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OPTIMAL MONETARY POLICY RULES FOR AVERTING PRODUCTIVITY INDUCED JOBLESS RECOVERIES

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Although high productivity growth is a primary economic goal across nations, it can lead to short run adjustment problems when it temporarily achieves high levels. This may induce a jobless recovery when labor productivity is high while an economy is experiencing sluggish growth or a recession. This paper creates a framework for empirically modeling these effects. This model is used in the context of an optimal control framework in order to derive policy rules for guiding monetary policy during such episodes.

JEL Classifications: E52, E61, E65

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INTRODUCTION

One of the most fundamental principles of macroeconomics is that productivity growth determines a nation's material standard of living in the long run. Sustained levels of high productivity growth lead to higher levels of per capita income and national welfare. In the short run, however, a plethora of variables determine real wages and output growth. Even productivity growth itself may have undesired short run effects, amplifying instability in economies that are experiencing recessionary or inflationary employment gaps, Gali (1999). These negative effects have been borne out empirically in various situations, even leading to the widespread discussions over periods of jobless recoveries in the early 1990's and the post millennium U.S. economy, Bernanke (2003).

In the short run, increases in labor productivity can cause reductions in the employment of labor for two reasons. First, increases in labor productivity exert pressures on real wages to rise. Second, increases in labor productivity mean that any given level of output can be produced with a smaller number of or worker hours. If the level of output does not increase to accommodate the productivity growth, then the reduction in the labor hours will occur, leading to increased unemployment in the sector.

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This creates an ironic frustration for policymakers and political administrations. Whereas the universally accepted primary economic goal of high productivity growth is being met, its effects are causing short run problems. If the productivity growth can be sustained over time, only then will its effects eventually positively ripple through the economy, aiding other macroeconomic variables, spreading wealth and optimism, and increasing voter approval. If adverse short run effects are not stifled, then any positive benefits will accrue solely to future administrations.

The purpose of this analysis is to model these effects and explore macroeconomic policy rules for facilitating economic adjustment to productivity gains. This will be done by first presenting a new model framework which focuses entirely upon singling out this short run productivity effect during jobless recovery phases where it is most likely to have a substantial economic impact. Secondly, an optimal control policy analysis will use the empirical results to determine the appropriate response by the monetary authorities seeking to achieve a balance between stable money supply growth and short run macroeconomic stability.

LITERATURE REVIEW

The problems caused by productivity growth stem from the failure of economies to make adjustments in the short run. Assuming sticky prices, Gali (1999) finds evidence that technology induced productivity shocks and total labor hours are inversely related for a variety of model specifications for most of the G7 countries. Using a VAR model for employment and productivity growth, Kiley (1997) confirms that this negative correlation between technology shocks and employment also holds within a multisectoral framework where a positive technology shock in one sector leads to reduced aggregate employment. Godal's (1999) also found evidence that employment hours are negatively related to productivity shocks.

While the empirical evidence supports the negative correlation between productivity shocks and employment in the short run, this paper offers an additional empirical clarification. It finds evidence that this negative correlation is likely to hold in the case where the economy is operating below its natural rate of output. Whereas the Real Business Cycle (RBC) models and Godal's (1999) model test for continuous correlations between productivity shocks and employment, the current analysis stresses that this correlation should be negative only during periods of sluggish output growth or during recessions.

Both the empirical evidence and recent experience have shown a negative correlation in high short run productivity and employment levels. Given this relationship, what is the appropriate macroeconomic policy? This analysis uses monetary control as the most appropriate target for alleviating the problems associated with jobless recovery episodes. Bernanke's (2003) and Tambalotti (2003) both conclude that monetary policy is the most appropriate policy tool for smoothing labor market fluctuations that arise due to productivity shocks. The effect of the money supply is also empirically confirmed by Godal's (1999) study which found evidence that employment hours are positively related to monetary shocks.

As long as the dampened economic performance, or jobless recovery, is not primarily the result of an excessively high degree of structural unemployment, the employment benefits of accommodative monetary policy will likely dominate any resulting inflationary pressures,

Bernanke (2003). But structural considerations also have broader implications. Shupp (1983) shows that differential productivity gains across sectors can lead to aggregate inflation. Even though underlying structural changes have important effects, both Hudgins (1993) and Shupp (1983) have shown that effective monetary policy rules can be optimally derived within empirical models that account for sectoral asymmetries.

PROBLEM FORMULATION

The problems associated with productivity growth tend to be experienced more during economic slumps than in other phases of the business cycle. Thus, any sudden short-run jumps in productivity may cause workers to be laid off or dismissed from their jobs, resulting in temporary increases in unemployment. In the long-run, sustained high productivity will lead to high growth, low unemployment, and higher real wages, Tambalotti (2003). This situation is modeled by equations (1) and (2):

$$u_{t+1} = u_t + s_1 (u_t - u_t^*) (pr_t - pr_t^*) d_t + s_2 pr_t^* + s_3 (m_t - p_t - pr_t^*) \quad (1)$$

$$s_1 > 0, s_2 < 0, s_3 < 0$$

$$pr_t^* = \tau pr_t + (1 - \tau) pr_{t-1}^* \quad 0 < \tau < 1 \quad (2)$$

where

- u_t = the unemployment rate in quarter t
- u_t^* = the natural unemployment rate, or NAIRU, in quarter t
- pr_t = the per centage growth rate of labor productivity in quarter t
- pr_t^* = the long-run trend annualized per centage growth rate of labor productivity in quarter t
- m_t = the per centage change in the nominal money supply in quarter t
- p_t = the aggregate rate of inflation in quarter t
- s_1 = parameter determining the short-run effect of high productivity on unemployment during periods of slow or negative economic growth
- s_2 = parameter determining the effect of a high trend rate of productivity on unemployment during quarter t
- s_3 = parameter determining the response to monetary policy or other policy options.
- d_t = dummy variable for period t, taking the value 1 during recessionary periods and 0 otherwise

The middle term in equation (1), $s_1 (u_t - u_t^*) (pr_t - pr_t^*) d_t$, allows for negative effects of short-run productivity jumps. If national output growth is small or negative, then the dummy variable is activated. During these periods of slow growth, the current unemployment rate is above the natural level of unemployment. Also during these periods, higher than average current productivity gains adversely affect the labor market by causing layoffs. In that case, firms are not willing to increase production due to slow sales, high inventory, and/or pessimistic expectations for the near future. The additional gains in labor productivity mean that firms can

hit their output targets with fewer workers, thereby causing them to release some of their current employees.

The next term in equation (1), $s_2 pr_t^*$, shows that increases in the long-run trend in productivity tend to have a positive effect on the labor market by lowering unemployment. This term captures the standard macroeconomic assumption of long run positive correlation between productivity and economic growth. It also represents the theoretical positive correlation between productivity and employment suggested by RBC models.

When taken together, terms 1 and 2 in equation (1) present a new way of modeling the effects of productivity shocks. This approach reconciles the theoretical and empirical results of standard macroeconomic analysis. Because of term 2, productivity does tend to decrease unemployment in the long run, as theoretically suggested by standard economic theory and RBC models. However, because of term 1, excessive short term productivity will cause an increase in unemployment, but only during economic slumps. Thus, this model provides an important contribution to the economic literature by reconciling what was formerly seen as two conflicting views on the correlation of employment and productivity.

The final term in equation (1) allows for the effect of policy actions and nominal variables on the unemployment rate. When modeling the labor market, this relationship is generally expressed in terms of real output via Okun's Law, or in terms of real wages, or alternatively as some other variable that captures the response by the unemployment rate.

Okun's law specifies that unemployment and national output are inversely related. The equation of exchange suggests that increases in the real money supply are positively related to changes in real output. Since the growth rate of real output is primarily determined by productivity growth in the long run, labor productivity can be used to capture the relationship between growth and the real money supply. Incorporating the equation of exchange within the modified Okun's law framework, equation (1) uses the growth in the real money supply above the productivity trend to capture the effect on the level of unemployment.

Equation (2) represents the long run trend in labor productivity. The equation assumes that this trend can be captured by an exponential smoothing process, or a Koyck transformation. The higher the value of t , the more weight that is given to current period changes in productivity. Such an equation allows for a current and long run influence of technical innovations, human capital, and other factor which influence productivity. Whenever current productivity is high, it will have a positive effect on the long run trend in equation (2), but it may also have the negative effect of an increase in the unemployment rate in equation (1).

Equations (1) and (2) were estimated for the U.S. using data from the 19-year period of 1974–2003, with data taken from BLS and Economagic. M2 was used for the nominal money supply and the GDP deflator index was used to measure inflation. Results were obtained using various smoothing constants for the trend variables u_t^* and pr_t^* , with best fits obtained with a constant natural unemployment rate of 5% and smoothing constant of $\tau = .5$ for the productivity trend values. Since the natural unemployment rate is considered by most analysts to be highly stable, especially in the short run, it was presumed to be constant for this analysis. This yielded

better empirical results while avoiding the specification bias and additional error that might result when trying to identify some unknown fluctuation in the trend. Also, when modeled as a constant, the level of the natural rate does not affect the significance of the regression coefficients, but only the scale. The value of the productivity smoothing constant was chosen to be .5 since that gives equal weight to the current value and previously forecasted trend value. With these specifications, the regressions yielded the following results (standard errors in parentheses):

$$\hat{s}_1 = .1462 (.0329), \hat{s}_2 = -.13085 (.0493), \hat{s}_3 = -.05956 (.0254)$$

All three coefficients hold the correct sign and are statistically significant, with p-values of .00002, .0091, and .0207. Equation (1) was also estimated for various specifications of the dummy variable, where slow economic performance was given cutoffs for quarterly GDP growth rates below values ranging from annualized rates from 0 (as reported above) to 1.5 per cent. Most of the regressions resulted in the expected signs for the coefficients and yielded similar magnitudes. The results from the best fit are reported above.

POLICY RULES WITH A NUMERICAL EXAMPLE

The above results not only bear out the short run economic adjustment problems to productivity shocks, but they also provide for an empirical magnitude within a framework that can be used by policymakers to improve macroeconomic performance. As mentioned above, previous studies support the usefulness of monetary policy as perhaps the most appropriate policy tool for dealing with productivity shocks. This is viable partially due to the obvious effects of monetary policy on wages and expectations, but also through interest rate channels. High levels of productivity growth tend to push the potential rate of return on investment upward. But the flip side of the rate of return is that it determines the real interest rate. Thus, without monetary accommodation, both current production and long term capital expansions may remain even farther below their potential levels during periods of relative stagnation.

Increases in the money supply thus work through the standard monetary interest rate transmission mechanism to influence output and employment. In this case, a monetary expansion can be used partially just to offset the downward rigidity in the interest rates caused by other short-term economic distortions arising from productivity gains. Moreover, expansionary policy can also be used as a stimulus to firms to go ahead and expand short-run production in light of additional profit possibilities, and undertake investment projects due to high productivity and favorable rates of return relative to borrowing costs. Tambalotti (2003) also concludes that monetary accommodation and slightly lower nominal interest rates are necessary in order to optimally counteract disinflation pressures induced by productivity surges, and that the Federal Reserve's active monetary policy during the late 1990's was the most appropriate policy.

Determination of a monetary policy rule requires the selection of an appropriate set of targets. Ireland's (1996) analysis concludes that a constant money growth rule is appropriate for demand shocks, but that a pro-cyclical monetary policy is appropriate for supply shocks. Within a jobless recovery scenario, the transitory path of macroeconomic variables defies the possibility or usefulness of defining accommodative policy as being pro- or counter-cyclical.

Shupp (1976) and Tambalotti (2003) conclude that a wage inflation target is preferable to an output inflation target; however, Tambalotti shows that monetary accommodation also helps avoid price dispersions by balancing wage and price distortions. Whereas Tambalotti (2003) concludes that output gap forecast targeting is the superior rule during periods of excessive productivity growth, the result is an indirectly accommodative monetary policy. The foregoing analysis uses the nominal money supply as the primary policy instrument target that is to be used to alleviate the unemployment gap.

The policymaker's objective is to choose the money supply so as to minimize the deviation of the unemployment rate from its natural rate, while keeping money growth consistent with the real growth rate of the economy. This criterion is simply specified by the following quadratic performance index, where u_{T+1}^e is the expected unemployment rate that will prevail at the end of the planning horizon in period $T + 1$.

$$J = \frac{1}{2} \sum_{t=1}^T \left[\alpha_1 (u_t - u_t^*)^2 + (m_t - pr_t^*)^2 \right] + \alpha_2 (u_{T+1}^e - u_{T+1}^*)^2 \quad (3)$$

The objective is to minimize expression (3) subject to equations (1) and (2) over the time horizon $t = (1, 2, \dots, T)$. The criterion penalizes the monetary authorities for any deviation of the money supply from the trend rate of productivity. This follows from the equation of exchange. Given a stable velocity of circulation and a target of zero inflation, then the money supply should track the growth rate of real output, which is primarily determined by the growth in labor productivity.

The criterion given in equation (3) also penalizes for deviations from the natural level of unemployment. Whenever the economy is sluggish or in a recessionary phase, it will experience higher than normal levels of unemployment. Reduction in this employment gap requires short run expansionary monetary policy. Larger values of α_1 lead to higher penalties for recessionary gaps and therefore cause the central bank to pursue a more vigorous monetary policy. Smaller values of α_1 allow the central bank to react less to short run economic fluctuations while concentrating on tracking the long run growth rate in labor productivity.

The terminal state of unemployment expectations is a driving force for both the economic agents and in the policy index. If the expected terminal unemployment rate u_{T+1}^e is high, then firms and workers are basing decisions based on recessionary expectations throughout the control period and beyond. This is one of the factors that actually initiate the prolonged jobless recovery. When firms and workers expect sluggish economic performance, they delay investment expansions, hiring increases, and output growth. To avoid this problem, authorities must place some weight in the criterion index that forces monetary policy to react to these negative expectations. Higher values of α_2 cause the central bank to react with a more active short run monetary policy to counter deviations of the expected unemployment rate from the natural unemployment rate. In practice, these recessionary expectations may be diminished whenever the monetary authorities credibly announce their stance of pursuing policies aimed at reducing such gaps.

Once the control horizon has lapsed, it is also desirable that workers and firms should not immediately jump to a new unemployment level due to a latent buildup in disequilibrium pressures brought on by the control policy. Thus, the labor market should anticipate a level of unemployment close to the natural rate. This will also be insured by placing weight on the terminal state of the expected unemployment rate as weighted by the parameter α_2 .

Assume that the unemployment expectations are formed by the mechanism

$$u_t^e = u_{t-1}^e + k(u_{t-1} - u_{t-1}^e) \quad 0 < k < 1 \quad (4)$$

The value for k determines the weight placed on the updating mechanism. Higher values of k place more weight on forecast errors and cause economic agents to more quickly revise their expectations. Given that this is necessarily a short-term problem arising due to temporary productivity imbalances, the problem can be simplified by assuming that the natural rate of unemployment and the trend growth in productivity are approximately constant. By letting $\alpha_t = \alpha_1 + k(1-k)^{T-t} \alpha_2$ equations (3) and (4) are combined to yield

$$J = \frac{1}{2} \sum_{t=1}^T [\alpha_t (u_t - u^*)^2 + (m_t - pr_t^*)^2] \quad (5)$$

Once the monetary authorities exogenously determine their preferred values for α_t , the problem is choose a monetary policy that will minimize the criterion function given in (5) subject to equation (1). This discrete time-variant linear-quadratic optimal control tracking problem can be solved by employing the Hamiltonian function

$$H = \frac{1}{2} [\alpha_t (u_t - u^*)^2 + (m_t - pr^*)^2] + \lambda_{t+1} (c_1 u_t + s_3 m_t + c_2) \quad (6)$$

where

$$c_1 = 1 + s_1 pr - s_1 pr^*$$

$$c_2 = -s_1 (pr)u^* + s_1 pr^* u^* + s_2 pr^* - s_3 p - s_3 pr^*$$

Optimization requires that $\frac{\partial H}{\partial m_t} = 0$, $u_{t+1} = \frac{\partial H}{\partial \lambda_{t+1}}$, and $\lambda_t = \frac{\partial H}{\partial u_t}$. These conditions lead to the respective equations¹

$$m_t = -s_3 \lambda_{t+1} + pr^* \quad (7)$$

$$u_{t+1} = c_1 u_t + s_3^2 \lambda_{t+1} + s_3 pr^* + c_2 \quad (8)$$

$$\lambda_t = \alpha_t (u_t - u^*) + c_1 \lambda_{t+1} \quad (9)$$

For a given time horizon T and the initial condition $u_1 = u(1)$, equations (7), (8), and (9) can be solved to yield the optimal values in each quarter for the control variable m , the state variable u , and the shadow price λ .

For an exposition, consider a 5-quarter planning horizon using data from the U.S. for a jobless recovery period during the quarters 2002.4 – 2003.4, where both actual and forecasted economic performance were sluggish relative to productivity, Schweitzer (2003) and Witte (2003). The simulations use a constant average quarterly inflation rate of .5%, an average quarterly productivity increase of 1%, an average trend quarterly productivity increase of .75%, and set the expectation updating parameter k equal to .5. The initial unemployment rate at the end of year 2002 was about 5.8%.

Optimal Policy Simulations								
quarter	simulated: $\alpha_1 = .25$ $\alpha_2 = .5$			simulated: $\alpha_1 = .75$ $\alpha_2 = 10$			actual values	
	λ	m^*	u	λ	m^*	u	m	u
2002.4	0.0417	0.0149	5.80%	0.0882	0.0172	5.80%	0.0171	5.80%
2003.1	0.0395	0.0146	6.34%	0.0797	0.0162	6.22%	0.0240	5.77%
2003.2	0.0357	0.0144	6.06%	0.0629	0.0153	5.77%	0.0140	6.17%
2003.3	0.0324	0.0143	5.80%	0.0474	0.0145	5.42%	0.0202	6.13%
2003.4	0.0294	0.0141	5.55%	0.0336	0.0140	5.16%	0.0180	5.95%
2004.1	0.0266	-	5.33%	0.0247	-	5%	0.0003	5.60%

The table² shows that monetary authorities will initially take a more aggressive policy action and then steadily decrease the vigor across the periods of the planning horizon. The unemployment rate encounters an initial jump due to the initial condition, but then steadily decreases causing it to terminate at a lower rate than that which occurred in the actual data. The shadow price, λ , measures the marginal disutility from each period to the end the planning horizon, and therefore must fall in each consecutive period. If the policymakers shift their focus by increasing the relative importance of achieving a goal of low unemployment, then they will increase the penalty for deviations from the natural unemployment rate by increasing α_1 , α_2 , or both. The simulations show that as these parameters are increased, the monetary growth is larger, thereby driving down the unemployment rate faster.

CONCLUSION

High rates of productivity growth are indisputably a primary determinant of economic advancement in the long run. However, the adverse transitional effects of such increases can amplify short run economic cycles. The problem of finding an appropriate policy to guide the economy through the frustrating modern jobless recovery episodes is extremely important given the likely continuing widespread prevalence of this phenomenon. The size of the impacts can be estimated, and rules such as the one above provide an economically optimal and political feasible approach to handling such situations.

Though the thrust of short run stabilization policy continues to be a matter of debate, the above analysis has shown that optimal monetary policy rules can be formulated to dampen the negative slumping effects related to productivity gains. Utilizing this particular framework is

superior to ad hoc policies since it provides a direct objective method that can then be used as an aid to improve policy-making decisions and enhance economic stability.

Further analysis might consider policy coordination between countries which are jointly experiencing sluggish recoveries over the course of economic adjustments to productivity shocks. In this case, domestic monetary policy would also react to output gaps experienced by its primary trading partners. The above approach could be utilized in such a situation by augmenting the equations to include terms that captured the effects of international productivity shocks and employment gaps. Such a strategy would provide insight into international policy coordination. Even the announcement of this type of strategy would likely result in less pessimistic expectations of economic agents during jobless recovery episodes both at home and abroad.

NOTES

1. It should be noted that in equations (7) and (8), the coefficients s_1 and s_2 are combined with other variables and embedded within the c_1 and c_2 terms for ease of mathematical manipulation. Thus, any change in the parameter values will affect the resulting path for optimal monetary policy.
2. The authors acknowledge the assistance of Sean Crowell in programming the simulations.

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