

Zero Inflation in Five Years:

Simulations with MQEM

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Introduction

There has been some discussion recently about the feasibility and cost, in terms of increased unemployment and loss of output, of using monetary policy to reduce the rate of inflation to zero over the next five years. In this paper the Michigan Quarterly Econometric Model is used to simulate the impact of a restrictive monetary policy on output, employment and the rate of price inflation.

Before turning to the simulation results, optimal disinflationary policy within the context of a simple price adjustment equation is discussed briefly.

Optimal Disinflationary Policy

Suppose that the policy objective is to minimize

$$J = \sum_{t=1}^T [\{u(t) - u^*(t)\}^2 + w\{p(t) - p^*(t)\}^2]$$

subject to the price adjustment equation (Phillips curve)

$$p(t) = p(t-1) - .384 [u(t-1) - u^*(t-1)]$$

and the terminal conditions

$$u(T) = u^*(T)$$

$$p(T) = p^*(T).$$

These terminal conditions guarantee that $p(t) = p^*(t)$ for $t > T$ if $u(t)$ remains equal to $u^*(t)$ for $t > T$. The variable $u^*(t)$ is

interpreted as the natural rate of unemployment and $p^*(t)$ as the target rate of inflation.

The parameter w in the objective function indicates the relative weight given to squared deviations of the rate of inflation from the target rate. If w equals zero, deviations of the rate of inflation do not enter the objective function and the objective is simply to reduce the rate of inflation from its current rate to the target value $p^*(T)$ over the period $t = 2, \dots, T$. (The rate of inflation in the first period is predetermined by $p(0)$ and $u(0)$.) This reduction in the rate of inflation is to be achieved in such a way as to minimize the (squared) deviations of the unemployment rate from the natural rate of unemployment. If w is positive, deviations of both the rate of inflation and the unemployment rate from their target values enter the objective function. As would be expected, this leads to a more aggressive deflationary policy. For this exercise it is assumed that monetary or fiscal policy can be used to achieve whatever unemployment rate is necessary to minimize the objective function.

The results of three disinflation policies ($w = 0, 1, \text{ and } 10$) are shown in Table 1 and the corresponding inflation and unemployment paths are shown in Figure 1. For these calculations the natural rate of unemployment is taken to be 6%, the target rate of inflation is zero, and the policy horizon is five years.

(The results for other assumed natural rates of unemployment can be readily obtained. If the natural rate of unemployment were equal to some smaller value, say 5.5%, the unemployment rate column in the table would be reduced by .5% for 1990 - 1996.) With $w = 0$, the optimal policy involves an increase in the unemployment rate to 8.8% for four years and then a reduction to the natural rate thereafter. After the first year, the rate of inflation falls steadily to zero, achieving the target of zero

inflation in the fifth year and remaining at zero thereafter. For purposes of comparison, the optimal inflation and unemployment paths for $w = 1$ and $w = 10$ are also shown. With $w = 10$, an unemployment rate of 13.7% is required in the first year followed by a steady reduction to the natural rate in the fifth year and thereafter. The rate of inflation is reduced more rapidly in this case with a rate of inflation of less than .5% in the third year and almost zero in the fourth year of the policy horizon.

The increase in the unemployment rate that is required to achieve the desired reduction in the rate of inflation is determined by the price adjustment equation. The equation that was used above was estimated using annual data (Robert J. Gordon, Macroeconomics (Third Edition), Table A-1) for the period 1954 - 1985. The calculations assume that the price adjustment equation is invariant to changes in monetary and fiscal policy. Whether that is a reasonable assumption is debatable. However, the result is not necessarily inconsistent with a rational expectations approach to the price adjustment equation. Suppose, for example, that the price adjustment equation is given by

$$p(t) = \beta_0 + \beta_1 p(t-1) + \beta_2 [u(t-1) - u^*(t-1)] \\ + \beta_3 p(t|t-1) + e(t)$$

where $p(t|t-1)$ denotes the expected rate of inflation for period t based on information available in period $t-1$. If expectations are rational in the sense that

$$p(t|t-1) = E[p(t)|p(t-1),u(t-1),u^*(t-1)],$$

it follows that, provided $\beta_3 \neq 1$,

$$p(t|t-1) = \beta_0' + \beta_1'p(t-1) + \beta_2'[u(t-1) - u^*(t-1)]$$

where

$$\beta_i' = \beta_i / (1 - \beta_3).$$

The price adjustment equation becomes

$$p(t) = \beta_0' + \beta_1'p(t-1) + \beta_2'[u(t-1) - u^*(t-1)] + e(t)$$

which implies that the price adjustment equation is consistent with rational expectations. (Notice, however, that without some additional assumptions the individual coefficients β_i are not identified.)

If $\beta_3 = 1$, the original price adjustment equation is not consistent with rational expectations unless $\beta_0 = \beta_1 = \beta_2 = 0$. In this case the price adjustment equation reduces to

$$p(t) = p(t|t-1) + e(t).$$

If the expected rate of inflation is given by

$$p(t|t-1) = \alpha_0 + \alpha_1 p(t-1) + \alpha_2 [u(t-1) - u^*(t-1)]$$

the price adjustment equation is

$$P(t) = \alpha_0 + \alpha_1 p(t-1) + \alpha_2 [u(t-1) - u^*(t-1)] + e(t)$$

The point is that a price adjustment equation of the above form is not necessarily inconsistent with rational expectations.

Similarly, if price expectations are given by

$$p(t|t-1) = \gamma_1 p(t-1)$$

the price adjustment equation is given by

$$p(t) = \beta_0 + (\beta_1 + \beta_3 \gamma_1) p(t-1) + \beta_2 [u(t-1) - u^*(t-1)] + e(t).$$

Once again, even though price expectations are not rational in this case, the price adjustment equation will continue to hold even in the face of an announced disinflationary policy, unless the way in which price expectations are formed changes.

If the way in which expectations are generated changes as a result of the announcement or implementation of a disinflationary policy, the price adjustment equation may change. For example, if agents believe that the announced deflationary policy is

credible, $p(t|t-1)$ might immediately decline, deviating from the endogenous path that it would otherwise follow. Alternatively, the expected rate of inflation might not change immediately with the announcement of the disinflationary policy, but might adjust downward when it is observed that sustained disinflationary monetary and fiscal policy actions are being undertaken. For example a sustained increase in the interest rate might signal that the Federal Reserve is serious about reducing the rate of inflation and hence inflationary expectations would be modified even though the effects of the deflationary policy were not yet visible in the actual rate of inflation. Or inflationary expectations might change only in response to an observed decline in the rate of inflation as the result of a publicized and sustained deflationary policy. Any such shifts in inflationary expectations would reduce the increase in the unemployment rate that would otherwise be required to achieve the inflationary target. The Michigan Model simulations to which we now turn will examine several such hypothetical shifts in expectations formation.

Michigan Model Simulations

Control Solution. In order to use the Michigan Quarterly Econometric Model of the U. S. Economy to simulate the impact of a restrictive monetary policy on the inflation and unemployment rates, it was necessary to generate a control solution for the seven year period 1990:1 - 1996:4. The control solution used here corresponds to the March 1990 forecast for the first three years of the simulation period and was extended in a fairly mechanical way for the remaining four years. Annual averages of selected variables are given in Table 2 and control paths for the rate of inflation and the unemployment rate are shown in Figure 2.

Restrictive Monetary Policy. The disinflationary policy that was initiated (retroactively) in the first quarter of 1990 was a 400 basis point increase in the nominal interest rate. This policy move could have been achieved by a decrease in the monetary base with the discount rate set to follow the resultant increase in the interest rate. The actual simulation was carried out by switching the treasury bill rate from an endogenous to an exogenous variable and the discount rate from an exogenous to an endogenous variable in the model.

The response to this highly restrictive change in monetary policy depends critically on what is assumed about the response of the rest of the world. Two cases were considered which are referred to as the closed and open economy responses to the policy shock. In the closed economy case, the exchange rate was set equal to its value in the control solution. Thus any changes in the exchange rate that would otherwise be induced by changes in the balance of trade or changes in the differential between domestic and foreign interest rates were suppressed. (The closed economy label is something of a misnomer since the export and import equations were retained in the model; but the feedback effects on exports and imports that would otherwise occur as a result of changes in the exchange rate were suppressed.) In the open economy simulations, the exchange rate was allowed to respond to changes in the balance of trade and changes in the differential between domestic and foreign interest rates. However, two different cases were examined: in one case the ratio of domestic to foreign interest rates was held equal to the control ratio and in the other case the level of the average foreign interest rate was held at control. The first case produces results that are almost identical to the closed economy run and therefore are not reported here. (In fact, these are the results that are reported here as the closed economy simulation

results. This will be cleaned up in the next revision.) The latter case results in a fairly dramatic movement in the exchange rate which reinforces the restrictive domestic monetary policy and that is what is reported as the open economy simulation result. In neither the closed nor open economy simulations were foreign inflation rates or growth rates varied from their control paths. Thus there was no allowance for the possible reduction in world inflation rates and growth rates as a result of the U. S. deflationary policy.

Annual averages of selected variables are shown in Table 3 for the closed economy simulation and in Table 4 for the open economy simulation. The closed and open economy simulation paths of the rate of inflation and the unemployment rate are shown in Figure 3.

In the closed economy simulation, the annual rate of price inflation as measured by the nonfarm price deflator declines to 2.7% in 1994 which is .6 percentage point below the control value. By 1994, the unemployment rate has increased to 6.4%, or 1.1 percentage points above the control value. The rather meager reduction in the rate of inflation should not be surprising in view of the expository results of the preceding section. As we saw, it takes a fairly dramatic increase in the unemployment rate to have a significant impact on the rate of inflation. In the Michigan Model, the closed economy response to an increase in the interest rate does not result in a very dramatic increase in the unemployment rate, even over a period of five years.

The open economy response is considerably more dramatic. By 1994 the rate of inflation is reduced to 1.7% while the unemployment rate is increased by 4.1 percentage points over the control solution to 9.4%. Notice, however, that the rate of

inflation as measured by the GNP or PCE deflators has changed very little relative to the control solution. This is not a surprising result for the following reason. Import prices rise in this simulation because the exchange rate falls while foreign prices remain fixed at their control values by assumption. And import prices have a larger impact on the PCE deflator than they have on the nonfarm price deflator.

Expectational Effects. The closed and open economy responses described above assume that expectations continue to be generated endogenously as specified in the model. In order to estimate the potential impact of a shift in expectations formation, two important equations in the model in which expectations appear were identified. One is the wage adjustment equation and the other is the equation for the term structure of interest rates. Three different assumptions were made about the way in which expectations might change. The most extreme assumption is that market participants immediately reduce their inflationary expectations to zero in response to the announced deflationary policy. The two other more moderate assumptions modify the timing of the change in inflationary expectations. In the intermediate case, it was assumed that market participants change their expectations formation after observing the increased interest rate for four quarters. The least extreme assumption was that market participants wait until they actually see a decline in the rate of price inflation before they revise their expectations generating mechanism. In this simulation this occurs eight quarters into the simulation period.

The closed and open economy responses with the extreme expectations assumption are summarized in Tables 5 and 6. The simulation paths for the inflation and unemployment rates are shown in Figure 4.

The extreme expectations assumption takes an additional

point out of the rate of inflation as measured by the nonfarm price deflator. By 1994, the rate of inflation is only .6% in the open economy experiment and continues to fall in 1995 and 1996. The unemployment rate does not increase as much in this case as in the endogenous expectations case. Thus there appears to be a more favorable trade-off between inflation and unemployment. It should be emphasized, however, that both the inflation and unemployment rates are endogenous variables in the model and both are being driven by the monetary policy change. The lower inflation rate relative to the control path is relatively expansionary and this attenuates the increase in the unemployment rate. Notice, however, what happens to the twin deficits! Notice also how little of the reduction in the rate of change of the nonfarm price deflator filters through to the GNP and PCE deflators.

Conclusion

With an extreme expectations assumption and no reaction on the part of the rest of the world to the deflationary (contractionary) U.S. policy, a 400 basis point increase in the treasury bill rate is successful in reducing the annual rate of increase in the nonfarm price deflator in 1994 from a control solution value of 3.4% to .6%. The cost is an increase in the unemployment rate of 3.9 percentage points and real GNP in 1994 is 9.2% below the control value. Smaller reductions occur in the rate of inflation as measured by the GNP and PCE deflators.

Table 1. Optimal Disinflation Policies
 $p(t) = p(t - 1) - .384 [u(t - 1) - 6]$

	w = 0		w = 1		w = 10	
	p	u	p	u	p	u
1989	4.10	5.30	4.10	5.30	4.10	5.30
1990	4.37	8.82	4.37	10.03	4.37	13.74
1991	3.28	8.82	2.81	8.95	1.37	8.44
1992	2.19	8.82	1.67	8.30	0.43	6.79
1993	1.09	8.82	0.77	8.00	0.12	6.31
1994	0.00	6.00	0.00	6.00	0.00	6.00
1995	0.00	6.00	0.00	6.00	0.00	6.00
1996	0.00	6.00	0.00	6.00	0.00	6.00

Table 2. Michigan Model Control Solution: 1990 - 1996

	1989	1990	1991	1992	1993	1994	1995	1996
GNP82	4143.7	4248.5	4369.0	4478.7	4623.2	4787.5	4943.5	5104.1
C82	2669.4	2738.6	2808.2	2866.7	2930.0	3004.2	3079.7	3157.3
IBF82	509.9	521.3	537.9	553.7	575.9	608.1	640.9	673.2
NX82	-52.8	-41.5	-27.9	3.7	36.6	48.8	59.4	75.2
NIASF	-148.5	-146.6	-116.6	-93.0	-71.8	-68.9	-70.8	-73.4
NX	-57.3	-53.2	-60.2	-42.4	-21.6	-23.8	-31.5	-35.3
PGNP	126.3	130.8	135.8	141.1	146.1	151.3	156.7	162.5
PPNF	124.3	128.8	133.8	138.6	143.2	147.9	153.0	158.6
PC	130.0	135.6	141.9	148.5	155.3	162.1	169.4	177.2
JCMH	209.7	221.9	234.7	248.3	262.7	278.0	294.6	312.7
JEXR	98.52	90.74	88.02	86.45	85.86	85.70	85.39	84.76
RAAA	9.26	9.29	9.38	9.28	9.31	9.36	9.45	9.58
RTB	8.11	7.76	7.67	7.44	7.6	7.75	7.9	8.06
RUG	5.27	5.29	5.41	5.61	5.59	5.40	5.30	5.23
PPNF%		3.68	3.82	3.58	3.36	3.29	3.43	3.65
PGNP%		3.55	3.84	3.88	3.58	3.55	3.59	3.71
PC%		4.33	4.60	4.68	4.53	4.44	4.48	4.60

Table 3. Michigan Model Closed Economy Simulation: 1990 - 1996

	1989	1990	1991	1992	1993	1994	1995	1996
GNP82	4143.7	4223.6	4276.4	4357.9	4483.2	4622.6	4752.7	4890.9
C82	2669.4	2736.2	2791.4	2841.6	2898.3	2963.8	3029.3	3096.9
IBF82	509.9	516.9	508.9	508.6	524.2	550.3	576.9	603.9
NX82	-52.8	-37.3	-6.3	32.7	58.6	58.9	57.5	61.4
NIASF	-148.5	-168.1	-171.3	-164.5	-158.0	-174.5	-199.6	-227.8
NX	-57.3	-48.0	-30.8	3.7	24.2	15.1	0.3	-11.3
PGNP	126.3	130.8	136.2	141.5	146.2	150.9	155.6	160.6
PPNF	124.3	129.0	134.3	139.0	143.0	146.8	150.8	155.0
PC	130.0	135.7	142.1	148.6	154.9	161.2	167.7	174.5
JCMH	209.7	221.9	234.4	247.1	259.9	273.1	287.1	302.1
JEXR	98.52	90.7	88.0	87.3	88.1	89.5	90.6	91.4
RAAA	9.26	11.01	12.09	12.56	12.88	13.07	13.22	13.38
RTB	8.11	11.76	11.67	11.44	11.6	11.75	11.9	12.06
RUG	5.27	5.43	6.08	6.52	6.56	6.43	6.39	6.33
PPNF%		3.80	4.13	3.46	2.89	2.68	2.71	2.80
PGNP%		3.59	4.07	3.89	3.33	3.20	3.17	3.21
PC%		4.37	4.73	4.60	4.23	4.04	4.02	4.07

Table 4. Michigan Model Open Economy Simulation: 1990 - 1996

Year	1989	1990	1991	1992	1993	1994	1995	1996
GNP82	4143.7	4216.9	4216.1	4199.5	4212.5	4233.5	4241.5	4258.0
C82	2669.4	2736.3	2784.3	2814.1	2840.9	2869.0	2890.9	2910.1
IBF82	509.9	516.6	501.3	479.2	465.1	459.5	453.4	448.4
NX82	-52.8	-47.6	-56.3	-60.6	-76.5	-121.3	-169.7	-214.8
NIASF	-148.5	-165.4	-180.5	-206.0	-239.9	-300.3	-376.3	-461.2
NX	-57.3	-43.9	-44.9	-33.8	-33.1	-59.5	-90.0	-117.9
PGNP	126.3	131.2	137.1	143.0	148.2	153.0	157.6	161.7
PPNF	124.3	129.0	134.3	138.7	141.9	144.3	146.0	147.3
PC	130.0	135.6	141.9	148.1	153.7	158.8	163.6	168.0
JCMH	209.7	221.9	234.1	245.6	255.8	264.7	272.3	278.6
JEXR	98.52	93.27	95.40	99.68	105.91	113.28	121.03	128.98
RAAA	9.26	11.01	12.09	12.56	12.86	13.01	13.11	13.20
RTB	8.11	11.76	11.67	11.44	11.6	11.75	11.9	12.06
RUG	5.27	5.46	6.49	7.71	8.66	9.40	10.20	10.91
PPNF%		3.80	4.10	3.27	2.33	1.65	1.21	0.86
PGNP%		3.85	4.53	4.32	3.60	3.27	2.96	2.66
PC%		4.32	4.60	4.38	3.81	3.32	2.98	2.70

Table 5. Michigan Model Closed Economy Simulation: 1990 - 1996
Announcement Credibility

Year	1989	1990	1991	1992	1993	1994	1995	1996
GNP82	4143.7	4222.1	4275.5	4359.2	4486.4	4629.0	4765.0	4912.9
C82	2669.4	2733.1	2784.2	2831.4	2884.9	2947.5	3010.6	3076.8
IBF82	509.9	516.7	508.1	507.6	523.3	550.3	578.6	608.4
NX82	-52.8	-37.2	-7.1	28.4	49.6	45.5	40.7	42.7
NIASF	-148.5	-168.2	-174.9	-173.5	-174.9	-200.4	-234.7	-272.1
NX	-57.3	-47.8	-31.2	-1.1	12.5	-3.2	-24.2	-41.8
PGNP	126.3	130.6	135.1	139.2	142.5	145.8	149.1	152.5
PPNF	124.3	128.8	133.1	136.4	138.8	141.0	143.4	146.1
PC	130.0	135.5	141.2	146.5	151.5	156.3	161.3	166.6
JCMH	209.7	220.2	229.3	237.7	245.8	254.2	263.2	272.9
JEXR	98.52	90.80	88.90	89.39	91.48	93.95	96.00	97.46
RAAA	9.26	10.80	11.65	11.98	12.26	12.48	12.67	12.84
RTB	8.11	11.76	11.67	11.44	11.6	11.75	11.9	12.06
RUG	5.27	5.44	6.09	6.51	6.53	6.38	6.30	6.19
PPNF%		3.66	3.35	2.43	1.78	1.60	1.71	1.88
PGNP%		3.44	3.45	3.02	2.38	2.26	2.26	2.33
PC%		4.25	4.16	3.80	3.36	3.17	3.21	3.32

Table 6. Michigan Model Open Economy Simulation: 1990 - 1996
Announcement Credibility

Year	1989	1990	1991	1992	1993	1994	1995	1996
GNP82	4143.7	4215.5	4215.3	4201.2	4216.8	4242.3	4258.5	4287.4
C82	2669.4	2733.1	2777.3	2804.7	2829.5	2856.9	2879.7	2901.3
IBF82	509.9	516.4	500.4	478.2	464.3	459.7	455.8	454.0
NX82	-52.8	-47.6	-57.2	-65.5	-86.9	-137.4	-190.6	-239.3
NIASF	-148.5	-165.5	-184.1	-214.2	-254.3	-320.8	-401.2	-488.3
NX	-57.3	-43.7	-45.1	-37.8	-42.7	-74.1	-108.9	-140.6
PGNP	126.3	131.0	136.1	140.8	144.6	148.0	151.2	154.2
PPNF	124.3	128.8	133.1	136.1	137.8	138.7	139.1	139.3
PC	130.0	135.5	140.9	146.0	150.3	154.0	157.5	160.8
JCMH	209.7	220.2	229.0	236.4	242.3	246.9	250.7	253.6
JEXR	98.52	93.40	96.43	102.09	109.88	118.80	127.91	136.91
RAAA	9.26	10.80	11.65	11.98	12.26	12.48	12.67	12.84
RTB	8.11	11.76	11.67	11.44	11.6	11.75	11.9	12.06
RUG	5.27	5.47	6.50	7.70	8.62	9.32	10.05	10.65
PPNF%		3.66	3.32	2.25	1.25	0.63	0.32	0.12
PGNP%		3.70	3.91	3.47	2.68	2.39	2.16	1.96
PC%		4.20	4.04	3.58	2.95	2.49	2.24	2.09

Figure 1. Optimal Disinflation Policies

$$p(t) = p(t-1) - .384 [u(t-1) - 6]$$

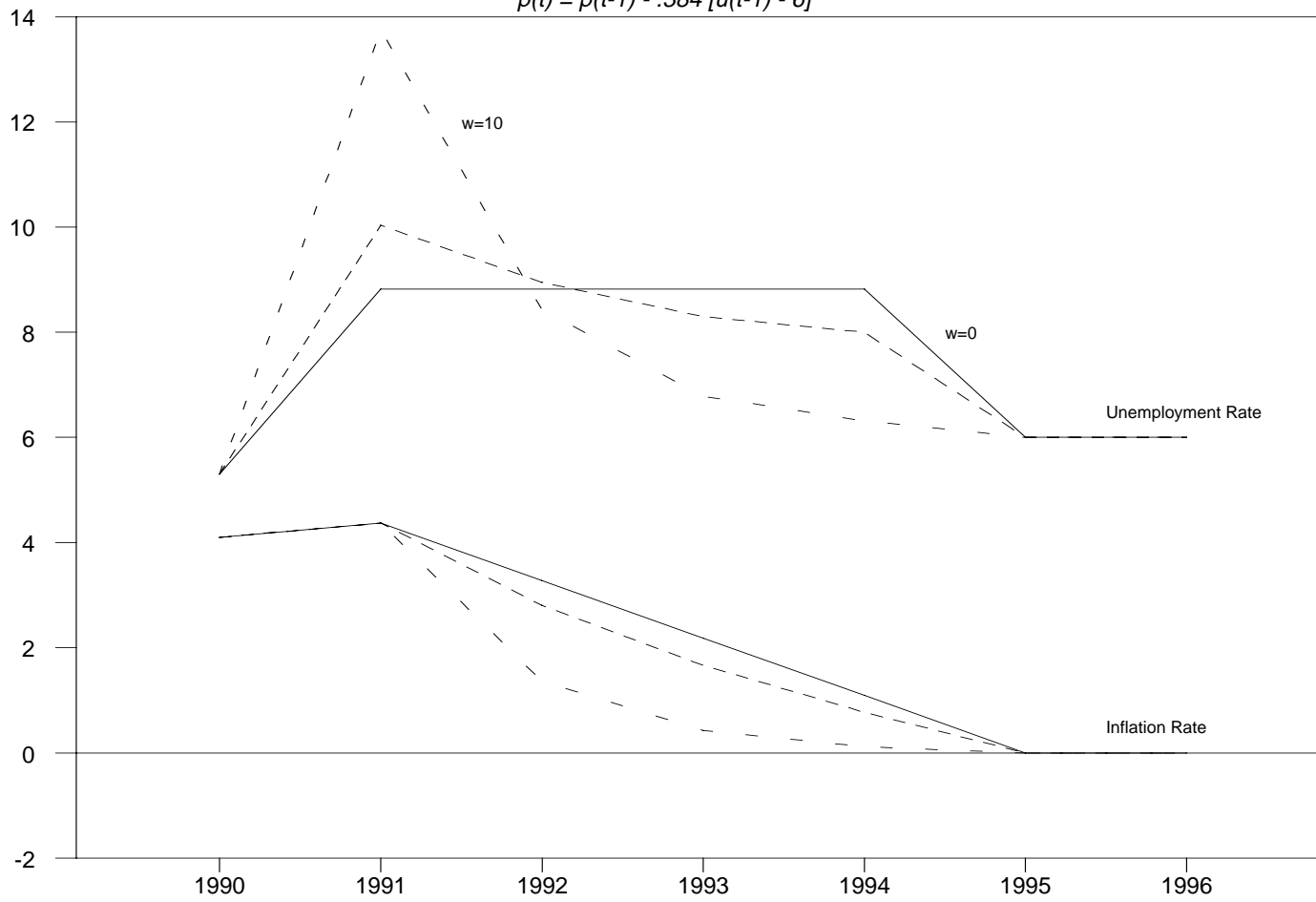


Figure 2. Inflation and Unemployment Rates

Michigan Model Control Solution

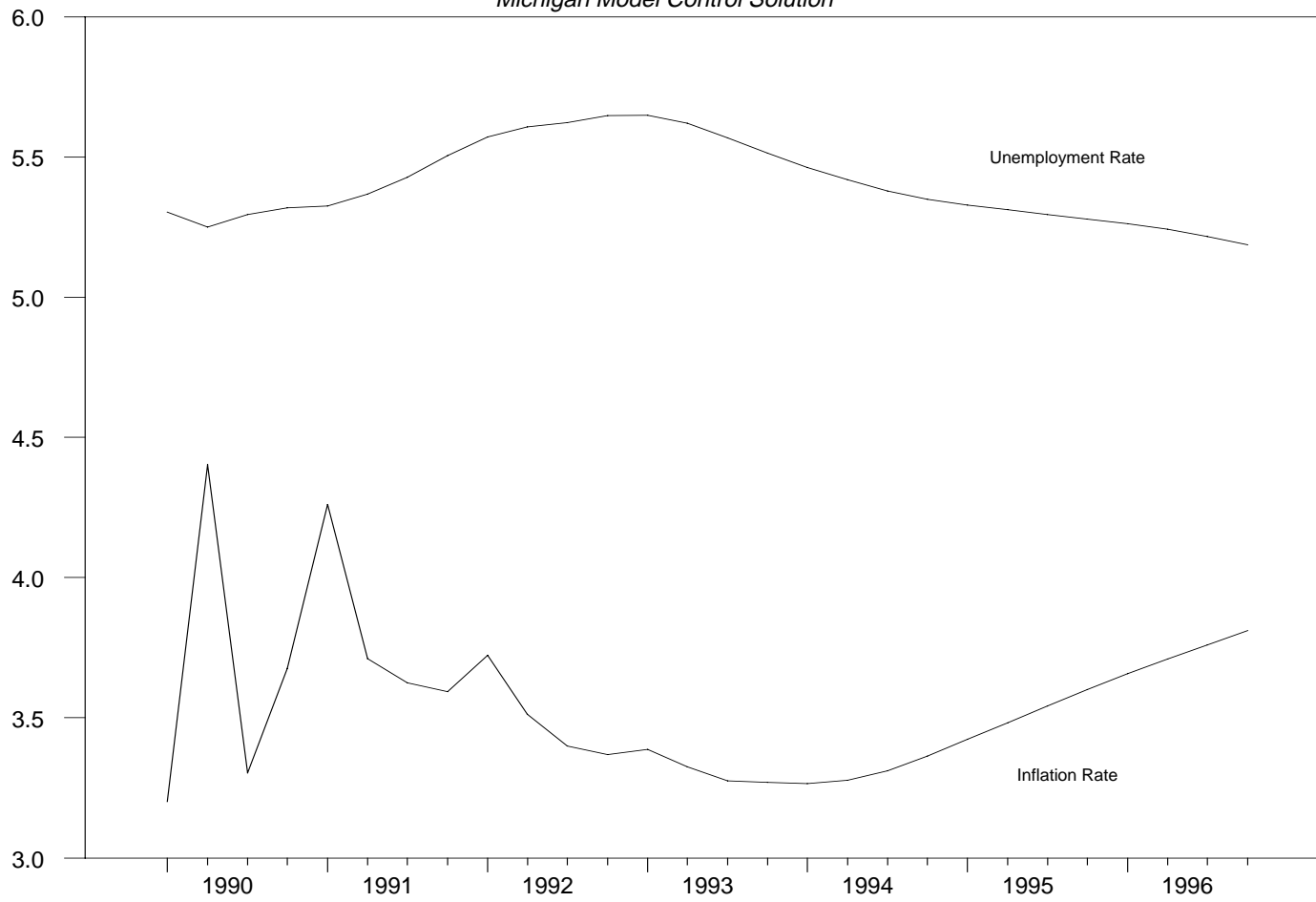


Figure 3. Inflation and Unemployment Rates

Endogenous Expectations

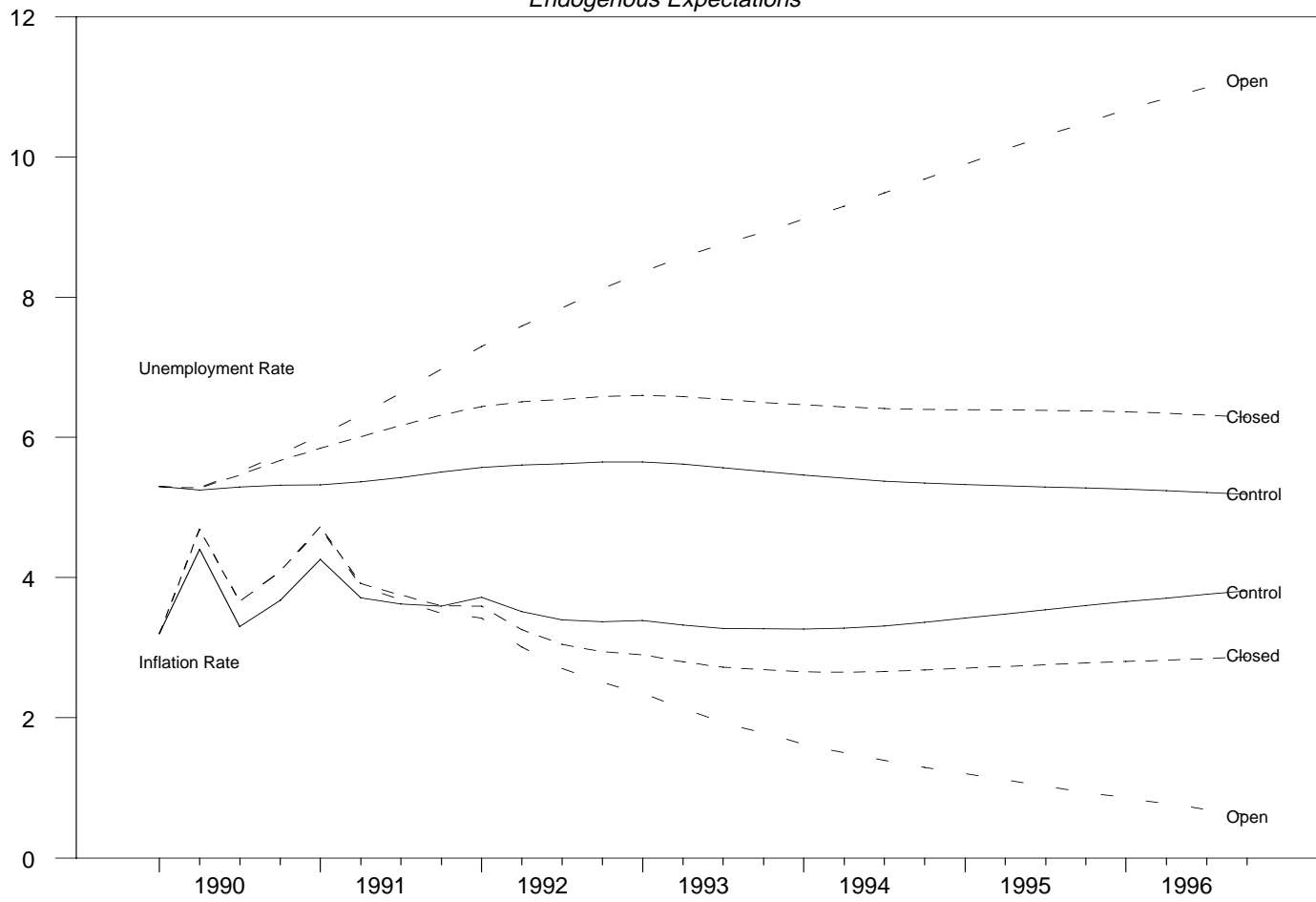


Figure 4. Inflation and Unemployment Rates

Announcement Credibility

