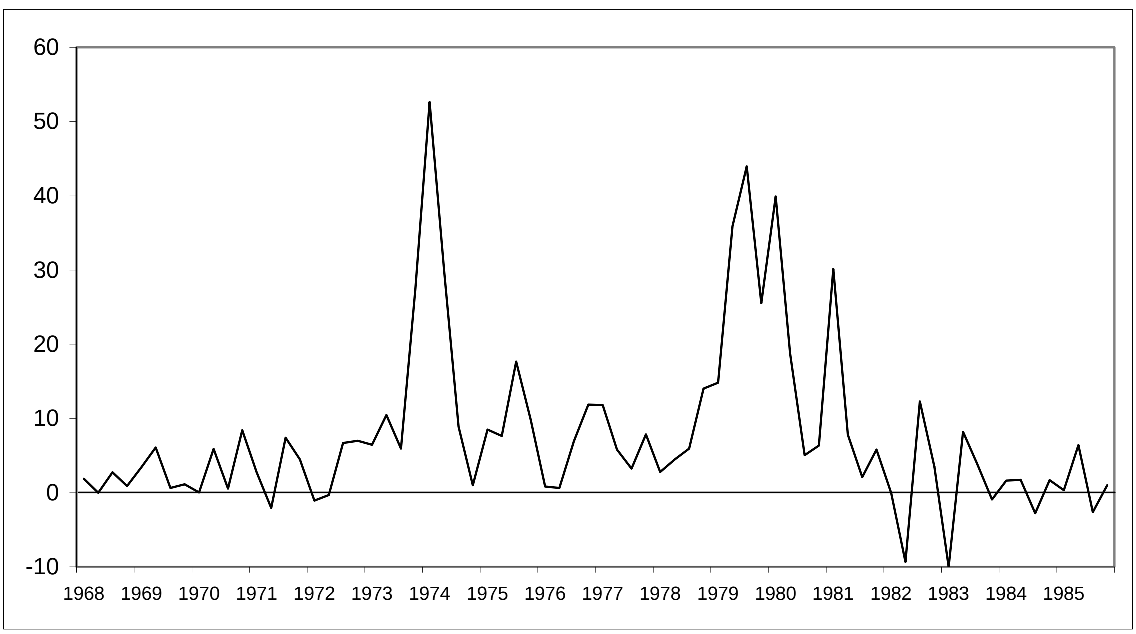
[33] Market-based PCE is intended to capture market transactions for which actual prices are paid—with the exception of owner-occupied housing, which is included in market-based PCE. It is therefore more comparable to, though by no means identical to, the CPI than the standard PCE deflator. (As discussed in Appendix 1, we construct the market-based PCE deflator ourselves prior to 1997.) In the 1960s and 1970s, market-based goods and services represented about 90 percent of total nominal PCE and about 87 percent of the core; currently, the corresponding shares are 85 and 81 percent.
[34] The only notable difference between these data and Blinder's is that the latter included the effects of mortgage interest rates (we discuss this influence later).
[35] Blinder (1979, 1982) had to construct PCE minus food and energy on his own. Core PCE is now an official BEA series, and the vintage used here matches Blinder's original construction very closely.

3 percent in 1972 up to around 11 percent in 1974, and then fell back to about 5 percent by 1976. In the second, it rose from about 6½ percent in 1977 to around 10-11 percent in 1979 and 1980, and then dropped back to 5 percent or so by 1982. But this is not an unobserved-components exercise in which the econometrician must use statistical techniques to identify unseen shocks. The shocks were plainly visible, and we know precisely what they were: oil, food, and price controls. We take them up in turn.

3.1.1 The oil price shocks of 1973-1974 and 1979-1981

Since the two OPEC shocks are well-known and have been studied extensively, we can be brief. Figure 9 displays the behavior of PCE energy inflation from 1968 to 1985.

Figure 9
Consumer energy price inflation, 1968-1985



Note: Annualized quarterly log differences of the energy component of the PCE deflator.

OPEC I, which resembled the jump to a higher plateau shown in Figure 5(a), was kicked off by the so-called Arab oil embargo in October 1973, which roughly quadrupled the OPEC price of crude.[36] But given transportation costs and the blending of lower-price domestic crude (which then predominated) with imported oil, the composite U.S. refiners' acquisition cost (RAC) "only" doubled. As one example of the retail price impact, the CPI for motor fuel rose 42 percent between September 1973 and May 1974, which is a 68 percent annual rate. At the macro level, energy *directly* added 2½ percentage points to the annualized PCE inflation rate during the last quarter of 1973 and the first two quarters of 1974. Then energy ceased being an engine of inflation as the real price of crude oil remained roughly flat from 1974 until late 1978 (see Figure 3).

OPEC II came when the 1978-1979 revolution in Iran, followed by the 1980 invasion of Iran by Iraq, sent crude prices skyrocketing again.[37] From 1978 to 1981, the composite RAC nearly tripled. But unlike OPEC I, OPEC II proved to be short-lived, looking much more like the price spike in Figure 4(a) than the jump to a higher plateau in Figure 5(a). The composite RAC fell from its 1981 peak ($35.24 per barrel) to a trough in 1986 ($14.55 per barrel) that was not much above its 1978 average ($12.46 per barrel). It did not persistently rise above $30 per barrel (in nominal terms) until 2004, and it only re-attained its 1981 real price peak in late 2007.

Two points are worth emphasizing for later reference, especially in Section 4, where we will examine the claims that inflationary monetary policy caused the oil shocks, rather than the other way around. First, it should be obvious that both OPEC shocks were set in motion by geopolitical events that cannot possibly be attributed to, say, money growth in the U.S. or even to world economic growth.[38]

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[36] See Yergin (1993, chapters 29-30) for an historical account, and Adelman (1995, chapter 5) for a detailed analysis.
[37] See Yergin (1993, chapters 33-34) and Adelman (1995, chapter 6).
[38] This is not to deny that strong world growth helped OPEC make the price increases stick.

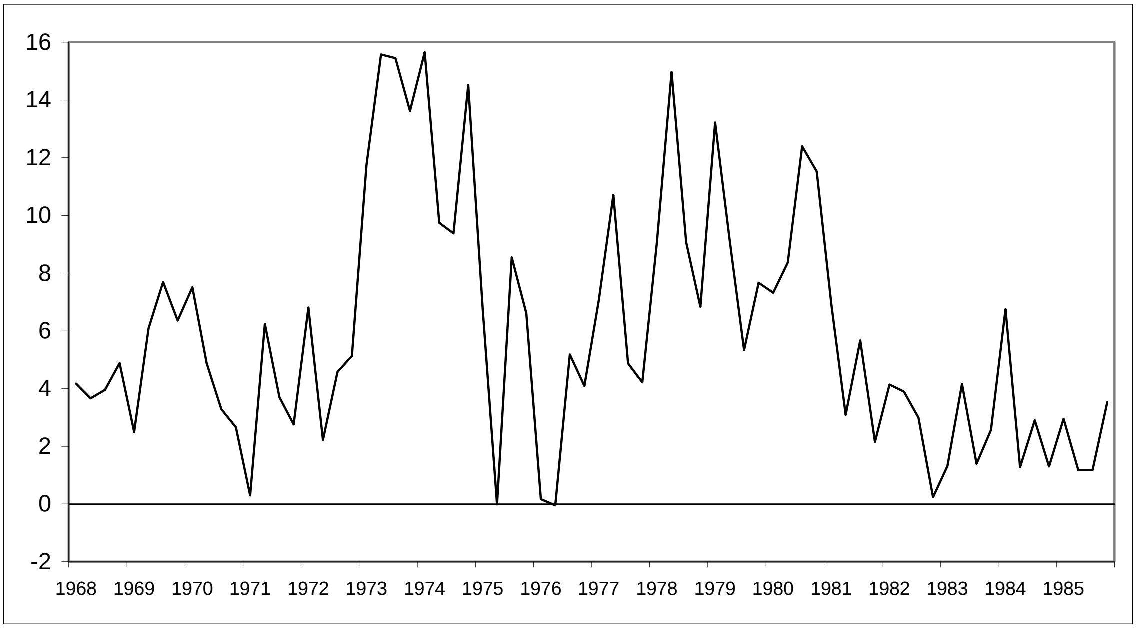
Second, notice how sharply price increases are damped as we move up the stage-of-processing chain from crude oil prices to overall inflation. In the case of OPEC I, a 300 percent increase in crude prices led to a 100 percent increase in refiners' acquisition costs, and thence to a 45 percent (annualized) increase in total retail energy prices, and finally to a 2½ percentage point increase in overall inflation. If OPEC had, hypothetically, reacted by restoring the real value of its crude oil, it would have raised prices by another 2½ percent. The subsequent reactions of overall US inflation would have amounted to rounding error. Thus, observers who fretted about the feedback loop from U.S. inflation back to OPEC pricing (via the exchange rate, say) in both the 1970s and in 2006-2008 should have been thinking harder about magnitudes.

3.1.2 The food price shocks of 1973-1974 and 1978-1980

We all remember the big oil shocks, but many economists seem to have forgotten that each of the two inflationary episodes also featured a sizable food-price shock. The two food shocks are apparent in Figure 10. Since food has a much higher weight in the price indexes than energy, ignoring them constitutes a major omission.[39]

[39] In December 1972, food was 22.5 percent of the CPI and 20.7 percent of the PCE deflator; energy was only 6 percent of the CPI and 6.5 percent of PCE.

Figure 10
Consumer food price inflation, 1968-1985



Note: Annualized quarterly log differences of the food and beverages component of the PCE deflator.

At the retail level, the 1973-1974 food-price shock corresponded pretty closely to the 24 calendar months of those two years. The CPI for food rose 20.1 percent from December 1972 to December 1973 and another 12.1 percent from December 1973 to December 1974. Compared to the 4.6 percent rate in the year preceding the shock or the 6.7 percent rate in the year following it, that represents a sharp though temporary burst of food inflation. In terms of their contribution to overall inflation, food prices added 4½ percentage points to headline inflation in 1973, and a touch less than 3 percentage points in 1974 (and nothing directly to core inflation).[40]

[40] The corresponding contribution of food prices to headline PCE price inflation was 3.1 percentage points in 1973 and 2.7 percentage points in 1974. Note that the core PCE deflator removes food *and* alcoholic beverages from the headline index; this is also the definition we use in discussing the contribution of "food" to headline PCE inflation.

What happened to cause this stunning turn of events? Seemingly everything—including corn blight, crop failures and depleted inventories in many parts of the world (especially for grains), and the then-famous disappearance of the Peruvian anchovies.[41]

The 1978-1980 food shock was less dramatic, but it lasted longer and was far too large to ignore—even though most economists have managed to do so. The aforementioned food component of the CPI rose 11.4 percent in 1978, and 10.3 percent in both 1979 and 1980, before falling back to 4.4 percent in 1981. Food price inflation contributed 2 percentage points to overall inflation in 1978, and 1¾ percentage points in both 1979 and 1980.[42] Weather and disease, of course, explained most of the food problems. Again, we are deeply skeptical that agricultural diseases, bad weather, and the hog cycle were lagged effects of monetary policy.

3.1.3 The end of price controls, 1973-1974

A third shock—the removal of wage and price controls in stages starting in 1973—also made an important contribution to the 1973-1974 burst of inflation, but was often ignored in the subsequent economic literature.[43] Unlike OPEC and the weather, the 1971-1974 price controls might conceivably be viewed as a lagged effect of earlier inflation. But other episodes of inflation *in peacetime*, both before and since, were *not* followed by controls. So we prefer to view the price controls more as a part of Richard Nixon's re-election campaign than as an endogenous response to past inflation.

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[41] See Bosworth and Lawrence (1982, pp. 88-107) for a detailed discussion.

[42] Food's relative importance in the CPI dropped in 1977 (to 17.7 percent of the overall index) with the introduction of the all-urban CPI-U. (Prior to this time, the published CPI only covered urban wage earners.) Food continued to represent about 20 percent of PCE; the corresponding contributions of food to PCE price inflation over the three years 1978-80 were 2.1, 1.9, and 2.0 percentage points, respectively.

[43] A major exception is the series of Phillips curve papers by Robert Gordon—see, for example, Gordon (1977, 1982). In addition, several studies of the effects of price controls appeared in the mid 1970s.

Price controls were first put in place on August 15, 1971, starting with a short-term freeze. As measured by the fraction of the CPI that was subject to controls, they had their maximum effect in the period from September 1971 to April 1973. After that, they began to be dismantled in stages, and were completely removed by May 1974.[44] The two biggest doses of decontrol came in July-September 1973 and February-May 1974. Notice how well the timing of decontrol aligns with the first of the two inflation hills.

It is obvious that removing price controls—thereby letting prices that were held artificially low bounce back to equilibrium levels—should result in a sudden burst of inflation that naturally peters out. In Figure 11, which illustrates the effect of controls in a single market, the controlled price, P^c, is held below the equilibrium price, P^*, which forces the market to equilibrate at point *A* (with excess demand) rather than at point *E*. When controls are lifted, the market quickly moves from point *A* to point *E*. If the percentage price gap Δ ($\equiv P^*/P^c - 1$) is erased quickly, the item-specific inflation rate can be enormous.[45]

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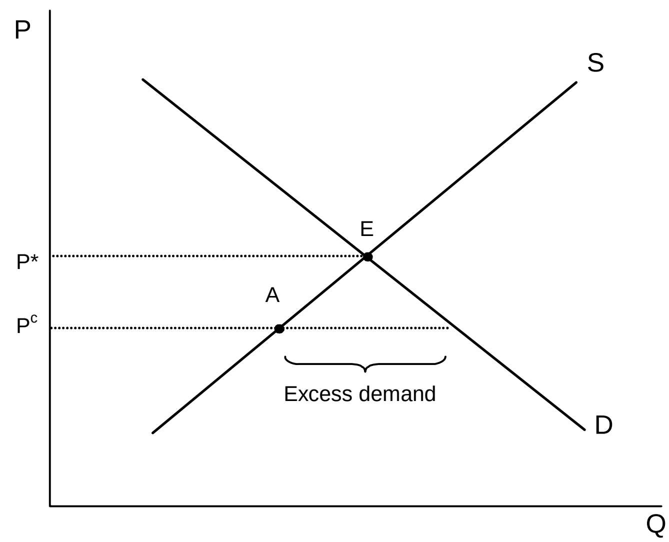
44 Their removal was briefly interrupted by "Freeze II" in the summer of 1973.

45 For example, if $\Delta = 0.07$ and the gap is closed in three months, the item-specific annualized inflation rate is 31 percent. Blinder and Newton (1981) estimated the typical value of Δ to range from 0.062 to 0.088, depending on the specification of their wage-price system. In our own replication of Blinder and Newton's work (discussed below), we obtain estimates for this parameter that range from 0.062 to 0.075, remarkably similar to their estimates.

Figure 11
Effect of price controls in a single market



Blinder and Newton (1981) used this simple idea—together with a monthly time series that they constructed for the fraction of the CPI under price controls—to assess the impact of controls on U.S. inflation in the 1970s. They fit wage-price systems with two different measures of aggregate demand, and then ran simulations that allowed them to estimate both the *reduction* in core inflation that resulted from the controls and the *increase* in inflation that occurred when the controls were lifted. They found that the maximum *negative* effect of price controls on the core *price level* came in February 1974; its estimated magnitude was 3.1 or 4.2 percent, depending on the model used. In their first specification, the estimated contribution that controls made to reducing the price level dropped to zero by October 1974—implying that decontrol raised the *annual* rate of core CPI inflation during the February-October 1974 period by a stunning 4.6 percentage points. In their second specification, the estimated price level impact declined only to −2.2 percent by October, which implies a 3 percentage point contribution to annualized core inflation. In both cases, the estimated inflation impacts were negligible after October 1974.[46]

Panel A of Table 3 reproduces results from Blinder and Newton (1981, Table 4, p. 20). They observed that core CPI inflation reached a double-digit "peak" rate over the eight months from February to October 1974, with much lower inflation rates over the eight-month periods either immediately before or immediately after. Specifically, in the CPI data that were available to Blinder and Newton at the time, the run-up in core inflation from the pre-peak period to the peak was 6.8 percentage points, and the subsequent decline from peak to post-peak was 4.9 percentage points (line 2 in the table). According to their first model, lifting price controls accounted for virtually the *entire* swing in core inflation (see line 4 of the table); in their second model, controls accounted for about half (line 6).

To take a fresh look at this old finding, we used the Blinder-Newton time series for the fraction of the CPI under controls in a monthly price-price Phillips curve model fit to the current-methods core CPI. (Appendix 2 provides details on the model's specification.) The current-methods CPI suggests a slightly different dating for the inflation peak, so we considered a *nine*-month peak period from February to November of 1974, with nine-month pre- and post-peak periods defined symmetrically.

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[46] However, the first model found roughly a zero long-run effect on the price level, while the second found that price controls permanently reduced the price level by about 2.4 percent.

Table 3. Contribution of Price Controls to Core CPI Inflation, 1973-1975

	Pre-peak	Peak	Post-peak
A. Results from Blinder-Newton (1981)			
Actual data			
1. Inflation rate (AR)	5.90	12.72	7.84
2. Change in inflation		+6.82	−4.88
Estimated effect of controls, model 1			
3. Contribution to inflation	−1.34	5.12	0.28
4. Contribution to change in inflation		+6.46	−4.84
Estimated effect of controls, model 2			
5. Contribution to inflation	−1.82	2.17	−0.20
6. Contribution to change in inflation		+3.99	−2.37
B. Results from current data and model			
Actual data			
7. Inflation rate (AR)	3.94	10.00	5.58
8. Change in inflation		+6.06	−4.42
Estimated effect of controls			
9. Contribution to inflation	−1.73	2.73	0.77
10. Contribution to change in inflation		+4.45	−1.96

Note: Dating of inflation peaks differs across Blinder-Newton results and results using current data; see text for details. Inflation rates from Blinder-Newton paper are average monthly percent changes at annual rates; rates using current data are annualized log differences. All contributions and changes are given in percentage points.

Panel B of Table 3 summarizes our updated results. First, as can be seen from line 8 of the table, our revised definition of the peak inflation period implies a pre- and post-peak swing that is not too different from what Blinder and Newton obtained with their dating.[47] Second, the estimated contribution of controls to the swing in core inflation that we find (line 10) implies that controls account for more than two-thirds of the increase in

[47] The levels and changes in inflation given in lines 7 and 8 of the table differ from Blinder and Newton's for three reasons: We use a current-methods CPI, we use a slightly longer peak period, and we compute the inflation rate as an annualized log change.

core CPI inflation and nearly half of its subsequent decline—magnitudes that are roughly comparable to what Blinder and Newton found with their second specification. Our estimate of the depressing effect of controls on inflation in the "pre-peak" period is also very close to Blinder and Newton's.[48]

These updated results verify that price controls made significant contributions to both sides of the first inflation "hill." And they show that anyone who tries to explain the rise and fall of *core* inflation over the 1972-1975 period *without* paying careful attention to price controls is missing something very important.

3.1.4 The mis-measurement of homeownership costs, 1979-1980

Our last important special factor during the Great Inflation was not a shock at all, but rather a measurement problem. We mention it briefly here only for completeness.

Prior to January 1983, the nominal mortgage interest rate was among the prices included in the CPI, and it had a large weight. Since the nominal mortgage rate, R, depends *inter alia* on expected inflation, $R = r + \pi^e$, and since π^e surely reacts to π, this odd treatment created a dynamic feedback loop within the measurement system: Any increase (decrease) in π would raise (lower) R, which would in turn feed back into yet-higher (lower) measured π. When mortgage rates fluctuated a lot, as they did in the late 1970s and early 1980s, this quirk induced a great deal of volatility in measured inflation—which is why the Bureau of Labor Statistics changed its procedure for measuring the price of owner-occupied housing services in 1983. Specifically, Blinder

[48] As noted, Blinder and Newton's first specification implied that controls left the price level 0.2 percent higher in the long run (defined as the estimated impact in December 1975), while their second specification yielded a long-run reduction in the price level of 2.4 percent. Our updated model implies a long-run reduction in the price level of 0.7 percent, which is within Blinder and Newton's range of estimates.

(1982, p. 273) showed that mortgage interest costs added about 2½ percentage points to CPI inflation in both 1979 and 1980.

Since we use the current-methods CPI here, this measurement problem disappears. Indeed, that is the main reason why the data shown in Figure 1 display a smaller inflation "hill" in 1978-1980 than the data showed in real time.[49]

3.2 The pass-through of food and energy shocks into core inflation

One key question about supply shocks is how they filter into other prices (including wages), thereby inducing "second-round" effects. In Section 2, we used an estimated price-price Phillips curve (described in Appendix 2) to show how some highly stylized energy shocks would pass through into core inflation. We now perform that same exercise using the time series on *actual* food and energy shocks during 1973-1980 period. The counterfactual question to which we seek an answer is this: How different would the Great Inflation (1972-1982) have been if the food and energy shocks had never occurred?

To do so, we compare a baseline path for core inflation, obtained by inputting the actual behavior of food and energy prices, with a counterfactual path in which food and energy prices grow steadily at 4 percent and 3 percent per annum respectively. We perform the simulations separately for current-methods core CPI inflation (Figure 12) and market-based core PCE inflation (Figure 13). In each figure, the upper panel plots actual inflation together with the baseline and counterfactual paths, while the lower panel shows the difference between the two paths (that is, the estimated contribution of food and energy price pass-through to core inflation).

[49] Consistent with Blinder's (1982) calculation, the difference in annualized inflation rates between the officially published CPI-U and an experimental CPI that uses a rental-equivalence approach to recalculate the owner-occupied housing component of the index (the CPI-U-X1) is 2¼ percentage points over the two-year period from May 1978 to May 1980. (On a twelve-month-change basis, the differential reaches a peak of 3¼ percentage points in June 1980.)

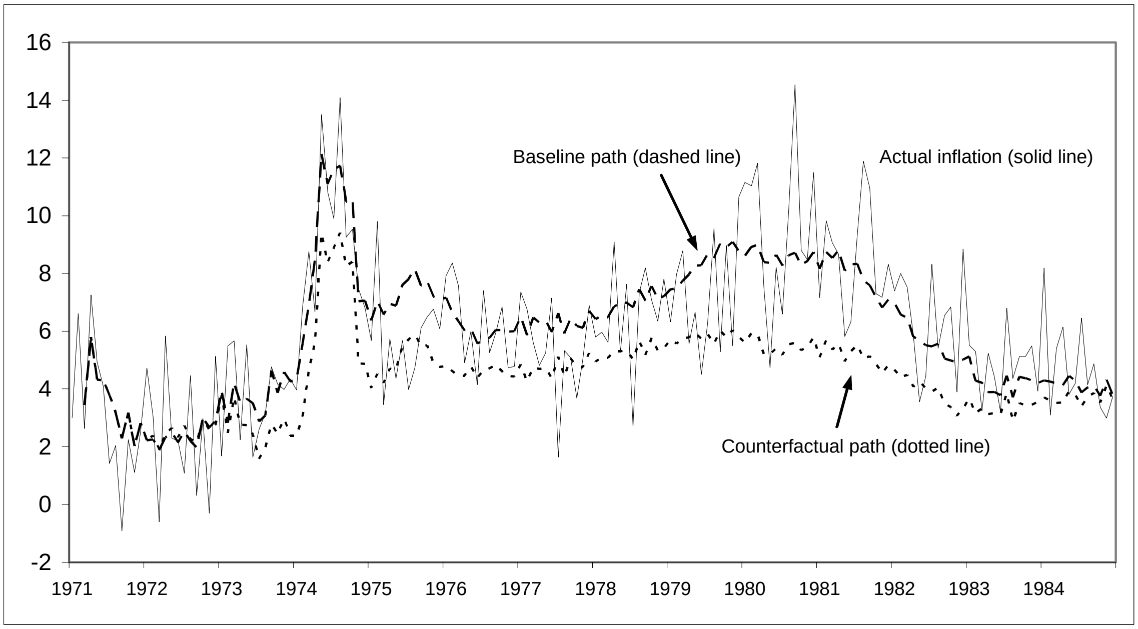
In the 1973-1974 episode, the simulations indicate that pass-through of food and energy prices added about 2½ percentage points to core CPI inflation and about 1½ percentage points to core market-based PCE inflation.[50] And in both cases, core inflation remained above its pre-shock level after the supply shocks dissipated, precisely as suggested by Figure 5. In the 1978-1980 episode, the simulations imply that pass-through of the supply shocks contributed about 3 percentage points to core inflation by either measure. In this period, the energy shock was larger, and the food price shock persisted longer.

A second way to estimate pass-through is to simulate a two-equation wage-price system. As the first step, we estimate a wage-price Phillips curve in which wage inflation depends on *headline* price inflation, generate fitted values using *actual* food and energy inflation, and compare this to the fitted values that obtain under the *counterfactual* path for food and energy inflation. The results are shown in the upper panel of Figure 14; as can be seen, wage inflation would have been roughly flat over much of this period had headline inflation not been boosted by the food and energy price shocks.

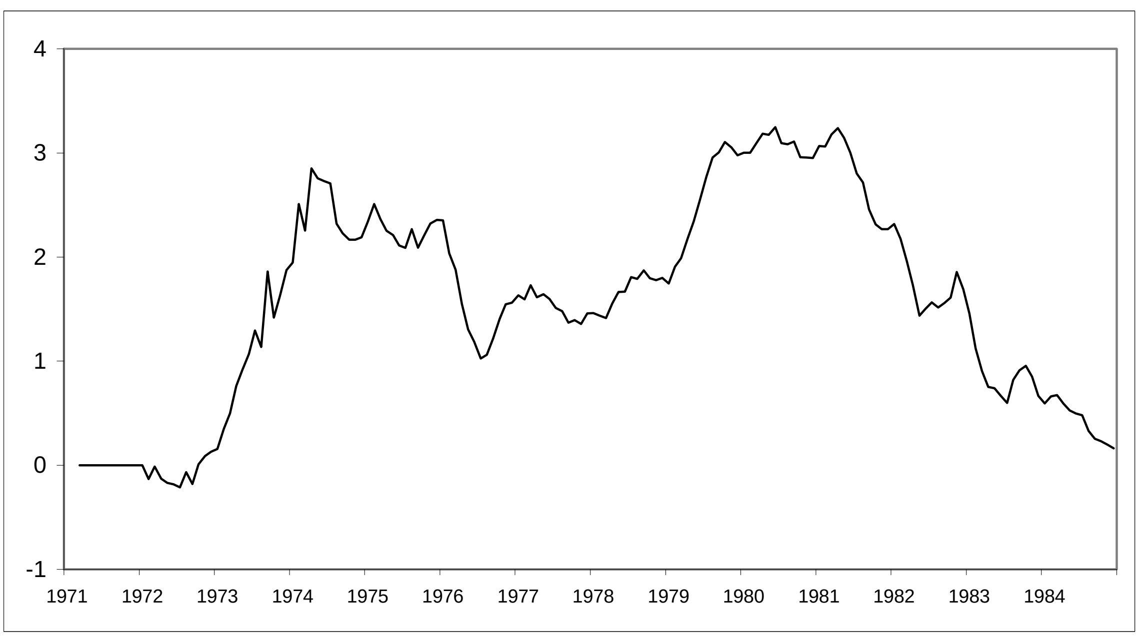
[50] The difference between the two estimates mainly reflects the fact that the CPI for food rose faster than the PCE-based measure of food price inflation. Food prices also receive a slightly smaller coefficient in the PCE model.

Figure 12
Effects of supply shocks on core CPI inflation

A. Baseline and counterfactual core CPI inflation



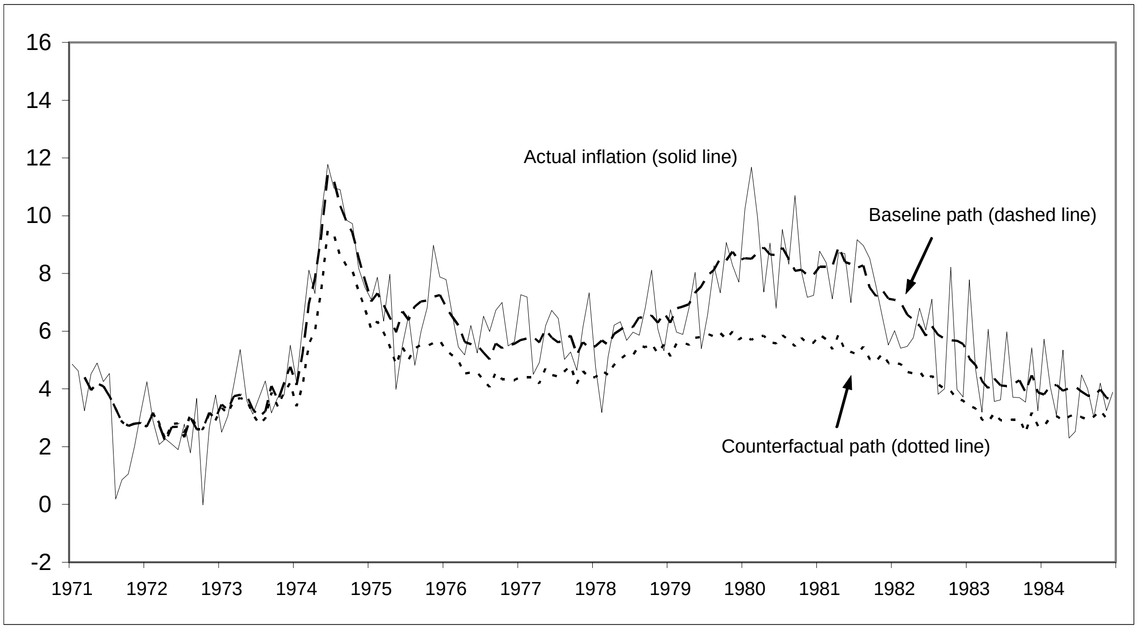
B. Difference between baseline and counterfactual paths



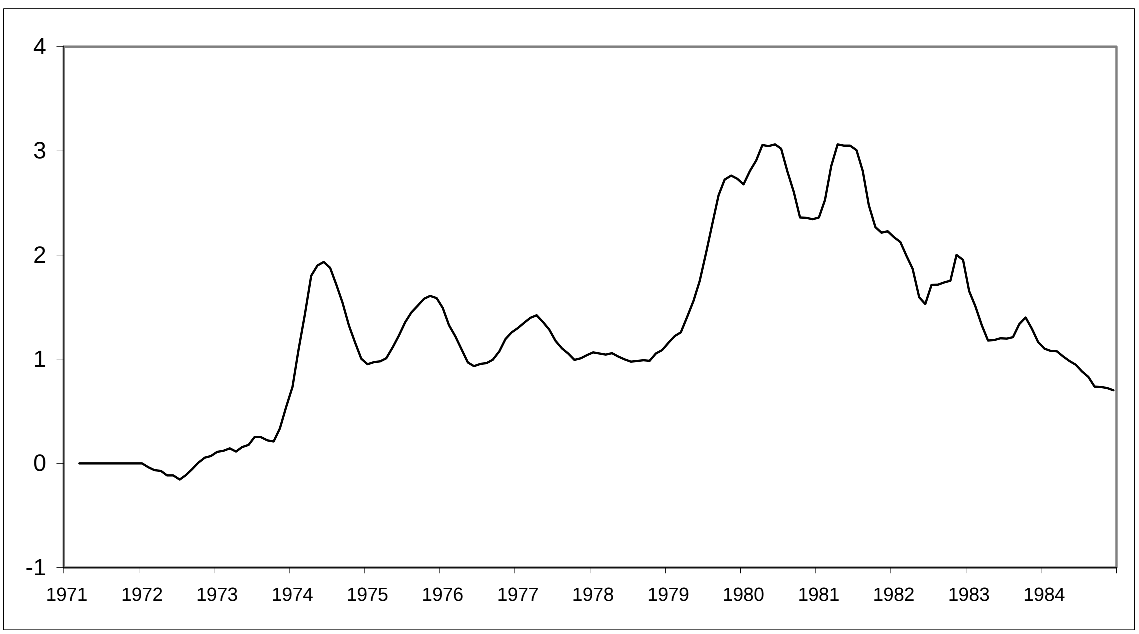
Note: Inflation rates expressed as annualized monthly log differences.

Figure 13
Effects of supply shocks on core market-based PCE inflation

A. Baseline and counterfactual core market-based PCE inflation



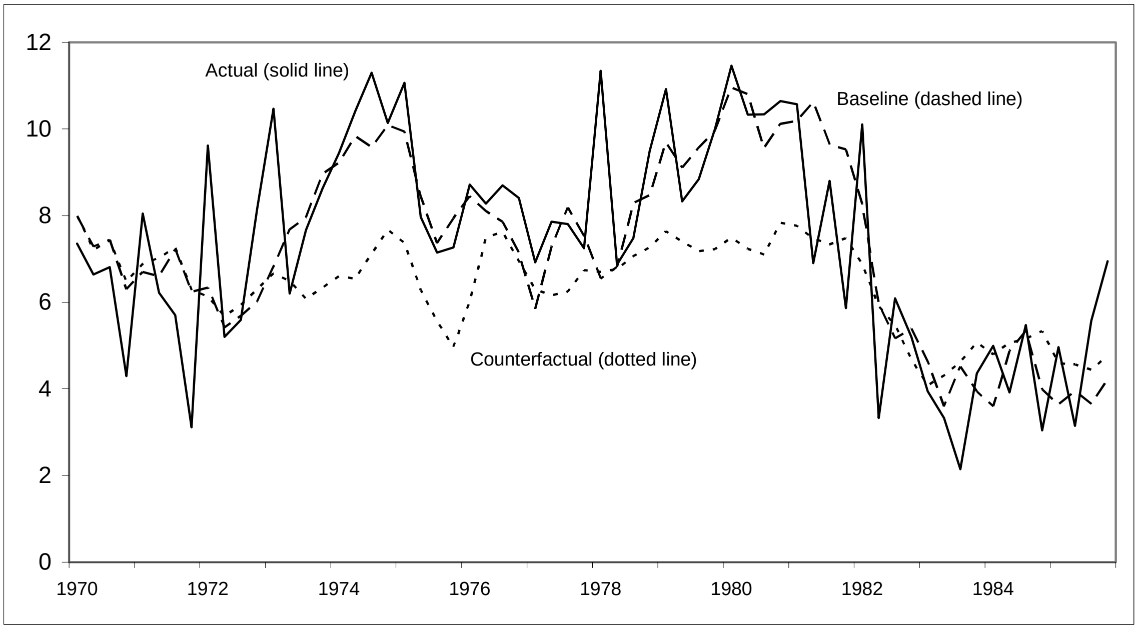
B. Difference between baseline and counterfactual paths



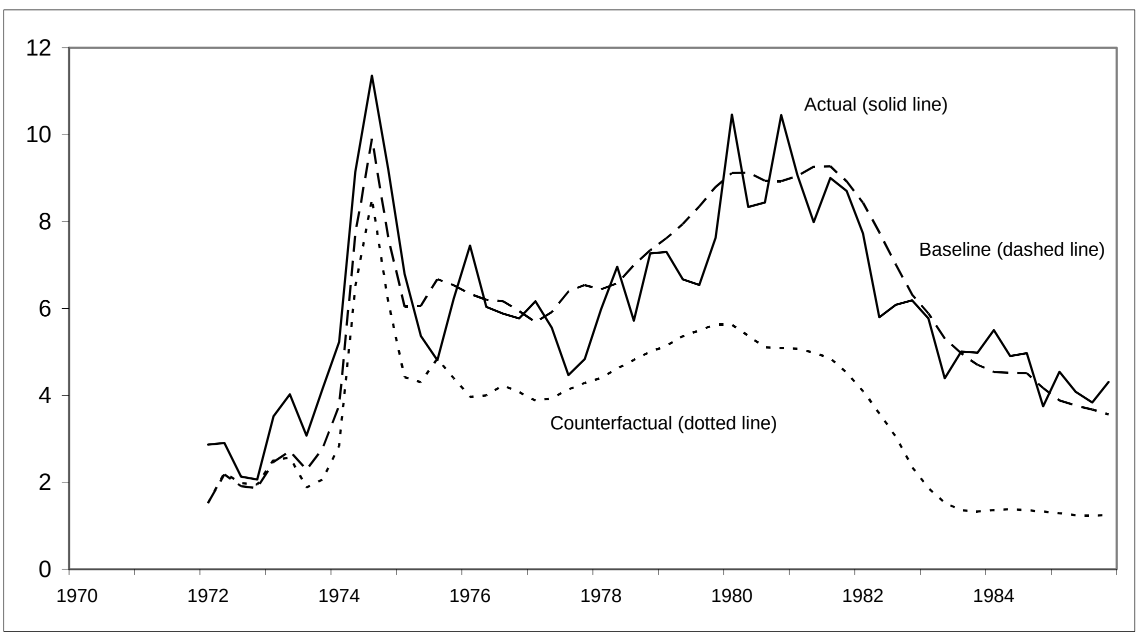
Note: Inflation rates expressed as annualized monthly log differences.

Figure 14
Supply shocks and wage-price dynamics

A. Nonfarm business compensation inflation from wage-price equation



B. Core CPI inflation from wage-price system



Note: Inflation rates expressed as annualized quarterly log differences.

As was shown in the stylized example in Section 2.4, the lower unit labor costs that result from less wage inflation lead to lower core price inflation as well. This in turn puts additional downward pressure on wage inflation, leading to further reductions in core inflation, and so on. These familiar wage-price interactions are captured by a two-equation system consisting of the aforementioned wage-price Phillips curve and a markup equation relating core CPI inflation to unit labor cost growth.[51] The results are shown in the lower panel of Figure 14, which plots *actual* core CPI inflation against two simulated paths from the full wage-price system. The two simulations differ in their assumptions about food and energy prices. As can be seen in the figure, the model implies a comparably large pass-through of food and energy prices into core inflation, despite the fact that these shocks now affect the core *only* to the extent that they feed into wages.

3.3 The effect of the business cycle

As we have mentioned repeatedly, oil and food shocks are expected to be contractionary as well as inflationary. But by how much? And by how much would we expect the resulting recessions to mitigate the inflationary consequences of the shocks?

To obtain quantitative answers, we use a small structural VAR model to estimate how much of the increase in unemployment that followed the energy and food shocks can be attributed to them. Our baseline VAR includes core PCE inflation, the unemployment rate, the weighted sum of relative (to core) food and energy price inflation, and the federal funds rate, with the variables ordered so that inflation is at the top of the ordering

[51] We also considered a version of the model that used the market-based PCE price index; the results were essentially similar. (Details of both models' specifications are in Appendix 2.)

and the federal funds rate is at the bottom.[52] We also consider an augmented system in which commodity price inflation (measured by the log change in the crude PPI) is included after the food and energy price term and before the funds rate.

To assess the contribution of the supply shocks to the 1973-75 and 1980-82 recessions, we utilize a standard variance decomposition technique to apportion actual movements in the unemployment rate into a baseline path (the forecast implied by the VAR with all shocks set to zero) and the contributions of each stochastic shock. The contributions of the shocks, of course, reflect the full dynamic structure of the VAR. For example, one key way in which a positive shock to food and energy price inflation raises unemployment is through its effect on the federal funds rate (higher inflation results in a higher funds rate, which reduces activity).[53]

The results from the two VAR models for the 1973-75 and 1980-82 recessions are shown in Figures 15 and 16, respectively. For each specification, the figure shows the baseline forecast for the unemployment rate along with the estimated effects of the food and energy shocks in the left-hand panels and the combined effects of the commodity, food, and energy shocks in the right-hand panels. Taken together, the four figures show that the models attribute a significant share of the increases in unemployment to the supply shocks that occurred in both recessions. But they also remind us that the effects are long delayed. In the 1973-75 episode, the supply shocks only start to have appreciable effects on the unemployment rate after the end of 1974. Similarly, the supply

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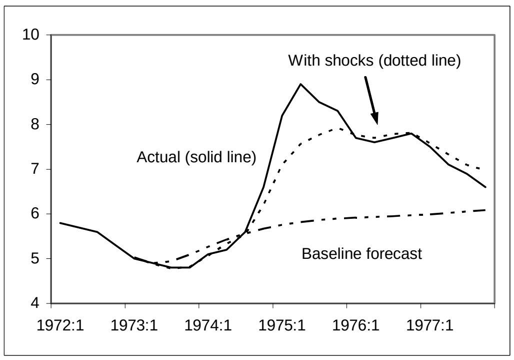
[52] Specifically, the food and energy term is defined as the difference between headline and core PCE inflation. It is straightforward to demonstrate that this equals the weighted sum of *relative* food and energy inflation, where the relatives are expressed in terms of core inflation and the weights are the shares of food and energy in the total index.

[53] Full details on the VAR specifications can be found in Appendix 2.

shocks make a relatively small contribution to unemployment in the first year of the 1980-82 downturns.

Figure 15
Contribution of supply shocks to unemployment rate increase, 1973-75 recession

A. Food and energy price shocks only



B. Food, energy, and crude PPI shocks

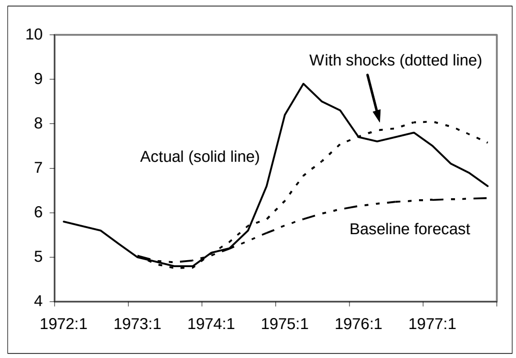
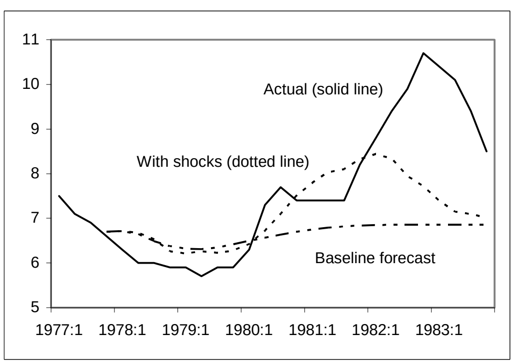
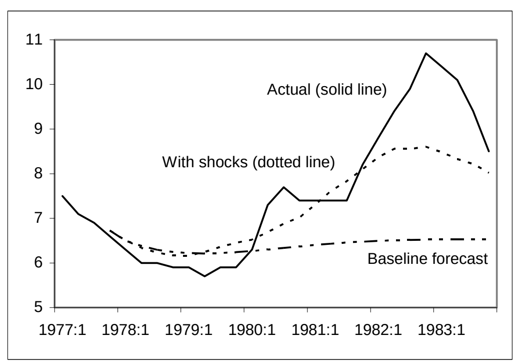


Figure 16
Contribution of supply shocks to unemployment rate increase, 1980-82 recessions

A. Food and energy price shocks only



B. Food, energy, and crude PPI shocks



One important implication of this familiar lag pattern is that the recessions that followed each supply shock came *after* most of the inflation damage was already done. While the two recessions no doubt played roles in the downsides of each inflation hill in

Figure 1 (and thereafter), they played little role in limiting the upsides.[54] Thus, since our focus is on explaining the two hills, the offset from economic slack is small enough to be ignored.

On this point, our results are consistent with recent work of Blanchard and Gali (2007), who use a VAR model in which oil prices are replaced by a broader measure of crude materials prices to consider the contributions of materials price shocks to output fluctuations. For the 1973-75 recession, they find that these shocks account for about half of the swing in real GDP, with the biggest contribution coming at roughly the same time as the trough in output—which is comparable to the effect that we find in our baseline VAR (see panel A of Figure 15). For the back-to-back recessions of 1980-82, the Blanchard-Gali model attributes a larger fraction (perhaps two-thirds) of the swing in output to materials price shocks. But actual output falls faster in 1980 than their model predicts, with the most rapid predicted declines in output occurring in 1981. Once again, this seems consistent with our finding of only a small effect.

3.4 Putting the pieces together

Table 4 is a rough—and deliberately impressionistic—summary of the findings of this long section. It puts together the estimated contributions to *headline* inflation of the two energy shocks (Section 3.1.1), the two food shocks (Section 3.1.2), their pass-through into core inflation (Section 3.2), and the end of price controls (Section 3.1.3). In coming up with these numbers, we roughly average our findings both over the two different price indexes (CPI and PCE) and over time—and we stick to round numbers. Thus we view

[54] For the 1973-75 recession, this conclusion is strengthened by the observation that the NAIRU was likely increasing rapidly over much or all of this period. For example, our simple estimate of trend unemployment rises nearly a percentage point from the end of 1973 to the end of 1975. (Note that the trend continues to rise—albeit at a slower rate—until the start of the 1980s.)

the first of the two inflation "hills" as rising from about 4 percent to about 10 percent and the second as rising from a bit over 6 percent to a bit over 10 percent (see Figure 1).

Table 4
Approximate Impacts of Special Factors on the Two Inflation "Hills"
(in percentage points)

Special Factor	**1973-1974 episode**	**1978-1980 episode**
Energy prices	2½	2
Food prices	3½	2
Pass-through of food and energy prices*	1½	2¼
End of price controls*	2	0
Total	**9½**	**6¼**
Memo: Actual rise in inflation	*6*	*4*

*Adjusted for core inflation's weight in overall inflation.

The basic finding is dramatic, although it should come as no surprise at this point. For each of the two inflation hills shown in Figure 1, the special factors account for *much more than 100 percent* of the rise (and subsequent fall) of headline inflation—that is, the supply shock explanation, with no role for aggregate demand, actually *over-explains* the Great Inflation.

But since we have emphasized that the Great Inflation was really the Great *Stagflation*, we also note that the numbers underlying Figure 15 imply that roughly 60 percent of the run-up in unemployment in the 1973-75 recession, and roughly 45 percent of the run-up in the back-to-back recessions of 1980-82, can be attributed to the supply shocks.

4. Arguments against the supply-shock explanation

Four related sets of arguments have been raised against the supply-shock explanation of the Great Stagflation. Each evokes, in its own way, shadows of the classical dichotomy:

that real phenomena cannot affect inflation. But since they are subtly different, we take each one up in turn.

4.1 Relative price shocks cannot affect absolute prices.

The simplest argument, which was raised immediately after OPEC I, holds that it is logically fallacious to believe that a change in a *relative* price can be a source of generalized *inflation*. Instead, a rise in the relative price of energy (P_E/P) should be effectuated by some combination of higher nominal prices for energy products (P_E) and lower nominal prices for a variety of other things (call these P_O, for "other" prices). There is no reason for the overall price level, $P = \omega P_E + (1-\omega)P_O$, to rise unless the money supply does. As Milton Friedman (1975) asked at the time in a much-quoted *Newsweek* column, "Why should the *average* level of all prices be affected significantly by changes in the prices of some things relative to others?"[55]

This attitude, of course, reflects pre-Keynesian thinking. Ever since the Keynesian revolution, most (but not all) economists have believed in pervasive nominal price and wage rigidities, so that relative price increases can and do lead to a higher price level—as, for example, when P_E rises and P_O does not fall. Furthermore, if one of the sticky nominal prices is the nominal wage, then real wages will get stuck too high for a while, causing unemployment.

We find it remarkable that the classical dichotomy still has such a hold on the minds of economists. Indeed, as recently as 2006, Ball made much the same argument in a different context—namely, that globalization cannot possibly affect inflation because it is

[55] In the next sentence—which is never quoted—Friedman provided a partial answer: "Thanks to delays in adjustment, the rapid rises in oil and food prices may have temporarily raised the rate of inflation somewhat." As with so many "strong monetarist" positions, the question boils down to one of degree, not direction.

fundamentally a series of *real* events. A similar view underpins Barsky and Kilian's (2002) attempt to re-write the history of the Great Inflation. They argue that oil price shocks can affect "gross output price measures such as the CPI, but not necessarily the price of value added" (such as the GDP price index). We have already studied one counterargument: The wage-price spiral provides an obvious channel through which higher food and energy prices can affect domestic output prices, even if food and energy are both imported.[56]

One way to conceptualize this debate is to recognize that, with sticky wages and prices, the causation between inflation and relative-price changes undoubtedly runs in both directions. On the one hand, since some prices are stickier than others, an inflationary demand shock will induce changes in relative prices. On the other hand, a supply shock that requires a large change in some relative price(s) can be a source of overall inflation because other prices do not fall easily. The empirical question then becomes: Which channel is quantitatively more important in practice? We think the answer is obvious, especially for the years of the Great Inflation.

Taylor (1981) noticed years ago that inflation accelerated in the late 1960s with *low* relative price variability, but then accelerated much more in the 1970s with *high* relative price variability. He attributed the first acceleration to demand shocks and the second to supply shocks—precisely as we do. Based on his econometric investigation, he concluded that the data suggest "a causal ordering in which relative price variability (due to *exogenous* supply shocks) is the main reason for variability in the overall inflation rate" (p. 69, emphasis added).

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[56] See Blanchard (2002). In addition, the proposition that intermediate price increases (such as a rise in the price of oil) can have no effect on a value-added deflator only holds true under perfect competition, as Rotemberg and Woodford (1996) discuss.

Fourteen years later, focusing on the importance of the *skewness* rather than the *variance* (of relative price changes) in a menu-cost model of price stickiness, Ball and Mankiw (1995) argued for causation running from higher skewness (*e.g.*, very large increases in a few prices) to higher average inflation.[57] They pointed in particular to the extreme skewness of relative price changes in the years 1973-1974, 1979-1980, and 1986 (their sample ended in 1989). To Ball and Mankiw (1995, p. 190), "the explanation for these episodes is obvious: OPEC…The direction of causation is clear: *exogenous* events in the Middle East induced skewness in the distribution of relative prices, which led to changes in the U.S. inflation rate" (emphasis again added). This seems obvious to us, too, and we fail to see why some economists are so intent on denying the obvious.

4.2 "Inflation is always and everywhere a monetary phenomenon."

Friedman's famous dictum holds that an economy does not produce rising inflation without an increase in the growth rate of the money supply. And, indeed, he and his disciples emphasized this point in arguing for a tightening of monetary policy at the time of OPEC I. In this view, supply shocks could not have been the main culprit explaining the surge in inflation. It must have been excessive money growth.

This is neither the time nor the place to document and discuss the profound disconnect between inflation and *measured* money growth since the 1970s. The literature on this issue is vast, but not much of it is recent because the issue was resolved years ago. However, one should not read too much into this dismissal of "the Ms": After all, "money growth" and "monetary policy" are not synonymous. We would certainly never

[57] Not everyone agreed with their interpretation. For example, Balke and Wynne (2000) suggested that an alternative theoretical model with flexible prices and suitably distributed technology shocks could give rise to a similar relation, while Bryan and Cecchetti (1999) argued that the statistical correlation between mean inflation and skewness is biased upward in small samples.

claim that a central bank's reactions have nothing to do with the propagation of the inflationary impact of a supply shock.

4.3 The Fed's reactions make supply shocks contractionary.

Indeed, it has long been recognized that the central bank's reaction function exerts a strong—some might even say determinative—influence on the inflationary consequences of any shock, whether it comes from the demand or the supply side.[58] Refer back to the aggregate supply and demand diagram in Figure 2—which, we now assume, depicts what happens when the central bank holds the money supply constant. A more accommodative monetary policy, designed to cushion the impact on output, would shift the aggregate demand curve outward, causing more inflation. A tighter monetary policy, designed to limit the inflationary consequences of the supply shock, would shift the aggregate demand curve inward, causing a larger output decline. This is simple stuff that every Economics 101 student learns—or should learn.

Bernanke, Gertler, and Watson (1997) accept the notion that oil shocks are inflationary, but they dispute the idea that they are recessionary *per se.* Instead, they use VAR-based evidence to argue that it is the central bank's reactions—to wit, tightening monetary policy to fight inflation—that causes the ensuing recessions. In their words, "…the endogenous monetary policy response can account for a very substantial portion (in some cases, nearly all) of the depressing effects of oil shocks on the real economy" (p. 94).

In some sense, we have no need to dispute their proposition. After all, Bernanke *et al.* agree that *exogenous* adverse oil shocks lead to both higher inflation and

[58] Some early papers on this subject, as it pertains to oil shocks, include Gordon (1975), Phelps (1978), and Blinder (1981).

slower real growth; they just attribute the latter to the Fed's monetary policy response rather than to OPEC directly. And we noted earlier that the pure neoclassical effects of oil shocks are far too small to explain actual events; large demand-side effects are necessary to explain the ensuing recessions.

However, the Bernanke *et al.* analysis of the two big oil shocks has been criticized by Hamilton and Herrera (2004) on a couple of grounds. First, Hamilton and Herrera argue that Bernanke *et al*.'s conclusions are based on unrealistic counterfactual assumptions—*e.g.*, very large changes in monetary policy—whose effects are unlikely to be captured well by a VAR estimated on historical data. Second, they argue that Bernanke *et al.*'s estimated real effects of oil shocks are too small; alternative estimates imply that oil shocks continue to have contractionary effects of their own, even after controlling for monetary policy.[59]

And there are other entrants in this debate. Leduc and Sill (2004) use a calibrated model to argue that roughly 40 percent of the observed drop in output after an oil shock is attributable to the monetary policy response, while Carlstrom and Fuerst (2006) use an alternative theoretical framework to conclude that a smaller amount (perhaps none) of the drop in output is due to monetary policy. After reviewing the literature, Kilian (2007a, p. 25) concludes that "how much the Fed's endogenous response to higher oil prices contributed to the subsequent economic declines still remains unresolved."

Stepping back from the detail, the central empirical question here is the degree to which the contractionary effects of the supply shocks were exacerbated or mitigated by tighter or looser monetary policy. To investigate this issue, we reprise the structural

[59] In their reply to Hamilton and Herrera, Bernanke *et al.* (2004) consider an alternative model and find that the response of monetary policy to an oil shock still accounts for roughly half of the shock's real impact. This is less than their original estimate, though still economically significant.

VAR models that we used earlier in Section 3.3. In these models, a significant portion of the increase in the federal funds rate that follows an inflationary supply shock is offset by the subsequent rise in unemployment, as increasing slack induces an easing of monetary policy. We therefore consider a counterfactual specification in which the policy rate is constrained *not* to respond to unemployment. We focus on our four-variable VAR, since this model attributes relatively more of the increase in unemployment over the 1973-75 recession to the supply shocks.[60]

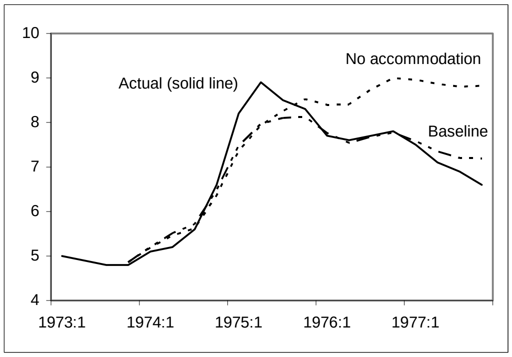
Figure 17 depicts the responses of unemployment and core inflation under the two specifications following a sequence of supply shocks like those seen in 1973-74. As is evident from panel A, the Fed's accommodation of the shock (defined here as the reduction in the federal funds rate that the VAR attributes to the unemployment increase that results from the shock) has a large effect on the path of unemployment. Importantly, however, most of the impact on the unemployment rate comes some time *after* the recession because of the long lags between changes in the funds rate and changes in unemployment. Panel B shows the effects on core inflation under the two alternatives; accommodating the shock results in a core inflation rate that is nearly ¾ percentage point higher by the end of the simulation period.[61]

[60] The VAR system becomes very unstable when the response of the federal funds rate to unemployment is shut off. We therefore detrend the unemployment rate before including it in the VAR. However, we add the trend back in Figure 17 in order to make the simulated series comparable to the actual unemployment rate.

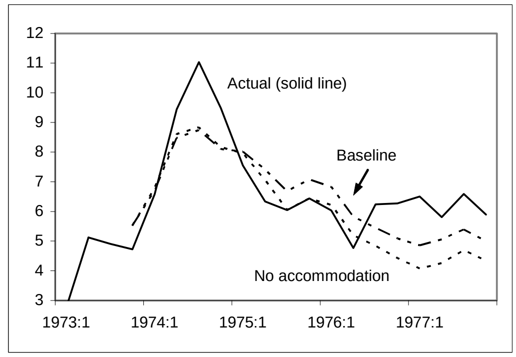
[61] We would not want to push these results too hard. As our discussion of Bernanke, Gertler, and Watson (1997) makes clear, there are important econometric issues associated with an experiment of this sort. For example, our "no accommodation" scenario implies a federal funds rate that is on average more than 200 basis points higher than the baseline over the entire simulation period. At best, then, this exercise should be viewed as suggesting a likely order of magnitude for the effect of monetary accommodation following the 1973-74 shocks.

Figure 17
Contribution of policy accommodation to unemployment and inflation, 1973-75 recession

A. Unemployment rate



B. Core PCE inflation



4.4 Monetary policy, not supply shocks, caused the Great Inflation.

Notice that the Bernanke, Gertler, and Watson (1997) critique does not dispute the idea that exogenous increases in the price of oil set in motion reactions, including those of the Fed, that resulted in both inflation and recession. Their quarrel is only with the notion that higher oil prices *per se*, rather than tighter monetary policy, caused the recessions that followed OPEC I and OPEC II.

The final version of the monetary-policy criticism of the supply-shock explanation of the Great Inflation goes a step further—a step too far, in our view. This criticism has been expressed in at least three different ways. What they have in common is that each lays the blame for the Great Inflation squarely at monetary policy's door. In its strongest form—which we consider first—the criticism argues that the jumps in oil prices in 1973-74 and again in 1979-80 were not really "exogenous," but rather were largely reactions to previous inflationary monetary policies.

4.4.1. Barsky and Kilian (2002)

In the Barsky-Kilian (2002) variant, expansionary monetary policies in the U.S. and other countries led *both* to the aggregate inflation we observed in the 1970s and 1980s *and* to increases in world commodity prices—including the price of oil. In words that evoke what Friedman and other monetarists were saying at the time, they claim that "in the 1970s the rise in oil prices…was in significant measure a response to macroeconomic forces, ultimately driven by monetary conditions" (p. 139).

We would never claim that the state of world demand, of which a non-trivial share emanates from the U.S., is irrelevant to OPEC's ability to push through price increases *and make them stick*. So there must be *some* causal link from prior U.S. monetary policy to oil prices. The dispute is about magnitudes. Like Taylor (1981), Ball and Mankiw (1995), Gordon (in various papers), and many other observers, we can't help thinking that geopolitical factors were *far* more important in October 1973 than the state of world aggregate demand—which in any case fell sharply in 1974. In particular, should we ignore the fact that OPEC I came right after the Yom Kippur War? (Just a coincidence?) Or that OPEC's oil output *fell* rather than *rose* after the shock—suggesting that it was supply rather than demand driven?

Indeed, a close reading of the history of the period suggests that the main effect of the OPEC I production cuts, which were neither exceptionally large nor long-lasting, was to create significant uncertainties about oil supply, which induced a surge in precautionary *demand* for oil.[62] Similarly, the rise in prices associated with the second OPEC shock appears to have been driven more by fear of future shortages than by *actual*

[62] See Adelman (1995, pp. 110-18), and Yergin (1993, pp. 613-17).

reductions in supply.[63] But from a macroeconomic perspective, these are nevertheless "exogenous" shocks inasmuch as they were sparked by political or other events—and not (mainly) by an overheated world economy.

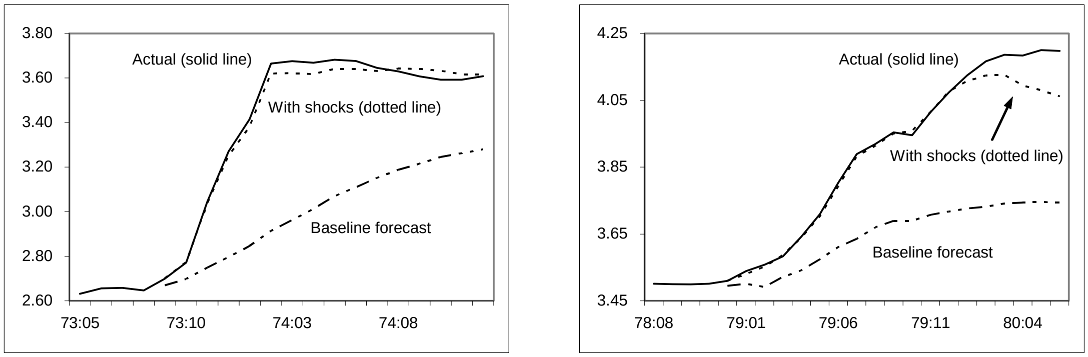
To obtain explicit quantitative evidence regarding the nature of the two oil shocks, we adapt Kilian's (2007b) recent model of the oil market. He uses a VAR with measures of oil production, aggregate commodity demand, and the real oil price to identify three types of shocks: shocks to general commodity demand (including for oil), shocks to oil supply, and shocks to oil demand specifically. In line with our preceding discussion, he identifies the last shock with exogenous shifts in precautionary oil demand or shifts in expectations about future oil supply.

We implemented a version of Kilian's empirical framework and used it to consider the contribution of oil-specific demand shocks to the OPEC I and OPEC II price increases.[64] We find that large shocks of this type did in fact hit the oil market around these two periods. Moreover, we can use the same technique applied in Figures 15 and 16 to decompose the actual movement in oil prices into a baseline forecast and the contribution of the oil-market-specific shocks. This is done in Figure 18 for the OPEC I and OPEC II periods. As is evident from the figure—and as one would expect given the historical evidence cited above—these shocks account for most of the run-up in real oil prices seen around these episodes.

[63] Adelman (1995, pp. 167-78), Yergin (1993, chapter 33).
[64] Once again, a detailed description of the model is in Appendix 2.

Figure 18
Contribution of oil-specific demand shocks to log real oil price

A. OPEC I shock B. OPEC II shock



What about the broader rise in commodity prices that Barsky and Kilian (2002) point to as evidence of a money-fueled boom? It is true that a number of observers at the time blamed higher commodity prices on rapid world economic growth in 1972-73.[65] But the effects of the increase in demand were exacerbated by supply-side factors, most notably underinvestment in capacity by primary producers that resulted from price controls and low rates of return in these industries. In addition, some have attributed the emergence of a "shortage mentality" to the first oil shock, as uncertainty about supplies of other raw materials led to precautionary stockbuilding. Finally, year-to-year movements in commodity prices in the 1970s do not appear to correlate well with movements in world money supply or reserves.[66]

4.4.2. DeLong (1997)

DeLong (1997) also blames the Great Inflation on faulty monetary policy, but in a different way. He argues that trend inflation was rising well before the supply shocks hit

[65] See chapter 4 of the 1976 *Report of the National Commission on Supplies and Shortages*, from which most of this discussion is taken.
[66] See Bosworth and Lawrence (1982, chapter 4), who also discuss the role of stockbuilding of commodities in the face of perceived supply problems.

because (a) the Fed was trying to exploit what it saw as a non-vertical Phillips curve and (b) policymakers still remembered (and were terrified of) the Great Depression. The latter factor, in particular, made them fearful of using higher unemployment to fight inflation. In DeLong's view, this situation made a burst of inflation inevitable. The food and energy shocks played only subsidiary roles, creating transitory swings in inflation around a trend that was rising for other reasons.[67]

As noted at the outset, the gradual buildup of inflation during the 1960s is beyond the scope of this paper. But there is obviously a kernel of truth in DeLong's argument. After all, Figure 1 shows that inflation did rise in the 1965-1970 period, long before OPEC I and higher oil prices. Indeed, following a rapid acceleration in prices from 1965 to 1968, there was a modest upward trend in the *core* inflation rate from 1968 until about 1976 or 1977. It is also true that, prior to 1972, most economists viewed the *empirical* Phillips curve as non-vertical even though the *theoretical* long-run Phillips curve should be vertical à la Friedman and Phelps.

But a more balanced view of this early inflation would recognize a few other pertinent factors. One was the strong influence of Vietnam War spending on chronic excess demand in the late 1960s—an inflationary *fiscal* (not monetary) policy. Second, we should remember that this loose fiscal policy was subsequently reversed by the 1968 income-tax surcharge *and a tightening of monetary policy*—both of which were explicitly rationalized as anti-inflationary measures. These actions show that the authorities were

[67] DeLong (1997, pp. 268-70) argues that the supply shocks had no effect on wages, and so did not enter trend inflation. But the results in Section 3.2 from our wage-price models suggest that this claim is incorrect.

not paralyzed by fear of higher unemployment.[68] Third, the pre-1973 inflation was dwarfed by what came after. Had inflation remained below 5 percent, as it did prior to 1973, we would never have had a conference on The Great Inflation. As we have argued at length in this paper, something very different happened after 1972. Fourth, the sharp reflation of the U.S. economy in 1972, using both expansionary monetary and fiscal policy, was almost certainly designed to assist Richard Nixon's reelection campaign, as were the wage-price controls that reduced inflation in 1971-1973 but then raised it in 1973-1974.[69] Bad memories of Nixon's defeat in the 1960 election were probably more relevant to the macroeconomic policies of 1971-1972 than were bad memories of the Great Depression.[70] Finally, the breakdown of the Bretton Woods system in 1972-1973 ended one traditional aspect of monetary discipline.

In sum, to attribute the Great Inflation to unemployment-phobic central bankers trying to exploit what they thought was a downward-sloping Phillips curve seems to be a grotesque exaggeration of a much more complex reality.

4.4.3. Cecchetti et al. (2007)

Although they reject any mono-causal explanation, Cecchetti *et al.* (2007) also argue that underlying inflation picked up before 1972 because of insufficient concern about inflation by monetary policymakers combined with a reluctance to use unemployment as a remedy. Their work uses cross-country evidence; and given the striking similarity in timing of the Great Inflation in many countries, they are rightly skeptical of country-

[68] Nor were they sufficiently paralyzed by fears of an economic downturn to prevent the 1973-75 recession from being exceptionally long and severe.

[69] For details on the behavior and impact of fiscal and monetary policy over this period, including quantitative estimates, see Blinder (1979), pp. 29-35, 141-146, and 179-194.

[70] For evidence from the horse's mouth, see Nixon (1962, pp. 309-11). Also see Abrams (2006) for summaries of relevant conversations between Nixon and then-Fed Chairman Arthur Burns. All that said, it must be admitted that Richard Nixon and Arthur Burns were not the only advocates of expansionary monetary and fiscal policies in 1972.

specific explanations. One might think such an attitude would have led Cecchetti *et al.* straight to the supply-shock explanation; after all, the oil and food shocks of 1972-1974 were *worldwide* phenomena.[71] But they actually downplay the importance of supply shocks because their data-driven dating of the Great Inflation places the start date in the late 1960s. We have already argued that the evidence for this dating is not very persuasive.[72]

5. Energy and food shocks before and after the Great Stagflation

If food and energy shocks are so critical to understanding the Great Stagflation, why didn't the U.S. experience them either before or after the 1973-1982 period? And if so, why didn't they have similarly dramatic effects? Let's start, briefly, with the period before 1973, and then go on to the period after 1982.

Regarding oil shocks, OPEC I seemed to be something new, if not indeed something *sui generis*, at the time. As Nordhaus (2007) emphasized, it truly was a "shock" to Americans in every sense of the word. But Hamilton (1983) subsequently showed that OPEC I was not as unique as it seemed at the time. The U.S. economy had not only experienced oil shocks before, it had reacted to them similarly.

Regarding food shocks, Blinder (1982) showed that we had indeed experienced two sharp inflationary food-price shocks in the 1940s. The unusual period was the placid years from 1952 through 1972, when CPI food price inflation exceeded 5 percent only

[71] The title of Bruno and Sachs' famous 1985 book was "Economics of *Worldwide* Stagflation."
[72] To be clear, we are *not* advancing a mono-causal explanation of U.S. inflation from 1965 to 1982. Monetary and fiscal policy, for example, clearly mattered. Our point is that the two big hills in Figure 1 are *mainly* attributable to special factors (supply shocks and price controls).

once in 21 years.[73] And, of course, the United States did experience a sharp surge of inflation when World War II price controls were lifted in 1946.

The period after 1982 is more puzzling; and it is, of course, the subject of more recent research. While the United States has experienced several oil-price shocks, both positive and negative, since 1982, none of them seem to have had such dramatic effects on either output or inflation as the supply shocks of the 1970s and early 1980s. Hooker (1996, 2002), Blanchard and Gali (2007), and Nordhaus (2007), among others, present econometric evidence that the more recent oil shocks had smaller macroeconomic effects than the earlier ones. The basic stylized facts from this research seem to be that the positive response of core inflation has diminished sharply over time and the negative responses of real GDP and employment have nearly vanished.[74] Why might that be?

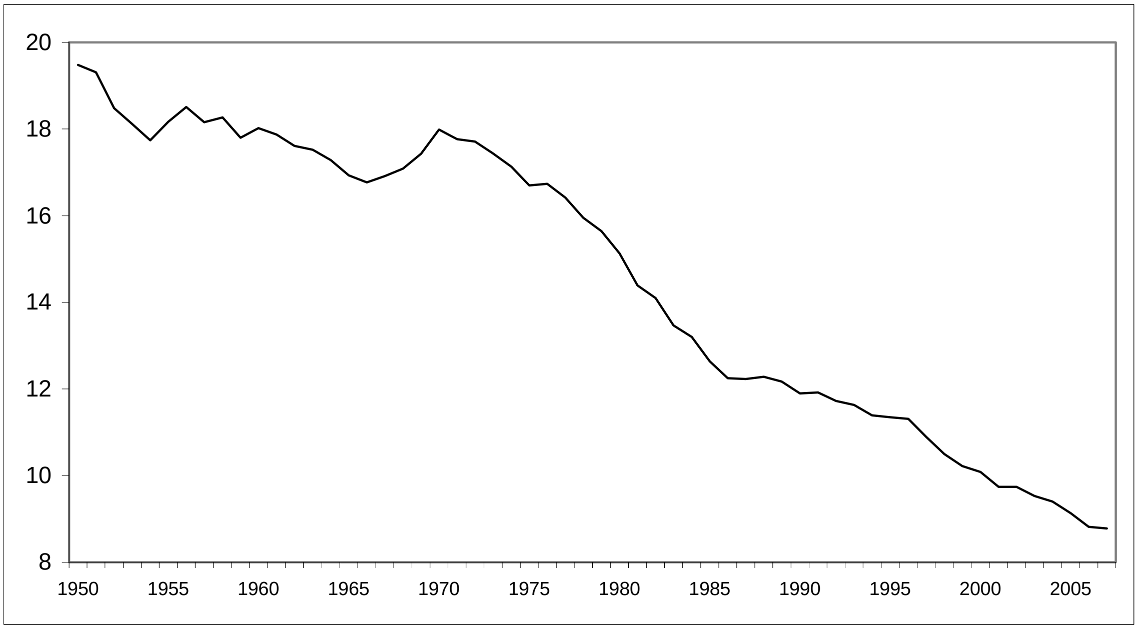
One reason is obvious: Thanks largely to an array of market reactions to higher energy prices after OPEC I and II, the U.S. and other industrialized countries are now far less energy intensive than they were in 1973. In the case of the United States, the energy content of GDP has fallen dramatically since 1973, and is now about half of what it was then. This dramatic change is depicted in Figure 19, which shows the number of BTUs consumed (in thousands) per dollar of real GDP annually from 1950 to 2007. The rate of decline of this measure of energy intensity picks up after OPEC I and slows in the mid-1980s with the cartel's collapse and attendant drop in oil prices—though the series has continued to trend down since then. By itself, this halving of the U.S. economy's

[73] See Blinder (1982), Tables 12.7 and 12.8, page 277. After the Great Stagflation ended, we once again lived in a food-shock-free era until 2008. From December 2007 to September 2008, the food component of the CPI rose at a 7.5 percent annual rate. But even that was only about 3 percentage points above overall CPI inflation and about 5 percentage points above core.

[74] For example, Nordhaus's (2007, Table 2, p. 224) descriptive regression for output shows the coefficient of the oil-shock variable falling from −0.50 in the 1960-1980 sample to −0.19 over 1970-1990 and to −0.06 over 1980-2000.

energy intensity would reduce the macroeconomic impacts of oil shocks by about 50 percent—with the reductions roughly equal for prices and quantities.

Figure 19
Energy intensity in the U.S. economy, 1950-2007



Source: Energy Information Administration, *Annual Energy Review 2007* , Table 1.5.

However, Hooker (2002) finds that pass-through from oil prices to other prices has diminished to negligible proportions over time—which is about twice the change that can be explained by energy's shrinking share. Furthermore, he cannot link the smaller pass-through to the reductions in energy's share. In fact, this is a very general result, and can be extended to Phillips curve models that use share-weighted relative *energy* prices in lieu of oil prices. Moreover, as the rightmost column of Table 1 showed, repeating our input-output exercise for the five-year period 2002-2007 reveals essentially no positive relationship between the energy intensity of consumption goods and their price change over this period. So there must be more to the story.

A fascinating paper by Nordhaus (2007) explores three possibilities. The first is that the more gradual nature of the 2002-2008 oil price increases weakened their effects. While huge in total, the rolling oil shock of 2002-2008 is far smaller than either OPEC I or OPEC II *when viewed on an annualized basis*—just 0.7 percent of GDP per annum (through the second quarter of 2006, when Nordhaus's study ends) *versus* roughly 2 percent of GDP per annum for both OPEC I and II (see Table 3 on page 227 of his paper). More gradual oil price increases are easier to cope with.

Nordhaus also finds modest evidence that wages have absorbed more of the recent oil shocks than was true in the 1970s. Greater wage flexibility makes the responses to an oil shock more neoclassical and less Keynesian—and therefore smaller.

Perhaps most important, Nordhaus uses econometric Taylor rules to estimate that the Federal Reserve responded more to *headline* inflation until 1980 but more to *core* inflation afterward. If so, the work of Bernanke, Gertler, and Watson (1997) would predict substantially smaller contractionary effects following the more recent oil shocks because of the limited effect that oil shocks now appear to have on core inflation. And remember that the empirical puzzle is at least somewhat greater for the real effects of oil shocks than for the effects on non-energy inflation, even though both have diminished a great deal.[75]

Blanchard and Gali (2007) also adduce some modest evidence in favor of greater wage flexibility in recent years.[76] But their more speculative hypothesis is that the anti-

[75] Hooker (2002) also points out that it is difficult to use the Bernanke *et al.* idea to explain the empirically observed instability in the U.S. Phillips curve. Bernanke *et al.* find—and Hooker confirms—that policy appears to respond *less* aggressively to oil price shocks in recent years (this is, of course, consistent with Nordhaus's finding). But that makes it difficult to attribute the reduced pass-through of oil prices into the core to less-accommodative monetary policy.
[76] They consider six countries but concentrate on the United States—a point that Blanchard emphasized in his discussion.

inflation credibility of monetary policy has increased since the 1970s—which would reduce both the inflationary impacts and the output losses from an oil shock, presumably by limiting the reaction of inflationary expectations. Blanchard and Gali (2007) do find smaller recent impacts on *expected* inflation; but they warn that, "The model we have developed is too primitive in many dimensions, and its quantitative implications must be taken with caution" (pp. 65-66).[77]

Kilian (2007a) adds two other empirically appealing ideas to the list, both connected with international trade. First, the changed structure of the U.S. automobile industry since 1973—arguably itself a reaction to the OPEC shocks—means that Americans no longer turn only to imports when they seek smaller, more fuel-efficient vehicles.[78] So domestic aggregate demand falls by less after an oil shock than it formerly did. The domestic auto industry, which is of course especially vulnerable to higher gasoline prices, is also a much smaller share of the economy now than in the 1970s.

Second, the rolling 2002-2008 oil shock seems to have been driven by strong global demand for industrial output, not by supply or demand shocks specific to the oil market. While rising oil prices still constitute an "oil shock" to importing nations like the United States, the recent shock came accompanied by stronger export performance, which cushioned the blow to aggregate demand.

In sum, the search for an explanation of why oil shocks have smaller impacts now than they did in the 1970s has not come up empty. Rather, it has turned up a long list of

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[77] In particular, the treatment of inflation expectations is both critical to credibility issues like this and hard to adjudicate empirically.

[78] The SUV craze clearly represented some back-sliding in this regard, and the auto industry is now paying the price.

factors, no one of which appears to be dominant. But each may play some role. Alas, reality is sometimes complicated, as Einstein understood.

6. A summing up

Blinder (1979, 1982), Gordon (1982), and others concluded decades ago that the two OPEC shocks, the two roughly contemporaneous food price shocks, and the removal of wage-price controls in 1973-1974 played starring roles in the macroeconomic events that constituted the Great Stagflation. Money and aggregate demand were, by comparison, bit players. This supply-shock explanation, which we summarized in the ten points in the Preamble, was never intended to *exclude* influences from the demand side, whether monetary or fiscal. But it did take the empirical view that, compared to the powerful special factors that were at work, conventional demand-side influences were minor during the years from 1973 to 1982.[79]

More than a quarter century has now passed since Blinder's 1982 paper was published. How well has the supply-shock explanation held up to the accumulation of new data, new theories, and new econometric evidence since then? Our answer is: for the most part, pretty well.

New data: The passage of time has changed the historical data that Blinder and others studied at the time. But we have shown in this paper that data revisions, while altering the precise numbers, do not change the basic story of the period in any important ways. Whether simply tabulating data or making more complicated econometric estimates, the events of 1973-1982 look much the same with current data as they did with

[79] We exclude from this statement the demand-side impacts of the supply shocks, which we have discussed extensively.

earlier data vintages.[80] A far bigger change to our interpretation of this period comes from Hamilton (1983) and subsequent work, which has taught us that OPEC I was not the first oil shock.

But the experience since 1982 *has* been different, and far more benign, than what OPEC I and II led us to expect. While there were no food shocks between the late 1970s and 2007, the quarter century from 1982 to 2007 did witness several sizable oil shocks, both positive and negative. And compared to the experience of the 1970s, these shocks seem to have packed far less punch, on both inflation and output. Why?

New developments in the economy: First, and most obviously, the U.S. economy became far less energy-intensive after the big oil-price shocks of the 1970s and early 1980s. That adjustment alone should have reduced the impact of an oil shock by half. Second, and related, the U.S. automobile industry has downsized, both relative to GDP and in the type of cars it produces. Third, it is easier for the economy to adjust to more gradual shocks, such as the one we experienced from 2002 until mid-2008. Fourth, while the OPEC I and II shocks received plenty of help from food prices, other commodity prices, and wage-price controls, the recent rolling oil shock took place during (and to some extent because of) a worldwide boom. A fifth set of reasons stems from changes in monetary policy: The Fed came to focus more on core inflation and, perhaps, gained anti-inflation credibility that now helps keep expected inflation under control. Finally, and also conjecturally, the United States and other industrial economies may now be more flexible, and hence better able to handle oil shocks, than they were in the 1970s.

New theoretical or empirical analyses: Notice that none of the factors on this list calls for a revisionist history of the 1970s. In particular, not much on the list suggests

[80] The main exception is that mortgage interest rates have been removed from the CPI.

that new economic theories or new econometric findings have undermined the conventional wisdom on the supply-shock explanation *circa* 1982.[81] Rather, this list of candidate explanations—some of which are clear facts, and others of which are conjectures—suggests that economies, like organisms, adapt to difficulties. The U.S. economy changed in a variety of ways that made the impact of oil shocks smaller in the 1990s and 2000s than in the 1970s and early 1980s.

If that is correct, the supply-shock explanation of stagflation remains *qualitatively* relevant today, but is less important *quantitatively* than it used to be. Thus with luck and sensible policy, the food and energy shocks that pummeled the U.S. economy in the first two or three quarters of 2008 need not have the devastating effects that the supply shocks of the 1970s and early 1980s did.[82] Contrary to a popular misconception, we are *not* condemned to repeat history.

[81] One possible exception is the role of monetary-policy credibility in controlling inflationary expectations, which did not receive much attention before 1980, and which may or may not be quantitatively important.
[82] At the time of the conference (late September 2008), the energy shock was reversing and food price inflation appeared to be cresting. But the financial panic that followed the failure of Lehman Brothers was about to move into high gear. It got much worse, and a sharp drop in output ensued in 2008:Q4 and 2009:Q1. But most observers—at least so far—attribute those sharp output declines to the financial crisis, not to the oil shock.

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Appendix

This appendix gives the definitions and sources for the data series that we employ, describes the specification of our empirical models, and details the calculations that underpin Figures 4 through 6, the Bruno-Sachs estimates from Section 2.2, and the input/output-based calculations from Section 2.4.

1. Data definitions and sources

All standard data from the National Income and Product Accounts (NIPAs) were downloaded from the Bureau of Economic Analysis website; all published CPI, PPI, and employment data were downloaded from the Bureau of Labor Statistics website (both accessed on December 6, 2007, with the data in Figure 3 updated through the third quarter of 2008 with data accessed on November 25, 2008).[83]

Market-based PCE prices: Official data for the market-based PCE price index (headline and core) are published from 1997 to the present. To extend the market-based series back prior to 1997, we use a Fisher aggregation routine that replicates the procedure followed by the Bureau of Economic Analysis (BEA) in constructing the NIPAs. We then use detailed personal consumption expenditures (PCE) data from the NIPAs to strip out the prices of non-market PCE components from the published indexes, where our definition of "non-market" mimics BEA's. (As a check, we compared the monthly changes in our constructed index to the corresponding changes in the official series; the correlation between the two series was nearly perfect.)

Current-methods CPI: A research series that puts the CPI on a methodologically consistent basis over the period 1978-present (the CPI-U-RS) is available from the Bureau of Labor Statistics (BLS), while an experimental CPI that uses a rental-equivalence approach to recalculate the owner-occupied housing component of the index (the CPI-U-X1) extends from 1967-1983. Our current-methods CPI is constructed as follows.

1957-1966: Published CPI-U less 0.2 percentage point per year
1967-1977: CPI-U-X1 less 0.2 percentage point per year
1978-present: CPI-U-RS (the published CPI-U is used in the most recent period)

The 0.2 percentage point adjustment controls for the effect of lower-level geometric means aggregation, which was introduced in 1999. In addition, we subtract additional small amounts (0.1 percentage point per year for the headline CPI and 0.12 percentage point per year for the core) in 1987-1989 and 1996-1997 to control for the effect of expenditure-weight updates, which the BLS do not consider to be methodological changes. The various splices are done on a NSA basis; the resulting

[83] The core PCE and market-based PCE price indexes that are used in this paper are therefore constructed according to the definitions that were in place prior to the 2009 comprehensive revision to the NIPAs.

index is seasonally adjusted with seasonal factors that are obtained from the published or rental-equivalence series, depending on the period involved.

In addition, research series for the food and energy components of the CPI are available from 1978 to the present. We splice these to the published indexes prior to 1978, making an additional subtraction of 0.3 percentage point per year to the published food index in order to capture the effect of methodological changes that are specific to this component. (For the calculations in Sections 3.1.1 and 3.1.2, we use published detail on energy and food because current-methods data are not available for the detailed components of the CPI.)

CPI relative importance weights: Published values for the CPI relative importance weights are available for December of most years. Where necessary, these are interpolated using the same dynamic updating formula that is employed in constructing the published index.

Oil prices: The nominal oil price that is shown in Figure 3 and used in the VARs and oil-market models is a spliced series that combines the PPI for crude petroleum (domestic production) and the refiners' acquisition cost (RAC) for imported crude oil.

The PPI for crude petroleum extends back to 1947. However, this series is affected by price controls in the early 1970s, and is therefore an imperfect measure of the world oil price. The refiners' acquisition cost (RAC) for imported and domestic crude oil extends back to 1968 on an annual basis, with published monthly data available starting in 1974. (These data are available from the Department of Energy's Energy Information Administration website.) In addition, the 1975 *Economic Report of the President* contains monthly data for the domestic and composite RAC for November and December of 1973, and monthly data for the imported RAC starting in September of 1973.

We therefore use the imported RAC when it is available, and extend it back before September of 1973 by splicing it to the PPI. On an annual-average basis, the log change in the resulting spliced series is 124 log points from 1970 to 1974, compared with 144 log points for the imported RAC; there is similar congruence with the domestic RAC.

World oil production: World crude oil production (thousands of barrels per day) from the *Oil and Gas Journal*, downloaded from the Haver Analytics database. These data are available monthly from 1970 to the present.

Energy intensity: Energy consumption in thousands of BTUs per dollar of real GDP, from Table 1.5 of the Energy Information Administration's *Annual Energy Review 2007*.

G-7 industrial production: OECD industrial production for the G-7 economies, downloaded from the Haver Analytics database. These data are available monthly from 1961 to the present.

Labor income share: Ratio of compensation of employees to gross value added, nonfinancial business sector (from the National Income and Product Accounts).

Hourly compensation, nonfarm sector; output per hour, nonfarm sector: Published indexes from the BLS Productivity and Costs release.

2. Detailed descriptions of empirical specifications

Price-control models: The model used in Section 3 to estimate the effect of price controls on core CPI inflation is a standard price-price Phillips curve with additional terms to capture the impact of the controls. The basic specification takes the form

$$\pi_t = \alpha_0 + A(L)\pi_{t-1} + B(L)x_{t-1} + G(L)\zeta_{t-1} + \varepsilon_t,$$

where π_t is the inflation rate (defined as an annualized log difference), x is a measure of slack, ζ is a supply-shock term, and ε is a stochastic error. Slack is defined as the detrended unemployment rate; the trend is defined as the low-frequency component obtained from a bandpass filter with the filter width and cutoffs set equal to the values used by Staiger, Stock, and Watson (2001) and with an ARIMA model used for endpoint padding. The number of inflation lags was determined with the Akaike criterion, with twelve lags used as the default; note, however, that we do not impose the "accelerationist" restriction $A(1) = 1$. The models are estimated at the monthly frequency from January 1961 to March 1979.

Two additional terms are added to the model in order to capture the effect of price controls. The first is the relative importance of controlled prices, λ_t, which is taken from Blinder and Newton (1981). The second term is a set of variables that are intended to capture the "catch-up" effect that occurs when the controls are lifted. In the original Blinder-Newton paper, this term was defined as

$$(1-\lambda_t)g\sum_{j=0}^{R} v_j \delta_{t-j} \ ,$$

where δ_t is the fraction of the CPI that is decontrolled in month t. This is in turn defined as

$$\begin{array}{lll} \delta_t = \lambda_{t-1} - \lambda_t & \text{if} & \lambda_{t-1} \le \lambda_t \\ \delta_t = 0 & & \lambda_{t-1} > \lambda_t \end{array}.$$

(This condition is modified so as to ensure that δ_t is only positive or zero; in particular, δ_t is set to zero from May 1973 to August 1973—when "Freeze II" resulted in a temporary increase in the fraction of the CPI that was subject to controls—and $\delta_{1973:09}$ is set equal to $\lambda_{1973:05} - \lambda_{1973:09}$.) The v_j terms are lag coefficients, while the g parameter is a measure of the "disequilibrium gap"—the percent difference between the representative industry's actual and desired price—when the controls are lifted; it can be obtained implicitly under the assumption that the sum of the v_j coefficients equals one.

In the original Blinder-Newton work, the v_j were constrained to lie along a (linear) polynomial—an assumption that is less satisfactory in the current data. We therefore implement the model by defining an alternative set of terms

$$
\begin{aligned}
D_0 &= (1-\lambda_t)\delta_t \\
D_1 &= (1-\lambda_t)\delta_{t-1} \\
&\vdots \\
D_i &= (1-\lambda_t)\delta_{t-i}\ ,
\end{aligned}
$$

with as many consecutive D_i terms added (starting with D_0) as are statistically significant. The full model for estimation is therefore given by

$$\pi_t = \alpha_0 + \alpha_1\lambda_t + A(L)\pi_{t-1} + B(L)x_{t-1} + G(L)\zeta_{t-1} + \sum_{i=0}^{R}\theta_i D_i + u_t.$$

Note that the sum of the θ coefficients (suitably scaled to reflect inflation's being expressed at an annual rate) yields an estimate of the disequilibrium gap g. The core CPI model used to generate the results in the text has fifteen lags of the dependent variable, three lags of the unemployment gap, and the contemporaneous value and five lags of the D_i terms.

The supply-shock terms ζ_t in our baseline specification are defined with reference to a weighted change in relative food and energy prices, $\tilde{\omega}_t(\pi_t^s - \pi_t)$, where π_t^s is food or energy inflation, π_t is core inflation, and $\tilde{\omega}_t$ is the twelve-month average share of nominal food or energy expenditures in total nominal PCE.[84] We then take a six-month moving average of the weighted relative price changes, and use their first lag in the model (additional lags did not enter).

As noted in the text, we examined the robustness of these results along a number of dimensions. First, we tried using a different measure of aggregate demand pressure—the rate of capacity utilization in manufacturing—in our Phillips curves; while this alternative demand indicator was only borderline significant (with p-values around 15 percent), using it had only a small effect on our results. Second, we experimented with alternative specifications for the model's relative energy and food price terms; this typically implied a slightly *larger* contribution of controls to the pre- and post-peak

[84] As noted in the text, a CPI-based model would ideally use CPI relative importance weights rather than PCE shares. There are, however, significant breaks in the relative importance weight series over time—notably in 1978, when the CPI moved from measuring prices faced by wage earners to prices faced by all urban consumers, and again after owner-occupied housing costs moved to a rental equivalence basis. In any case, whether weighting is used turns out to make little difference to the results.

swing in core inflation. We also fit similar price-price models for the market-based core PCE price index (the specification of this model is described below), and fit a wage-price system for the CPI (again described below); once again, the estimated relative impact of controls on inflation was similar. Finally, we note that the model used for this exercise is estimated through the beginning of 1979, which maximizes its ability to track actual inflation in the dynamic simulations. If we instead extend the sample period to December 1984 (to include the second set of supply shocks and the Volcker disinflation period), which requires a few minor changes to the model's specification (see the next section), the resulting dynamic simulations slightly overpredict inflation over a portion of the post-peak period. As a result, the model attributes only a little more than a third of the post-peak decline in inflation to price controls; however, the estimated contribution of controls to the *increase* in inflation is found to be around 85 percent, which is somewhat larger than our baseline estimate.

Price-price Phillips curves: The price-price Phillips curves used in Section 3.2 to compute the pass-through of the food and energy price shocks into core inflation are variants of the price control model. Specifically, for the core CPI model we extend the estimation period of the price control model to the end of 1984; this requires a minor adjustment to the specification (we drop all but the contemporaneous value and first lag of the unemployment gap, as the remaining terms are not statistically significant).[85]

For the core market-based PCE deflator, we construct a similar price-price model in which inflation is related to fifteen lags of the dependent variable (lag length was again determined by the Akaike criterion), six lags of the unemployment gap, one lag each of the relative food and energy price terms (defined in a parallel fashion to the terms used in the core CPI equation), the fraction of the CPI under price controls (we do not have a corresponding estimate of the fraction of the PCE deflator subject to controls), and the contemporaneous value and six lags of the price control catch-up term. Dynamic simulations of the resulting specifications do a reasonably good job tracking actual core CPI and core market-based PCE price inflation over the estimation period.

The resulting core CPI model is also used to generate the stylized supply shocks shown in Figures 4 through 6.

Wage-price systems: We estimate a wage equation in which nonfarm hourly compensation growth (expressed as an annualized log-difference) is related to eight lags of the headline (current-methods) CPI, the unemployment rate, and a 40-quarter moving average of trend productivity growth. Trend productivity growth is obtained by regressing productivity growth on a constant and a dummy variable set equal to one

[85] Index rounding is quite severe for the CPI prior to the mid-1960s (this is why month-to-month inflation rates often manifest a sawtooth pattern with flat "peaks" in the early part of the sample). We therefore checked that our models' tracking performance was robust to this property of the data by considering an estimation period that started in 1965 (it was).

starting in 1974:Q1 (the estimation period for this productivity equation is 1950-1994).[86] All data are quarterly, and the wage and markup equations are estimated from 1960:Q1 to 1985:Q4.

The markup equation relates core (current-methods) CPI inflation to four of its lags, the contemporaneous value and one lag of trend unit labor costs, the unemployment gap, the fraction of the CPI subject to controls, and the contemporaneous value and one lag of the price control catch-up term (defined on a quarterly basis).[87]

To obtain the estimates shown in Figure 14, we set food and energy price inflation equal to the values indicated in the text. The CPI relative importance weight for food were set to 0.225 through 1977 and then to 0.180 from 1978-forward; the corresponding weights for energy were 0.06 and 0.085.[88]

In contrast to the price-price Phillips curves that we employ, these models impose an accelerationist restriction in which the coefficients of the wage equation are constrained such that the real consumption wage rises with trend productivity growth in a steady state, and the coefficients on trend unit labor costs and lagged inflation in the markup equation are constrained to sum to one. (Unlike the price-price case, the data do not reject this restriction for the wage-price system.) As a result, the implied pass-through of higher food and energy prices into core inflation is larger and more persistent than what is implied from the corresponding price-price model. We also experimented with models that relaxed the accelerationist condition for the price markup equation; while the results were closer to those obtained from the price-price model, this alternative wage-price system underpredicts core inflation somewhat by the end of the simulation period.

Oil-market model (Kilian, 2007b): The oil-market model is a three-variable recursive VAR in oil production growth, aggregate commodity demand, and the real oil price (with that ordering). We define oil production growth as the log-difference of world crude oil production from the *Oil and Gas Journal*, and use the log real oil price shown in Figure 3.

For his measure of aggregate commodity demand, Kilian (2007b) uses an index of shipping prices that he constructs himself. The reason for using this index, as opposed to a measure of industrial-country production, is that Kilian seeks to capture the recent contribution to world commodity demand from emerging-market economies like China. Over the period we are concerned with (the 1970s and early 1980s), this factor is less

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[86] We also experimented with using the low-frequency component of productivity growth from a band-pass filter. The results were similar, though a moving average of this latter measure was not always significant in every estimation period we considered.

[87] We obtained similar results from a model that used PCE price inflation in the wage equation and a markup equation for the market-based core PCE deflator. (To simulate this alternative system, we assumed that the path of relative nonmarket price inflation was equal to its actual path in both cases.)

[88] The relative importance weights for food and energy in the CPI shift in 1978 when the index moves from a wage-earners basis to an all-urban-consumers basis.

important. In addition, in the early 1970s Kilian's index appears to be largely based on shipping costs for grains; these are probably unduly affected by the food price increases that occurred during this period. We therefore use OECD industrial production for the G-7 economies as our commodity-demand proxy (in the VAR, this variable is expressed as a log-deviation from a cubic trend fit from January 1961 to June 2007).

The VAR is estimated using monthly data from February 1971 to December 1987. (Note that the impulse responses from our specification appear qualitatively similar to what Kilian obtains from his system.)

Structural VAR model: We fit two recursive VAR specifications. The first is a four-lag, four-variable VAR in core PCE inflation (defined as an annualized log-difference), the unemployment rate, weighted relative food and energy price inflation (computed as the difference between headline and core PCE inflation) and the federal funds rate. The second model uses two lags and five variables—the first three variables listed above, the annualized log change in the Producer Price Index for crude materials, and the federal funds rate. (This is also their ordering in the VAR.) The data are quarterly, and the sample extends from 1959 (this is dictated by the availability of the core PCE deflator) to the end of 1985.

Our use of retail food and energy prices, rather than, say, oil prices, is motivated by two considerations. First, as discussed in Section 2.2, the direct impact of higher oil (and food) prices on production is most likely second-order. The important recessionary impacts of the shocks come from their effects on aggregate demand, and these are best measured by retail prices (*e.g.*, consumer energy prices rather than oil prices). Second, the impact of oil shocks on real activity and inflation appears to have diminished since the early 1980s. We therefore choose to end the model's estimation period around that time. And since we are constrained by the availability of the core inflation series, which only starts in the late 1950s, degrees of freedom are at a premium. Hence, a more parsimonious specification is preferable, and the specification we consider allows food and energy prices to enter in as economical a fashion as possible.

3. Detailed descriptions of calculations

Stylized supply-shock examples (Figures 4 to 6): We use the price-price Phillips curves for the core CPI estimated over the extended sample (1961-1984) to calibrate the effect of an increase in the relative price of energy. We set the share of energy in consumption (which is used to weight the relative energy price term) equal to its 1973-2007 average of 0.063. To compute headline inflation, we note that the change in the headline CPI equals the change in the core CPI plus ω times the change in energy prices relative to the core, where ω denotes the relative importance weight of energy in the total CPI. We set this equal to its 1973-2007 average of 0.081.

Neoclassical effect of supply shocks (Bruno-Sachs): To implement the Bruno-Sachs calculations in Section 2.2, we require a measure of gross output and its deflator, the share of (imported) energy in gross output, and the price of imported energy. We use NIPA data on imported petroleum and products (nominal values and prices), and compute nominal gross output as nominal GDP plus oil imports. We use a Tornqvist aggregation formula to compute the gross output deflator (specifically, we combine the imported oil and GDP deflators according to the formula). Each quarter's change in the real price of imported oil (the log difference in the oil import deflator less the log difference in the computed gross output deflator) is then multiplied by $-s/(1-s)$, where s is the share of imported oil in gross output. (Note that each share s at time t is computed as an average of the shares in quarters t and $t-1$.) This gives the quarter-by-quarter effects on value added (GDP) of changes in the real price of oil, which are then cumulated over a specified period to yield the estimated overall impact on real GDP of the change in imported oil prices.

As noted in the text, the Bruno-Sachs analysis can be extended to include imported materials inputs more generally. This is done in our calculation by using NIPA data on imports of petroleum and products (as above) along with data on imports of nonoil materials (nominal values and prices). For these calculations, we modify the definition of gross output accordingly (that is, we define it as GDP plus oil imports plus imports of nonoil materials).

Input-output estimates of energy intensity: We used the 85-item 1972 and 1977 commodity-by-commodity total requirements tables from the input-output accounts, along with the corresponding PCE bridge tables (which provide estimates of the commodity content of the detailed components of PCE) to construct estimates of the crude energy content of individual PCE components. We define crude energy as coal and crude petroleum and natural gas (commodity codes 7 and 8). The bridge tables were inputted by hand from various issues of the *Survey of Current Business*, while the 1972 and 1977 total requirements tables were downloaded from the BEA website.

For the 2002-2007 calculation that is referred to in Section 5, we use the 1992 total requirements table and PCE bridge table; both of these were obtained from the BEA website.