Online Appendix to "Hours and Employment Over the Business Cycle: A Bayesian Approach"

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Abstract

This Appendix gathers supplementary material to Cacciatore, Fiori, and Traum (2017).

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A Data Description

We consider three alternative sets of labor market variables. The estimation in the main text uses the first set, while the alternative sets are considered for robustness. We apply the following transformation to Total Hours and Employment: $\ln\left(\frac{x}{Pop}\right) * 100$ where Pop is the civilian noninstitutional population (series LNU00000000 of the BLS). We apply the following transformation to hours per worker: $\ln(h) * 100$.

1. Current Employment Statistics (CES) data.

Total Hours, TH is economy-wide total hours measure of the BLS, taken from www.bls.gov/lpc/special_requests/us_total_hrs_emp.xlsx.

Employment, L is the economy-wide employment series of the BLS (from same source as total hours).

Hours, h is average weekly hours calculated as $(TH/L)/52$.

2. Current Population Survey (CPS) data.

Total Hours, TH is an economy-wide measure constructed as in Ramey (2012). The total hours series of Cociuba et al. (2012), which is constructed from the BLS' CPS data for all industries, combined with total hours of the armed forces, taken from www.bls.gov/lpc/special_requests/us_total_

Employment, L is an economy-wide employment series constructed from combining CPS employment for all industries with armed forces employment (from same sources as total hours).

Hours, h is average weekly hours calculated as $(TH/L)/52$.

3. Smets-Wouters (SW) data.

Hours, h is defined as the index for nonfarm business, all persons, average weekly hours duration, 2009 = 100, seasonally adjusted (from the Major Sector Productivity and Cost series PRS85006023 of the BLS).

Employment, L is civilian employment for all industries for ages sixteen years and over, seasonally adjusted (from the CPS series LNS12000000Q of the BLS).

Total Hours, TH is calculated as $h * L$.

In addition to the labor market variables, the following data are used for estimation. Unless otherwise noted, data are from the National Income and Product Accounts tables of the Bureau of Economic Analysis.

GDP. Gross domestic product (Table 1.1.5 line 1). Output (y) growth is

$$100\left[\ln\left(\frac{y_t}{gdpp_t pop_t}\right) - \ln\left(\frac{y_{t-1}}{gdpp_{t-1} pop_{t-1}}\right)\right]$$

where $gdpp$ is the GDP deflator (Table 1.1.4, line 1) and Pop is the civilian noninstitutional population (series LNU00000000 of the BLS).

Consumption. Total personal consumption expenditures on nondurables and services (Table 1.1.5, lines 5 and 6). Consumption (c) growth is

$$100\left[\ln\left(\frac{c_t}{gdpp_t pop_t}\right) - \ln\left(\frac{c_{t-1}}{gdpp_{t-1} pop_{t-1}}\right)\right]$$

where $gdpp$ is the GDP deflator (Table 1.1.4, line 1) and Pop is the civilian noninstitutional population (series LNU00000000 of the BLS).

Investment. Gross private domestic investment (Table 1.1.5, line 7) and personal consumption expenditures on durables (Table 1.1.5, line 4). Investment (i) growth is

$$100\left[\ln\left(\frac{i_t}{gdpp_t pop_t}\right) - \ln\left(\frac{i_{t-1}}{gdpp_{t-1} pop_{t-1}}\right)\right]$$

where $gdpp$ is the GDP deflator (Table 1.1.4, line 1) and Pop is the civilian noninstitutional population (series LNU00000000 of the BLS).

Wage Rate. The wage rate w is the index for hourly compensation for nonfarm business, all persons, 2009 = 100 (from the Major Sector Productivity and Cost series PRS85006103 of the BLS). Wage growth is $100\left[\ln\left(\frac{w_t}{gdpp_t}\right) - \ln\left(\frac{w_{t-1}}{gdpp_{t-1}}\right)\right]$ where $gdpp$ is the GDP deflator (Table 1.1.4, line 1).

Inflation. The gross inflation rate is the log first difference of the GDP deflator (Table 1.1.4, line 1).

Interest Rate. The nominal interest rate is the average of daily figures of the Federal Funds Rate (from the Board of Governors of the Federal Reserve System) divided by 4.

Inflation and the interest rate are demeaned, while total hours and employment are linearly detrended. Figure A.1 illustrates our preference for linearly detrended data. Over the sample period, hours per worker exhibits a downward trend while employment exhibits an upward trend. When these (logged) variables are linearly detrended, their sum almost perfectly matches the original, demeaned total hours series (their correlation is 0.9999). Thus, the linear filtering appears to account for the low-frequency structural features of employment and hours per worker while preserving the original properties of the total hours series. In contrast, HP filtered hours per worker and employment change the properties of a total hours measure. GDP, consumption, investment, and wages are neither demeaned nor detrended. Observables are linked to model variables in the following manner:

$$\begin{bmatrix} \text{GDP}_t \\ \text{Cons}_t \\ \text{Inv}_t \\ \text{Wage}_t \\ \text{TotalHour}_t \\ \text{Emp}_t \\ \text{Infl}_t \\ \text{FedFunds}_t \end{bmatrix} = \begin{bmatrix} 100 \log \bar{g_A} \\ 100 \log \bar{g_A} \\ 100 \log \bar{g_A} \\ 100 \log \bar{g_A} \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} \hat{y}_t - \hat{y}_{t-1} + \hat{g}_{At} \\ \hat{c}_t - \hat{c}_{t-1} + \hat{g}_{At} \\ \hat{\imath}_t - \hat{\imath}_{t-1} + \hat{g}_{At} \\ \hat{w}_t - \hat{w}_{t-1} + \hat{g}_{At} \\ T\hat{H}_t \\ \hat{L}_t \\ \hat{\pi}_t \\ \hat{R}_t \end{bmatrix}$$

Hours and Employment with Alternative Data

We document the robustness of the results of section 2 of the main paper to alternative measures of the labor market variables. Table A.1 displays the shares of hours per worker and employment for the variance of total hours for the two alternative labor market data sets described above, based on CPS data and Smets and Wouters (2007) observables. The shares are calculated after applying various transformations on the data and for two alternative sample periods. In all but one case, the covariance of hours per worker and employment is positive. Hours per worker accounts for 15-48% of the variance of total hours.

Figure A.2 reports the time-varying comovement in recession-recovery episodes using alternative detrending methods using the CES dataset. In addition to the linear detrending procedure, we apply a HP filter with smoothing parameters of 10^5 and a band pass filter as in Christiano and Fitzgerald (2003). Results also hold for the alternative measures of labor-market variables (not pictured).

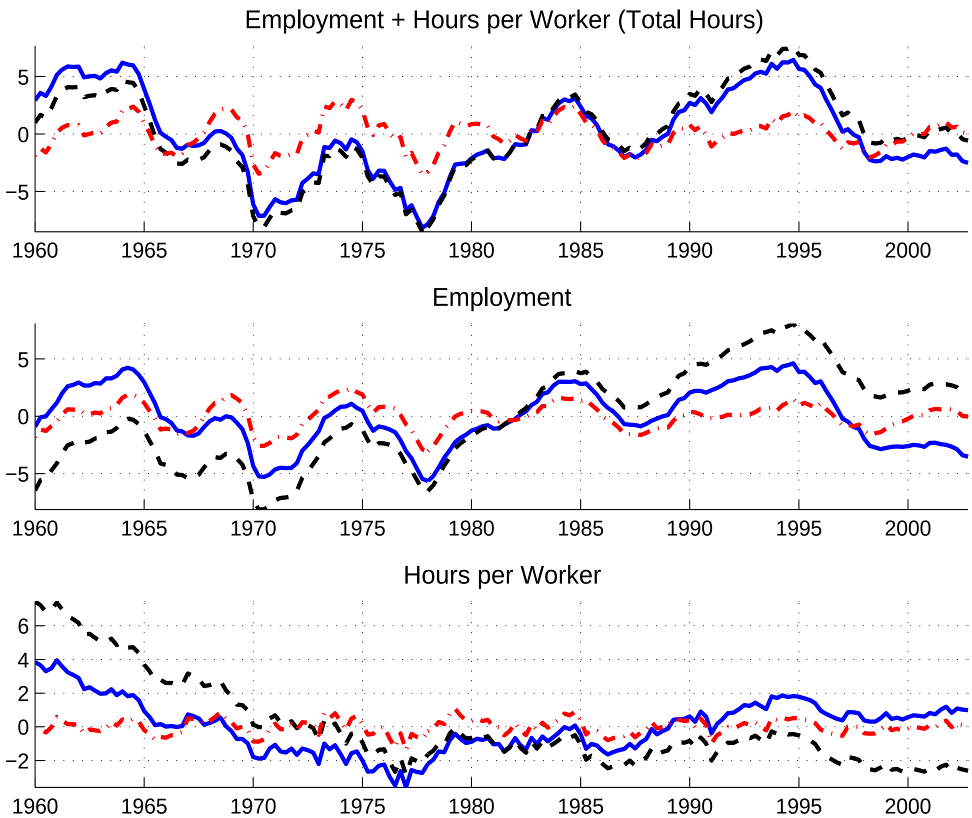

Figure A.1. CES labor market variables. Black dashed lines: demeaned data; blue solid lines: linearly detrended data; Red dotted-dashed lines: HP filtered with smoothing parameter of 1600.

TABLE A.1: Components of the Variance of Total Hours for Alternative Data Sources

	Filtering	$\left(\frac{\text{cov}(TH_t,h_t)}{\text{var}(TH_t)}\right)$	$\left(\frac{\text{cov}(TH_t,L_t)}{\text{var}(TH_t)}\right)$	$\left(\frac{\text{var}(h_t)}{\text{var}(TH_t)}\right)$	$\left(\frac{\text{var}(L_t)}{\text{var}(TH_t)}\right)$	$\left(\frac{2\text{cov}(h_t,L_t)}{\text{var}(TH_t)}\right)$
		1965:1-2007:IV				
CPS data						
	Demeaned	0.15	0.85	0.07	0.78	0.15
	Linear	0.34	0.66	0.15	0.46	0.39
	HP	0.28	0.72	0.12	0.56	0.32
SW data						
	Linear	0.48	0.52	0.39	0.44	0.17
	HP	0.28	0.72	0.14	0.57	0.29
		1965:1-2014:IV				
*CPS data**						
	Demeaned	0.17	0.83	0.09	0.74	0.17
	Linear	0.29	0.71	0.11	0.53	0.37
	HP	0.31	0.69	0.14	0.51	0.35
SW data						
	Linear	0.16	0.84	0.24	0.92	-0.16
	HP	0.27	0.73	0.13	0.58	0.29

*Data from 1965:1-2011:IV.

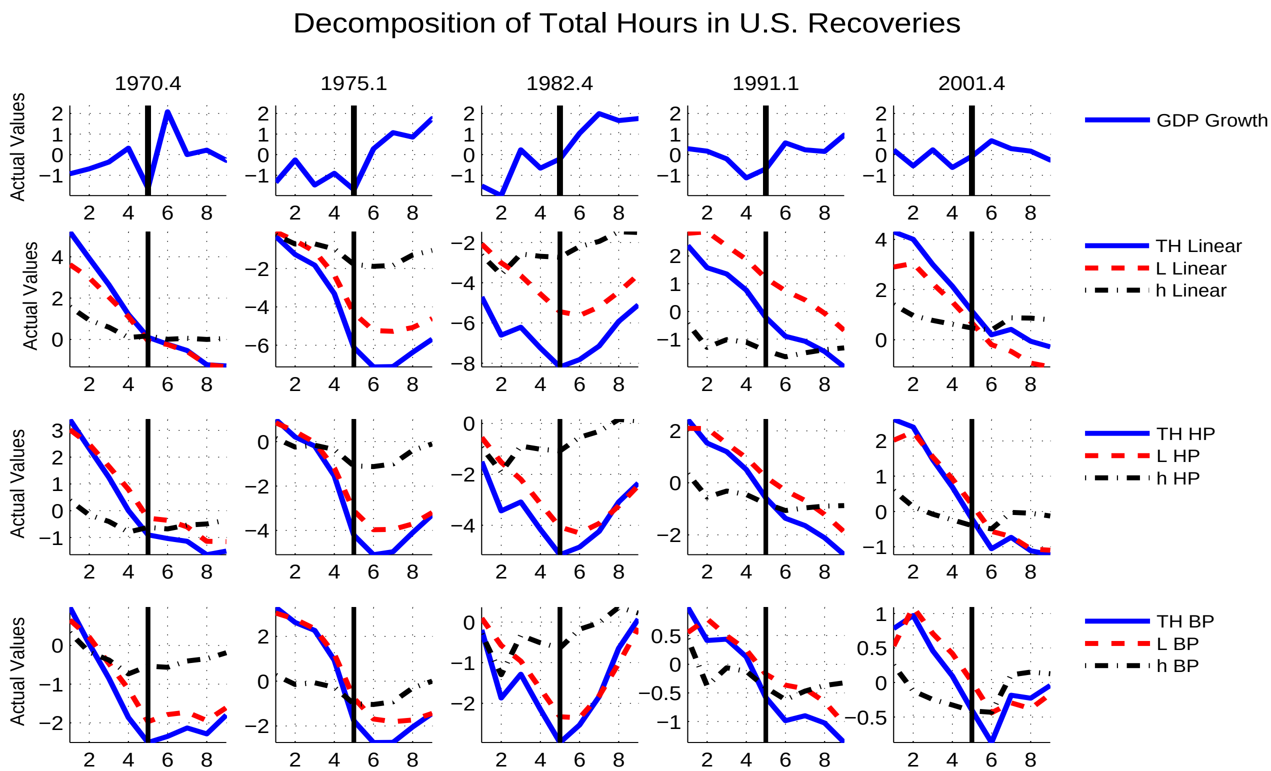

Figure A.2. CES labor market variables. Linear denotes linearly detrended data; HP denotes Hodrick-Prescott filtered series with smoothing parameter of 10^5; BP denotes series filtered with the Christiano and Fitzgerald (2003) procedure with frequency 2,32.

B Wage Bargaining

The firm and worker maximize the Nash product

$$\left(S_t^f\right)^{1-\bar{\eta}_t}\left(S_t^w\right)^{\bar{\eta}_t},$$

where, as detailed in the main text:

$$S_t^f = (1-\alpha)\,\varphi_t\left(\frac{K_t}{\bar{A}h_tL_t}\right)^{\alpha}\bar{A}_th_t - \frac{w_t^n h_t}{P_t} - \frac{\phi^w\bar{A}_t}{2}\left(\frac{w_t^n}{w_{t-1}^n}\pi_C^{\iota_w-1}\pi_{Ct-1}^{-\iota_w} - \bar{g}_A\right)^2 + E_t\beta_{t,t+1}\left(1-\lambda\right)S_{t+1}^f$$

and

$$S_t^w = \frac{w_t^n}{P_t}h_t - b\bar{A}_t - \frac{W_{Lt}}{W_{Ct}} + (1-\lambda)\,E_t\left[\beta_{t,t+1}S_{t+1}^w\left(1-\frac{M_{t+1}}{U_{t+1}}\right)\right].$$

The first-order condition with respect to w_t^n implies

$$(1-\bar{\eta}_t)\,S_t^w\frac{\partial S_t^f}{\partial w_t^n} + \bar{\eta}_tS_t^f\frac{\partial S_t^w}{\partial w_t^n} = 0, \tag{A-1}$$

where

$$\frac{\partial S_t^f}{\partial w_t^n} = -\frac{h_t}{P_t} - \phi^w\bar{A}_t\left(\frac{w_t^n}{w_{t-1}^n}\pi_C^{\iota_w-1}\pi_{Ct-1}^{-\iota_w} - \bar{g}_A\right)\frac{\pi_C^{\iota_w-1}\pi_{Ct-1}^{-\iota_w}}{w_{t-1}^n} + (1-\lambda)\,E_t\left(\beta_{t,t+1}\frac{\partial S_{t+1}^f}{\partial w_t^n}\right) \tag{A-2}$$

and

$$\frac{\partial S_t^w}{\partial w_t^n}P_t = h_t.$$

(Notice that we have used the fact that $\partial w_t^n/\partial h_t = 0$, which stems from equation (8) in the main text.) Moreover, notice that

$$\frac{\partial S_{t+1}^f}{\partial w_t^n} = \phi^w\bar{A}_{t+1}\left(\frac{w_{t+1}^n}{w_t^n}\pi_C^{\iota_w-1}\pi_{Ct}^{-\iota_w} - \bar{g}_A\right)\frac{w_{t+1}^n\pi_C^{\iota_w-1}\pi_{Ct}^{-\iota_w}}{\left(w_t^n\right)^2}. \tag{A-3}$$

By inserting (A-3) into (A-2), we finally obtain:

$$\frac{\partial S_t^f}{\partial w_t^n}P_t = -h_t - \phi^w\bar{A}_t\left(\pi_{wt}\pi_C^{\iota_w-1}\pi_{Ct-1}^{-\iota_w} - \bar{g}_A\right)\frac{\pi_C^{\iota_w-1}\pi_{Ct-1}^{-\iota_w}\pi_{Ct}}{w_{t-1}} \tag{A-4}$$

$$+\,\phi^w(1-\lambda)\,E_t\left[\beta_{t,t+1}\bar{A}_{t+1}\left(\pi_{wt+1}\pi_C^{\iota_w-1}\pi_{Ct}^{-\iota_w} - \bar{g}_A\right)\frac{\pi_{wt+1}\pi_C^{\iota_w-1}\pi_{Ct}^{-\iota_w}}{w_t}\right], \tag{A-5}$$

where $w_t \equiv w_t^n/P_t$.

Finally,let

$$\eta_{wt} = \frac{\bar{\eta}_t \frac{\partial S_t^w}{\partial w_t^n}}{\bar{\eta}_t \frac{\partial S_t^w}{\partial w_t^n} - (1 - \bar{\eta}_t) \frac{\partial S_t^f}{\partial w_t^n}}.$$

The latter means that

$$1 - \eta_{wt} = \frac{-(1 - \bar{\eta}_t) \frac{\partial S_t^f}{\partial w_t^n}}{\bar{\eta}_t \frac{\partial S_t^w}{\partial w_t^n} - (1 - \bar{\eta}_t) \frac{\partial S_t^f}{\partial w_t^n}}.$$

Using the above expression, the sharing rule in (A-1) can be written more compactly as

$$(1 - \eta_{wt}) S_t^w = \eta_{wt} S_t^f,$$

where η_{wt} measures the effective bargaining power of the worker and $1 - \eta_{wt}$ is the effective bargaining power of the firm. Notice that, using equation (A-4), the effective bargaining power of the worker can be written as

$$\eta_{wt} = \frac{\bar{\eta}_t h_t}{\bar{\eta}_t h_t - (1 - \bar{\eta}_t) \left[\begin{array}{c} -h_t - \phi^w \bar{A}_t \left(\pi_{wt} \pi_C^{\iota_w - 1} \pi_{Ct-1}^{-\iota_w} - \bar{g}_A \right) \frac{\pi_C^{\iota_w - 1} \pi_{Ct-1}^{-\iota_w} \pi_{Ct}}{w_{t-1}} \\ + \phi^w E_t \beta_{t,t+1} (1 - \lambda) \bar{A}_{t+1} \left(\pi_{wt+1} \pi_C^{\iota_w - 1} \pi_{Ct}^{-\iota_w} - \bar{g}_A \right) \frac{\pi_{wt+1} \pi_C^{\iota_w - 1} \pi_{Ct}^{-\iota_w}}{w_t} \end{array} \right]}.$$

When $\phi^w = 0$, the expression above simplifies to $\eta_{wt} = \bar{\eta}_t$.

C Balanced Growth Path and Log-linearized Model

All the non-stationary variables are normalized by the level of labor productivity, i.e., $X_t / \bar{A}_t$ (with the exception of the marginal utility of consumption, which is normalized by $u_{Ct} \bar{A}_t$). In order to economize on notation, we do not change notation for those variables. Table A.3 below describes the stationary version of the baseline model, while Table A.4 presents the stationary version of the alternative model's equations.

We log-linearize the model around the deterministic balanced growth path. Below, endogenous variables that appear without a time subscript denote constant normalized variables. Notice that, in the deterministic steady state:

$$\bar{Z} = \bar{\beta} = \bar{p}_K = \zeta_K = \pi_C = u_K = 1,$$

while $\pi_w = g_A$. The parameter δ_{K1} is calibrated so that $u_K = 1$ at steady state (that is, $rk = \delta_{K1}$). $\delta_K = \delta_{K0}$ at steady state. For future reference, we define the parameter ς such that $\delta_{K2}/\delta_{K1} = \varsigma/(1-\varsigma)$. Finally, let $\hat{x}_t \equiv dx_t/x \simeq \log(x_t) - \log(x)$. Table A.5 presents the log-linearized equations. Finally, notice that, starting from the stationary log-linear system, we recover a given non-stationary variables x_t^L by constructing $x_t^L = \left(e^{\hat{x}_t + x}\right) \bar{A}_t$. The growth rate of the non-stationary variable is then obtained as follows:

$$\Delta x_t^L \equiv \log\left(x_t^L\right) - \log\left(x_{t-1}^L\right) = \hat{x}_t - \hat{x}_{t-1} + \hat{g}_{At} + \log\left(g_A\right).$$

D Discussion of Parameter Estimates

The columns under the heading "7 obs" in Table 2 of the main text list the posterior mean and 90 percentile estimates of the baseline model estimated with seven observables, while the columns under the headings '8 obs' and 'Benchmark Model' list the estimates with eight observables. Posterior estimates for the inverse Frisch elasticity ω and value of the workers' bargaining power $\bar{\eta}$ are significantly different from those estimated with eight observables. In the seven observable case, the Frisch elasticity is estimated to be in the mid-end of microeconomic estimates, which range between 0.1 and 0.6 (see Card, 1991, for a survey). By contrast, in the eight observable scenario, the value is closer to the low-end of microeconomic estimates.[1] Concerning the worker's bargaining power, in the seven observable model, the posterior mean for $\bar{\eta}$ is 0.76, slightly above the range commonly used in calibrated models, 0.4 and 0.6.[2] Interestingly, in the eight observable specification, η's posterior mean drops to 0.56, in the ballpark of the estimates by Flinn (2006). All together, these results suggest that the inability of the model to account for the margins of labor adjustment is not intrinsically linked to specific parameterizations of these two labor market parameters.

The column "Preferred Model" under the heading "8 obs" in Table 2 of the main text lists the posterior mean and 90 percentile estimates of the preferred model. First, notice that the estimate of the Frisch elasticity in the preferred model is higher than the baseline specification. Second, the posterior mean of the hours adjustment cost, ϕ_h, implies that an increase by one percent in hours per worker relative to the steady state lowers the marginal product of hours by about 6 percent,

[1] Ceteris paribus, ω also affects the disutility of labor which, together with the replacement rate, determines the outside option of the worker. The latter evaluated at the posterior mean is 0.83 with seven observables, while it is 0.69 with eight observables. The larger outside option increases the sensitivity of the surplus and employment to aggregate shocks, other things equal.

[2] A higher workers' bargaining power also increases employment's response to innovations. Ceteris paribus, a high workers' bargaining power reduces the firm's surplus, making the latter more sensitive to shocks—a mechanism in the spirit of Hagedorn and Manovskii (2008).

other things equal. Moreover, although both ϕ_h and the (higher) values of the Frisch elasticity tend to reduce the sensitivity of hours worked to changes in the value of the marginal product of hours, the two parameters are not observationally equivalent. In particular, ϕ_h only enters the equation that determines hours, while the Frisch elasticity also affects the outside option of the worker.

The posterior mean of the replacement rate $b/(wh)$ is 0.47 in the preferred model, consistent with U.S. data (OECD, 2004). In addition, the posterior interval is tighter relative to the prior. The posterior mean of the flow value of unemployment—the sum of the unemployment benefit and the real value of leisure—relative to the steady-state wage is larger and equal to 0.75, closer to the value assumed by Hall (2008). By contrast, in the baseline model with eight observables, the replacement rate tends to be larger, with a 90 percentile interval between 0.41 and 0.69. The estimate for the bargaining power remains close to the value proposed by Flinn (2006).

The other estimated parameters are affected little across the baseline and preferred specifications with eight observables. The shock processes in the preferred model in general have lower persistence and larger standard deviations, for instance the process for the preference shock. Overall the variability of the exogenous variables is similar across specifications.

E Aggregate Shocks in the Benchmark & Preferred Models

To further examine the differences in the preferred and baseline models' transmission channels, we examine the propagation mechanism of individual shocks, focusing on the adjustment of the two labor margins. For the two model specifications, we focus on the dynamics following innovations to aggregate TFP, investment-specific productivity, preference, worker's bargaining power and to the nominal interest rate. In the preferred model, these shocks account for over 85 percent of the variance of the growth rate of output, consumption, and investment on impact and 10 periods after the shocks. For total hours, the contribution is 80 percent on impact and 60 percent after 10 periods.

Figure A.3 reports the 90 percent posterior intervals for the impulse responses of output growth, employment, and hours per worker. Solid lines denote the responses of the baseline model estimated with eight observables, while dashed lines correspond to the preferred framework. In all cases, responses are computed following a one standard deviation shock. As reported in Table 2 of the main text, the estimated persistence and standard deviations of innovations are similar across the baseline and preferred specifications, suggesting that the improved fit can be traced to an improvement in the propagation mechanism rather than to different estimates of the shock processes.

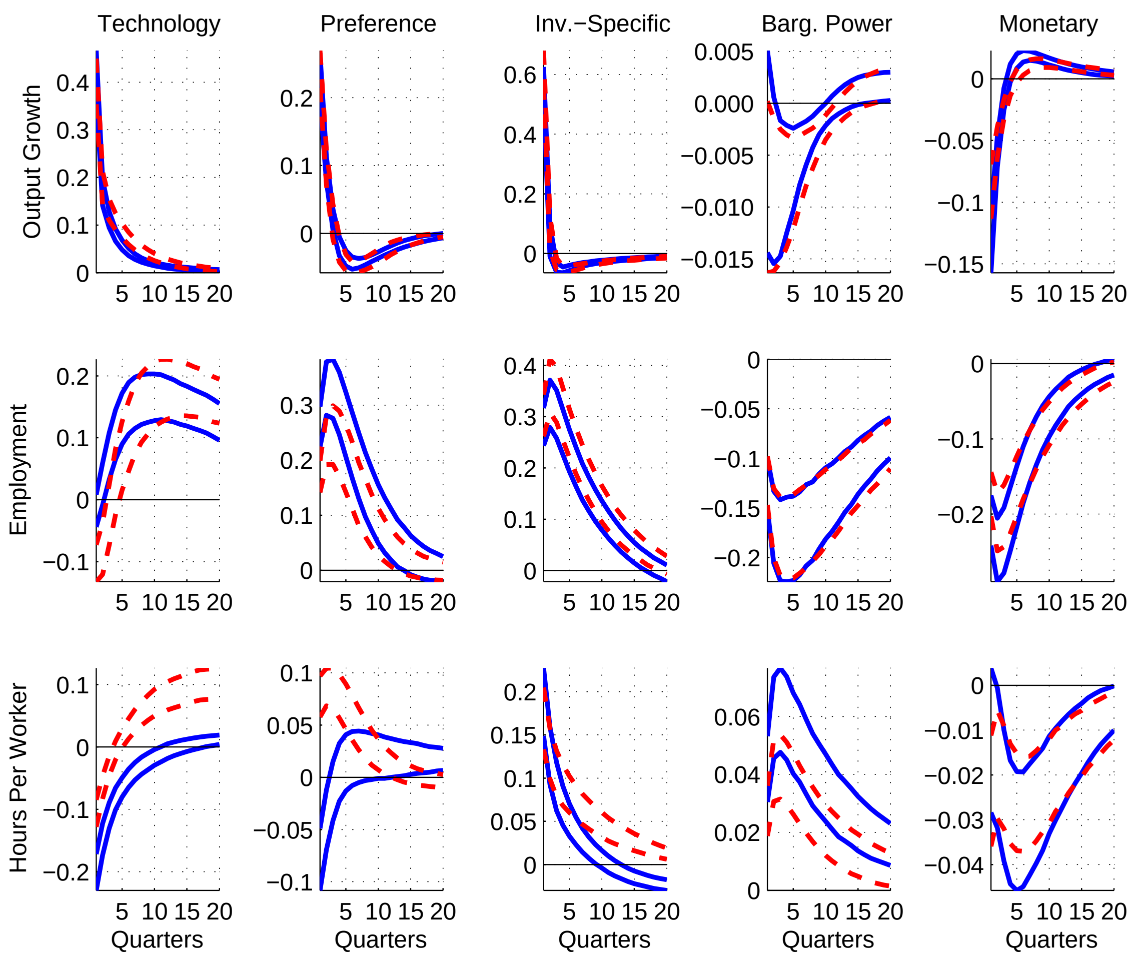

Figure 3. Impulse response following a standard deviation innovation. Bands represent 90 percent confidence intervals. Solid lines denote the responses of the benchmark model estimated with eight observables, while dashed lines correspond to the preferred framework.

The first column displays the responses following a positive shock to the growth rate of aggregate productivity. Other things equal, price stickiness induces lower labor demand, rather than lower goods prices. However, in the baseline model, the brunt of the impact adjustment of total hours is on the intensive margin, as higher productivity induces a positive wealth effect that reduces labor supply. By contrast, employment is virtually unaffected initially. The initial decline in hours per worker reduces the flow value of unemployment, leading to wage moderation. As a consequence, the surplus of hiring a worker increases, leading to higher employment after the first period. The relative contribution of the two margins is altered in our preferred model. JR preferences reduce the wealth effect on the labor supply, causing hours per worker to drop less on impact. This, in turn, reduces its effect on the firm's surplus, leading employment to decline on impact as well. Thus, reducing the wealth effect on the labor supply induces positive comovement between the intensive and the extensive margin. A similar mechanism is at work following an increase in the degree of impatience of households—the preference shock $\bar{\beta}_t$ reported in column two of figure A.3. In this case, households substitute from investment to consumption. Higher aggregate demand boosts employment in both models. However, in the preferred model, due again to the limited wealth effect, the expansionary demand shock results in an increase in hours per worker (rather than in a fall, as in the baseline model), and thus implies a positive comovement with employment. The same logic applies to the monetary shock as well (column five), with the exception that the increase in the policy rate translates into reductions in demand, as the real interest rate increases. Finally, an increase in productivity specific to the production of the investment good displays positive comovement between the labor margins in both specifications (column three of figure A.3). In this case, the wealth effect is small, independently of the particular form of preferences assumed because of the low estimated persistence of the shock. The limited persistence implies a short-lived increase in output growth with little effect on permanent income and consumption. As a result, the wealth effect is not large enough to induce a negative comovement between hours per worker and employment on impact.

An exogenous increase in the workers' bargaining power (column four of figure A.3) directly affects employment, since workers appropriate a larger share of the surplus through higher wages. Firms have fewer incentives to create jobs and total hours worked adjusts through the relatively cheaper intensive margin. The shock is recessionary as it increases the cost of production, leading output, investment and consumption to decline. The impulse responses are qualitatively similar in the baseline and preferred models, although hours per worker in the preferred model, insulated by the wealth effect, tends to respond less. The responses of macroaggregates and total hours following an increase in the disutility of hours worked $\bar{h}_t$ (not reported) are comparable to those following the bargaining power shock. In this case, the adjustment of the labor market margins are reversed, with hours per worker declining and employment rising.

F Variance Decomposition

Table A.2 reports the forecast error variance decompositions at the posterior mean estimates of the preferred model for the observables, as well as for hours per worker, unemployment, and vacancies.

Table A.2: Forecast Error Variance Decompositions at Different Horizons.

Variable	**Shock**							
	Technology	Pref	Inv Specific	Barg Power	Labor Supply	Markup	Govt Spending	Monetary
Output Growth	0.23	0.09	0.56	0.00	0.00	0.01	0.10	0.01
Cons Growth	0.13	0.81	0.02	0.00	0.00	0.00	0.02	0.02
Inv Growth	0.01	0.00	0.96	0.00	0.00	0.01	0.00	0.01
Wage Growth	0.03	0.00	0.00	0.79	0.00	0.18	0.00	0.00
Inflation	0.10	0.04	0.04	0.01	0.02	0.75	0.01	0.03
Interest Rate	0.08	0.04	0.07	0.00	0.02	0.07	0.02	0.70
Total Hours	0.09	0.14	0.47	0.02	0.08	0.04	0.08	0.08
Employment	0.05	0.15	0.42	0.07	0.07	0.05	0.06	0.13
Hours per Worker	0.08	0.04	0.19	0.00	0.63	0.00	0.04	0.00
Unemployment	0.02	0.01	0.01	0.93	0.02	0.00	0.00	0.00
Vacancies	0.05	0.15	0.42	0.07	0.07	0.05	0.06	0.13

G Historical Decompositions and The Margins of Labor Adjustment

Figure 4 plots the historical decomposition of the growth rate of employment, hours per worker, and output using the posterior mean estimates of the preferred model.

The historical decompositions display the structural innovations responsible for the time-varying comovement between hours per worker and employment in U.S. recoveries. For instance, employment and hours per worker comove positively in the recoveries of the first part of the sample. Figure 4 shows that the recoveries of 1970, 1975, and 1982 are preceded by negative investment-specific shocks, as well as negative markup shocks in 1975 and 1982 (see Appendix F for the smoothed shocks in the recessions and recoveries we analyze). During the recoveries, these shocks are dampened or reversed, which simultaneously boosts employment and hours per worker. By contrast, the

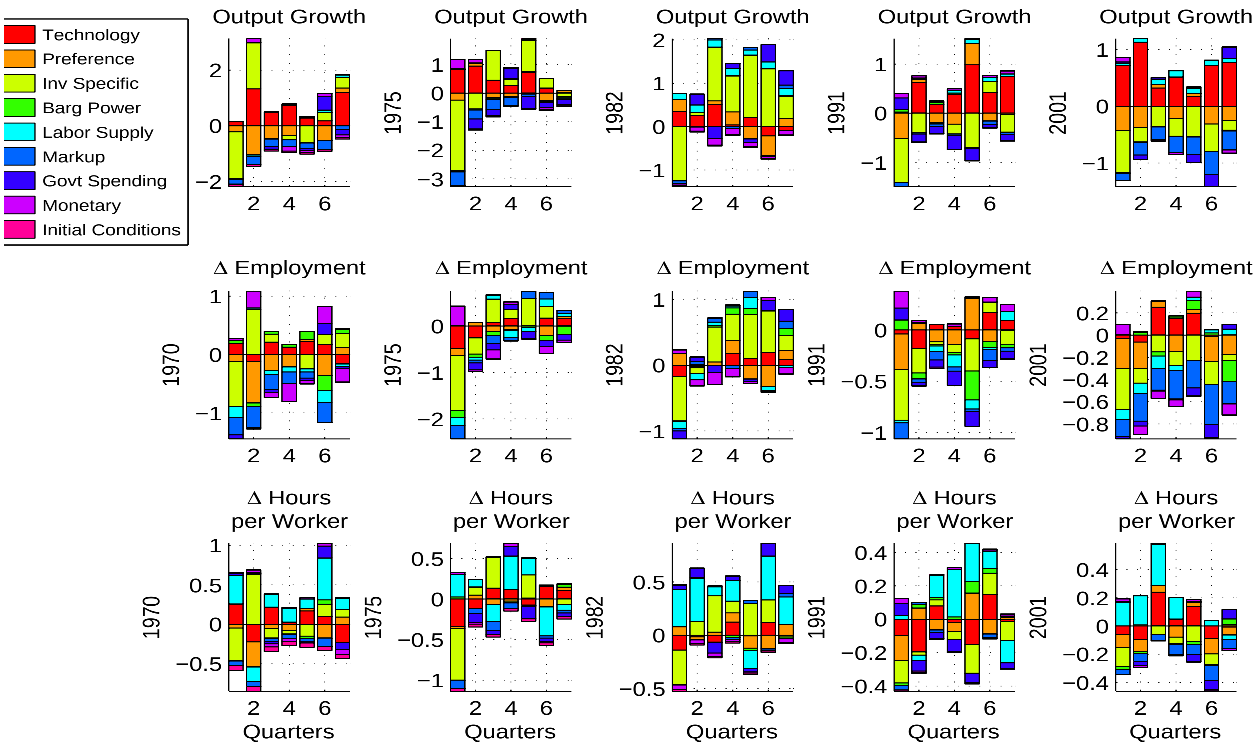

Figure 4. Historical decomposition for US business cycle recoveries.

recoveries of 1991 and 2001 feature negative comovement between employment and hours. In these episodes, the reversion of investment-specific shocks is significantly weaker. Moreover, the recoveries of 1991 and 2001 are characterized by a larger role for labor market disturbances: positive shocks to the workers' bargaining power in 1991 and lower disutility of hours in 2001. In line with the previous discussion, both labor market shocks and the reduced importance of supply shocks break the positive comovement between the margins of labor adjustment during these recoveries.

TABLE A.3: MODEL EQUATIONS, STATIONARY DEVIATIONS FROM TREND

(1)	$L_t = (1-\lambda) L_{t-1} + M_t$
(2)	$\frac{\bar{\beta}_t \bar{h}_t h_t^{\omega}}{u_{Ct}} = (1-\alpha)\varphi_t \left(\frac{u_{Kt}\tilde{K}_t}{\bar{g}_{At} L_t h_t}\right)^{\alpha}$
(3)	$\tilde{K}_{t+1} = (1-\delta_{Kt})\frac{\tilde{K}_t}{\bar{g}_{At}} + \bar{p}_t^K I_{Kt}\left[1 - \frac{\nu}{2}\left(\bar{g}_{At}\frac{I_{Kt}}{I_{Kt-1}} - g_A\right)^2\right]$
(4)	$r_{Kt} = \zeta_{Kt}[\delta_{K1} + \delta_{K2}(u_{Kt}-1)]$
(5)	$\zeta_{Kt} = \beta E_t\left\{\frac{u_{Ct+1}}{u_{Ct}}\frac{1}{\bar{g}_{At+1}}\left[r_{Kt+1}u_{Kt+1} + (1-\delta_{Kt+1})\zeta_{Kt+1}\right]\right\}$
(6)	$1 = \zeta_{Kt}\bar{p}_t^K\left[1 - \frac{\nu}{2}\left(\bar{g}_{At}\frac{I_{Kt}}{I_{Kt-1}} - g_A\right)^2 - \nu\left(\bar{g}_{At}\frac{I_{Kt}}{I_{Kt-1}} - g_A\right)\bar{g}_{At}\frac{I_{Kt}}{I_{Kt-1}}\right]$ $+\nu\beta E_t\left[\frac{u_{Ct+1}}{u_{Ct}}\bar{g}_{At+1}\bar{p}_{t+1}^K\zeta_{Kt+1}\left(\bar{g}_{At+1}\frac{I_{Kt+1}}{I_{Kt}} - g_A\right)\left(\frac{I_{Kt+1}}{I_{Kt}}\right)^2\right]$
(7)	$M_t = \bar{\chi}_t U_t^{\varepsilon} V_t^{1-\varepsilon}$
(8)	$\kappa\frac{V_t^{\tau}}{q_t} = S_t^f$
(9)	$\eta_{wt} S_t^f = (1-\eta_{wt}) S_t^w$
(10)	$\pi_{wt} = \bar{g}_{At}\frac{w_t}{w_{t-1}}\pi_{Ct}$
(11)	$1 = \beta i_t E_t\left[\frac{u_{Ct+1}}{u_{Ct}\bar{g}_{At+1}}\frac{1}{\pi_{Ct+1}}\right]$
(12)	$\frac{i_t}{i} = \left(\frac{i_{t-1}}{i}\right)^{\varrho_i}\left[\left(\frac{1+\pi_{Ct}}{1+\pi_C}\right)^{\varrho_\pi}\left(\frac{Y_{gt}}{Y_g}\right)^{\varrho_Y}\right]^{1-\varrho_i}\left(\frac{Y_{gt}}{Y_{gt-1}}\right)^{\varrho_{dY}}\bar{\imath}_{it}$
(13)	$1 = \frac{\bar{\theta}_t}{(\bar{\theta}_t - 1)\Xi_t}\varphi_t$
(14)	$\left(\frac{u_{Kt}\tilde{K}_t}{\bar{g}_{At}}\right)^{\alpha}(L_t h_t)^{1-\alpha}\left[1 - \frac{\nu}{2}\left(\pi_{Ct}\pi_C^{\iota_p - 1}\pi_{Ct-1}^{-\iota_p} - 1\right)^2\right] = C_t + I_{Kt} + \kappa_t V_t + G_t$
(15)	$r_{Kt} = \varphi_t\alpha\left(\frac{u_{Kt}\tilde{K}_t}{\bar{g}_{At}L_t h_t}\right)^{\alpha-1}$
(D.1)	$Y_t^g = \frac{C_t + I_{Kt} + G_t}{\tilde{C}_t + \tilde{I}_{Kt} + G_t}$
(D.2)	$U_t = 1 - (1-\lambda) L_{t-1}$
(D.3)	$\Xi_t \equiv 1 - \frac{\phi^p}{2}\left(\pi_{Ct}\pi_{Ct-1}^{-\iota_p}\pi_C^{\iota_p-1} - 1\right)^2 + \frac{\phi^p}{\bar{\theta}_t - 1}\left\{\begin{array}{c} \pi_C^{\iota_p-1}\left(\pi_{Ct}\pi_{Ct-1}^{-\iota_p}\pi_C^{\iota_p-1} - 1\right)\pi_t(\omega)\pi_{Ct-1}^{-\iota_p} \\ -E_t\left[\beta\frac{u_{Ct+1}}{u_{Ct}}\left(\pi_{Ct+1}\pi_{Ct}^{-\iota_p}\pi_C^{\iota_p-1} - 1\right)\pi_{Ct+1}\pi_{Ct}^{-\iota_p}\frac{Y_{t+1}^C}{Y_t^C}\right]\end{array}\right\}$
(D.4)	$S_t^f = (1-\alpha)\varphi_t\left(\frac{u_{Kt}\tilde{K}_t}{\bar{g}_{At}L_t h_t}\right)^{\alpha} h_t - w_t h_t - \frac{\phi^w}{2}\left(\pi_{wt}\pi_C^{\iota_w-1}\pi_{Ct-1}^{-\iota_w} - \bar{g}_A\right)^2 + (1-\lambda)\beta E_t\left(\frac{u_{Ct+1}}{u_{Ct}}S_{t+1}^f\right)$
(D.5)	$S_t^w = w_t h_t - b - \frac{\bar{\beta}_t\bar{h}_t h_t^{1+\omega}}{(1+\omega)u_{Ct}} + (1-\lambda)\beta E_t\left[\frac{u_{Ct+1}}{u_{Ct}}S_{t+1}^w\left(1 - \frac{M_{t+1}}{U_{t+1}}\right)\right]$
(D.6)	$u_{Ct} = \bar{\beta}_t\frac{1}{\left(C_t - h_C\frac{C_{t-1}}{\bar{g}_{At}}\right)} - h_C\beta E_t\left[\bar{\beta}_{t+1}\frac{1}{(C_{t+1}\bar{g}_{At+1} - h_C C_t)}\right]$
(D.7)	$q_t = \frac{M_t}{V_t}$
(D.8)	$\delta_{Kt} \equiv \delta_{K0} + \delta_{K1}(u_{Kt}-1) + (\delta_{K2}/2)(u_{Kt}-1)^2$
(D.9)	$\kappa_t = \kappa V_t^{\tau}/(1+\tau)$
(D.10)	$\eta_{wt} = \frac{\bar{\eta}_t h_t}{\bar{\eta}_t h_t + (\bar{\eta}_t - 1)\left[\begin{array}{c} -h_t - \phi^w\bar{g}_{At}\left(\pi_{wt}\pi_C^{\iota_w-1}\pi_{Ct-1}^{-\iota_w} - \bar{g}_A\right)\frac{\pi_C^{\iota_w-1}\pi_{Ct-1}^{-\iota_w}\pi_{Ct}}{w_{t-1}} \\ +\phi^w(1-\lambda)\beta E_t\left[\frac{u_{Ct+1}}{u_{Ct}}\left(\pi_{wt+1}\pi_C^{\iota_w-1}\pi_{Ct}^{-\iota_w} - \bar{g}_A\right)\frac{\pi_{wt+1}\pi_C^{\iota_w-1}\pi_{Ct}^{-\iota_w}}{w_t}\right]\end{array}\right]}$

Note: $\tilde{C}_t$and $\tilde{I}_{Kt}$ in equation (D.1) are consumption and investment observed when $\phi^w = \phi^p = \varepsilon_{\bar{\eta}t} = \varepsilon_{\bar{\theta}t} = 0$. Variable without a time subscript denotes steady-state values.

TABLE A.4: ALTERNATIVE MODEL, STATIONARY DEVIATIONS FROM TREND, NEW EQUATIONS

(2')	$\frac{\Psi_t^{-1}\bar{\beta}_t\bar{h}_t h_t^{\omega} X_t}{u_{Ct}} = (1-\alpha)\,\varphi_t\left(\frac{K_t}{\bar{g}_{At}\tilde{h}_t L_t}\right)^{\alpha}\Delta_{\tilde{h}t}.$
(14')	$\left(\frac{u_{Kt}\tilde{K}_t}{\bar{g}_{At}}\right)^{\alpha}\left(L_t\tilde{h}_t\right)^{1-\alpha}\left[1-\frac{\nu}{2}\left(\pi_{Ct}\pi_C^{\iota_p-1}\pi_{Ct-1}^{-\iota_p}-1\right)^2\right] = C_t + I_{Kt} + \kappa_t V_t + G_t$
(15')	$r_{Kt} = \varphi_t\alpha\left(\frac{u_{Kt}\tilde{K}_t}{\bar{g}_{At}L_t\tilde{h}_t}\right)^{\alpha-1}$
(D.4')	$S_t^f = (1-\alpha)\,\varphi_t\left(\frac{u_{Kt}\tilde{K}_t}{\bar{g}_{At}\tilde{h}_t L_t}\right)^{\alpha}\tilde{h}_t - w_t h_t - \frac{\phi^w}{2}\left(\pi_{wt}\pi_C^{1-\iota_w}\pi_{Ct-1}^{-\iota_w}-g_A\right)^2 + (1-\lambda)\,\beta E_t\left(\frac{u_{Ct+1}}{u_{Ct}}S_{t+1}^f\right)$
(D.5')	$S_t^w = w_t h_t - b - \frac{\Psi_t^{-1}\bar{\beta}_t\bar{h}_t h_t^{1+\omega}X_t}{(1+\omega)u_{Ct}} + (1-\lambda)\,\beta E_t\left[\frac{u_{Ct+1}}{u_{Ct}}S_{t+1}^w\left(1-\frac{M_{t+1}}{U_{t+1}}\right)\right]$
(D.6')	$u_{Ct} = \left[\begin{array}{c}\bar{\beta}_t\Psi_t^{-1} + \gamma\mu_t\left(C_t - h_C\frac{C_{t-1}}{\bar{g}_{At}}\right)^{\gamma-1}X_{t-1}^{1-\gamma}\bar{g}_{At}^{\gamma-1} - \beta h_C E_t\left[\bar{\beta}_{t+1}\left(\Psi_{t+1}\bar{g}_{At+1}\right)^{-1}\right] \\ -\gamma\beta h_C E_t\left[\frac{\mu_{t+1}}{\bar{g}_{At+1}}\left(C_{t+1}\bar{g}_{At+1} - h_C C_t\right)^{\gamma-1}X_t^{1-\gamma}\right]\end{array}\right]$
(D.11)	$\mu_t = -\bar{\beta}_t\Psi_t^{-1}L_t\bar{h}_t\frac{h_t^{1+\omega}}{1+\omega} + (1-\gamma)\beta E_t\left\{\frac{\mu_{t+1}}{\bar{g}_{At+1}}\left(C_{t+1}\bar{g}_{At+1} - h_C C_t\right)^{\gamma}\tilde{X}_t^{-\gamma}\right\}$
(D.12)	$\Psi_t = C_t - h_C\frac{C_{t-1}}{\bar{g}_{At}} - \frac{\bar{h}_t L_t h_t^{1+\omega}X_t}{1+\omega}$
(D.13)	$X_t = \left(C_t - h_C\frac{C_{t-1}}{\bar{g}_{At}}\right)^{\gamma}\left(\frac{X_{t-1}}{\bar{g}_{At}}\right)^{1-\gamma}$
(D.14)	$\tilde{h}_t = h_t\left[1-\frac{\phi_h}{2}\left(h_t - h\right)^2\right]$
(D.15)	$\Delta_{\tilde{h}t} = \frac{\tilde{h}_t}{h_t} - \phi_h h_t\left(h_t - h\right)$

Note: Other equations are unchanged relative to Table A.3.

TABLE A.5: LOG-LINEARIZED MODEL EQUATIONS

(1)	$L\hat{L}_t = L(1-\lambda)\hat{L}_{t-1} + M\hat{M}_t$
(2)	$\hat{\bar{\beta}}_t + \hat{\bar{h}}_t + \omega\hat{h}_t - \hat{u}_{Ct} = \hat{\varphi}_t + \alpha\left(\hat{u}_{Kt} + \hat{\tilde{K}}_t - \hat{g}_{At} - \hat{L}_t - \hat{h}_t\right)$
(3)	$\hat{\tilde{K}}_{t+1} = (\frac{1-\delta_{K0}}{g_A})(\hat{\tilde{K}}_t - \hat{g}_{At}) - (\frac{\delta_{K0}}{g_A})\hat{\delta}_{Kt} + \left(1 - \frac{1-\delta_{K0}}{g_A}\right)[\hat{\bar{P}}_t^K + \hat{I}_{Kt}]$
(4)	$\hat{r}_{Kt} = \hat{\zeta}_{Kt} + \frac{\varsigma}{1-\varsigma}\hat{u}_{Kt}$
(5)	$\hat{\zeta}_{Kt} = E_t\hat{u}_{Ct+1} - \hat{u}_{Ct} - E_t\hat{g}_{At+1} + \frac{\beta}{g_A}r_K\left(E_t\hat{r}_{Kt+1} + E_t\hat{u}_{Kt+1}\right) + \frac{\beta}{g_A}(1-\delta_{K0})E_t\hat{\zeta}_{Kt+1} - \frac{\beta}{g_A}\delta_{K1}E_t\hat{u}_{Kt+1}$
(6)	$(1+\beta)\hat{I}_{kt} - \frac{1}{g_A^2\nu}\left(\hat{\zeta}_{Kt} + \hat{\bar{p}}_t^K\right) - \beta E_t\hat{I}_{Kt+1} + \hat{g}_{At} - \beta E_t\hat{g}_{At+1} = \hat{I}_{Kt-1}$
(7)	$\hat{M}_t = \hat{\bar{\chi}}_t + \varepsilon\hat{U}_t + (1-\varepsilon)\hat{V}_t$
(8)	$\tau\hat{V}_t - \hat{q}_t = \hat{S}_t^f$
(9)	$\hat{\eta}_{wt} + \hat{S}_t^f = -\frac{\eta_w}{1-\eta_w}\hat{\eta}_{wt} + \hat{S}_t^w$
(10)	$\hat{\pi}_{wt} = \hat{g}_{At} + \hat{w}_t - \hat{w}_{t-1} + \hat{\pi}_{Ct}$
(11)	$\hat{\imath}_t + E_t\hat{u}_{Ct+1} - \hat{u}_{Ct} - E_t\hat{g}_{At+1} - E_t\hat{\pi}_{Ct+1} = 0$
(12)	$\hat{\imath}_t = \varrho_i\hat{\imath}_{t-1} + (1-\varrho_i)\varrho_\pi\hat{\pi}_{Ct} + (1-\varrho_i)\varrho_Y\hat{Y}_{gt} + \varrho_{dY}\left(\hat{Y}_{gt} - \hat{Y}_{gt-1}\right) + \hat{\bar{\imath}}_t$
(13)	$0 = -\frac{1}{\theta-1}\hat{\bar{\theta}}_t - \hat{\Xi}_t + \hat{\varphi}_t$
(14)	$\alpha(\hat{u}_{Kt} + \hat{\tilde{K}}_{t-1} - \hat{g}_{At}) + (1-\alpha)(\hat{L}_t + \hat{h}_t) = \frac{C}{Y}\hat{C}_t + \frac{I_K}{Y}\hat{I}_{Kt} + \frac{\kappa V^{1+\tau}}{Y(1+\tau)}\left(\hat{\kappa}_t + \hat{V}_t\right) + \frac{\bar{G}}{Y}\hat{\bar{G}}_t$
(15)	$\hat{r}_{Kt} = \hat{\varphi}_t + (\alpha-1)\left(\hat{u}_{Kt} + \hat{\tilde{K}}_t - \hat{g}_{At} - \hat{L}_t - \hat{h}_t\right)$
(D.1)	$\hat{Y}_{gt} = C\left(\hat{C}_t - \hat{\tilde{C}}_t\right) + I_K\left(\hat{I}_{Kt} - \hat{\tilde{I}}_{Kt}\right) + G\hat{G}_t$
(D.2)	$U\hat{U}_t = -(1-\lambda)L\hat{L}_{t-1}$
(D.3)	$\hat{\Xi}_t = -\frac{1}{\theta-1}\left[\phi^p\left(\hat{\pi}_{pt} - \iota_p\hat{\bar{\pi}}_{pt-1}\right) - \phi^p\beta\left(E_t\hat{\pi}_{pt+1} - \iota_p\hat{\bar{\pi}}_{pt}\right)\right]$
(D.4)	$S_t^f\hat{S}_t^f = \left[\begin{array}{l}(1-\alpha)\varphi\left(\frac{u_K\tilde{K}}{\bar{g}_A Lh}\right)^\alpha h\left[\alpha\left(\hat{u}_{Kt} + \hat{\tilde{K}}_t - \hat{g}_{At} - \hat{L}_t\right) + (1-\alpha)\hat{h}_t\right] \\ -wh(\hat{w}_t + \hat{h}_t) + \beta(1-\lambda)S^f\left[E_t\hat{u}_{Ct+1} - \hat{u}_{Ct} + E_t\hat{S}_{t+1}^f\right]\end{array}\right]$
(D.5)	$S^w\hat{S}_t^w = \left[\begin{array}{l}wh(\hat{w}_t + \hat{h}_t) - \frac{\bar{h}h^{1+\omega}}{(1+\omega)u_C}[\hat{\bar{h}}_t + \hat{\bar{\beta}}_t + (1+\omega)\hat{h}_t - \hat{u}_{Ct}] \\ +(1-\lambda)\beta S^w\left(1-\frac{M}{U}\right)(E_t\hat{u}_{Ct+1} - \hat{u}_{Ct} + E_t\hat{S}_{t+1}^w) - (1-\lambda)\beta S^w\frac{M}{U}(E_t\hat{M}_{t+1} - E_t\hat{U}_{t+1})\end{array}\right]$
(D.6)	$\hat{u}_{Ct} = \left[\begin{array}{l}\frac{g_A\beta h_C}{(g_A-\beta h_C)(g_A-h_C)}E_t\hat{C}_{t+1} - \frac{g_A^2+\beta h_C^2}{(g_A-\beta h_C)(g_A-h_C)}\hat{C}_t \\ +\frac{g_A h_C}{(g_A-\beta h_C)(g_A-h_C)}\hat{C}_{t-1} + \frac{g_A\beta h_C\rho_{g_A} - h_C g_A}{(g_A-\beta h_C)(g_A-h_C)}\hat{g}_{At} + \frac{g_A-\beta h_C\rho_b}{g_A-\beta h_C}\hat{\bar{\beta}}_t\end{array}\right]$
(D.7)	$\hat{q}_t = \hat{M}_t - \hat{V}_t$
(D.8)	$\hat{\delta}_{Kt} \equiv \frac{\delta_{K1}}{\delta_{K0}}\hat{u}_{Kt}$
(D.9)	$\hat{\kappa}_t = \tau\hat{V}_t$
(D.10)	$\hat{\eta}_{wt} = \hat{\bar{\eta}}_t + \hat{h}_t - \frac{1}{h}\left\{\hat{\bar{\eta}}_t h\bar{\eta} + \hat{h}_t h\bar{\eta} + (1-\bar{\eta})\left[\begin{array}{c}-h\hat{h}_t - \phi^w g_A\frac{\pi_C}{w}(\hat{\pi}_{wt} - \iota_w\tilde{\pi}_{wt}) \\ +\phi^w(1-\lambda)\beta E_t\left(\frac{\pi_w\pi_C^{-1}}{w}(\hat{\pi}_{wt+1} - \iota_w\tilde{\pi}_{wt+1})\right)\end{array}\right]\right\}$

Note: $\tilde{C}_t$and $\tilde{I}_{Kt}$ in equation (D.1) are consumption and investment observed when $\phi^w = \phi^p = \varepsilon_{\bar{\eta}t} = \varepsilon_{\bar{\theta}t} = 0$. Variables without a time subscript denote steady-state values; $\varsigma/(1-\varsigma) = \delta_{K2}/\delta_{K1}$.

TABLE A.6: ALTERNATIVE MODEL, LOG-LINEARIZED EQUATIONS

(2')	$\widehat{\bar{\beta}}_t + \omega \widehat{\bar{h}}_{xt} - \hat{\Psi}_t + \hat{h}_t + \hat{X}_t - \hat{u}_{Ct} = \hat{\varphi}_t + \alpha \left(\hat{u}_{Kt} + \hat{\tilde{K}}_t - \hat{g}_{At} - \hat{L}_t - \hat{\tilde{h}}_t \right) + \hat{\Delta}_{\tilde{h}t}$
(14')	$\alpha(\hat{u}_{Kt} + \hat{\tilde{K}}_{t-1} - \hat{g}_{At}) + (1-\alpha)(\hat{L}_t + \hat{\tilde{h}}_t) = \frac{C}{Y}\hat{C}_t + \frac{I_K}{Y}\hat{I}_{Kt} + \frac{\kappa V^{1+\tau}}{Y(1+\tau)} \left(\hat{\kappa}_t + \hat{V}_t \right) + \frac{\bar{G}}{Y}\hat{\bar{G}}_t$
(15')	$\hat{r}_{Kt} = \hat{\varphi}_t + (\alpha - 1) \left(\hat{u}_{Kt} + \hat{\tilde{K}}_t - \hat{g}_{At} - \hat{L}_t - \hat{\tilde{h}}_t \right)$
(D.4')	$S_t^f \hat{S}_t^f = \left[\begin{array}{l} (1-\alpha)\varphi \left(\frac{u_K \tilde{K}}{\bar{g}_A L h} \right)^{\alpha} h \left[\alpha \left(\hat{u}_{Kt} + \hat{\tilde{K}}_t - \hat{g}_{At} - \hat{L}_t \right) + (1-\alpha) \hat{\tilde{h}}_t \right] \\ -wh(\hat{w}_t + \hat{h}_t) + \beta(1-\lambda) S^f \left[E_t \hat{u}_{Ct+1} - \hat{u}_{Ct} + E_t \hat{S}_{t+1}^f \right] \end{array} \right]$
(D.5')	$S^w \hat{S}_t^w = \left[\begin{array}{l} wh(\hat{w}_t + \hat{\tilde{h}}_t) - \frac{\Psi^{-1}\bar{\beta}\bar{h}h^{1+\omega}X}{(1+\omega)u_C} [\widehat{\bar{\beta}}_t - \hat{\Psi}_t + \widehat{\bar{h}}_t + (1+\omega)\hat{h}_t + \hat{X}_t - \hat{u}_{Ct}] \\ +(1-\lambda)\beta S^w \left(1 - \frac{M}{U}\right) (E_t \hat{u}_{Ct+1} - \hat{u}_{Ct} + E_t \hat{S}_{t+1}^w) - (1-\lambda)\beta S^w \frac{M}{U} (E_t \hat{M}_{t+1} - E_t \hat{U}_{t+1}) \end{array} \right]$
(D.6')	$\hat{u}_{Ct} u_C = \left[\begin{array}{c} \Psi^{-1} \left(\widehat{\bar{\beta}}_t - \tilde{\Psi}_t \right) + \gamma\mu \left[C \left(1 - \frac{h_C}{g_A} \right) \right]^{\gamma-1} X^{1-\gamma} g_A^{\gamma-1} \left[\hat{\mu}_t + (1-\gamma)\hat{X}_{t-1} + (\gamma-1)\hat{g}_{At} \right] \\ +\gamma(\gamma-1)\mu X^{1-\gamma} g_A^{\gamma-1} \left[C \left(1 - \frac{h_C}{g_A} \right) \right]^{\gamma-2} \left[\hat{C}_t C - h_C \frac{C}{g_A} \left(\hat{C}_{t-1} - \hat{g}_{At} \right) \right] \\ -\beta h_C (\Psi g_A)^{-\sigma} E_t \left[\widehat{\bar{\beta}}_{t+1} - \left(\hat{\Psi}_{t+1} + \hat{g}_{At+1} \right) \right] \\ -\gamma\beta h_C \mu g_A^{-1} \left[C(g_A - h_C) \right]^{\gamma-1} X^{1-\gamma} \left(E_t \hat{\mu}_{t+1} - E_t g_{At+1} + (1-\gamma)\hat{X}_t \right) \\ -(\gamma-1)\gamma\beta h_C \tilde{\mu} g_A^{-1} \left[C(g_A - h_C) \right]^{\gamma-2} X^{1-\gamma} \left(E_t \hat{C}_{t+1} C g_A + E_t \hat{g}_{At+1} C g_A - h_C \hat{C}_t C \right) \end{array} \right]$
(D.11)	$\hat{\mu}_t \mu = \left[\begin{array}{c} -\Psi^{-1} L \frac{h^{1+\omega}}{1+\omega} \left(\widehat{\bar{\beta}}_t - \hat{\Psi}_t + L_t + \widehat{\bar{h}}_t + (1+\omega)\hat{h}_t \right) \\ +(1-\gamma)\beta\mu g_A^{-1} \left[C(g_A - h_C) \right]^{\gamma} X^{-\gamma} \left[\hat{\mu}_{t+1} - \hat{g}_{At+1} - \gamma \hat{X}_t \right] \\ +\gamma(1-\gamma)\beta\mu g_A^{-1} \left[C(g_A - h_C) \right]^{\gamma-1} X^{-\gamma} \left(E_t \hat{C}_{t+1} C g_A + E_t g_{At+1} C g_A - h_C \hat{C}_t C \right) \end{array} \right]$
(D.12)	$\hat{\Psi}_t \Psi = \hat{C}_t C - h_C \frac{C}{g_A} \left(\hat{C}_{t-1} - \hat{g}_{At} \right) - L \frac{h^{1+\omega}}{1+\omega} X \left(\widehat{\bar{h}}_t + \hat{L}_t + (1+\omega)\hat{h}_t + \hat{X}_t \right)$
(D.13)	$\hat{X}_t X = \left[\begin{array}{c} \gamma \left[C \left(1 - \frac{h_C}{g_A} \right) \right]^{\gamma-1} \left(\frac{X}{g_A} \right)^{1-\gamma} \left[\hat{C}_t C - h_C \frac{C}{g_A} \left(\hat{C}_{t-1} - \hat{g}_{At} \right) \right] \\ +(1-\gamma) \left[C \left(1 - \frac{h_C}{g_{At}} \right) \right]^{\gamma} \left(\frac{X}{g_A} \right)^{1-\gamma} \left(\hat{X}_{t-1} - \hat{g}_{At} \right) \end{array} \right]$
(D.14)	$\tilde{h}_t = \hat{h}_t$
(D.15)	$\Delta_{\tilde{h}} \hat{\Delta}_{\tilde{h}t} = \left(\hat{\tilde{h}}_t - \hat{h}_t \right) - \phi_h h^2 \hat{h}_t$

Note: Other equations are unchanged relative to Table A.5.

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