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MONEY, INFLATION, AND SECTORAL SHIFTS

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I. Introduction

Recent empirical evidence has cast doubt on both the sticky-price model (see Fischer (1977) and Phelps and Taylor (1977)) and incomplete-information model (see Lucas (1972)) of the unemployment/inflation trade-off.[1] This paper presents an alternative model of the short-run Phillips curve based on the idea that money has distributional effects that cause dispersion in growth across sectors. In addition to explaining the short-run Phillips curve relationship, the model predicts a long-run positive relationship between inflation and unemployment.

These results are reminiscent of Milton Friedman's Nobel Prize address (1977), where he argued that there exists a negatively sloped Phillips curve in the short run and a positively sloped Phillips curve in the long run. Recently, Kormendi and Maguire (1985) have provided supporting evidence for Friedman's hypothesis. Using cross-country data, they show that there is a negative relationship between the inflation rate and the growth rate of real output. This paper presents a model which explains these observations without relying on sticky prices or incomplete information.

In addition, this paper is consistent with Lilien's sectoral shifts hypothesis. Lilien (1982) has shown that unemployment is positively related to sectoral dispersion. He argues that periods of high unemployment are characterized by a substantial amount of labor force reallocation.

The model in this paper postulates that money has distributional effects that cause dispersion in the growth rate of output across sectors. The distributional effects of money may be motivated on several grounds.

For example, Feldstein (1980) argues that because depreciation is deducted at historic costs, the high inflation rates of the 1970s caused a decline in the real stock value of firms. This effect should be most pronounced in capital-intensive industries, such as manufacturing. In addition, since capital-intensive industries have relatively long-lived assets, a higher inflation rate will hurt the manufacturing sector more than it will the service sector: capital-intensive industries have more assets that must be deducted at historic costs, and these assets are older on average. Consequently, a greater differential exists between the firm's historic price and the current purchase price of an asset.

It follows that higher inflation will lead to increased sectoral dispersion as workers in the manufacturing sector relocate to the service sector. The implication that increased inflation leads to increased sectoral dispersion is tested by regressing Lilien's dispersion index on the rate of inflation. The regression yields a positive and significant coefficient on the inflation rate.

Our model also explains the short-run negative relationship between unemployment and inflation. We assume that there are short-run frictions that prevent workers from immediately switching sectors. A higher inflation rate causes more sectoral dispersion, which leads to an increase in the unemployment rate. The short-run effect, however, is a decrease in unemployment as the currently unemployed accept jobs at a faster rate than the workers in the low-demand sector sever their employment relationships.

This friction can be motivated on several grounds. For example, Shultze (1985) argues that it is more costly to sever an employment relationship than it is to commence one. Alternatively, this friction may be the result of industry-specific human capital. If a fraction of the training necessary to switch sectors can be achieved while workers are employed in the original sector, then the model can explain the short-run negative Phillips curve relationship. The paper is organized as follows. Section II introduces the model and discusses its implications. Section III presents the simulations and empirical work. Section IV concludes with a discussion of additional empirical tests of the model.

II. The Model

This section presents a two-period, two-sector, overlapping-generations model in which fiat money is the only store of value. Agents are heterogeneous in the sense that they have different preferences for the two goods produced in the economy. Each agent consumes one, but not both, of the two goods produced. We label the goods "C" and "D" and assume that half of each generation is born with a preference for the C-good (henceforth called the C-agents) and the other half is born with a preference for the D-good (henceforth called the D-agents). For simplicity, we assume that C-agents are born into the C-sector and D-agents are born into the D-sector. Agents may produce in either sector; however, an agent born in one sector can produce in the other sector only if he undergoes a period of training, costing δ. It is assumed that this training takes place on the job.

As usual, money enters this world via transfers to the old agents of each generation. The asymmetric growth across sectors is generated by assuming that the old agents who consume the D-good get a larger per-capita money transfer than the old agents who consume the C-good. The assumption that money is transferred to agents based on their preferences is used as a proxy for the distributional effects of money or inflation in the real world. Agents consume only in the second period of their life and have linear preferences over second-period consumption. Each young person faces the constraint that his consumption is less than or equal to his total lifetime production plus his money transfer. When young, each agent produces a unit of output in the sector in which he is born. When old, an agent either produces in the sector in which he was born, moves to the other sector and produces, or consumes leisure. If an agent chooses to move to the other sector, there is a probability a that he will find employment. This probability is derived endogenously in a simple-search "model in which workers search across firms for a good job match. It is assumed that an unemployed worker cannot return to his original sector to work.

Formally, the preferences and constraints are as follows:

Preferences

$$U_t = C_{t+1} \qquad \text{for C-agents}$$
$$U_t = D_{t+1} \qquad \text{for D-agents}$$

Constraints

$$C_{t+1} \leq P_{t+1}(1/P_t + m_{t+1}^c) + 1 \qquad \text{C-agents employed in C-sect}$$
$$C_{t+1} \leq P_{t+1}(1/P_t + m_{t+1}^c) + P_{t+1}^d(1 + \varepsilon) \qquad \text{C-agents employed in D-sect}$$
$$C_{t+1} \leq P_{t+1}m_{t+1}^c \qquad \text{C-agents unemployed}$$
$$D_{t+1} \leq P_{t+1}/P_{t+1}^d(P_t^d/P_t + m_{t+1}^d) \qquad \text{D-agents}$$

where m_{t+1}^c = money transfer to C-agents and

m_{t+1}^d = money transfer to D-agents.

We follow the usual convention that P_t is the C-good price of money at time t, and P_t^d is the C-good price of the D-good. Agents who remain in the sector in which they were born produce one unit of output. Agents who move to the other sector produce $1 + \varepsilon$ units of output, where ε is a random productivity component assumed to be uniformly distributed between -1 and 1. The variable ε is assumed to be an individual- or firm-specific job-matching component. Unlike a standard job-matching model, unemployed workers learn their job match after applying for a job instead of after working for a firm. However, an unemployed worker can apply for only a limited number of jobs (for simplicity assumed to be 1) each period.

The first constraint says that a C-agent who remains in the C-sector can sell his unit of output in period t for P_t units of fiat currency, can carry that money into period t+1, and can purchase P_{t+1} units of the C-good. In addition to the value of first-period production, this agent can consume the value of his money transfer $P_{t+1}m^c_{t+1}$ and the additional unit produced in his second period of life. The rest of the constraints are constructed in a similar fashion.

Note that the above constraints consider only movements from the C-sector to the D-sector. Since we consider only inflationary economies (those that favor the D-good over the C-good), this restriction will not affect our results. Therefore, we do not consider a matching component for agents born in the D-sector who wish to move to the C-sector. We impose this assumption in order to highlight the sectoral reallocation aspects of the model. Allowing a matching component for D-sector workers would not affect our general results.

The C-agents of generation t face the decision in period t of whether to remain in their original sector for both periods or move to the D-sector at time t+1. We assume that an agent must undergo training in order to move. The training costs 6, takes one period to complete, and takes place while the young C-agent is employed.

A fraction, 8, of agents who decide to train and incur the cost δ to switch sectors will quit in order to search for a job in the D-sector. Once they move to the D-sector they will accept a job as long as the productivity component, ε, is greater than or equal to their reservation productivity, $\bar{\varepsilon}_t$. Formally, C-agents will retrain for a job in the D-sector as long as the following condition holds:

$$1 < -\delta + \theta_{t+1}[\alpha_{t+1}P^d_{t+1}(1 + E[\varepsilon_{t+1}|\varepsilon_{t+1} \geq \bar{\varepsilon}_{t+1}) + B(1 - \alpha_{t+1})]$$

$$+ (1 - \theta_{t+1}) \qquad (1)$$

&here 6 - cost of training

a - probability of accepting a job

θ - probability of moving once a worker is trained

B - utility value of leisure

ε - worker-/.firm-specificproductivity component

$\bar{\varepsilon}_t$ = reservation productivity

E[•] is the expectations operator.

The left side of equation (1) represents the value of staying in the C-sector. Agents who stay in the C-sector produce and consume one unit of the C-good. The right side represents the expected return from migrating to the D-sector, less the cost of retraining, 6. There is a probability θ_{t+1} that a C-agent will switch sectors. The expected return from switching sectors is the probability that a worker accepts a job multiplied by the value of his production in that sector, plus the probability that he does not accept a job multiplied by the utility value of leisure. In equilibrium, C-agents will train to move to the D-sector until equation (1) holds with equality.

Retraining for a job and moving to another sector are separate decisions. Equation (1) determines γ, the proportion of C-agents who retrain for jobs in the D-sector. We also need to determine 8, the proportion of retrained C-agents who will migrate to the D-sector. Once a C-agent has retrained, he will move as long as the following condition holds:

$$1 < \alpha_{t+1} P_{t+1}^{d}(1 + E[\varepsilon_{t+1} | \varepsilon_{t+1} \geq \bar{\varepsilon}_{t+1}) + B(1 - \alpha_{t+1}). \qquad (2)$$

Notice that if there is no cost of training, $\delta = 0$, and $\theta = 1$, then equations (1) and (2) are identical. Although the retraining and migrating decisions are separate, casual inspection of equations (1) and (2) reveals that with perfect foresight, $\theta = 1$. However, if money growth is less than expected, θ may be less than 1. Recall that agents must plan one period ahead in order to move. If their one-period-ahead plans are based on high inflation and if the realized inflation rate is low, the return to switching sectors may be so low as to reverse the inequality in equation (2).

For workers who chose to retrain and subsequently decided to quit, their reservation match is given by $\bar{\varepsilon}$. This reservation productivity is derived from a standard search model. Workers' productivities are assumed to be randomly distributed across firms. Unemployed workers compare the return from accepting a job with a particular match, ε, with the value of remaining unemployed, B. Unemployed workers can apply for only one job during the second period of their life. After the application process, both the applicant and the firm observe the worker's productivity, $1 + \varepsilon$. The reservation productivity is determined by

$$P_{t+1}^{d}(1 + \bar{\varepsilon}_{t+1}) = B. \qquad (3)$$

An agent is indifferent between a match of $\bar{\varepsilon}$ and not working, in which case the agent consumes the value of his leisure B. A C-agent who accepts a job producing $1 + \varepsilon$ units of the D-good can sell it and consume $P^d_{t+1}(1 + \varepsilon_{t+1})$. Recalling that ε is uniformly distributed from -1 to 1, the probability that a C-agent will accept a job is equal to

$$\alpha_t = \text{Prob}(\varepsilon \geq \bar{\varepsilon}_t) = (1/2)\int_{\bar{\varepsilon}_t}^{1} d\varepsilon = 1/2 - \bar{\varepsilon}_t/2. \qquad (4)$$

Money transfers in this economy are asymmetric, that is, D-agents get a larger per-capita money transfer than C-agents. This assumption implies the following money transfer scheme:

$$m^c_t = \lambda\pi m_{t-1}$$

$$m^d_t = (1-\lambda)\pi m_{t-1}$$

where π = growth rate of the money supply and

λ = distribution parameter: $0 \leq \lambda \leq 1/2$.

We restrict $0 \leq \lambda \leq 1/2$ in order to induce the asymmetric effects described above. To close the model, we use the preferences and constraints to solve for equilibrium in the C-good and D-good markets.

C-good equilibrium (supply = demand)

$$1 + (1 - \theta_t\gamma_{t-1}) = (1 - \theta_t\gamma_{t-1}) + P_t/P_{t-1} + \lambda\pi m_{t-1}P_t$$

$$+ \gamma_{t-1}\theta_t P^d_t\alpha_t(1 + E[\varepsilon|\varepsilon \geq \bar{\varepsilon}_t]) \qquad (5)$$

D-good equilibrium (supply = demand)

$$2 + \gamma_{t-1}\theta_t P_t^d \alpha_t (1 + E[\varepsilon | \varepsilon \geq \bar{\varepsilon}_t])$$

$$= 1 + (1 - \lambda)\pi m_{t-1} P_t / P_t^d + (P_{t-1}^d P_t)/(P_{t-1} P_t^d) \qquad (6)$$

The left side of equation (5) represents the supply of the C-good at time t. The first term is the supply of the young. The second term, $1 - \theta_t \gamma_{t-1}$, is the supply of the old who remained in the C-sector. There are $1 - \theta_t \gamma_{t-1}$ old C-agents who remain in the C-sector at time t, each of whom produces one unit of output. The first term on the right side is the demand by the old who remain in the C-sector. The second term represents the goods purchased in period t by those who were young in period t-1. Each young C-agent in period t-1 purchases $1/P_{t-1}$ units of currency. This currency can purchase P_t/P_{t-1} units of the C-good in period t. The third term represents the amount of the C-good that can be purchased with the money transfer given to the old C-agents. The last term is the demand by the old who moved to the D-sector and accepted employment.

Equation (6) was constructed in a similar fashion. The "2" represents the supply of the young and old D-agents. The second term is the supply of the old C-agents who accepted employment in the D-sector. The right side of equation (6) is the demand for the D-good.

Equilibrium in this economy is characterized by a set of sequences $\{P_t, P_t^d, D_t, C_t, \theta_t, \gamma_t, \alpha_t, \bar{\varepsilon}_t\}$ for $t = 1, \ldots,$ that satisfy equations (1) through (6). These six equations can be solved for six reduced-form expressions (see the appendix for the details of this procedure):

$P_t = P(B, \lambda, \pi, \delta, m_t)$ Price of money

$P_t^d = P^d(B, \lambda, \pi, \delta)$ Price of D-good

$\gamma_t = \gamma(B,\lambda,\pi,\delta)$	Proportion of C-agents training for jobs in the D-sector
$\theta_t = \theta(B,\lambda,\pi,\delta)$	Proportion of trained workers who migrate
$\bar{\varepsilon}_t = \varepsilon(B,\lambda,\pi,\delta)$	Keservation productivity
$\alpha_t = \alpha(B,\lambda,\pi,\delta)$	Probability of accepting a job

Since these equations are algebraically quite cumbersome and do not yield an analytical solution, we parameterize the model and calculate the solution using a computer program designed to solve nonlinear difference equations.

By choosing parameter values for β, A, π, 6, and m_0, we could simulate the dynamics of the economy starting from date $t = 0$. However, we are interested in both the short-run and long-run effects of changes in money on the unemployment and inflation rates. We address these questions by first calculating a steady-state solution for a given set of parameter values. We use the steady-state solutions for mP (real money balances), P^d, γ, θ, $\bar{\varepsilon}$ and a as initial values and then calculate the transition path to the new steady-state solution that results from a change in the growth rate of money, π.

The choice of using a steady-state solution as initial starting values is arbitrary. We could alternatively simulate the transition from any non-steady-state solution; however, there are an infinite number to choose from. We therefore follow the usual practice of starting from a steady-state solution.[2]

Formally, the procedure for calculating a solution to this model involves the following three steps:

(1) Choose parameter values for B, A, π_0, 6, m_0.

(2) Calculate the steady-state solution for mP, P^d, γ, θ, $\bar{\varepsilon}$, and a

(3) Change the growth rate of money, x, and calculate the transition path to the new steady-state solution.

This three-step procedure is accomplished using the MINPACK-1 FORTRAN subroutines.[3] The steady-state equations and the transition equations are programmed into the computer as a system of 90 nonlinear equations in 90 unknowns. This allows 12 equations for the calculation of two initial steady states and 78 equations (13 time periods) for the transition between steady states. Using a variation on Powell's hybrid method, MINPACK-1 then solves for the endogenous variables of the system.[4] The following section presents the simulation results and empirical work.

III. Simulations and Empirical Work

Simulations

This section presents and discusses the simulations of the model. Tables 1 through 9 present the results of our simulations. The entries for time periods 1 and 2 in each table represent the steady-state solutions to the model when the growth rate of money is equal to π_0. Time periods 3 through 15 are the transition paths from the old steady state to the new steady state, with the growth rate of money equal to π. Each table also reports the norm of the residuals from the simulations. This is simply the Euclidean norm of the solution error vector for the 90-equation system. The free parameter δ is fixed throughout the simulations at .01. We experimented with various values for δ without affecting the nature of our results. The free parameter B, the utility value of leisure, is chosen within the interval (0,1). If $B \geq 1$, then all unemployed C-agents would choose to consume leisure, $a = 0$. If $B \leq 0$, then all unemployed C-agents would accept employment in the D-sector, $a = 1$. We report experiments with two values of B: B = .8 and B = .95.

Tables 1 through 4 show the effects of an increase in the growth rate of money, assuming that all money transfers go to the D-agents, $\lambda = 0$. Time periods 1 and 2 show the steady-state solution when the growth rate of money is π_0. Time periods 3 through 15 show the effects of an increase in the growth rate of money from π_0 to π.

The dynamics of this economy can be understood by examining table 1. Here the experiment is to increase the growth rate of money from 15 percent to 16 percent with B = .80. Notice that the initial effect of an increase in the growth rate of money is to increase the price of the D-good in time period 3. This result follows directly from the assumed asymmetric money transfer. The increase in P_3^d has two separate effects. First, it causes more unemployed C-agents to accept jobs, that is, a increases. Second, it causes a larger proportion of the young C-agents to decide to train for work in the D-sector, that is, γ increases. It would at first seem that the overall effect is ambiguous. However, because of'the one-period waiting, the first effect dominates in the short run(that is, for one period). The short-run Phillips curve obtains because the unemployed C-agents accept jobs faster than the young C-agents can retrain and switch sectors. Notice also that inflation rises to only 15.35 percent in time period 3 although money growth, π, increases to 16 percent. This results from the non-neutral effects of money described above.

All agents take only one period to retrain and switch sectors, so this short-run effect lasts for only one period. In time period 4, there is an overshooting of the unemployment rate. Because C-agents are constrained from moving to the D-sector in period 3, the price of the D-good overshoots. The demand for the D-good rises, but because of the one-period waiting, the supply is relatively inelastic. This overshooting causes a large increase in y in time period 3 and, therefore, an overshooting of the unemployment rate in time period 4.[5]

The long-run effect of an increase in the growth rate of money is an increase in the proportion of C-agents who migrate to the D-sector, $\gamma\theta$. This is the increase in sectoral dispersion tested later in this section.

Table 2 presents the results from a similar experiment. The only difference is that B = .95, which, as expected, causes an increase in the unemployment rates but no change in the overall dynamics of the economy. Tables 3 and 4 present results for changes in the growth rate of money from 4 percent to 5 percent. Table 3 shows the effects of this change when B = .80. Table 4 shows the results when B = .95. Again, these experiments show the same dynamics as the first experiment. In each case there is a short-run decrease and a long-run increase in unemployment. The only differences are in levels of the variables.

Tables 5 through 8 show the effects of a decrease in the growth rate of money. Recall that unexpected decreases in the growth rate of money may cause θ to fall below 1. To simplify our presentation, we chose changes in the growth rate of money that were small enough in magnitude so that θ did not change.

Table 5 shows the effects of a decrease in the growth rate of money from 15 percent to 14 percent with B = .80. The initial effect of this decrease is a decrease in P_3^d. This causes fewer unemployed C-agents to accept jobs; that is, a decreases. At the same time, there is a decrease in the proportion of C-agents who train for work in the D-sector; that is, γ decreases. The short-run Phillips curve again obtains because of the time lag between the decrease in demand and the decrease in the flow of workers from the C-sector to the D-sector. In the long run, this flow decreases and the unemployment rate permanently falls.

Tables 6 through 8 show the results from additional experiments with decreases in the growth rate of money. Again, the dynamics are the same as those presented in table 5. The only differences are in the magnitudes of the variables.

Table 9 shows what happens when money is distributed evenly among all agents in the economy, that is, $\lambda = .50$. Notice that there is still a slight Phillips curve relationship in time period 3. Although half of the money goes to agents with a preference for the C-good and the other half goes to agents with a preference for the D-good, money is not neutral. The reason for this non-neutrality is that C-agents hold more real balances than D-agents, because of the matching component for C-agents who switch sectors and accept jobs. These C-agents will produce more than the D-agents ($1 + \varepsilon$ as compared to 1) and therefore will carry more real balances into the next period.

Even though C-agents and D-agents receive equal money transfers, C-agents are worse off since they bear more of the inflation tax on their larger money balances. This asymmetry causes the price of the D-good to rise in period 3. The increase in the price of the D-good, P_t^d, in the third time period causes a larger fraction of unemployed workers to accept employment, that is, α_3 increases and, because of the one-period waiting (due to the one-period job training) there is a slight Phillips curve effect.

Empirical Work

This section presents evidence in support of the implication that sectoral dispersion is positively related to the inflation rate. Recall that the model presented above yields this implication because money is assumed to have distributional effects that cause dispersion in the growth of output across the two sectors. This dispersion in growth leads to an increase in the flow of workers from the C-sector to the D-sector (an increase in $\gamma_{t-1}\theta_t$), which leads to an increase in unemployment. Since the growth rate of money is positively related to the inflation rate, the model yields a positive relationship between inflation and sectoral shifts.

These results are consistent with the empirical work by Lilien (1982), who showed that half of the variation in post-World War II unemployment was due to sectoral shifts unemployment. To measure sectoral shifts, Lilien constructed an index of sectoral dispersion. Using an eleven-industry decomposition of aggregate employment, he defined sectoral dispersion as

$$\sigma = [\sum_{i=1}^{11} (x_{it}/X_t)(\Delta \log x_{it} - \Delta \log X_t)^2]^{.5},$$

where x_{it} is employment in industry i at time t and X_t is aggregate employment at time t.[6] He then regressed unemployment on this measure of sectoral dispersion and found a significant positive relationship.[7]

In the economy we have modeled, an increase in the growth rate of money leads to an increase in inflation and an increase in sectoral dispersion as a larger proportion of C-agents switch to the D-sector. In the real world, one could expect inflation or changes in money to cause sectoral dispersion. One way in which money may have direct distributional effects is through the discount window. Discount-window transactions can be thought of as a direct subsidy to the banking sector. However, the volume of transactions through the window is small and therefore probably not empirically important.[8]

Inflation may have direct distributional effects as well. As discussed in the introduction, these distributional effects may arise because of the asymmetry imposed by the tax laws. Another way in which inflation may have distributional effects is through the inflation tax on real cash balances. For example, if the interest elasticity of money demand is positively related to income, as would be the case if there is some fixed cost associated with transacting in the bond market, then inflation will redistribute income from the relatively poor to the relatively rich. This would cause sectoral dispersion if the relatively rich buy a different basket of goods than do the relatively poor.

To test the implication that inflation and sectoral shifts are positively related, we regress a on the rate of inflation as measured by the annual percentage rate of change in the Consumer Price Index. The results from this regression are presented in table 10. The first row shows the results of a regressed on only contemporaneous inflation. The coefficient of .002 is significantly different from 0 at the .10 level. Rows 2 and 3 show the results from regressing a on contemporaneous inflation and one and two lags of inflation, respectively. In both cases, the sums of the coefficients on inflation are significantly different from zero. In regression 2, the sum is significant at the .01 level; in regression 3, the sum is significant at the .10 level. These results are consistent with the implication of our model.[9]

The implication that an increase in inflation permanently increases the unemployment rate arises in our model because of the overlapping generations structure. Half of the population is born into the C-sector and half of the population is born into the D-sector each period; that is, even after the economy permanently moves to a higher inflation rate, agents continue to be born into the "wrong" sector. This feature of the model can be thought of as capturing the continuous churning that occurs in the real world. In other words, because of individual- or firm-specific productivity, workers are continuously moving across sectors, even in the absence of any asymmetric growth.

The empirical work presented above can be thought of as capturing the distributional effect of inflation. We may also be capturing the effects of an increase in the variance of inflation. Whenever the inflation rate changes, the distributional effects are reversed and sectoral dispersion increases. It is quite possible that our regressions reflect this relationship, since the inflation rate is positively related to its own variance.

IV. Summary and Conclusion

This paper presents an alternative model of the Phillips curve based on the distributional effects of money and/or inflation. These distributional effects imply a positive relationship between inflation and sectoral dispersion, which was tested and found to be significant.

These preliminary results suggest that zero inflation and zero inflation variance should be a policy goal.[10] To the extent that inflation has distributional effects, increases in the inflation rate may actually lead to a long-run increase in the unemployment rate as suggested by Friedman (1977), and more recently as argued by Stockman (1981). These results are preliminary, however, and much additional empirical work needs to be done before we fully understand the linkages between inflation and sectoral dispersion. This work suggests that we take a closer look at measuring the distributional effects of inflation. In particular, we need to determine whether the distributional effects correspond to the direction of employment flows. In other words, if inflation hurts manufacturing more than services, then we would expect to see a reallocation of workers from manufacturing to services when inflation is high (casual inspection of the U.S. data suggests that this is true). This question is best addressed by looking at panel data.

In addition to looking more closely at the long-run implications, further empirical work must be done to establish whether the short-run Phillips relation arises because of our assumed frictions. This could be accomplished by looking more closely at data measuring the inflows into, and outflows from, unemployment. Our model predicts that the short-run fluctuations in unemployment are due mainly to changes in outflows, but current empirical evidence is mixed. Darby, Haltiwanger and Plant (1986) find that changes in unemployment are dominated by changes in inflows. However, evidence for the United Kingdom shows that outflows dominate. Neither study decomposes shocks into real and monetary. One would expect that if real shocks are the major sources of sectoral dispersion, then changes in unemployment are dominated by inflows. Our model, however, suggests that sectoral dispersion caused by monetary and/or inflation shocks would be dominated by outflows.

Footnotes

See Ahmed (1987) for evidence against the sticky-wage models of the business cycle. Barro and Hercowitz (1980) and Boschen and Grossman (1982) discuss the problems of reconciling contemporaneous monetary information with the incomplete-information models of the business cycle.

2. For an example bf this technique see Auerbach and Kotlikoff (1987).

3. The MINPACK-1 subroutines are public domain. They are available from Argonne National Laboratory, Argonne, Illinois.

4. For a discussion of this method see Moré, Garbow, and Hillstrom (1980).

5. We suspect that in the real world, information about production opportunities in other sectors arrives at a more even pace. If we modeled that assumption explicitly, then the increase in the proportion of workers flowing to the D-sector would be a distributed lag process that would smooth the overshooting considerably.

6. The 11 industries used in Lilien's measure are mining; construction; manufacturing; transportation; wholesale trade; retail trade; finance, insurance, and real estate; services; federal government; state government; and local government.

Recently, Abraham and Katz (1987) have shown that Lilien may have overestimated the magnitude of sectoral shifts unemployment by not correctly considering the interaction between aggregate shocks and sectoral dispersion.

8. For evidence on the volume of discount-window transactions, see Mengle (1986).

9. In addition to testing the relationship between inflation and sectoral shifts, we also regressed σ on changes in the monetary base. The regressions yielded insignificant coefficients on contemporaneous and lagged money. In addition, the sums of the coefficients on money were insignificantly different from zero.

10. This policy goal has been argued elsewhere on the grounds that inflation may have distributional effects. For example, see Gavin and Stockman (1988).

TABLE 1

$\pi_0 = .15$ $\pi = .16$

$B = .80$ $\delta = .01$ $\lambda = 0.0$

NORM OF THE RESIDUALS 0.6192512E-04

TIME	ALPHA	THETA	P	PD	GAMMA
1	0.50815	1.00000	1.57675	0.81326	0.21157
2	0.50815	1.00000	1.37109	0.81326	0.21157
3	0.51422	1.00000	1.18860	0.82342	0.23151
4	0.50815	1.00000	1.01892	0.81326	0.22373
5	0.50815	1.00000	0.87841	0.81326	0.22373
6	0.50815	1.00000	0.75725	0.81326	0.22372
7	0.50815	1.00000	0.65279	0.81326	0.22372
8	0.50815	1.00000	0.56275	0.81326	0.22372
9	0.50815	1.00000	0.48513	0.81326	0.22373
10	0.50815	1.00000	0.41822	0.81326	0.22372
11	0.50815	1.00000	0.36053	0.81326	0.22372
12	0.50815	1.00000	0.31080	0.81326	0.22372
13	0.50815	1.00000	0.26793	0.81326	0.22372
14	0.50815	1.00000	0.23098	0.81326	0.22372
15	0.50815	1.00000	0.19912	0.81326	

TIME	INFLATION	UNEMPLOYMENT RATE
1	15.0000010	10.4057684
2	15.0000010	10.4057703
3	15.3529053	10.2773161
4	16.6527996	11.3868980
5	15.9961462	11.0040016
6	15.9999371	11.0040302
7	16.0024529	11.0037317
8	16.0006046	11.0036144
9	15.9990311	11.0037413
10	15.9995556	11.0038481
11	16.0001049	11.0038424
12	16.0000439	11.0038166
13	15.9999971	11.0038128
14	15.9999971	11.0038109
15	15.9999971	11.0038090

TABLE 2

$\pi_0 = .15$ $\pi = .16$

$B = .95$ $\delta = .01$ $\lambda = 0.0$

NORM OF THE RESIDUALS 0.5062552E-04

TIME	ALPHA	THETA	P	PD	GAMMA
1	0.29782	1.00000	1.45779	0.67646	0.38036
2	0.29782	1.00000	1.26765	0.67646	0.38036
3	0.30495	1.00000	1.09732	0.68340	0.41258
4	0.29782	1.00000	0.94207	0.67646	0.40222
5	0.29782	1.00000	0.81213	0.67646	0.40222
6	0.29782	1.00000	0.70011	0.67646	0.40222
7	0.29782	1.00000	0.60354	0.67646	0.40222
8	0.29782	1.00000	0.52030	0.67646	0.40222
9	0.29782	1.00000	0.44853	0.67646	0.40221
10	0.29782	1.00000	0.38666	0.67646	0.40221
11	0.29782	1.00000	0.33333	0.67646	0.40221
12	0.29782	1.00000	0.28735	0.67646	0.40222
13	0.29782	1.00000	0.24772	0.67646	0.40222
14	0.29782	1.00000	0.21355	0.67646	0.40221
15	0.29782	1.00000	0.18410	0.67646	

TIME	INFLATION	UNEMPLOYMENT RATE
1	15.0000010	26.7078190
2	15.0000010	26.7078304
3	15.5218010	26.4366245
4	16.4801483	28.9704266
5	15.9999609	28.2427673
6	15.9999733	28.2427673
7	15.9998894	28.2428036
8	15.9997587	28.2428226
9	15.9998894	28.2428436
10	16.0006161	28.2427254
11	16.0017853	28.2424088
12	16.0002956	28.2423458
13	15.9963255	28.2430382
14	16.0014744	28.2427616
15	16.0002480	28.2427044

TABLE 3

$\pi_0 = .05$ $\pi = .06$

$B = .80$ $\delta = .01$ $\lambda = 0.0$

NORM OF THE RESIDUALS 0.3187718E-04

TIME	ALPHA	THETA	P	PD	GAMMA
1	0.50815	1.00000	1.72691	0.81326	0.07724
2	0.50815	1.00000	1.64468	0.81326	0.07724
3	0.51682	1.00000	1.56407	0.82785	0.10402
4	0.50815	1.00000	1.46376	0.81326	0.09181
5	0.50815	1.00000	1.38090	0.81326	0.09181
6	0.50815	1.00000	1.30274	0.81326	0.09181
7	0.50815	1.00000	1.22900	0.81326	0.09181
8	0.50815	1.00000	1.15943	0.81326	0.09181
9	0.50815	1.00000	1.09381	0.81326	0.09181
10	0.50815	1.00000	1.03190	0.81326	0.09181
11	0.50815	1.00000	0.97349	0.81326	0.09181
12	0.50815	1.00000	0.91839	0.81326	0.09181
13	0.50815	1.00000	0.86640	0.81326	0.09181
14	0.50815	1.00000	0.81735	0.81326	0.09181
15	0.50815	1.00000	0.77107	0.81326	

TIME	INFLATION	UNEMPLOYMENT RATE
1	5.0000000	3.7989280
2	5.0000000	3.7989280
3	5.1539660	3.7319825
4	6.8528175	5.1163921
5	6.0000300	4.5157032
6	6.0000777	4.5157018
7	6.0000420	4.5157003
8	5.9999108	4.5157065
9	5.9996963	4.5157156
10	5.9995770	4.5157366
11	5.9996724	4.5157499
12	6.0001254	4.5157390
13	6.0008168	4.5157032
14	6.0014009	4.5156484
15	6.0015678	4.5155754

TABLE 4

$\pi_0 = .05$ $\pi = .06$

$B = .95$ $\delta = .01$ $\lambda = 0.0$

NORM OF THE RESIDUALS 0.4694517E-04

TIME	ALPHA	THETA	P	PD	GAMMA
1	0.29782	1.00000	1.59663	0.67646	0.13886
2	0.29782	1.00000	1.52060	0.67646	0.13886
3	0.30974	1.00000	1.44453	0.68815	0.18410
4	0.29782	1.00000	1.35333	0.67646	0.16506
5	0.29782	1.00000	1.27672	0.67646	0.16506
6	0.29782	1.00000	1.20445	0.67646	0.16506
7	0.29782	1.00000	1.13627	0.67646	0.16506
8	0.29782	1.00000	1.07195	0.67646	0.16506
9	0.29782	1.00000	1.01127	0.67646	0.16506
10	0.29782	1.00000	0.95404	0.67646	0.16506
11	0.29782	1.00000	0.90005	0.67646	0.16506
12	0.29782	1.00000	0.84911	0.67646	0.16506
13	0.29782	1.00000	0.80106	0.67646	0.16506
14	0.29782	1.00000	0.75571	0.67646	0.16506
15	0.29782	1.00000	0.71292	0.67646	

TIME	INFLATION	UNEMPLOYMENT RATE
1	5.0000000	9.7504597
2	5.0000000	9.7504597
3	5.2662730	9.5848894
4	6.7388296	12.9272852
5	6.0000777	11.5901403
6	6.0003042	11.5901546
7	6.0004354	11.5900316
8	6.0003877	11.5900145
9	6.0000062	11.5900431
10	5.9993386	11.5901041
11	5.9987307	11.5902309
12	5.9985399	11.5904160
13	5.9990406	11.5905056
14	6.0006499	11.5904665
15	6.0026646	11.5901423

TABLE 5

$\pi_0 = .15$ $\pi = .14$

$B = .80$ $\delta = .01$ $\lambda = 0.0$

NORM OF THE RESIDUALS 0.2718234E-05

TIME	ALPHA	THETA	P	PD	GAMMA
1	0.50815	1.00000	1.57675	0.81326	0.21157
2	0.50815	1.00000	1.37109	0.81326	0.21157
3	0.50190	1.00000	1.19594	0.80305	0.19114
4	0.50815	1.00000	1.05501	0.81326	0.19919
5	0.50815	1.00000	0.92544	0.81326	0.19919
6	0.50815	1.00000	0.81179	0.81326	0.19919
7	0.50815	1.00000	0.71210	0.81326	0.19919
8	0.50815	1.00000	0.62465	0.81326	0.19919
9	0.50815	1.00000	0.54794	0.81326	0.19919
10	0.50815	1.00000	0.48065	0.81326	0.19919
11	0.50815	1.00000	0.42162	0.81326	0.19919
12	0.50815	1.00000	0.36984	0.81326	0.19919
13	0.50815	1.00000	0.32442	0.81326	0.19919
14	0.50815	1.00000	0.28458	0.81326	0.19919
15	0.50815	1.00000	0.24963	0.81326	

TIME	INFLATION	UNEMPLOYMENT RATE
1	15.0000010	10.4057713
2	15.0000010	10.4057713
3	14.6454458	10.5380573
4	13.3582354	9.4010134
5	13.9998913	9.7972584
6	14.0001297	9.7972441
7	13.9999390	9.7972527
8	13.9999514	9.7972565
9	14.0000820	9.7972469
10	13.9999990	9.7972460
11	13.9999514	9.7972536
12	14.0000343	9.7972479
13	14.0000105	9.7972460
14	13.9999752	9.7972479
15	13.9999990	9.7972517

TABLE 6

$\pi_0 = .15$ $\pi = .14$

$B = .95$ $\delta = .01$ $\lambda = 0.0$

NORM OF THE RESIDUALS 0.1075217E-03

TIME	ALPHA	THETA	P	PD	GAMMA
1	0.29781	1.00000	1.45778	0.67646	0.38037
2	0.29781	1.00000	1.26764	0.67646	0.38037
3	0.29050	1.00000	1.10734	0.66948	0.34743
4	0.29781	1.00000	0.97542	0.67646	0.35813
5	0.29781	1.00000	0.85563	0.67646	0.35813
6	0.29781	1.00000	0.75054	0.67646	0.35812
7	0.29781	1.00000	0.65837	0.67646	0.35812
8	0.29781	1.00000	0.57752	0.67646	0.35812
9	0.29781	1.00000	0.50659	0.67646	0.35812
10	0.29781	1.00000	0.44438	0.67646	0.35811
11	0.29781	1.00000	0.38981	0.67646	0.35811
12	0.29781	1.00000	0.34192	0.67646	0.35810
13	0.29781	1.00000	0.29992	0.67646	0.35810
14	0.29781	1.00000	0.26309	0.67646	0.35809
15	0.29781	1.00000	0.23079	0.67646	

TIME	INFLATION	UNEMPLOYMENT RATE
1	15.0000010	26.7087898
2	15.0000010	26.7088680
3	14.4753695	26.9872093
4	13.5249739	24.3964024
5	14.0006189	25.1474915
6	14.0008812	25.1473637
7	14.0001297	25.1470718
8	14.0000944	25.1468658
9	14.0002728	25.1466522
10	13.9994745	25.1464462
11	14.0001297	25.1462402
12	14.0039806	25.1458130
13	14.0056496	25.1452408
14	14.0004044	25.1450272
15	13.9955997	25.1447716

TABLE 7

$\pi_0 = .05$ $\pi = .04$

$B = .80$ $\delta = .01$ $\lambda = 0.0$

NORM OF THE RESIDUALS 0.1782243E-04

TIME	ALPHA	THETA	P	PD	GAMMA
1	0.50815	1.00000	1.72691	0.81326	0.07724
2	0.50815	1.00000	1.64468	0.81326	0.07724
3	0.49915	1.00000	1.56868	0.79865	0.04971
4	0.50815	1.00000	1.52060	0.81326	0.06238
5	0.50815	1.00000	1.46211	0.81326	0.06238
6	0.50815	1.00000	1.40588	0.81326	0.06238
7	0.50815	1.00000	1.35180	0.81326	0.06238
8	0.50815	1.00000	1.29981	0.81326	0.06238
9	0.50815	1.00000	1.24982	0.81326	0.06238
10	0.50815	1.00000	1.20175	0.81326	0.06238
11	0.50815	1.00000	1.15553	0.81326	0.06238
12	0.50815	1.00000	1.11109	0.81326	0.06238
13	0.50815	1.00000	1.06836	0.81326	0.06239
14	0.50815	1.00000	1.02727	0.81326	0.06239
15	0.50815	1.00000	0.98777	0.81326	

TIME	INFLATION	UNEMPLOYMENT RATE
1	5.0000000	3.7989280
2	5.0000000	3.7989280
3	4.8451066	3.8684514
4	3.1617045	2.4450269
5	3.9999962	3.0683615
6	4.0000439	3.0683591
7	4.0001154	3.0683589
8	4.0001512	3.0683522
9	4.0001392	3.0683496
10	4.0000558	3.0683472
11	3.9999008	3.0683522
12	3.9996982	3.0683601
13	3.9994597	3.0683780
14	3.9993167	3.0683944
15	3.9991498	3.0684204

TABLE 8

$\pi_0 = .05$ $\pi = .04$

$B = .95$ $\delta = .01$ $\lambda = 0.0$

NORM OF THE RESIDUALS *0.14763503-05*

TIME	ALPHA	THETA	P	PD	GAMMA
1	0.29782	1.00000	1.59663	0.67646	0.13886
2	0.29782	1.00000	1.52060	0.67646	0.13886
3	0.28545	1.00000	1.45190	0.66476	0.09243
4	0.29782	1.00000	1.40588	0.67646	0.11216
5	0.29782	1.00000	1.35181	0.67646	0.11216
6	0.29782	1.00000	1.29982	0.67646	0.11216
7	0.29782	1.00000	1.24982	0.67646	0.11216
8	0.29782	1.00000	1.20175	0.67646	0.11216
9	0.29782	1.00000	1.15553	0.67646	0.11216
10	0.29782	1.00000	1.11109	0.67646	0.11216
11	0.29782	1.00000	1.06835	0.67646	0.11216
12	0.29782	1.00000	1.02726	0.67646	0.11216
13	0.29782	1.00000	0.98775	0.67646	0.11216
14	0.29782	1.00000	0.94976	0.67646	0.11216
15	0.29782	1.00000	0.91323	0.67646	

TIME	INFLATION	UNEMPLOYMENT RATE
1	5.0000000	9.7504597
2	5.0000000	9.7504635
3	4.7314882	9.9222097
4	3.2736182	6.4905844
5	3.9999843	7.8753772
6	3.9999723	7.8753700
7	3.9999723	7.8753791
8	4.0000200	7.8753791
9	4.0000319	7.8753839
10	4.0000319	7.8753600
11	4.0000200	7.8753600
12	3.9999962	7.8753681
13	3.9999723	7.8753748
14	3.9999366	7.8753457
15	3.9999604	7.8753686

TABLE 9

π_0 = **.15** π = **.16**

B = .80 δ = .01 λ = .50

NORM OF THE RESIDUALS 0.4267722E-04

TIME	ALPHA	THETA	P	PD	GAMMA
1	0.50815	1.00000	1.57675	0.81326	0.01975
2	0.50815	1.00000	1.37109	0.81326	0.01975
3	0.50890	1.00000	1.18278	0.81449	0.02184
4	0.50815	1.00000	1.01893	0.81326	0.02089
5	0.50815	1.00000	0.87840	0.81326	0.02089
6	0.50815	1.00000	0.75724	0.81326	0.02089
7	0.50815	1.00000	0.65279	0.81326	0.02089
8	0.50815	1.00000	0.56275	0.81326	0.02089
9	0.50815	1.00000	0.48513	0.81326	0.02089
10	0.50815	1.00000	0.41821	0.81326	0.02089
11	0.50815	1.00000	0.36053	0.81326	0.02089
12	0.50815	1.00000	0.31080	0.81326	0.02089
13	0.50815	1.00000	0.26793	0.81326	0.02089
14	0.50815	1.00000	0.23098	0.81326	0.02089
15	0.50815	1.00000	0.19912	0.81326	

TIME	INFLATION	UNEMPLOYMENT RATE
1	15.0000010	0.9715822
2	15.0000010	0.9715796
3	15.9206991	0.9701118
4	16.0806179	1.0740389
5	15.9977322	1.0274286
6	16.0009155	1.0274181
7	16.0009155	1.0274101
8	15.9987097	1.0274211
9	15.9999971	1.0274198
10	16.0009270	1.0274129
11	15.9994249	1.0274135
12	15.9998541	1.0274249
13	16.0004978	1.0274128
14	15.9996986	1.0274196
15	15.9998894	1.0274208

TABLE 10

REGRESSION RESULTS

Dependent Variable: a

Annual Observation: 1951 - 1980.

Regression	Constant	Trend	π_t	π_{t-1}	π_{t-2}	sum
1	.030 (.047)	-.0008 (.0004)	.002 (.001)			
2	.028 (.004)	-.0008 (.0003)	.0002 (.0013)	.0022 (.0012)		.0024 (.0009)
3	.027 (.004)	-.0007 (.0004)	.0001 (.0016)	.0023 (.0018)	-.0001 (.0013)	.0023 (.0012)

Note: Standard errors are in parentheses below the estimated coefficients. All regressions were corrected for first-order serial correlation.

Source: a is from Lilien (1982).

Appendix

Derivation of Equations Used in Simulations

Determination of γ, the proportion of C-agents who train for work in the D-sector:

$$1 < -\delta + \theta_{t+1}[\alpha_{t+1}P^{d}_{t+1}(1 + E[\varepsilon|\varepsilon \geq \bar{\varepsilon}_{t+1}]) + B(1 - \alpha_{t+1})] + (1 - \theta_{t+1}) \quad (1)$$

Determination of θ, the proportion of trained workers who choose to move to the D-sector:

$$1 < \alpha_{t+1}P^{d}_{t+1}(1 + E[\varepsilon|\varepsilon \geq \bar{\varepsilon}_{t+1}]) + B(1 - \alpha_{t+1}) \quad (2)$$

Determination of ε_t, the reservation productivity for a trained C-agent:

$$P^{d}_{t+1}(1 + \bar{\varepsilon}_{t+1}) = B. \quad (3)$$

Determination of the probability of accepting employment:

$$\alpha_t = \text{Prob}(\varepsilon \geq \bar{\varepsilon}_t) = (1/2)\int_{\bar{\varepsilon}t}^{1} d\varepsilon = 1/2 - \bar{\varepsilon}/2 \quad (4)$$

C-good equilibrium (supply = demand):

$$1 + (1 - \theta_t\gamma_{t-1}) = (1 - \theta_t\gamma_{t-1}) + P_t/P_{t-1} + \lambda\pi m_{t-1}P_t + \gamma_{t-1}\theta_t P^{d}_{t}\alpha_t(1 + E[\varepsilon|\varepsilon \geq \bar{\varepsilon}_t]) \quad (5)$$

D-good equilibrium (supply = demand):

$$2 + \gamma_{t-1}\theta_t P_t^d \alpha_t (1 + E[\varepsilon | \varepsilon \geq \bar{\varepsilon}_t])$$

$$= 1 + (1 - \lambda)\pi m_{t-1} P_t / P_t^d + (P_{t-1}^d P_t)/(P_{t-1} P_t^d) \qquad (6)$$

In equilibrium, equation (1) holds at equality. For the economies we consider, the changes in inflation are small enough to make (2) hold at strict inequality at all times. This implies that $\theta = 1$. To derive the equations used in the simulation program, substitute in for the conditional expectation of $\bar{\varepsilon}_t$:

$$E[\varepsilon | \varepsilon \geq \bar{\varepsilon}_t] = (1/4 - \bar{\varepsilon}_t^2/4)/\alpha_t.$$

The final six equations used in the simulations are

$$1 = -\delta + \alpha_{t+1}\theta_{t+1}P_{t+1}^d$$
$$+ \theta_{t+1}P_{t+1}^d(1/4 - \bar{\varepsilon}^2/4) + \theta_{t+1}B(1 - \alpha_{t+1}) \qquad (1)$$

$$1 < \alpha_{t+1}\theta_{t+1}P_{t+1}^d + \theta_{t+1}P_{t+1}^d(1/4 - \bar{\varepsilon}^2/4) + \theta_{t+1}B(1 - \alpha_{t+1}) \qquad (2)$$

$$\bar{\varepsilon}_{t+1} = B/P_{t+1}^d - 1 \qquad (3)$$

$$\alpha_t = 1/2 - \bar{\varepsilon}_t/2 \qquad (4)$$

$$1 = P_t/P_{t-1} + \lambda\pi m_{t-1}P_t + \gamma_{t-1}\theta_t P_t^d \alpha_t + \gamma_{t-1}\theta_t P_t^d (1/4 - \bar{\varepsilon}^2/4) \qquad (5)$$

$$1 + \gamma_{t-1}\theta_t P_t^d \alpha_t + \gamma_{t-1}\theta_t P_t^d (1/4 - \bar{\varepsilon}^2/4)$$
$$= (1 - \lambda)\pi m_{t-1} P_t / P_t^d + (P_{t-1}^d P_t)/(P_{t-1} P_t^d). \qquad (6)$$

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