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HYPOTHESIS: A TIME-VARYING  
PARAMETER APPROACH**

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# Testing the Expectations Trap Hypothesis: A Time-Varying Parameter Approach

Naveen Srinivasan

## Abstract

*The expectations trap hypothesis is an influential but untested model of monetary policy. The hypothesis conjectures that high inflation during the 1970s was the outcome of a shift in private sector beliefs which were then validated by monetary policy. The subsequent fall in inflation was mainly due to changes in those beliefs. We provide a formal test of the model, using US data from 1948-2008. The flexible least squares approach of Kalaba and Tesfatsion (1988, 1989) is used to evaluate its empirical likelihood. Strong formal support is found for this proposition. Specifically, our results suggest that supply shocks interacting with private sector beliefs about the nature of monetary regime together account for the rise and fall of U.S. inflation.*

**Keywords:** *E31; E42; E52; E58*

**JEL Codes:** *Monetary policy; Expectations Trap; Time-varying parameters; Flexible Least Squares*

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## INTRODUCTION

The Great Inflation of the late 1960s and 1970s was one of the defining moments of postwar U.S. economic history. After more than a decade of stable prices, the U.S., embarked on a path of steadily rising inflation. A substantial literature has developed that revisits the U.S. inflation experience of the 1970s. This literature has advanced a variety of explanations for why macroeconomic outcomes were poor during this period compared to the period since then, when inflation has been lower and more stable.

Many economists believe that differences in monetary policy remain critical to the story.<sup>1</sup> While there is widespread agreement that "loose" monetary policy played a major role in contributing to the Great Inflation, there is less agreement on what caused inflationary expectations to drift in the first place. The standard textbook explanation relies on the *time-inconsistency* problem highlighted by Kydland and Prescott (1977) and Barro and Gordon (1983). Nevertheless, despite the model's popularity it has been questioned by both policymakers as well as by some academics on the grounds of realism (McCallum, 1997 and Blinder, 1998). Moreover, the model has lost some of its appeal in recent years since empirical evidence appeared to contradict it.<sup>2</sup>

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<sup>1</sup> For example, Clarida et al., (2000) find that the Federal Reserve was highly "accommodative" in the pre-Volcker years to expected inflation. While it raised nominal rates, it typically did so by less than the increase in expected inflation. On the other hand, during the Volcker-Greenspan era the Federal Reserve adopted a more proactive stance toward controlling inflation: it systematically raised real interest rates in response to higher expected inflation.

<sup>2</sup> Specifically, from an empirical standpoint the time-inconsistency model implies that the higher (lower) the natural rate of unemployment is, the higher (lower) the equilibrium inflation rate is (see Parkin, 1993 and Ireland, 1999). As Taylor (1997) observes, this property of the model fails to explain the dynamics of inflation in Europe. He argues that in Europe incentive to inflate stood at a post-war high in the 1980s and 1990s because the unemployment rate was so high, and yet inflation was very low. Furthermore, in the United States, a major, persistent drop in the rate of inflation occurred starting in 1980, about three years before the unemployment rate started to come down (see Christianano and Gust, 1999).

A different interpretation of the Great Inflation posits that a bad supply shock (e.g. increase in crude oil prices) triggered a jump in expected inflation which then became transformed into higher actual inflation because of the nature of monetary policy.<sup>3</sup> In the language of Chari, Christiano, and Eichenbaum (1998), when a central bank is pressured to produce inflation because of a rise in inflation expectations, the economy has fallen into an *expectations trap*.

But what caused inflationary expectations to rise in the first place? According to the expectations trap hypothesis when the central bank's commitment to fighting inflation is *perceived* to be weak, as may have been the case during the 1970s, self-confirming increases in expected inflation are possible in response to adverse supply-side developments (see Albanesi, Chari, and Christiano, 2003). It also suggests that if the government finds a way to credibly commit to price stability, then costly jumps in inflation expectations will not occur in the first place.

As far as one is aware no one has yet formally tested this hypothesis. The prime purpose of this article is to evaluate its empirical likelihood using U.S. data from 1948-2008. The flexible least squares (FLS) approach of Kalaba and Tesfatsion (1988, 1989) is used for this purpose. Since it is well known that both the structure of the U.S. economy and the way monetary policy was conducted have undergone a fundamental transformation during this period, the model parameters

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<sup>3</sup> As Christiano and Gust (2000) point out, this interpretation is very close to the hypothesis Blinder advances as an explanation of the takeoff of inflation in the early 1970s: Inflation from special factors can “get into” the baseline rate if it causes an acceleration of wage growth. At this point policymakers face an agonizing choice - the so called accommodation issue. To the extent that aggregate nominal demand is *not* expanded to accommodate the higher wages and prices, unemployment and slack capacity will result. There will be a recession. On the other hand, to the extent that aggregate demand *is* expanded (say, by raising the growth rate of money above previous targets), inflation from the special factor will get built into the baseline rate (Blinder, 1982, p. 264).

must be allowed to vary, in accordance with the Lucas critique. The FLS approach precisely does that by explicitly allowing for time variation in model parameters.

To anticipate our findings, strong formal support is found for the expectations trap hypothesis. Specifically, our results suggest that supply shocks interacting with private sector beliefs about the nature of monetary regime together account for the rise and fall of U.S. inflation. When adverse shocks hit the economy in the 1970s the central bank's commitment to fighting inflation was perceived to be weak. As a result inflation expectations started to rise and inflation outcomes worsened. The subsequent fall in inflation was mainly due to changes in those beliefs.

The remainder of the paper is structured as follows. Section 2 outlines the model to be estimated. To ensure the paper is self-contained, section 3 reviews the FLS estimation technique. Section 4 summarizes the principal empirical findings of the current study while Section 5 examines the robustness of our result. Concluding comments are given in section 6.

## **A SIMPLE MODEL OF EXPECTATIONS TRAP**

The theoretical framework consists of a stylized model in which the central bank aims to minimize a quadratic loss function with inflation and the output gap as arguments. The policymakers' objective is to stabilize inflation,  $\pi_t$  (around a constant long-run target,  $\pi^*$ ) and output,  $y_t$  around its natural rate,  $y^*$ ). We assume that the central bank chooses a sequence of short-term interest rates ( $i_t$ ) in order to minimize the present discounted value of its loss function. Formally, the central bank faces the following problem:

$$L(\pi_t, y_t) = \frac{1}{2} \left\{ (\pi_t - \pi^*)^2 + \lambda (y_t - y^*)^2 \right\}, \quad (2.1)$$

where,  $0 < \lambda < 1$  is the relative weight on output gap stabilization. This parameter is a key determinant of the dynamics of inflation in our model. The underlying idea resembles that expressed by Cogley and Sargent (2001), that the dynamics of inflation are fundamentally related to the nature of the monetary regime.

The private sector behavior is characterized by an expectations augmented Phillips curve:

$$\pi_t = \pi_t^e + \alpha (y_t - y^*) + u_t, \quad \alpha > 0 \quad (2.2)$$

where,  $\pi_t^e$  denotes expectations conditional upon the information available at time  $t-1$ . The supply disturbance,  $u_t$ , in turn, fluctuates over time in response to a random shock,  $\varepsilon_t$ , according to the autoregressive process (with drift),

$$u_t = \rho_0 + \rho_1 u_{t-1} + \varepsilon_t, \quad (2.3)$$

where,  $0 < \rho_1 < 1$ ,  $\rho_0 > 0$ . The drift term in (2.3) permits persistent supply shocks to affect equilibrium inflation if policymaker's are perceived to be recession averse ( $\lambda > 0$ ) - the expectations trap hypothesis (see Chari et al., 1998).<sup>4</sup>

Finally, the central bank is assumed to have imperfect control over the rate of inflation. In particular,

$$\pi_t = i_{t-1} + \xi_t, \quad (2.4)$$

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<sup>4</sup> However, notice that the introduction of the drift in (2.3) implies that the natural rate hypothesis is violated. In this regard we note that one popular interpretation of the run-up in inflation in the late 1960's and 1970's suggest that monetary authorities during this period believed that there was an exploitable trade-off between inflation and unemployment (see DeLong, 1997, Taylor, 1998, and Sargent, 1999). This belief induced them to accept the temptation to inflate more and more. Our modeling framework is consistent with this viewpoint.

where,  $i_{t-1}$  is the policy instrument (short-term interest rate) at  $t-1$  and  $\xi_t \sim N(0, \sigma_\xi^2)$  is a control error that represents imperfections in the conduct of monetary policy and is assumed to be uncorrelated with,  $u_t$ . Since the policy instrument is chosen at time  $t-1$ , it follows that,  $i_{t-1} \in \Omega_{t-1}$ .

In order to understand the implications of the model for inflation dynamics we solve the policymakers' optimization problem. Thus, minimizing the period loss function subject to the constraints provided by the structure of the economy yields:

$$\pi_t = \left( \frac{\alpha^2}{\lambda + \alpha^2} \right) \pi^* + \left( \frac{\lambda}{\lambda + \alpha^2} \right) \pi_t^e + \left( \frac{\lambda}{\lambda + \alpha^2} \right) u_t . \quad (2.5)$$

Finally, taking expectations conditional upon information available in period  $t-1$  yields:

$$\pi_t^e = a_0 + a_1 u_{t-1} , \quad (2.6)$$

where,  $a_0 = \left( \frac{\alpha^2 \pi^* + \lambda \rho_0}{\alpha^2} \right)$  and  $a_1 = \left( \frac{\lambda \rho_1}{\alpha^2} \right)$ . The solution for

expected inflation depends on the underlying parameters of the model. The model in this case predicts a systematic relationship between the level of supply shocks and expected inflation. In particular, the model implies that an adverse shock ( $u > 0$ ) can translate into higher expected inflation if the policymaker's commitment to fighting inflation is perceived to be weak. In other words, if the private sector believes that the policymaker would not be willing to tolerate a recession ( $\lambda > 0$ ), there is a rise in inflation expectations.

In contrast, if the policymaker's commitment to fighting inflation is perceived to be strong, then there is little reason for inflation

expectations to suddenly jump in response to adverse shocks. For example, if the private sector believes that price stability is the overriding objective of monetary policy, so that,  $\lambda = 0$ , then expectations traps just couldn't happen. It is clear that under this regime (see 2.6) inflation expectations are well anchored. In sum, the expectations trap hypothesis lays responsibility for inflation with monetary institutions themselves.

### **Inflation Reduced-form**

We now proceed to empirically evaluate our model. To do this, we substitute (2.6) in (2.4) for,  $i_{t-1} = \pi_t^e$ . Thus, our benchmark reduced-form model for inflation is given by,

$$\pi_t = a_0 + a_1 u_{t-1} + \xi_t . \tag{2.7}$$

where,  $\xi_t \sim N(0, \sigma_\xi^2)$  is a control error. From an empirical standpoint the expectations trap hypothesis suggests that the slope parameter in a regression of inflation on the level of supply shock should be positive. Moreover, we would expect the slope coefficient ( $a_1$ ) to rise when policymaker's commitment to fighting inflation is perceived to be weak and fall when the policymaker acquires sufficient anti-inflation credibility.

To capture the shift in private sector beliefs we allow the coefficients in (2.7) to vary over time. Thus, the  $a_0$  the  $a_1$  in (2.7) are replaced by  $a_{0t}$  the  $a_{1t}$  respectively. The FLS approach will be used to determine the time paths of the coefficients. In the next section the FLS method is briefly described.

## THE FLEXIBLE LEAST SQUARES (FLS) APPROACH

Kalaba and Tesfatsion (1988, 1989) formulate a time varying linear regression problem as follows. Suppose noisy observations,  $y_1, \dots, y_T$  over a time-span  $1, \dots, T$  have been generated by a linear regression model with coefficients that evolve only slowly over time. Letting  $y_t = \pi_t$  denote the time- $t$  observed dependent variable,  $x_t$  denote the vector of time- $t$  regressor variables, and  $b_t$  denote the vector of time- $t$  regressor coefficients, the *prior measurement specification* (2.7) can equivalently be expressed as

$$y_t \approx x_t' b_t, \quad t = 1, \dots, T. \quad (3.1)$$

Rather than impose strict time constancy on the coefficients, FLS approach captures time variation through a *prior dynamic specification* (smoothness prior) for successive coefficient vectors:

$$b_{t+1} \approx b_t, \quad t = 1, \dots, T-1. \quad (3.2)$$

The measurement and dynamic specifications reflect the prior beliefs of linear measurement and coefficient stability in a simple direct way, without any distributional assumptions about the error term that are required for OLS or Kalman filter estimation.<sup>5</sup>

Associated with each possible coefficient sequence estimate  $b = (b_1 \dots, b_T)$  are two basic types of model specification error. First,  $b$  could fail to satisfy the prior measurement specification (3.1) because of discrepancy between the observed dependent variable  $y_t$  and the

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<sup>5</sup> FLS is a generalization of Kalman filtering, as discussed in several works (see Lütkepohl, 1993). Typically, Kalman filtering requires the analyst to assume a particular stochastic structure for the time-varying coefficients and that the disturbances follow a specific distribution. The problem is that we are seldom in a position to know beforehand the stochastic process that moves the coefficients and may have little confidence that the disturbances are normal.

estimated linear regression model  $x_t' b_t$  at each time  $t$ . This discrepancy could arise because of misspecification, wrong functional form, etc. Second,  $b$  could fail to satisfy the prior dynamic specification (3.2) because of possible coefficient variation for the included variables. Suppose the cost assigned to  $b$  for the first type of error is measured by the sum of squared residual measurement errors

$$r_M^2(b; \mathcal{T}) = \sum_{t=1}^T [y_t - x_t' b_t]^2, \quad (3.3)$$

and the cost assigned to  $b$  for the second type of error is measured by the sum of squared residual dynamic errors

$$r_D^2(b; \mathcal{T}) = \sum_{t=1}^{T-1} [b_{t+1} - b_t]' D [b_{t+1} - b_t], \quad (3.4)$$

where  $D$  is a suitably chosen scaling matrix that makes the cost function essentially invariant to the choice of units for the regressor variables. Kalaba and Tesfatsion (1988, 1989) define the flexible least squares solution as the collection of all coefficient sequence estimates  $b$  which yield vector-minimal sums of squared measurement and dynamic errors for the given observations -- that is, which attain the residual efficiency frontier (REF). The REF reveals the cost in terms of residual measurement error that must be paid in order to achieve the *zero* residual dynamic error (time-constant coefficients) required by OLS estimation.

How might the REF be found? The incompatibility cost function  $C(b; \delta, \mathcal{T})$  that attains the REF for all possible choices is formed by taking the weighted sum of these two types of specification error as follows.

$$C(b; \delta, \mathcal{T}) = \frac{\delta}{1-\delta} \sum_{t=1}^{T-1} [b_{t+1} - b_t]' D [b_{t+1} - b_t] + \sum_{t=1}^T [y_t - x_t' b_t]^2, \quad (3.5)$$

where  $0 < \delta < 1$  is the weight factor that assigns a relative priority to the two priors in the model specification. OLS is just a special case of FLS

in that a restriction is imposed that fixes the potentially time-varying coefficients to constant values. Indeed, it can be seen from (3.5) that FLS  $\rightarrow$  OLS as  $\delta \rightarrow 1$ . In other words, the OLS solution lies on one end of the REF, so it is just a limiting case of FLS.

As (3.5) indicates, the incompatibility cost function  $C(b; \delta, T)$  generalizes the goodness-of-fit criterion function for OLS estimation by permitting the coefficient vectors  $b$ , to vary over time. The incompatibility cost function is a strictly convex function of the coefficient sequence estimate  $b$ , and there exists a unique estimate  $b$  which attains the minimum cost. The use of a quadratic loss function implies that the resulting problem can be solved within the framework of optimal control. The FLS solution is defined to be the collection of all coefficient sequence estimates which minimizes the incompatibility cost function. The coefficient sequence estimates,  $b$ , which attains this frontier is referred to as *FLS estimates*.

In Kalaba and Tesfatsion (1988, 1989) a procedure is developed for sequentially generating the FLS solution. The algorithm gives directly the estimate  $b_t^{FLS}(\delta, t)$  for the time- $t$  coefficient vector  $b_t$ , conditional on the observations,  $y_1, \dots, y_t$ , as each successive observation  $y_t$  is obtained. The algorithm also yields smoothed (back-updated) estimates for all intermediate coefficient vectors for times 1 through  $t - 1$ , conditional on the observations,  $y_1, \dots, y_t$ .

## EMPIRICAL ANALYSIS

### Data and Basic Facts

The analysis spans the period 1948:1-2008:2 and it is conducted on quarterly data that have been obtained from the website of the Federal Reserve Bank of St. Louis. Inflation is measured as the year-on-year percentage change in seasonally adjusted consumer price index (CPI) for

all urban consumers (all items). With regard to supply shock researchers have traditionally used energy prices as a proxy. So we use year-on-year percentage change in producer price index (fuel and related products and power) as a proxy for supply shock.

**Figure 1: Quarterly U.S. inflation rate and supply shock**

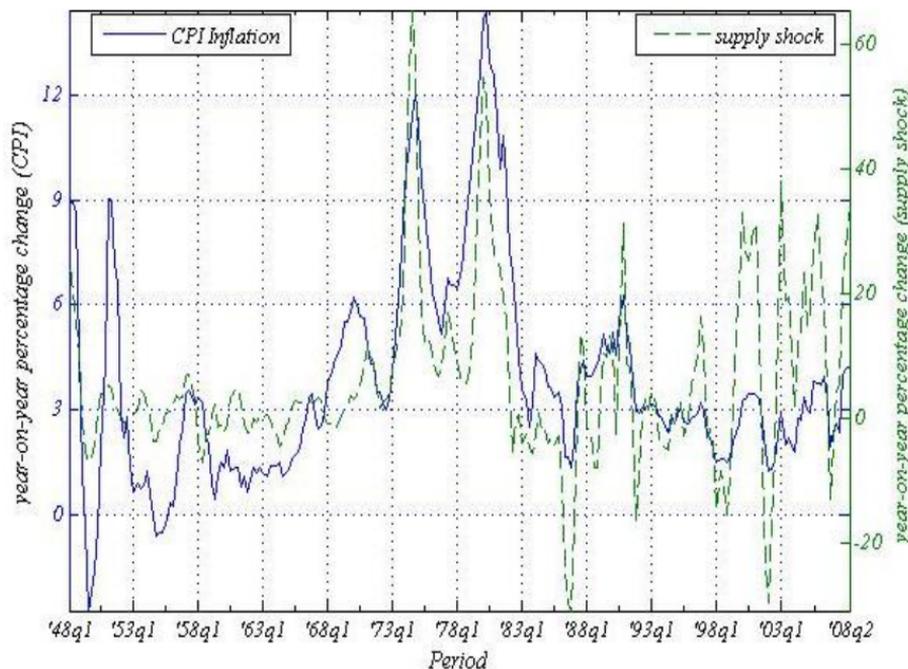


Figure 1 displays CPI inflation (left axis) and our proxy for supply shock (right axis). Three critical observations arise immediately from the Figure. First, inflation starts out high in the 1950s and then falls back to initial levels. From the mid-1960s inflation rose steadily until the early 1980s, and declined over time thereafter. Second, including the most recent episode, there have been five significant periods of rising oil prices since 1970: 1973-74, 1978-79, 1990, 1999-2000 and 2004-05. Finally, oil price jumped sharply twice in the 1970s, as did inflation. But this relationship appears to have deteriorated over the latter part of the

sample. For example, since the late 1990s, the U.S. economy has experienced two oil shocks of sign and magnitude comparable to those of the 1970s but, in contrast with the earlier episodes, inflation has remained relatively stable.

## Estimation Results

With this background we proceed to empirically evaluate our model. The model (2.7) is estimated using the FLS procedure in SHAZAM and results are discussed below.<sup>6</sup> The REF is graphed in Figure 2. The shape of the frontier can provide a qualitative indication of whether or not the OLS solution provides a good description of the observations. Residual-measurement error is on the vertical axis, while residual-dynamic error is on the horizontal axis. The downward sloping curve is that set of all pair combinations of  $r_M^2$ ,  $r_D^2$  which attain the REF conditional on  $\delta$ .

The left endpoint of the frontier gives the minimum possible values of  $r_M^2$  subject to  $r_D^2 = 0$ . Hence, this endpoint reveals the cost in terms of residual-measurement error that must be for choosing the fixed coefficient solution. This is called the OLS extreme point. The right endpoint of the frontier gives the minimum possible values of  $r_D^2$  subject to  $r_M^2 = 0$ . Hence, this endpoint reveals the minimum amount of time variation in the coefficients that must be allowed in order to have no residual-measurement error (i.e., a perfect fit for the regression).<sup>7</sup>

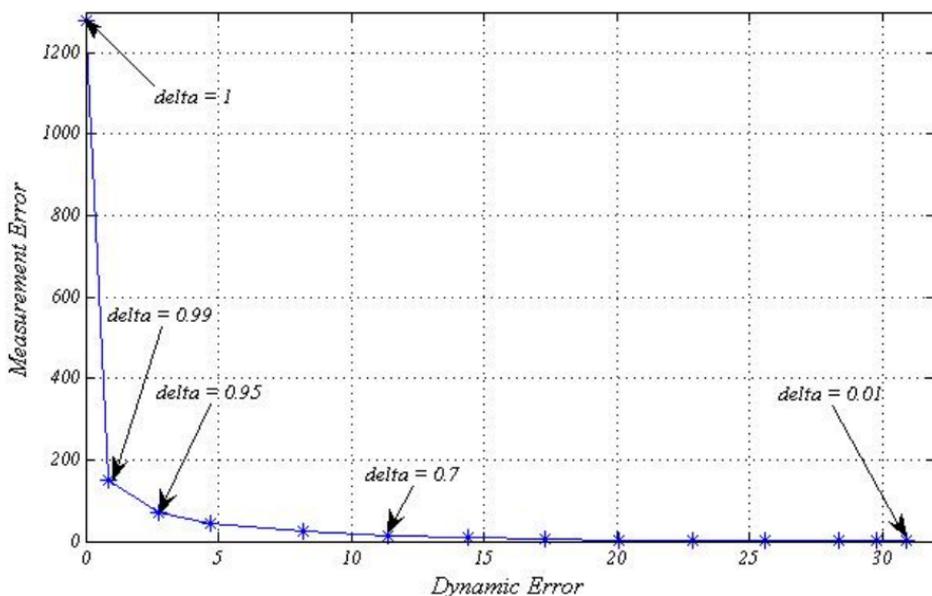
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<sup>6</sup> The FLS method, being cast in a completely deterministic framework, does not have the capability to automatically update the covariance matrices of the system state. In the absence of a complete set of stochastic assumptions, it is difficult to argue that a model represents an adequate or a poor description of the data generating process. Given this limitation, we should view FLS as a diagnostic or exploratory tool for evaluating the basic compatibility of data with theories.

<sup>7</sup> If the true model generating the observations has time-constant coefficients, then, the frontier should be rather flat in a neighbourhood of the OLS extreme point. On the other hand, if the true model generating the observations has time-varying coefficients, the frontier should be fairly steeply sloped in a neighbourhood of the OLS extreme point. In this case the OLS solution is unlikely to provide a good description of the given observations.

In Figure 2, the efficiency frontier for the inflation model is quite steeply sloped in a neighborhood of the OLS extreme point. The constant-coefficient version of the benchmark model (2.7) was first estimated using OLS to obtain reference estimates for comparison against FLS. Thus, permitting even a very small degree of time variation in the coefficients for model result in large decreases in measurement error, thereby, providing strong evidence that the coefficients are changing through time. The FLS estimation results for the alternative values of  $\delta$ , along with the corresponding means, standard deviations and coefficients of variation (standard deviation divided by the mean) are shown in Table 1.<sup>8</sup>

**Figure 2: Residual Efficiency Frontier for Inflation Model**



<sup>8</sup> The reason for doing so is to gather evidence concerning which particular coefficients exhibit the most time variation. The coefficient means will vary if the OLS weighting scheme produces a bias; the coefficient standard deviations will increase monotonically if there is coefficient variation. As we change  $\delta$  by a small amount, the coefficient averages shift, as do the standard deviations. As we move  $\delta$  toward zero, the coefficient averages and standard deviations start to stabilize.

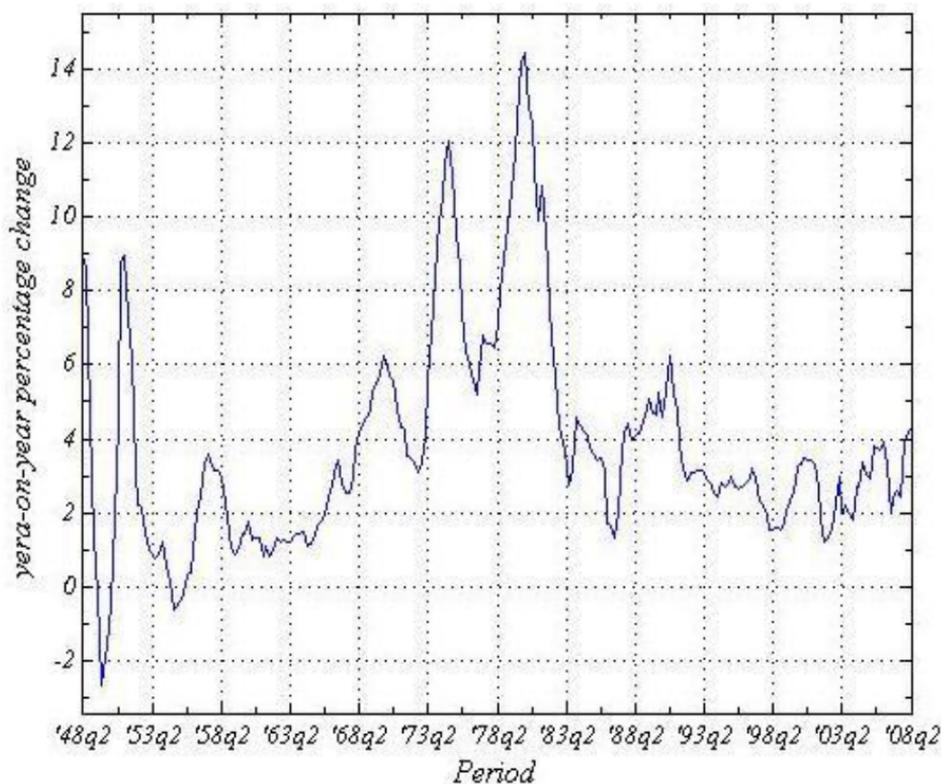
**Table 1: The Summary Statistics of FLS Estimates**

$\delta$	Equation (2.7)		Equation (2.3)		Equation (2.7)	
	$a_0$	$a_1$	$\rho_0$	$\rho_1$	$a_0^c$	$a_1^c$
1.00	3.017	0.139	0.773	0.870	0.756	0.061
0.99	2.917 (0.07) [0.40]	0.158 (0.01) [1.35]	0.701 (0.07) [1.59]	0.805 (0.02) [0.39]	2.651 (0.054) [0.312]	0.009 (0.002) [3.02]
0.95	2.929 (0.09) [0.46]	0.144 (0.02) [1.68]	0.759 (0.11) [2.18]	0.783 (0.03) [0.59]	2.700 (0.065) [0.37]	0.009 (0.002) [3.405]
0.90	2.919 (0.09) [0.48]	0.137 (0.02) [1.79]	0.889 (0.13) [2.30]	0.776 (0.04) [0.71]	2.708 (0.069) [0.391]	0.009 (0.002) [3.554]
0.80	2.903 (0.09) [0.49]	0.131 (0.02) [1.87]	1.077 (0.16) [2.34]	0.772 (0.04) [0.85]	2.707 (0.072) [0.409]	0.008 (0.002) [3.694]
0.70	2.891 (0.09) [0.49]	0.128 (0.02) [1.92]	1.206 (0.18) [2.34]	0.770 (0.05) [0.93]	2.703 (0.074) [0.419]	0.009 (0.219) [3.766]
0.60	2.882 (0.09) [0.50]	0.126 (0.02) [1.95]	1.302 (0.20) [2.34]	0.767 (0.05) [1.00]	2.670 (0.075) [0.425]	0.009 (0.002) [0.811]
0.50	2.875 (0.09) [0.50]	0.124 (0.02) [1.98]	1.381 (0.21) [2.33]	0.764 (0.05) [1.06]	2.697 (0.076) [0.430]	0.009 (0.002) [3.842]
0.40	2.870 (0.09) [0.50]	0.122 (0.02) [2.01]	1.448 (0.22) [2.32]	0.760 (0.05) [1.11]	2.694 (0.076) [0.433]	0.009 (0.002) [3.865]
0.30	2.866 (0.09) [0.51]	0.121 (0.02) [2.03]	1.506 (0.22) [2.31]	0.756 (0.06) [1.16]	2.692 (0.077) [0.436]	0.009 (0.002) [3.883]
0.20	2.863 (0.09) [0.51]	0.120 (0.02) [2.06]	1.560 (0.23) [2.30]	0.750 (0.06) [1.20]	2.691 (0.077) [0.438]	0.009 (0.002) [3.898]
0.10	2.861 (0.09) [0.51]	0.119 (0.02) [2.20]	1.609 (0.24) [2.29]	0.744 (0.06) [1.25]	2.689 (0.077) [0.439]	0.009 (0.002) [3.910]
0.05	2.860 (0.09) [0.51]	0.118 (0.02) [2.12]	1.633 (0.24) [2.29]	0.741 (0.06) [1.28]	2.689 (0.077) [0.440]	0.009 (0.002) [3.915]
0.01	2.859 (0.09) [0.51]	0.118 (0.02) [2.13]	1.652 (0.24) [2.28]	0.738 (0.06) [1.30]	2.688 (0.077) [0.441]	0.009 (0.002) [3.919]

*Note:* The numbers in the table are time-varying coefficient averages at each specified,  $\delta$ . The numbers in parentheses are time-varying coefficient standard deviations and coefficient of variations respectively at each specified,  $\delta$ .

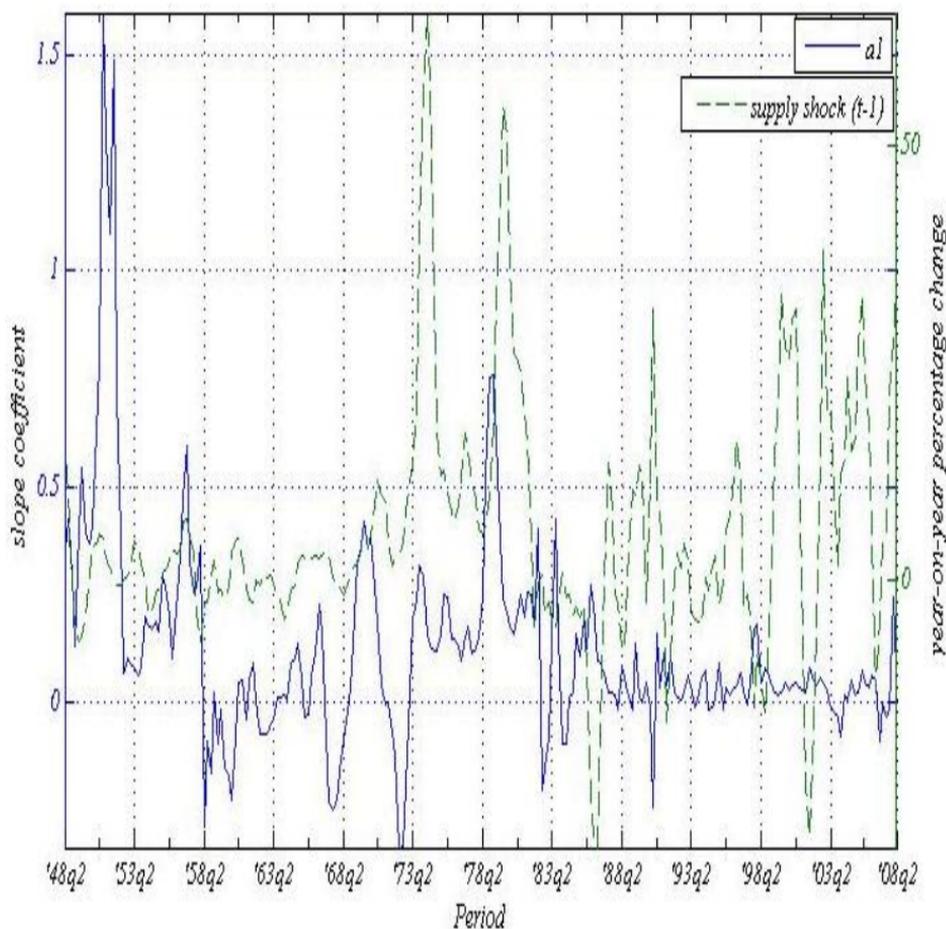
Figure 3 traces out the behaviour of expected inflation implied by our model. We do so by substituting our FLS coefficient estimates of  $a_{0t}$  and  $a_{1t}$  corresponding to the balanced smoothness weight,  $\delta = 0.5$  (where there is a one-for-one trade-off between measurement and dynamic error) along with our proxy for supply shock in (2.6). In the early 1950s, expected inflation moved up sharply and then falls back to initial levels. After that inflation expectations started drifting up once again in the mid-1960s for reasons which were at first unrelated to the oil market. Why did this happen?

**Figure 3: Inflation Expectations generated from the model**



To understand this Figure 4 plots our FLS coefficient estimate of the slope coefficient,  $a_{1t}$  (left axis) along with our proxy for supply shock (right axis). The picture is pretty similar to the behaviour of inflation expectations. We can clearly see that the slope coefficient moved up sharply in the early 1950s and then slowly drifted down. It once again began to rise in the mid-1960s. An interesting question is what prompted this shift in private sector beliefs.

**Figure 4: FLS coefficient ( $a_1$ ) and supply shock**



Mayer (1999) and Bordo (2007) point out that during the 1960s inflation control lacked the vocal political constituency that low interest rates and fast growth had. Mainstream thinking at that time was dominated by Keynesian conviction that if the economy was performing below its potential, then it was the responsibility of the government to use the fiscal and monetary policies at its command to restore it to strength. As a result the Fed shifted its priorities from low inflation toward high employment. Other possible reasons include the belief that the Phillips curve trade-off was exploitable. Indeed, Taylor (1997) contends that policymakers during this period believed that there was a permanent long-run trade-off between the level of unemployment and the level of inflation. This may also explain why the Fed shifted its priorities toward high employment.<sup>9</sup>

The consequence of this shift in priority was expansionary monetary policy, deliberately undertaken to stimulate a weak economy.<sup>10</sup> The private sector internalized this information. As a result the slope coefficient started drifting up and unanchored inflation expectations. Thus, the restraining influence of the nominal anchor had already disappeared by the time the oil shocks occurred in the 1970s.<sup>11</sup> When the first oil shock occurred in 1973-74, inflation expectations took off. As Figure 4 reveals, the slope coefficient rose sharply in response to these developments, suggesting that the private sector believed that the Fed is

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<sup>9</sup> This argument has been formalized by Sargent (1999) and Sargent, Williams and Zha (2006), among others.

<sup>10</sup> This is consistent with the argument put forward in Christiano and Gust (2000) that the initial rise in inflation expectations is not an example of an expectations trap. This is because supply shocks were largely absent in the early 1950s and in the mid-1960s. Inflation expectations rose during these periods as a consequence of expansionary monetary policy, deliberately undertaken to stimulate the economy.

<sup>11</sup> Moreover, as argued by De Long (1997) and Barsky and Killan (2001), the onset of sustained high inflation occurred prior to the oil shocks of the 1970s, thereby raising doubts about the importance of the supply shocks in general, and the 1973-1974 and 1979-1980 oil price shocks in particular, as the primary explanation of the Great Inflation. Indeed, until the time of the first oil shock in 1974, the price of oil is steadily declining, while inflation is steadily rising (see figure 1). Our results are consistent with this interpretation.

likely to be more preoccupied with tackling near-term weakness in economic activity rather than control inflation.

In fact, the policymakers' very public expression of concern about the costs of stopping inflation through monetary restraint helped cement this belief. For example, in the 1974 White House *Economists Conference on Inflation* many distinguished economists stressed the high costs of disinflation. Walter Heller said "in bringing inflation to its knees, we will put the economy flat on its back." Paul Samuelson said we do not need a Winston Churchill-like "blood, sweat, and tears" program to reduce inflation (cited in Taylor, 2002).

The rise in inflationary expectations placed the Fed in a dilemma: either respond with an accommodating monetary policy which then produces a rise in actual inflation or refuse to accommodate and risk a recession. In this case, the Fed ends up validating the original rise in inflation expectations i.e., falls into an expectations trap. As a result inflation outcomes worsened. By the end of the 1970s, inflation had reached levels unheard of in peacetime.

By the end of the 1970s high inflation and slow growth had discredited Keynesian notions of a trade-off between inflation and unemployment. Furthermore, as Mayer (1999) argues, the public's understanding of the costs of inflation had increased, in part because of experiences of high inflation in the 1970s. Public opinion eventually turned against allowing inflation to continue. Politicians, in turn, came to accept the need for an abrupt tightening of policy. Meltzer (2005), for instance, argues that without political and popular support, the Fed would have found it hard to take decisive action. This public pressure forced Volcker to undertake aggressive anti-inflation action from 1979 to 1982, which involved monetary tightening and the raising of policy interest rates to double digits.

The policy led to a sharp recession, but it was successful in breaking the back of high inflation expectations. As Bernanke (2003) argues, the severity of the 1981-82 recession was precisely because of the monetary policies of the preceding fifteen years, which had unanchored inflation expectations and squandered the Fed's credibility (also see Goodfriend and King, 2005). Indeed, as Figure 3 reveals, the dis-inflation program was only partially credible during the initial years as inflation expectations started drifting down only gradually. The behaviour of the slope coefficient during this period is consistent with this interpretation. Notice that the slope coefficient ( $a_{1t}$ ) remained stubbornly high until the mid-1980s, suggesting that the public, in spite of the Fed's anti-inflation actions, continued to doubt its resolve to bring inflation down.

By the time Greenspan came to office in 1987 inflationary expectations had sufficiently stabilized. Nevertheless, Greenspan inherited an inflation scare in the bond market only a few weeks after he arrived at the Fed. The stock market crashed in October 1987, delaying the Fed's inflation-fighting actions and instead causing the Fed to supply liquidity to the financial markets to stabilize financial conditions. As a result both the slope coefficient ( $a_{1t}$ ) and inflation expectations rose temporarily and peaked near 6 percent in 1990. Since then the stability of inflation expectations is particularly striking, especially since this is the period in which the U.S. economy experienced two oil shocks of sign and magnitude comparable to those of the 1970s. It is therefore natural to ask why U.S. inflation expectations appear well anchored during this period.

According to the expectations trap hypothesis if the government finds a way to credibly commit to price stability, then costly jumps in inflation expectations will not occur in the first place. Indeed, the behaviour of the slope coefficient ( $a_{1t}$ ) in Figure 4 reinforces this point.

Whereas the two oil price shocks in the 1970s were associated with significant jump in the slope coefficient, recent surges in energy prices have not had a similar effect. In fact, the slope coefficient hardly budged, suggesting that the public had full faith in the Fed's inflation fighting credentials. Rising credibility of U.S. monetary policy has been cited by various other researchers and leading Federal Reserve officials (i.e., Mishkin, 2007) as playing the dominant role in the improved dynamics of U.S. inflation. But what prompted this shift in private sector beliefs?

A plausible explanation is that both Volcker and Greenspan stressed the benefits of low inflation virtually every time they testified to Congress about monetary policy during their tenures. In 1980, Volcker explained (cited in Romer and Romer, 2004, p.145): *"In the past, at critical junctures for economic stabilization policy, we have usually been more preoccupied with the possibility of near-term weakness in economic activity or other objectives than with the implications of our actions for future inflation. . . . The result has been our now chronic inflationary problem. . . . The broad objective of policy must be to break that ominous pattern. . . . Success will require that policy be consistently and persistently oriented to that end. Vacillation and procrastination, out of fears of recession or otherwise, would run grave risks"*.

Greenspan was also a consistent proponent of the view that low inflation is critical to long-run growth. At his confirmation hearing, he said: *"it is absolutely essential that [the Federal Reserve's] central focus be on restraining inflation because if that fails, then we have very little opportunity for sustained long-term economic growth"* (cited in Romer and Romer 2004, p.157).

Moreover, the sustained decline in inflation that the Fed had managed to engineer since the early 1980s, in spite of two damaging recessions, may have strengthened the public's belief that the Fed was willing to stabilize inflation at any cost. In a recent paper Blinder and Reis

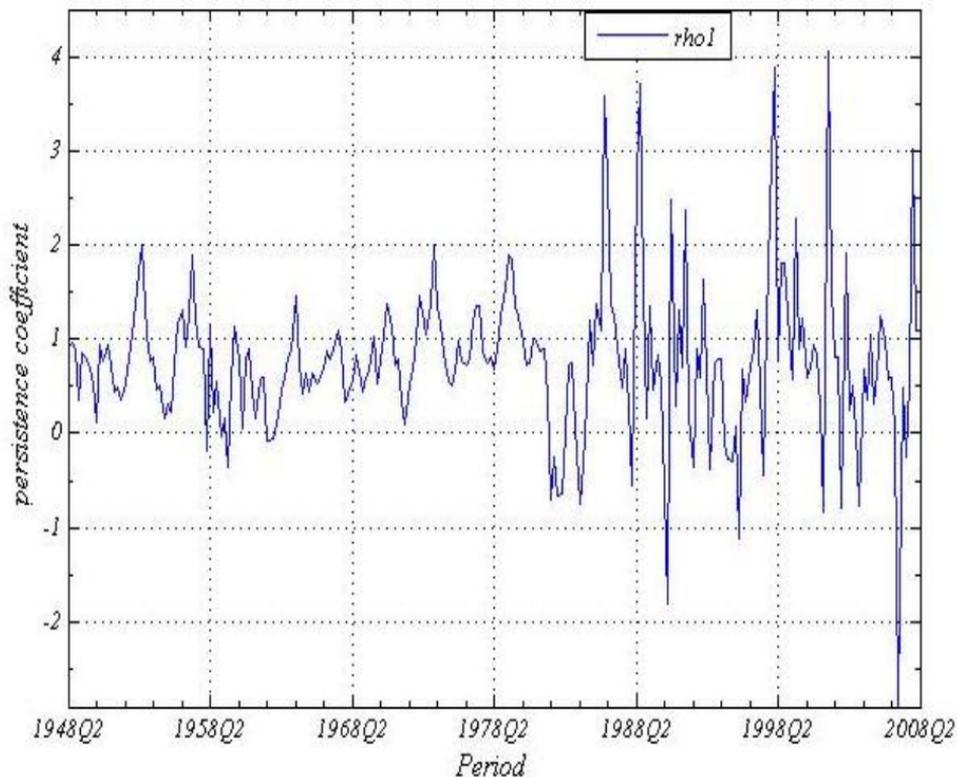
(2005) summarize their views on this issue as follows: “*The Fed brought inflation down dramatically under Paul Volcker and has controlled both inflation and real fluctuations well under Greenspan. In the process, it has built up an enormous reservoir of trust and credibility*”. In sum, both words followed up by action may have helped shift private sector beliefs. Nevertheless, the cause of this moderation in inflationary expectations is much debated. Whether the greater stability experienced during the Greenspan regime reflects better policy or better luck (i.e., smaller shocks) is the subject of much current research (see Mankiw, 2002 and Blanchard and Gali, 2007, for example). Indeed, as our reduced-form inflation model suggests, although an estimate of the slope parameter,  $a_{1t}$ , can reveal whether monetary authorities’ incentive to inflate weakens in response to a bad supply shock, it cannot however reveal the extent to which this is due to changes in the inflation-output trade off,  $\alpha$ , persistence parameter,  $\rho_1$ , and/or shifts in central banker’s preference parameter,  $\lambda$ . Therefore, disentangling the relative importance of each of these competing explanations remains an important challenge.

## **GOOD LUCK OR GOOD POLICY?**

One possibility for why inflation expectations did not take off during the Greenspan regime is that shocks were much less persistent during this period, thereby reducing,  $a_{1t}$ , in our model. This, so the story goes, has diminished the challenges faced by policymakers charged with controlling inflation. We examine this hypothesis more formally by estimating the model (2.3) by the FLS procedure discussed above. The estimation results for the alternative values of  $\delta$ , along with the corresponding means, standard deviations and coefficients of variation are reported in Table 1. Figure 5 depicts time paths for the persistence coefficient ( $\rho_1$ ) estimates corresponding to the balanced smoothness weight,  $\delta = 0.5$ . Interestingly, supply shocks were much more persistent during the

Greenspan era than before. Therefore, this hypothesis cannot account for the decline in the slope coefficient,  $a_{1t}$ .

**Figure 5: FLS coefficient ' $\rho_1$ '**



Another possibility is that the Phillips curve became steeper (rise in  $\alpha$ ) during this period, thereby reducing,  $a_{1t}$ , in our model. Indeed, in a recent paper Rogoff (2003) argues that globalization has led to greater price flexibility, which has reduced the ability of central banks to use inflation surprises to boost output. As a result, policymakers' would be less tempted to try and exploit the Phillips curve, and so will be less likely to pursue overly expansionary monetary policy that leads to

higher inflation. A major problem with this argument is that instead of becoming steeper during this period, the Phillips curve has become flatter in many countries including the U.S. (see Mishkin (2007, 2008).

**Figure 6: Energy intensity of the U.S. economy**



The final hypothesis considered is that the reduced influence of energy and other commodity prices on expected inflation probably reflects, to some extent, the increased energy-efficiency of a more service-oriented U.S. economy. To evaluate this hypothesis we use the Department of Energy's estimates of energy consumption per dollar of GDP (an annual series reported in its *Annual Energy Review*, Table 1). The *AER* data run through 1949-2007 which we interpolate to a quarterly frequency. As Figure 6 shows there is a gradual but notable decline in

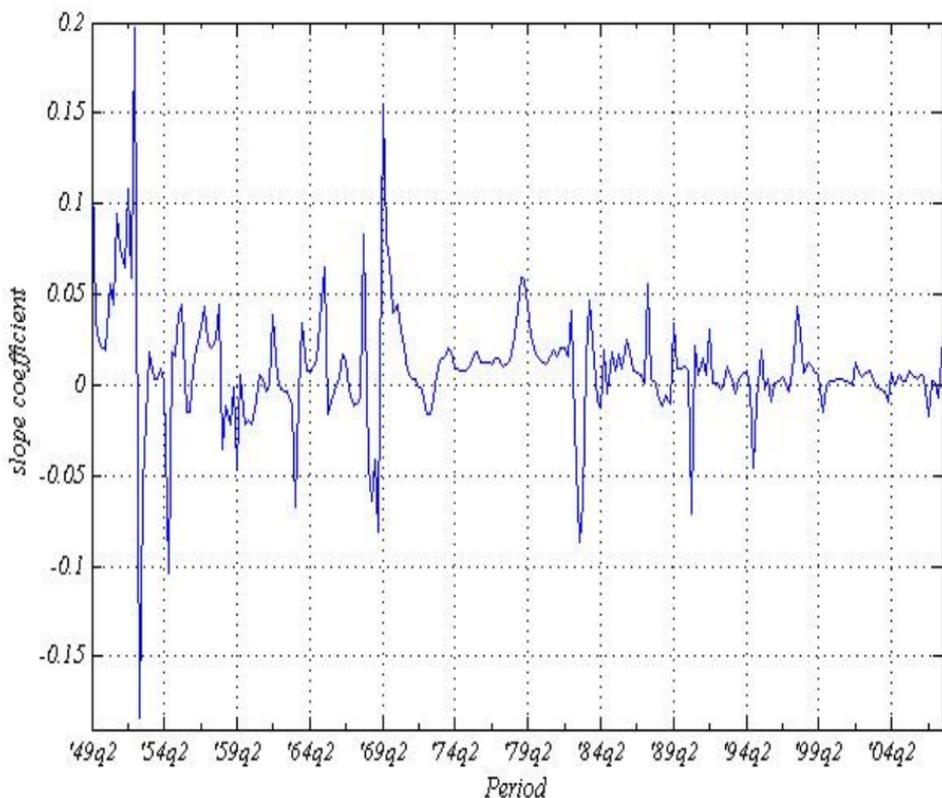
the amount of energy the U.S. economy consumes per dollar of real GDP over the period 1949:1-2007:4. This series is then interacted with the supply shock term in (2.7) and the FLS procedure is repeated. This would in turn allow us to evaluate the behavior of the slope coefficient after controlling for a decline in energy intensity.<sup>12</sup>

The FLS estimation results of the intercept ( $a_{0t}^c$ ) and slope ( $a_{1t}^c$ ) coefficients for alternative values of  $\delta$ , along with the corresponding means, standard deviations and coefficients of variation are shown in Table 1. Finally, the time paths of the slope coefficient traced out by the FLS estimates are plotted in Figure 7. Clearly, when we control for a decline in energy intensity, there is a substantial decline in the magnitude of the slope coefficient. This suggests that the decline in energy intensity partly accounts for the decline in the slope coefficient observed in recent decades.

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<sup>12</sup> Hooker (2002) found that the relationship between oil prices and inflation had declined considerably, even after allowance was made for a secular decline in the energy intensity of the U.S. economy.

**Figure 7: FLS coefficient ( $a_1$ ) after controlling for decline in energy intensity**



Nevertheless, even after controlling for energy intensity, we find a substantial decline in the slope coefficient, specifically after the 1980s. This suggests that changes in private sector beliefs about the conduct of monetary policy also had an important role to play. Specifically, the commitment that no matter what unpredictable shocks the economy is subjected to, the Fed will do what it takes to restore price stability has helped anchor inflation expectations. This interpretation is consistent with the findings of Hooker (2002), Mankiw (2002) and Blanchard and Gali (2007). In sum, we conclude that both institutional commitment to price stability, which influenced private sector beliefs and 'good luck' in the

form of a decline in energy intensity together account for the stability of inflation expectations observed during the Greenspan regime.

## **SUMMARY AND CONCLUDING REMARKS**

The expectations trap hypothesis provides a new perspective on the policy roots of inflation in developed economies. Rather than being due to a systematic attempt to maintain employment above its natural level (or output above potential) this literature raises the possibility that much of the inflationary bursts experienced by developed economies in the 1970s were due to weak monetary institutions. It thereby provides an alternative to the time inconsistency explanation for excessively loose monetary policies. But this literature also suggests that, during periods in which the central bank's resolve to stabilize inflation is strong, as may have been the case during the 1980s and 1990s in the U.S., costly jumps in inflation expectations will not occur in the first place.

We show that the predictions of the expectations-trap hypothesis match the U.S. experience surprisingly well. Specifically, our results suggest that inflation expectations moved up sharply in response to adverse supply shocks in the 1970s mainly because the central bank's commitment to fighting inflation was perceived to be weak. The subsequent fall in inflation expectations was mainly because the Fed acquired sufficient anti-inflation credibility through both words and deeds.

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