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Kamalyan, Hayk

American University of Armenia

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Phase-Dependent Monetary and Fiscal Policy

Hayk Kamalyan

Manoogian Simone College of Business and Economics, American University of Armenia, 40 Marshal Baghramyan Avenue, Armenia

(e-mail: hkamalyan@aua.am)

CERGE-EI Foundation Teaching Fellow

Abstract

This paper studies how the effects of monetary and fiscal policy vary depending on the business cycle phase. It shows that in a medium-scale DSGE model, estimated on US data, monetary policy has a stronger impact on the economy in downturns and booms. Labor and capital income taxes display similar patterns. Government expenditure shocks and consumption tax shocks, on the contrary, have a stronger impact on output in depressions and recoveries. The paper also shows that accounting for the source of business cycle fluctuations is potentially important when assessing state-dependence in policy transmission.

JEL classification: E31, E32, E37, E52, E62.

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I. Introduction

This paper studies how the effects of economic policies vary depending on the phase of the business cycle. The objective is to quantitatively assess state-dependence in the output response to monetary and fiscal policy shocks in a canonical model of business cycle fluctuations.

The analysis proceeds in three steps. First, I introduce a standard medium-scale DSGE model along the lines of Christiano et al. (2005), Smets and Wauters (2007), and Uribe and Shmidth-Grohe (2005). A small subset of parameters is fixed to conventional values from related studies and long-run targets in the data. The rest are estimated on US data via Bayesian methods.

In the second step, I solve the model via second-order approximation to account for state-dependent effects of policy shocks. I generate the state space by simulating the model for a large number of periods. The Bry and Boschan (1972) algorithm is further applied to identify business cycle chronologies from the simulated path of output. The four stages of the business cycle considered in the quantitative simulations are depicted in Figure 1. In phase I (from A to B) the economy operates below the trend and continues to contract until it reaches the trough of the cycle (point B). I refer to this phase as depression. In phase II (from B to C), the economic activity is expanding; however, the latter is still below the trend. I call this phase recovery. In phase III (C to D), the economic activity is above the trend and continues expanding. This phase lasts until the business cycle peak (point D). I refer to this phase as boom. Finally, in phase IV, (from D to E), the economy is still operating above trend, but the economic activity is slowing. This phase is called downturn.

In the third step, I evaluate state-dependence in the impact of monetary and fiscal policy shocks by computing the generalized impulse response functions at different phases of the business cycle.

The baseline results are as follows. The impact of monetary policy on the economy is stronger in downturns and booms than in recoveries and depressions. The labor and capital income taxes display similar patterns: the multipliers are higher when the economy is booming and is in downturns. Government expenditure shocks and consumption tax shocks, on the contrary, have a stronger impact on output in depressions and recoveries.

I further consider state-dependence in policy transmission mechanism conditional on the cycle driven by a particular macroeconomic shock. I find that state-dependence crucially depends on the sources of business cycle fluctuations. For example, the state-dependent effects of monetary policy shocks become significantly stronger across states conditional on marginal efficiency of investment shocks.[1]

Empirical literature that primarily relies on reduced-form time series models has not yet settled to a single conclusion on how the effects of economic policies vary depending upon the state of the business cycle. While Cover (1992), Thoma (1994), and Tenreyro and Thwaites (2016) find that monetary shocks have more significant effects in expansions than recessions, Peersman and Smets (2005) and Lo and Piger (2005) show that policy impact is more potent in recessions.[2] Likewise, one strand of literature argues that fiscal multipliers are higher in recessions than in expansions (see, among others, Auerbach and Gorodnichenko (2012a), (2012b), Mittnik and Semmler (2012) and Candelon and Lieb (2013)). On the contrary, Ramey and Zubairy (2018) do not find evidence that fiscal multipliers vary significantly over

[1] The output response to a monetary policy shock is more than two times larger in downturns than in recoveries.

[2] In the literature, expansions are frequently defined as states where output is above the trend. In recessions, on the contrary, the economy is operating below the trend.

the business cycle. The current paper is not a part of this debate. It considers the state-dependent effects of policy shocks in a structural general equilibrium model.

There is a significant body of literature on the theoretical front that tries to rationalize the findings in empirical studies. Santoro et al. (2014) embeds loss-aversion utility into an otherwise standard sticky-price model to show that monetary policy innovations have a greater impact on output during contractions. In Bernstein (2021), the interplay of occasionally binding borrowing constraints and heterogeneous households implies that output responds less to monetary policy in recessions. In Canzoneri et al. (2016), costly financial intermediation give rise to strongly countercyclical fiscal multipliers. Michaillat (2014) employs a New-Keynesian model with search and matching frictions to explain why the fiscal multiplier is larger when the economy is operating below its trend. The distinctive feature of the current paper is that it does not attempt to develop a model to match any empirical finding from the relevant literature. It instead quantitatively evaluates state-dependence in monetary and fiscal policy transmission mechanism in a canonical model of business cycle fluctuations. From the methodological perspective, this work is closest to Sims and Wolff (2018a) and Sims and Wolff (2018b). The latter, however, study variation in fiscal multipliers across the entire state-space and do not explicitly account for policy efficiency at different phases of the business cycle. These studies do not address state-dependence in monetary policy transmission mechanism either.

The rest of the paper proceeds as follows. The second section introduces the baseline DSGE model that is employed in quantitative simulations. It also discusses the calibration and estimation procedures. The third section shortly describes the procedure of computing the generalized impulse response functions. It next proceeds with the presentation of the baseline results. The fourth section studies state-dependence in monetary and fiscal policy transmission mechanism when the business cycle is driven by a particular macroeconomic shock. Finally, the last section summarizes and concludes the analysis.

II. Model Environment

The current section briefly describes the model environment used to study the state-dependent effects of economic policies across the business cycle phases. I consider a standard medium-scale DSGE model along the lines of Christiano et al. (2005), Smets and Wouters (2007), and Schmitt-Grohé and Uribe (2005). The structure of the model is quite well-known; thus, its presentation is short. The complete list of equilibrium conditions is in Appendix A.

Households

The representative household has a period utility function over consumption and labor:

$$u(C_t, N_t) = \frac{((C_t - hC_{t-1})^{\gamma}(1 - N_t)^{1-\gamma})^{1-\sigma} - 1}{1 - \sigma} \tag{1}$$

C_t denotes the aggregate consumption index, N_t is the labor supply. The parameter h measures the degree of internal habit formation in consumption.

The household supplies labor to a continuum of labor markets of measure one. Nominal wages are sticky. Each period, the household is able to set the nominal wage optimally in a fraction $1 - \theta_w$ of arbitrary chosen labor markets ($0 < \theta_w < 1$). Non-updated nominal wages are indexed to the previous period's inflation rate with an indexation parameter ξ_w.

The household ows the capital syock that accumulates according to:

$$K_{t+1} = (1 - \frac{\tau}{2}(\frac{I_t}{I_{t-1}} - 1)^2)I_t Z_t + (1-\delta)K_t \tag{2}$$

Z_t denotes the shock to the marginal efficiency of investment. The household also chooses how intensively to work the existing capital stock. The capital utilization rate is denoted by u_t. Working capital stock more intensively is costly. The cost is measured in units of physical capital and is given by the function $\Lambda(u_t) = \phi_0(u_t - 1) + \frac{1}{2}\phi_1(u_t-1)^2$.

The household's problem can be written as:

$$\begin{aligned}
\max_{C_t, I_t, u_t, K_{t+1}, N_t, B_t, w_{j,t}} \quad & E_0 \sum_{t=0}^{\infty} \beta^t \mu_t u(C_t, N_t) \\
\text{s.t.} \quad & (1+\tau_{c,t})C_t + I_t + \Lambda(u_t)K_t + \frac{B_t}{P_t} = \\
& (1-\tau_{n,t})\int_0^1 w_{j,t}N_{j,t}dj + (1-\tau_{k,t})r_t u_t K_t + (1-i_{t-1})\frac{B_{t-1}}{P_t} + \Xi_t - T_t \\
& K_{t+1} = (1 - \frac{\tau}{2}(\frac{I_t}{I_{t-1}} - 1)^2)I_t Z_t + (1-\delta)K_t \\
& \Lambda(u_t) = \phi_0(u_t - 1) + \frac{1}{2}\phi_1(u_t-1)^2 \\
& N_{j,t} = N_t^d(\frac{w_{j,t}}{w_t})^{-\epsilon_w} \\
& N_t = N_t^d \int (\frac{w_{j,t}}{w_t})^{-\epsilon_w} dj \\
& w_{j,t} = \begin{cases} w_t^{op}, & \text{if } w_{j,t} \text{ is set optimally in } t \\ w_{j,t-1}\frac{(\pi_{t-1}+1)^{\xi_w}}{\pi_t+1}, & \text{otherwise.} \end{cases}
\end{aligned} \tag{3}$$

P_t is the aggregate price index. B_{t-1} is the stock of nominal bonds with which the household enters period t. The nominal interest rate is denoted by i_t. Distributed profit from firm ownership is given by Ξ_t. $w_{j,t}$ and w_t are the real wage in market j and the real wage in the whole economy, respectively, and w_t^{op} is the optimal real reset wage. N_t^d is the aggregate labor demand and $\epsilon_w > 1$ measures labor substitutability in different markets. μ_t is a preference shock. $\tau_{c,t}$, $\tau_{n,t}$ and $\tau_{k,t}$ denote distortionary tax rates on consumption, labor income, and capital income, respectively. Finally, T_t is a lump sum tax.

Firms

The aggregate output in the economy is produced by a representative, competitive firm with the following technology:

$$Y_t = \left(\int_0^1 Y_{j,t}^{\frac{\epsilon_p - 1}{\epsilon_p}} \, dj \right)^{\frac{\epsilon_p}{\epsilon_p - 1}} \tag{4}$$

ϵ_p is the elasticity of substitution between different varieties. The representative firm takes the aggregate price level, P_t, and the price of intermediate goods, $P_t(j)$, as given. It chooses intermediate good quantities, $Y_t(j)$ to maximize profits. The usual demand schedule is given by:

$$Y_{j,t} = (\frac{P_{j,t}}{P_t})^{-\epsilon_p} Y_t \tag{5}$$

At the same time, the zero profit condition of the representative firm yields the following relation for the aggregate price level:

$$P_t = \left(\int_0^1 P_{j,t}^{1-\epsilon_p} \, dj \right)^{\frac{1}{1-\epsilon_p}} \tag{6}$$

A continuum of competitive monopolists produce differentiated goods using labor and capital services:

$$Y_{j,t} = A_t(u_t K_{j,t})^{\alpha} N_{j,t}^{1-\alpha} \tag{7}$$

A_t is a common productivity factor.

The intermediate good firms set prices as in Calvo (1983). In every period, each firm faces a constant probability, $1-\theta_p$, of being able to adjust its nominal price. The ability to adjust prices is independent across the firms and time. Similar to Christiano et al. (2005), those firms which are unable to optimize their prices in the current period automatically index them to the previous period's inflation with the indexation parameter ξ_p. The maximization problem for a firm j takes the following form:

$$\max_{P_{j,t}} E_t\{(\beta\theta_p)^s \frac{\lambda_{t+s}}{\lambda_t}(\Pi_{t-1,t+s-1}^{\xi_p(1-\epsilon_p)} P_{j,t}^{1-\epsilon_p} P_{t+s}^{\epsilon_p-1} Y_{t+s} - mc_{t+s}\Pi_{t-1,t+s-1}^{-\xi_p\epsilon_p} P_{j,t}^{-\epsilon_p} P_{t+s}^{\epsilon_p} Y_{t+s})\} \tag{8}$$

λ_t is the marginal utility of consumption and mc_t denotes real marginal cost common to all firms. $\Pi_{t-1,t+s-1}$ is the cumulative gross inflation between $t-1$ and $t+s-1$, $\Pi_{t-1,t+s-1} = \frac{P_{t+s-1}}{P_{t-1}}$.

Government

The government sets monetary and fiscal policy. Monetary policy is conducted via a standard interest rate rule:

$$i_t = (1-\rho_i)i + \rho_i i_{t-1} + (1-\rho_i)(\phi_\pi(\pi_t - \pi) + \phi_Y(\ln Y_t - \ln Y_{t-1})) + e_{i,t} \tag{9}$$

ρ_i describes interest-rate smoothing. ϕ_π and ϕ_Y control the responses to inflation and output growth. Finally, m_t is a monetary policy shock.

The government budget constraint takes the following form:

$$G_t + \frac{B_{t-1}(1+i_{t-1})}{P_t} = \tau_{c,t}C_t + \tau_{n,t}N_t w_t + \tau_{k,t} r_t u_t K_t + T_t + \frac{B_t}{P_t} \tag{10}$$

Government spending, G_t follows an AR(1) process in the natural log:

$$\ln G_t = (1-\rho_G)G + \rho_G \ln G_{t-1} + e_{G,t} \tag{11}$$

Likewise, I assume that the distortionary tax rates obey exogenous AR(1) processes:

$$\tau_{j,t} = (1-\rho_j)\tau_j + \rho_j \tau_{j,t-1} + e_{j,t} \tag{12}$$

where $j = c, n, k$.

Aggregation and Equilibrium

The aggregate production function for the whole economy is given by:

$$Y_t = \frac{A_t(u_t K_t)^{\alpha} N_t^{\alpha}}{d_t^p} \tag{13}$$

$d_t^p = \int_0^1 (\frac{P_{j,t}}{P_t})^{-\epsilon_p} dj$ describes relative price dispersion. The aggregate resource constraint has the following form:

$$Y_t = C_t + I_t + \Lambda(u_t)K_t + G_t \tag{14}$$

Parameter Values

Some of the parameter values are calibrated to match long-run targets or conventional values in the literature. The remaining parameters are estimated via Bayesian methods. The list of calibrated parameters is shown in Table 1.

The estimation is carried out using US data. The data covers the period 1984Q1-2008Q4.[3] Private consumption is the sum of personal consumption expenditures on nondurable goods and services. Investment is the sum of personal consumption expenditures on durable goods and gross private fixed investment. Hours worked is defined as the product of average weekly hours in the non-farm business sector with total civilian employment aged sixteen and over. The real wage is the hourly compensation in the non-farm business sector. The nominal interest rate is the three-month Treasury Bill rate. Inflation is the growth rate of the price index for personal consumption expenditures. The real series are obtained by deflating the corresponding nominal variables by the GDP deflator. The data is obtained from the Fred database. I construct the tax rate data following Leeper et al. (2010) (Appendix B, page 320).

Table 2 presents the estimation results. The estimated parameters are generally in line with the current estimates in the literature. The model solved at the mode of the estimated parameters implies that productivity and marginal efficiency of investment shocks account for about 32 % of the unconditional variance of output growth. The price markup shocks explain approximately 35 % of output's variance. The government expenditure shocks explain about 17 % of output's variance. The remaining shocks account for the rest.

[3] The end date is chosen to exclude the zero lower bound period.

III. Results

This section explores the effects of policy shocks over the state space. I start the section by presenting non-linear impulse response functions. I also describe the procedure of identifying the state vectors corresponding to different phases of the business cycle. I next study the effects of monetary and fiscal policy across the generated state space.

Quantitative simulations

I solve the model at the posterior mode of estimated parameters via a second-order approximation to account for state dependence in the policy actions. [4] The generalized impulse response functions are computed via simulations similar to the procedure of Koop et al. (1996). Given the vector of initial states, I simulate the model by drawing random sequences of shocks. These are baseline simulations. Next, I use the same sequences of shocks, except I replace the first shock with the policy shock of interest (alternative simulation). This procedure is repeated 100 times. The response is the difference between the two mean paths.

Impulse response functions at second-order approximation depend on the state values. [5] I simulate 5000 periods of data from the model starting from the non-stochastic steady state to get the state vectors. I next apply the Bry and Boschan routine on the simulated series of GDP to identify the turning points and, thereby, the four stages of the business cycle. I consider the points where the GDP is 1.1% above and 0.72% below its mean value within this set of states. These are the figures

[4] One can get similar results by applying to a higher-order approximation.

[5] The size and the sign of the shock also matter in the non-linear model. However, I do not explore these questions in the current paper.

by which the GDP was, on average, above (below) trend over the period 1984–2008.[6]

Baseline results

Figure 2 plots the average output response to one standard deviation expansionary monetary policy shock across the business cycle phases. Considering maximum response, we can observe that the effects of monetary policy on economic activity are, on average, the strongest in downturns. Monetary policy is slightly less efficient in boosting output in boom periods. Meanwhile, it has the weakest impact on the economy in recoveries. The average output response in downturns is nearly 50 % larger than in recoveries. In fact, on average, monetary policy has a more substantial impact on economic activity in states where output is above the trend. I also report the variability of the maximum output response across the four stages of the cycle. Table 3 presents the corresponding summary statistics. It also contains the minimum, the maximum, and the average values of the maximum output response. The distribution of the output response has lower dispersion in booms and downturns compared to depressions and recoveries.

I next turn to analyze state-dependence in fiscal policy. Figures 3 to 6 plot the average impulse response functions of output to shocks to government expenditure, distortionary consumption, labor, and capital tax rates across the business cycle phases. For tax shocks, the response functions are scaled by the impact response of the steady-state tax revenue. For government expenditure shocks, the output responses are scaled by the inverse of the response of the government expenditure on impact. Thus, all responses are expressed in multiplier form. Table 4 contains the corresponding summary statistics on the distribution of maximum multipliers.[7]

[6] I compute the trend output using HP filter with a smoothing parameter of 1600.

[7] The maximum tax multiplier is obtained by dividing the maximum output response by the

We observe that government expenditure shocks have a more substantial impact on economic activity in depressions and recoveries. Meanwhile, the efficiency of stimulating output is somewhat limited in downturns and booms. In other words, the expenditure multiplier is higher in states where output is below its long-run level. The multiplier ranges from 0.51 (the minimum value in boom periods) to 1.02 (the maximum value in depressions) across the state space. Finally, the expenditure multiplier is somewhat more dispersed in depressions.

Similar to government expenditure, consumption tax changes are, on average, more efficient in stimulating output during depressions and recoveries. We observe that there is little state-dependence in the effects of consumption tax shocks across the state-space. Also, the consumption tax multiplier displays moderate variability across all stages of the business cycle.

Consider next the state-dependent effects of capital and labor tax shocks. A change in the labor income tax has the most substantial impact on output in downturns. Meanwhile, the labor tax multiplier is the lowest when the economy is in a recovery. The multiplier is the least dispersed in recoveries, and it has the largest dispersion in depressions. As for the capital tax, higher multiplier values are observed in downturns and booms, i.e., when the economy operates above the trend. Moreover, the variability of the multiplier is lower in downturns and boom periods. It has the highest volatility when the economy is in a depression.

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steady-state revenue response. The maximum expenditure multiplier is the ratio of the largest response of output by the initial exogenous spending shock.

IV. Further results: The source of business cycle fluctuations

The current section asks whether phase-dependence in the output response to policy shocks is conditional on the source of business cycle fluctuations. To resolve the question, I run the simulations assuming that the business cycle is driven by one shock at a time. I only consider the non-policy shocks that account for a significant share of output variance: productivity, marginal efficiency of investment, and price markup shocks. In all cases, the size of the shock is such that it generates the same volatility of output as in the baseline case.

Table 5 reports the corresponding statistics on the effects of monetary policy shocks. We observe that state-dependence in monetary policy shocks becomes notably pronounced when marginal efficiency of investment shocks drive the business cycle. The average impact of a monetary policy shock is more than two times larger in downturns than in recoveries. Moreover, compared to the baseline results, the output response becomes more volatile across the business cycle phases. As for the other two shocks, the difference from the baseline results is not significant.

Table 6 contains summary statistics on the distribution of fiscal multipliers over the state space. Consider first the effects of government expenditure shocks. We notice that state-dependence in the output response becomes stronger across states conditional on neutral productivity shocks: the maximum multiplier is, on average, 0.88 in depressions, while it is only 0.68 in booms. Also, when the only drivers of the business cycle are neutral productivity, marginal efficiency of investment, and markup shocks, the expenditure multipliers are less volatile compared to the benchmark case.

Similar to monetary policy shocks, state-dependence in the output response to capital tax shocks becomes stronger conditional on the cycle driven by marginal efficiency of investment shocks. Also, the capital tax multiplier becomes more volatile within each phase when the cycle is dominated by marginal efficiency of investment shocks. For consumption and labor income taxes, the state-dependence in the output response conditional on separate shocks is somewhat similar to the baseline results.

To sum up, these results suggest that accounting for the source of the business cycle is potentially important when empirically assessing state-dependence in policy transmission.

V. Conclusion

This paper studies how the effects of monetary and fiscal policy vary across the business cycle in an estimated general equilibrium model. To account for state-dependence in policy actions, the model is solved via second-order perturbation. Monetary policy is found to have a more potent impact on the economy in downturns and booms. In the case of labor and capital income taxes, similar observations can be made. Government expenditure shocks and consumption tax shocks, on the contrary, have a stronger impact on output in depressions and recoveries. I also study state-dependence in policy action conditional on the cycle driven by a particular macroeconomic shock. I find that state-dependence crucially depends upon the sources of business cycle fluctuations. The latter suggests that accounting for the source of the business cycle is essential when empirically assessing the state-dependent effects of policy shocks.

TABLE 1

Calibrated parameters

Parameter	Description	Value
β	Time discount factor	0.99
δ	Depreciation rate	0.025
α	Share of Capital	$\frac{1}{3}$
ϕ_0	Linear term utilization cost	$\frac{1}{\beta}+1-\delta$
ϕ_1	Quadratic term utilization cost	0.01
π	Inflation target	0

Note: This table reports the values of calibrated parameters in the baseline DSGE model.

TABLE 2

Parameter estimates

		Prior			Posterior		
Parameter	Description	Dist	Mean	SD	Mean	90th Percentile	
h	Habit formation	B	0.75	0.05	0.72	0.67	0.79
σ	Utility curvature	N	2.00	0.25	2.23	1.92	2.53
γ	Utility curvature	B	0.15	0.01	0.20	0.19	0.22
τ	Inv. adj. cost	N	2.00	0.2	2.23	1.95	2.68
ξ_w	Wage indexation	B	0.50	0.05	0.49	0.41	0.57
ξ_p	Price indexation	B	0.50	0.05	0.42	0.34	0.50
θ_w	Wage stickiness	B	0.5	0.05	0.66	0.61	0.72
θ_p	Price stickiness	B	0.5	0.05	0.76	0.73	0.80
ϵ_w	Labor substitutability	N	16.00	2.00	17.13	14.09	20.29
ϵ_p	Product substitutability	N	16.00	2.00	17.88	14.59	20.66
ϕ_π	Response to inflation	N	1.50	0.1	1.51	1.34	1.65
ϕ_Y	Response to GDP growth	N	0.15	0.01	0.15	0.13	0.17
ρ_i	Interest rate persistence	B	0.60	0.1	0.80	0.77	0.84
ρ_A	Productivity persistence	B	0.60	0.1	0.92	0.89	0.94
ρ_Z	MEI persistence	B	0.60	0.1	0.81	0.73	0.88
ρ_μ	Preference persistence	B	0.60	0.1	0.68	0.57	0.80
ρ_{v_w}	Wage markup persistence	B	0.60	0.1	0.64	0.54	0.76
ρ_{v_p}	Price markup persistence	B	0.60	0.1	0.89	0.85	0.92

		Prior			Posterior		
Parameter	Description	Dist	Mean	SD	Mean	90th Percentile	
$100 * s_A$	SD Productivity shock	IG	0.50	0.20	0.99	0.87	1.11
$100 * s_Z$	SD MEI shock	IG	0.50	0.20	2.04	1.60	2.50
$100 * s_\mu$	SD preference shock	IG	0.50	0.20	1.81	1.45	2.20
$100 * s_{v_w}$	SD wage markup shock	IG	0.50	0.20	1.85	1.54	2.18
$100 * s_{v_p}$	SD price markup shock	IG	0.50	0.20	0.40	0.33	0.46
$100 * s_i$	SD monetary policy shock	IG	0.50	0.20	0.19	0.17	0.22
$100 * s_g$	SD government expenditure shock	IG	0.50	0.20	2.58	2.29	2.86
$100 * s_{\tau_c}$	SD consumption tax shock	IG	0.50	0.20	0.14	0.13	0.14
$100 * s_{\tau_n}$	SD labor income tax shock	IG	0.50	0.20	0.44	0.39	0.47
$100 * s_{\tau_k}$	SD capital income tax shock	IG	0.50	0.20	0.76	0.67	0.85

Notes: B stands for beta distribution, N for normal distribution, and IG stands for inverse gamma. The posterior is generated with 50000 random walk Metropolis Hastings draws with an acceptance rate of about 17 %. Under posterior results, the ranges display 90 % confidence intervals.

TABLE 3

State-dependent effects of monetary policy

	Downturn	Depression	Recovery	Boom
Min	0.29	0.13	0.14	0.26
Max	0.46	0.39	0.36	0.45
Mean	0.38	0.27	0.25	0.35
Stdev	0.03	0.04	0.04	0.03

Notes: The table shows statistics for output response to a monetary shock at different phases of the business cycle. It reports the maximum, the minimum, the mean and the standard deviation of maximum responses.

TABLE 4

State-dependent effects of fiscal policy

		Downturn	Depression	Recovery	Boom
G	Min	0.54	0.65	0.69	0.51
	Max	0.87	1.02	0.99	0.87
	Mean	0.71	0.85	0.85	0.70
	Stdev	0.06	0.07	0.06	0.06
τ_c	Min	0.36	0.39	0.37	0.33
	Max	0.44	0.47	0.45	0.43
	Mean	0.40	0.43	0.41	0.39
	Stdev	0.01	0.01	0.02	0.02
τ_n	Min	0.63	0.51	0.49	0.59
	Max	0.91	0.84	0.79	0.90
	Mean	0.78	0.65	0.61	0.75
	Stdev	0.06	0.07	0.06	0.06
τ_k	Min	1.18	1.05	1.05	1.18
	Max	1.55	1.48	1.42	1.56
	Mean	1.39	1.24	1.21	1.34
	Stdev	0.07	0.09	0.08	0.07

Notes: The table shows statistics for fiscal multipliers computed at different phases of the business cycle. It reports the maximum, the minimum, the mean and the standard deviation of the maximum multipliers.

TABLE 5

State-dependent effects of monetary policy conditional on the source of the business cycle

	Productivity shock				MEI shock				Price Markup shock			
	Down	Depres	Recov	Boom	Down	Depres	Recov	Boom	Down	Depres	Recov	Boom
Min	0.32	0.15	0.13	0.30	0.36	0.09	0.03	0.36	0.33	0.17	0.16	0.30
Max	0.44	0.37	0.32	0.39	0.53	0.37	0.37	0.54	0.45	0.34	0.30	0.40
Mean	0.37	0.29	0.25	0.34	0.42	0.22	0.18	0.42	0.37	0.28	0.25	0.35
Stdev	0.02	0.03	0.03	0.02	0.03	0.05	0.06	0.03	0.02	0.03	0.03	0.02

Notes: The table shows statistics for maximum output response to a monetary shock conditional on the cycle being driven by a particular macroeconomic shock.

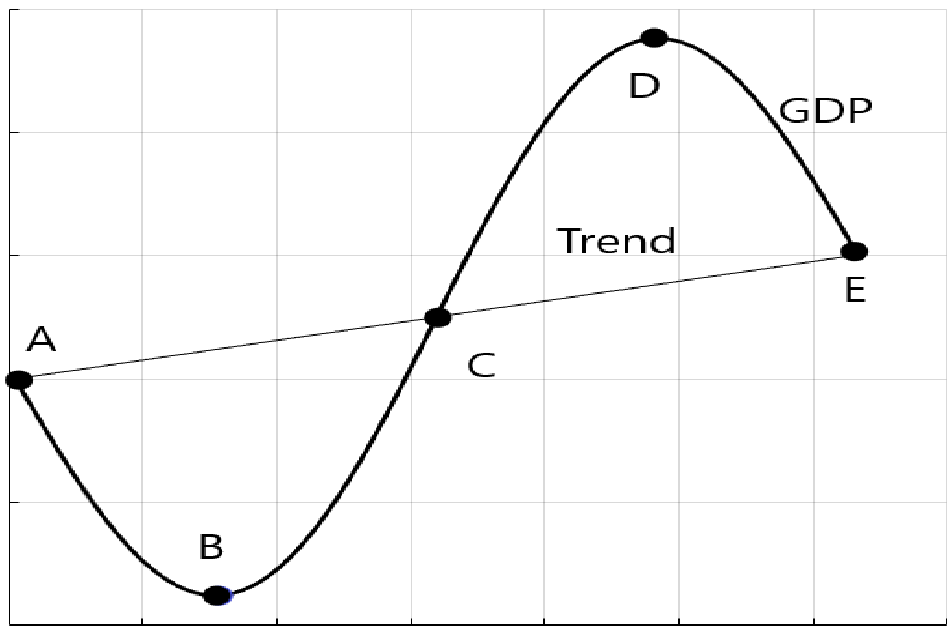
TABLE 6

State-dependent effects of fiscal policy conditional on the source of the business cycle

		Productivity shock				MEI shock				Price Markup shock			
		Down	Depres	Recov	Boom	Down	Depres	Recov	Boom	Down	Depres	Recov	Boom
G	Min	0.60	0.80	0.80	0.58	0.65	0.79	0.79	0.64	0.60	0.82	0.82	0.58
	Max	0.74	1.06	1.05	0.74	0.74	1.04	1.06	0.74	0.75	0.97	0.96	0.75
	Mean	0.70	0.88	0.87	0.68	0.71	0.86	0.88	0.71	0.71	0.86	0.86	0.70
	Stdev	0.03	0.04	0.04	0.03	0.02	0.03	0.05	0.02	0.03	0.03	0.03	0.03
τ_c	Min	0.37	0.40	0.38	0.34	0.37	0.40	0.38	0.33	0.37	0.39	0.37	0.34
	Max	0.45	0.49	0.47	0.43	0.46	0.52	0.53	0.44	0.44	0.47	0.45	0.42
	Mean	0.40	0.44	0.42	0.38	0.40	0.45	0.44	0.38	0.40	0.43	0.41	0.39
	Stdev	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
τ_n	Min	0.63	0.48	0.49	0.65	0.66	0.58	0.55	0.60	0.63	0.48	0.49	0.61
	Max	1.04	0.90	0.86	1.03	1.09	1.04	1.01	1.05	0.91	0.78	0.75	0.89
	Mean	0.82	0.66	0.62	0.78	0.84	0.77	0.70	0.77	0.78	0.64	0.61	0.74
	Stdev	0.07	0.07	0.06	0.06	0.08	0.08	0.07	0.07	0.05	0.05	0.05	0.05
τ_k	Min	1.21	1.05	1.06	1.25	1.31	1.16	0.98	1.16	1.21	1.01	1.04	1.20
	Max	1.68	1.55	1.52	1.68	1.88	1.78	1.72	1.82	1.54	1.40	1.39	1.53
	Mean	1.43	1.29	1.23	1.40	1.53	1.39	1.26	1.42	1.38	1.21	1.20	1.35
	Stdev	0.08	0.08	0.07	0.07	0.11	0.11	0.11	0.10	0.06	0.06	0.07	0.06

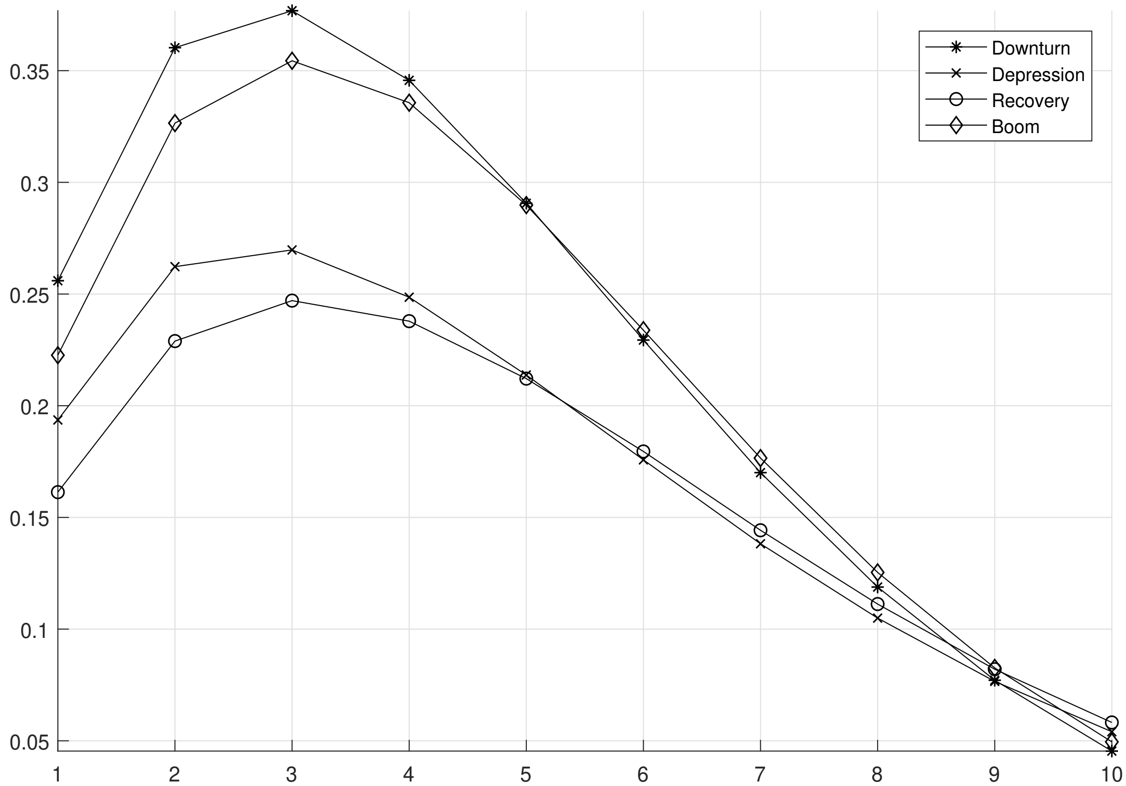
Notes: The table shows statistics for fiscal (maximum) multipliers conditional on the cycle being driven by a particular macroeconomic shock.

Figure 1. Business Cycle Phases



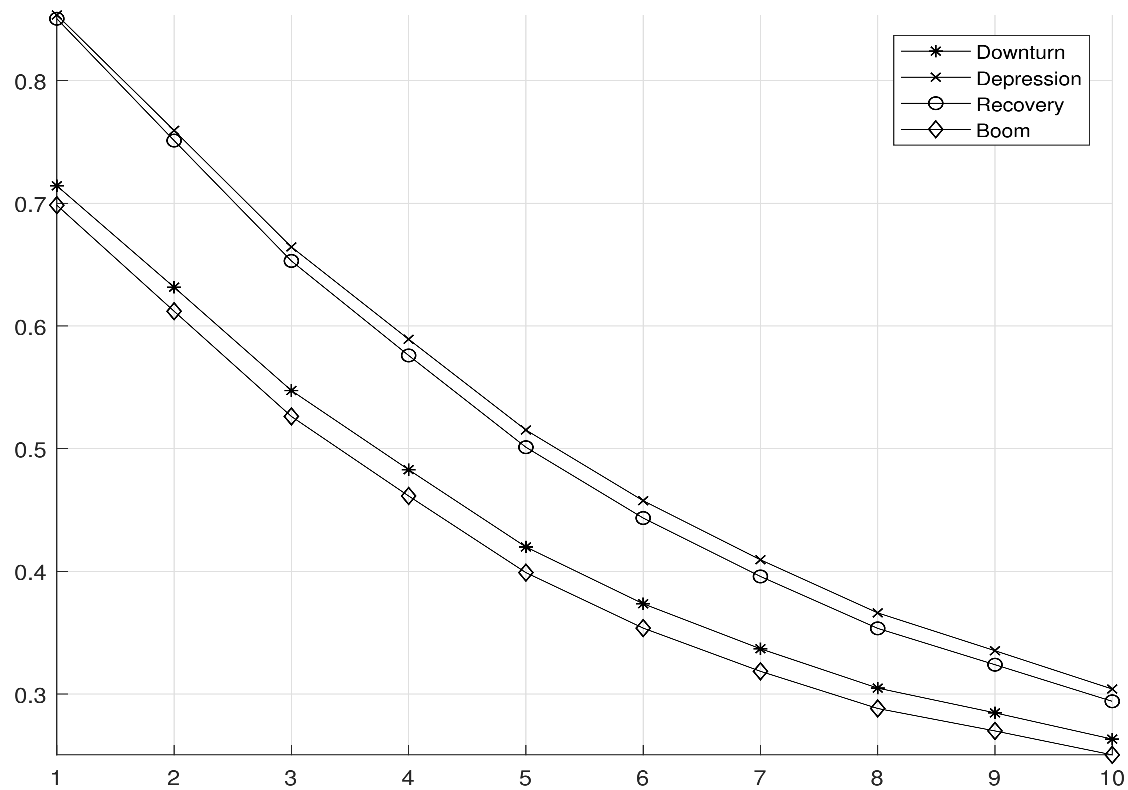
Notes: The figure plots the cyclical variation of the GDP around its trend.

Figure 2. State-Dependent Effects of Monetary Policy Shocks



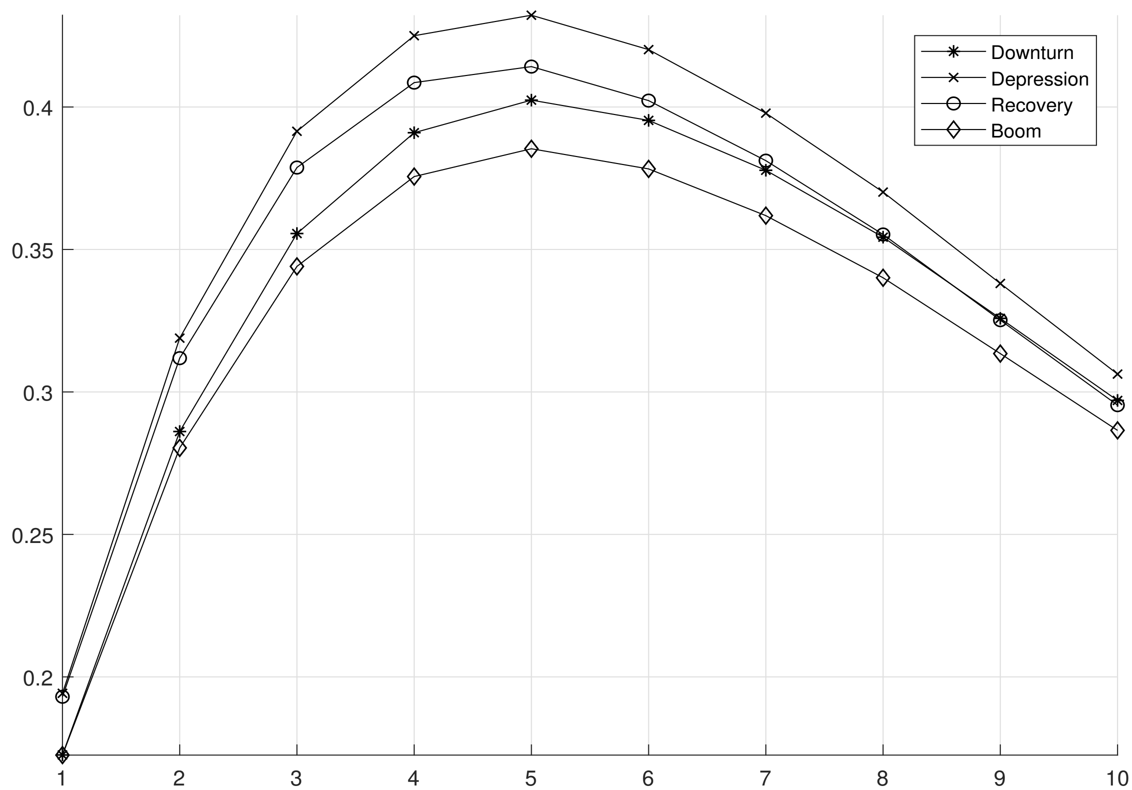
Notes: The figure plots the average impulse response functions of output to an expansionary monetary policy shock across the phases of the business cycle. The responses are in percent deviations from corresponding mean values.

Figure 3. State-Dependent Effects of Government Expenditure Shocks



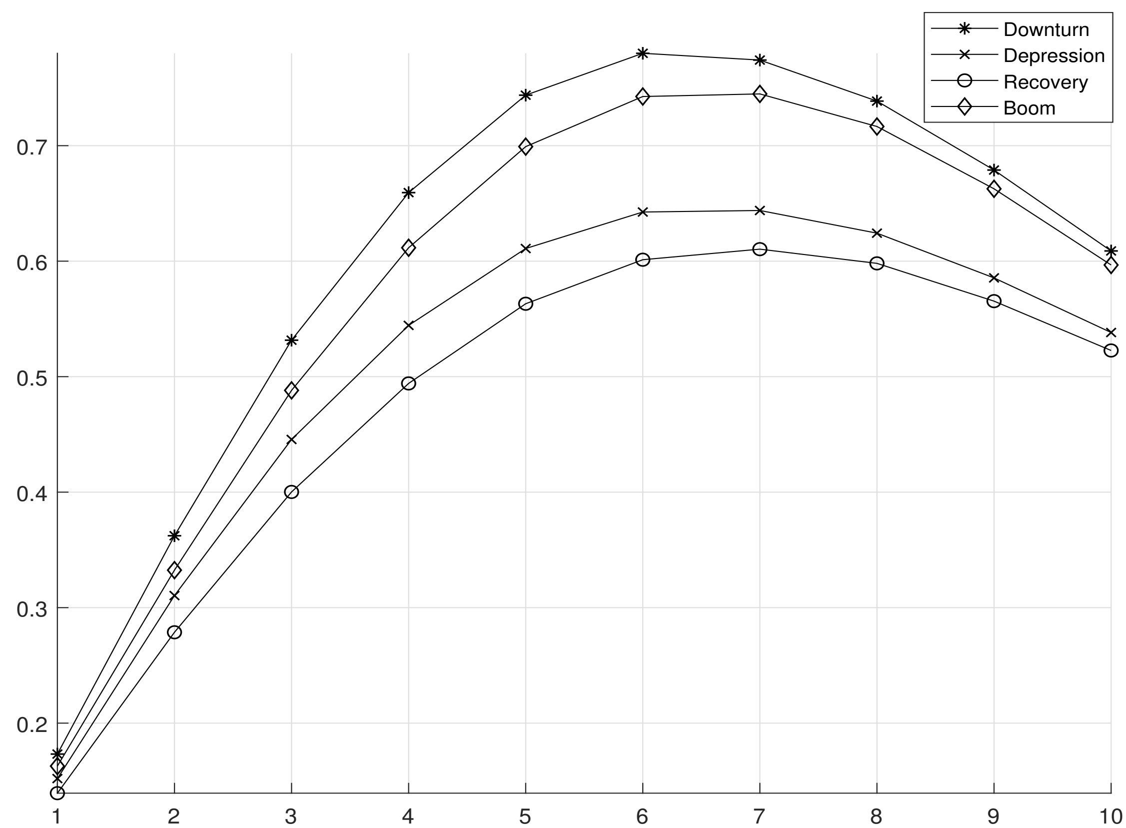
Notes: The figure plots the average impulse response functions of output to an expansionary government expenditure shock across the phases of the business cycle. The responses are in multiplier form.

Figure 4. State-Dependent Effects of Consumption Tax Shocks



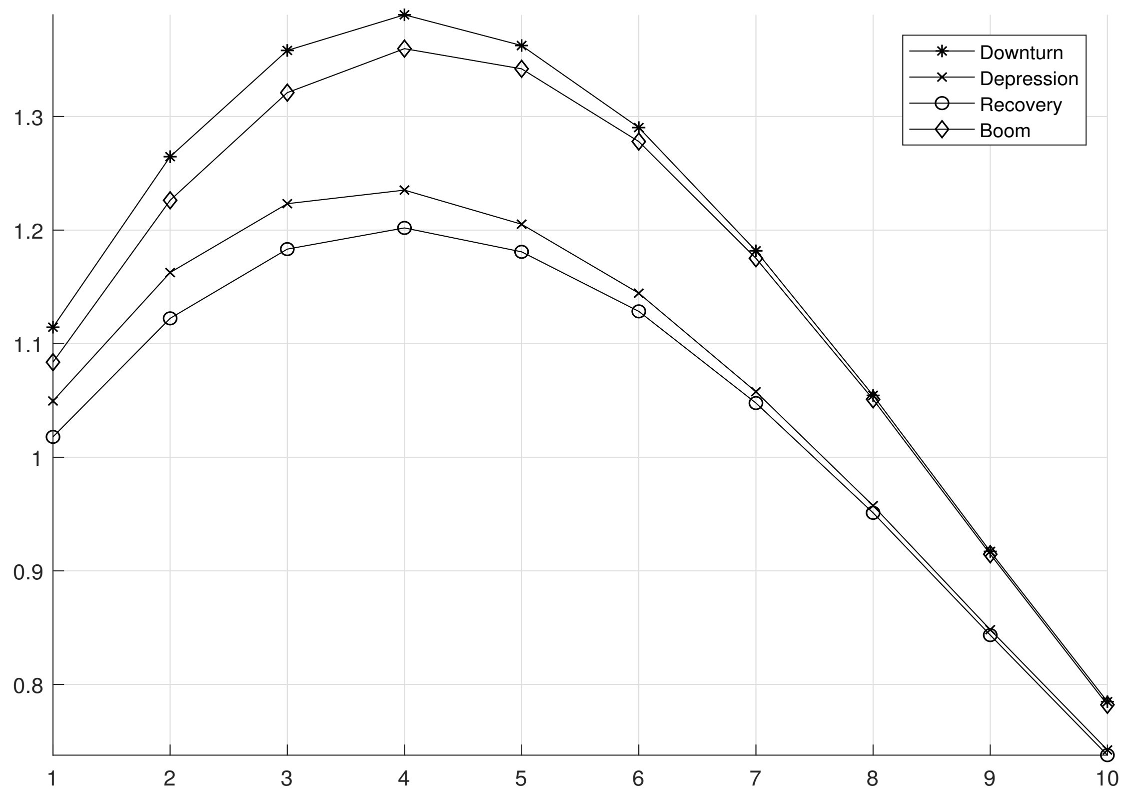
The figure plots the average impulse response functions of output to an expansionary consumption tax shock across the phases of the business cycle. The responses are in multiplier form.

Figure 5. State-Dependent Effects of Labor Income Tax Shocks



The figure plots the average impulse response functions of output to an expansionary labor income tax shock across the phases of the business cycle. The responses are in multiplier form.

Figure 6. State-Dependent Effects of Capital Income Tax Shocks



The figure plots the average impulse response functions of output to an expansionary capital income tax shock across the phases of the business cycle. The responses are in multiplier form.

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Appendix A

The equilibrium conditions of the model

Households

$$\lambda_t = \beta E_t \lambda_{t+1} \frac{i_t + 1}{\pi_{t+1} + 1} \tag{.15}$$

$$w_t^{op} = \frac{\epsilon_w}{\epsilon_w - 1} \frac{X_{1,t}^w}{X_{2,t}^w} \upsilon_{w,t} \tag{.16}$$

$$X_{1,t}^w = \mu_t U_N(.) w_t^{\epsilon_w} N_t^d + \theta_w \beta E_t (\pi_t + 1)^{-\epsilon_w \xi_w} (\pi_{t+1} + 1)^{\epsilon_w} X_{1,t+1}^w \tag{.17}$$

$$X_{2,t}^w = \mu_t (1 - \tau_{n,t}) w_t^{\epsilon_w} N_t^d + \theta_w \beta E_t (\pi_t + 1)^{-\epsilon_w \xi_w} (\pi_{t+1} + 1)^{\epsilon_w} X_{2,t+1}^w \tag{.18}$$

$$(1 - \tau_{k,t}) r_t = \Lambda'(u_t) \tag{.19}$$

$$q_t Z_t (1 - \Omega(\frac{I_t}{I_{t-1}}) - \Omega'(\frac{I_t}{I_{t-1}}) \frac{I_t}{I_{t-1}}) + \beta E_t \frac{\lambda_{t+1}}{\lambda_t} q_{t+1} Z_{t+1} \Omega'(\frac{I_{t+1}}{I_t})(\frac{I_{t+1}}{I_t})^2 = 1 \tag{.20}$$

$$q_t = \beta E_t \frac{\lambda_{t+1}}{\lambda_t} (1 - \tau_{k,t+1})(r_{t+1} u_{t+1} - \Lambda(u_{t+1}) + (1 - \delta) q_{t+1}) \tag{.21}$$

$$K_{t+1} = (1 - \Omega(\frac{I_t}{I - t - 1})) I_t Z_t + (1 - \delta) K_t \tag{.22}$$

λ_t is the marginal utility of consumption. q_t is the relative price of capital in terms of consumption good. $\upsilon_{w,t}$ is a wage markup shock.

Firms

$$r_t = \alpha mc_t A_t \bar{K}_t^{\alpha-1} (N_t^d)^{1-\alpha} \tag{.23}$$

$$w_t = (1 - \alpha) mc_t A_t \bar{K}_t^{\alpha} (N_t^d)^{-\alpha} \tag{.24}$$

$$\pi_t^{op} + 1 = \frac{\epsilon_p}{\epsilon_p - 1} (\pi_t + 1) \frac{X_{1,t}^p}{X_{2,t}^p} \upsilon_{p,t} \tag{.25}$$

$$X_{1,t}^p = \lambda_t Y_t mc_t + \beta \theta_p E_t (\pi_t + 1)^{-\epsilon_p \xi_p} (\pi_{t+1} + 1)^{\epsilon_p} X_{1,t+1}^p \tag{.26}$$

$$X_{2,t}^p = \lambda_t Y_t + \beta \theta_p E_t (\pi_t + 1)^{(1-\epsilon_p)\xi_p} (\pi_{t+1} + 1)^{\epsilon_p - 1} X_{2,t+1}^p \tag{.27}$$

$v_{p,t}$ is a price markup shock

Government

$$i_t = (1-\rho_i)i + \rho_i i_{t-1} + (1-\rho_i)(\phi_\pi(\pi_t - \pi) + \phi_Y(\ln Y_t - \ln Y_{t-1})) + e_{i,t} \quad (.28)$$

$$\ln G_t = (1-\rho_G)G + \rho_G \ln G_{t-1} + e_{G,t} \quad (.29)$$

$$\tau_{c,t} = (1-\rho_c)\tau_c + \rho_c \tau_{c,t-1} + e_{c,t} \quad (.30)$$

$$\tau_{n,t} = (1-\rho_n)\tau_n + \rho_n \tau_{n,t-1} + e_{n,t} \quad (.31)$$

$$\tau_{k,t} = (1-\rho_k)\tau_k + \rho_k \tau_{k,t-1} + e_{k,t} \quad (.32)$$

Aggregation and equilibrium

$$Y_t = \frac{A_t \bar{K}_t^\alpha N_t^\alpha}{d_t^p} \quad (.33)$$

$$d_t^p = ((1-\theta_p)(\pi_t^{op}+1)^{-\epsilon_p} + \theta_p(\pi_{t-1}+1)^{-\epsilon_p\xi_p} d_{t-1}^p)(\pi_t+1)^{\epsilon_p} \quad (.34)$$

$$N_t = N_t^d d_t^w \quad (.35)$$

$$d_t^w = (1-\theta_w)(\frac{w_t^{op}}{w_t})^{-\epsilon_w} + \theta_w(\frac{w_{t-1}}{w_t})^{-\epsilon_w}\frac{(\pi_{t-1}+1)^{-\epsilon_w\xi_w}}{(\pi_t+1)^{\epsilon_w}} d_{t-1}^w \quad (.36)$$

$$(\pi_t+1)^{1-\epsilon_p} = (1-\theta_p)(\pi_t^{op}+1)^{1-\epsilon_p} + \theta_p(\pi_{t-1}+1)^{(1-\epsilon_p)\xi_p} \quad (.37)$$

$$w_t^{1-\epsilon_w} = (1-\theta_w)(w_t^{op})^{1-\epsilon_w} + \theta_w(\pi_{t-1}+1)^{(1-\epsilon_w)\xi_w}(\pi_t+1)^{\epsilon_w-1} w_{t-1}^{1-\epsilon_w} \quad (.38)$$

$$Y_t = C_t + I_t + \Lambda(u_t)K_t + G_t \quad (.39)$$

Shocks

$$\ln A_t = \rho_A \ln A_{t-1} + e_{A,t} \quad (.40)$$

$$\ln Z_t = \rho_Z \ln Z_{t-1} + e_{Z,t} \quad (.41)$$

$$\ln \mu_t = \rho_\mu \ln \mu_{t-1} + e_{\mu,t} \quad (.42)$$

$$\ln v_{p,t} = \rho_{v_p} \ln v_{p,t-1} + e_{v_p,t} \quad (.43)$$

$$\ln v_{w,t} = \rho_{v_w} \ln v_{w,t-1} + e_{v_w,t} \quad (.44)$$