Author(s): Alan A. Carruth, Mark A. Hooker, and Andrew J. Oswald
Article Title: Unemployment Equilibria and Input Prices: Theory and Evidence from the United States
Year of publication: 1997
Link to published version: http://dx.doi.org/10.1162/003465398557708
Publisher statement:None

Unemployment Equilibria and Input Prices: Theory and Evidence from the United States

ALAN A. CARRUTH, MARK A. HOOKER and ANDREW J. OSWALD[1]

Final Revision, January 1998

JEL classification codes E24, E32

This paper develops an efficiency-wage model where input prices affect the equilibrium rate of unemployment. We show that a simple framework based on only two prices (the real price of oil and the real rate of interest) is able to explain the main post-war movements in the rate of U.S. joblessness. The equations do well in forecasting unemployment many years out-of-sample, and provide evidence that the oil-price spike associated with Iraq's invasion of Kuwait appears to be a component of the "mystery" recession which followed.

1. Introduction

Unemployment is a central object of study in macroeconomics, yet it remains poorly understood. Wide disagreement persists about such basic questions as whether unemployment is mostly voluntary or involuntary, and whether business cycles mostly reflect movements in equilibrium unemployment or fluctuations around a relatively stable equilibrium. In this paper, we propose a model that generates substantial, business-cycle frequency movements in the equilibrium unemployment rate. These movements are driven by real input prices via a "worker discipline device" efficiency wage model, where firms use other inputs along with labor. In this model, increases in nonwage input prices

[1] Alan A. Carruth - University of Kent, UK; Mark A. Hooker - Federal Reserve Board, USA; Andrew J. Oswald - Warwick University, UK. For helpful comments and discussions, we thank Daron Acemoglu, Charlie Bean, Mike Clements, Jeff Fuhrer, Mike Knetter, Richard Layard, Alan Manning, Marcus Miller, Steve Nickell, Edmund Phelps, Peter Sinclair, Dennis Snower, Ken Wallis, and several anonymous referees and the editor. This work was partially supported by the ESRC's grant to the Centre for Economic Performance, LSE and by the Leverhulme Trust. The views expressed are those of the authors, and do not necessarily represent those of the Federal Reserve System.

lead to reductions in wages, due to a zero-profit condition in the product market, and unemployment must increase for workers to accept the lower wages. The two input prices we focus on are real oil prices and interest rates.

We find the efficiency wage framework attractive for several reasons. First, it provides a theoretical explanation for the apparent relationship between unemployment, oil prices, and other factor prices (see Figure 1). Second, its unemployment is not all voluntary. Third, it overcomes the objection to classical and neoclassical theory that observed movements in wages are too small and in employment are too large. Since efficiency wage models generate a downward sloping locus in wage-unemployment space which takes the place of the labor supply curve, they do not require particular assumptions about the elasticity of labor supply. Fluctuations in labor market equilibria thus may be caused by movements in labor demand caused by changes in real input prices. This simple idea motivates the paper.

The existing literature on efficiency wage models mostly ignores the role of input prices other than wages (a notable exception regarding the interest rate is Phelps' 1994 book). Other models which have assigned a role to energy prices are in Bruno and Sachs (1982), Hamilton (1988), Layard, Nickell and Jackman (1991), Phelps (1994), and Rotemberg and Woodford (1996). Our model differs in important ways from each of these: Hamilton's and Bruno and Sachs' models do not have equilibrium unemployment—the effects of oil price changes are temporary. Layard, Nickell and Jackman allows for the oil price only indirectly—as one of the import prices that might influence the consumption "wedge". Phelps does not treat oil as an input, while Rotemberg and Woodford (1996) has imperfectly competitive product rather than factor markets.

The hypothesis that equilibrium unemployment is driven by oil prices and real interest rates is tested here primarily using an error-correction model (ECM) on US postwar quarterly data. Beginning with the seminal work of Hamilton (1983) and Burbidge and Harrison (1984), most empirical work on the macroeconomic effects of oil prices has used unrestricted VARs and Granger causality tests. We compute tests of the hypotheses that oil prices and real interest rates Granger cause unemployment for comparability with this literature, and obtain results consistent with those from our error-correction model (strongly supporting a role for oil prices and mixed for interest rates). However, we prefer the latter approach because the error-correction framework has coherence with the theoretical model, as it estimates an equilibrium relationship between unemployment and input prices and a path of adjustment of unemployment towards that equilibrium level. By contrast, it is difficult to interpret VAR equations in terms of a theoretical model.

The ECM estimates that we obtain are consistent with the theoretical model. Assuming that the variables are reasonably well-described as I(1), tests do not reject a cointegrating relationship among them, with positive signs and reasonable magnitudes estimated on oil prices and interest rates. In our preferred specification, based on the annual change in the series, the oil price variable is strongly significant, the interest rate marginally so, and the adjustment terms—lagged changes in unemployment and the ECM components—are strongly significant as well, again with correct signs and reasonable magnitudes.

A major focus of the paper is on out-of-sample forecasts generated from the ECM, which provide a challenging check on the model's ability to explain the data. The first is over a long horizon (1979-95), to see whether predictions based only on oil prices and interest rates can track the unemployment rate, as they should if the equilibrium characterization is accurate. The second is over the early 1990s, to evaluate how well our model explains that hard-to-understand recession, and what role it assigns to the Iraqi oil price spike as a contributing cause.

The model performs surprisingly well in these exercises, given its severely restricted information set. In the first case, it predicts reasonably sucessfully the general path of unemployment over the entire decade and a half, based only on actual out-of-sample values of oil prices and real interest rates. The second is a true out-of-sample exercise (it uses only data available at the beginning of the forecast period); there its predictions for unemployment over the 8 quarters of

1991 and ’92 are significantly better than those of two major professional forecasters.

The remainder of the paper has the following structure. Section 2 develops an efficiency wage model in which real input prices play a central role in shaping the equilibrium rate of unemployment. In Section 3, the empirical relationship between unemployment, real oil prices, and real interest rates in the US is examined. Section 4 provides a summary and conclusions.

2. A Model of Equilibrium Unemployment

The basic model—to which we add a role for input prices—is a version of the efficiency-wage framework due to Shapiro and Stiglitz (1984). Related models in the early literature include Calvo (1979) and Bowles (1985), recent variants are provided by Akerlof and Yellen (1990) and Phelps (1992), and a precursor to this paper is Miller (1976).

Since the Shapiro and Stiglitz model is familiar to many readers, we begin here from the wage equation of the model and leave its derivation to an appendix. It comes from substituting the utility of a fired worker into the no-shirking condition, and states that the equilibrium wage must equal the sum of (i) the income value of not working (ii) the required job effort and (iii) a mixture of shirking detection rate, the effort level and the probability of finding work once unemployed:

$$\log w = \log b + e + e.d[1 - a(U)](1 - d) \quad [1]$$

Here w is the wage, b is the level of unemployment benefits, e is the level of on-the-job effort (fixed due to technology), d is the probability of successfully shirking, U is the unemployment rate and a(U) is the probability of an unemployed worker finding work. It will be useful below to rewrite [1] in the compressed form $\log w = \log b + h(U)$, where h(U) is a declining function.

We assume that three inputs, labor n, capital k, and an energy input labeled “oil,” x, are used to produce a single output sold at price p. Oil is traded on a world market at exogenously given price p_o. Output is generated through a constant returns to scale technology $y = \mu f(n, k, x)$, where y is output and $f(...)$ is homogeneous of degree one. The variable μ measures neutral technical progress. Perfect competition in the product market is assumed.

Firms operate at the minimum point on their cost schedules, so from the assumption of constant returns it is useful to define the unit minimum cost function

$$C = 1\mu \;\; c(w, r, p_o). \text{ [2]}$$

Given perfect competition, profits must be eliminated in equilibrium, so $p - C = 0$. The cost function c(...) is homogenous of degree one, so p can be set to unity without loss of generality. Therefore the real prices in the economy are tied together by the relation

$$\mu = c(w, r, p_o) \text{ [3]}$$

where the wage w, interest rate or rental rate of capital r, and oil price p_o can now all be thought of as in real units.

As technology μ improves, the economy gets richer. The higher output goes to labor through w, to the owners of capital through r, and to the owners of oil through p_o.

Finally, real income while unemployed, b, must be adjusted in line with the economy’s technology. Define this relationship as b(μ); it can be thought of as the rule the government uses for updating real unemployment benefits as the economy becomes more productive over time.

This model has sharp predictions. It implies that the equilibrium unemployment rate, which may be derived from [1] and [3] by substituting out the wage, is a function of the real prices in the economy: it depends upon the real interest rate and real oil price, the real value of being unemployed, and the exogenous effort and detection parameters:

$$U^* = U^*(r, p_o, b(\mu), e, d) \quad [4]$$

Equilibrium unemployment

Because of its simplicity, the model is easily manipulated. Remembering that $h'(U) < 0$, its comparative static predictions for increases in the real rate of interest and the real oil price are

$$\text{sgn}\ {}^*U^*r \quad = \ \text{sgn}\ c_2 > 0 \ [5]$$

$$\text{sgn}\ {}^*U^*p_o \quad = \ \text{sgn}\ c_3 > 0 \ [6]$$

Intuitively, the mechanism at work is the following. An increase in, for example, the price of oil leads to an erosion of profit margins. Firms lose money, and begin to go out of business. To restore a zero-profit equilibrium, some variable in the economy has to alter. If labor and energy are the key inputs and interest rates are largely fixed internationally, it is labor’s price that must decline.

But there is only one way in which this can happen. If wages and unemployment are connected inversely by a no-shirking condition, equilibrium unemployment must rise, because only that will induce workers to accept the lower levels of pay necessitated by the fact that the owners of oil are taking a larger share of the economy’s real income.

The same kind of process follows any rise in the real rate of interest. When capital owners’ returns increase, the new zero-profit equilibrium requires workers’ returns to be lower. In a world where the level of unemployment acts as a “discipline device,” higher real input prices lead to lower wages and greater unemployment rates.

It is conventionally argued that a good theory should predict—consistent with the historical facts—that equilibrium unemployment is neutral with respect to (i) total labor supply and (ii) the state of technology. In this model, (i) follows immediately. This is because the framework determines an unemployment rate that is homogeneous of degree zero with respect to the size of the labor force or economy. Feature (ii) is not automatic, but depends, as intuitively it should, on the form of the rule the government uses to update unemployment benefits as technology improves. For the utility function that we use, the equilibrium rate of unemployment is independent of technology when the elasticity of the unemployment benefits up-dating rule is set equal to one over labor's share of total cost (by Shephard's lemma).

3. Evidence

The equilibrium condition [4], and the comparative static predictions of [5] and [6], suggest that the equilibrium unemployment rate should depend upon the real price of oil and the real interest rate (plus the unobserved effort and detection parameters and the unemployment benefit function).

A Look at the Raw Data

We begin by plotting the raw unemployment, oil price and interest rate data in Figures 1a and 1b. Unemployment is the standard 16-and-over rate, the real oil price is the producer price index for crude oil divided by the GDP deflator, and the real interest rate is the five-year Treasury constant-maturity rate minus the contemporaneous rate of growth of the GDP deflator. The data are quarterly, and run from 1954:2 (the earliest date that the interest rate is available) to 1995:2.

A notable feature of Figure 1a is the timing of the comovement between unemployment and the real price of oil. This correlation has been paid relatively little attention in the unemployment literature. Unemployment appears to follow the oil price with a lag of about one year: the simple correlation between unemployment and the four-quarter lagged oil price is 0.72; it steadily declines to 0.64 for the contemporaneous measure. The real interest rate, displayed in

Figure 1b, shows much more short-term volatility than the price of oil or the rate of joblessness, and a limited degree of comovement with unemployment. The contemporaneous correlation is 0.39; unemployment and real interest rates move together in some periods like 1954-66 and 1984-90, but move sharply in opposite directions over some periods like 1975 and 1991-92.

Granger Causality Tests

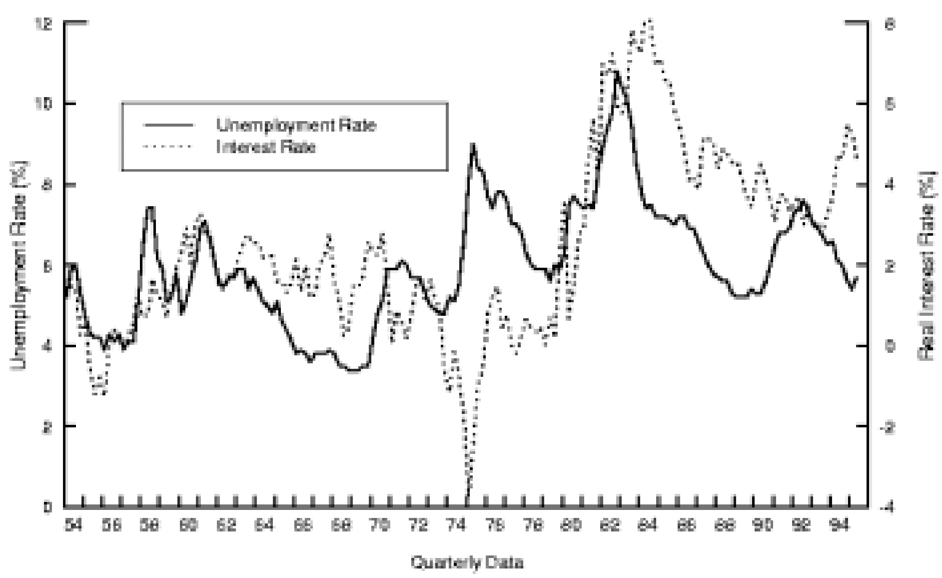
There is a tradition of testing whether oil prices affect the macroeconomy using Granger causality tests, beginning with Hamilton (1983). Our model implies that oil prices (in real levels) ought to Granger cause the unemployment rate in a bivariate system or a trivariate system including real interest rates. Oil prices should continue to Granger cause the unemployment rate in larger systems, according to the model, if the additional variables are not too collinear with oil. Hamilton (1983) showed that oil prices strongly Granger caused US GNP growth and the unemployment rate, in bivariate equations and the 6-variable system of Sims (1980), with data up through 1980. Subsequent research, however—all of which uses five- or six-variable systems like Sims'—has found a very different result, namely that oil prices no longer Granger cause unemployment or output when data from the 1980s and '90s are included.

Several authors have alleged that this breakdown is due to an incorrect functional form for the oil price, which was exposed by the falling and more variable oil prices that the post-1980 period has witnessed (see Figure 1a). Mork (1989) suggested that only oil price increases affect the economy; Lee, Ni and Ratti (1995) and Ferderer (1996) argued that (different) measures of oil price volatility are what matter; and Hamilton (1996) claimed that only price changes which establish new annual highs should be counted. Hooker (1996, 1997) has shown that none of these specifications reestablishes a robust Granger-causal relationship on post-1980 data.

Much less attention has been given to the Granger-causal properties of oil prices in smaller systems, and the possibility that the reduction in oil's Granger-causal powers comes from conditioning variables rather than functional form. Here we begin with the bivariate and trivariate systems that are implied by the model, and then compare with the results discussed above.

Figure 1a: Unemployment Rate and Log Real Oil Price

Figure 1b: Unemployment Rate and Real Interest Rate



Since many economists have argued that a regime shift took place in the US macroeconomy around 1972-73, we split the sample at that time, and perform tests for each of the two subsamples in addition to the full sample. Likelihood ratio tests do not accept lag-length restrictions on the VARs in most of the tests that were performed, so we allow fairly long lags of 8 quarters in the subsample tests and 12 lags in the full sample tests.

The results provide strong evidence that real oil prices Granger cause unemployment, and weak evidence regarding real interest rates. Table 1 shows that in bivariate tests, oil prices Granger cause unemployment in both level and difference specifications, in all samples, at significance levels below 3.5%. Real interest rates strongly Granger cause unemployment in the 1973-95 subsample, but not in the earlier subsample or in the full sample. In trivariate tests, the real oil price still strongly Granger causes unemployment in levels but does so less strongly in differences. The real interest rate does not Granger cause unemployment at the 5% level in any trivariate specification, although it does in two cases at 10%. This evidence is contrary to that found in Hooker (1996) and the papers mentioned above: oil prices here continue to Granger cause unemployment in samples that include 1980s and ’90s data.

Further investigation reveals that the most important difference between our tests and theirs is the inclusion or exclusion of money market variables like Treasury bill or Fed funds rates. This suggests two possible explanations. The first is that oil prices do not affect the macroeconomy, but appear to do so because of their comovement with monetary policy, as Bohi (1989) has argued. This is contradicted by the evidence that oil prices strongly Granger-cause output and unemployment in the presence of money market variables with pre-1980 data. The second is that money market variables—due to Fed policy and to private sector expectations—now systematically respond to oil price changes, and so oil price effects now appear weaker due to multicollinearity. While we do not view oil price-macroeconomy Granger causality questions as settled, we now turn to the empirical focus of this paper on unemployment and oil prices in an equilibrium/adjustment model context. Cointegration and Error-correction

Specifications One interpretation of the theoretical model is that there should be a cointegrating relationship between unemployment and those real prices which are important inputs to the economy's production processes. (Of course, if the variables are stationary then they cointegrate trivially. However, their substantial persistence means that cointegration tests, error-correction models, and long horizon out-of-sample forecasts will have some power to assess the degree to which they move together in a long-run equilibrium). Cointegration is also a sensible empirical interpretation of Phelps's (1994) claim that variables like oil prices drive the "long swings" observed in unemployment.

Table 2 presents with-trend and without-trend ADF tests of cointegration between the variables. The coefficients on oil prices and interest rates in the cointegrating regression are positive, and the results are quite supportive of cointegration.

Table 3 reports our preferred error correction model, based on the annual change in the series, which is a popular parameterization in dynamic modeling of quarterly data. ECMs impose the static (cointegration) relationships, and use the cointegrating regression residuals, called the ECM terms, as disequilibrium feedback to maintain the long-run relationship. We estimate the ECMs over the full sample, and over restricted subsamples for out-of-sample forecasting. A dummy variable for the hypothesized regime change in 1973 was not near statistical significance either interacted with the oil price variable or as an intercept shifter. The results in Table 3 are supportive of the model and consistent with our Granger causality results.

The impact of changes in real oil prices and real interest rates is consistent with the long run relationships suggested by the theory. A rise in either the real rate of interest or in the real price of oil leads to higher unemployment (although the interest rate terms are not significantly different from zero).

The equations display significant serial correlation in the residuals, most likely indicating omitted variables. These might be technology changes or benefit levels from the theory, or unmodelled short-run factors like changes in monetary policy. The ECM terms taken together suggest that only a small fraction of any disequilibrium from the long run outcome is removed each period (on the order of 10 or 20 per cent of the gap). Because the ECM terms are highly significant, the Table provides indirect evidence in support of the static relationship in Table 2 (Engle and Granger, 1987, provide a discussion of the isomorphism between ECMs and cointegrated relationships).

Out-of-Sample Forecasting

If a dynamic modeling approach is to be convincing, it needs to be able to say something about the behavior of unemployment out-of-sample. This is a demanding criterion for econometric analysis. In our long-horizon experiment, the model of Table 3 was estimated on quarterly data from 1954 through 1978 (deliberately stopping there, to see how the framework would cope with the oil shock of 1979). The model was then used to generate predicted values of unemployment through the end of the dataset. Lagged dependent variables in the model were set equal to their predicted values, and not merely replaced with their actual values, while oil prices and interest rates were set to actual values.

In Forecasting approach A, the ECM terms were calculated using actual unemployment values, while in Forecasting approach B, the ECM terms were generated using the model's predicted unemployment values rather than actual values. The forecasts of annual changes in quarterly unemployment are presented in Figure 2a. While the predictions are off in a few years, like 1982, 1986, and 1991, they both track movements in US joblessness fairly successfully over this long horizon—remember that in neither approach are the lagged dependent variables updated with actual unemployment. Figure 2b presents these forecasts in terms of the level of unemployment. Approach A stays quite closely on track (except for a brief diversion near the beginning of 1981) for the entire period.

Approach B does less well, overpredicting unemployment in the early 1980s and, although it captures the upward move around the end of 1990, underestimating the persistence in joblessness around 1992-93. Nevertheless, it should be borne in mind that the model is being asked to pass an exceptionally hard examination: these are forecasts out fifteen years which could have been generated by an economist working in 1979 with foresight only about oil prices and real interest rates. What is interesting about Figure 2b is that it correctly forsees the broad path of the US unemployment rate for a decade and a half.

It should be noted that this forecast period consists of roughly equal periods of rising and falling oil prices. Thus the results do not support the idea that oil price shocks generate unemployment mostly through sectoral reallocation and the concomitant search and wait unemployment. Such a view would predict that unemployment ought to rise after any large change in the price of energy—whether up or down. A good deal of the success of Figure 2b comes from reductions in unemployment associated with drops in oil prices. In fact, the model overpredicts the unemployment changes in two years that followed sharp drops in oil prices, 1981 and 1986.

In the second forecasting exercise, we compare the performance of our model with professional forecasters' predictions. The longest horizon available from professionals is generally two calendar years; we chose the period 1991:1-1992:4 for several reasons. It contains most of the 'cyclical' unemployment from that recession; it provides a good challenge, as the path of unemployment in this period was as difficult to predict as it was to understand; and there was an oil price spike at the beginning of this recession associated with Iraq's invasion of Kuwait, and debate over the macroeconomic consequences of that shock. The professional forecasts that we compare to are from Blue Chip Economic Indicators, a firm which compiles about forty major professional forecasts of an array of macroeconomic and financial variables (we use their "consensus"), and DRI, a leading private forecasting firm. We use the ECM model estimated over the sample 1954:2-1990:4 (column 3 of Table 3). The values assumed for the real oil price and interest rate over 1991 and 1992 are the 1990 averages, so these are truly out-of-sample forecasts which use no more information than was available to the professional forecasters at the end of 1990.

Figure 2a: Unemployment Changes, Actual vs. Out-of-Sample Forecast

Forecasts from Error Correction Model estimated on data through 1978 (Table 3 Column 2)

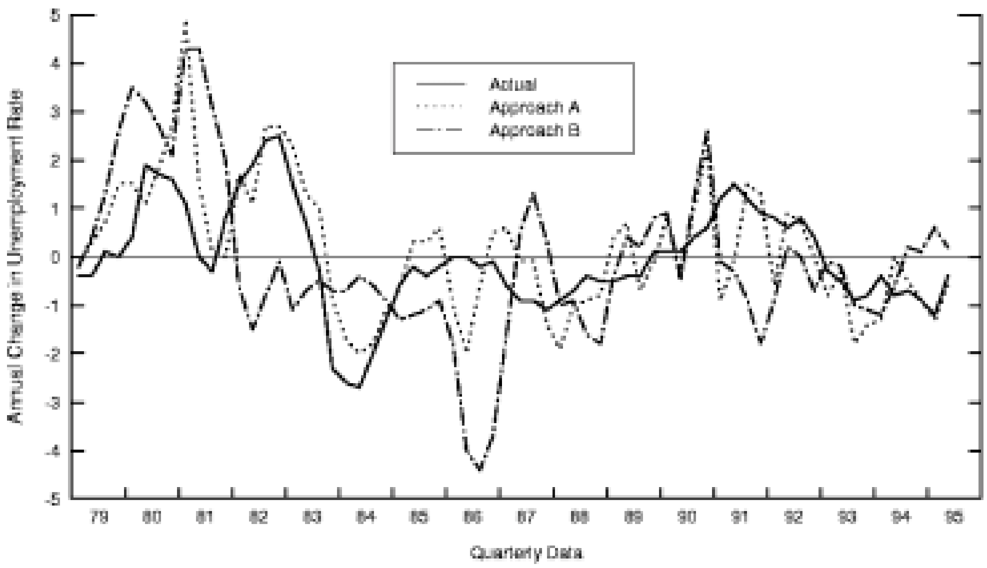
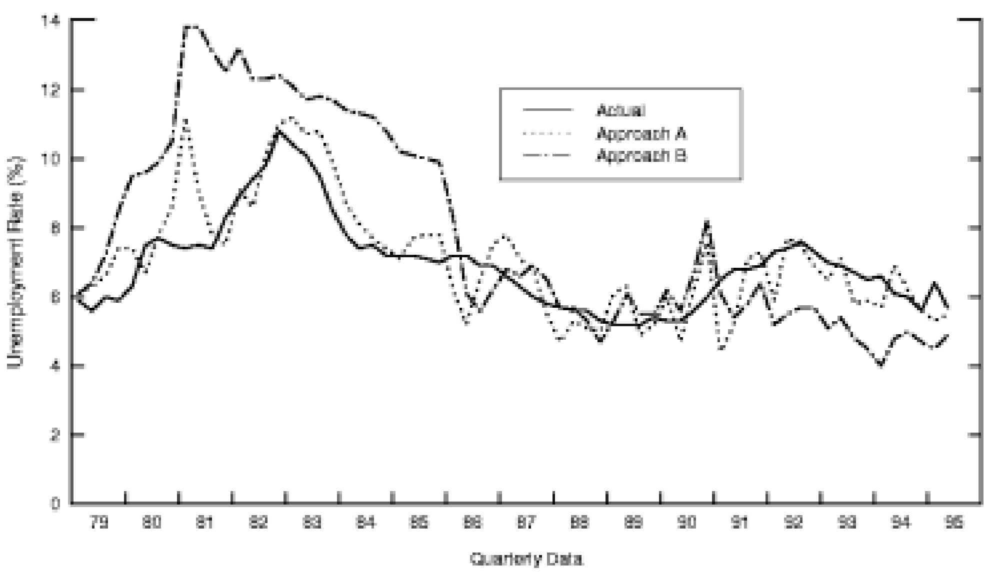


Figure 2b: Unemployment Levels, Actual vs. Out-of-Sample Forecast

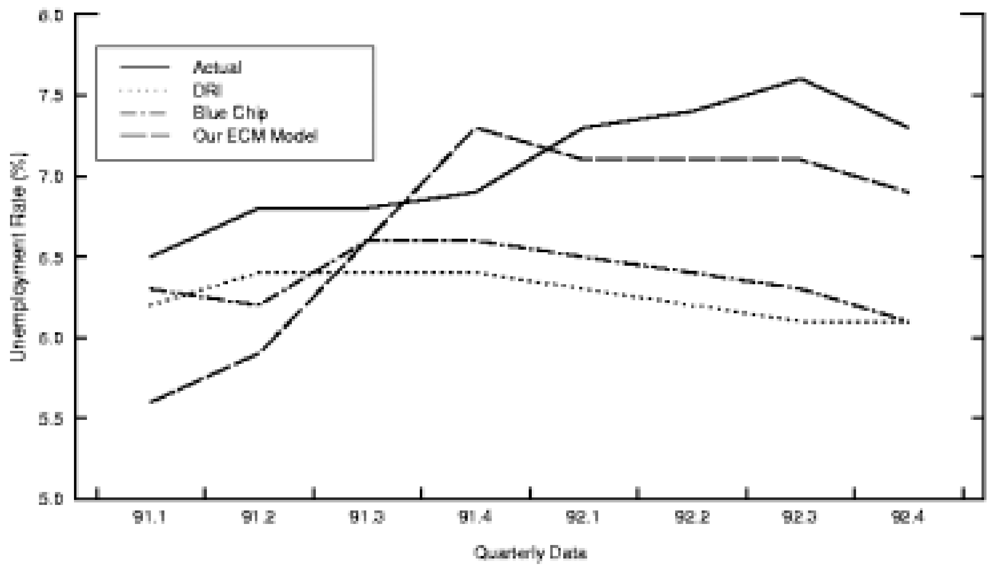
Forecasts from Error Correction Model estimated on data through 1978 (Table 3 Column 2)



Does our framework out-perform the professionals? It does, by a fair margin. As Figure 3 shows, the actual unemployment rate rose slowly over 1991 and more sharply during 1992 before turning down somewhat in the final quarter. DRI and BCEI anticipated almost no recessionary movement, however: their projections were for an increase of two- to three-tenths of a percentage point in unemployment by the end of 1991 which was to be more than reversed in 1992. By contrast, our ECM model predicts a nearly two percentage-point increase in unemployment during 1991 (after starting below the actual rate), flattening out at over 7% in 1992. The root mean squared errors for these forecasts over the eight quarters are 0.92 for DRI, 0.81 for BCEI, and 0.54 for the ECM, so the simple approach of explaining unemployment as a function of real oil price and interest rate levels leads to relative forecast improvements of 41% and 34%, respectively. A decomposition of the forecast into its component parts shows how the model translates the short-lived oil price spike of late 1990 into a more enduring period of higher unemployment. In the first two quarters of 1991, most of the predicted increases in unemployment (over year-ago) come from oil prices predicted to be above their year-ago level. However, after that the increases come almost entirely from persistence in unemployment changes (actual unemployment rose seventy basis points over 1990 and is predicted to rise further in 1991) and lagged adjustment to equilibrium.

Figure 3: Out-of-Sample Unemployment Rate Forecasts, Early 1990s Recession

Forecasts from Error Correction Model estimated on data through 1990 (Table 3 Column 3)



4. Conclusions

The paper suggests a way to think about unemployment fluctuations. An efficiency-wage model is developed in which the equilibrium unemployment rate depends upon firms' input prices, in particular the real price of energy and the real cost of borrowing. The model is supported by evidence from a cointegration/error-correction model and Granger causality tests, with oil prices playing a strong and significant role and interest rates a weaker and less significant one. Using only real interest rates and oil prices, the model is able to track the general path of unemployment from 1979 through 1995, and to significantly outperform professionals in out-of-sample forecasts of the early 1990s recession.

Appendix 1: Derivation of Equation [1]

Assume that workers are risk-averse, and get utility from income and disutility from effort. Define the wage as w and the level of on-the-job effort as e. For simplicity, adapting Shapiro and Stiglitz slightly, let workers' utility u equal the difference between the logarithm of income and the level of effort so

$$u = \log w - e$$

Assume also that effort at work, e, is a fixed number determined by technology, but that individual employees can decide to "shirk" and exert zero effort. If undetected by the firm, these individuals earn wage w and have $e=0$, so that their utility is $u=\log w$. They are then better off than employees who provide effort. These assumptions simplify the algebra and can be generalized without affecting the main argument.

Following Shapiro and Stiglitz, assume that an individual who shirks runs the risk of being discovered. Designate as d the probability of escaping detection. Assume that anyone caught shirking is fired, and has then to find work elsewhere.

The expected utility of a fired worker, denoted w~ , equals an average of the utility from working at the required effort level and of the income-equivalent value of being unemployed, weighted by the probability of finding work:

$$\tilde{w} = a(U)(\log w - e) + [1 - a(U)]\log b \quad [A1]$$

a(U), the probability of finding work, depends inversely on the level of unemployment, while the value of b will include an element of government unemployment benefits. A worker who decides to exert no effort in his or her job faces the risk of being sacked.

Implicit in the above definition of w~ is the assumption that the individual cannot shirk twice, that is, that a shirker who is re-hired earns (with certainty) utility logw - e. This assumption can be thought of as embodying the notion that a firm will closely supervise the behavior of anyone known to have been dismissed from another employer. Our assumption simplifies the algebra without altering the conclusions; it can be dispensed with by using a value-function method outlined in Shapiro and Stiglitz.

Because individuals decide whether to supply effort equal to e or to zero, firms have to behave in a way that guarantees that sufficient numbers of employees do not shirk. Assuming that workers are identical—to keep the analytical structure simple—this implies that in equilibrium everyone must provide effort, e, because otherwise output would be zero and the outcome could not be sustainable.

The no-shirking wage is the smallest wage required to persuade employees to offer effort; it is obtained by equating the utility from not shirking and the expected utility from shirking:

$$\log w - e = d\log w + (1-d)\tilde{w} \quad [A2]$$

Substituting [A1] into [A2] and simplifying yields equation [1] in the text.

Appendix 2: Data Definitions and Means

The three main data series are the unemployment rate, real oil prices, and real interest rates.

Unemployment

Percent of the civilian labor force, total 16 years and over (BLS/Dept. of Labor), monthly aggregated to quarterly using middle month observation. Seasonally adjusted. Mean = 6.00.

Oil Prices

US Producer Price Index for crude oil, not seasonally adjusted, monthly aggregated to quarterly using middle month observation, index (1982=100), from the Survey of Current Business (Dept. of Commerce); converted to real using the GDP deflator from the National Income and Product Accounts. Mean = 60.51.

Interest Rates

US 5 year Treasury Note yield, not seasonally adjusted, monthly aggregated to quarterly using middle month observation, less contemporaneous change in GDP deflator. Mean = 2.43.

References

Akerlof, George A., and Janet L. Yellen, “The Fair Wage-Effort Hypothesis and Unemployment,” *Quarterly Journal of Economics* 105 (1990), 255-83.

Bean, Charles R., "European Unemployment: A Survey," *Journal of Economic Literature* 32 (1994), 573-619.

Blanchflower, David G., and Andrew J. Oswald, The Wage Curve (Cambridge: MIT Press, 1994).

Bohi, Douglas R., Energy Price Shocks and Macroeconomic Performance (Washington D.C.: Resources for the Future, 1989).

Bowles, Samuel, "The Production Process in a Competitive Economy: Walrasian, Neo-Hobbesian, and Marxian Models," *American Economic Review* 75 (1985), 16-36.

Bruno, Michael, and Jeffrey Sachs, "Input Price Shocks and the Slowdown of Economic Growth: The Case of UK Manufacturing," *Review of Economic Studies* 49 (1982), 679-705.

Burbidge, John, and Alan Harrison, "Testing for the Effects of Oil-Price Rises Using Vector Autoregressions," *International Economic Review* 25 (1984), 459-484.

Calvo, Guillermo, "Quasi-Walrasian Theories of Unemployment," *American Economic Review* 69 (1979), 102-107.

Carruth, Alan A., Mark A. Hooker, and Andrew J. Oswald, "Unemployment, Oil Prices, and the Real Interest Rate: Evidence from Canada and the U.K.," in Louis N. Christofides, E. Kenneth Grant, and Robert Swidinsky (eds.), Aspects of Labour Market Behaviour: Essays in Honour of John Vanderkamp (Toronto: University of Toronto Press, 1995).

Cochrane, John H., "Shocks," *Carnegie-Rochester Conference Series* 41 (1994), 295-364.

Engle, Robert F. and C.W.J. Granger, "Co-integration and Error Correction: Representation, Estimation and Testing," *Econometrica* 55, (1987), 251-276.

Engle, Robert F. and C.W.J. Granger (eds.), <u>Long-Run Economic Relationships</u> (Oxford: Oxford University Press, 1991).

Ferderer, J.Peter, "Oil Price Volatility and the Macroeconomy," *Journal of Macroeconomics* 18 (1996), 1-16.

Hamilton, James D., "Oil and the Macroeconomy since World War II," *Journal of Political Economy* 91 (1983), 228-248.

_____, "A Neoclassical Model of Unemployment and the Business Cycle," *Journal of Political Economy* 96 (1988), 593-617.

_____, "Analysis of the Transmission of Oil Price Shocks Through the Macroeconomy," UCSD Manuscript (1996).

Hooker, Mark A., "What Happened to the Oil Price-Macroeconomy Relationship?," *Journal of Monetary Economics* 38 (1996), 195-213.

_____, "Exploring the Robustness of the Oil Price-Macroeconomy Relationship," FEDS Working Paper No. 1997-56, Federal Reserve Board (1997).

Jorgenson, Dale W., "The Role of Energy in Productivity Growth," *American Economic Review* 74 (1984), 26-30.

Keane, Michael P., and Eswar S. Prasad, "The Employment and Wage Effects of Oil Price Changes: A Sectoral Analysis," *Review of Economics and Statistics* 78 (1996), 389-400.

Kim, In-Moo, and Prakash Loungani, "The Role of Energy in Real Business Cycle Models," *Journal of Monetary Economics* 29 (1992), 173-189.

Layard, Richard, Stephen J. Nickell, and Richard Jackman, Unemployment: Macroeconomic Performance and the Labor Market (Oxford: Oxford University Press, 1991).

Lee, Kiseok, Shawn Ni, and Ronald A. Ratti, "Oil Shocks and the Macroeconomy: The Role of Price Variability," *Energy Journal* 16 (1995), 39-56.

MacKinnon, James, "Critical Values for Cointegration Tests," in Engle, Robert F., and C.W.J. Granger (eds.), Long-Run Economic Relationships (Oxford: Oxford University Press, 1991).

McNees, Stephen K., "The 1990-91 Recession in Historical Perspective," New England Economic Review January/February 1992, 3-22. Miller, Marcus H., "Can a Rise in Import Prices be Inflationary and Deflationary?," *American Economic Review* 66 (1976), 501-519.

Mork, Knut Anton, "Oil and the Macroeconomy When Prices Go Up and Down: An Extension of Hamilton's Results," *Journal of Political Economy* 91 (1989), 740-744.

Nickell, Stephen J., "Unemployment: A Survey," *Economic Journal* 100 (1990), 391-439.

Oswald, Andrew J., "A Conjecture on the Explanation for High Unemployment in the Industrialized Nations: Part I," Working Paper No. 475, University of Warwick (1996).

Phelps, Edmund S., “Consumer Demand and Equilibrium Unemployment in a Working Model of the Customer-Market Incentive-Wage Economy,” *Quarterly Journal of Economics* CVII (1992), 1003-1032.

_____, Structural Slumps (Cambridge: Harvard University Press, 1994).

Phillips, A. W. “Stabilization Policy and the Time Form of Lagged Responses,” *Economic Journal* 67 (1957), 265-277.

Rasche, Robert H., and John A. Tatom, “Energy Price Shocks, Aggregate Supply and Monetary Policy: The Theory and the International Evidence,” *Carnegie-Rochester Conference Series* 14 (1981), 9-93.

Rotemberg, Julio J., and Michael Woodford, “Imperfect Competition and the Effects of Energy Price Increases on Economic Activity,” *Journal of Money, Credit and Banking* 28 (1996), 549-77.

Rowthorn, R.E., “Conflict, Inflation and Money,” *Cambridge Journal of Economics* 1 (1977), 215-239.

Sargan, John Denis, “Wages and Prices in the United Kingdom: A Study in Econometric Methodology,” in P.E. Hart, G. Mills, and J.K. Whitaker, (eds.), Econometric analysis for National Planning (London: Butterworths, 1964).

Shapiro, Carl., and Stiglitz, Joseph E., “Equilibrium Unemployment as a Worker Discipline Device,” *American Economic Review* 74 (1984), 433-444.

Sims, Christopher A., “Macroeconomics and Reality,” *Econometrica* 48 (1980), 1-48.