# Online appendix to
# International Recessions

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# A Model with capital accumulation and labor utilization

In normalized form, the optimization problem solved by an individual firm is

$$\tilde{V}(\tilde{\mathbf{s}}_t;\tilde{k}_t,\tilde{b}_t) \quad = \quad \max_{\tilde{d}_t,\tilde{h}_t,\tilde{i}_t,\tilde{b}_{t+1}} \left\{ \tilde{d}_t + g_t^{1-\sigma}\mathbb{E}\tilde{m}_{t+1}\tilde{V}(\tilde{\mathbf{s}}_{t+1};\tilde{k}_{t+1},\tilde{b}_{t+1}) \right\}$$

subject to

$$\tilde{b}_t + \tilde{d}_t + \tilde{i}_t = z_t\tilde{k}_t^{\theta}l_t^{\nu} - \tilde{w}_t(h_t+e_t) - \kappa(h_t-\bar{h})^2\tilde{w}_t + \frac{g_t\tilde{b}_{t+1}}{R_t},$$

$$g_t\tilde{k}_{t+1} = (1-\tau)\tilde{k}_t + \Upsilon\left(\frac{\tilde{i}_t}{\tilde{k}_t}\right)\tilde{k}_t,$$

$$\xi_t g_t\tilde{k}_{t+1} \geq z_t\tilde{k}_t^{\theta}l_t^{\nu} + \frac{g_t\tilde{b}_{t+1}}{R_t}.$$

This corresponds to problem (22) in the paper. Differentiating with respect to $h_t$, $e_t$, $\tilde{b}_{t+1}$, $\tilde{i}_t$ and $\tilde{k}_{t+1}$, we obtain

$$\nu z_t\tilde{k}_t^{\theta}l_t^{\nu-1}A_h(h_t,e_t) = \frac{\tilde{w}_t}{1-\mu_t}\Big[1+2\kappa(h_t-\bar{h})\Big],$$

$$\nu z_t\tilde{k}_t^{\theta}l_t^{\nu-1}A_e(h_t,e_t) = \frac{\tilde{w}_t}{1-\mu_t},$$

$$\frac{1-\mu_t}{R_t} + g_t^{-\sigma}\mathbb{E}_t\tilde{m}_{t+1}\tilde{V}_b(\tilde{\mathbf{s}}_{t+1};\tilde{k}_{t+1},\tilde{b}_{t+1}) = 0,$$

$$Q_t\Upsilon'\left(\frac{\tilde{i}_t}{\tilde{k}_t}\right) = 1,$$

$$Q_t = \xi_t\mu_t + g_t^{-\sigma}\mathbb{E}_t\tilde{m}_{t+1}\tilde{V}_k(\tilde{\mathbf{s}}_{t+1};\tilde{k}_{t+1},\tilde{b}_{t+1}),$$

where $\mu_t$ is the Lagrange multiplier associated with the enforcement constraint and $Q_t$ is the lagrange multiplier associated with the law of motion for capital (Tobin's $q$). The multiplier associated with the budget constraint is 1. The envelope conditions are

$$\tilde{V}_b(\tilde{\mathbf{s}}_t;\tilde{k}_t,\tilde{b}_t) = -1,$$

$$\tilde{V}_k = (1-\mu_t)\theta z_t\tilde{k}_t^{\theta-1}l_t^{\nu} + \left[1-\tau+\Upsilon\left(\frac{\tilde{i}_t}{\tilde{k}_t}\right) - \Upsilon'\left(\frac{\tilde{i}_t}{\tilde{k}_t}\right)\frac{\tilde{i}_t}{\tilde{k}_t}\right]Q_t.$$

Substituting and imposing the equilibrium conditions $k_t = K_t$, $\tilde{k}_t = \tilde{K}_t$, $h_t = H_t$, $l_t = L_t$,

$i_t = I_t$, we obtain

$$\nu z_t \tilde{K}_t^{\theta} L_t^{\nu-1} A_h(h_t, e_t) = \frac{\tilde{w}_t}{1-\mu_t}\Big[1 + 2\kappa(h_t - \bar{h})\Big],$$
$$\nu z_t \tilde{K}_t^{\theta} L_t^{\nu-1} A_e(h_t, e_t) = \frac{\tilde{w}_t}{1-\mu_t},$$
$$g_t^{-\sigma} R_t \mathbb{E}_t \tilde{m}_{t+1} = 1 - \mu_t,$$
$$Q_t \Upsilon'\left(\tilde{I}_t\right) = 1,$$
$$Q_t = \xi_t \mu_t + \bar{g}_t^{-\sigma} \mathbb{E}_t \tilde{m}_{t+1} \Big\{ (1-\mu_{t+1})\theta z_{t+1} \tilde{K}_{t+1}^{\theta-1} L_{t+1}^{\nu} - \tilde{I}_{t+1} + \Big[1 - \tau + \Upsilon\left(\tilde{I}_{t+1}\right)\Big] Q_{t+1} \Big\}.$$

For the foreign country we have the same conditions with asterisk on country-specific variables.

**Dynamic system and numerical solution procedure** The aggregate states are given by $\tilde{\mathbf{s}}_t = (\tilde{W}_t, \tilde{K}_t)$. The variable $\tilde{W}_t$ is the normalized worldwide wealth of workers and $\tilde{K}_t = K_t/\bar{K}_t$ is the normalized per-worker capital of domestic firms. The equilibrium conditions are

$$1 = \delta g_t^{-1} R_t \mathbb{E}_t \left( \frac{\tilde{C}_{t+1} + \tilde{C}_{t+1}^*}{\tilde{C}_t + \tilde{C}_t^*} \right)^{-1} \tag{1}$$

$$\tilde{C}_t^* = \chi \tilde{C}_t \tag{2}$$

$$\tilde{w}_t \Big[ H_t + \mathbb{E}_t + \kappa(H_t - \bar{h})^2 \Big] + \tilde{w}_t^* \Big[ H_t^* + E_t^* + \kappa(H_t^* - \bar{h})^2 \Big] + \tilde{W}_t = \tilde{C}_t + \tilde{C}_t^* + \frac{g_t \tilde{W}_{t+1}}{R_t} \tag{3}$$

$$\tilde{W}_t + \tilde{D}_t + \tilde{D}_t^* + \tilde{I}_t + \tilde{I}_t^* = z_t \tilde{K}_t^{\theta} L_t^{\nu} + z_t^* (\tilde{K}_t^*)^{\theta} (L_t^*)^{\nu} - \tilde{w}_t(H_t + E_t) - \tilde{w}_t^*(H_t^* + E_t^*) + \frac{\bar{g}_t \tilde{W}_{t+1}}{R_t} \tag{4}$$

$$g_t(\xi_t \tilde{K}_{t+1} + \xi_t^* \tilde{K}_{t+1}^*) \geq \frac{g_t \tilde{W}_{t+1}}{R_t} + z_t \tilde{K}_t^{\theta} L_t^{\nu} + z_t^* (\tilde{K}_t^*)^{\theta} (L_t^*)^{\nu}, \qquad (= \text{if } \mu_t > 0) \tag{5}$$

$$1 - \mu_t = g_t^{-\sigma} R_t \mathbb{E}_t \tilde{m}_{t+1} \tag{6}$$

$$\alpha (H_t + E_t)^{\frac{1}{\eta}} = \frac{\tilde{w}_t}{\tilde{C}_t} \tag{7}$$

$$\alpha (H_t^* + E_t^*)^{\frac{1}{\eta}} = \frac{\tilde{w}_t^*}{\tilde{C}_t^*} \tag{8}$$

$$g_t \tilde{K}_{t+1} = (1-\tau)\tilde{K}_t + \Upsilon\left(\frac{\tilde{I}_t}{\tilde{K}_t}\right) \tilde{K}_t \tag{9}$$

$$g_t \tilde{K}_{t+1}^* = (1-\tau)\tilde{K}_t^* + \Upsilon\left(\frac{\tilde{I}_t^*}{\tilde{K}_t^*}\right) \tilde{K}_t^* \tag{10}$$

$$\nu z_t \tilde{K}_t^{\theta} L_t^{\nu-1} A_h(H_t, E_t) = \frac{\tilde{w}_t}{1-\mu_t} \Big[ 1 + 2\kappa(H_t - \bar{h}) \Big] \tag{11}$$

$$\nu z_t^* (\tilde{K}_t^*)^{\theta} (L_t^*)^{\nu-1} A_h(H_t^*, E_t^*) = \frac{\tilde{w}_t^*}{1-\mu_t} \Big[ 1 + 2\kappa^*(H_t^* - \bar{h}^*) \Big] \tag{12}$$

$$\nu z_t \tilde{K}_t^{\theta} L_t^{\nu-1} A_e(H_t, E_t) = \frac{\tilde{w}_t}{1-\mu_t} \tag{13}$$

$$\nu z_t^* (\tilde{K}_t^*)^{\theta} (L_t^*)^{\nu-1} A_e(H_t^*, E_t^*) = \frac{\tilde{w}_t^*}{1-\mu_t} \tag{14}$$

$$Q_t \Upsilon'\left(\frac{\tilde{I}_t}{\tilde{K}_t}\right) = 1 \tag{15}$$

$$Q_t^* \Upsilon' \left( \frac{\tilde{I}_t^*}{\tilde{K}_t^*} \right) = 1 \tag{16}$$

$$Q_t = \xi_t \mu_t + g_t^{-\sigma} \mathbb{E}_t \tilde{m}_{t+1} \left\{ (1-\mu_{t+1}) \theta z_{t+1} \tilde{K}_{t+1}^{\theta-1} H_{t+1}^{\nu} - \frac{\tilde{I}_{t+1}}{\tilde{K}_{t+1}} + \left[ 1 - \tau + \Upsilon \left( \frac{\tilde{I}_{t+1}}{\tilde{K}_{t+1}} \right) \right] Q_{t+1} \right\} \tag{17}$$

$$Q_t^* = \xi_t^* \mu_t + g_t^{-\sigma} \mathbb{E}_t \tilde{m}_{t+1} \left\{ (1-\mu_{t+1}) \theta z_{t+1}^* (\tilde{K}_{t+1}^*)^{\theta-1} (H_{t+1}^*)^{\nu} - \frac{\tilde{I}_{t+1}^*}{\tilde{K}_{t+1}^*} + \left[ 1 - \tau + \Upsilon \left( \frac{\tilde{I}_{t+1}^*}{\tilde{K}_{t+1}^*} \right) \right] Q_{t+1}^* \right\} \tag{18}$$

$$L_t = A(H_t, E_t) \tag{19}$$

$$L_t^* = A(H_t^*, E_t^*) \tag{20}$$

$$\tilde{m}_{t+1} = \beta \left( \frac{\tilde{D}_{t+1} + \tilde{D}_{t+1}^*}{\tilde{D}_t + \tilde{D}_t^*} \right)^{-\sigma} \tag{21}$$

$$\pi \tilde{K}_{t+1} + (1-\pi) \tilde{K}_{t+1}^* = 1 \tag{22}$$

where in the last equation $\pi$ denotes the (constant) population share of the domestic country.

Equations (1)-(22) form a dynamic system of 22 equations. Given the states $\tilde{\mathbf{s}} = (\tilde{W}_t, \tilde{K}_t)$ and the liquidation prices $\xi_t$ and $\xi_t^*$, the unknown variables are $H_t$, $H_t^*$, $E_t$, $E_t^*$, $L_t$, $L_t^*$, $C_t$, $C_t^*$, $w_t$, $w_t^*$, $I_t$, $I_t^*$, $Q_t$, $Q_t^*$, $g_t$, $\mu_t$, $R_t$, $\tilde{D}_t$, $\tilde{D}_t^*$, $\tilde{m}_{t+1}$, $\tilde{W}_{t+1}$, $\tilde{K}_{t+1}$, $\tilde{K}_{t+1}^*$. Therefore, we have a dynamic system of 22 equations in 23 unknowns. However, since the dividends always enter as a sum in all equations, implying that they are not uniquely determined, we can consider $\tilde{D}_t + \tilde{D}_t^*$ as a single variable, bringing the unknowns to 22.

The computational procedure is based on the approximation of four functions:

$$\begin{aligned}
\Gamma_1(\mathbf{s}_{t+1}) &= (\tilde{C}_{t+1} + \tilde{C}_{t+1}^*)^{-1} \\
\Gamma_2(\mathbf{s}_{t+1}) &= (\tilde{D}_{t+1} + \tilde{D}_{t+1}^*)^{-\sigma} \\
\Gamma_3(\mathbf{s}_{t+1}) &= (\tilde{D}_{t+1} + \tilde{D}_{t+1}^*)^{-\sigma} \left\{ (1-\mu_{t+1}) \theta z_{t+1} \tilde{K}_{t+1}^{\theta-1} H_{t+1}^{\nu} - \frac{\tilde{I}_{t+1}}{\tilde{K}_{t+1}} + \left[ 1 - \tau + \Upsilon \left( \frac{\tilde{i}_{t+1}}{s_{t+1}} \right) \right] Q_{t+1} \right\} \\
\Gamma_4(\mathbf{s}_{t+1}) &= (\tilde{D}_{t+1} + \tilde{D}_{t+1}^*)^{-\sigma} \left\{ (1-\mu_{t+1}) \theta z_{t+1}^* (\tilde{K}_{t+1}^*)^{\theta-1} (H_{t+1}^*)^{\nu} - \frac{\tilde{I}_{t+1}^*}{\tilde{K}_{t+1}^*} + \left[ 1 - \tau + \Upsilon \left( \frac{\tilde{I}_{t+1}^*}{\tilde{K}_{t+1}^*} \right) \right] Q_{t+1}^* \right\}
\end{aligned}$$

We first construct a two-dimensional grid for the endogenous states $\tilde{W}$ and $\tilde{K}$. Then, we guess the values taken by these functions at the grid points. Values outside the grid are obtained through bilinear interpolation. Once we know the approximated functions, we can find the values of the 22 unknowns by solving the system (1)-(22) at each grid point and for each possible value of the expectation of the liquidation prices $\xi_t^e$ and $\xi_t^{e*}$ in the domestic and foreign countries. The reason we need to solve for each possible expectation of prices is to identify the type of equilibria that could emerge at the particular states. In fact, for each $\xi_t^e$ and $\xi_t^{e*}$ we check whether the solution is binding ($\mu_t > 0$) or not binding ($\mu_t = 0$. Based on this we determine the type of equilibria that are possible and select the equilibrium. Once we have done this for all grid points, we update the guesses for the four functions $\Gamma_1(\mathbf{s}_{t+1})$, $\Gamma_2(\mathbf{s}_{t+1})$, $\Gamma_3(\mathbf{s}_{t+1})$ and $\Gamma_4(\mathbf{s}_{t+1})$. If at the particular grid point there are multiple equilibria, then we average these functions using the probabilities with which tight and loose equilibria arise. We keep iterating until the guesses for $\Gamma_1(\mathbf{s}_{t+1})$, $\Gamma_2(\mathbf{s}_{t+1})$, $\Gamma_3(\mathbf{s}_{t+1})$ and $\Gamma_4(\mathbf{s}_{t+1})$, evaluated at the grid points, are equal to the values obtained by solving the dynamic system (also at the grid points).

## B Unconditional moments

Table 1 reports the unconditional standard deviations for the typical macroeconomic variables. The model used in the simulation is the baseline model with asymmetric labor rigidities: flexible in the United States and rigid in the other G7 countries (G6 aggregate). The data is generated by simulating the model for 5,000 periods. We use two de-trending methods: the Hodrik-Prescott filter with smoothing parameter equal to 100 and growth rate. Notice that in the model debt is not determined for each individual country but only for the aggregation of the two countries. This explains why the statistics in the model are the same for the two countries. The standard deviations of consumption in the model are also equal which is a consequence of financial integration.

Table 2 reports statistics for key financial variables. The top section shows the average values for the interest rate, the expected return on equity and the risk premium on equity. The return on equity is the return for investors from holding the shares of firms. See the investor's problem in the paper (Eq. (1)). Notice that the risk premium on equity is different from the equity premium. The equity premium is the difference between the expected return on equity and the interest rate. The risk premium, instead, is the difference between the equity premium and the differential between the intertemporal discount rate of investors and the intertemporal discount rate of workers. If investors and workers had the same intertemporal discount factors then the equity premium would be equal to the risk premium. However, since in our model they are different, part of the equity premium is generated by the fact that workers (which hold bonds) have a lower discount rate than investors (who hold the equity of firms).

The bottom section of Table 2 reports the standard deviations for the stock market value, the interest rate and the return on equity. The stock market value is the value of all outstanding shares of all firms at the beginning of the period before the payment of dividends. We can observe that the model generates significant volatility in stock market and equity returns but modest volatility in the interest rate. These are roughly consistent with the data for advanced economies. For example, Piazzesi, Schneider and Tuzel (2007) calculate for the United States a standard deviation for equity returns over the postwar period of about 16% while the standard deviation for the interest rate is only about 3%. The high volatility of equity return is obviously a consequence of the high volatility of the equity value since dividends and other forms of distributions are not very volatile.

Table 1: Business cycle statistics for macroeconomic variables

| | *HP Filtered* | | *Growth rates* | |
|---|---|---|---|---|
| | *Data* | *Model* | *Data* | *Model* |
| **United States** | | | | |
| Output | 1.65 | 1.89 | 1.74 | 2.28 |
| Hours | 1.63 | 1.69 | 1.64 | 2.52 |
| Consumption | 1.53 | 0.83 | 1.63 | 0.95 |
| Investment | 6.87 | 5.98 | 7.55 | 8.66 |
| Debt | 1.65 | 2.04 | 1.74 | 1.86 |
| | | | | |
| **G6 aggregate** | | | | |
| Output | 1.38 | 1.54 | 1.70 | 2.03 |
| Hours | 0.82 | 1.71 | 1.00 | 2.55 |
| Consumption | 0.94 | 0.83 | 1.13 | 0.95 |
| Investment | 5.12 | 5.61 | 6.42 | 8.41 |
| Debt | 2.23 | 2.04 | 2.15 | 1.86 |

Table 2: Business cycle statistics for financial variables

| | **Expected values** |
|---|---|
| Interest rate | 3.70 |
| Return on equity | 7.02 |
| Risk premium | 0.63 |

| | **Standard deviations** | |
|---|---|---|
| | *HP Filtered* | *Growth rates* |
| Stock market value | 6.85 | 10.29 |
| Interest rate | 1.20 | 1.25 |
| Return on equity | 12.27 | 12.43 |

# C Sensitivity analysis

In this section we conduct a sensitivity analysis with respect to several parameters: (1) the elasticity of labor supply; (2) the elasticity of substitution in production between labor utilization and hours; (3) the rigidities in changing labor hours in production; (4) the size of working capital financing; (5) the probability of the low sunspot shock. The statistics reported here can be compared to the baseline calibration reported in the previous section of this appendix.

## C.1 Labor elasticity

In the baseline model we calibrated the elasticity of labor to $\eta = 1$. We now increase the elasticity to $\eta = 2$.

Table 3: Business cycle statistics for macroeconomic variables. Sensitivity to labor supply elasticity, $\eta = 2.0$. Baseline $\eta = 1$.

| | *HP Filtered* | | *Growth rates* | |
|---|---|---|---|---|
| | *Data* | *Model* | *Data* | *Model* |
| **United States** | | | | |
| Output | 1.65 | 2.25 | 1.74 | 2.85 |
| Hours | 1.63 | 2.34 | 1.64 | 3.48 |
| Consumption | 1.53 | 0.94 | 1.63 | 1.19 |
| Investment | 6.87 | 6.60 | 7.55 | 9.67 |
| Debt | 1.65 | 1.82 | 1.74 | 1.74 |
| **G6 aggregate** | | | | |
| Output | 1.38 | 1.78 | 1.70 | 2.33 |
| Hours | 0.82 | 0.85 | 1.00 | 1.24 |
| Consumption | 0.94 | 0.94 | 1.13 | 1.19 |
| Investment | 5.12 | 6.25 | 6.42 | 9.37 |
| Debt | 2.23 | 1.82 | 2.15 | 1.74 |

Table 4: Business cycle statistics for financial variables. Sensitivity to labor supply elasticity, $\eta = 2.0$. Baseline $\eta = 1$.

| | **Expected values** |
|---|---|
| Interest rate | 3.70 |
| Return on equity | 7.07 |
| Risk premium | 0.68 |

| | **Standard deviations** | |
|---|---|---|
| | *HP Filtered* | *Growth rates* |
| Stock market value | 7.01 | 10.64 |
| Interest rate | 0.89 | 0.92 |
| Return on equity | 12.70 | 12.87 |

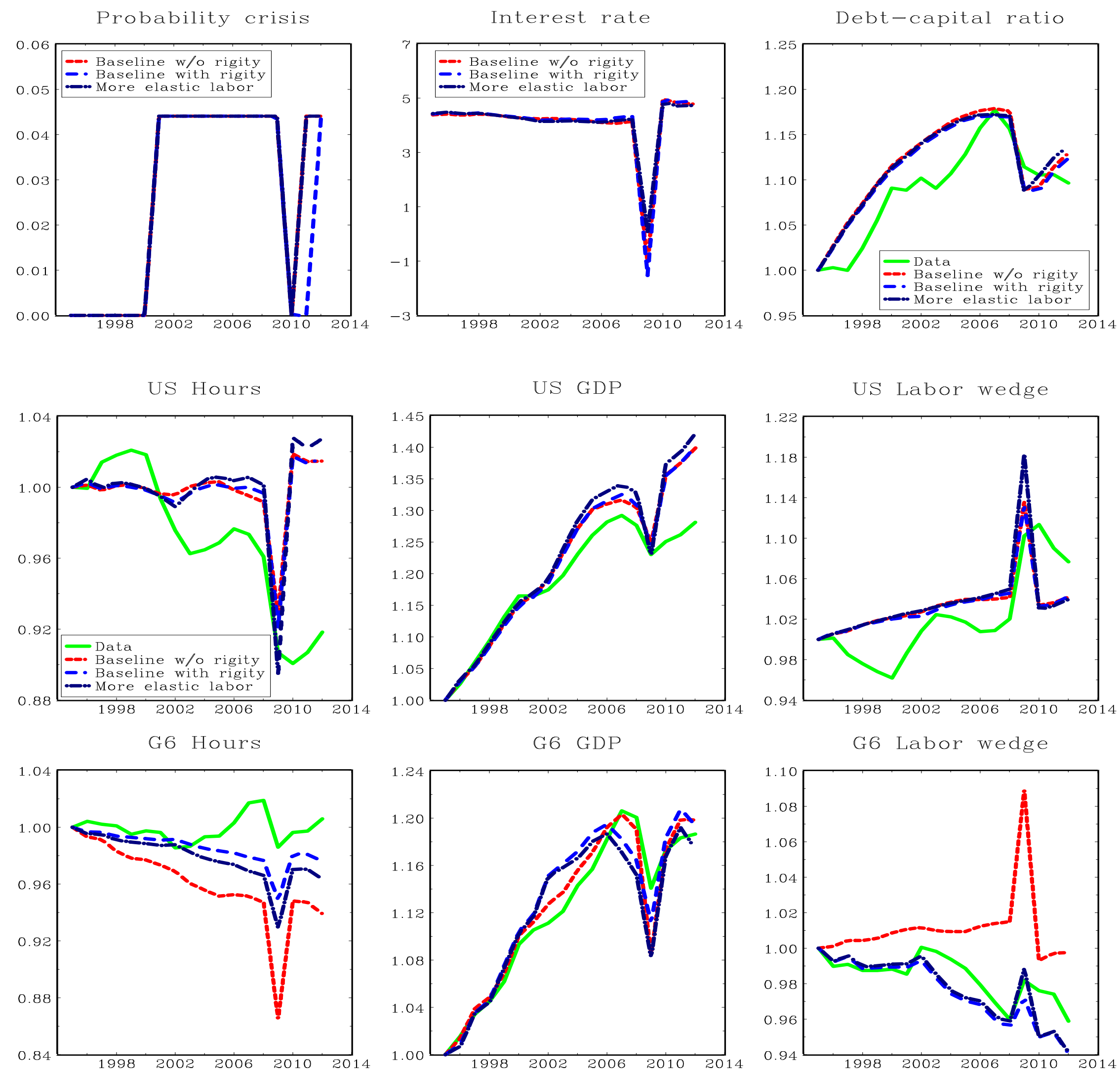


Figure 1: Sensitivity to labor supply elasticity. Data and model simulation for 1995-2012.

### C.2 Substitutability labour utilization and hours

In the baseline model we calibrated the elasticity of substitution between labor utilization and working hours to $\varrho = 5$. We now reduce this elasticity to $\varrho = 2$.

Table 5: Business cycle statistics for macroeconomic variables. Sensitivity to elasticity of substitution labor utilization and hours, $\varrho = 2$. Baseline $\varrho = 5$.

| | *HP Filtered* | | *Growth rates* | |
|---|---|---|---|---|
| | *Data* | *Model* | *Data* | *Model* |
| **United States** | | | | |
| Output | 1.65 | 1.94 | 1.74 | 2.33 |
| Hours | 1.63 | 1.76 | 1.64 | 2.61 |
| Consumption | 1.53 | 0.82 | 1.63 | 0.93 |
| Investment | 6.87 | 6.09 | 7.55 | 8.80 |
| Debt | 1.65 | 2.06 | 1.74 | 1.86 |
| **G6 aggregate** | | | | |
| Output | 1.38 | 1.47 | 1.70 | 1.91 |
| Hours | 0.82 | 0.98 | 1.00 | 1.46 |
| Consumption | 0.94 | 0.82 | 1.13 | 0.93 |
| Investment | 5.12 | 5.68 | 6.42 | 8.50 |
| Debt | 2.23 | 2.06 | 2.15 | 1.86 |

Table 6: Business cycle statistics for financial variables. Sensitivity to elasticity of substitution labor utilization and hours, $\varrho = 2$. Baseline $\varrho = 5$.

| | **Expected values** |
|---|---|
| Interest rate | 3.71 |
| Return on equity | 7.07 |
| Risk premium | 0.67 |

| | **Standard deviations** | |
|---|---|---|
| | *HP Filtered* | *Growth rates* |
| Stock market value | 7.04 | 10.54 |
| Interest rate | 1.27 | 1.33 |
| Return on equity | 12.68 | 12.86 |

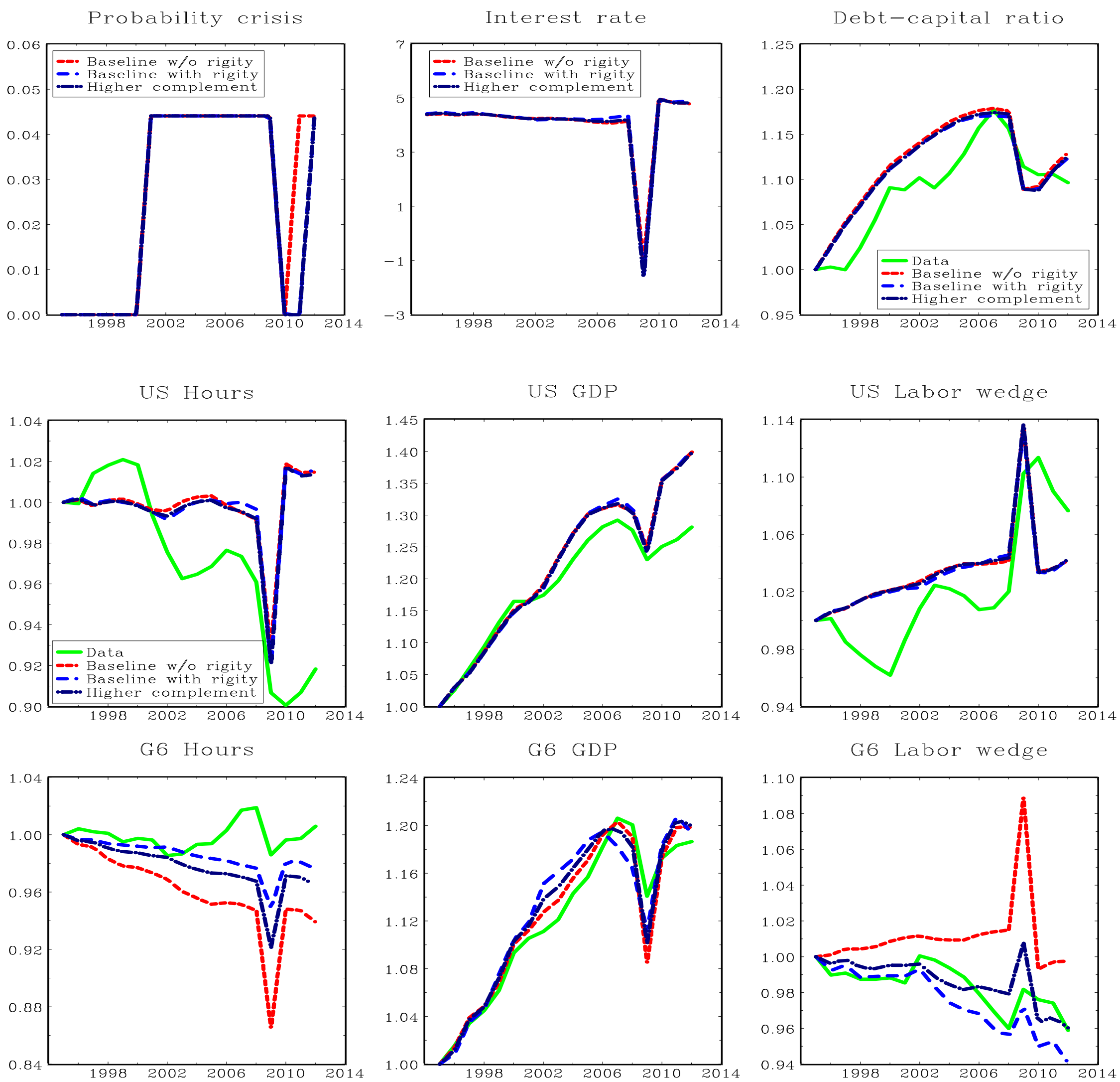


Figure 2: Sensitivity to substitutability labor utilization and hours. Data and model simulation for 1995-2012.

## C.3 Labor rigidity in G6 countries

In the baseline model we calibrated the parameter for labor rigidity in the G6 aggregate to $\kappa = 1$. We now reduce the value of this parameter to $\kappa = 0.5$.

Table 7: Business cycle statistics for macroeconomic variables. Sensitivity to labor rigidity G6 countries, $\kappa = 0.5$. Baseline $\kappa = 1$.

| | *HP Filtered* | | *Growth rates* | |
|---|---|---|---|---|
| | *Data* | *Model* | *Data* | *Model* |
| **United States** | | | | |
| Output | 1.65 | 1.89 | 1.74 | 2.33 |
| Hours | 1.63 | 1.69 | 1.64 | 2.53 |
| Consumption | 1.53 | 0.81 | 1.63 | 0.93 |
| Investment | 6.87 | 5.91 | 7.55 | 8.59 |
| Debt | 1.65 | 2.00 | 1.74 | 1.82 |
| **G6 aggregate** | | | | |
| Output | 1.38 | 1.48 | 1.70 | 1.91 |
| Hours | 0.82 | 0.92 | 1.00 | 1.36 |
| Consumption | 0.94 | 0.81 | 1.13 | 0.93 |
| Investment | 5.12 | 5.50 | 6.42 | 8.19 |
| Debt | 2.23 | 2.00 | 2.15 | 1.82 |

Table 8: Business cycle statistics for financial variables. Sensitivity to labor rigidity G6 countries, $\kappa = 0.5$. Baseline $\kappa = 1$.

| | **Expected values** |
|---|---|
| Interest rate | 3.71 |
| Return on equity | 7.02 |
| Risk premium | 0.62 |

| | **Standard deviations** | |
|---|---|---|
| | *HP Filtered* | *Growth rates* |
| Stock market value | 6.77 | 10.14 |
| Interest rate | 1.21 | 1.26 |
| Return on equity | 12.16 | 12.33 |

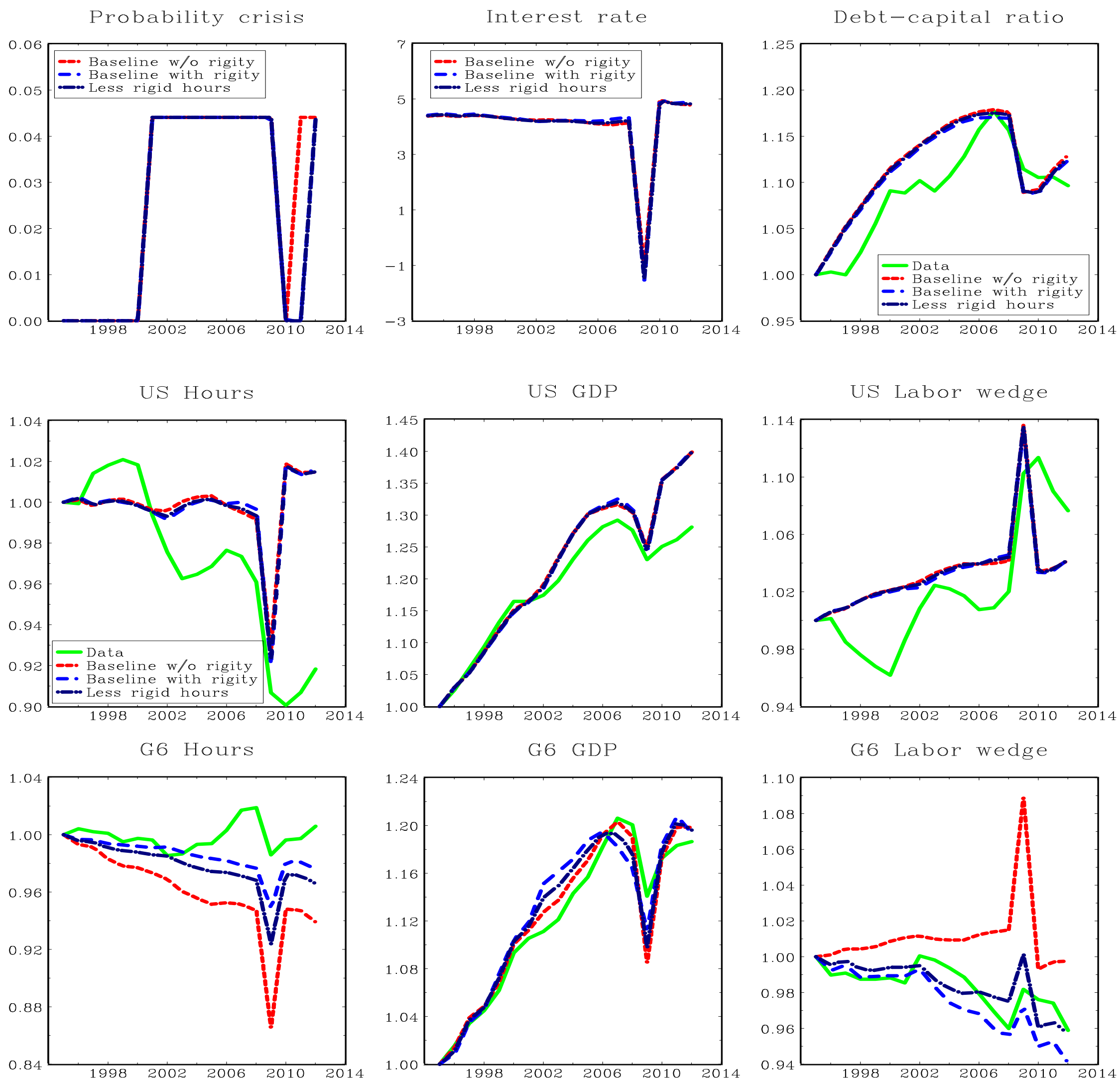


Figure 3: Sensitivity to labor market rigidity in G6 countries. Data and model simulation for 1995-2012.

## C.4 Working capital financing

In the baseline model we assumed that a firm needs to finance 20% of its cash flow mismatch. In the model the cash flow mismatch is equal to output. This was obtained by setting $\psi = 0.2$. We now reduce the value of this parameter to $\psi = 0.1$.

Table 9: Business cycle statistics for macroeconomic variables. Sensitivity to working capital financing, $\psi = 0.1$. Baseline, $\psi = 0.2$.

| | *HP Filtered* | | *Growth rates* | |
|---|---|---|---|---|
| | *Data* | *Model* | *Data* | *Model* |
| **United States** | | | | |
| Output | 1.65 | 1.72 | 1.74 | 2.04 |
| Hours | 1.63 | 1.45 | 1.64 | 2.12 |
| Consumption | 1.53 | 0.71 | 1.63 | 0.78 |
| Investment | 6.87 | 6.04 | 7.55 | 8.76 |
| Debt | 1.65 | 2.10 | 1.74 | 1.83 |
| | | | | |
| **G6 aggregate** | | | | |
| Output | 1.38 | 1.35 | 1.70 | 1.71 |
| Hours | 0.82 | 0.53 | 1.00 | 0.78 |
| Consumption | 0.94 | 0.71 | 1.13 | 0.78 |
| Investment | 5.12 | 5.70 | 6.42 | 8.52 |
| Debt | 2.23 | 2.10 | 2.15 | 1.83 |

Table 10: Business cycle statistics for financial variables. Sensitivity to working capital financing, $\psi = 0.1$. Baseline, $\psi = 0.2$.

| | **Expected values** |
|---|---|
| Interest rate | 3.71 |
| Return on equity | 7.15 |
| Risk premium | 0.76 |

| | **Standard deviations** | |
|---|---|---|
| | *HP Filtered* | *Growth rates* |
| Stock market value | 7.55 | 11.28 |
| Interest rate | 1.56 | 1.63 |
| Return on equity | 13.88 | 14.10 |

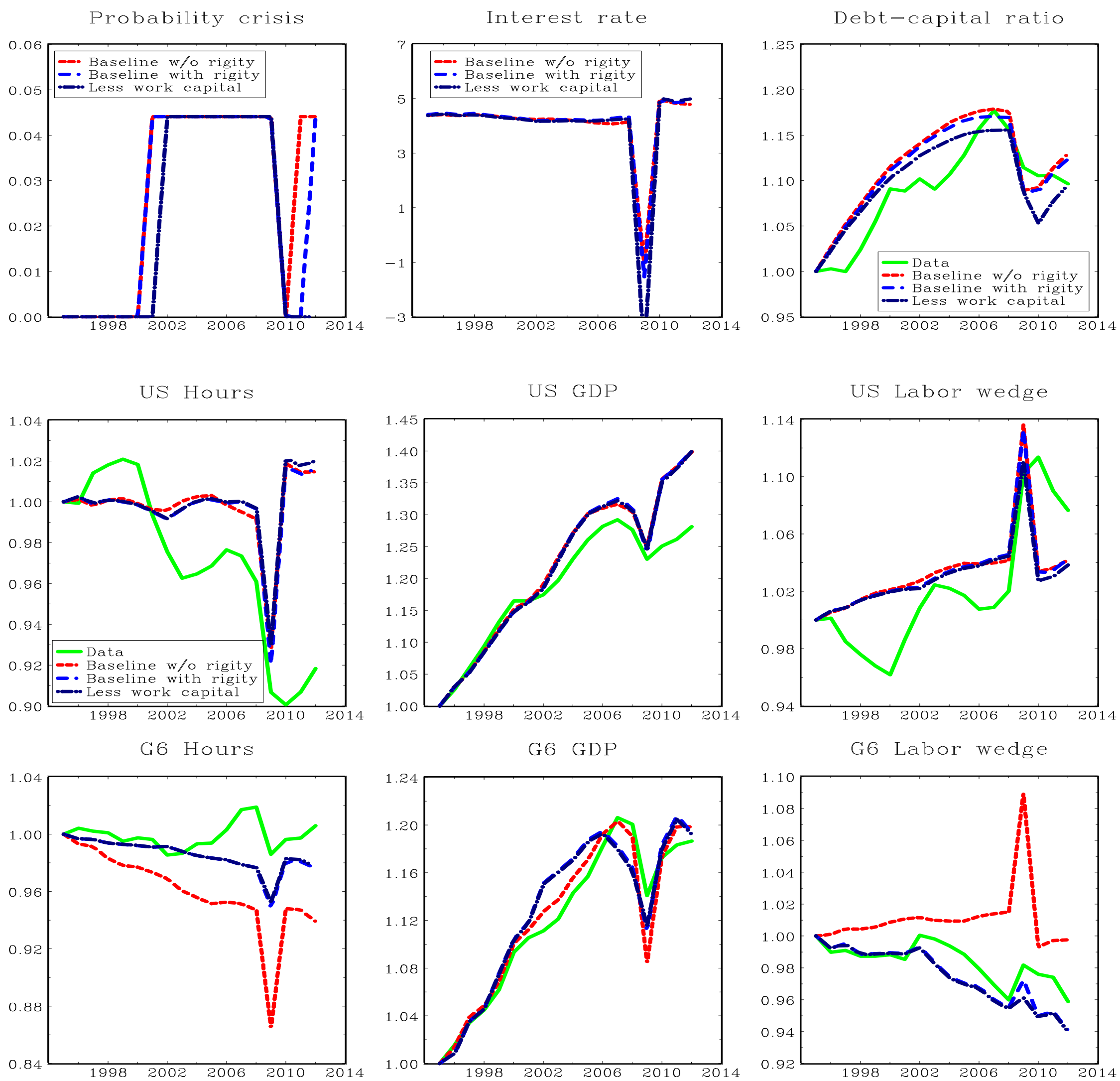


Figure 4: Sensitivity to working capital financing. Data and model simulation for 1995-2012.

## C.5 Probability of low sunspot shock

In the baseline model we calibrated the probability of a low sunspot shock to $\bar{p} = 0.21$. We now increase this number to $\bar{p} = 0.3$. This implies that the average probability of a crisis is about 9% compared to the baseline model where the probability of a crisis was about 4%.

Table 11: Business cycle statistics for macroeconomic variables. Sensitivity to probability low sunspot, $\bar{p} = 0.3$. Baseline, $\psi = 0.21$.

| | *HP Filtered* | | *Growth rates* | |
|---|---|---|---|---|
| | *Data* | *Model* | *Data* | *Model* |
| **United States** | | | | |
| Output | 1.65 | 1.90 | 1.74 | 2.26 |
| Hours | 1.63 | 1.60 | 1.64 | 2.38 |
| Consumption | 1.53 | 0.81 | 1.63 | 0.95 |
| Investment | 6.87 | 5.25 | 7.55 | 7.55 |
| Debt | 1.65 | 1.78 | 1.74 | 1.67 |
| **G6 aggregate** | | | | |
| Output | 1.38 | 1.42 | 1.70 | 1.86 |
| Hours | 0.82 | 0.59 | 1.00 | 0.88 |
| Consumption | 0.94 | 0.81 | 1.13 | 0.95 |
| Investment | 5.12 | 4.78 | 6.42 | 7.19 |
| Debt | 2.23 | 1.78 | 2.15 | 1.67 |

Table 12: Business cycle statistics for financial variables. Sensitivity to probability low sunspot, $\bar{p} = 0.3$. Baseline, $\psi = 0.21$.

| | **Expected values** |
|---|---|
| Interest rate | 3.69 |
| Return on equity | 6.88 |
| Risk premium | 0.50 |

| | **Standard deviations** | |
|---|---|---|
| | *HP Filtered* | *Growth rates* |
| Stock market value | 5.92 | 8.90 |
| Interest rate | 1.11 | 1.15 |
| Return on equity | 10.23 | 10.33 |

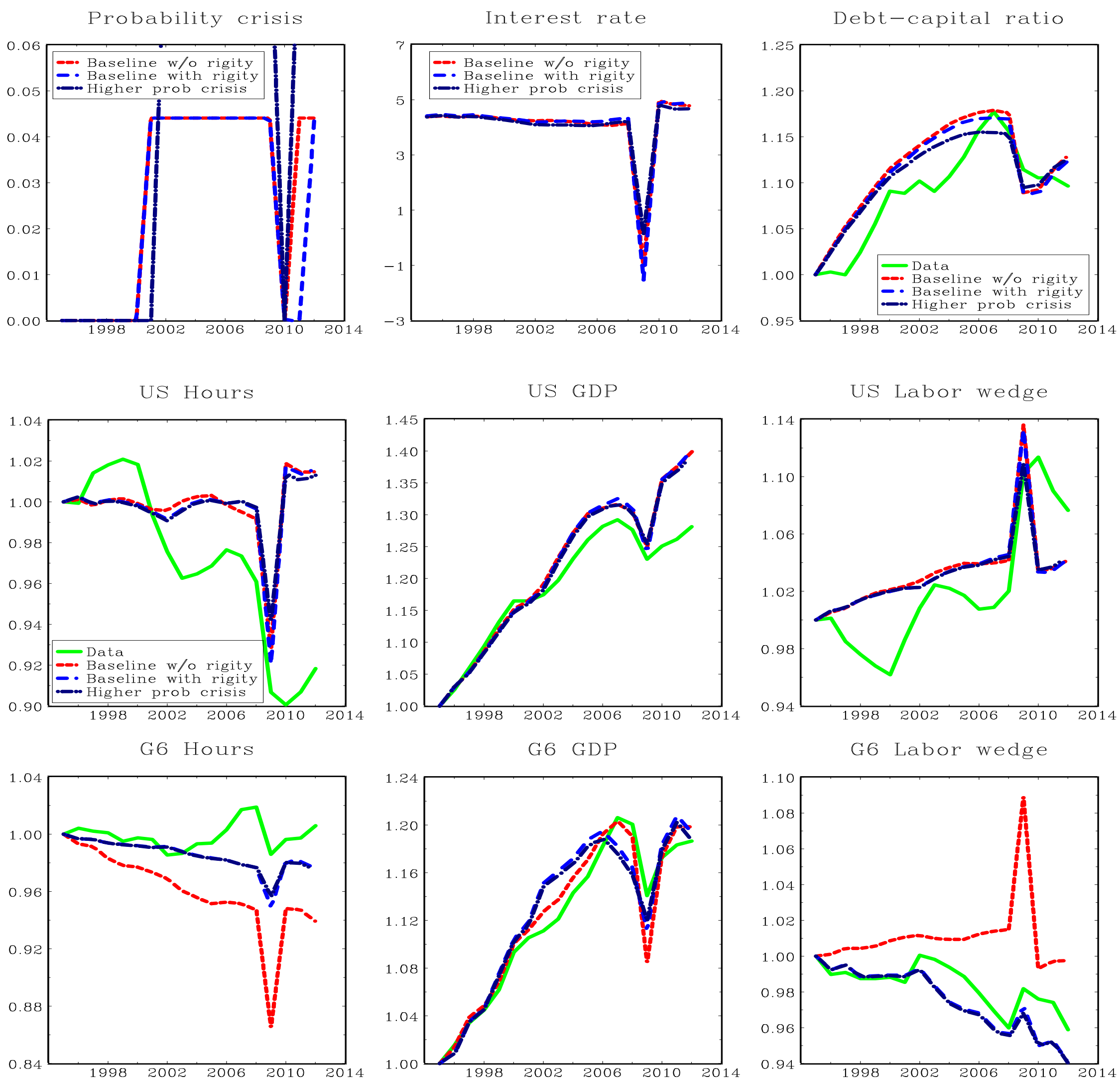


Figure 5: Sensitivity to probability low sunspot shock. Data and model simulation for 1995-2012.