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The NAIRU in Theory and Practice

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NAIRU stands for the nonaccelerating inflation rate of unemployment. It is beyond dispute that this acronym is an ugly addition to the English language. There are, however, two issues that fail to command consensus among economists, which we address in this essay.

The first issue is whether the concept of NAIRU is a useful piece of business cycle theory. We believe it is, and we begin this paper by attempting to explain why. In our view, the NAIRU is approximately a synonym for the natural rate of unemployment. This concept follows naturally from any theory that says that changes in monetary policy, and aggregate demand more generally, push inflation and unemployment in opposite directions in the short run. Once this short-run tradeoff is admitted, there must be some level of unemployment consistent with stable inflation.

The second issue is why the NAIRU changes over time and, in particular, why it fell in the second half of the 1990s. This question is more difficult, and the answer is open to debate. Most likely, various factors are at work, including demographics and government policies. Yet one hypothesis stands out as particularly promising: fluctuations in the NAIRU appear related to fluctuations in productivity. In the 1970s, the NAIRU rose when productivity growth slowed. In the 1990s, the NAIRU fell when productivity growth sped up. Developing and testing models that explain the links among inflation, unemployment, and productivity remains a challenge for students of business cycle theory.

1. The Role of NAIRU

The word "NAIRU" entered the language of macroeconomics in the 1970s, a period of rapid and rising inflation. Yet, in a deeper sense, the concept has been there all along.

A Building Block of Macroeconomic Theory

A long tradition in economics emphasizes that the supply of money influences both inflation and unemployment. In his classic 1752 essay "Of Money," David Hume wrote about the effects of monetary injections, such as gold discoveries: "It is easy to trace the money in its progress through the whole commonwealth; where we shall find that it must first quicken the diligence of every individual, before it increases the price of labour." This insight has motivated much of modern macroeconomic theory. Two prominent examples are Milton Friedman's (1968) presidential address to the American Economic Association and Robert Lucas's (1996) Nobel prize lecture. Lucas quotes exactly these words from Hume.

At times, some economists have questioned Hume's insight. The real business cycle theorists of the 1980s, for example, suggested that business cycles were technologically driven and that money had no role in explaining production and employment fluctuations (Prescott 1986; Long and Plosser 1983). But this view is a minority position, both historically and today. There is wide agreement about the fundamental insight that monetary fluctuations push inflation and unemployment in opposite directions. That is,

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society faces a tradeoff, at least in the short run, between inflation and unemployment.

According to conventional macroeconomic theory, the inflation-unemployment tradeoff is central to understanding not only the effects of monetary policy but also other policies and events that influence the aggregate demand for goods and services. But most of these other events and policies can potentially have effects through other channels as well. For example, tax policy influences both aggregate demand through disposable income and aggregate supply through work incentives. By contrast, belief that monetary policy has employment effects is inextricably tied to belief in the inflation-unemployment tradeoff.

Two centuries have passed since Hume penned the wise words quoted above, but the economics profession has yet to reach a consensus about why this tradeoff arises. In classical theory, money is neutral. It is only the numeraire in which prices are quoted. Changes in its quantity should affect the overall price level, but not relative prices, production, or employment. The key question facing business cycle theorists is why this classical theorem of monetary neutrality fails to hold in the world.

Many answers have been proposed. Short-run nonneutrality has been blamed on imperfections of information (Friedman 1968; Lucas 1973; Mankiw and Reis 2001); long-term labor contracts (Fischer 1977; Gray 1976; Taylor 1980); the costs of price adjustment (Rotemberg 1982; Mankiw 1985; Blanchard and Kiyotaki 1987; Ball and Romer, 1990); or departures from full rationality (Akerlof and

Yellen 1985).   Each of these approaches raises its own set of
difficult theoretical and empirical questions, which are beyond the
scope of this essay.   There is, however, a common theme: because of
some market imperfection absent from the classical model, changes
in the value of the unit of account matter.   Monetary neutrality
breaks down, and at least in the short run, monetary changes have
opposite effects on inflation and unemployment.

Without much loss of generality, we can write the short-run
tradeoff between inflation π and unemployment U as follows:

$$\pi = k - a\,U$$

where k and a>0 are parameters.   This equation does not really say
much, other than that π and U are negatively related.   One fact
about this relationship is clear: it cannot be constant over time.
If it were, the data on inflation and unemployment would trace a
nice, stable, downward-sloping Phillips curve.   There once was a
time when some economists took this possibility seriously, but data
since the early 1970s have made this simple view untenable.

The instability of this relationship is hardly a surprise.
Even Samuelson and Solow's (1960) classic discussion of the
Phillips curve suggested that the short-run menu of inflation-
unemployment combinations would likely shift over time.   Skeptics
are sometimes tempted to use the shifting Phillips curve as
evidence to deny the existence of a short-run tradeoff.   This is
pure sophistry.   It would be like observing that the United States

has more consumption and investment than India to deny that society faces a tradeoff between consumption and investment. The situation is not hard to understand and, in fact, arises frequently in economics. At any point in time, society faces a tradeoff, but the tradeoff changes over time. The next question is what factors cause the tradeoff to shift.

Expectations, the Natural Rate, and Supply Shocks

Since Friedman (1968) and Phelps's (1967,1968) seminal contributions, one variable has played center stage in explaining shifts in the inflation-unemployment tradeoff: expected inflation. Other things equal, an increase in expected inflation is associated with an equal increase in actual inflation. The reason why expected inflation plays such a role depends on the theory of short-run nonneutrality, Moreover, the choice of theory will influence the timing of when expectations are formed. But from a birds' eye view, the similarity of the theories is more significant than their differences. In most standard theories, we can write the inflation-unemployment tradeoff as

$$\pi = \pi^e - a(U-U^*)$$

where π^e is expected inflation and U^* is a parameter called the "natural rate of unemployment." The natural rate is the rate of unemployment that prevails when inflation expectations are confirmed. Seen in another light, the parameter U^* imbeds all

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shifts in the inflation-unemployment tradeoff previously represented by the parameter k, other than shifts arising from expected inflation.

The natural rate can be viewed as the unemployment rate that the economy reaches in the long. This interpretation arises from imposing a modicum of rationality to expectations. Over any long interval of time, the average of expected inflation should equal the average of actual inflation; otherwise, forecasts are systematically biased. Thus, over the same long interval, average unemployment should equal the average natural rate. In the long run, U cannot deviate from U*.

None of this means that the natural rate of unemployment is immutable, or even that it moves only slowly over time. In principle, U* can exhibit substantial high-frequency variation, so any other shift in the inflation-unemployment tradeoff can be described as a shift in U*. As a practical matter, however, the literature on inflation-unemployment dynamics has traditionally used an amended version of the above equation:

$$\Pi = \Pi^e - a(U-U^*) + v$$

where v is dubbed the "supply shock."

To some extent, the distinction between U* and v is arbitrary: both the natural rate U* and the supply shock v represent shifts in the inflation-unemployment tradeoff. But many economists view these two variables as measuring different kinds of shifts. The

natural rate U* is thought to reflect how well the labor market matches workers and job. It is altered by, for instance, by changes in demographics or labor-market institutions and is thought to move slowly over time. By contrast, the supply shock v reflects disruptions in the normal inflation process, such as that caused by an oil embargo or a change in the exchange rate. The supply shock is thought to exhibit more high-frequency variation than the natural rate.[1]

To implement this equation, something has to be said about how expectations are formed. One approach is to assume adaptive expectations, according to which expected inflation is a weighted average of past inflation. The simplest version is to posit that expected inflation equals last period's inflation: $\Pi^e = \Pi_{-1}$. The inflation-unemployment tradeoff then becomes:

$$\Pi = \Pi_{-1} - a(U-U^*) + v.$$

The rational expectations revolution was founded precisely on criticizing this approach. (Lucas 1972; Sargent 1971) And surely, it would be indefensible to accept adaptive expectations as a precise and immutable description of the world, regardless of the monetary regime. But over the past four decades, the assumption of adaptive expectations may not be so bad. Inflation has been close to a random walk during this period (Barsky 1987; Ball 2000).

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[1] For our attempt to derive a theory of the supply shock v, see Ball and Mankiw (1995).

Forecasting future inflation with past inflation, as is assumed by adaptive expectations, is not far from rational. In this environment, U* can be viewed as the NAIRU, the unemployment rate at which inflation will be stable, absent the high-frequency shocks represented by v.

One implication of this analysis is that the value of the NAIRU concept depends on the monetary regime. If we lived in a world where inflation was close to white noise, rather than highly persistent, then adaptive expectations would be a bad approximation to optimal behavior. The early part of the twentieth century, when the United States operated under a gold standard, may have been such a regime. (Barsky, 1987) In that world, expected inflation would be closer to a constant of zero, and the natural rate U* would be associated with stable prices rather than stable inflation.

In the U.S. monetary regime of recent decades, however, the NAIRU concept is useful, and it is synonymous with the natural rate of unemployment. In his classic paper introducing the natural-rate hypothesis, Friedman described the situation as follows:

"There is always a temporary tradeoff between inflation and unemployment; there is no permanent tradeoff. The temporary tradeoff comes not from inflation per se, but from unanticipated inflation, which generally means, from a rising rate of inflation."

Friedman didn't use the term "NAIRU," but the concept is implicit

in his analysis.

Hysteresis

Some economists have suggested that the labor market exhibits
a form of "hysteresis" (Blanchard and Summers, 1986). In physics,
hysteresis refers to the failure of an object to return to its
original value after being changed by an external force, even after
the force is removed. In the labor market, a similar phenomenon
would arise if the natural rate U* depended on past unemployment U.
In this case, a change in aggregate demand would first influence
unemployment by causing U to deviate from U*, but then would have
a persistent effect on unemployment as U* changed.

Several theories have been proposed to explain why this might
be the case. The most popular emphasize long-lasting damage
suffered by workers who experience unemployment. These workers
lose human capital, become less attractive to employers, and reduce
their job search as they become accustomed to being unemployed
(Layard et al., 1991). All these effects make workers less likely
to be employed in the future. A recession that raises unemployment
leaves a permanent scar on the economy, as U* is higher even after
the initial shock that caused the recession has disappeared. These
theories of hysterisis were first developed to explain the large
rise in the NAIRU in Europe during the 1980s: The increase in U*
came immediately after the disinflationary recession that started

the decade.[2]

The validity of hysteresis theories is a subject of some controversy, and we will not take up that debate here. Regardless of how this debate is resolved, the concept of NAIRU remains valid. At any point in time, there will be an unemployment rate consistent with stable inflation, which can be called the NAIRU. Hysteresis theories merely give one reason to expect the NAIRU to change over time. As we discuss below, there are many other reasons to expect that the NAIRU will not be a constant.

Two Econometric Difficulties

Let us now turn from theory to econometric implementation. A large literature has attempted to estimate inflation equations of this form:

$$\Pi = \Pi_{-1} - a(U-U^*) + v.$$

Often, the studies includes additional lags of inflation or unemployment. Sometimes, rather than leaving the supply shock v entirely in a residual, control variables are included, such as food and oil prices, exchange rates, and dummies for wage-price controls.[3]

One difficult issue that this literature has tried to skirt is the identification problem. If the macroeconometrican assumes that

2 For a recent study using hysteresis theories to explain the increase in the European NAIRU, see Ball (1999). For an attempt to explain the European NAIRU based on labor-market institutions and supply-side shocks, see Blanchard and Wolfers (2000).

3 For two examples from this large literature, see Gordon (1998) and Staiger, Stock, and Watson (1997).

U* is constant over the interval being studied and that v is contemporaneously uncorrelated with U, then this equation can be consistently estimated with ordinary least squares. The value of the NAIRU, U*, can then be inferred from the estimated parameters.

These identification assumptions are not at all innocuous. It is easy to imagine that the supply shocks represented by v are correlated with unemployment. For example, a burst in productivity growth, such as that experienced during the late 1990s, might well lower inflation and unemployment. The textbook solution to this problem is to find instrumental variables that are correlated with unemployment but uncorrelated with the supply shock. In practice, finding valid instruments is hard to do and rarely done.

Note that other strands of the literature make somewhat different identification assumptions. Lucas's (1973) classic paper on inflation-output tradeoffs used nominal GDP growth as the-right-hand side variable in a regression estimated with ordinary least squares. The implicit assumption was that the supply shocks in the residual do not influence nominal GDP, but can influence both real GDP and the price level in opposite directions. Similarly, Barro's (1977) classic work on unanticipated money implicitly assumed that supply shocks do not influence money growth. These identification schemes can also be questioned. Below we follow the traditional identification assumption, according to which the supply shock v is contemporaneously uncorrelated with unemployment U. Dealing with the identification problem in a more satisfactory way seems an important avenue for future research.

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A second, more tractable econometric issue is the computation of standard errors. Until recently, the empirical literature on the Phillips curve rarely provided standard errors for estimates of the NAIRU. This odd oversight was corrected in an important paper by Staiger, Stock, and Watson (1997). Using a conventional specification, they estimated the NAIRU in 1990 to be 6.2 percent, with a 95 percent confidence interval from 5.1 to 7.7 percent. This is a large range. In principle, better measures of supply shocks can reduce the residual variance and improve the precision of NAIRU estimates. But Staiger, Stock, and Watson showed that given standard specifications used in the literature, the NAIRU is not estimated precisely.

Its Use in Policy

How should monetary policymakers use the NAIRU? Most obviously, it is a forecasting tool. When unemployment is below the NAIRU, inflation can be expected to rise, and when it is above the NAIRU, inflation can be expected to fall. Thus, even if the policy regime were one of inflation targeting, monetary policymakers should keep an eye on unemployment and the NAIRU.

It may be tempting to point to the experience of the 1990s to suggest that this view is obsolete. And, indeed, as we discuss below, there is evidence that the late 1990s were different: the NAIRU declined substantially. But it would be rash to suggest that the NAIRU is obsolete as a forecasting tool. Stock and Watson (1999) offer a comprehensive study of various methods for

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forecasting inflation. Despite the finding of Staiger, Stock, and Watson (1997) that the NAIRU is imprecisely estimated, Stock and Watson (1999) report, "Inflation forecasts produced by the Phillips curve generally have been more accurate than forecasts based on other macroeconomic variables, including interest rates, money, and commodity prices."

Nonetheless, it also makes sense for monetary policymakers to give some weight to other forecasting tools. When looking ahead to future inflation, they should also look at, for example, the consensus of private forecasters and the spread between real and nominal bond yields. Of course, these tools themselves reflect the NAIRU concept, because private forecasts of inflation are often based on it. Using such private forecasts of inflation for policymaking can be viewed as a way to decentralize the decisionmaking over how the NAIRU is changing over time.

2. The U.S. NAIRU, 1960-2000

So much for theory. Let's now turn to the practical question: what is the level of the NAIRU for the U.S. economy?

An Approach

To see how one might estimate the NAIRU, rewrite the Phillips-curve equation as

$$\Delta\pi \ = \ aU^* - aU + v \ .$$

If one assumes that U* is constant and that U is uncorrelated with v, then the value of U* can be estimated by regressing the change in inflation $\Delta\pi$ on a constant and unemployment U. The ratio of the constant term (aU*) to the absolute value of the unemployment coefficient (a) is an estimate of U*. When we perform this exercise for annual U.S. data from 1960 to 2000, measuring inflation with the consumer price index, we obtain a constant term of 3.8 and an unemployment coefficient of -0.63. This yields a NAIRU estimate of 6.1 percent.

However, many economists have questioned the assumption of a constant NAIRU underlying this calculation, especially since the apparent fall in the NAIRU in the late 1990s. There is a growing literature that seeks to estimate the path of a time-varying NAIRU. This literature is based on the idea, discussed above, that movements in U* are long-term shifts in the unemployment-inflation relation, while the shock v captures short-run fluctuations. Authors such as Staiger et al. and Gordon (1998) estimate U* by positing a stochastic process for U* (such as a random walk) and a stochastic process for v (such as white noise) and then using a statistical procedure that separates Phillips-curve shifts into these two kinds of shocks. To build intuition, we use an approach that is simpler but yields similar results.

Suppose for the moment that we know the value of the parameter a, which gives the slope of the unemployment-inflation tradeoff. We can then rearrange to obtain the equation

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U* + v/a = U + Δπ/a.

The right-hand side can be computed from the data, yielding an estimate of U* + v/a, which measures the shifts in the Phillips curve. Within this sum, U* represents the longer-term trends, and v/a is proportional to the shorter-term supply shocks. It is therefore natural to try to extract U* from U* + v/a using a standard approach to estimating the trend in a series.

We use the Hodrick-Prescott filter (Hodrick and Prescott, 1997). The HP filter is a generalization of a linear time trend that allows the slope of the trend to change gradually over time. Formally, the HP filter minimizes the sum of squared deviations between the trend and the actual series, with a penalty for curvature that keeps the trend smooth. If there were no penalty, the filter would yield the original series; if the penalty were very high, it would yield a linear time trend.

To implement this procedure, we must choose two parameters. The first is the Phillips curve slope, a. In our results below, we use an a of 0.63, the slope coefficient obtained from regressing Δπ on unemployment and a constant. This value is consistent with conventional wisdom about the costs of disinflation (it implies that reducing inflation by one percentage point produces 1/0.63 = 1.6 point-years of unemployment). Reasonable variation in the assumed coefficient has little effect on our conclusions.

The other parameter is the smoothing parameter in the HP filter--the weight that the procedure gives to keeping the

estimated U* smooth rather than fitting every movement in U*+(v/a).
The choice of this parameter is largely arbitrary. In some ways,
this is not surprising: as we noted earlier, the distinction
between U* and v is not well-defined. Most economists have the
intuition that movements in U* are "smooth" and that v represents
a different kind of high-frequency shift in the Phillips curve, but
this intuition is too vague to have much practical import. In the
analysis below, we experiment with alternative values of the HP
smoothing parameter.

Results

    Figure 1 presents estimates of the U.S. NAIRU over the last
forty years. The solid line gives the values of U*+(v/a) computed
as described above; this represents the sum of long-term and
transitory shifts in the inflation-unemployment tradeoff. The two
dashed lines give smoothed versions of the series that serve as our
estimates of U*. The two versions correspond to different values
of the HP smoothing parameter: one value is 100, the most commonly-
used value with annual data, and the other is 1000, which imposes
greater smoothing as advocated by some researchers (e.g., Roberts,
1998).

    The two smoothed series tell broadly similar stories. The
NAIRU has followed a hump-shaped path: it trended up from the 1960s
until about 1980, then peaked and has declined since then. With
the smaller smoothing parameter, there is a small dip in the early
1960s before U* starts to rise, but this wiggle does not survive

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with greater smoothing. More generally, the movements in U* are smaller with the higher HP parameter. With a parameter of 1000, the estimated NAIRU is 5.4 percent in 1960, peaks at 6.8 percent in 1979, and falls to 4.9 percent in 2000. These results are broadly similar to those of Gordon and Staiger et al. The apparent increase in the NAIRU before 1980 and decline thereafter has been widely recognized. These movements have motivated papers with titles such as "Why Is Unemployment So Very High..." in the 1980s (Summers, 1986), and as "Why Has Unemployment Fallen" more recently (Shimer, 1998).

While there is a consensus that the NAIRU fell during the 1980s and 1990s, this consensus took some time to develop. The falling NAIRU was initially obscured by the run-up of actual unemployment in the recession of the early 1990s. Starting in the mid-1990s, many authors pointed out a run of favorable shifts in the Phillips curve, but these were sometimes interpreted as transitory supply shocks--that is, decreases in U*+(v/a) were interpreted as movements in v rather than U*. This interpretation was supported by direct evidence of favorable shocks during the period 1995-98, such as a fall in energy prices and a strengthening of the exchange rate, which reduced import prices (see, e.g., Gordon, 1998). Yet the period after 1998 did not see additional favorable shocks, and indeed energy prices moved back up. Because unemployment was low through 2000 without accelerating inflation, a consensus emerged that the NAIRU had fallen.

On the other hand, the magnitude of the NAIRU decrease is hard

to estimate. As illustrated above, it depends on an arbitrary decision about how much to smooth the NAIRU series. The precise timing of movements in the NAIRU is also unclear. Our estimated movements are smooth, with the decrease occurring slowly over almost two decades. Yet this is an artifact of our smoothing procedure. A number of authors have suggested that the NAIRU was fairly constant from the 1980s to the mid-90s, and then fell sharply in the late-90s "New Economy." Perhaps this is true, and our procedure artificially smooths out the fall in U*. There are limits to how much how one can learn about the NAIRU from unemployment and inflation data alone.

3. The Falling NAIRU: A More Employable Labor Force?

Many authors have sought to explain the movements in the U.S. NAIRU. This section and the next review some of the leading hypotheses, with a focus on those that might explain the declining NAIRU of the 1990s. Some of these theories also help explain the earlier NAIRU increase.

We begin in this section by reviewing stories that focus on the changing composition of the labor force. Economists have long recognized that unemployment rates are different for different kinds of workers, depending for example on their skills and their intensity of job search. Thus, changes in the sizes of groups with relatively high or low rates of unemployment can change the aggregate unemployment rate, even without changes in the rate for any individual group. In recent years, a number of authors have

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suggested changes in the labor force that reduce aggregate unemployment by reducing the sizes of high-unemployment groups.

Older Workers

The most obvious reason the labor force changes is demographics. In seeking to explain the evolution of the NAIRU, a number of authors point to a particular type of shift: the changing age structure as the baby boom generation has moved through the labor force. The proportion of the labor force aged 16-24 rose from 17 percent in 1960 to 24 percent in 1978 as the baby boomers entered the labor force as young workers, and this percentage fell to 16 percent in 2000 as the boomers have aged. These trends are potentially important because young workers have higher unemployment rates than older workers: over 1960-2000, the average unemployment rate was 12.2 percent for workers 16-24 and 4.4 percent for workers 25+. Gordon has argued that the increase in young workers accounts for much of the increase in the NAIRU before 1980, and Shimer (1998) argues that the recent decrease explains much of the NAIRU fall.

The classic method for measuring the effects of demographic changes is to compute a "Perry-weighted" unemployment rate (Perry, 1970; Katz and Krueger, 1998). This is a weighted average of unemployment rates for different demographic groups with fixed weights; by contrast, the usual aggregate unemployment rate has weights equal to labor-force shares, which change over time. A time series for Perry-weighted unemployment shows what would have

happened to the unemployment rate given the evolution of each group's unemployment if the sizes of groups did not change.

Following Staiger et el. (2001), we compute Perry-weighted unemployment based on 14 age-sex groups, with weights based on average labor-force shares over 1960-2000. We then compute our estimates of the time-varying NAIRU from unemployment and inflation data using the same method as in Figure 1 -- but using the Perry-weighted unemployment series. Figure 2 shows the resulting series (based on an HP smoothing parameter of 1000), along with the corresponding series based on the standard unemployment rate; the differences between the two series show the impact of demographics. The Figure shows that this impact has been modest. The hump-shaped pattern of the NAIRU remains after Perry-weighting, although it is dampened: the increase from 1960 to the peak and the decrease to 2000 are 0.9 points and 1.3 points respectively, compared to 1.4 and 1.9 with the standard unemployment rate. Thus the broad trends in the NAIRU remain to be explained even after one adjusts for demographics.[4]

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[4] The Perry-weighting procedure assumes that demographics affect labor force shares but not the unemployment rates of individual groups. This assumption has been questioned by Shimer (1998, 2001), who discusses a number of channels through which changing supplies of old and young workers can affect their unemployment rates. Shimer's 1998 paper argues that a younger labor force raises unemployment among the young, but his 2001 paper argues that it reduces unemployment for both age groups. If the later paper is correct, then differences between Perry-weighted and standard unemployment rates give an upper bound on the effects of demographics.

Disability and Incarceration

The labor force can also change if government policies cause people to leave it. The aggregate unemployment rate falls if the labor-force leavers are workers who otherwise would have high unemployment rates. Recent work has noted two policy shifts that work in this direction: the rising rate of incarceration (Katz and Krueger, 1999) and the greater generosity of disability insurance (Autor and Duggan, 2001). People who are removed from the labor force by being locked up or through certification of disability are likely to have experienced high unemployment rates while in the labor force.

Of these two factors, disability appears more important. The percentage of non-elderly adults receiving government disability insurance has risen steadily from 3.1 percent in 1984 to 5.3 percent in 2000. Autor and Duggan attribute this rise to reduced stringency in the screening of applicants and to a higher income-replacement ratio. They estimate the impact on unemployment by examining the effects of variation in the disability program across states. They find that the total effect of changes in the program has been to reduce aggregate unemployment by 0.65 percentage points from 1984 to 2000.

Katz and Krueger have observed that lower unemployment can reflect greater incarceration. However, while incarceration rates rose dramatically in the 1990s, the effect on aggregate unemployment was modest. Katz and Krueger estimate that this factor produced a total decrease in unemployment of 0.17 percentage

points.

Adding the effects of disability and incarceration yields a total reduction in unemployment of roughly 0.8 percentage points. This is a bit more than half of the decrease in the NAIRU in Figure 2 when unemployment is Perry-weighted. However, recall that the estimated fall in the NAIRU is larger if the HP smoothing parameter is set lower than 1000, in which case disability and incarceration can explain a smaller fraction of the decline.

The likely role of a changing labor force in explaining the NAIRU decrease depends on the timing of the decrease. As we discussed above, some economists suggest that the NAIRU fell sharply since 1995, although the aggregate data are also consistent with a gradual decrease since the early 1980s. If there was in fact a sharp shift from 1995 to 2000, the factors discussed so far cannot be the main explanation. The changes in disability benefits and incarceration are long-term trends, and only a small part of the changes have occurred after 1995. And the aging of the labor force was almost complete by 1995: the percentage aged 16-24 reached a trough of 15.8% in 1997 and has since risen slightly. The difference between Perry-weighted and standard unemployment rates fell only 0.2 points from 1992 to 2000. If the NAIRU fell significantly in the late 90s, we must look beyond the nature of the labor force to find the explanation. This brings us to another set of theories.

4. The Falling NAIRU: A New Economy?

The NAIRU can change not only because of changes in the labor force, but also because of broader changes in the economy. In the second half of the 1990s, many observers alleged the advent of a "New Economy"--one with new technologies, higher productivity growth, increased "competitiveness," and so on. If one believes that the NAIRU fell significantly in the period after 1995, it is natural to suspect a link between this fact and the broader changes in the economy. We now discuss several leading stories along these lines.[5]

Greater Openness to Trade

One story about the favorable Phillips curve shift is that it resulted from the "globalization" of the U.S. economy -- the greater openness to foreign trade (see, for example, Thurow [1998]). This argument starts with the fact that foreign trade has become more important in the United States in recent decades: the ratios of imports and exports to GDP have trended up. Some observers argue that this integration into the world economy has subjected U.S. firms to greater competition. This in turn is anti-

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[5] In addition to the stories we mention, some people have noted declines in unionization and the real minimum wage, and welfare reform. There appears to be a consensus, however, that these are not major factors. Changes in unionization and minimum wages were modest in the 1990s. Welfare reform affected a sizable number of workers -- roughly one million women have left the welfare rolls since 1994. However, most of these women were out of the labor force while on welfare. By joining the labor force, they are likely to have <u>raised</u> the unemployment rate slightly, because the incidence of unemployment is higher for them than for the average worker.

inflationary: even if unemployment is low, firms cannot raise prices aggressively because consumers will switch to foreign suppliers. In mainstream terminology, this means that the NAIRU has fallen.

Many journalists have picked up on this idea, but it has largely been ignored by academic economists. And they have ignored it, we believe, for good reason. The theoretical logic of the story is questionable, but the main problem is empirical. The U.S. has become more open in the last decade, with the import-GDP ratio rising from 11 percent in 1990 to 15 percent in 2000. But this is not a feature of the New Economy but rather a continuation of a trend through most of the period since World War II. The import-GDP ratio was 5 percent in 1950. If greater openness produces lower unemployment, we should have seen a steady downward trend in the NAIRU for the last 50 years, and this hasn't occurred. Indeed, the decade with the largest increase in the import-GDP ratio was the 1970s, and as shown in Figure 1, this decade saw a substantial increase in the NAIRU.

Better Job Matching

One reason for unemployment is job turnover. When workers move from jobs that disappear to those that open up, the process creates unemployment because it takes workers time to find new jobs. Several authors suggest that this process improved in the 1990s, leading to lower unemployment.

The most common version of this story focuses on the growth in

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the temporary-help industry (e.g. Katz and Krueger; Cohen et al.,
2001). The percentage of workers employed by temporary-help firms,
such as Manpower Inc., rose from 1.1% in 1989 to 2.2% in 1998.
This suggests that an increasing number of workers who are between
permanent jobs are employed as temps rather than unemployed. In
addition, temp jobs sometimes turn into permanent jobs, so temp
agencies help speed up the process of permanent job matching.

However, when researchers try to quantify the effects of temp
agencies on unemployment, the results are disappointing. Both Katz
and Krueger and Staiger et al.(2001) examine the relation across
states between unemployment and the size of the temp industry.
Katz and Krueger estimate that the growth of the temp industry in
the 1990s reduced aggregate unemployment by anywhere from zero to
0.4 percentage points. Staiger et al. fail to find a robust
relation between the temp industry and unemployment rates. Thus,
stories about the falling NAIRU based on the temp industry remain
speculative at best.

It is possible that the process of job matching improved in
ways beyond the growth of the temp industry. Cohen et al. (2001)
suggest that the New Economy features production processes that put
a greater emphasis on general rather than specific skills. As a
result, workers have become more interchangeable, making it easier
to match workers and jobs and thereby reducing unemployment. As
evidence for this idea, Cohen et al. cite the management literature
and interviews with human resource managers. It is an open
question, however, whether this phenomenon has had a sizable effect

on the aggregate unemployment rate.

The Productivity Acceleration

A central feature of the New Economy of the late 1990s was a rise in the growth rate of labor productivity. Average growth in output per hour of work was 1.5 percent over 1974-1995 and rose to 2.6 percent over 1996-2000. Most explanations of this change focus on the increased use of computers and the internet (for example, see the Symposium on productivity growth in JEP, Fall 2000). For our purposes, a key fact about the productivity acceleration is that it started in the mid-90s, around the same time that researchers started detecting a decline in the NAIRU. This coincidence suggests a link between the two phenomena.

Such a link is also suggested by the experience of the 1970s. This was the beginning of the infamous "productivity slowdown": average productivity growth fell to its 1974-95 average of 1.5 percent after an average of 3.3 percent over 1948-73. As discussed above, the 1970s were also a period of a rising NAIRU. If there is a link between shifts in productivity growth and in the NAIRU, it may help explain both the rising NAIRU of the 1970s and the falling NAIRU of the 1990s.

Such a link was suggested by students of the rising NAIRU in the 1970s, notably Grubb et. al (1982) and Braun (1984). These authors present a particular explanation for the link, one resting on the idea that "wage aspirations" adjust slowly to shifts in productivity growth. The concept of wage aspirations is a

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departure from the neoclassical theory of the labor market, but it builds on research by psychologists and industrial-relations specialists. The story goes as follows.[6]

In a steady state with constant growth of labor productivity, the growth of real wages is determined by the growth of productivity, as suggested by neoclassical theory (and empirical evidence). In such a situation, workers come to view the rate of real-wage increase that they receive as normal and fair, and to expect it to continue. If productivity growth falls, as in the 1970s, fundamentals dictate that real-wage growth must fall as well. Workers resist this decrease, however; they try to maintain the wage increases to which they are accustomed. To the extent that workers have some influence over wages, this means that wage setters will try to achieve real-wage increases above the level that can be sustained by productivity growth. This mismatch between real-wage aspirations and productivity growth worsens the inflation-unemployment tradeoff. In other words, the NAIRU rises.

This story received attention in the early 1980s and then faded from prominence. It has been resurrected in the last few years, as many economists have noticed the parallel between the 1970s and the 1990s. Today's version of the story reverses the signs. Productivity has accelerated but workers have become accustomed to the slow wage growth since the 1970s. A mismatch of productivity and wage aspirations in this direction shifted the

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[6] Of course, a more classical story linking productivity and employment is the real business cycle theory of Long and Plosser (1983) and Prescott (1986). For a critique, see Mankiw (1989).

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Phillips curve favorably. This story is told, for example, by Blinder (2000), DeLong (2000), and the 2000 Economic Report of the President.[7]

Following Staiger et al. (2001) and Ball and Moffitt (2001), we examine data on unemployment and productivity growth to see whether they fit the story. Figure 3 shows the NAIRU series from Figure 1; again there are two versions corresponding to different smoothing parameters.   The Figure also shows the trend in productivity growth, obtained with the HP filter and with the same smoothing parameters used to create the NAIRU series. Productivity growth is shown on an inverted scale to make it easier to see the negative comovement between the two trends. One can see broadly similar patterns in the two trends, although the match between them is far from perfect.

One important subtlety is that the rate of productivity growth is not exactly the relevant variable in the story discussed above. In a steady state, wage aspirations adjust to any growth rate. What causes a Phillips-curve shift is a change in productivity growth, because aspirations are tied to wage growth and hence

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[7] The shifts in the Phillips curve that occur in this story are eventually reversed when wage aspirations adjust to the new rate of productivity growth. This creates some ambiguity about the right way to describe the shifts. As we discussed earlier, the Phillips curve can move because of either a transitory "supply shock" or a change in the NAIRU, and the distinction between the two is based on a fuzzy notion of persistence. Since a Phillips-curve shift caused by a productivity speedup eventually goes away, one might call it a supply shock. We prefer to call it a change in the NAIRU, however, because the shift can last for many years. In particular, it lasts long enough to influence the NAIRU series in Figure 1, which filters out the year-to-year effects of supply shocks.

productivity growth in the past. Therefore, following Ball and Moffitt (2001), we examine the gap between current productivity growth and a long moving average of past growth (one that depends on productivity growth into the distant past, but with greater weight on recent observations). This gap, like other variables in the Figures, is smoothed with the HP filter to extract a trend. Figure 4 graphs this trend along with our NAIRU series. Here, the comovement is closer than when we examine the pure productivity growth rate.[8]

Two details of these graphs deserve notice. First, our inverted gap variable peaks in the early 80s and starts declining, as does the NAIRU. This occurs even though, as shown in the previous figure, actual productivity growth does not accelerate until the 1990s. This suggests an effect discussed by Stiglitz (1997): a catchup of wage aspirations to the productivity slowdown. In Stiglitz's story, the ongoing experience of the productivity slowdown caused wage aspirations to fall slowly, so the gap between aspirations and productivity narrowed over the slow-growth era. This narrowing caused the NAIRU to start falling; the fall was then magnified when productivity growth accelerated.

A related point is that the trend in our gap variable falls to its lowest level at the end of our sample -- as does the NAIRU, enhancing the fit of the two series. In contrast, productivity

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[8] If we denote productivity growth by g, the productivity variable in Figure 4 is $g - (1-b)[g(-1) + bg(-2) + b^2 g(-3) + ...]$. That is, the weighted average of past productivity growth in the expression has exponentially declining weights. The parameter b, which gives the rate of decline, is set at 0.95.

growth rises at the end of the sample, but is still below its level in the 1960s. That is, what is special about the New Economy of the late 1990s is not the rate of productivity growth, which was higher thirty years before, but the increase relative to the recent past. The high productivity growth of the sixties was a continuation of high growth since World War II; wage aspirations had largely adjusted, so there was little effect on the Phillips curve. In contrast, the Phillips curve shifted favorably in the late 1990s because of the combination of high contemporaneous growth and low growth in the preceding two decades.

The productivity-based explanation for the declining NAIRU is related to a common explanation in the popular press. In explaining why inflation failed to accelerate in the late 1990s despite low unemployment, many journalists cite the productivity acceleration. Their story goes as follows. According to the Phillips curve, low unemployment puts upward pressure on wage growth, which feeds into inflation. Low unemployment has led to more rapid wage growth. However, the productivity acceleration has reduced firms' costs, offsetting the increases from rapid wage growth. Because overall costs have not accelerated, inflation has not had to rise.[9]

This story has common-sense appeal. It does not contain any

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[9] For example, Louis Uchitelle (2000) discusses "the concern that low unemployment drives up wages and, in turn, prices." In explaining why inflation has not risen, he points to "improvements in productivity, effectively giving employers more revenue to pay for raises without raising prices." Uchitelle attributes this idea to Alan Greenspan.

explicit role for slow adjustment of wage aspirations, but such a role is in fact implicit. In a neoclassical world, a rise in productivity growth has no obvious effect on inflation, because higher productivity is reflected fully in higher real wages. The idea that a productivity acceleration reduces firm' costs depends on the implicit assumption that wages do not adjust fully to productivity movements. Thus the idea of slowly-adjusting wage aspirations provides an underpinning for a common journalistic explanation for the recent experience.[10]

5. The Beveridge Curve

In analyzing the labor market, a complement to the Phillips curve is the Beveridge curve, which has recently been emphasized by Blanchard and Diamond (1989). The Beveridge curve shows the relationships between unemployment (workers without jobs) and vacancies (jobs without workers). The Beveridge curve slopes downward in unemployment-vacancy space because an economic expansion that reduces unemployment also raises vacancies, as firms have trouble finding workers in a tighter labor market.

Like the Phillips curve, the Beveridge curve appears to shift over time. Figure 5 plots unemployment and job-vacancy rates for

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[10] The productivity hypothesis is also somewhat related to another popular story: Alan Greenspan (1997) has suggested that workers, cowed by job insecurity, lacked aggressiveness in wage negotiations. As discussed by Katz and Krueger (1999), there is no evidence to support an exogenous shift in workers' perceptions of job security. But what matters is aggressiveness of wage seekers relative to productivity growth. Failure to increase aggressiveness when productivity accelerates has the same effect on the NAIRU as an exogenous decrease in aggressiveness.

annual U.S. data from 1960 through 1998. The vacancy series is taken from Cohen et al. (2001), who, following Abraham (1987), estimate the level of vacancies based on help-wanted advertising in newspapers. In the figure, there appear to be stable Beveridge curves with different intercepts in different periods. The Beveridge curve shifted outward from the period 1960-69 to the period 1975-85, and shifted sharply inward after 1990. This pattern of an unfavorable shift in the 1970s and a favorable shift in the 1990s corresponds to the broad pattern of Phillips-curve shifts, as measured by time-varying NAIRU estimates.[11]

These facts suggest that movements in the Phillips curve and the Beveridge curve are linked. A number of authors, including Katz and Krueger and Cohen et al., argue that such a link helps isolate the right explanation for the recent fall in the NAIRU -- in particular, that it points towards stories about improved job matching. In theoretical work, the Beveridge curve is often derived from search models of the labor market, where frictions in matching jobs and workers produce unemployment and vacancies (e.g. Pissarides, 2000). In these models, improvements in the matching technology cause the Beveridge curve to shift in. Thus the recent behavior of the Beveridge curve is consistent with the existence of such improvements, arising for example from the growth of the temporary help industry.

Yet we doubt that the Beveridge curve is informative about the

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[11] Cohen et al. stop in 1998 because the rise of internet advertising makes the newspaper help-wanted index an unreliable measure of vacancies in recent years.

sources of NAIRU movements. Although the shift in the curve is consistent with improved matching technology, it is also consistent with other explanations for the falling NAIRU. For example, suppose the NAIRU falls because workers who do not search hard for jobs become incarcerated or receive disability benefits and, therefore, drop out of the labor force. This reduces unemployment but has little effect on vacancies, because these workers were unlikely to fill jobs anyway. Or suppose the NAIRU falls because wage aspirations fall relative to productivity growth. This makes workers more willing to take jobs when wages are a given level relative to productivity. When workers take jobs more readily, both unemployment and vacancies fall, and again the Beveridge curve shifts in. As these examples illustrate, most plausible stories about a shifting Phillips curve can explain a shifting Beveridge curve as well. Thus, the fact that the Beveridge curve shifted inward after 1985 says little about why NAIRU fell.

This argument is strengthened by the fact that the Beveridge curve shifted outward in the 1970s, when the NAIRU rose. While some authors suggest that the matching technology has improved recently, to our knowledge no one has argued that it deteriorated in the 1970s. The relationship between Phillips-curve and Beveridge-curve shifts appears to hold consistently over time, but it does not tell us much about why these shifts occur.

6. Conclusion

The NAIRU--or its approximate synonym, the natural rate of

unemployment--is an important building block of business cycle theory. Few economists would deny that shifts in aggregate demand, such as those driven by monetary policy, push inflation and unemployment in opposite directions, at least in the short run. That is all one needs to believe to accept the NAIRU concept.

The practical application is this concept, however, is less straightforward. The value of NAIRU is hard to measure, largely because it changes over time. The economy experiences many kinds of shocks that influence inflation and unemployment. In light of this fact, it would be remarkable if the level of unemployment consistent with stable inflation were easy to measure.

There is no shortage of hypotheses to explain what causes the NAIRU to change over time and, in particular, why it fell during the 1990s. The available evidence is too weak to establish decisively which hypothesis is right, but the literature on the NAIRU has made progress. Demography and government policy both play some role. In addition, changes in productivity growth appear to shift the inflation-unemployment tradeoff. In the past, most macroeconomists studying the Phillips curve have concentrated their attention on the dynamic relationship between inflation and unemployment. In the future, they should expand their scope to build and test models of inflation, unemployment, and productivity.

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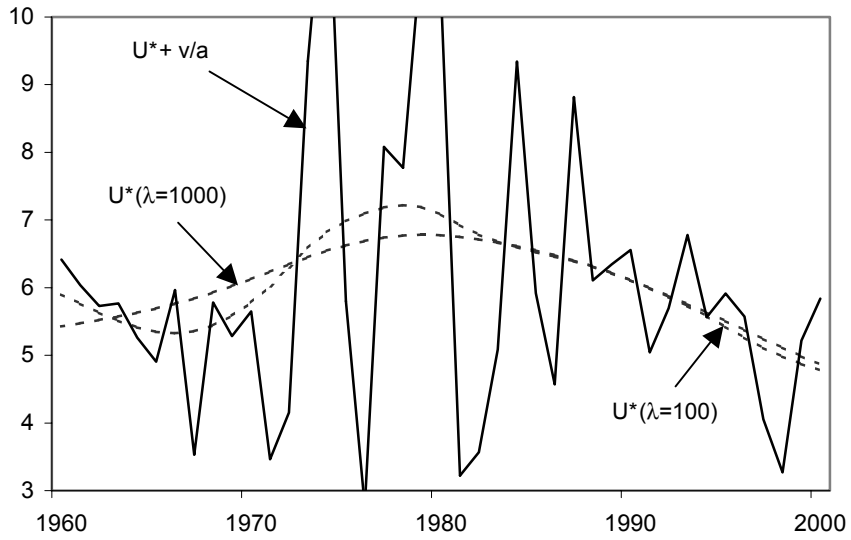
Figure 1
Time-Varying NAIRUs, 1960-2000

U*+ v/a

U*(λ=1000)

U*(λ=100)

Figure 2
The Effects of Demographic Adjustment

Unadjusted U*
(λ=1000)

Perry-weighted U*
(λ=1000)
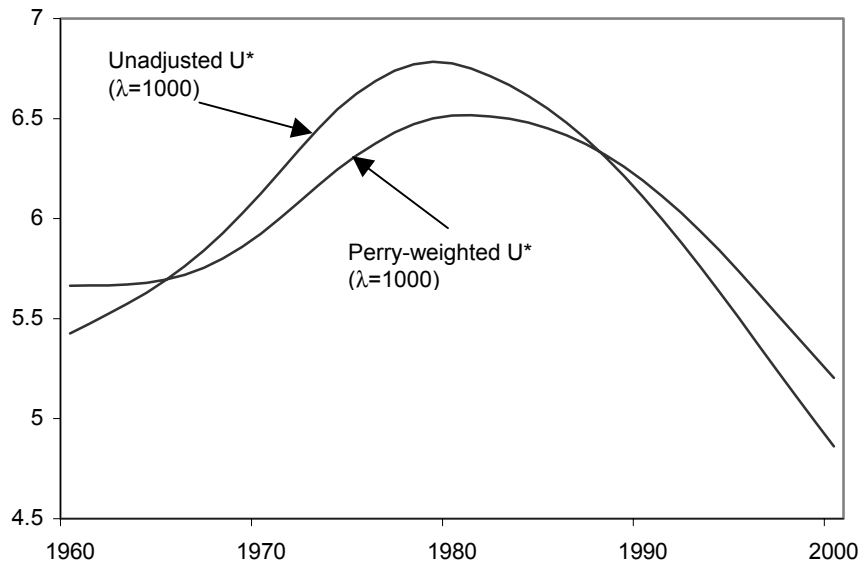
Figure 3

The NAIRU and Productivity Growth
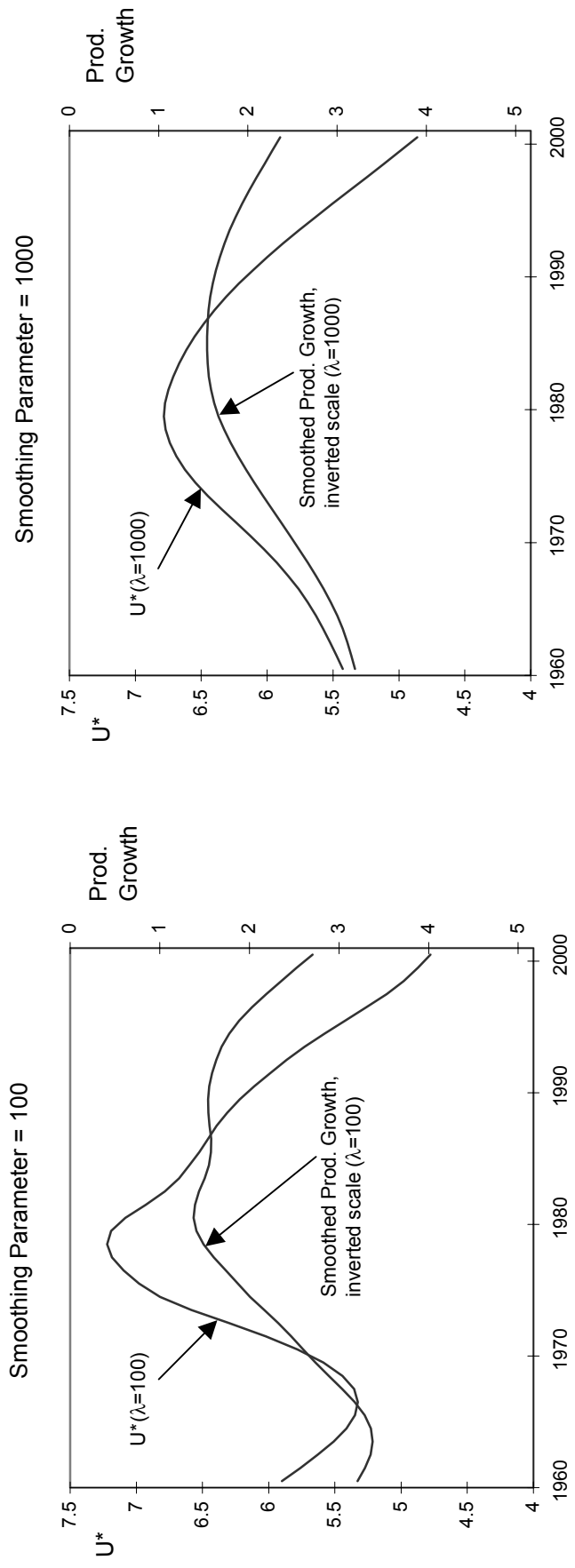
Figure 4

The NAIRU and the Change in Productivity Growth

Smoothing Parameter = 100

Smoothing Parameter = 1000

Figure 5

The Beveridge Curve

Unemployment Rate (vertical axis, 3 to 10)

Vacancy Rate (horizontal axis, 1 to 2.75)

1975-1985

1990-1995

1960-1969

82 83 75 76 81 84 85 80 77 78 79

61 63 60 62 89 64 86 71 88 87 74 72 70 65 73 67 66 68 69

92 91 93 94 95 96 97 98 90