

A Monetary Business Cycle Model with Unemployment

Michelle Alexopoulos

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Abstract

To reproduce the high variation of employment and low variation of real wages observed in the post-war U.S. data, many business cycle models must assume that there are high price markups and agents have high labour supply elasticities. The problem with these assumptions is that microeconomic evidence indicates that markups and labour supply elasticities are generally low. To eliminate the need for these assumptions, this paper introduces a labour market friction into a monetary general equilibrium model with limited participation. In the model, firms imperfectly observe their workers' effort levels, detected shirkers forgo an increase in their compensation and households make their decisions about their level of monetary deposits for the period in advance of seeing the shocks to the economy. The estimated model is: (1) able to account for the observed variation in employment and real wages over the business cycle, and (2) consistent with the existing evidence about the qualitative responses of the U.S. economy to fiscal and monetary policy shocks. (JEL E32)

1. INTRODUCTION

To reproduce the high variation of employment and low variation of real wages seen in the post-war U.S. data, monetary business cycle models generally require the presence of high price markups and the assumption that agents have high labour supply elasticities.¹ Microeconomic evidence, however, indicates that the labour supply elasticities for workers and price markups are generally low.² To reconcile these microeconomic estimates with the values needed in these business cycle models, a number of papers have focused on incorporating labour market frictions that mimic the effect of a high labour supply elasticity. Common examples include non-divisibility of labour, costly employment search, and home production technology.³ This paper embeds a different labour market friction into a monetary business cycle model – imperfectly observed effort.

The monetary business cycle model presented in this paper has three main characteristics: (i) households make nominal savings decisions before observing the period's shocks, (ii) workers' effort levels are imperfectly observed by firms, and (iii) shirkers who are detected by their firm forgo an increase in their compensation. The first feature is found in limited participation models, while the second feature is commonly seen in the shirking efficiency wage literature that originated with Shapiro and Stiglitz (1984). However, the third feature (that detected shirkers forgo a raise or a bonus) is a departure from the standard assumption

¹ See e.g., Christiano, Eichenbaum and Evans (1997), Gust (1997) and Rotemberg and Woodford (1996).

² According to studies such as MaCurdy (1981), Card (1991), Pencavel (1986), the labour supply elasticity of males is near zero in the United States. Mulligan (1995) argues that the elasticity of labour supply is higher than reported by these studies. However his estimates are still smaller than the value required to reconcile the standard business cycle models with the time series properties of real wages and employment. See Basu and Fernald (1997) for some evidence on price markups.

³ See e.g., Hansen (1985), Rogerson (1988), Mortensen and Pissardies (1994), and McGratten, Rogerson and Wright (1997) respectively.

used in the related Shapiro-Stiglitz style shirking efficiency wage models. This difference is largely responsible for the model's success.

Two main questions are addressed in this paper. First, can a limited participation model with imperfectly observed effort and a "monetary punishment", (herein referred to as the shirking model), account for the observed variation in employment and real wages over the business cycle? Second, is this model consistent with evidence about the qualitative responses of the U.S. economy to fiscal policy shocks, technology shocks and monetary policy shocks? The answers to these questions highlight the paper's main contribution.

The paper demonstrates that estimated versions of the shirking model are consistent with large employment fluctuations and small wage fluctuations. Moreover, the shirking model's ability to produce large employment variation alongside small wage variation does not depend on high levels of markups or large labour supply elasticities, in contrast to the standard limited participation model. The shirking model's responses to fiscal policy shocks, technology shocks and monetary shock are also shown to be qualitatively consistent with some of the existing empirical evidence about the U.S. economy's responses to these shocks.⁴ In particular, following an expansionary monetary policy shock, real output, employment, consumption, investment, profits and real wages rise, while interest rates fall. Following a expansionary fiscal policy shock, output, employment and investment increase in the shirking model while real wages, consumption and prices fall. Finally, following a positive technology shock, employment, real wages, consumption, profits and output rises,

⁴ See Ramey and Shapiro (1997), and Edelberg, Eichenbaum and Fisher (1998) for evidence on the economy's responses to fiscal policy shocks. See Christiano, Eichenbaum and Vigfussion (2002) for some evidence on the economy's response to technology shocks and see Christiano, Eichenbaum and Evans (1997, 1998), and Sims and Zha (1995) for evidence on how the economy responds to monetary policy shocks..

in the model while prices fall. Although the model's qualitative responses are insensitive to the nature of risk sharing arrangements between workers, the magnitudes of the responses are not. For example, following a technology or monetary policy shock, the shirking model with partial income insurance produces a much larger employment response and a smaller real wage response than the model with full income insurance.

Efficiency wage models, and the shirking model presented in the paper, start with the premise that wages affect a worker's productivity. However, the different types of efficiency wage models differ in the reason the link between wages and productivity emerges. In my shirking model, and in models following in the Shapiro and Stiglitz (1984) tradition, the link between wages and productivity emerges because firms only imperfectly observe workers' effort levels on the job.⁵ Therefore, firms take their workers' incentive compatibility constraints into account when they choose the size of their workforce, the wages they will pay their employees, and the level of effort that they will require from their workers. In equilibrium, the levels of these variables will ensure that each worker will voluntarily provide the optimal effort level since the worker's expected utility associated with providing the effort will be at least as large as his expected utility associated with shirking.

This type of model has a number of attractive features. First, it is consistent with the positive levels of unemployment seen in the U.S. data since the optimal number of workers hired need not correspond with full employment in equilibrium. Second, when there is unemployment, employment fluctuations represent changes in the number of people working as

⁵ Effort may be imperfectly observed because the firm's monitoring technology is imperfect. This may occur because there is no perfect monitoring system available or because the cost associated with implementing a perfect monitoring system is too high for it to be profitable for firms to buy it.

opposed to changes in the number of hours worked per person.⁶ Third, when there is equilibrium unemployment, the model's predictions for employment and wages are determined by the labour demand curve and the individuals' incentive compatibility constraints. Therefore, the behaviour of wages and employment does not depend on the elasticity of the labour supply curve. Fourth, the model is consistent with the evidence presented in Blanchflower and Oswald (1996) that suggests that the prevailing wage rate is inversely related to the level of unemployment. Fifth, the assumption of imperfectly observable effort is a relatively small departure from the assumptions in a standard business cycle model.

These features give rise to the possibility that this "shirking efficiency wage" friction may be able to mimic the effect of a high labour supply elasticity in standard business cycle models. For example, in Solow's (1979) simple efficiency wage model, firms choose to offer workers a real wage that is constant across periods and independent of shocks. Unemployment is involuntary in Solow's model so, if firms want to increase the size of their workforce in response to a shock, they can simply hire people from the pool of unemployed workers at the prevailing wage. Since employment responds to the market conditions, while wages do not, this simple model can produce the same responses as a standard business cycle model where workers have infinitely high labour supply elasticities.

Encouraged by the predictions of simple efficiency wage models Danthine and Donaldson (1995), Gomme (1999) and Kimball (1994) examine the behaviour of real wages and employment in general equilibrium Shapiro-Stiglitz style models where effort is imperfectly observable and individuals are fired if they are detected shirking on the job. Unfortunately,

⁶ Lilien and Hall (1986) report that most of the variation in employment hours is accounted for by changes in the number of people employed.

they find that their models are generally unable to generate the high employment and low real wage variability that is found in the partial equilibrium efficiency wage models. These findings are attributable to the assumption that firms fire detected shirkers.⁷ Therefore, in contrast to the original Shapiro-Stiglitz model, this paper incorporates imperfectly observable effort into a monetary model where individuals found shirking on the job forgo a portion of their possible pay for the period, (i.e., a bonus or a raise), instead of being dismissed.⁸

This alternative “monetary punishment” is of particular interest for two reasons. First, there is evidence which suggests that firms more commonly rely on this type of “monetary punishment” to discipline workers than on outright dismissal.⁹ Second, when it is assumed that detected shirkers forgo some compensation, firms can punish them even when there is full employment. Consequently, the model with this monetary punishment does not embed the same strong forces leading to strongly procyclical wages and weakly procyclical employment at low levels of unemployment as models with the traditional Shapiro and Stiglitz punishment. This is clearly illustrated by the results in this paper.

The remainder of the paper is organized as follows. Section 2 presents the limited participation model where effort is imperfectly observed and detected shirkers are assumed to forgo a bonus. Section 3 presents the results for the estimated versions of the model and the

⁷ When the only punishment associated with shirking is that detected shirkers are fired at the end of the period, firms must increase the wage paid to workers as the economy moves towards full employment since the punishment associated with being dismissed approaches zero because of the reduction in the expected duration of unemployment. This implies that the incentive compatibility constraint becomes infinitely steep as the unemployment rate approaches zero. Consequently, at low rates of unemployment, changes in the number of people employed greatly affects the duration of unemployment which leads to the model producing highly variable and procyclical real wages.

⁸ This environment is similar to the ones seen in Alexopoulos (2000), Burnside, Eichenbaum and Fisher (2000) and Felices (2001).

⁹ See e.g., Agell and Lundborg (1993), Malcomson (1998), Hall (1993), and Weiss (1990).

empirical implications for the model's second moment properties of real wages and employment. It also outlines the estimated model's responses to technology, monetary and fiscal policy shocks, and compares them to evidence about the U.S. economy's responses to these shocks. Finally, the results for the model with imperfectly observed effort are compared to results obtained from a standard limited participation model with divisible labour. Section 4 provides a summary of the results for the model and concludes the paper by suggesting areas for future research.

2. THE MODEL

The economy has 6 sectors: the monetary authority, the financial intermediaries, the government, the families, the intermediate goods firms and the final good firms. Each agent's problem is discussed in detail below.

2.1. The Monetary Authority

The monetary authority controls the period by period monetary injection, X_t , received by the financial intermediaries. The growth rate of money, x_t , is defined by $x_t = \frac{X_t}{M_t} = \frac{M_{t+1} - M_t}{M_t}$ where M_t is the nominal stock of money at the beginning of period t . For the purpose of this investigation, the money stock is assumed to be measured by M2 and x_t is the realization of an AR(1) process:

$$x_t - x^{ss} = \rho_x (x_{t-1} - x^{ss}) + \varepsilon_{xt}$$

where $-1 < \rho_x < 1$, x^{ss} is the mean growth rate of money and ε_{xt} is a serially uncorrelated

process with mean zero and standard deviation σ_x .^{10,11}

2.2. Financial Intermediaries

At the beginning of time t , the continuum of perfectly competitive financial intermediaries receives nominal deposits, D_t , from families to invest for the duration of the period. After these funds are deposited, the financial intermediaries receive the lump sum cash injection, X_t , from the monetary authority.

As in the standard limited participation model, it is assumed that intermediate goods firms require loans to finance their wage bills. The firms borrow these funds from the financial intermediaries for the duration of the period at a gross interest rate, R_t . This implies that the economy's loan market clearing condition is:

$$\mathcal{L}_t = D_t + X_t \tag{\#1}$$

where \mathcal{L}_t is the total amount of funds demanded by firms in time period t and $D_t + X_t$ is the total supply of available funds. At the end of the period, the intermediate goods firms repay their loans with interest, and the financial intermediaries distribute $R_t D_t$ to the households in return for their deposits and $R_t X_t$ in the form of profits.

2.3. The Government

The government finances its purchases of final goods, G_t , by levying lump-sum taxes on

¹⁰ The findings of Christiano, Eichenbaum and Evans (1998) indicate that x_t follows an AR(1) process if the money stock is measured by M2, and x_t follows an MA(2) process if the money stock is measured by M1. Although the results reported in this paper are derived using M2 as the measure of the monetary stock, the model was also simulated using M1 as the measure of money, and assuming that x_t is the realization of the MA(2) process reported in Christiano, Eichenbaum and Evans (1998). The results suggest that the findings of this paper are not dependent on which money stock, M1 or M2, is used.

¹¹ The money growth rate, x_t , is assumed to be unaffected by fiscal and technology shocks. This assumption is consistent with the results in papers such as Eichenbaum, Edelberg and Fisher (1998), and Christiano, Eichenbaum and Vigfussion (2002), which suggest that the stock of money does not significantly respond to these shocks.

families. Therefore, the government's period t budget constraint is:

$$G_t \leq Tax_t$$

where Tax_t is the amount of lump-sum taxes collected. Since all families are identical in the model, each is assumed to face an equal tax burden.

2.4. Families and Individuals

In models with unemployment, when agents' incomes are heterogeneous and agents are able to transfer wealth across periods, the individual's savings decision becomes dependent on his entire work history. To keep my model comparable to other standard representative agent models and isolate the role of the imperfect observability of effort, I introduce a family construct to ensure that the workers' problems will remain homogeneous.¹²

The economy is assumed to be populated by a large number of families, each of which contain a $[0, 1]$ -continuum of infinitely lived individuals.¹³ Although individuals do not directly own assets in this model, each individual's family owns an equal portion of the capital stock, as well as equal amounts of shares in the intermediate goods firms and the financial intermediaries. These shares entitle the family to a percentage of the profits earned by the financial intermediaries and intermediate good firms.

2.4.1. A Representative Family

The family owns all the assets in the economy, and makes all decisions regarding the

¹² Past research has suggested two other approaches to ensuring that agent's problems are homogeneous. The first method utilizes an insurance market that fully insures workers' incomes against unemployment. The second method involves having two types of agents in the model: entrepreneurs and workers. Entrepreneurs are identical and able to transfer wealth between periods, whereas workers do not have access to any savings technology in order to prevent their capital accumulation from becoming state dependent. Versions of the model that use these different structures gave approximately the same results.

¹³ The number of families is assumed to be large enough so that no individual family assumes it can influence firms' labour contracts. The role of the family is similar to the family's role in Shi (1997), and is seen in papers such as Alexopoulos (2000), Burnside, Eichenbaum and Fisher (2000), and Felices (2001).

amount of money dedicated to family consumption, $P_t c_t^f$, deposits, D_t , capital investment, $P_t I_t$, and money holdings, M_{t+1} , where P_t is the price level in time t . Consistent with the limited participation constraint, the family chooses the level of deposits before they observe the values of the period's shocks. After the shocks are revealed, the family pays taxes, Tax_t , and decides how much money to devote to capital investment and family consumption.

The family finances its period t family purchased consumption, c_t^f , taxes, deposits, and capital investment using their beginning of period real money balances, M_t/P_t , and their return on capital, $r_t K_t$. Profits are not distributed to the family until the end of the period and therefore are unavailable for purchasing period t goods. Under these assumptions, the family's cash in advance constraint and money holdings are described by the following equations:

$$P_t c_t^f \leq M_t - D_t - P_t Tax_t + P_t r_t K_t - P_t I_t \quad (\#2)$$

$$M_{t+1} = \left[M_t - D_t - P_t c_t^f - P_t Tax_t + P_t r_t K_t - P_t I_t \right] + R_t [D_t + X_t] + PR_t \quad (\#3)$$

where PR_t and $R_t X_t$ denote the profits from intermediate goods firms and financial intermediaries in period t respectively. Since the family decides how to distribute $P_t c_t^f$ among the members before firms hire employees, each family member is optimally given an equal share.

As in the standard limited participation model, families must be discouraged from removing large amounts of deposits from the financial intermediaries to generate persistent responses to monetary policy shocks. Therefore, I assume that the family faces adjustment costs whenever they alter their stock of capital or their flow of funds to the goods market. The adjustment costs on the flow of funds to the goods market and capital are similar to those

used in Christiano and Eichenbaum (1992a), and Christiano and Fisher (1998) respectively. Specifically, if the flow of funds to the goods market changes, I assume that each individual must spend a portion of his leisure time helping to reorganize his family's purchases. In addition, the final good cannot be freely converted to the capital goods used in production by the intermediate goods sector. Here, the end of period capital stock, K_{t+1} , is determined by the following technology:

$$K_{t+1} = [\gamma_1 I_t^v + \gamma_2 K_t^v]^{\frac{1}{v}} \quad (\#4)$$

where I_t is the amount of period t investment, $v \leq 1$ determines the cost of adjusting the capital stock, and γ_1 and γ_2 are positive constants. To ensure that the steady state values of the rental rate of capital and investment are invariant to the level of v , γ_1 and γ_2 are set to the values:

$$\gamma_1 = \delta^{1-v} \text{ and } \gamma_2 = (1 - \delta)$$

where δ represents the capital depreciation rate. In the benchmark case, I set $v = 1$ so that equation (#4) is the conventional linear capital accumulation equation.

2.4.2. Family Members

Although individual family members do not have direct access to financial or capital markets, they do receive some consumption financed by their family's return on financial and capital investments through $P_t c_t^f$. In addition to this family purchased consumption, c_t^f , family members may increase their consumption level by obtaining wage income from employment.

All intermediate goods firms are assumed to have identical production technologies. As a result, all firms will require the same effort levels from their workers and offer the same wage

levels. Since effort is imperfectly observed by the firms, workers who accept employment must choose whether to provide the required effort level. Workers hired by the intermediate goods firms receive a one period contract that specifies the number of hours an employee must work, f , the level of effort a worker is required to provide, e_t , and the wage rate, w_t , that a worker can earn.¹⁴ All workers receive a fraction, s , of their wages up front, but the final payment of $(1 - s)w_t f$ is only paid to workers who are not disciplined for shirking.¹⁵ In addition, workers know that if they shirk, they will be detected by their firm's exogenous monitoring technology with probability $d < 1$.

In this model, the optimal wage chosen by intermediate goods firms can result in equilibrium unemployment.¹⁶ Unemployed family members who do not reject a job offer can increase their consumption level about c_t^f by purchasing extra consumption goods with the funds they receive from their family's income insurance fund. This fully funded insurance is financed by working family members who each transfer a lump-sum F_t to a fund that is distributed among the unemployed during the period. This unemployment insurance ensures that an unemployment spell will not result in a large drop in consumption for the individual. In order to determine the effect of this type of unemployment insurance on the model's predictions, the two different risk sharing arrangements are examined: partial income insurance and full income insurance.

¹⁴ To reduce the amount of notation in this subsection, the subscript that identifies which firm is omitted here since all firms are identical and will choose the same values.

¹⁵ In this model, s is assumed to be an exogenous parameter. However, this model delivers the same results as a model where (i) there is a restriction on the minimum value of s , (e.g. a legal restriction or an industry norm), and (ii) s is chosen endogenously by firms, since firms would always set s to the lowest level possible to maximize the value of the punishment for shirking. The value of s in the model is determined by the US data and GMM procedure discussed later in the paper.

¹⁶ Although for some parameter values, the model will produce no equilibrium unemployment, in what follows I focus on the more interesting case where the model predicts positive levels of unemployment in equilibrium.

2.4.3. The Worker's Problem

Workers are able to purchase consumption with their family's consumption benefits, $P_t c_t^f$, and their after transfer wage income, while the unemployed purchase consumption with their family's consumption benefits, $P_t c_t^f$, and their transfer from the family insurance fund. Here, c_t , c_t^s and c_t^u denote the consumption level enjoyed by all workers not detected shirking (i.e., non-shirking workers and non detected shirkers), the consumption level for a detected shirker and the unemployed's consumption level respectively. As a result

$$c_t = c_t^f + w_t f - F_t \quad (\#5)$$

$$c_t^s = c_t^f + s w_t f - F_t \quad (\#6)$$

$$c_t^u = \begin{cases} c_t^f + \frac{N_t}{1-N_t} F_t & \text{if the individual had no job offer} \\ c_t^f & \text{if the individual rejects a job offer} \end{cases} \quad (\#7)$$

where N_t is the total number of family members employed in period t . Individuals' utility levels are then described by the function:

$$u(\tilde{c}_t, \hat{e}_t) = \ln(c_t) + \theta \ln(T - \vartheta(\hat{e}_t > 0)(f\hat{e}_t + \xi)) - \theta \ln(1 + H(Q_t, Q_{t-1})) \quad (\#8)$$

where \tilde{c}_t is the individual's realized consumption level, \hat{e}_t is the level of effort provided, T is the individual's time endowment, $\vartheta(\cdot)$ is an indicator function taking on the value of 1 when effort is provided, and ξ is the disutility associated with providing any effort.¹⁷ The term $-\theta \ln(1 + H(\cdot, \cdot))$ reflects the assumption that each individual spends a portion of his leisure time, $\frac{H(\cdot, \cdot)}{1+H(\cdot, \cdot)}$, involved in reorganizing the household's flow of funds to the goods market.

¹⁷ Since firms do not perfectly observe effort, firms also do not observe if individuals incur the cost ξ .

Here it is assumed that:

$$H(Q_t, Q_{t-1}) = a_0 \left\{ \exp \left[a_1 \left(\frac{Q_t}{Q_{t-1}} - 1 - x^s \right) \right] + \exp \left[-a_1 \left(\frac{Q_t}{Q_{t-1}} - 1 - x^s \right) \right] - 2 \right\}$$

where $Q_t = M_t - D_t$ (#9)

This formulation implies that when there are no changes in the flow of funds to the goods market, no adjustment costs are realized.¹⁸

Family members who are offered jobs must determine whether they will abide by the terms of the contract, if they accept employment, and whether working for the firm is optimal. The assumptions about unemployment insurance guarantee that workers will always accept employment. Moreover, the solution to an employed worker's problem is:

$$\hat{e}_t = \begin{cases} e_t & \text{if } e_t \leq \frac{T}{f} \left(1 - \left(\frac{c_t}{c_t^s} \right)^{-\frac{d}{\theta}} \right) - \frac{\xi}{f} \\ 0 & \text{if } e_t \geq \frac{T}{f} \left(1 - \left(\frac{c_t}{c_t^s} \right)^{-\frac{d}{\theta}} \right) - \frac{\xi}{f} \end{cases}$$

These conditions are equivalent to the statement that an individual will decide to provide the required effort if his incentive compatibility (IC) constraint is satisfied, i.e., if

$$u(c_t, e_t) \geq du(c_t^s, 0) + (1 - d)u(c_t, 0) \quad (\text{IC})$$

2.4.4. The Family's Problem

During the period firms hire N_t family members. Of these workers, N_t^s are shirkers who exert no effort on the job, and $N_t - N_t^s$ are non-shirkers who exert a positive level of effort, \hat{e}_t . Using the previously specified utility function and adjustment costs, and the definitions

¹⁸ This formulation also implies that, in equilibrium, unemployed members of the family will spend more time reorganizing the family's flow of funds to the market than their working counterparts.

of c_t , c_t^s and c_t^u , the family's problem can be written as:

$$\max_{\{c_t^f, K_{t+1}, M_{t+1}, D_t\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \begin{array}{l} (N_t - dN_t^s) \ln(c_t) + dN_t^s \ln(c_t^s) + (1 - N_t) \ln(c_t^u) \\ + (N_t - N_t^s) \theta \ln(T - f\hat{e}_t - \xi) + (1 - (N_t - N_t^s)) \theta \ln(T) \\ - \theta \ln(1 + H(Q_t, Q_{t-1})) \end{array} \right\}$$

subject to equations (#2) through (#4) where

$$F_t = \begin{cases} (1 - N_t)sw_t f & \text{under partial income insurance} \\ (1 - N_t)w_t f & \text{under full income insurance} \end{cases}$$

In equilibrium, the cash in advance constraint holds with equality since the gross interest rate on deposits exceeds unity, and no one shirks on the job (i.e., $N_t^s = 0$). Therefore, the family's Euler equations for deposits and capital accumulation reduce to:¹⁹

$$E_{t-1} \left\{ \begin{array}{l} \left(\frac{U_{c_t^f}}{P_t} \right) - \theta \frac{H_1(Q_t, Q_{t-1})}{1+H(Q_t, Q_{t-1})} - \beta \theta \frac{H_2(Q_{t+1}, Q_t)}{1+H(Q_{t+1}, Q_t)} \\ - \beta R_t \left[\left(\frac{U_{c_{t+1}^f}}{P_{t+1}} \right) - \theta \frac{H_1(Q_{t+1}, Q_t)}{1+H(Q_{t+1}, Q_t)} - \beta \theta \frac{H_2(Q_{t+2}, Q_{t+1})}{1+H(Q_{t+2}, Q_{t+1})} \right] \end{array} \right\} = 0$$

$$E_t \left\{ U_{c_t^f} \frac{\partial I_t}{\partial K_{t+1}} - \beta U_{c_{t+1}^f} (r_{t+1} - \frac{\partial I_{t+1}}{\partial K_{t+1}}) \right\} = 0$$

$$\text{where } U_{c_t^f} = \frac{N_t}{c_t} + \frac{1 - N_t}{c_t^u}$$

$$H_1(Q_t, Q_{t-1}) = \frac{a_0 a_1}{Q_{t-1}} \left\{ \begin{array}{l} \exp \left[a_1 \left(\frac{Q_t}{Q_{t-1}} - 1 - x^s \right) \right] \\ - \exp \left[-a_1 \left(\frac{Q_t}{Q_{t-1}} - 1 - x^s \right) \right] \end{array} \right\}$$

$$H_2(Q_t, Q_{t-1}) = -H_1(Q_t, Q_{t-1}) \frac{Q_t}{Q_{t-1}}$$

¹⁹ For simplicity, it is assumed that families do not believe that their choices affect the employment probability of their members. Alexopoulos (2001) discusses a way to rationalize this assumption. The more complex environment, described in Alexopoulos (2001) leads to precisely the same allocations as in this model.

$$\text{and } \frac{\partial I_t}{\partial K_{t+1}} = \delta^{\frac{v-1}{v}} (K_{t+1}^v - (1-\delta)K_t^v)^{\frac{1}{v}-1} K_{t+1}^{v-1}$$

$$\frac{\partial I_{t+1}}{\partial K_{t+1}} = \delta^{\frac{v-1}{v}} (K_{t+2}^v - (1-\delta)K_{t+1}^v)^{\frac{1}{v}-1} (\delta-1)K_{t+1}^{v-1}$$

2.5. Final Good Firms

The perfectly competitive final good firms produce the final good, Y_t , by combining the output of the continuum of intermediate firms using the technology:

$$Y_t = \left[\int_0^1 Y_{it}^{\frac{1}{\mu}} di \right]^{\mu}$$

where Y_{it} represents the input from the i^{th} intermediate firm in period t , and $1 \leq \mu < \infty$ is a measure of substitutability between inputs.

Given this technology, a representative final good firm faces the following profit maximization problem in period t :

$$\max_{Y_t, \{Y_{it}\}_0^1} P_t Y_t - \int_0^1 P_{it} Y_{it} di \text{ s.t. } Y_t = \left[\int_0^1 Y_{it}^{\frac{1}{\mu}} di \right]^{\mu}$$

where P_t is the price of the final good and P_{it} is the price of the i^{th} intermediate good at time t .

The Euler equations from this problem define the demand functions for the intermediate goods firm's output:

$$Y_{it} = Y_t \left(\frac{P_{it}}{P_t} \right)^{\frac{\mu}{1-\mu}}$$

Therefore, the demand for firm i 's product is both increasing in aggregate output, Y_t , and decreasing in the price of its intermediate good. Finally, using the demand equations and the zero profit condition, the price of the final good can be determined by:

$$P_t = \left[\int_0^1 P_{it}^{\frac{1}{1-\mu}} di \right]^{(1-\mu)}$$

2.6. Intermediate Goods Firms

The economy's intermediate goods are produced by a $[0,1]$ -continuum of monopolistic competitors. Entry and exit into the production of intermediate good i are ruled out and representative firm i is assumed to have the following production function:²⁰

$$Y_{it} = A_t K_{it}^\alpha ((N_{it} - N_{it}^s) f \widehat{e}_{it})^{1-\alpha}$$

Here $0 < \alpha < 1$, A_t is the level of technology where $\ln A_t = (1 - \rho_A) \ln A + \rho_A \ln A_{t-1} + \varepsilon_{A,t}$, $-1 < \rho_A < 1$ and $\varepsilon_{A,t}$ is a serially uncorrelated process with mean zero and standard deviation σ_A . Further, N_{it} , N_{it}^s and K_{it} denote the number of workers hired, the number of shirkers hired, and the amount of capital rented in period t by firm i respectively. Each labourer works a fixed shift, f , and provides an effective labour unit input of $f \widehat{e}_{it}$, if he chooses not to shirk on the job.

After the time t shocks are observed, firms rent capital from a perfectly competitive market, and publicly advertise employment opportunities. The advertisement specifies the number of workers they want to hire, the real wage rates they will pay workers, and the effort level they require from each worker. All parties understand that, although workers providing the required effort level are guaranteed wages $w_{it}f$, $(1 - d)N_{it}^s$ shirkers will receive $w_{it}f$ while dN_{it}^s shirking workers will receive compensation $sw_{it}f$.²¹

Firms are assumed to never “cheat” by withholding a bonus from a non-shirking worker. This assumption is made solely for simplicity. The results in this paper are unaffected if instead: (i) there are continuing matches between workers and firms that breakup with an

²⁰ This representation assumes that non-shirking workers provide an effort level of \widehat{e}_{it} while shirking workers provide no effort to firms.

²¹ In this case, $sw_{it}f$ can be interpreted as a base wage or salary, that is guaranteed to the worker, and $[1 - s]w_{it}f$ as a bonus payment only paid to non-disciplined workers.

exogenous probability, (ii) firms get a reputation as a bad employers if they do not pay the bonus to non-detected shirkers, (iii) workers will not provide effort to bad employers because they believe that bad employers will fail to provide them with their bonus, and (iv) there are reasonable levels of markups in the economy.^{22,23}

Once the employees are hired, each firm borrows its nominal wage bill, $P_t w_{it} f N_{it} = W_{it} f N_{it}$, from the bank at the gross interest rate R_t . Although the firm possesses the funds to pay its entire wage bill before the workers begin production, they choose to withhold a fraction, $(1 - s)$, of the funds.²⁴ This shows their intent to pay their workers while making the punishment for shirking credible. In this case, each worker is paid $s W_{it} f$ at the beginning of the period and the additional amount of $W_{it} f (1 - s)$ at the end of his contract period, provided he is not detected shirking.

After workers are hired, production takes place and the output is sold to the final good firms. The firm then pays for the rental of capital, $r_t K_t$, and repays the bank loan with interest. Any remaining proceeds from the sale are then distributed in the form of profits to the families at the end of the period.

Formally, a representative intermediate good firm, hiring identical workers, faces the

²² This richer environment is closer to that seen in MacLeod and Malcomson (1998). An examination of this richer environment demonstrated that when the household's discount rate, β , equals $(\frac{1}{1.03})^{0.25}$, and when markups are greater than 1%, the firm will have no incentive to withhold bonuses from non-detected shirkers since the value of withholding the bonus in any period is less than the discounted value of the future profits they will lose because of the bad reputation they get if they withhold the bonuses, i.e., the firm's incentive compatibility constraint will not be binding. As a result, the firm's problem will reduce back to a one period problem. Further, since it is assumed that the probability that the match breaks up is exogenous, in order to focus on the effects of having a monetary punishment, the individual's incentive compatibility constraints are the same as those in the simple version of the model.

²³ See Basu and Fernald (1997) for some evidence on mark-ups for the U.S. economy.

²⁴ Alexopoulos (2001) presents an extension of this model where firms endogenously choose the value of s to be positive and constant across time periods and all states of the world. The results of this paper are robust to this modification.

following problem in period t :

$$\max_{\{P_{it}, w_{it}, N_{it}, K_{it}, e_{it}\}} \left\{ \frac{P_{it}}{P_t} (A_t K_{it}^\alpha (f e_{it} N_{it})^{1-\alpha}) - R_t w_{it} f N_{it} - r_t K_{it} \right\}$$

subject to the period by period demand functions:

$$P_{it}^{\frac{\mu}{\mu-1}} (A_t K_{it}^\alpha (f e_{it} N_{it})^{1-\alpha}) - P_t^{\frac{\mu}{\mu-1}} Y_t = 0$$

and the period by period incentive compatibility constraints (IC) and individual rationality constraints (IR):

$$u(c_{it}, e_{it}) \geq du(c_{it}^s, 0) + (1-d)u(c_{it}, 0) \text{ (IC)}$$

$$u(c_{it}, e_{it}) \geq u(c_t^u, 0) \text{ (IR)}$$

Here $u(\cdot, \cdot)$ is the representative worker's utility for the period, e_{it} is the effort level specified in the contract, and $\{c_{it}, c_{it}^s, c_t^u\}$ are given by equations (#5) through (#7) when wages are equal to w_{it} .

In this problem, w_{it} denotes the real wage rate offered by the firm, and r_t is the real rate of return on capital. Since the form of the family's unemployment insurance implies that the IR constraint does not bind, the IC constraint holds with equality in equilibrium. Therefore, using the definitions of c_{it} , and c_{it}^s , effort can be expressed as a function of the real wage, the price level, the intra-family transfers and the family's non-deposited funds:

$$e_{it}(w_{it}) = \frac{T}{f} \left(1 - \left(\frac{c_{it}}{c_{it}^s} \right)^{-\frac{d}{\theta}} \right) - \frac{\xi}{f}$$

It follows that the Euler equations from an intermediate good firm's problem can be rear-

ranged to obtain the following equilibrium conditions:

$$\frac{e'_{it}(w_{it})w_{it}}{e_{it}(w_{it})} = 1 \text{ (The Solow Condition)}$$

$$\frac{Y_{it}}{N_{it}} \frac{(1-\alpha)}{\mu} = \frac{P_t}{P_{it}} f w_{it} R_t$$

$$\frac{Y_{it}}{K_{it}} \frac{\alpha}{\mu} = \frac{P_t}{P_{it}} r_t$$

$$P_{it}^{-\frac{\mu}{1-\mu}} Y_{it} = P_t^{-\frac{\mu}{1-\mu}} Y_t$$

The Solow Condition implies that the firm's choices will minimize the cost per unit of effort. Given the individuals utility function, it implies that wages will be chosen by firms to ensure that

$$\frac{c_{it}}{c_{it}^s} = \text{const} \rightarrow e_{it} = \frac{T}{f} \left(1 - (\text{const})^{-\frac{d}{\theta}} \right) - \frac{\xi}{f} = e$$

Since all of the intermediate goods firms have identical technologies and identical workers, they require the same effort level and offer the same wages to workers.

These Euler equations also imply that the firm chooses to set its time t price equal to a constant markup over the period's marginal costs:

$$P_{it} = \mu MC_{it}$$

Given the representative firm's problem for each good i , it follows that the equilibrium demand for funds can be expressed as:

$$\mathcal{L}_t = \int_0^1 W_{it} f N_{it} di$$

Since firms borrow funds from the financial intermediaries to finance their wage bills, $\mathcal{L}_t = D_t + X_t$. No one shirks in equilibrium and the unemployment rate is $1 - \int_0^1 N_{it} di$.

3. THE EMPIRICAL RESULTS

To estimate the model, growth is introduced by adding an exogenous labour augmenting technology to the production function as follows:

$$Y_{it} = A_t K_{it}^\alpha (\gamma^t N_{it} f \hat{e}_{it})^{1-\alpha}$$

and $\gamma \geq 1$. In addition, government expenditures are assumed to evolve according to $G_t = \gamma^t \exp(g_t)$, where $g_t = \mu_g + \rho_g g_{t-1} + \varepsilon_{g,t}$, $-1 < \rho_g < 1$, and $\varepsilon_{g,t}$ is a serially uncorrelated process with mean zero and standard deviation σ_g .

The generalized method of moments (GMM) procedure discussed in Christiano and Eichenbaum (1992b), along with quarterly data from 1955 to 1992, are used to estimate the parameters and diagnose the performance of the model.²⁵ The data used to estimate the second moments, $\left\{ \frac{\sigma_c}{\sigma_y}, \frac{\sigma_i}{\sigma_y}, \frac{\sigma_g}{\sigma_y}, \sigma_w, \sigma_n, \sigma_y \right\}$, are detrended using a Hodrick and Prescott (HP) filter to ensure that the estimates exist since the data displays marked time trends.²⁶

After the parameters and second moments are estimated, the model is tested by: (1) comparing the estimated second moments from the data to those computed from the model using a Wald test, and (2) examining if the model's predictions about how the economy responds to shocks are qualitatively consistent with the empirical evidence.^{27,28}

Not all of the model's parameters are estimated using the Euler equations. The values for $\beta, T, f, \xi, \theta, v, a_1$, and a_2 , are chosen to coincide with values commonly seen in the literature.

²⁵ A detailed description of the data is found in Appendix A followed by an outline of the exactly identified GMM procedure, based on the Euler equations from the model with technological growth, in Appendix B.

²⁶ σ_j denotes the standard deviation of variable j where $j = c, i, y, w$, and n .

²⁷ This Wald test formally explores the hypothesis that the two sets of estimates are the same in population and is discussed in detail in Christiano and Eichenbaum (1992b).

²⁸ Only single hypotheses are tested given the problems associated with small sample properties of GMM-based Wald statistics. See Burnside and Eichenbaum (1996) for a discussion of these problems.

Specifically,²⁹

β	T	f	ξ	θ	v	a_1	a_2
$(\frac{1}{1.03})^{0.25}$	1369	1	10	0.72	1	2	2

An additional assumption about the ratio $\frac{c_t}{c_t^s}$ is made to help identify the ratio $\frac{d}{\theta}$, and the parameter s , in the IC constraint.³⁰ Here, this ratio is assumed to equal 1.2853 based on Gruber's (1997) results that an unemployment spell results in a 22.2% drop in food consumption when there is no government run unemployment insurance.³¹ The GMM procedure and the data are used to estimate the remaining parameters

$$\left\{ \frac{d}{\theta}, \delta, \tau_g, \mu_g, \rho_g, \sigma_g, \ln(A), \rho_A, \sigma_A, A_y, \ln(\gamma), \alpha, \ln\left(\frac{g}{y}\right), x^{ss}, \mu, \rho_x, \sigma_x \right\}$$

in the model.³² The resulting parameter estimates for each case of the limited participation model with imperfectly observed effort (the shirking model) are reported in Tables 1-3 alongside estimates for a standard limited participation model with divisible labour for the cases where $v = \{1, 0.97, 0.95\}$.³³ An examination of these estimates reveals that the predicted values are similar to those commonly seen in the literature.³⁴ Moreover, the

²⁹ Since f only affects the scale of effort, it is normalized to 1, T is chosen to coincide with a time endowment of 15 hours per day per quarter, ξ represents a fix cost of 10 minutes a day, $v = 1$ implies there are no capital adjustment costs, a_1 and a_2 are set equal to the values in Christiano, Eichenbaum and Evans (1997), and θ and β are chosen so that they fall in the range commonly seen in the literature. The main findings are robust to small changes in the parameters ξ, θ, v, a_1 and a_2 .

³⁰ Once $\frac{d}{\theta}$ is estimated, the value of s can be determined from the Solow condition.

³¹ The model's sensitivity was assessed by varying the value of $\frac{c_t}{c_t^s}$ since this value is never observed in equilibrium. In general, the findings indicate that small movements in $\frac{c_t}{c_t^s}$ have little effect on the model's second moments and responses to shocks.

³² The parameter τ_g is included in the equation for g_t to capture the time trend in government purchases observed in the data, A_y is estimated using the condition: $E(\ln(Y_t) - A_y - t \times \ln(\gamma)) = 0$, and $\frac{d}{y}$ is estimated using the condition: $E\left(\ln(G_t) - \ln(Y_t) - \ln\left(\frac{d}{y}\right)\right) = 0$.

³³ The standard limited participation model with divisible labour is based on Christiano, Eichenbaum and Evans (1997) and is described in Appendix C.

³⁴ For example, the estimated markup, μ , is lower than the value of 1.2 reported by Hornstein (1993) and

estimated parameters for the shirking model are virtually identical to those in the limited participation model, with the exception of the values for θ and $\frac{d}{\theta}$.³⁵ From these results it is clear that the differences between the models' predictions are attributable to the equations and parameters that affect the labour market and adjustment costs.

Next, the models are solved using the estimated parameter values and the linearization technique described in Christiano (1998), and the impulse response functions are computed for fiscal policy shocks, technology shocks and monetary policy shocks.

3.1. Fiscal Policy Shocks

The shirking model's responses to an exogenous increase in government expenditures are depicted in Figure 1, and the responses for the standard limited participation model are illustrated in Figure 2. These figures demonstrate that both models share the same qualitative responses to a positive government expenditure shock. Consistent with the results reported in Edelberg, Eichenbaum and Fisher (1998) and Ramey and Shapiro (1997), in the models output, employment, investment and interest rates all increase, while consumption and real wages both decrease. However, the figures show that neither of the models can account for the observation that prices increase following an exogenous increase in government expenditure.

It is also evident from Figure 1 that the form of the intra-family transfer and the adjustment cost on capital affect the predicted responses to an exogenous fiscal policy shock.

lower than the value assumed in models such as Chistiano, Eichenbaum and Evans (1997) (i.e., $\mu = 1.4$). However, Basu and Fernald (1997) estimate much lower markups. In addition the value of α falls in the range [0.25,0.43] reported in Greenwood, Rogerson, and Wright (1995).

³⁵ For the limited participation model, the following parameters are estimated: $\left\{ \theta, \delta, \tau_g, \mu_g, \rho_g, \sigma_g, \ln(A), \rho_A, \sigma_A, A_y, \ln(\gamma), \alpha, \ln\left(\frac{d}{y}\right), x^{ss}, \mu, \rho_x, \sigma_x \right\}$ where θ is the coefficient on leisure in the individual's utility function.

Specifically, in the shirking model, the full income insurance case (\cdots and $\cdot - \cdot$ lines) produces smaller movements than the partial income insurance case ($-o-$ and $- \times -$ lines) in all variables except consumption. In addition, both figures show that an increase in the capital adjustment costs decreases the shock's effect on all variables. The effect of a rise in the capital adjustment cost is largest for the partial income insurance shirking model. Finally, comparing Figures 1 and 2, it is evident that a positive fiscal policy shock produces the greatest increase in employment, output and investment, and the greatest decrease in wages and prices occurs in the shirking model with partial income insurance.

To understand the shirking model's responses to a fiscal policy shock recall that, holding everything else constant, an exogenous increase in government expenditures initially decreases the amount of money spent on investment and family purchased consumption. The fall in c_t^f causes an increase in the relative consumption of a non-disciplined worker to a disciplined worker, $\frac{c_t}{c_t^f}$. Therefore, at the previously given real wage rate and effort level, the utility of a non-shirker worker is now strictly higher than the expected utility of a shirker. Since the Solow condition implies that firms want to keep the same level of effort as before, the firms respond to the change in c_t^f by lowering their workers' real wages back to the point where workers are again indifferent between providing effort and shirking, (i.e., to the point where $\frac{c_t}{c_t^f} = const$). At this lower wage the marginal product of labour exceeds the marginal cost, so firms optimally increase the size of their labour force. Since employment increases, and workers' effort levels remain the same, the number of effective labour hours increases and output rises.³⁶

³⁶ This is feasible as long as the economy initially contains enough unemployed workers to meet the firms extra demand.

The increase in output has two effects. First, the price of the final good declines to clear the final good market. Second, both the current and expected return on capital increase. Both the decrease in prices and the increase in the return on capital, increase the amount of goods the family can purchase. However, the change in c_t^f depends on how investment responds to the shock. For example, when the rise in government expenditures is persistent, families invest more in capital goods because of the increase in the expected future return on capital. In this case, since most of the increase in the family's purchasing power is devoted to investment, the change in c_t^f is small, and may be negative after the effect of taxes on c_t^f is incorporated.

In practice, c_t^f decreases because of the rise in taxes and the large increase in investment. As a result, real wages decline and firms hire more workers. Output then increases and prices decline. Finally, interest rates are initially unresponsive to the shock because the level of deposits is determined prior to the shock and there is no increase in the money stock.

3.2. Technology Shocks

Figure 3 displays the shirking models' responses to a shock that increases the level of technology by 1%, and Figure 4 displays the same responses for the standard limited participation model. The findings suggest that, in both models, a positive technology shock causes prices to decrease and all other variables to increase.³⁷ The figures imply that: (1) limiting the amount of income insurance available to agents will again increase the employment and output responses, and (2) increasing the costs of adjustment on capital dampens the positive effect of the shock on output, employment and investment, and increases the effect of

³⁷ Although these responses are common in the literature, recent papers such as, Basu, Fernald and Kimball (1999) and Gali (1999), have suggested that technology improvements may, in fact, be contractionary in the short run and expansionary only in the long run.

the shock on wages and consumption. A comparison of the standard limited participation and shirking models demonstrates that, in the shirking model, the price decrease is larger, real wages increase slightly less, and the employment, output, investment and consumption responses are generally larger.

In the shirking model, a positive technology shock increases both output and the marginal product of labour for firms. The increase in current output has two effects. First, holding all else equal, it decreases the price of the final goods, which causes an increase in the purchasing power of the family's cash balances. Second, the increase in production causes the real return on capital to rise. Both effects allow the family to purchase more consumption and investment goods.

The induced change in c_t^f then alters the punishment associated with being detected shirking though its effect on $\frac{c_t}{c_t^s}$ since $\frac{c_t}{c_t^s} = \left(\frac{w_t f - F_t + c_t^f}{s w_t f - F_t + c_t^f} \right)$. Consequently, the resulting wages and employment responses depend on the change in c_t^f .

In addition to the change in c_t^f caused by the change in output, a positive shock also increases the expected future return on capital since the technology shock is persistent. This induces the family to increase their investment in capital goods, thereby dampening the effects of the increase in $r_t K_t$ and the decrease in P_t on c_t^f . The results suggest that c_t^f increases in response to a technology shock.

Firms respond to the rise in the level of family consumption purchased by increasing wages to dissuade workers from shirking. This in turn increases the marginal cost of labour. However, in practice the increase in the marginal product of labour is larger than the increase in the marginal cost of labour. Therefore, the models predict that, following a positive technology shock, output, employment, consumption, investment and wages increase, while

prices decrease. Finally, the models predict that the interest rate is initially unaffected because the money stock is unaffected by the shock and the level of deposits is initially fixed.

3.3. Monetary Policy Shocks

Figures 5 and 6 display the efficiency wage and limited participation models' impulse response functions for an expansionary monetary policy shock respectively. Despite the fact that all the models are consistent with the qualitative results outlined in Christiano, Eichenbaum and Evans (1997) and Sims and Zha (1995), they differ with respect to their quantitative responses. Specifically, the magnitude of the shirking model's responses depend on the form of the intra-family transfer. For example, the partial income insurance case produces the least inflation, the smallest real wage response, and the largest output, consumption, employment and investment responses, compared to the full income insurance case and the standard limited participation model. Similar to the previously discussed shocks, increasing the costs of capital adjustment lessens the increase in employment, output and investment in response to a positive monetary shock, and increases the real wage response.

In the shirking models, an unexpected increase in the stock of money initially has two effects. First, financial intermediaries have more funds to loan to firms. In response, the financial intermediaries lower the interest rate on loans to induce firms to borrow the excess funds. Everything else held equal, this decrease in the interest rate lowers the firms' marginal cost of labour. Since profit maximizing firms choose employment to equate the marginal product of labour to the marginal cost of labour, the decrease in the marginal cost of labour causes firms to expand the size of their labour force. In turn, this increases the economy's output, and the return on capital.

Second, the increase in the stock of money puts upward pressure on prices, if the response of output is small since the goods market clearing condition implies:³⁸

$$P_t Y_t = \frac{1}{\left(1 - \frac{\alpha}{\mu}\right)} (M_t + X_t)$$

It follows that an increase in the price level causes the family's purchasing power to decrease since their cash balances can now buy less family consumption and investment.

The effect of an expansionary monetary policy shock on c_t^f is generally uncertain. For example, if families choose to reduce capital investment enough in response to the shock, c_t^f may increase overall, despite the decrease in purchasing power. If this occurs, the punishment associated with being detected shirking decreases and firms must raise wages in order to maintain the same effort level in equilibrium. The increase in wages raises the marginal cost of labour for a given interest rate and causes firms to decrease the number of workers hired all else held equal. Depending on the magnitude of the increase in c_t^f , the real wage could increase enough to offset the effect of the decreasing interest rates on the marginal cost of labour. However, in the estimated versions of the model, it is clear that employment rises following the positive monetary policy shock.

3.4. The J-Test

Tables 4-6 present the Wald tests that formally explore the hypothesis that the second moments from the estimated models are the same in population as the second moments estimated from the data. The results clearly indicate that the shirking model is better able to produce low wage variation and high employment variation. The lowest real wage

³⁸ The goods market clearing condition is obtain by: (i) substituting the firm's Euler equation for capital, and the accounting equation $Y_t = I_t + C_t + G_t$ into the family's cash in advance constrain, and (ii) using the fact that $C_t = c_t^f + w_t N_t$ and $w_t N_t = \frac{D_t + X_t}{P_t}$.

variation and highest employment variation is obtained from the shirking model with partial income insurance.

These tables demonstrates that the standard limited participation model produces too little employment variation and too much variation in wages. In contrast, the shirking model tends to overshoot the point estimate of employment variation, σ_n^2 . Increasing the cost of adjustment on capital decreases the employment variation and increases the wage variation in both models. Therefore, small costs of adjustment improve the fit of the shirking model, but decrease the performance of the standard limited participation model further.

4. CONCLUSIONS

This paper develops a monetary business cycle model where: (1) individuals make nominal savings decisions before observing the period's shocks, (2) a worker's effort level is only imperfectly observed by firms, and (3) detected shirkers forgo an increase in their compensation. The first assumption is commonly seen in limited participation models, while the second is found in the shirking efficiency wage literature. The third assumption, which is motivated by empirical evidence, is a departure from the assumption made in the standard shirking models. This difference in the punishment is largely responsible for the model's ability to produce large employment variation and small real wage variation without relying on a high labour supply elasticity, or on a high mark-up. Therefore, this model is more consistent with microeconomic evidence about the size of markups and the value of individuals' labour supply elasticities than the standard limited participation model.

In addition, the findings in the paper illustrate that the quantitative results are sensitive to the type of income insurance provided to the unemployed. In particular, it is found

that the shirking model with partial income insurance tends to overshoot the employment variation seen in the data, and that the model's performance is improved by small adjustment costs on capital. Since the model is able to generate very large employment fluctuations, adjustment costs on labour should improve the model's performance further.

The model's impulse responses to monetary and fiscal policy shocks as well as technology shocks are examined. Consistent with the existing empirical evidence, the shirking model predicts that, in response to a positive monetary policy shock, real wages, output, employment, investment and prices increase, while the gross interest rate decreases. In response to a positive fiscal policy shock, employment, output, and investment increases, the gross interest rate weakly increases, while real wages and consumption decrease. Although these responses are consistent with the empirical findings in Ramey and Shapiro (1997) and Edelberg, Eichenbaum and Fisher (1998), the model also predicts that the price level decreases in response to the shock, which is inconsistent with the evidence.

Finally, the model's responses to a positive technology shock are examined. The responses to the technology shock are qualitatively consistent with the predictions of the standard limited participation model. In particular, the shirking model predicts that in response to an exogenous increase in the level of technology: real wages increase, employment increases, output increases, investment increases, gross interest rates increase, and the price level decreases. Although there is evidence that positive technology shocks are expansionary (i.e., Christiano, Eichenbaum and Vigfussion (2002)) the model does not replicate the findings in papers, such as Basu, Fernald and Kimball (1997), that an increase in the level of technology may initially be contractionary.

Examining the implied impulse responses to fiscal policy, technology and monetary pol-

icy shocks for the standard limited participation and comparing them to the corresponding figures for the shirking model, it is evident that the models produce different quantitative results. For example, the shirking model produces larger increases in employment, output, and investment in response to all the shocks considered. However, the responses of wages, prices and consumption depend on the type of shock. In particular, the estimated shirking model predicts larger movements in real wages and smaller movements in consumption in response to a fiscal policy shock while technology and monetary policy shocks predicted smaller wage movements with larger movements in consumption. In the shirking model, prices respond less to a monetary policy shock, and respond more to fiscal policy and technology shocks, in comparison to the standard limited participation model.

The results support the hypothesis that introducing efficiency wage considerations can help reproduce the low real wage variation and high employment variation seen in the data, and the observed responses of the U.S. economy to fiscal and monetary policy shocks without relying on the presence of a high labour supply elasticity. Future work should concentrate on: *(i)* improving the predicted response to a technology shock and the price responses to a fiscal policy shock, *(ii)* eliminating the need for adjustment costs on the flow of funds to the goods market, and *(iii)* introducing labour adjustment costs.

APPENDIX A: The Data

The models were estimated using quarterly data from the time period 1955-1993. This data is available from: the Citibase Database, the Federal Reserve Bank and the Bureau of Economic Analysis. The official capital stock was obtained from the Bureau's Survey of Current Business-Fixed Reproducible Tangible Wealth in the U.S. Using these statistics, the

capital stock, K_t , was defined as the sum of the net stocks of consumer durables, producer structures, and equipment and private residential capital plus the government non-residential capital.

Private consumption, C_t , was then defined as the sum of private-sector expenditures on non-durable goods and services plus the imputed service flow from the stock of consumer durable goods. Moreover, the private sector data on non-durables and services was obtained from Citibase while the imputed service flow from the stock of durable goods was created using the method described in Brayton and Mauskopf (1985).

Next gross investment, I_t , was measured as the sum of consumer expenditures on durable good, gross private non-residential (structures and equipment) and residential investment, as well as the change in the gross stock of government capital (computed using the data from the Survey of Current Business). government expenditures, G_t , was computed using the statistics reported in Citibase for federal, state and local expenditures on goods and services minus real government investment (measured by the change in the gross stock of government capital). The measure of output at time t was then defined as real GDP as found in Citibase. Specifically, this measure includes $C_t + I_t + G_t$ plus net exports and time t inventory adjustments.

The GDP deflator with base year 1987, obtained from Citibase, was assumed to be the price data used to convert data variables between their nominal and real levels. The interest rate was measured using data available from the Federal Reserve Bank on the prime lending rate on loans. Finally, the monetary aggregate represented in the model was measured by M2, and was measured by combining the numbers available from Citibase with the earlier estimates from Rasche.

Two additional variables were needed to estimate the model: wages and employment/hours. The employment data was defined by using Citibase's unemployment rate while the wage series was created by combining the Citibase data on wages and other labour income. Although the employment rate is directly used in the shirking models, the standard divisible and indivisible labour models generally are estimated using the number of hours worked normalized by the number of leisure/labour hours available to individuals over the period.

To keep the dataset as consistent as possible across the different models, all the data was converted to per-capita terms by dividing by the size of the labour force obtained from Citibase. This normalization then allowed for a computation of an implied hourly employment series by taking a stand on the number of hours an individual worked per week. For the purposes of this model, individuals were assumed to work 40 hours per week. The series for quarterly hours worked was then created using the formula: $\frac{40 \times 52}{4}(1 - u_t)$ where u_t is the unemployment rate. This series was used in the divisible and indivisible labour models after it was normalized by the number of leisure/labour hours available to individuals during the quarters.

APPENDIX B: The Estimated Equations

The shirking model's parameters,

$$\left\{ \frac{d}{\theta}, \delta, \tau_g, \mu_g, \rho_g, \sigma_g, \ln(A), \rho_A, \sigma_A, A_y, \ln(\gamma_y), \alpha, \ln\left(\frac{g}{y}\right), x^{ss}, \mu, \rho_x, \sigma_x \right\}$$

are simultaneously estimated from the following Exactly Identifying restrictions:

$$E \left(\frac{(1 - \alpha)}{\mu} - \frac{R_t w_t N_t}{Y_t} \right) = 0$$

$$E (\ln(A_t) - \ln A - \rho_A \ln(A_{t-1})) = 0$$

$$\begin{aligned}
E((\ln(A_t) - \ln A - \rho_A \ln(A_{t-1})) \times \ln(A_{t-1})) &= 0 \\
E((\ln(A_t) - \ln A - \rho_A \ln(A_{t-1}))^2 - \sigma_A^2) &= 0 \\
E(\ln(Y_t) - A_y - t \times \ln(\gamma)) &= 0 \\
E\left((\ln(Y_t) - A_y - t \ln(\gamma)) \times \frac{t}{149}\right) &= 0 \\
E\left(I_t - \delta^{(1-\frac{1}{v})} (K_{t+1}^v - (1-\delta)K_t^v)^{\frac{1}{v}}\right) &= 0 \\
E\left(\begin{array}{c} muc_t \delta^{(1-\frac{1}{v})} (K_{t+1}^v - (1-\delta)K_t^v)^{\frac{1}{v}-1} K_{t+1}^{v-1} \\ -\beta muc_{t+1} \left(\frac{\alpha}{\mu} \frac{Y_{t+1}}{K_{t+1}} + (1-\delta)\delta^{(1-\frac{1}{v})} (K_{t+2}^v - (1-\delta)K_{t+1}^v)^{\frac{1}{v}-1} K_{t+1}^{v-1}\right) \end{array}\right) &= 0 \\
E(N_t - N^{ss}) &= 0 \\
E\left(\ln(G_t) - \ln(Y_t) - \ln\left(\frac{g}{y}\right)\right) &= 0 \\
E\left(\ln\left(\frac{G_t}{\gamma^t}\right) - \mu_g - t \times \tau_g\right) &= 0 \\
E\left(\left(\ln\left(\frac{G_t}{\gamma^t}\right) - \mu_g - t \times \tau_g\right) \times \frac{t}{149}\right) &= 0 \\
E\left(\begin{array}{c} \left((1-\rho_g L) \times \left(\ln\left(\frac{G_t}{\gamma^t}\right) - \mu_g - t \times \tau_g\right)\right) \\ \times \left(\ln\left(\frac{G_{t-1}}{\gamma^{t-1}}\right) - \mu_g - \tau_g \times (t-1)\right) \end{array}\right) &= 0 \\
E\left(\left(\left((1-\rho_g L) \times \left(\ln\left(\frac{G_t}{\gamma^t}\right) - \mu_g - t \times \tau_g\right)\right)\right)^2 - \sigma_g^2\right) &= 0 \\
E(x_t - (1-\rho_x)x^{ss} - x_{t-1}) &= 0 \\
E((x_t - (1-\rho_x)x^{ss} - x_{t-1}) \times x_{t-1}) &= 0 \\
E((x_t - (1-\rho_x)x^{ss} - x_{t-1})^2 - \sigma_x^2) &= 0
\end{aligned}$$

where muc_t is the marginal utility of c_t^f for the family. The Standard Limited Participation model's parameters are estimated using the same identification scheme with this model's marginal utility of consumption data, muc_t , hourly employment data, N_t , and the its expression for the steady state value of employment, N^{ss} . In this case, the equation equating the

employment hours and the steady state value of employment hours identifies the parameter value θ , instead of the variable $\frac{d}{\theta}$ as in the shirking model.

The Identifying Restrictions for the J-test:

To test the models' predictions for $\left\{ \frac{\sigma_c}{\sigma_y}, \frac{\sigma_i}{\sigma_y}, \frac{\sigma_g}{\sigma_y}, \sigma_w, \sigma_n, \sigma_y \right\}$ the HP filtered data, $\left\{ c_t^{hp}, l_t^{hp}, g_t^{hp}, y_t^{hp}, n_t^{hp}, w_t^{hp} \right\}$ are used along with the follow equations:³⁹

$$\begin{aligned}
 E \left(\left(y_t^{hp} \right)^2 \left(\frac{\sigma_c}{\sigma_y} \right)^2 - \left(c_t^{hp} \right)^2 \right) &= 0 \\
 E \left(\left(y_t^{hp} \right)^2 \left(\frac{\sigma_i}{\sigma_y} \right)^2 - \left(l_t^{hp} \right)^2 \right) &= 0 \\
 E \left(\left(y_t^{hp} \right)^2 \left(\frac{\sigma_g}{\sigma_y} \right)^2 - \left(g_t^{hp} \right)^2 \right) &= 0 \\
 E \left(\left(n_t^{hp} \right)^2 - \left(\sigma_n \right)^2 \right) &= 0 \\
 E \left(\left(y_t^{hp} \right)^2 - \left(\sigma_y \right)^2 \right) &= 0 \\
 E \left(\left(w_t^{hp} \right)^2 - \left(\sigma_w \right)^2 \right) &= 0
 \end{aligned}$$

These moments were simultaneously estimated with the models' parameters.

APPENDIX C: The Standard Limited Participation Model

The standard limited participation model with divisible labour is based on Christiano, Eichenbaum and Evans (1997) and has the same six sectors as the shirking model presented in the paper. The problems facing the monetary authority, the final goods firms and the government are identical to the ones described in the shirking model. However, the individual's problem, the intermediate goods firms' problems and the loan market clearing condition

³⁹ $\lambda = 1600$ when the data was filtered.

differ slightly due to the observability of effort and the divisibility of labour , and are stated below.

The individual's problem in the standard limited participation model is:

$$\max_{\{C_t, K_{t+1}, M_{t+1}, D_t\}_{t=0}^{\infty}} E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \{ \ln(C_t) + \theta \ln(1 - N_t) - \theta \ln(1 + H(Q_t, Q_{t-1})) \} \right\}$$

subject to $P_t C_t \leq M_t - D_t - P_t Tax_t + P_t r_t K_t - P_t I_t + W_t N_t$ and

$$M_{t+1} = M_t - D_t - P_t C_t - P_t Tax_t + P_t r_t K_t + W_t N_t - P_t I_t + R_t [D_t + X_t] + PR_t$$

where $H(Q_t, Q_{t-1}) = a_0 \left\{ \exp \left[a_1 \left(\frac{Q_t}{Q_{t-1}} - 1 - x^s \right) \right] + \exp \left[-a_1 \left(\frac{Q_t}{Q_{t-1}} - 1 - x^s \right) \right] - 2 \right\}$
and $Q_t = M_t - D_t$

where C_t is the individual's consumption, N_t is the percent of time the individual spends working for firms, r_t is the real return on capital, K_t is the amount of capital available during time t , P_t is the price level, M_t is the beginning of period stock of money, I_t is investment, W_t is the nominal wage, D_t is the amount of nominal deposits chosen in advance of the shocks, R_t is the nominal interest rate, Tax_t is the amount of taxes owned at time period t and $R_t X_t$ and PR_t are the profits received from financial intermediaries and intermediate goods firms respectively.

In the limited participation model, firms do not require effort from workers for production.

The resulting intermediate good firm's period t problem in this case is:

$$\max_{\{P_{it}, N_{it}, K_{it}\}} \{ P_{it} (A_t K_{it}^\alpha (N_{it})^{1-\alpha}) - R_t P_t w_{it} N_{it} - P_t r_t K_{it} \}$$

subject to the period by period demand functions:

$$P_{it}^{\frac{-\mu}{1-\mu}} (A_t K_{it}^\alpha (N_{it})^{1-\alpha}) - P_t^{\frac{-\mu}{1-\mu}} Y_t = 0$$

Finally, using the fact that the intermediate goods firms borrow their wage bill from the financial intermediaries, the loan market clearing condition becomes:

$$\int_0^1 W_{it}N_{it}di = D_t + X_t$$

where $W_{it}N_{it}$ is firm i 's wage bill in period t , D_t are the deposits and X_t is the amount of the monetary injection.

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TABLE 1.
PARAMETER ESTIMATES FOR THE MODELS ($v = 1$)

Parameter:	Estimates		Estimates
	Shirking Model		Standard Limited
	P.I.I.Case ¹	F.I.I.Case ²	Participation Model
μ	1.1579 (0.0176)	1.1568 (0.0164)	1.1568 (0.0164)
$\ln A$	0.0118 (0.0104)	0.0118 (0.0104)	0.0276 (0.0238)
ρ_A	0.9745 (0.0217)	0.9745 (0.0218)	0.9745 (0.0218)
σ_A	0.0077 (0.0005)	0.0077 (0.0005)	0.0077 (0.0005)
A_y	1.9806 (0.0205)	1.9806 (0.0205)	1.9806 (0.0205)
$\ln(\gamma)$	0.0024 (0.0002)	0.0024 (0.0002)	0.0024 (0.0002)
δ	0.0205 (0.0003)	0.0205 (0.0003)	0.0205 (0.0003)
α	0.3597 (0.0102)	0.3603 (0.0095)	0.3603 (0.0095)
$\ln(\frac{z}{y})$	-1.6862 (0.0179)	-1.6862 (0.0179)	-1.6862 (0.0179)
$\frac{d}{\theta}$	0.0904 (0.0018)	0.0889 (0.0017)	n/a
θ	n/a	n/a	1.6822 (0.0300)
ρ_g	0.9796 (0.0208)	0.9796 (0.0208)	0.9796 (0.0208)
τ_g	-0.0021 (0.0001)	-0.0021 (0.0001)	-0.0021 (0.0001)
σ_g	0.0134 (0.0011)	0.0134 (0.0011)	0.0134 (0.0011)
μ_g	0.4537 (0.0250)	0.4537 (0.0250)	0.4537 (0.0250)
ρ_x	0.5202 (0.0761)	0.5202 (0.0761)	0.5202 (0.0761)
x^{ss}	0.0133 (0.0013)	0.0133 (0.0013)	0.0133 (0.0013)
σ_x	0.0076 (0.0009)	0.0076 (0.0009)	0.0076 (0.0009)

Notes : Standard errors in parentheses. ¹Partial income insurance ²Full income insurance

TABLE 2.

PARAMETER ESTIMATES FOR THE MODELS ($v = 0.97$)

Parameter:	Estimates		Estimates
	Shirking Model		Standard Limited
	P.I.I.Case ¹	F.I.I.Case ²	Participation Model
μ	1.1593 (0.0182)	1.1582 (0.0171)	1.1582 (0.0171)
$\ln A$	0.0119 (0.0105)	0.0119 (0.0105)	0.0277 (0.0239)
ρ_A	0.9745 (0.0217)	0.9745 (0.0217)	0.9745 (0.0217)
σ_A	0.0077 (0.0005)	0.0077 (0.0005)	0.0077 (0.0005)
A_y	1.9806 (0.0205)	1.9806 (0.0205)	1.9806 (0.0205)
$\ln(\gamma)$	0.0024 (0.0002)	0.0024 (0.0002)	0.0024 (0.0002)
δ	0.0205 (0.0004)	0.0205 (0.0004)	0.0205 (0.0004)
α	0.3590 (0.0104)	0.3596 (0.0098)	0.3596 (0.0098)
$\ln(\frac{g}{y})$	-1.6862 (0.0179)	-1.6862 (0.0179)	-1.6862 (0.0179)
$\frac{d}{\theta}$	0.0905 (0.0019)	0.0891 (0.0018)	n/a
θ	n/a	n/a	1.6794 (0.0306)
ρ_g	0.9796 (0.0208)	0.9796 (0.0208)	0.9796 (0.0208)
τ_g	-0.0021 (0.0001)	-0.0021 (0.0001)	-0.0021 (0.0001)
σ_g	0.0134 (0.0011)	0.0134 (0.0011)	0.0134 (0.0011)
μ_g	0.4537 (0.0250)	0.4537 (0.0250)	0.4537 (0.0250)
ρ_x	0.5202 (0.0761)	0.5202 (0.0761)	0.5202 (0.0761)
x^{ss}	0.0133 (0.0013)	0.0133 (0.0013)	0.0133 (0.0013)
σ_x	0.0076 (0.0009)	0.0076 (0.0009)	0.0076 (0.0009)

Notes : Standard errors in parentheses. ¹Partial income insurance ²Full income insurance

TABLE 3.

PARAMETER ESTIMATES FOR THE MODELS ($v = 0.95$)

Parameter:	Estimates		Estimates
	Shirking Model		Standard Limited
	P.I.I. Case ¹	F.I.I. Case ²	Participation Model
μ	1.1602 (0.0189)	1.1591 (0.0178)	1.1591 (0.0178)
$\ln A$	0.0120 (0.0105)	0.0119 (0.0105)	0.0277 (0.0240)
ρ_A	0.9745 (0.0217)	0.9745 (0.0217)	0.9745 (0.0217)
σ_A	0.0077 (0.0005)	0.0077 (0.0005)	0.0077 (0.0005)
A_y	1.9806 (0.0205)	1.9806 (0.0205)	1.9806 (0.0205)
$\ln(\gamma)$	0.0024 (0.0002)	0.0024 (0.0002)	0.0024 (0.0002)
δ	0.0205 (0.0004)	0.0205 (0.0004)	0.0205 (0.0004)
α	0.3585 (0.0108)	0.3591 (0.0101)	0.3591 (0.0101)
$\ln(\frac{d}{y})$	-1.6862 (0.0179)	-1.6862 (0.0179)	-1.6862 (0.0179)
$\frac{d}{\theta}$	0.0906 (0.0019)	0.0892 (0.0018)	n/a
θ	n/a	n/a	1.6775 (0.0315)
ρ_g	0.9796 (0.0208)	0.9796 (0.0208)	0.9796 (0.0208)
τ_g	-0.0021 (0.0001)	-0.0021 (0.0001)	-0.0021 (0.0001)
σ_g	0.0134 (0.0011)	0.0134 (0.0011)	0.0134 (0.0011)
μ_g	0.4537 (0.0250)	0.4537 (0.0250)	0.4537 (0.0250)
ρ_x	0.5202 (0.0761)	0.5202 (0.0761)	0.5202 (0.0761)
x^{ss}	0.0133 (0.0013)	0.0133 (0.0013)	0.0133 (0.0013)
σ_x	0.0076 (0.0009)	0.0076 (0.0009)	0.0076 (0.0009)

Notes : Standard errors in parentheses. ¹Partial income insurance ²Full income insurance

TABLE 4.
SECOND MOMENTS

$v = 1$

Moment	$\frac{\sigma_c}{\sigma_y}$	$\frac{\sigma_i}{\sigma_y}$	$\frac{\sigma_g}{\sigma_y}$	σ_n	σ_w	σ_y
U.S. Data	0.4977 (0.0323)	3.0571 (0.1141)	1.2486 (0.2041)	0.0081 (0.0009)	0.0067 (0.0006)	0.0148 (0.0015)
Shirking Model Partial Income Insurance	0.3437 (0.0975)	3.5156 (0.3079)	0.6985 (0.1654)	0.0265 (0.0068)	0.0072 (0.0009)	0.0249 (0.0053)
p-value	0.0998	0.1502	0.0051	0.0046	0.6227	0.0510
Shirking Model Full Income Insurance	0.4718 (0.1316)	3.1340 (0.3767)	1.0570 (0.1890)	0.0123 (0.0028)	0.0078 (0.0012)	0.0164 (0.0025)
p-value	0.8375	0.8413	0.3300	0.0978	0.4245	0.5086
Standard Limited Participation	0.5706 (0.1603)	2.9483 (0.4401)	1.3559 (0.1908)	0.0059 (0.0012)	0.0092 (0.0008)	0.0128 (0.0013)
p-value	0.6356	0.8069	0.5756	0.0648	0.0087	0.2053

TABLE 5.
SECOND MOMENTS

$v = 0.97$

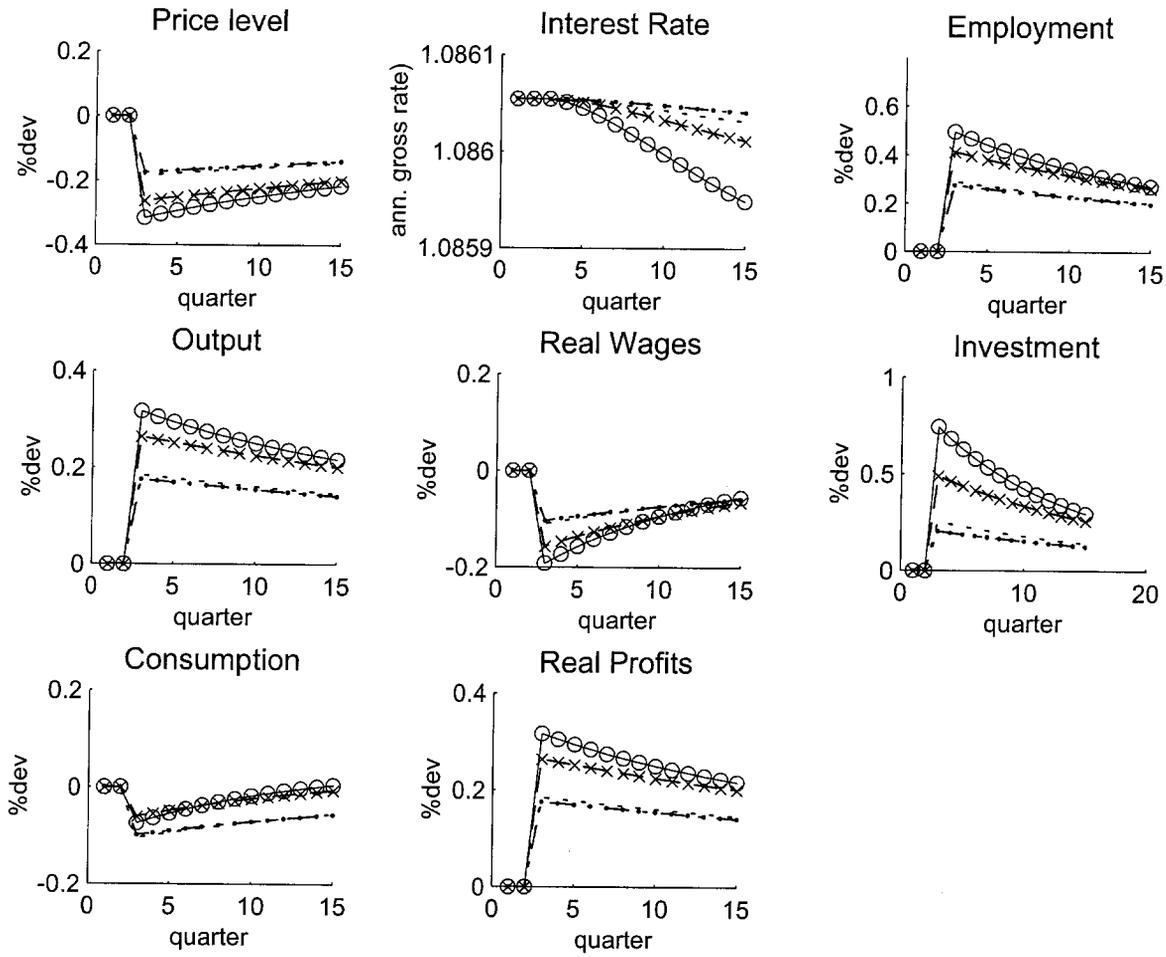
Moment	$\frac{\sigma_c}{\sigma_y}$	$\frac{\sigma_i}{\sigma_y}$	$\frac{\sigma_g}{\sigma_y}$	σ_n	σ_w	σ_y
U.S. Data	0.4977 (0.0323)	3.0571 (0.1141)	1.2486 (0.2041)	0.0081 (0.0009)	0.0067 (0.0006)	0.0148 (0.0015)
Shirking Model Partial Income Insurance	0.4428 (0.1034)	3.1916 (0.3035)	0.8583 (0.1727)	0.0193 (0.0042)	0.0072 (0.0014)	0.0202 (0.0036)
p-value	0.5795	0.6694	0.0437	0.0038	0.7550	0.1157
Shirking Model Full Income Insurance	0.5448 (0.1260)	2.9262 (0.3514)	1.1452 (0.1859)	0.0105 (0.0020)	0.0083 (0.0011)	0.0152 (0.0020)
p-value	0.6963	0.7168	0.5918	0.1952	0.1964	0.8601
Standard Limited Participation	0.6309 (0.1507)	2.7864 (0.4054)	1.4033 (0.1886)	0.0053 (0.0010)	0.0094 (0.0007)	0.0124 (0.0012)
p-value	0.3569	0.5110	0.4148	0.0100	0.0031	0.1017

TABLE 6.
SECOND MOMENTS

$v = 0.95$

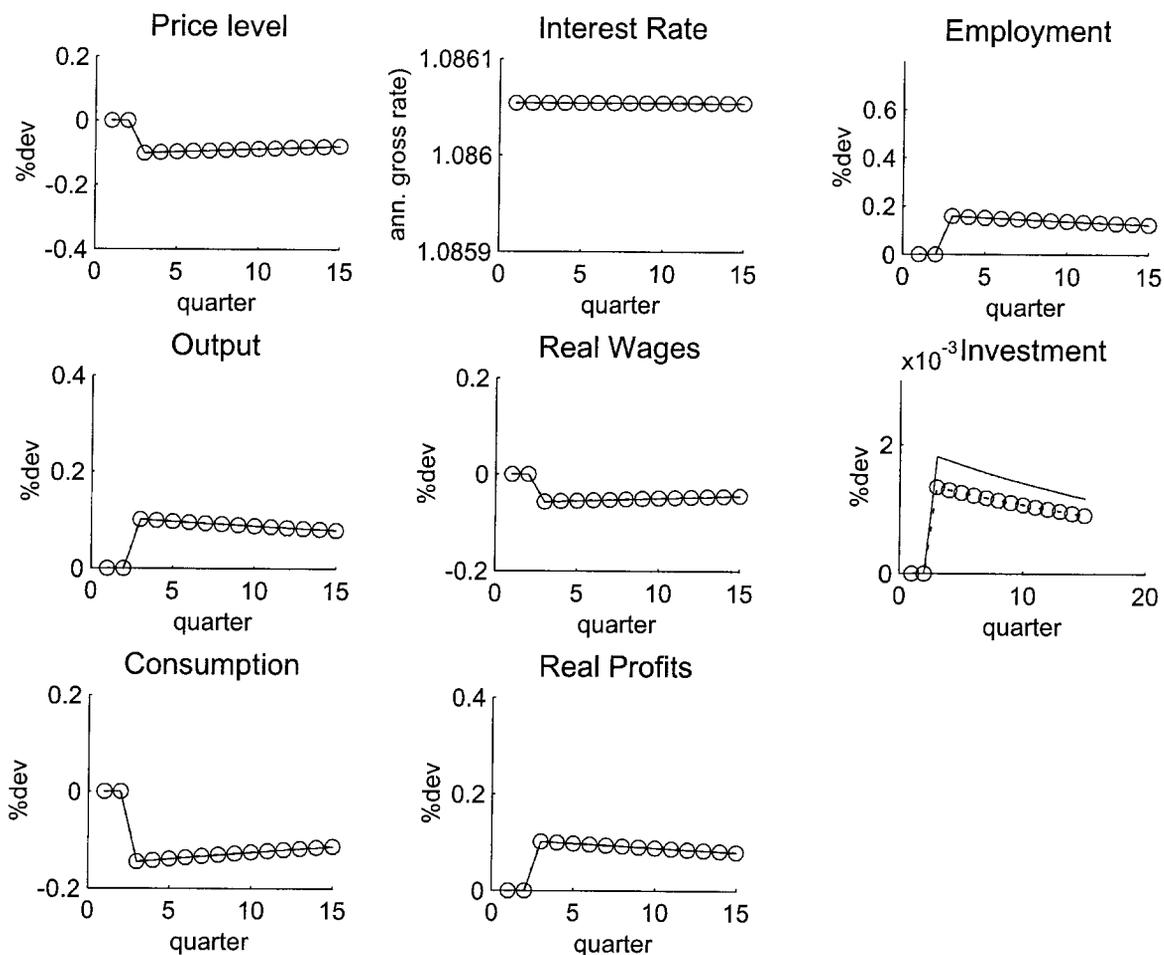
Moment	$\frac{\sigma_c}{\sigma_y}$	$\frac{\sigma_i}{\sigma_y}$	$\frac{\sigma_g}{\sigma_y}$	σ_n	σ_w	σ_y
U.S. Data	0.4977 (0.0323)	3.0571 (0.1141)	1.2486 (0.2041)	0.0081 (0.0009)	0.0067 (0.0006)	0.0148 (0.0015)
Shirking Model Partial Income Insurance	0.4992 (0.1008)	3.0241 (0.2919)	0.9421 (0.1718)	0.0166 (0.0031)	0.0075 (0.0014)	0.0184 (0.0029)
p-value	0.9873	0.9138	0.1074	0.0029	0.5740	0.1955
Shirking Model Full Income Insurance	0.5883 (0.1222)	2.8069 (0.3385)	1.1958 (0.1852)	0.0097 (0.0017)	0.0085 (0.0010)	0.0145 (0.0020)
p-value	0.4387	0.4727	0.7822	0.3294	0.1095	0.8832
Standard Limited Participation	0.6677 (0.1441)	2.6898 (0.3845)	1.4315 (0.1872)	0.0051 (0.0009)	0.0095 (0.0007)	0.0121 (0.0011)
p-value	0.2185	0.3489	0.3329	0.0028	0.0016	0.0634

Figure 1: The Shirking Model's Responses to a Positive Fiscal Policy Shock



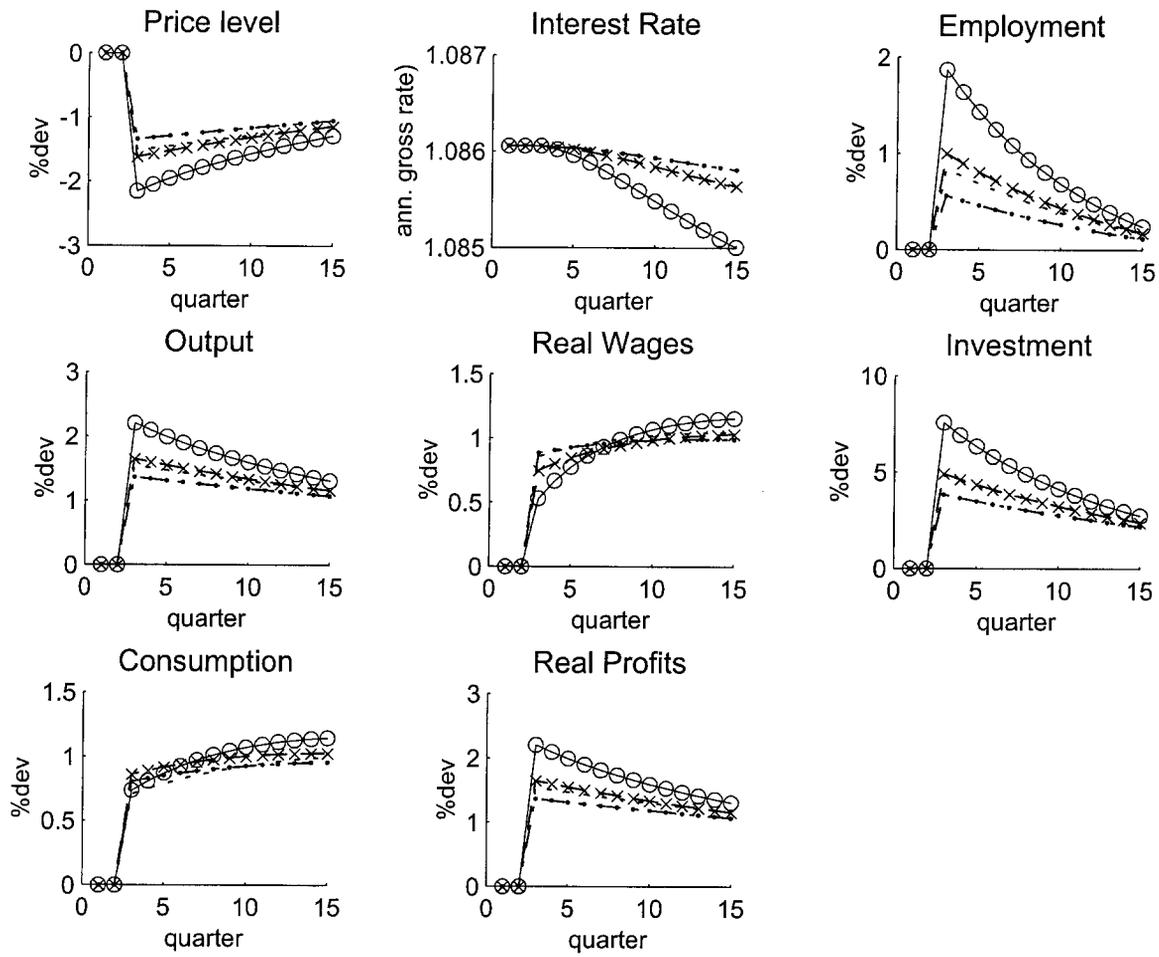
Partial Income Insurance, $v=1$: -o-o-
Partial Income Insurance, $v=0.95$: -x-x-
Full Income Insurance, $v=1$:
Full Income Insurance, $v=0.95$: - - - -

Figure 2. The Limited Participation Model's Responses to a Positive Fiscal Policy Shock



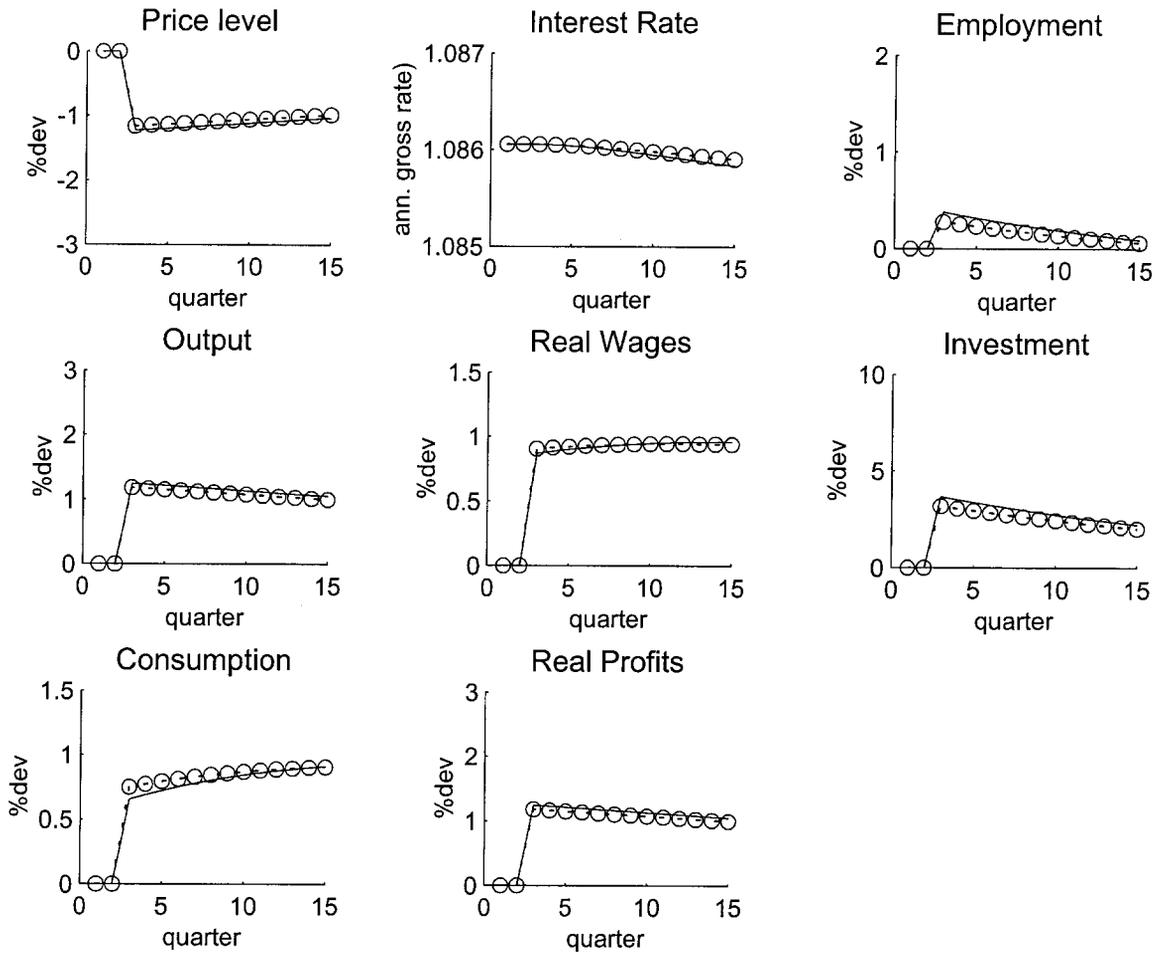
$v=1$:	-----
$v=0.95$:	-o-o-o-

Figure 3. The Shirking Model's Responses to a Positive Technology Shock



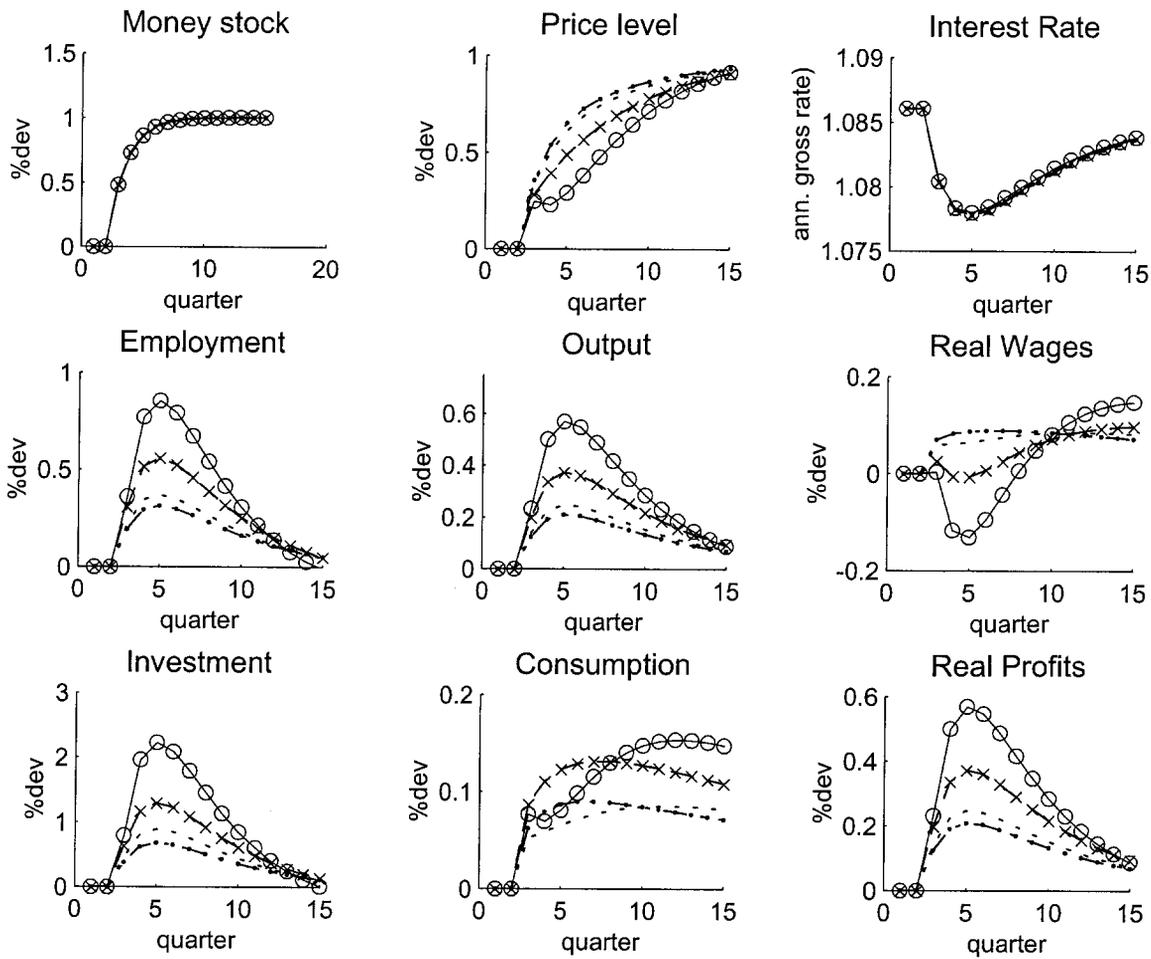
Partial Income Insurance, $v=1$: -o-o-
Partial Income Insurance, $v=0.95$: -x-x-
Full Income Insurance, $v=1$:
Full Income Insurance, $v=0.95$: - . - .

Figure 4. The Limited Participation Model's Responses to a Positive Technology Shock



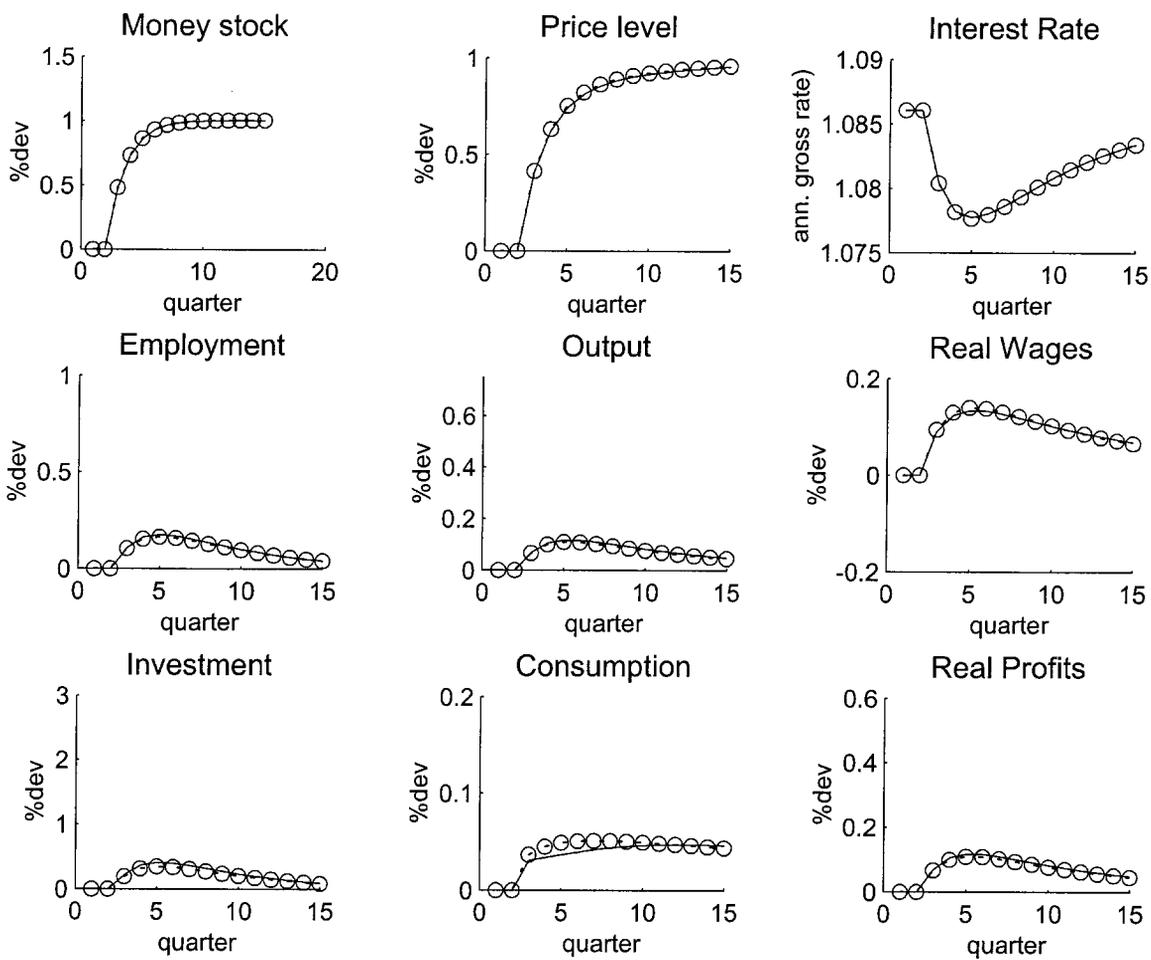
$v=1$:	-----
$v=0.95$:	-o-o-o-

Figure 5. The Shirking Model's Responses to a Positive Monetary Policy Shock



Partial Income Insurance, $v=1$: -o-o-
Partial Income Insurance, $v=0.95$: -x-x-
Full Income Insurance, $v=1$:
Full Income Insurance, $v=0.95$: - . - .

Figure 6. The Limited Participation Model's Responses to a Positive Monetary Policy Shock



$v=1$:	-----
$v=0.95$:	-o-o-o-