News and Financial Intermediation in Aggregate Fluctuations: On-Line Appendix

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A On-line Appendix with supplementary material

This on-line Appendix contains material that are referred to in the paper. Section A of the Appendix reports supplementary and additional results refereed to in the paper. Appendix B describes the data sources. Appendix C describes the model in detail.

A.1 Parameter estimates—Baseline model

Table 1 below describes the model's calibrated parameters discussed in section 3.

Table 1: Calibrated Parameters

Parameter	Value	Description
δ_C	0.025	Consumption sector capital depreciation
δ_I	0.025	Investment sector capital depreciation
a_c	0.3	Consumption sector share of capital
a_I	0.3	Investment sector share of capital
β	0.9974	Discount factor
$\pi_C - 1$	0.6722	Steady state consumption sector net inflation rate (percent quarterly)
$\pi_I - 1$	0.0245	Steady state investment sector net inflation rate (percent quarterly)
λ_p	0.15	Steady state price markup
λ_w	0.15	Steady state wage markup
g_a	0.141	Steady state C-sector TFP growth (percent quarterly)
g_v	0.434	Steady state I-sector TFP growth (percent quarterly)
$p_i \frac{i}{c}$	0.399	Steady state investment / consumption
$\frac{G}{Y}$	0.19	Steady state government spending / output
θ_B	0.96	Fraction of bankers that survive
ϖ	0.0021	Share of assets transferred to new bankers
λ_B	0.69	Fraction of funds bankers can divert
ϱ	5.47	Steady state leverage ratio
$R^B - R$	0.5	Steady state spread (percent quarterly)

Notes. β, π_C, π_I, g_a, g_v, $p_i \frac{i}{c}$, ϱ, $R^B - R$ are based on sample averages. ϖ and λ_B are set to be consistent with the average values of the leverage ratio, ϱ, and $R^B - R$.

Table 2 below reports parameter estimates for the baseline model described in section 2.

Table 2: Prior and Posterior Distributions

Parameter	Description	Prior Distribution			Posterior Distribution		
		Distribution	Mean	Std. dev.	Mean	10%	90%
h	Consumption habit	Beta	0.50	0.10	0.6275	0.5599	0.6949
ν	Inverse labour supply elasticity	Gamma	2.00	0.75	0.8718	0.2447	1.4893
ξ_w	Wage Calvo probability	Beta	0.66	0.10	0.6599	0.6196	0.7003
ξ_C	C-sector price Calvo probability	Beta	0.66	0.10	0.7785	0.7465	0.8132
ξ_I	I-sector price Calvo probability	Beta	0.66	0.10	0.7058	0.6334	0.7773
ι_w	Wage indexation	Beta	0.50	0.15	0.1306	0.0581	0.2034
ι_{p_C}	C-sector price indexation	Beta	0.50	0.15	0.0726	0.0281	0.1139
ι_{p_I}	I-sector price indexation	Beta	0.50	0.15	0.3033	0.1348	0.4702
χ_I	I-sector utilization	Gamma	5.00	1.00	4.9975	3.3997	6.6080
χ_C	C-sector utilization	Gamma	5.00	1.00	4.6983	3.0598	6.3562
κ	Investment adj. cost	Gamma	4.00	1.00	2.2881	1.7747	2.7620
ϕ_π	Taylor rule inflation	Normal	1.70	0.30	1.5864	1.3976	1.7665
ρ_R	Taylor rule inertia	Beta	0.60	0.20	0.8434	0.8191	0.8681
ϕ_{dX}	Taylor rule output growth	Normal	0.25	0.10	0.6822	0.5706	0.7921
	Shocks: Persistence						
ρ_z	C-sector TFP	Beta	0.40	0.20	0.7498	0.6973	0.801
ρ_v	I-sector TFP	Beta	0.40	0.20	0.1415	0.0455	0.2328
ρ_b	Preference	Beta	0.60	0.20	0.9136	0.8762	0.9542
ρ_g	Government spending	Beta	0.60	0.20	0.9826	0.9664	0.9993
$\rho_{\lambda_p^C}$	C-sector price markup	Beta	0.60	0.20	0.0539	0.0145	0.0919
$\rho_{\lambda_p^I}$	I-sector price markup	Beta	0.60	0.20	0.8871	0.8442	0.9337
ρ_{λ_w}	Wage markup	Beta	0.60	0.20	0.0523	0.0087	0.0945
$\rho_{\xi^K,C}$	C-sector capital quality	Beta	0.60	0.20	0.8437	0.8133	0.8765
$\rho_{\xi^K,I}$	I-sector capital quality	Beta	0.60	0.20	0.0862	0.0215	0.1471
	Shocks: Volatilities						
σ_z	C-sector TFP unanticipated	Inv Gamma	0.50	2	0.1721	0.1288	0.2147
σ_{z4}	C-sector TFP. 4Q ahead news	Inv Gamma	$0.5/\sqrt{2}$	2	0.1174	0.0839	0.1521
σ_{z8}	C-sector TFP. 8Q ahead news	Inv Gamma	$0.5/\sqrt{2}$	2	0.2014	0.1544	0.2470
σ_v	I-sector TFP unanticipated	Inv Gamma	0.50	2	1.8718	1.5932	2.1517
σ_{v4}	I-sector TFP. 4Q ahead news	Inv Gamma	$0.5/\sqrt{2}$	2	0.2959	0.1090	0.4712
σ_{v8}	I-sector TFP. 8Q ahead news	Inv Gamma	$0.5/\sqrt{2}$	2	0.7001	0.5282	0.8661
σ_b	Preference	Inv Gamma	0.10	2	1.4524	1.1644	1.7339
σ_g	Government spending	Inv Gamma	0.50	2	0.5102	0.4357	0.5794
σ_{mp}	Monetary policy	Inv Gamma	0.10	2	0.1204	0.1023	0.1386
$\sigma_{\lambda_p^C}$	C-sector price markup	Inv Gamma	0.10	2	0.6045	0.5184	0.6839
$\sigma_{\lambda_p^I}$	I-sector price markup	Inv Gamma	0.10	2	0.2282	0.1647	0.2863
σ_{λ_w}	Wage markup	Inv Gamma	0.10	2	0.3689	0.3100	0.4274
$\sigma_{\xi^K,C}$	C-sector capital quality	Inv Gamma	0.50	2	0.3118	0.2237	0.3948
$\sigma_{\xi^K,I}$	I-sector capital quality	Inv Gamma	0.50	2	2.4029	2.0458	2.7600

Notes. The posterior distribution of parameters is evaluated numerically using the random walk Metropolis-Hastings algorithm. We simulate the posterior using a sample of 500,000 draws and discard the first 100,000 of the draws.

A.2 Full variance decomposition

Variance decomposition. Table 3 below reports the full decomposition results referred to in section 4.

Table 3: Variance decomposition at posterior estimates—business cycle frequencies (6-32 quarters)

	All TFP Sum of cols. 1 to 6	z	z^4	z^8	v	v^4	v^8	b	η_{em}	λ_p^C	λ_p^I	λ_w	g	ξ_C	ξ_I
Output	0.748	0.195	0.093	0.213	0.187	0.006	0.054	0.009	0.047	0.005	0.089	0.010	0.018	0.067	0.006
		[0.177 0.221]	[0.084 0.104]	[0.193 0.231]	[0.169 0.207]	[0.004 0.008]	[0.049 0.060]	[0.008 0.011]	[0.043 0.052]	[0.004 0.005]	[0.073 0.110]	[0.008 0.011]	[0.015 0.020]	[0.057 0.079]	[0.005 0.006]
Consumption	0.568	0.241	0.106	0.185	0.023	0.001	0.011	0.113	0.020	0.032	0.037	0.020	0.003	0.196	0.007
		[0.220 0.266]	[0.094 0.117]	[0.170 0.202]	[0.020 0.027]	[0.000 0.001]	[0.010 0.013]	[0.102 0.126]	[0.018 0.023]	[0.029 0.036]	[0.028 0.048]	[0.018 0.022]	[0.003 0.004]	[0.180 0.217]	[0.006 0.008]
Investment	0.730	0.040	0.043	0.165	0.384	0.009	0.090	0.004	0.017	0.003	0.188	0.002	0.003	0.041	0.011
		[0.035 0.047]	[0.038 0.048]	[0.150 0.182]	[0.356 0.415]	[0.006 0.012]	[0.082 0.100]	[0.003 0.004]	[0.016 0.019]	[0.002 0.003]	[0.154 0.225]	[0.002 0.003]	[0.002 0.003]	[0.036 0.048]	[0.009 0.012]
Total Hours	0.720	0.063	0.091	0.341	0.163	0.006	0.057	0.009	0.040	0.001	0.159	0.012	0.007	0.048	0.003
		[0.055 0.074]	[0.080 0.101]	[0.316 0.366]	[0.145 0.183]	[0.004 0.008]	[0.052 0.064]	[0.008 0.012]	[0.036 0.044]	[0.001 0.001]	[0.132 0.190]	[0.010 0.013]	[0.006 0.007]	[0.041 0.056]	[0.003 0.004]
Real Wage	0.623	0.206	0.083	0.131	0.038	0.015	0.150	0.007	0.007	0.129	0.018	0.135	0.001	0.075	0.003
		[0.188 0.228]	[0.074 0.092]	[0.119 0.145]	[0.034 0.043]	[0.011 0.021]	[0.134 0.164]	[0.005 0.009]	[0.006 0.008]	[0.119 0.137]	[0.014 0.023]	[0.126 0.145]	[0.001 0.001]	[0.064 0.085]	[0.003 0.004]
Nominal Interest Rate	0.719	0.036	0.070	0.466	0.122	0.003	0.024	0.055	0.020	0.058	0.089	0.004	0.004	0.046	0.005
		[0.030 0.043]	[0.061 0.079]	[0.441 0.491]	[0.111 0.135]	[0.002 0.004]	[0.020 0.028]	[0.048 0.061]	[0.017 0.022]	[0.052 0.066]	[0.072 0.111]	[0.003 0.004]	[0.003 0.004]	[0.040 0.053]	[0.004 0.005]
C-Sector Inflation	0.443	0.006	0.017	0.231	0.103	0.007	0.079	0.122	0.057	0.278	0.041	0.037	0.007	0.013	0.001
		[0.004 0.008]	[0.013 0.022]	[0.205 0.257]	[0.092 0.115]	[0.005 0.009]	[0.067 0.090]	[0.110 0.134]	[0.052 0.064]	[0.254 0.302]	[0.032 0.052]	[0.032 0.041]	[0.006 0.009]	[0.011 0.016]	[0.001 0.001]
I-Sector Inflation	0.663	0.028	0.044	0.315	0.226	0.003	0.047	0.021	0.052	0.003	0.155	0.017	0.008	0.026	0.053
		[0.023 0.034]	[0.038 0.051]	[0.289 0.341]	[0.208 0.246]	[0.002 0.004]	[0.043 0.054]	[0.019 0.024]	[0.047 0.057]	[0.003 0.004]	[0.125 0.187]	[0.015 0.019]	[0.007 0.009]	[0.022 0.031]	[0.048 0.057]
C-Sector Spread	0.556	0.077	0.078	0.313	0.080	0.001	0.009	0.013	0.017	0.138	0.048	0.006	0.003	0.196	0.022
		[0.067 0.088]	[0.069 0.087]	[0.289 0.333]	[0.072 0.088]	[0.001 0.001]	[0.007 0.011]	[0.012 0.015]	[0.015 0.019]	[0.128 0.148]	[0.038 0.060]	[0.005 0.006]	[0.003 0.003]	[0.174 0.220]	[0.020 0.024]
I-Sector Spread	0.675	0.093	0.083	0.329	0.140	0.001	0.029	0.038	0.026	0.170	0.074	0.008	0.005	0.002	0.002
		[0.083 0.107]	[0.074 0.092]	[0.305 0.352]	[0.126 0.155]	[0.001 0.002]	[0.024 0.034]	[0.033 0.043]	[0.023 0.028]	[0.157 0.182]	[0.059 0.094]	[0.007 0.009]	[0.004 0.005]	[0.001 0.003]	[0.001 0.002]
Equity	0.668	0.190	0.088	0.324	0.056	0.002	0.008	0.003	0.078	0.027	0.019	0.005	0.012	0.150	0.037
		[0.172 0.211]	[0.078 0.099]	[0.301 0.346]	[0.051 0.063]	[0.001 0.003]	[0.007 0.009]	[0.003 0.004]	[0.071 0.086]	[0.024 0.029]	[0.015 0.024]	[0.004 0.005]	[0.011 0.014]	[0.134 0.169]	[0.033 0.040]
Rel. Price of Investment	0.787	0.086	0.021	0.021	0.583	0.009	0.066	0.002	0.009	0.036	0.113	0.001	0.002	0.014	0.037
		[0.077 0.098]	[0.019 0.024]	[0.018 0.024]	[0.560 0.603]	[0.007 0.013]	[0.060 0.073]	[0.001 0.002]	[0.008 0.010]	[0.034 0.039]	[0.092 0.136]	[0.001 0.001]	[0.001 0.002]	[0.011 0.016]	[0.033 0.041]

Median shares reported with values in brackets denoting 5 and 95 percentiles. z = TFP in consumption sector, z^x = x quarters ahead consumption sector TFP news shock, v = TFP in investment sector, v^x = x quarters ahead investment sector TFP news shock, b = Preference shock, g = Government spending shock, η_{em} = Monetary policy, λ_p^C = Consumption sector price markup, λ_p^I = Investment sector price markup, λ_w = Wage markup, ξ_C = consumption sector capital quality, ξ_I = investment sector capital quality. Business cycle frequencies considered in the decomposition correspond to periodic components with cycles between 6 and 32 quarters. The decomposition is performed using the spectrum of the DSGE model and an inverse first difference filter to reconstruct the levels for output, consumption, total investment, the real wage and equity. The spectral density is computed from the state space representation of the model with 500 bins for frequencies covering the range of periodicities.

Variance decomposition of core real model , baseline and extended baseline of section 6. Table 4 reports the decomposition of variance attributed to TFP news shocks for all observables.

Table 4: Share of variance explained by TFP news shocks

	Real model		Baseline model		Extended baseline	
	business cycle freq.	unconditional decomposition	business cycle freq.	unconditional decomposition	business cycle freq.	unconditional decomposition
Output	0.107	0.075	0.354	0.393	0.167	0.275
Consumption	0.157	0.245	0.151	0.253	0.117	0.278
Investment	0.074	0.049	0.346	0.351	0.225	0.273
Total Hours	0.057	0.069	0.612	0.241	0.230	0.253
Real Wage	0.019	0.041	0.267	0.297	0.141	0.252
Nom. Interest Rate	0.044	0.095	0.327	0.132	0.141	0.115
C-Sector Inflation	0.041	0.087	0.273	0.187	0.124	0.100
I-Sector Inflation	0.040	0.084	0.295	0.195	0.140	0.120
TFP	0.147	0.176	0.409	0.337	0.365	0.322
Log Marginal Likelihood	-898		-703		-706	

Notes. The real model is a (nearly) perfectly competitive model without financial frictions. It is a restricted estimated version of the baseline model. It strips off the financial channel and sets the steady state mark-ups, $\lambda_p = \lambda_w = 0.01$, indexation parameters, $\iota_{p_C} = \iota_{p_I} = \iota_w = 0.01$, and Calvo probabilities for prices and wages, $\xi_C = \xi_I = \xi_w = 0.01$. The extended baseline model is estimated with 4 and 8 ahead news components in all exogenous processes, except monetary policy shock. Business cycle frequencies considered in the decomposition correspond to periodic components with cycles between 6 and 32 quarters. The spectral density is computed from the state space representation of the model with 500 bins for frequencies covering the range of periodicities. The spectral decomposition is performed using the spectrum of the DSGE model and an inverse first difference filter to reconstruct the levels for output, consumption, total investment, and TFP. The numbers for the unconditional decomposition are reported for the growth rates of these variables. We report median shares.

Variance decomposition of the baseline model without demeaning the data. We have re-estimated the model without making this transformation. We report, the estimated variance decomposition. We note that the role attributed to TFP news shocks is very much in line to that estimated and reported in section 4, suggesting the robustness of our findings to this consideration.

Table 5: Variance decomposition at posterior estimates using the data without removing the sample averages—business cycle frequencies (6-32 quarters)

	TFP shocks:						financial shocks:	all other shocks	all TFP shocks	all TFP news shocks
	z	z^4	z^8	v	v^4	v^8	sum of ξ_C, ξ_I		sum of cols. 1-6	sum of cols. 2,3,5,6
Output	0.180	0.144	0.175	0.155	0.008	0.046	0.095	0.294	0.706	0.372
Consumption	0.147	0.121	0.176	0.052	0.003	0.054	0.212	0.447	0.553	0.354
Investment	0.039	0.069	0.163	0.403	0.010	0.055	0.055	0.261	0.739	0.297
Total Hours	0.072	0.146	0.288	0.139	0.009	0.053	0.057	0.293	0.708	0.496
Real Wage	0.136	0.153	0.273	0.031	0.004	0.036	0.078	0.368	0.632	0.465
Nom. Interest Rate	0.029	0.102	0.400	0.107	0.008	0.040	0.048	0.314	0.687	0.550
C-Sector Inflation	0.003	0.029	0.187	0.079	0.019	0.112	0.017	0.571	0.429	0.347
I-Sector Inflation	0.028	0.071	0.284	0.230	0.005	0.041	0.076	0.341	0.660	0.402
C-Sector Spread	0.047	0.110	0.301	0.081	0.006	0.025	0.152	0.432	0.568	0.441
I-Sector Spread	0.054	0.120	0.326	0.103	0.004	0.050	0.004	0.343	0.657	0.500
Equity	0.135	0.114	0.311	0.067	0.003	0.013	0.148	0.358	0.642	0.440
Rel. Price of Investment	0.078	0.033	0.008	0.593	0.008	0.034	0.061	0.246	0.754	0.084

z = TFP in consumption sector, $z^x = x$ quarters ahead consumption sector TFP news shock, v = TFP in investment sector, $v^x = x$ quarters ahead investment sector TFP news shock, ξ_C and ξ_I = capital quality shocks in the consumption and investment sector. Business cycle frequencies considered in the decomposition correspond to periodic components with cycles between 6 and 32 quarters. The decomposition is performed using the spectrum of the DSGE model and an inverse first difference filter to reconstruct the levels for output, consumption, total investment, the real wage, equity and the relative price of investment. The spectral density is computed from the state space representation of the model with 500 bins for frequencies covering the range of periodicities. We report median shares. The posterior distribution of parameters is evaluated numerically using the random walk Metropolis-Hastings algorithm. We simulate the posterior using a sample of 500,000 draws and discard the first 100,000 of the draws.

A.3 Identification tests

We perform two tests referred to in section 3. First, a test of (local) parameter identifiability as proposed by Iskrev (2010) the results of which suggest all parameters we estimate are identifiable in a neighborhood of our estimates. This test evaluates the Jacobian of the vector containing all parameters (including the parameters describing the exogenous processes) which determine the first two moments of the data. When evaluated at the posterior mean of our parameter estimates this Jacobian matrix has full column rank—equal to the number of parameters to be estimated. This implies that any chosen vector of parameters around our estimates will give rise to an auto-covariance function that is different than that implied by our estimates.[1] Nevertheless because this test is a yes/no proposition it cannot precisely scrutinize for weak identifiability. For this reason we adopt an indicator of Bayesian learning proposed by Koop et al. (2013), namely the "Bayesian learning rate indicator", which given the focus on asymptotics gives an indication of the informativeness of the data. This indicator examines the rate at which the posterior precision of parameters gets updated with the sample size. For identified parameters the posterior precision increases at rate T (with T denoting the sample size). The indicator suggests no evidence of weak identification: we measure this by taking the product of posterior variances with T and examine if it converges to a constant for all parameters, which we find that it does, suggesting the posterior precision of parameters is updated at the same rate as T. To implement this test we generate a large sample of simulated data from the model equal to 30,000 observations. We then estimate the model on samples of increasing size which we set to $T = 50, 100, 1,000, 10,000, 20,000, 25,000, 30,000$, and compute the posterior variance of parameters for these consecutive samples. We check the rate at which these variances are declining in comparison to the sample size. In the interest of space we do not report the results, but are available upon request.

Finally we provide a Figure which confirms the informativeness of the data for our

[1] All estimations are done using DYNARE (see Adjemian et al. (2011)), http://www.dynare.org. We calculate convergence diagnostics in order to check and ensure the stability of the posterior distributions of parameters as described in Brooks and Gelman (1998).

estimates of TFP news shocks. The Figure displays the prior and posterior distributions of the standard deviation parameters (σ_{z4}, σ_{z8}) and (σ_{v4}, σ_{v8}) in the consumption and investment specific TFP process respectively. It suggests the update of the prior by the data yields an informative posterior.

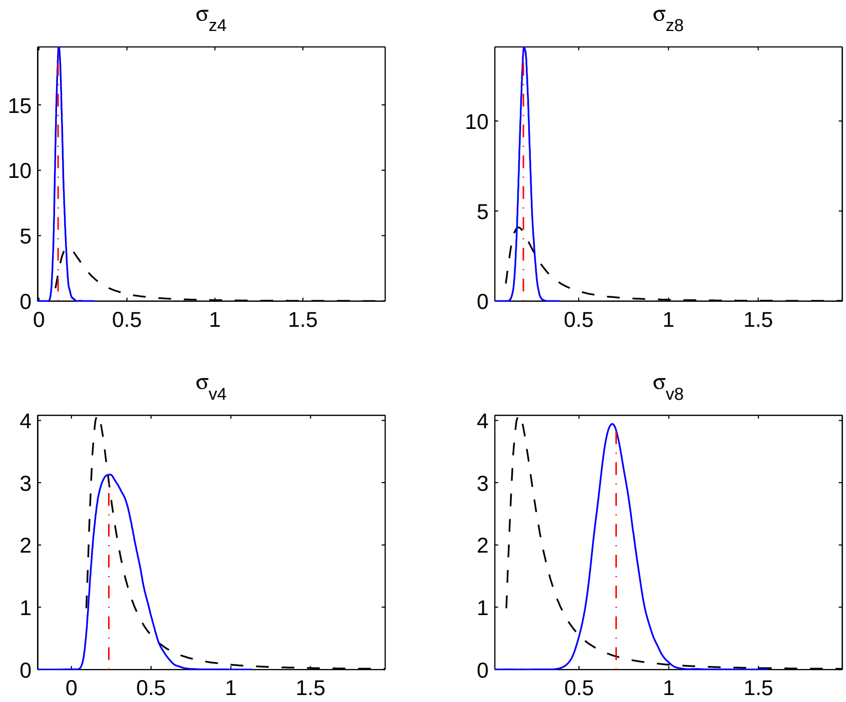

Figure 1: Prior densities (black, dashed), posterior densities (blue, solid) and posterior mode (red, dashes with dots) of the standard deviations of the news components of sectoral TFP shocks. Posterior densities are calculated using 500,000 draws of the posterior distribution of the respective parameter after discarding the first 100,000 draws.

A.4 The relative price of investment and investment specific news shocks

Consider the expression for the relative price of investment in the model,

$$\frac{P_{I,t}}{P_{C,t}} = \frac{\text{mark up}_{I,t}}{\text{mark up}_{C,t}} \frac{1-a_c}{1-a_i} \frac{A_t}{V_t} \left(\frac{K_{I,t}}{L_{I,t}}\right)^{-a_i} \left(\frac{K_{C,t}}{L_{C,t}}\right)^{a_c}$$

where, a_c, a_i are capital shares in consumption, and investment sector respectively. V_t, A_t, is TFP in the investment and consumption sector respectively, and $\frac{K_{x,t}}{L_{x,t}}, x = I, C$

the capital-labor ratio in sector x. mark $\text{up}_{x,t}$ is the price mark-up or inverse of the real marginal cost in sector x. V_t corresponds to the investment specific shock. Notice how the relative price of investment can be driven—at least in the short run—by, (a) mark up shocks, via their impact on the sectoral price-cost mark ups, (b) sector specific TFP and, (c) differences in capital labor ratios across sectors (due to the sector specific nature of capital in the model). The fact that (c) above affects the relative price of investment implies that all shocks can in principle affect this price. In the restricted one sector version the expression above simplifies to, $\frac{P_{I,t}}{P_{C,t}} = \frac{A_t}{V_t}$, suggesting relative technologies are immediately reflected in relative prices.[2] Basu et al. (2010) provide evidence against this assumption. Specifically, they estimate that the pass through of technologies to prices is slow, taking at least 3 years to complete, invalidating the restriction that maps sector specific technology shocks on the relative price implied by standard one sector models.

The Figure below shows IRFs to an investment specific news shock. Note in particular, the inability of this shock to predict the counter-cyclicality of bond spreads and procyclicality of capital prices.

A.5 A comparison with a one sector model

The role of the two-sector setup. It is interesting to compare the dynamics of a TFP news shock in one and two sector environments. To this end, and to keep in line with the DSGE literature that studies neutral and investment specific technology shocks in estimated one sector models, we consider an experiment with a TFP sector-neutral news shock.[3] Figure 3 below plots responses of the four main macro aggregates. The IRFs

[2] A slightly different and simpler formulation of a two sector model, where investment producers buy final goods and convert them to investment would effectively deliver this restriction (see Justiniano et al. (2011)). This is the predominant approach followed in the DSGE literature. Further, one can readily redefine the investment sector TFP process as $V_t = A_t V_t^*$, where in this formulation A_t denotes sector neutral TFP, while V_t^* denotes investment specific TFP. Under this equivalent formulation the expression above becomes, $\frac{P_{I,t}}{P_{C,t}} = (V_t^*)^{-1}$, a commonly used restriction in one sector estimated DSGE models.

[3] A sector-neutral shock affects both sectors symmetrically. The one sector model is a restricted version of the baseline model, assuming perfect capital mobility between sectors and a perfectly competitive investment sector and retains financial frictions. It is calibrated with the parameters of the baseline model.

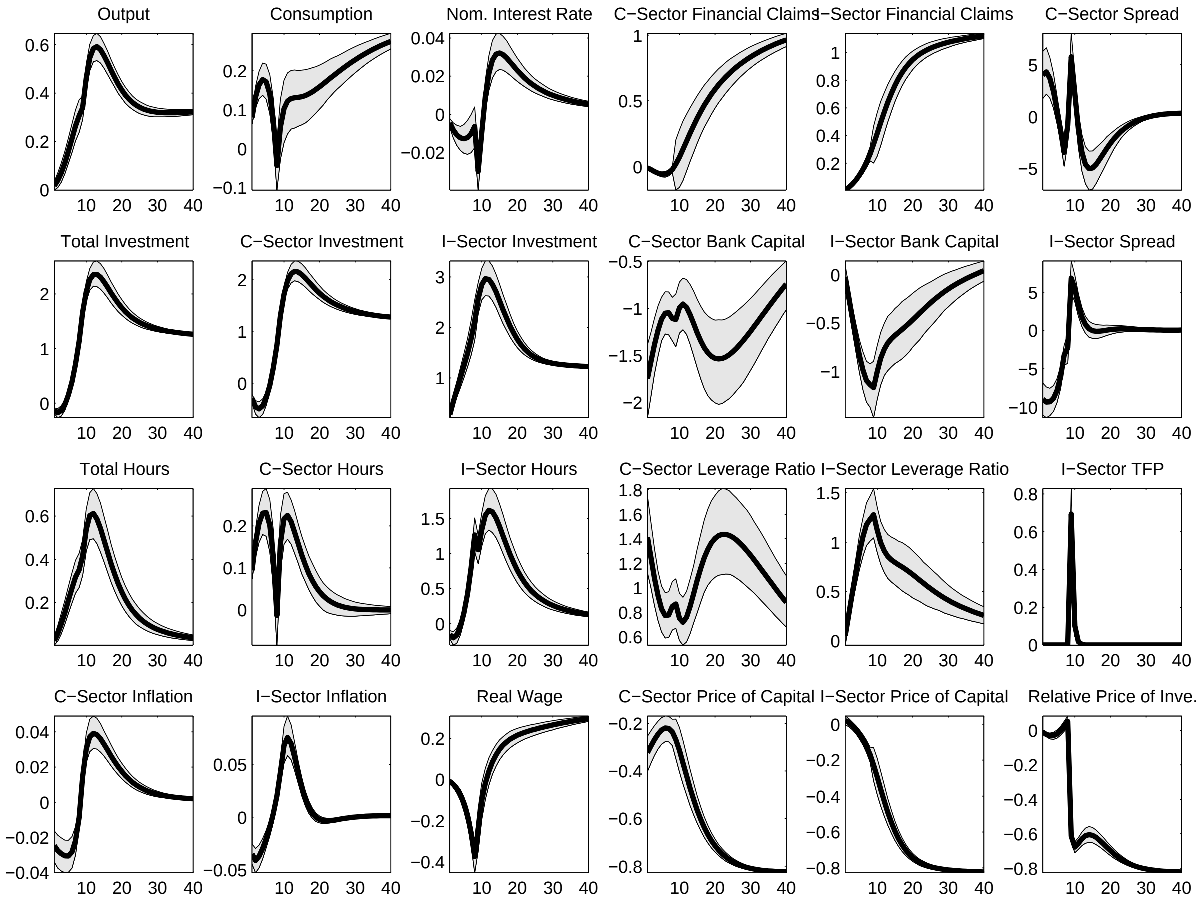

Figure 2: Responses to a one std. deviation TFP news shock (anticipated 8 quarters ahead) in the investment sector.

are broadly similar across the one and two sector versions. Specifically, beyond the first 8-10 quarters the IRFs generated by the one sector model have very similar dynamics and amplitude compared to the IRFs from the baseline, especially for investment and hours. Thus, in those horizons, there is very small quantitative difference in the responses of the main macro aggregates. Further, this difference largely disappears after about 16 quarters for output and consumption. The difference in the magnitudes of IRFs in very short run horizons between the baseline and one sector models can be explained by appealing to limited capital mobility. The one sector model allows installed capital to move freely between sectors, while in the baseline installed capital cannot move, and re-allocation can only occur through new investment. In the baseline, on the arrival of the news, the investment sector must rely on employing more hours worked to produce new capital for the C-sector, since installed capital cannot move to that sector. Thus, agents want to bring investment spending forward in order to have the optimal amount of capital installed when the TFP shock materializes in the C-sector, which generates a larger short run increase in hours and investment in the baseline.

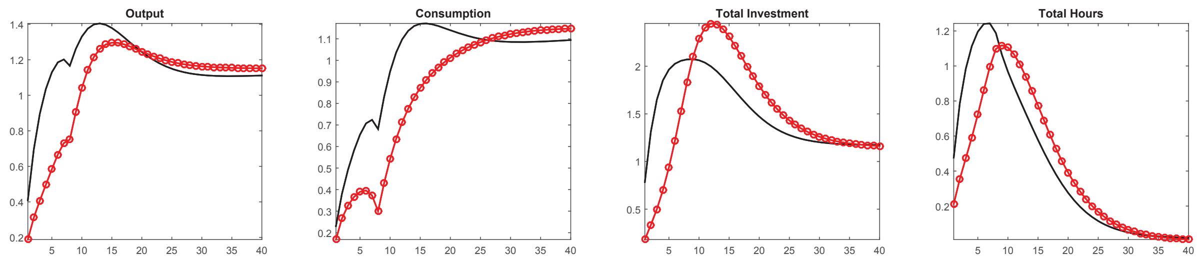

Figure 3: Responses to a one std. deviation sector-neutral TFP news shock (anticipated 8 quarters ahead). Baseline model (black solid line) vs. (nested) one sector model (line with circles). The horizontal axes refer to quarters and the units of the vertical axes are percentage deviations. In both experiments the shock is normalized to be of the same size.

A.6 Robustness checks

As explained in the main text, section 4, we undertake several robustness checks to assess the sensitivity of our key result, namely the strong empirical significance of TFP news shocks. To this end, we have estimated several different specifications. We summarize the variance decompositions (focussing on TFP shocks, unanticipated and news) from each of those specifications in Table 6.

Table 6. Our first specification removes observations from the most recent "Great Recession" period (2008Q1 to 2011Q1) addressing a potential concern that the volatility and disruption in financial markets following the Lehman collapse may be, at least partly, driving the important role of TFP news shocks in fluctuations, as well as potential misspecification of the monetary policy rule when the policy rate approaches the zero lower bound.

The second specification introduces smaller prior means for the standard deviations for all TFP news shocks, assuming that the sum of the variances of all TFP news components, evaluated at the prior means, is only one third of the variance of the respective unanticipated TFP component vs. one half assumed in the baseline.

The third specification, assumes Gamma distributions for all shocks in the model, allowing for a non-zero probability mass at zero for the standard deviations of news shocks.

The fourth specification, introduces a common stationary aggregate TFP process with unanticipated and news components. The common TFP process is assumed to follow,

$$f_t = (1-\rho_f)f + \rho_f f_{t-1} + \varepsilon_t^f, \qquad \text{with} \qquad \varepsilon_t^f = \varepsilon_{t,0}^f + \varepsilon_{t-4,4}^f + \varepsilon_{t-8,8}^f.$$

Here, each component is assumed, $N(0, \sigma^2_{f,t-h})$, $h = 0, 4, 8$, uncorrelated across horizon and time, and the parameter $\rho_f \in (0,1)$ determines the persistence of the process. This aggregate TFP shock is a natural candidate in generating broad based and sectoral comovement so it is interesting to check whether the importance of consumption sector TFP news shocks in accounting for the variance in the data is robust in this specification. With the common aggregate TFP process the sectoral production functions become,

$$C_t(i) = max\Big\{A_t f_t (L_{C,t}(i))^{1-a_c}(K_{C,t}(i))^{a_c} - A_t V_t^{\frac{a_c}{1-a_i}} F_C; 0\Big\}.$$

$$I_t(i) = max\Big\{V_t f_t (L_{I,t}(i))^{1-a_i}(K_{I,t}(i))^{a_i} - V_t^{\frac{1}{1-a_i}} F_I; 0\Big\},$$

In the estimated specification with the aggregate TFP shock, we indeed find that an aggregate TFP news shock induces qualitatively similar dynamics—and thus co-movement—to a consumption sector TFP news shock with the notable exception of hours worked. While hours worked rise on impact, they nevertheless decline significantly at the time when the positive aggregate TFP shock materializes.[4] This is grossly at odds with the empirical autocorrelations of hours worked in the data, which are strongly positively autocorrelated even at very long lags (extending even at 10 lags, see Figure 5, right bottom plot). A positive common TFP news shock at the four quarter horizon would instead generate counterfactual negative autocorrelations of hours worked at lags and leads beyond 1 and 2. Moreover, the variance shares explained by the aggregate TFP news components are very small and never exceed five percent in any observable.

The next specification introduces two wedges (as explained in the main text) between model implied and data corporate bond spread series. The processes for these are as follows,

$$wedge_t^{spread^x} = \rho_\kappa wedge_{t-1}^{spread^x} + \varepsilon_t^k. \quad x = C, I$$

As Table 6 reports, the estimated specifications discussed above identify a quantitatively important role played by TFP news shocks in accounting for fluctuations, consistent with the findings from the baseline specification.

[4]The IRFs are not shown but are available upon request.

Table 6: Spectral Variance Decompositions: Robustness

	Baseline Model			Baseline estimated with data prior to financial crisis			Model with smaller prior weights on news components		
	C-Sector TFP News	All TFP News	All TFP Shocks	C-Sector TFP News	All TFP News	All TFP Shocks	C-Sector TFP News	All TFP News	All TFP Shocks
Output	0.306	0.366	0.748	0.293	0.378	0.708	0.285	0.351	0.745
Consumption	0.291	0.303	0.568	0.276	0.309	0.537	0.268	0.282	0.563
Investment	0.208	0.306	0.730	0.194	0.337	0.727	0.196	0.304	0.734
Total Hours	0.432	0.494	0.720	0.406	0.501	0.697	0.410	0.482	0.717
Real Wage	0.215	0.379	0.623	0.230	0.434	0.653	0.179	0.371	0.618
Nom. Interest Rate	0.536	0.562	0.719	0.503	0.549	0.698	0.527	0.552	0.720
C-Sector Inflation	0.249	0.334	0.443	0.264	0.399	0.508	0.245	0.338	0.452
I-Sector Inflation	0.359	0.410	0.663	0.326	0.403	0.642	0.344	0.401	0.662
C-Sector Spread	0.390	0.400	0.556	0.362	0.382	0.526	0.372	0.381	0.548
I-Sector Spread	0.412	0.442	0.675	0.407	0.457	0.684	0.394	0.430	0.677
Equity	0.412	0.422	0.668	0.379	0.393	0.627	0.392	0.400	0.658
Rel. Price of Investment	0.042	0.117	0.787	0.051	0.142	0.765	0.041	0.110	0.762

	Model with Gamma distribution for all shock priors			Model with common aggregate TFP shock			Baseline with measurement wedges in bond spread equations		
	C-Sector TFP News	All TFP News	All TFP Shocks	C-Sector TFP News	All TFP News	All TFP Shocks	C-Sector TFP News	All TFP News	All TFP Shocks
Output	0.220	0.304	0.729	0.319	0.409	0.730	0.185	0.272	0.660
Consumption	0.253	0.269	0.642	0.309	0.376	0.620	0.251	0.288	0.403
Investment	0.150	0.270	0.642	0.224	0.308	0.661	0.085	0.215	0.709
Total Hours	0.306	0.390	0.622	0.408	0.476	0.669	0.215	0.300	0.588
Real Wage	0.159	0.352	0.650	0.177	0.356	0.574	0.059	0.343	0.499
Nom. Interest Rate	0.401	0.447	0.608	0.545	0.563	0.690	0.307	0.334	0.573
C-Sector Inflation	0.124	0.258	0.358	0.175	0.267	0.423	0.007	0.013	0.122
I-Sector Inflation	0.204	0.264	0.513	0.346	0.412	0.674	0.085	0.146	0.546
C-Sector Spread	0.405	0.424	0.612	0.403	0.441	0.573	0.327	0.409	0.549
I-Sector Spread	0.281	0.313	0.531	0.389	0.452	0.643	0.291	0.346	0.667
Equity	0.260	0.272	0.584	0.413	0.438	0.655	0.215	0.237	0.477
Rel. Price of Investment	0.019	0.117	0.738	0.062	0.108	0.693	0.036	0.147	0.746

Notes. The Table reports only the variance shares accounted for by all TFP shocks, unanticipated and news, thus they sum to less than 1. All specifications are estimated with the financial observables included. Business cycle frequencies considered in the decomposition correspond to periodic components with cycles between 6 and 32 quarters. The decomposition is performed using the spectrum of the DSGE model and an inverse first difference filter to reconstruct the levels for output, consumption, total investment, the real wage, equity and the relative price of investment. The spectral density is computed from the state space representation of the model with 500 bins for frequencies covering the range of periodicities. We report median shares. In the bottom right panel of the Table the wedges between model implied and data corporate bond spread series explain 15.6% (4.7%) of the forecast error variance in the C-sector (I-sector) spread and no variation in any other observable.

A.7 Prior and posterior distributions

Figure 4 displays the prior and posterior density functions of the share of the variance of the four main aggregates accounted for by TFP news shocks. The posterior distributions indicate a shift to the left of the priors as well as a smaller dispersion relative to the latter, suggesting an informative posterior.

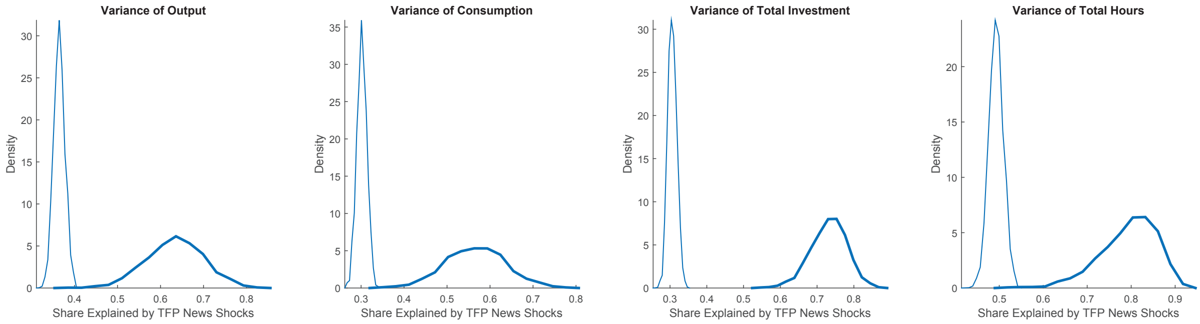

Figure 4: Prior (thick line) and posterior (thin line) probability density functions of the share explained by anticipated TFP shocks in the variance of key variables. Prior and posterior probability density functions were computed using 10,000 draws from the prior and posterior distributions, respectively. Business cycle frequencies considered in the decomposition correspond to periodic components with cycles between 6 and 32 quarters. The decomposition is performed using the spectrum of the DSGE model and an inverse first difference filter to reconstruct the levels for output, consumption and total investment. The spectral density is computed from the state space representation of the model with 500 bins for frequencies covering the range of periodicities. We consider median shares.

A.8 Capital quality shocks

Consumption specific TFP news shocks, relative to other disturbances, generate the right type of co-movements between aggregate quantities and prices. More specifically, (a) procyclical movements in quantities, (b) countercyclical movements in corporate bond spreads and a set of cross correlations of the latter with real macro aggregates in line with those in the data.

It is interesting to compare TFP news shocks with capital quality (or broadly interpreted financial) shocks that play a large role in the calibrated models of Gertler and Karadi (2011), Gertler and Kiyotaki (2010). Figure 5 presents dynamic correlations among key variables pertaining to facts (a) and (b) above, in the data (solid line), model with all shocks active (line with '+'), model with the dominant TFP news shock only active (and all other shocks set to zero—line with circles) and model with financial shocks only active. The dynamic correlations implied by the model simulated with consumption specific TFP news shocks only are very similar to the correlations generated by the model with all shocks active. Moreover, in some dimensions the correlations implied by the former (e.g. see subplots (1,3)—output growth with hours, (2,2)—output growth with C sector spread, (3,1)—investment growth with C sector spread, (3,2)—sectoral bond spreads, (3,3)—hours worked) are extremely well aligned to the empirical ones, highlighting their importance for the ability of the model to match them so closely. By contrast, the correlations implied by financial shocks are (in most dimensions) not as well aligned with the empirical correlations. Specifically, they fail in replicating key correlations in the data, most notably the correlation between the sectoral bond spreads—they imply a counterfactually negative correlation. Consequently, capital quality shocks are displaced in favor of TFP news shocks and they are estimated to play a relatively small role in accounting for fluctuations in the data.[5] A clue for this result lies in the sector specificity of these shocks. In a one sector model, a positive capital quality shock makes the entire capital stock worth more and generates the 'right' co-movement dynamics being a disturbance that increases the incentive to build capital overall. However, in our two sector framework a (sector specific) shock of this type creates a wedge in the relative attractiveness of capital. For example, a positive shock that hits the consumption sector capital, creates a strong incentive for agents to build more capital in that sector at the expense of capital allocated in the investment sector. The signal is provided by a rising price of capital in the consumption sector and a declining price of capital in the investment sector. This negative co-movement in capital prices results in the counterfactual (negative) correlation between the sectoral spreads.

The Figure below confirms the property of capital quality shocks discussed above.

[5]We have computed the historical decomposition of the model and found that these shocks, contribute significantly, namely about a third in the decline of GDP during the first stages of the Great Recession, consistent with their interpretation.

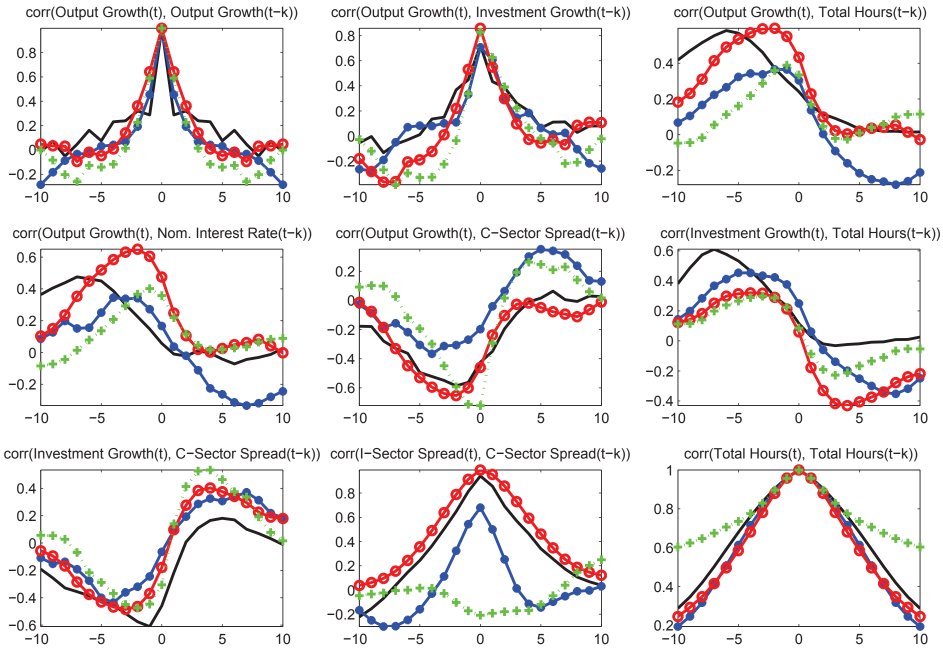

Figure 5: Dynamic correlations between key variables in the data (solid black line), implied by the baseline model with all shocks (blue line with stars), the baseline model with the eight quarter ahead consumption sector TFP news shock only (red line with circles) and the model with consumption and investment sector capital quality shocks only (green line with crosses).

Note in particular, the inability of this type of shock to predict the counter-cyclicality of both bond spreads and procyclicality of the I-sector capital price.

B Data Sources and Time Series Construction

Table 7 provides an overview of the data used to construct the observables. All the data transformations we have made in order to construct the dataset used for the estimation of the model are described in detail below.

Real and nominal variables. Consumption (in current prices) is defined as the sum of personal consumption expenditures on services and personal consumption expenditures on non-durable goods. The times series for real consumption is constructed as follows. First, we compute the shares of services and non-durable goods in total (current price) consumption. Then, total real consumption growth is obtained as the chained weighted (using the nominal shares above) growth rate of real services and growth rate

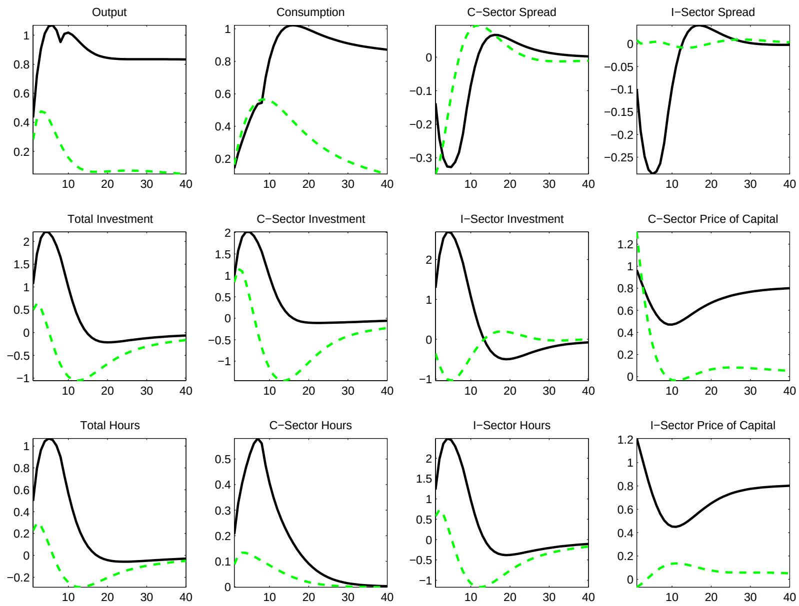

Figure 6: Black solid line is the IRF to the eight quarter ahead consumption sector TFP news shock. Dotted line is the IRF to a consumption specific capital quality shock.

of real non-durable goods. Using the growth rate of real consumption we construct a series for real consumption using 2005 as the base year. The consumption deflator is calculated as the ratio of nominal over real consumption. Inflation of consumer prices is the growth rate of the consumption deflator. Analogously, we construct a time series for the investment deflator using series for (current price) personal consumption expenditures on durable goods and gross private domestic investment and chain weight to arrive at the real aggregate. The relative price of investment is the ratio of the investment deflator and the consumption deflator. Real output is GDP expressed in consumption units by dividing current price GDP with the consumption deflator.

The hourly wage is defined as total compensation per hour. Dividing this series by the consumption deflator yields the real wage rate. Hours worked is given by hours of all persons in the non-farm business sector. All series described above as well as the equity capital series (described below) are expressed in per capita terms using the series of non-institutional population, ages 16 and over. The nominal interest rate is the effective federal funds rate. We use the monthly average per quarter of this series and divide it by four to account for the quarterly frequency of the model. The time series for hours is in

Table 7: Time Series used to construct the observables and steady state relationships

Time Series Description	Units	Code	Source
Gross domestic product	CP, SA, billion \$	GDP	BEA
Gross Private Domestic Investment	CP, SA, billion \$	GPDI	BEA
Real Gross Private Domestic Investment	CVM, SA, billion \$	GPDIC1	BEA
Personal Consumption Exp.: Durable Goods	CP, SA, billion \$	PCDG	BEA
Real Personal Consumption Exp.: Durable Goods	CVM, SA, billion \$	PCDGCC96	BEA
Personal Consumption Expenditures: Services	CP, SA, billion \$	PCESV	BEA
Real Personal Consumption Expenditures: Services	CVM, SA, billion \$	PCESVC96	BEA
Personal Consumption Exp.: Nondurable Goods	CP, SA, billion \$	PCND	BEA
Real Personal Consumption Exp.: Nondurable Goods	CVM, SA, billion \$	PCNDGC96	BEA
Civilian Noninstitutional Population	NSA, 1000s	CNP160V	BLS
Nonfarm Business Sector: Compensation Per Hour	SA, Index 2005=100	COMPNFB	BLS
Nonfarm Business Sector: Hours of All Persons	SA, Index 2005=100	HOANBS	BLS
Effective Federal Funds Rate	NSA, percent	FEDFUNDS	BG
Total Equity	NSA	EQTA	IEC
Total Assets	NSA	H.8	FRB
All Employees	SA	B-1	BLS
Average Weekly Hours	SA	B-7	BLS

CP = current prices, CVM = chained volume measures (2005 Dollars), SA = seasonally adjusted, NSA = not seasonally adjusted. BEA = U.S. Department of Commerce: Bureau of Economic Analysis, BLS = U.S. Department of Labor: Bureau of Labor Statistics and BG = Board of Governors of the Federal Reserve System, IEC = Federal Financial Institutions Examination Council, FRB = Federal Reserve Board.

logs. Moreover, all series used in estimation (including the financial time series described below) are expressed in deviations from their sample average.

Financial variables. Reuters' Datastream provides U.S. credit spreads for companies which we map into the two sectors using The North American Industry Classification System (NAICS). Details about the mapping are reported in Section 3.

C Model Details and Derivations

We provide the model details and derivations required for solution and estimation of the model. We begin with the pricing and wage decisions of firms and households, the financial sector followed by the normalization of the model to render it stationary, the description of the steady state and the log-linearized model equations.

C.1 Intermediate and Final Goods Producers

Intermediate producers pricing decision. A constant fraction $\xi_{p,x}$ of intermediate firms in sector $x = C, I$ cannot choose their price optimally in period t but reset their price — as in Calvo (1983) — according to the indexation rule,

$$P_{C,t}(i) = P_{C,t-1}(i)\pi_{C,t-1}^{\iota_{pC}}\pi_C^{1-\iota_{pC}},$$
$$P_{I,t}(i) = P_{I,t-1}(i)\pi_{I,t-1}^{\iota_{pI}}\pi_I^{1-\iota_{pI}}\left[\left(\frac{A_t}{A_{t-1}}\right)^{-1}\left(\frac{V_t}{V_{t-1}}\right)^{\frac{1-a_c}{1-a_i}}\right]^{\iota_{pI}},$$

where $\pi_{C,t} \equiv \frac{P_{C,t}}{P_{C,t-1}}$ and $\pi_{I,t} \equiv \frac{P_{I,t}}{P_{I,t-1}}\left(\frac{A_t}{A_{t-1}}\right)^{-1}\left(\frac{V_t}{V_{t-1}}\right)^{\frac{1-a_c}{1-a_i}}$ is gross inflation in the two sectors and π_C, π_I denote steady state values. The factor that appears in the investment sector expression adjusts for investment specific progress.

The remaining fraction of firms, $(1-\xi_{p,x})$, in sector $x = C, I$ can adjust the price in period t. These firms choose their price optimally by maximizing the present discounted value of future profits.

The resulting aggregate price index in the consumption sector is,

$$P_{C,t} = \left[(1-\xi_{p,C})\tilde{P}_{C,t}^{\frac{1}{\lambda_{p,t}^C}} + \xi_{p,C}\left(\left(\frac{\pi_{C,t-1}}{\pi}\right)^{\iota_{pC}}\pi_C^{1-\iota_{pC}}P_{C,t-1}\right)^{\frac{1}{\lambda_{p,t}^C}}\right]^{\lambda_{p,t}^C}.$$

The aggregate price index in the investment sector is,

$$P_{I,t} = \left[(1-\xi_{p,I})\tilde{P}_{I,t}^{\frac{1}{\lambda_{p,t}^I}} + \xi_{p,I}\left(P_{I,t-1}\left(\frac{\pi_{I,t-1}}{\pi}\right)^{\iota_{pI}}\pi_I^{1-\iota_{pI}}\left[\left(\frac{A_t}{A_{t-1}}\right)^{-1}\left(\frac{V_t}{V_{t-1}}\right)^{\frac{1-a_c}{1-a_i}}\right]^{\iota_{pI}}\right)^{\frac{1}{\lambda_{p,t}^I}}\right]^{\lambda_{p,t}^I}.$$

Final goods producers. Profit maximization and the zero profit condition for final good firms imply that sectoral prices of the final goods, $P_{C,t}$ and $P_{I,t}$, are CES aggregates of the prices of intermediate goods in the respective sector, $P_{C,t}(i)$ and $P_{I,t}(i)$,

$$P_{C,t} = \left[\int_0^1 P_{C,t}(i)^{\frac{1}{\lambda^C_{p,t}}} di \right]^{\lambda^C_{p,t}}, \qquad P_{I,t} = \left[\int_0^1 P_{I,t}(i)^{\frac{1}{\lambda^I_{p,t}}} di \right]^{\lambda^I_{p,t}}.$$

The elasticity $\lambda^x_{p,t}$ is the time varying price markup over marginal cost for intermediate firms. It is assumed to follow the exogenous stochastic process,

$$\log(1 + \lambda^x_{p,t}) = (1 - \rho_{\lambda^x_p}) \log(1 + \lambda^x_p) + \rho_{\lambda^x_p} \log(1 + \lambda^x_{p,t-1}) + \varepsilon^x_{p,t},$$

where $\rho_{\lambda^x_p} \in (0, 1)$ and $\varepsilon^x_{p,t}$ is $i.i.d.$ $N(0, \sigma^2_{\lambda^x_p})$, with $x = C, I$.

C.1.1 Household's wage setting

Each household $j \in [0, 1]$ supplies specialized labor, $L_t(j)$, monopolistically as in Erceg et al. (2000). A large number of competitive "employment agencies" aggregate this specialized labor into a homogenous labor input which is sold to intermediate goods producers in a competitive market. Aggregation is done according to the following function,

$$L_t = \left[\int_0^1 L_t(j)^{\frac{1}{1+\lambda_{w,t}}} dj \right]^{1+\lambda_{w,t}}.$$

The desired markup of wages over the household's marginal rate of substitution (or wage mark-up), $\lambda_{w,t}$, follows the exogenous stochastic process,

$$\log(1 + \lambda_{w,t}) = (1 - \rho_w) \log(1 + \lambda_w) + \rho_w \log(1 + \lambda_{w,t-1}) + \varepsilon_{w,t},$$

where $\rho_w \in (0, 1)$ and $\varepsilon_{w,t}$ is $i.i.d.$ $N(0, \sigma^2_{\lambda_w})$.

Profit maximization by the perfectly competitive employment agencies implies the labor demand function,

$$L_t(j) = \left(\frac{W_t(j)}{W_t} \right)^{-\frac{1+\lambda_{w,t}}{\lambda_{w,t}}} L_t, \qquad (1)$$

where $W_t(j)$ is the wage received from employment agencies by the supplier of labor of type j, while the wage paid by intermediate firms for the homogenous labor input is,

$$W_t = \left[\int_0^1 W_t(j)^{\frac{1}{\lambda_{w,t}}} dj \right]^{\lambda_{w,t}}.$$

Following Erceg et al. (2000), in each period, a fraction ξ_w of the households cannot freely adjust its wage but follows the indexation rule,

$$W_{t+1}(j) = W_t(j)\Big(\pi_{c,t}e^{z_t+\frac{a_c}{1-a_i}v_t}\Big)^{\iota_w}\Big(\pi_c e^{g_a+\frac{a_c}{1-a_i}g_v}\Big)^{1-\iota_w}.$$

The remaining fraction of households, $(1-\xi_w)$, chooses an optimal wage, $W_t(j)$, by maximizing,

$$E_t\Bigg\{\sum_{s=0}^{\infty}\xi_w^s\beta^s\Bigg[-b_{t+s}\varphi\frac{L_{t+s}(j)^{1+\nu}}{1+\nu}+\Lambda_{t+s}W_t(j)L_{t+s}(j)\Bigg]\Bigg\},$$

subject to the labor demand function (1). The aggregate wage evolves according to,

$$W_t = \Bigg\{(1-\xi_w)(\tilde{W}_t)^{\frac{1}{\lambda_w}}+\xi_w\Bigg[\Big(\pi_c e^{g_a+\frac{a_c}{1-a_i}g_v}\Big)^{1-\iota_w}\Big(\pi_{c,t-1}e^{z_{t-1}+\frac{a_c}{1-a_i}v_{t-1}}\Big)^{\iota_w}W_{t-1}\Bigg]^{\frac{1}{\lambda_w}}\Bigg\}^{\lambda_w},$$

where $\tilde{W}_t$ is the optimally chosen wage.

C.2 Physical capital producers

Capital producers in sector $x = C, I$ use a fraction of investment goods from final goods producers and undepreciated capital stock from capital services producers (as described above) to produce new capital goods, subject to investment adjustment costs as proposed by Christiano et al. (2005). These new capital goods are then sold in perfectly competitive capital goods markets to capital services producers. The technology available for physical capital production is given as,

$$O'_{x,t} = O_{x,t} + \Bigg(1 - S\Big(\frac{I_{x,t}}{I_{x,t-1}}\Big)\Bigg)I_{x,t},$$

where $O_{x,t}$ denotes the amount of used capital at the end of period t, $O'_{x,t}$ the new capital available for use at the beginning of period $t+1$. The investment adjustment cost function $S(\cdot)$ satisfies the following: $S(1) = S'(1) = 0$ and $S''(1) = \kappa > 0$, where "′"s denote differentiation. The optimization problem of capital producers in sector $x = C, I$ is given as,

$$\max_{I_{x,t},O_{x,t}} E_t\sum_{t=0}^{\infty}\beta^t\Lambda_t\Bigg\{Q_{x,t}\Bigg[O_{x,t}+\Bigg(1-S\Big(\frac{I_{x,t}}{I_{x,t-1}}\Big)\Bigg)I_{x,t}\Bigg]-Q_{x,t}O_{x,t}-\frac{P_{I,t}}{P_{C,t}}I_{x,t}\Bigg\},$$

where $Q_{x,t}$ denotes the price of capital (i.e. the value of installed capital in consumption units). The first order condition for investment goods is,

$$\frac{P_{I,t}}{P_{C,t}} = Q_{x,t}\left[1 - S\Big(\frac{I_{x,t}}{I_{x,t-1}}\Big) - S'\Big(\frac{I_{x,t}}{I_{x,t-1}}\Big)\frac{I_{x,t}}{I_{x,t-1}}\right] + \beta E_t Q_{x,t+1}\frac{\Lambda_{t+1}}{\Lambda_t}\left[S'\Big(\frac{I_{x,t+1}}{I_{x,t}}\Big)\Big(\frac{I_{x,t+1}}{I_{x,t}}\Big)^2\right].$$

From the capital producer's problem it is evident that any value of $O_{x,t}$ is profit maximizing. Let $\delta_x \in (0,1)$ denote the depreciation rate of capital and $\bar{K}_{x,t-1}$ the capital stock available at the beginning of period t in sector $x = C, I$. Then setting $O_{x,t} = (1-\delta)\xi^K_{x,t}\bar{K}_{x,t-1}$ implies the available (sector specific) capital stock in sector x, evolves according to,

$$\bar{K}_{x,t} = (1-\delta_x)\xi^K_{x,t}\bar{K}_{x,t-1} + \left(1 - S\Big(\frac{I_{x,t}}{I_{x,t-1}}\Big)\right)I_{x,t}, \qquad x = C, I, \tag{2}$$

as described in the main text.

C.3 Financial Intermediaries

This section describes in detail how the setup of Gertler and Karadi (2011) is adapted for the two sector model and describes in detail how the equations for financial intermediaries in the main text are derived.

The balance sheet for the consumption or investment sector branch can be expressed as,

$$P_{C,t}Q_{x,t}S_{x,t} = P_{C,t}N_{x,t} + B_{x,t}, \qquad x = C, I,$$

where $S_{x,t}$ denotes the quantity of financial claims held by the intermediary branch and $Q_{x,t}$ denotes the sector specific price of a claim. The variable $N_{x,t}$ represents the bank's wealth (or equity) at the end of period t and $B_{x,t}$ are the deposits the intermediary branch obtains from households. The sector specific assets held by the financial intermediary pay the stochastic return $R^B_{x,t+1}$ in the next period. Intermediaries pay at $t+1$ the non-contingent real gross return R_t to households for their deposits made at time t. Then, the intermediary branch equity evolves over time as,

$$
\begin{aligned}
N_{x,t+1}P_{C,t+1} &= R^B_{x,t+1}\pi_{C,t+1}P_{C,t}Q_{x,t}S_{x,t} - R_tB_{x,t}\\
N_{x,t+1}\frac{P_{C,t+1}}{P_{C,t}} &= R^B_{x,t+1}\pi_{C,t+1}Q_{x,t}S_{x,t} - R_t(Q_{x,t}S_{x,t} - N_{x,t})\\
N_{x,t+1} &= \left[(R^B_{x,t+1}\pi_{C,t+1} - R_t)Q_{x,t}S_{x,t} + R_tN_{x,t}\right]\frac{1}{\pi_{C,t+1}}.
\end{aligned}
$$

The premium, $R^B_{x,t+1}\pi_{C,t+1} - R_t$, as well as the quantity of assets, $Q_{x,t}S_{x,t}$, determines the growth in bank's equity above the riskless return. The bank will not fund any assets with a negative discounted premium. It follows that for the bank to operate in period i the following inequality must hold,

$$E_t\beta^i\Lambda^B_{t+1+i}(R^B_{x,t+1+i}\pi_{C,t+1+i} - R_{t+i}) \geq 0, \qquad i \geq 0,$$

where $\beta^i\Lambda^B_{t+1+i}$ is the bank's stochastic discount factor, with,

$$\Lambda^B_{t+1} \equiv \frac{\Lambda_{t+1}}{\Lambda_t},$$

where Λ_t is the Lagrange multiplier on the household's budget equation. Under perfect capital markets, arbitrage guarantees that the risk premium collapses to zero and the relation always holds with equality. However, under imperfect capital markets, credit constraints rooted in the bank's inability to obtain enough funds may lead to positive risk premia. As long as the above inequality holds, banks will keep building assets by borrowing additional funds from households. Accordingly, the intermediary branch objective is to maximize expected terminal wealth,

$$
\begin{aligned}
V_{x,t} =& maxE_t\sum_{i=0}(1-\theta_B)\theta_B^i\beta^i\Lambda^B_{t+1+i}N_{x,t+1+i}\\
=& maxE_t\sum_{i=0}(1-\theta_B)\theta_B^i\beta^i\Lambda^B_{t+1+i}[(R^B_{x,t+1+i}\pi_{C,t+1+i} - R_{t+i})\frac{Q_{x,t+i}S_{x,t+i}}{\pi_{C,t+1+i}} + \frac{R_{t+i}N_{x,t+i}}{\pi_{C,t+1+i}}],
\end{aligned}
\tag{3}
$$

where $\theta_B \in (0,1)$ is the fraction of bankers at t that survive until period $t+1$.

Following the setup in Gertler and Kiyotaki (2010) and Gertler and Karadi (2011) the banks are limited from infinitely borrowing additional funds from households by a moral hazard/costly enforcement problem. On the one hand, the agent who works in the bank can choose, at the beginning of each period, to divert the fraction λ_B of available funds and transfer it back to the household. On the other hand, depositors can force the bank into bankruptcy and recover a fraction $1-\lambda_B$ of assets. Note that the fraction, λ_B, which intermediaries can divert is the same across sectors to guarantee that the household is indifferent between lending funds between different branches.

Given this tradeoff, depositors will only lend funds to the intermediary when the latter's maximized expected terminal wealth is larger or equal to the gain from diverting the fraction λ_B of available funds. This incentive constraint can be formalized as,

$$V_{x,t} \geq \lambda_B Q_{x,t} S_{x,t}, \qquad 0 < \lambda_B < 1. \tag{4}$$

Using equation (3), the expression for $V_{x,t}$ can be written as the following first-order difference equation,

$$V_{x,t} = \nu_{x,t} Q_{x,t} S_{x,t} + \eta_{x,t} N_{x,t},$$

with,

$$\nu_{x,t} = E_t\{(1-\theta_B)\Lambda^B_{t+1}(R^B_{x,t+1}\pi_{C,t+1} - R_t) + \theta_B \beta Z^x_{1,t+1}\nu_{x,t+1}\},$$
$$\eta_{x,t} = E_t\{(1-\theta_B)\Lambda^B_{t+1}R_t + \theta_B \beta Z^x_{2,t+1}\eta_{x,t+1}\},$$

and,

$$Z^x_{1,t+1+i} \equiv \frac{Q_{x,t+1+i}S_{x,t+1+i}}{Q_{x,t+i}S_{x,t+i}}, \qquad Z^x_{2,t+1+i} \equiv \frac{N_{x,t+1+i}}{N_{x,t+i}}.$$

The variable $\nu_{x,t}$ can be interpreted as the expected discounted marginal gain of expanding assets $Q_{x,t}S_{x,t}$ by one unit while holding wealth $N_{x,t}$ constant. The interpretation of $\eta_{x,t}$ is analogous: it is the expected discounted value of having an additional unit of wealth, $N_{x,t}$, holding the quantity of financial claims, $S_{x,t}$, constant. The gross growth rate in assets is denoted by $Z^x_{1,t+i}$ and the gross growth rate of net worth is denoted by $Z^x_{2,t+i}$.

Then, using the expression for $V_{x,t}$, we can express the intermediary's incentive constraint (4) as,

$$\nu_{x,t} Q_{x,t} S_{x,t} + \eta_{x,t} N_{x,t} \geq \lambda_B Q_{x,t} S_{x,t}.$$

As indicated above, under perfect capital markets banks will expand borrowing until the risk premium collapses to zero which implies that in this case $\nu_{x,t}$ equals zero as well. Imperfect capital markets however, limit the possibilities for this kind of arbitrage because the intermediaries are constrained by their equity capital. If the incentive constraint binds it follows that,

$$\begin{aligned} Q_{x,t} S_{x,t} &= \frac{\eta_{x,t}}{\lambda_B - \nu_{x,t}} N_{x,t} \\ &= \varrho_{x,t} N_{x,t}. \end{aligned} \tag{5}$$

In this case, the quantity of assets which the intermediary can acquire depends on the equity capital, $N_{x,t}$, as well as the intermediary's leverage ratio, $\varrho_{x,t}$, limiting the bank's ability to acquire assets. This leverage ratio is the ratio of the bank's intermediated assets to equity. The bank's leverage ratio is limited to the point where its maximized expected terminal wealth equals the gains from diverting the fraction λ_B from available funds. However, the constraint (5) binds only if $0 < \nu_{x,t} < \lambda_B$ (given $N_{x,t} > 0$). This inequality is always satisfied with our estimates.

Using the leverage ratio (5) we can express the evolution of the intermediary's wealth as,

$$N_{x,t+1} = [(R^B_{x,t+1} \pi_{C,t+1} - R_t) \varrho_{x,t} + R_t] \frac{N_{x,t}}{\pi_{C,t+1}}.$$

From this equation it also follows that,

$$Z^x_{2,t+1} = \frac{N_{x,t+1}}{N_{x,t}} = \left[(R^B_{x,t+1} \pi_{C,t+1} - R_t) \varrho_{x,t} + R_t\right] \frac{1}{\pi_{C,t+1}},$$

and,

$$Z^x_{1,t+1} = \frac{Q_{x,t+1} S_{x,t+1}}{Q_{x,t} S_{x,t}} = \frac{\varrho_{x,t+1} N_{x,t+1}}{\varrho_{x,t} N_{x,t}} = \frac{\varrho_{x,t+1}}{\varrho_{x,t}} Z^x_{2,t+1}.$$

Financial intermediaries which are forced into bankruptcy are replaced by new entrants. Therefore, total wealth of financial intermediaries is the sum of the net worth of existing, $N^e_{x,t}$, and new ones, $N^n_{x,t}$,

$$N_{x,t} = N^e_{x,t} + N^n_{x,t}.$$

The fraction θ_B of bankers at $t-1$ which survive until t is equal across branches. Then, the law of motion for existing bankers is given by,

$$N^e_{x,t} = \theta_B[(R^B_{x,t}\pi_{C,t} - R_{t-1})\varrho_{x,t-1} + R_{t-1}]\frac{N_{x,t-1}}{\pi_{C,t}}, \qquad 0 < \theta_B < 1. \tag{6}$$

where a main source of variation is the ex-post excess return on assets, $R^B_{x,t}\pi_{C,t} - R_{t-1}$.

New banks receive startup funds from their respective household, equal to a small fraction of the value of assets held by the existing bankers in their final operating period. Given that the exit probability is *i.i.d.*, the value of assets held by the existing bankers in their final operating period is given by $(1-\theta_B)Q_{x,t}S_{x,t}$. The transfer to new intermediaries is a fraction, ϖ, of this value, leading to the following formulation for new banker's wealth,

$$N^n_{x,t} = \varpi Q_{x,t}S_{x,t}, \qquad 0 < \varpi < 1. \tag{7}$$

Existing banker's net worth (6) and entering banker's net worth (7) lead to the law of motion for total net worth,

$$N_{x,t} = \big(\theta_B[(R^B_{x,t}\pi_{C,t} - R_{t-1})\varrho_{x,t-1} + R_{t-1}]\frac{N_{x,t-1}}{\pi_{C,t}} + \varpi Q_{x,t}S_{x,t}\big).$$

The excess return, $x = C, I$ can be defined as,

$$R^S_{x,t} = R^B_{x,t+1}\pi_{C,t+1} - R_t.$$

Since R_t, λ_B, ϖ and θ_B are equal across sectors, the institutional setup of the two representative banks in the two sectors is symmetric. Both branches hold deposits from households and buy assets from firms in the sector they provide specialized lending. Their performance differs because the demand for capital differs across sectors resulting in sector specific prices of capital, $Q_{x,t}$, and nominal rental rates for capital, $R^K_{x,t}$. Note that the institutional setup of banks does not depend on firm-specific factors. Gertler and Karadi (2011) show that this implies a setup with a continuum of banks is equivalent to a formulation with a representative bank. Owing to the symmetry of the banks this also holds for our formulation of financial intermediaries in the two-sector setup.

C.4 Resource Constraints

The resource constraint in the consumption sector is,

$$C_t + (a(u_{C,t})\xi^K_{C,t}\bar{K}_{C,t-1} + a(u_{I,t})\xi^K_{I,t}\bar{K}_{I,t-1})\frac{A_t V_t^{\frac{a_c}{1-a_i}}}{V_t^{\frac{1}{1-a_i}}} = A_t L_{c,t}^{1-a_c} K_{c,t}^{a_c} - A_t V_t^{\frac{a_c}{1-a_i}} F_C.$$

The resource constraint in the investment sector is,

$$I_{I,t} + I_{C,t} = V_t L_{I,t}^{1-a_i} K_{I,t}^{a_i} - V_t^{\frac{1}{1-a_i}} F_I.$$

Hours worked are aggregated as,

$$L_t = L_{I,t} + L_{C,t}.$$

Bank equity is aggregated as,

$$N_t = N_{I,t} + N_{C,t}.$$

C.5 Stationary Economy

The model includes two non-stationary TFP shocks, A_t and V_t. This section shows how we normalize the model to render it stationary. Lower case variables denote normalized stationary variables.

The model variables can be stationarized as follows:

$$k_{x,t} = \frac{K_{x,t}}{V_t^{\frac{1}{1-a_i}}}, \qquad \bar{k}_{x,t} = \frac{\bar{K}_{x,t}}{V_t^{\frac{1}{1-a_i}}}, \qquad k_t = \frac{K_t}{V_t^{\frac{1}{1-a_i}}}, \tag{8}$$

$$i_{x,t} = \frac{I_{x,t}}{V_t^{\frac{1}{1-a_i}}}, \qquad i_t = \frac{I_t}{V_t^{\frac{1}{1-a_i}}}, \qquad c_t = \frac{C_t}{A_t V_t^{\frac{a_c}{1-a_i}}}, \tag{9}$$

$$r^K_{C,t} = \frac{R^K_{C,t}}{P_{C,t}} A_t^{-1} V_t^{\frac{1-a_c}{1-a_i}}, \qquad r^K_{I,t} = \frac{R^K_{I,t}}{P_{C,t}} A_t^{-1} V_t^{\frac{1-a_c}{1-a_i}}, \qquad w_t = \frac{W_t}{P_{C,t} A_t V_t^{\frac{a_c}{1-a_i}}}. \tag{10}$$

From

$$\begin{aligned}
\frac{P_{I,t}}{P_{C,t}} &= \frac{mc_{C,t}}{mc_{I,t}} \frac{1-a_c}{1-a_i} \frac{A_t}{V_t} \left(\frac{K_{I,t}}{L_{I,t}}\right)^{-a_i} \left(\frac{K_{C,t}}{L_{C,t}}\right)^{a_c} \\
&= \frac{mc_{C,t}}{mc_{I,t}} \frac{1-a_c}{1-a_i} A_t V_t^{\frac{a_c-1}{1-a_i}} \left(\frac{k_{I,t}}{L_{I,t}}\right)^{-a_i} \left(\frac{k_{C,t}}{L_{C,t}}\right)^{a_c},
\end{aligned}$$

follows that,

$$p_{i,t} = \frac{P_{I,t}}{P_{C,t}} A_t^{-1} V_t^{\frac{1-a_c}{1-a_i}}. \tag{11}$$

and the multipliers are normalized as,

$$\lambda_t = \Lambda_t A_t V_t^{\frac{a_c}{1-a_i}}, \qquad \phi_{x,t} = \Phi_{x,t} V_t^{\frac{1}{1-a_i}}. \tag{12}$$

where $\Phi_{x,t}$ denotes the multiplier on the respective capital accumulation equation. Using the growth of investment, it follows that the prices of capital can be normalized as,

$$q_{x,t} = Q_{x,t} A_t^{-1} V_t^{\frac{1-a_c}{1-a_i}}.$$

with the price of capital in sector x, defined as,

$$q_{x,t} = \phi_{x,t}/\lambda_t, \quad x = C, I.$$

Using the growth of capital, it follows,

$$s_{x,t} = \frac{S_{x,t}}{V_t^{\frac{1}{1-a_i}}}.$$

Then, it follows from entering bankers wealth equation (7) that,

$$n^n_{x,t} = N^n_{x,t} A_t^{-1} V_t^{\frac{-a_c}{1-a_i}}.$$

Total wealth, wealth of existing and entering bankers has to grow at the same rate,

$$n^e_{x,t} = N^e_{x,t} A_t^{-1} V_t^{\frac{-a_c}{1-a_i}}, \qquad n_{x,t} = N_{x,t} A_t^{-1} V_t^{\frac{-a_c}{1-a_i}}.$$

C.5.1 Intermediate goods producers

Firm's production function in the consumption sector:

$$c_t = L_{C,t}^{1-a_c} k_{C,t}^{a_c} - F_C. \tag{13}$$

Firm's production function in the investment sector:

$$i_t = L_{I,t}^{1-a_i} k_{I,t}^{a_i} - F_I. \tag{14}$$

Marginal costs in the consumption sector:

$$mc_{C,t} = (1-a_c)^{a_c-1} a_c^{-a_c} (r_{C,t}^K)^{a_c} w_t^{1-a_c}. \tag{15}$$

Marginal costs in the investment sector:

$$mc_{I,t} = (1-a_i)^{a_i-1} a_i^{-a_i} w_t^{1-a_i} (r_{I,t}^K)^{a_i} p_{i,t}^{-1}, \qquad \text{with} \quad p_{i,t} = \frac{P_{I,t}}{P_{C,t}}. \tag{16}$$

Capital labour ratios in the two sectors:

$$\frac{k_{C,t}}{L_{C,t}} = \frac{w_t}{r_{C,t}^K}\frac{a_c}{1-a_c}, \qquad\qquad \frac{k_{I,t}}{L_{I,t}} = \frac{w_t}{r_{I,t}^K}\frac{a_i}{1-a_i}. \tag{17}$$

C.5.2 Firms' pricing decisions

Price setting equation for firms that change their price in sector $x = C, I$:

$$0 = E_t\left\{\sum_{s=0}^{\infty} \xi_{p,x}^s \beta^s \lambda_{t+s} \tilde{x}_{t+s}\left[\tilde{p}_{x,t}\tilde{\Pi}_{t,t+s} - (1+\lambda_{p,t+s}^x) mc_{x,t+s}\right]\right\}, \tag{18}$$

with

$$\tilde{\Pi}_{t,t+s} = \prod_{k=1}^{s}\left[\left(\frac{\pi_{x,t+k-1}}{\pi_x}\right)^{\iota_{px}}\left(\frac{\pi_{x,t+k}}{\pi_x}\right)^{-1}\right] \quad \text{and} \quad \tilde{x}_{t+s} = \left(\frac{\tilde{P}_{x,t}}{P_{x,t}}\tilde{\Pi}_{t,t+s}\right)^{-\frac{1+\lambda_{p,t+s}^x}{\lambda_{p,t+s}^x}} x_{t+s}$$

$$\text{and} \quad \frac{\tilde{P}_{x,t}}{P_{x,t}} = \tilde{p}_{x,t}.$$

Aggregate price index in the consumption sector:

$$1 = \left[(1-\xi_{x,p})(\tilde{p}_{x,t})^{\frac{1}{\lambda_{p,t}^x}} + \xi_{x,p}\left[\left(\frac{\pi_{x,t-1}}{\pi_x}\right)^{\iota_{px}}\left(\frac{\pi_{x,t}}{\pi_x}\right)^{-1}\right]^{\frac{1}{\lambda_{p,t}^x}}\right]^{\lambda_{p,t}^x}.$$

It further holds that

$$\frac{\pi_{I,t}}{\pi_{C,t}} = \frac{p_{i,t}}{p_{i,t-1}}. \tag{19}$$

C.5.3 Household's optimality conditions and wage setting

Marginal utility of income:

$$\lambda_t = \frac{b_t}{c_t - hc_{t-1}\left(\frac{A_{t-1}}{A_t}\right)\left(\frac{V_{t-1}}{V_t}\right)^{\frac{a_c}{1-a_i}}} - \beta h \frac{b_{t+1}}{c_{t+1}\left(\frac{A_{t+1}}{A_t}\right)\left(\frac{V_{t+1}}{V_t}\right)^{\frac{a_c}{1-a_i}} - hc_t}. \tag{20}$$

Euler equation:

$$\lambda_t = \beta E_t \lambda_{t+1}\left(\frac{A_t}{A_{t+1}}\right)\left(\frac{V_t}{V_{t+1}}\right)^{\frac{a_c}{1-a_i}} R_t \frac{1}{\pi_{c,t+1}}.$$

Labor supply

$$\lambda_t w_t = b_t \varphi (L_{C,t} + L_{I,t})^{\nu},$$

C.5.4 Capital services

Optimal capital utilization:

$$r^K_{C,t} = a'_C(u_{C,t}), \qquad r^K_{I,t} = a'_I(u_{I,t}).$$

Definition of capital services:

$$k_{C,t} = u_{C,t}\xi^K_{C,t}\bar{k}_{C,t-1}\left(\frac{V_{t-1}}{V_t}\right)^{\frac{1}{1-a_i}}, \qquad k_{I,t} = u_{I,t}\xi^K_{I,t}\bar{k}_{I,t-1}\left(\frac{V_{t-1}}{V_t}\right)^{\frac{1}{1-a_i}}. \tag{21}$$

Optimal choice of available capital in sector $x = C, I$:

$$\phi_{x,t} = \beta E_t \xi^K_{x,t+1}\left\{\lambda_{t+1}\left(\frac{V_t}{V_{t+1}}\right)^{\frac{1}{1-a_i}}(r^K_{x,t+1}u_{x,t+1} - a(u_{x,t+1})) + (1-\delta)E_t\phi_{x,t+1}\left(\frac{V_t}{V_{t+1}}\right)^{\frac{1}{1-a_i}}\right\}, \tag{22}$$

C.5.5 Physical capital producers

Optimal choice of investment in sector $x = C, I$:

$$\lambda_t p_{i,t} = \phi_{x,t}\Bigg[1 - S\Big(\frac{i_{x,t}}{i_{x,t-1}}\Big(\frac{V_t}{V_{t-1}}\Big)^{\frac{1}{1-a_i}}\Big) - S'\Big(\frac{i_{x,t}}{i_{x,t-1}}\Big(\frac{V_t}{V_{t-1}}\Big)^{\frac{1}{1-a_i}}\Big)\frac{i_{x,t}}{i_{x,t-1}}\Big(\frac{V_t}{V_{t-1}}\Big)^{\frac{1}{1-a_i}}\Bigg]$$
$$+ \beta E_t \phi_{x,t+1}\Big(\frac{V_t}{V_{t+1}}\Big)^{\frac{1}{1-a_i}}\Bigg[S'\Big(\frac{i_{x,t+1}}{i_{x,t}}\Big(\frac{V_{t+1}}{V_t}\Big)^{\frac{1}{1-a_i}}\Big)\Big(\frac{i_{x,t+1}}{i_{x,t}}\Big(\frac{V_{t+1}}{V_t}\Big)^{\frac{1}{1-a_i}}\Big)^2\Bigg]. \tag{23}$$

Accumulation of capital in sector $x = C, I$:

$$\bar{k}_{x,t} = (1-\delta_x)\xi^K_{x,t}\bar{k}_{x,t-1}\Big(\frac{V_{t-1}}{V_t}\Big)^{\frac{1}{1-a_i}} + \Bigg(1 - S\Big(\frac{i_{x,t}}{i_{x,t-1}}\Big(\frac{V_t}{V_{t-1}}\Big)^{\frac{1}{1-a_i}}\Big)\Bigg)i_{x,t}, \tag{24}$$

C.5.6 Household's wage setting

Household's wage setting:

$$E_t\sum_{s=0}^{\infty}\beta^s\xi_w^s\lambda_{t+s}\tilde{L}_{t+s}\Bigg[\tilde{w}_t\tilde{\Pi}^w_{t,t+s} - (1+\lambda_{w,t+s})b_{t+s}\varphi\frac{\tilde{L}^{\nu}_{t+s}}{\lambda_{t+s}}\Bigg] = 0, \tag{25}$$

with

$$\tilde{\Pi}^w_{t,t+s} = \prod_{k=1}^{s}\Bigg[\Bigg(\frac{\pi_{C,t+k-1}e^{a_{t+k-1}+\frac{a_c}{1-a_i}v_{t+k-1}}}{\pi_c e^{g_a+\frac{a_c}{1-a_i}g_v}}\Bigg)^{\iota_w}\Bigg(\frac{\pi_{C,t+k}e^{a_{t+k}+\frac{a_c}{1-a_i}v_{t+k}}}{\pi_C e^{g_a+\frac{a_c}{1-a_i}g_v}}\Bigg)^{-1}\Bigg]$$

and

$$\tilde{L}_{t+s} = \Big(\frac{\tilde{w}_t\tilde{\Pi}^w_{t,t+s}}{w_{t+s}}\Big)^{-\frac{1+\lambda_{w,t+s}}{\lambda_{w,t+s}}}L_{t+s}.$$

Wages evolve according to

$$w_t = \Bigg\{(1-\xi_w)\tilde{w}_t^{\frac{1}{\lambda_{w,t}}} + \xi_w\Bigg[\Big(\frac{\pi_{c,t-1}e^{a_{t-1}+\frac{a_c}{1-a_i}v_{t-1}}}{\pi_c e^{g_a+\frac{a_c}{1-a_i}g_v}}\Big)^{l_w}\Big(\frac{\pi_{c,t}e^{a_t+\frac{a_c}{1-a_i}v_t}}{\pi_c e^{g_a+\frac{a_c}{1-a_i}g_v}}\Big)^{-1}w_{t-1}\Bigg]^{\frac{1}{\lambda_{w,t}}}\Bigg\}^{\lambda_{w,t}}.$$

C.5.7 Financial Intermediation

The stationary stochastic discount factor can be expressed as,

$$\lambda^B_{t+1} = \frac{\lambda_{t+1}}{\lambda_t}.$$

Then, one can derive expressions for $\nu_{x,t}$ and $\eta_{x,t}$,

$$\nu_{x,t} = E_t\{(1-\theta_B)\lambda^B_{t+1}\frac{A_t}{A_{t+1}}\Big(\frac{V_t}{V_{t+1}}\Big)^{\frac{a_c}{1-a_i}}(R^B_{x,t+1}\pi_{C,t+1}-R_t)+\theta_B\beta z^x_{1,t+1}\nu_{x,t+1}\},$$
$$\eta_{x,t} = E_t\{(1-\theta_B)\lambda^B_{t+1}\frac{A_t}{A_{t+1}}\Big(\frac{V_t}{V_{t+1}}\Big)^{\frac{a_c}{1-a_i}}R_t+\theta_B\beta z^x_{2,t+1}\eta_{x,t+1}\},$$

with

$$z^x_{1,t+1+i} \equiv \frac{q_{x,t+1+i}s_{x,t+1+i}}{q_{x,t+i}s_{x,t+i}}\frac{A_{t+1}}{A_t}\Big(\frac{V_{t+1}}{V_t}\Big)^{\frac{a_c}{1-a_i}}, \qquad z^x_{2,t+1+i} \equiv \frac{n_{x,t+1+i}}{n_{x,t+i}}\frac{A_{t+1}}{A_t}\Big(\frac{V_{t+1}}{V_t}\Big)^{\frac{a_c}{1-a_i}}.$$

It follows that if the bank's incentive constraint binds it can be expressed as,

$$\nu_{x,t}q_{x,t}s_{x,t}+\eta_{x,t}n_{x,t} = \lambda_B q_{x,t}s_{x,t}$$
$$\Leftrightarrow q_{x,t}s_{x,t} = \varrho_{x,t}n_{x,t},$$

with the leverage ratio given as,

$$\varrho_{x,t} = \frac{\eta_{x,t}}{\lambda_B-\nu_{x,t}}.$$

It further follows that:

$$z^x_{2,t+1} = \frac{n_{x,t+1}}{n_{x,t}}\frac{A_{t+1}}{A_t}\Big(\frac{V_{t+1}}{V_t}\Big)^{\frac{a_c}{1-a_i}} = \big[(R^B_{x,t+1}\pi_{C,t+1}-R_t)\varrho_{x,t}+R_t\big]\frac{1}{\pi_{C,t+1}},$$

and

$$z^x_{1,t+1} = \frac{q_{x,t+1}s_{x,t+1}}{q_{x,t}s_{x,t}}\frac{A_{t+1}}{A_t}\Big(\frac{V_{t+1}}{V_t}\Big)^{\frac{a_c}{1-a_i}} = \frac{\varrho_{x,t+1}n_{x,t+1}}{\varrho_{x,t}n_{x,t}}\frac{A_{t+1}}{A_t}\Big(\frac{V_{t+1}}{V_t}\Big)^{\frac{a_c}{1-a_i}} = \frac{\varrho_{x,t+1}}{\varrho_{x,t}}z^x_{2,t+1}.$$

The normalized equation for bank's wealth accumulation is,

$$n_{x,t} = \big(\theta_B[(R^B_{x,t}\pi_{C,t}-R_{t-1})\varrho_{x,t-1}+R_{t-1}]\frac{A_{t-1}}{A_t}\Big(\frac{V_{t-1}}{V_t}\Big)^{\frac{a_c}{1-a_i}}\frac{n_{x,t-1}}{\pi_{C,t}}+\varpi q_{x,t}s_{x,t}\big).$$

The borrow in advance constraint:

$$\bar{k}_{x,t+1} = s_{x,t}.$$

The leverage equation:

$$q_{x,t}s_{x,t} = \varrho_{x,t}n_{x,t}.$$

Bank's stochastic return on assets can be described in normalized variables as:

$$R^B_{x,t+1} = \frac{r^K_{x,t+1}u_{x,t+1}+q_{x,t+1}(1-\delta_x)-a(u_{x,t+1})}{q_{x,t}}\xi^K_{x,t+1}\frac{A_{t+1}}{A_t}\Big(\frac{V_{t+1}}{V_t}\Big)^{-\frac{1-a_c}{1-a_i}},$$

knowing from the main model that

$$r_{x,t}^K = \frac{R_{x,t}^K}{P_{x,t}} A_t^{-1} V_t^{\frac{1-a_c}{1-a_i}}.$$

C.5.8 Monetary policy and market clearing

Monetary policy rule:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\left(\frac{\pi_{C,t}}{\pi_C}\right)^{\phi_\pi} \left(\frac{y_t}{y_{t-1}}\right)^{\phi_{\Delta Y}}\right]^{1-\rho_R} \eta_{mp,t},$$

Resource constraint in the consumption sector:

$$c_t + (a(u_{C,t})\xi_{C,t}^K \bar{k}_{C,t-1} + a(u_{I,t})\xi_{I,t}^K \bar{k}_{I,t-1}) \left(\frac{V_{t-1}}{V_t}\right)^{\frac{1}{1-a_i}} = L_{C,t}^{1-a_c} k_{C,t}^{a_c} - F_C.$$

Resource constraint in the investment sector:

$$i_t = L_{I,t}^{1-a_i} k_{I,t}^{a_i} - F_I.$$

Definition of GDP:

$$y_t = c_t + p_{i,t} i_t + \left(1 - \frac{1}{g_t}\right) y_t. \tag{26}$$

Moreover

$$L_t = L_{I,t} + L_{C,t}, \qquad i_t = i_{C,t} + i_{I,t}, \qquad n_t = n_{C,t} + n_{I,t}.$$

C.6 Steady State

This section describes the model's steady state.

From the optimal choice of available capital (22) and the optimal choice of investment (23) in both sectors:

$$r_C^K = \left(\frac{e^{\frac{1}{1-a_i} g_v}}{\beta} - (1 - \delta_C)\right) p_i, \tag{27}$$

$$r_I^K = \left(\frac{e^{\frac{1}{1-a_i} g_v}}{\beta} - (1 - \delta_I)\right) p_i. \tag{28}$$

From firm's price setting in both sectors (18),

$$mc_C = \frac{1}{1+\lambda_p^C}, \qquad mc_I = \frac{1}{1+\lambda_p^I}. \tag{29}$$

Using equations (29) and imposing knowledge of the steady state expression for r_C^K and r_I^K, one can derive expressions for the steady state wage from the equations that define marginal costs in the two sectors ((15) and (16)).

Consumption sector:

$$w = \left(\frac{1}{1+\lambda_p^C}(1-a_c)^{1-a_c} a_c^{a_c} (r_C^K)^{-a_c}\right)^{\frac{1}{1-a_c}}. \tag{30}$$

Investment sector:

$$w = \left(\frac{1}{1+\lambda_p^I}(1-a_i)^{1-a_i} a_i^{a_i} (r_I^K)^{-a_i} p_i\right)^{\frac{1}{1-a_i}}. \tag{31}$$

Since labour can move across sectors the steady state wage has to be the same in the consumption and investment sector. The equality is verified by p_i. An expression for p_i can be found by setting (30) equal to (31):

$$\begin{aligned}
&\left(\frac{1}{1+\lambda_p^C}(1-a_c)^{1-a_c} a_c^{a_c} (r_C^K)^{-a_c}\right)^{\frac{1}{1-a_c}} = \left(\frac{1}{1+\lambda_p^I}(1-a_i)^{1-a_i} a_i^{a_i} (r_I^K)^{-a_i} p_i\right)^{\frac{1}{1-a_i}} \\
\Leftrightarrow &\left(\frac{1}{1+\lambda_p^C}(1-a_c)^{1-a_c} a_c^{a_c} \left(\frac{e^{\frac{1}{1-a_i}g_v}}{\beta} - (1-\delta_C)\right)^{-a_c} p_i^{-a_c}\right)^{\frac{1}{1-a_c}} \\
= &\left(\frac{1}{1+\lambda_p^I}(1-a_i)^{1-a_i} a_i^{a_i} \left(\frac{e^{\frac{1}{1-a_i}g_v}}{\beta} - (1-\delta_I)\right)^{-a_i} p_i^{-a_i} p_i\right)^{\frac{1}{1-a_i}} \\
\Leftrightarrow &p_i = \frac{\frac{1}{1+\lambda_p^C}(1-a_c)^{1-a_c} a_c^{a_c} \left(\frac{e^{\frac{1}{1-a_i}g_v}}{\beta} - (1-\delta_C)\right)^{-\alpha_c}}{\left[\frac{1}{1+\lambda_p^I}(1-a_i)^{1-a_i} a_i^{a_i} \left(\frac{e^{\frac{1}{1-a_i}g_v}}{\beta} - (1-\delta_I)\right)^{-\alpha_i}\right]^{\frac{1-a_c}{1-a_i}}}.
\end{aligned} \tag{32}$$

Knowing w, r_C^K and r_I^K, the expressions given in (17) can be used to find the steady state capital-to-labour ratios in the two sectors:

$$\frac{k_C}{L_C} = \frac{w}{r_C^K}\frac{a_c}{1-a_c}, \tag{33}$$

$$\frac{k_I}{L_I} = \frac{w}{r_I^K}\frac{a_i}{1-a_c}. \tag{34}$$

The zero profit condition for intermediate goods producers in the consumption sector,

$c - r_C^K k_C - wL_C = 0$, and (13) imply:

$$L_C^{1-a_c} k_C^{a_c} - F_C - r_C^K k_C - wL_C = 0$$
$$\Leftrightarrow \frac{F_C}{L_C} = \left(\frac{k_C}{L_C}\right)^{a_c} - r_C^K \frac{k_C}{L_C} - w.$$

Analogously the zero profit condition for intermediate goods producers in the investment sector, $i - r_I^K k_I - wL_I = 0$, and (14) imply:

$$\frac{F_I}{L_I} = \left(\frac{k_I}{L_I}\right)^{a_i} - r_I^K \frac{k_I}{L_I} - w.$$

These expressions pin down the steady state consumption-to-labour and investment-to-labour ratios which follow from the intermediate firms' production functions ((13) and (14)):

$$\frac{c}{L_C} = \left(\frac{k_C}{L_C}\right)^{a_c} - \frac{F_C}{L_C}, \qquad \frac{i}{L_I} = \left(\frac{k_I}{L_I}\right)^{a_i} - \frac{F_I}{L_I}.$$

$$1 + \lambda_p^C = \frac{c + F_C}{c} \Leftrightarrow \lambda_p^C c = F_C, \qquad \text{and} \qquad 1 + \lambda_p^I = \frac{i + F_I}{i} \Leftrightarrow \lambda_p^I i = F_I.$$

This and the steady state consumption-to-labour ratio can be used to derive an expression for steady state consumption:

$$c = \left(\frac{k_C}{L_C}\right)^{a_c} L_C - F_C$$
$$\Leftrightarrow c = \left(\frac{k_C}{L_C}\right)^{a_c} L_C - \lambda_p^C c$$
$$\Leftrightarrow c = \frac{1}{1 + \lambda_p^C} \left(\frac{k_C}{L_C}\right)^{a_c} L_C.$$

Analogously one can derive an expression for steady state investment:

$$i = \frac{1}{1 + \lambda_p^I} \left(\frac{k_I}{L_I}\right)^{a_i} L_I.$$

Combining these two expressions leads to,

$$p_i\frac{i}{c} = \frac{\frac{1}{1+\lambda_p^I}\left(\frac{k_I}{L_I}\right)^{a_i} L_I}{\frac{1}{1+\lambda_p^C}\left(\frac{k_C}{L_C}\right)^{a_c} L_C} p_i$$

$$\Leftrightarrow \frac{L_I}{L_C} = p_i\frac{i}{c}\frac{\frac{1}{1+\lambda_p^C}\left(\frac{k_C}{L_C}\right)^{a_c}}{\frac{1}{1+\lambda_p^I}\left(\frac{k_I}{L_I}\right)^{a_i}} p_i^{-1}.$$

Total labour L is set to unity in the steady state. However, since a_i and a_c are not necessarily calibrated to be equal one needs to fix another quantity in addition to $L = 1$. We fix the steady state investment-to-consumption ratio, $p_i\frac{i}{c}$, which equals 0.399 in the data. This allows us to derive steady state expressions for labour in the two sectors. Steady state labour in the investment sector is given by

$$L_I = 1 - L_C, \tag{35}$$

and the two equations above imply that steady state labour in the consumption sector can be expressed as,

$$L_C = \left(1 + p_i\frac{i}{c}\frac{\frac{1}{1+\lambda_p^C}\left(\frac{k_C}{L_C}\right)^{a_c}}{\frac{1}{1+\lambda_p^I}\left(\frac{k_I}{L_I}\right)^{a_i}} p_i^{-1}\right)^{-1}. \tag{36}$$

The steady state values for labour in the two sectors imply:

$$k_C = \frac{k_C}{L_C}L_C, \quad k_I = \frac{k_I}{L_I}L_I, \quad c = \frac{c}{L_C}L_C, \quad i = \frac{i}{L_I}L_I, \quad F_C = \frac{F_C}{L_C}L_C, \quad F_I = \frac{F_I}{L_I}L_I.$$

It follows from (21) that,

$$k_C = \bar{k}_C e^{-\frac{1}{1-a_i}g_v}, \qquad \text{and} \qquad k_I = \bar{k}_I e^{-\frac{1}{1-a_i}g_v}.$$

The accumulation equation of available capital (24) can be used to solve for investment in the two sectors:

$$i_C = k_C\left(e^{\frac{1}{1-a_i}g_v} - (1-\delta_C)\right), \tag{37}$$

$$i_I = k_I\left(e^{\frac{1}{1-a_i}g_v} - (1-\delta_I)\right). \tag{38}$$

From the definition of GDP (26):

$$y = c + p_i i + \left(1 - \frac{1}{g}\right)y.$$

From the marginal utility of income (20):

$$\lambda = \frac{1}{c - hce^{-g_a - \frac{a_c}{1-a_i}g_v}} - \frac{\beta h}{ce^{g_a + \frac{a_c}{1-a_i}g_v} - hc}.$$

From the household's wage setting (25)

$$\sum_{s=0}^{\infty} \beta^s \xi_w^s \lambda L\big[w - (1+\lambda_w)\varphi\frac{L^\nu}{\lambda}\big] = 0,$$

follows the expression for L:

$$w - (1-\lambda_w)\varphi\frac{L^\nu}{\lambda} = 0 \quad \Rightarrow \quad L = \Big[\frac{w\lambda}{(1+\lambda_w)\varphi}\Big]^{\frac{1}{\nu}}.$$

This expression can be solved for φ to be consistent with $L = 1$:

$$1 = \Big[\frac{w\lambda}{(1+\lambda_w)\varphi}\Big]^{\frac{1}{\nu}}$$
$$\Leftrightarrow \varphi = \frac{\lambda w}{1+\lambda_w}.$$

It further holds from equation (19) that,

$$\frac{\pi_I}{\pi_C} = e^{g_a - \frac{1-a_c}{1-a_i}g_v}$$

A system of 10 equations (27, 28, 30, 32, 33, 34, 35, 36, 37, 38) can be solved for the 10 steady state variables k_C, k_I, w, i_C, i_I, r_C^K, r_I^K, L_C, L_I and p_i. The steady state values for the remaining variables follow from the expressions above.

Given these steady state variables, the remaining steady state values which are mainly related to financial intermediaries can be derived as follows.

The nominal interest rate is given from the Euler equation as,

$$R = \frac{1}{\beta}e^{g_a + \frac{a_c}{1-a_i}g_v}\pi_C.$$

The bank's stationary stochastic discount factor can be expressed in the steady state as

$$\lambda^B = 1.$$

The steady state borrow in advance constraint implies that

$$\bar{k}_x = s_x.$$

The steady state price of capital is given by

$$q_{x,t} = p_{i,t}.$$

The steady state leverage equation is set equal to it's average value in the data over the sample period.

$$\frac{q_x s_x}{n_x} = \varrho_x = 5.47.$$

The parameters ϖ and λ_B help to align the value of the leverage ratio and the corporate bond spread with their empirical counterparts. Using the calibrated value for θ_B, the average value for the leverage ratio (5.47) and the weighted quarterly average of the corporate spreads ($R_x^B - R = 0.5\%$) allows calibrating ϖ using the bank's wealth accumulation equation,

$$\varpi = \Big[1 - \theta_B[(R_x^B \pi_C - R)\varrho_x + R]e^{-g_a - \frac{a_c}{1-a_i}g_v}\frac{1}{\pi_C}\Big]\Big(\frac{q_x s_x}{n_x}\Big)^{-1}.$$

Given the non-linearity in the leverage ratio, we solve numerically for the steady state expressions for η and ν using,

$$\nu_x = (1-\theta_B)\lambda^B e^{-g_a - \frac{a_c}{1-a_i}g_v}(R_x^B \pi_C - R) + \theta_B \beta z_1^x \nu_x,$$
$$\eta_x = (1-\theta_B)\lambda^B e^{-g_a - \frac{a_c}{1-a_i}g_v} R + \theta_B \beta z_2^x \eta_x,$$

with

$$z_2^x = \big[(R_x^B \pi_C - R)\varrho_x + R\big]\frac{1}{\pi_C}, \qquad \text{and} \qquad z_1^x = z_2^x,$$

and the steady state leverage ratio,

$$\varrho_x = \frac{\eta_x}{\lambda_B - \nu_x}.$$

C.7 Log-linearized Economy

This section collects the log-linearized model equations. The log-linear deviations of all variables are defined as

$$\hat{\varsigma}_t \equiv \log \varsigma_t - \log \varsigma,$$

except for

$$\hat{z}_t \equiv z_t - g_a,$$
$$\hat{v}_t \equiv v_t - g_v,$$
$$\hat{\lambda}^C_{p,t} \equiv \log(1+\lambda^C_{p,t}) - \log(1+\lambda^C_p),$$
$$\hat{\lambda}^I_{p,t} \equiv \log(1+\lambda^I_{p,t}) - \log(1+\lambda^I_p),$$
$$\hat{\lambda}_{w,t} \equiv \log(1+\lambda_{w,t}) - \log(1+\lambda_w).$$

C.7.1 Firm's production function and cost minimization

Production function for the intermediate good producing firm (i) in the consumption sector:

$$\hat{c}_t = \frac{c+F_I}{c}[a_c\hat{k}_{C,t} + (1-a_c)\hat{L}_{C,t}].$$

Production function for the intermediate good producing firm (i) in the investment sector:

$$\hat{i}_t = \frac{i+F_I}{i}[a_i\hat{k}_{I,t} + (1-a_i)\hat{L}_{I,t}].$$

Capital-to-labour ratios for the two sectors:

$$\hat{r}^K_{C,t} - \hat{w}_t = \hat{L}_{C,t} - \hat{k}_{C,t}, \qquad \hat{r}^K_{I,t} - \hat{w}_t = \hat{L}_{I,t} - \hat{k}_{I,t}. \tag{39}$$

Marginal cost in both sectors:

$$\hat{mc}_{C,t} = a_c\hat{r}^K_{C,t} + (1-a_c)\hat{w}_t, \qquad \hat{mc}_{I,t} = a_i\hat{r}^K_{I,t} + (1-a_i)\hat{w}_t - \hat{p}_{i,t}. \tag{40}$$

C.7.2 Firm's prices

Price setting equation for firms that change their price in sector $x = C, I$:

$$0 = E_t \left\{ \sum_{s=0}^{\infty} \xi_{p,x}^s \beta^s \left[\hat{\tilde{p}}_{x,t} \hat{\tilde{\Pi}}_{t,t+s} - \hat{\lambda}_{p,t+s}^x - \hat{mc}_{x,t+s} \right] \right\},$$

with

$$\hat{\tilde{\Pi}}_{t,t+s} = \sum_{k=1}^{s} [\iota_{p_x} \hat{\pi}_{t+k-1} - \hat{\pi}_{t+k}].$$

Solving for the summation

$$\begin{aligned}
\frac{1}{1-\xi_{p,x}\beta} \hat{\tilde{p}}_{x,t} =& E_t \left\{ \sum_{s=0}^{\infty} \xi_{p,x}^s \beta^s \big[-\hat{\Pi}_{t,t+s} + \hat{\lambda}_{p,t+s}^x + \hat{mc}_{x,t+s} \big] \right\} \\
=& -\hat{\Pi}_{t,t} + \hat{\lambda}_{p,t}^x + \hat{mc}_{x,t} - \frac{\xi_{p,x}\beta}{1-\xi_{p,x}\beta} \hat{\Pi}_{t,t+1} \\
&+ \xi_{p,x}\beta E_t \left\{ \sum_{s=1}^{\infty} \xi_{p,x}^{s-1} \beta^{s-1} \big[-\hat{\Pi}_{t+1,t+s} + \hat{\lambda}_{p,t+s}^x + \hat{mc}_{x,t+s} \big] \right\} \\
=& \hat{\lambda}_{p,t}^x + \hat{mc}_{x,t} + \frac{\xi_{p,x}\beta}{1-\xi_{p,x}\beta} E_t \big[\hat{\tilde{p}}_{x,t+1} - \hat{\Pi}_{t,t+1} \big],
\end{aligned}$$

where we used $\hat{\Pi}_{t,t} = 0$.

Prices evolve as

$$0 = (1-\xi_{p,x}) \hat{\tilde{p}}_{x,t} + \xi_{p,x} (\iota_{p_x} \hat{\pi}_{t-1} - \hat{\pi}),$$

from which we obtain the Phillips curve in sector $x = C, I$:

$$\begin{aligned}
\hat{\pi}_{x,t} &= \frac{\beta}{1+\iota_{p_x}\beta} E_t \hat{\pi}_{x,t+1} + \frac{\iota_{p_x}}{1+\iota_{p_x}\beta} \hat{\pi}_{x,t-1} + \kappa_x \hat{mc}_{x,t} + \kappa_x \hat{\lambda}_{p,t}^x, \\
\text{with} \quad \kappa_x &= \frac{(1-\xi_{p,x}\beta)(1-\xi_{p,x})}{\xi_{p,x}(1+\iota_{p_x}\beta)}.
\end{aligned} \tag{41}$$

From equation (19) it follows that

$$\hat{\pi}_{I,t} - \hat{\pi}_{C,t} = \hat{p}_{I,t} - \hat{p}_{I,t-1}.$$

C.7.3 Households

Marginal utility:

$$
\begin{aligned}
\hat{\lambda}_t =& \frac{e^G}{e^G - h\beta}\left[\hat{b}_t + \left(\hat{z}_t + \frac{a_c}{1-a_i}\hat{v}_t\right) - \left(\frac{e^G}{e^G-h}\left(\hat{c}_t + \hat{z}_t + \frac{a_c}{1-a_i}\hat{v}_t\right) - \frac{h}{e^G-h}\hat{c}_{t-1}\right)\right] \\
& - \frac{h\beta}{e^G - h\beta}E_t\left[\hat{b}_{t+1} - \left(\frac{e^G}{e^G-h}\left(\hat{c}_{t+1} + \hat{z}_{t+1} + \frac{a_c}{1-a_i}\hat{v}_{t+1}\right) - \frac{h}{e^G-h}\hat{c}_t\right)\right] \\
\Leftrightarrow \hat{\lambda}_t =& \alpha_1 E_t\hat{c}_{t+1} - \alpha_2\hat{c}_t + \alpha_3\hat{c}_{t-1} + \alpha_4\hat{z}_t + \alpha_5\hat{b}_t + \alpha_6\hat{v}_t,
\end{aligned}
\tag{42}
$$

with

$$
\begin{aligned}
&\alpha_1 = \frac{h\beta e^G}{(e^G-h\beta)(e^G-h)}, \quad \alpha_2 = \frac{e^{2G}+h^2\beta}{(e^G-h\beta)(e^G-h)}, \quad \alpha_3 = \frac{he^G}{(e^G-h\beta)(e^G-h)}, \\
&\alpha_4 = \frac{h\beta e^G\rho_z - he^G}{(e^G-h\beta)(e^G-h)}, \quad \alpha_5 = \frac{e^G - h\beta\rho_b}{e^G-h\beta}, \quad \alpha_6 = \frac{(h\beta e^G\rho_v - he^G)\frac{a_c}{1-a_i}}{(e^G-h\beta)(e^G-h)}, \\
&e^G = e^{g_a + \frac{a_c}{1-a_i}g_v}.
\end{aligned}
$$

This assumes the shock processes for $\hat{z}_t$ and $\hat{b}_t$.

Euler equation:

$$
\hat{\lambda}_t = \hat{R}_t + E_t\left(\hat{\lambda}_{t+1} - \hat{z}_{t+1} - \hat{v}_{t+1}\frac{a_c}{1-a_i} - \hat{\pi}_{C,t+1}\right). \tag{43}
$$

C.7.4 Investment and Capital

Capital utilization in both sectors:

$$
\hat{r}^K_{C,t} = \chi_C\hat{u}_{C,t}, \qquad \hat{r}^K_{I,t} = \chi_I\hat{u}_{I,t}, \qquad \text{where} \quad \chi_x = \frac{a''_x(1)}{a'_x(1)}. \tag{44}
$$

Choice of investment for the consumption sector:

$$
\begin{aligned}
\hat{q}_{C,t} =& e^{2(\frac{1}{1-a_i}g_v)}\kappa\left(\hat{i}_{C,t} - \hat{i}_{C,t-1} + \frac{1}{1-a_i}\hat{v}_t\right) - \beta e^{2(\frac{1}{1-a_i}g_v)}\kappa E_t\left(\hat{i}_{C,t+1} - \hat{i}_{C,t} + \frac{1}{1-a_i}\hat{v}_{t+1}\right) \\
& + \hat{p}_{i,t},
\end{aligned}
\tag{45}
$$

with $\hat{q}_{C,t} = \hat{\phi}_{C,t} - \hat{\lambda}_t$.

Choice of investment for the investment sector:

$$\begin{aligned}\hat{q}_{I,t} =& e^{2(\frac{1}{1-a_i}g_v)}\kappa\Big(\hat{\hat{i}}_{I,t} - \hat{\hat{i}}_{I,t-1} + \frac{1}{1-a_i}\hat{\upsilon}_t\Big) - \beta e^{2(\frac{1}{1-a_i}g_v)}\kappa E_t\Big(\hat{\hat{i}}_{I,t+1} - \hat{\hat{i}}_{I,t} + \frac{1}{1-a_i}\hat{\upsilon}_{t+1}\Big)\\ &+ \hat{p}_{i,t},\end{aligned} \tag{46}$$

with $\hat{q}_{I,t} = \hat{\phi}_{I,t} - \hat{\lambda}_t$.

Capital services input in both sectors:

$$\hat{k}_{C,t} = \hat{u}_{C,t} + \xi^K_{C,t} + \hat{\bar{k}}_{C,t-1} - \frac{1}{1-a_i}\hat{\upsilon}_t, \qquad \hat{k}_{I,t} = \hat{u}_{I,t} + \xi^K_{I,t} + \hat{\bar{k}}_{I,t-1} - \frac{1}{1-a_i}\hat{\upsilon}_t. \tag{47}$$

Capital accumulation in the consumption and investment sector:

$$\hat{\bar{k}}_{C,t} = (1-\delta_C)e^{-\frac{1}{1-a_i}g_v}\Big(\hat{\bar{k}}_{C,t-1} + \xi^K_{C,t} - \frac{1}{1-a_i}\hat{\upsilon}_t\Big) + \Big(1-(1-\delta_C)e^{-\frac{1}{1-a_i}g_v}\Big)\hat{\hat{i}}_{C,t}, \tag{48}$$

$$\hat{\bar{k}}_{I,t} = (1-\delta_I)e^{-\frac{1}{1-a_i}g_v}\Big(\hat{\bar{k}}_{I,t-1} + \xi^K_{I,t} - \frac{1}{1-a_i}\hat{\upsilon}_t\Big) + \Big(1-(1-\delta_I)e^{-\frac{1}{1-a_i}g_v}\Big)\hat{\hat{i}}_{I,t}. \tag{49}$$

C.7.5 Wages

The wage setting equation for workers renegotiating their salary:

$$0 = E_t\Big\{\sum_{s=0}^{\infty}\xi_w^s\beta^s\Big[\hat{\tilde{w}}_t + \hat{\tilde{\Pi}}^w_{t,t+s} - \hat{\lambda}_{w,t+s} - \hat{b}_{t+s} - \nu\hat{\tilde{L}}_{t+s} + \hat{\lambda}_{t+s}\Big]\Big\},$$

with

$$\hat{\tilde{\Pi}}^w_{t,t+s} = \sum_{k=1}^{s}\Big[\iota_w\Big(\hat{\pi}_{c,t+k-1} + \hat{z}_{t+k-1} + \frac{a_c}{1-a_i}\hat{\upsilon}_{t+k-1}\Big) - \Big(\hat{\pi}_{c,t+k} + \hat{z}_{t+k} + \frac{a_c}{1-a_i}\hat{\upsilon}_{t+k}\Big)\Big],$$

and

$$\hat{\tilde{L}}_{t+s} = \hat{L}_{t+s} - \Big(1+\frac{1}{\lambda_w}\Big)\big(\hat{\tilde{w}}_t + \hat{\tilde{\Pi}}^w_{t,t+s} - \hat{w}_{t+s}\big).$$

Then using the labor demand function,

$$
\begin{aligned}
0 =& E_t\Big\{\sum_{s=0}^{\infty}\xi_w^s\beta^s\Big[\hat{\tilde{w}}_t+\hat{\tilde{\Pi}}^w_{t,t+s}-\hat{\lambda}_{w,t+s}-\hat{b}_{t+s}\\
&-\nu\Big(\hat{L}_{t+s}-\Big(1+\frac{1}{\lambda_w}\Big)\big(\hat{\tilde{w}}_t+\hat{\tilde{\Pi}}^w_{t,t+s}-\hat{w}_{t+s}\big)\Big)+\hat{\lambda}_{t+s}\Big]\Big\}\\
\Leftrightarrow 0 =& E_t\Big\{\sum_{s=0}^{\infty}\xi_w^s\beta^s\Big[\hat{\tilde{w}}_t\Big(1+\nu\Big(1+\frac{1}{\lambda_w}\Big)\Big)+\hat{\tilde{\Pi}}^w_{t,t+s}-\hat{\lambda}_{w,t+s}-\hat{b}_{t+s}\\
&-\nu\Big(\hat{L}_{t+s}-\Big(1+\frac{1}{\lambda_w}\Big)\big(\hat{\tilde{\Pi}}^w_{t,t+s}-\hat{w}_{t+s}\big)\Big)+\hat{\lambda}_{t+s}\Big]\Big\}.
\end{aligned}
$$

Solving for the summation,

$$
\begin{aligned}
\frac{\nu_w}{1-\xi_w\beta}\hat{\tilde{w}}_t =& E_t\Big\{\sum_{s=0}^{\infty}\xi_w^s\beta^s\Big[-\Big(1+\nu\big(1+\frac{1}{\lambda_w}\big)\Big)\hat{\tilde{\Pi}}^w_{t,t+s}+\hat{\psi}_{t+s}\Big]\Big\}\\
=& -\nu_w\hat{\tilde{\Pi}}^w_{t,t}+\hat{\psi}_t+E_t\Big\{\sum_{s=0}^{\infty}\xi_w^s\beta^s\Big[-\nu_w\hat{\tilde{\Pi}}^w_{t,t+s}+\hat{\psi}_{t+s}\Big]\Big\}\\
=& \hat{\psi}_t-\frac{\xi_w\beta}{1-\xi_w\beta}\nu_w\hat{\Pi}^w_{t,t+1}+\xi_w\beta E_t\Big\{\sum_{s=0}^{\infty}\xi_w^s\beta^s[-\nu_w\hat{\Pi}^w_{t+1,t+1+s}+\hat{\psi}_{t+1+s}]\Big\}\\
=& \hat{\psi}_t+\frac{\xi_w\beta}{1-\xi_w\beta}\nu_w E_t\big[\hat{\tilde{w}}_{t+1}-\hat{\tilde{\Pi}}^w_{t,t+1}\big].
\end{aligned}
\tag{50}
$$

where

$$
\begin{aligned}
\hat{\psi}_t &\equiv \hat{\lambda}_{w,t}+\hat{b}_t+\nu\hat{L}_t+\nu\Big(1+\frac{1}{\lambda_w}\Big)\hat{w}_t-\hat{\lambda}_t, \qquad (51)\\
\nu_w &\equiv 1+\nu\Big(1+\frac{1}{\lambda_w}\Big),
\end{aligned}
$$

and recall that $\hat{\tilde{\Pi}}^w_{t,t}=0$.

Wages evolve as,

$$
\begin{aligned}
\hat{w}_t &= (1-\xi_w)\hat{\tilde{w}}_t+\xi_w\Big(\hat{w}_{t-1}+\iota_w\hat{\pi}_{c,t-1}+\iota_w\Big(\hat{z}_{t-1}+\frac{a_c}{1-a_i}\hat{v}_{t-1}\Big)-\hat{\pi}_{c,t}-\hat{z}_t-\frac{a_c}{1-a_i}\hat{v}_t\Big)\\
\Leftrightarrow \hat{w}_t &= (1-\xi_w)\hat{\tilde{w}}_t+\xi_w(\hat{w}_{t-1}+\hat{\tilde{\Pi}}^w_{t,t-1}).
\end{aligned}
\tag{52}
$$

Equation (52) can be solved for $\hat{\tilde{w}}_t$. This expression, as well as the formulation for $\hat{\psi}_t$ given in (51) can be plugged into equation (50). After rearranging this yields the wage Phillips curve,

$$\begin{aligned}\hat{w}_t =& \frac{1}{1+\beta}\hat{w}_{t-1} + \frac{\beta}{1+\beta}E_t\hat{w}_{t+1} - \kappa_w\hat{g}_{w,t} + \frac{\iota_w}{1+\beta}\hat{\pi}_{c,t-1} - \frac{1+\beta\iota_w}{1+\beta}\hat{\pi}_{c,t} \\ &+ \frac{\beta}{1+\beta}E_t\hat{\pi}_{c,t+1} + \kappa_w\hat{\lambda}_{w,t} + \frac{\iota_w}{1+\beta}\big(\hat{z}_{t-1} + \frac{a_c}{1-a_i}\hat{v}_{t-1}\big) \\ &- \frac{1+\beta\iota_w - \rho_z\beta}{1+\beta}\hat{z}_t - \frac{1+\beta\iota_w - \rho_v\beta}{1+\beta}\frac{a_c}{1-a_i}\hat{v}_t. \end{aligned} \tag{53}$$

where

$$\kappa_w \equiv \frac{(1-\xi_w\beta)(1-\xi_w)}{\xi_w(1+\beta)\big(1+\nu\big(1+\frac{1}{\lambda_w}\big)\big)},$$

$$\hat{g}_{w,t} \equiv \hat{w}_t - (\nu\hat{L}_t + \hat{b}_t - \hat{\lambda}_t).$$

C.7.6 Financial sector

The part of the economy concerned with the banking sector is described by the following equations:

The stochastic discount factor:

$$\hat{\lambda}_t^B = \hat{\lambda}_t - \hat{\lambda}_{t-1}. \tag{54}$$

Definition of ν for $x = C, I$:

$$\begin{aligned}\hat{\nu}_{x,t} =& (1-\theta_B\beta z_1^x)[\hat{\lambda}_{t+1}^B - \hat{z}_{t+1} - \frac{a_c}{1-a_i}\hat{v}_{t+1}] \\ &+ \frac{1-\theta_B\beta z_1^x}{R_x^B\pi_C - R}[R_x^B\pi_C\hat{R}_{x,t+1}^B + R_x^B\pi_C\hat{\pi}_{C,t+1} - R\hat{R}_t] + \theta_B\beta z_1^x[\hat{z}_{1,t+1}^x + \hat{\nu}_{x,t+1}]. \end{aligned} \tag{55}$$

Definition of η:

$$\begin{aligned}\hat{\eta}_{x,t} =& (1-\theta_B\beta z_2^x)[\hat{\lambda}_{t+1}^B - \hat{z}_{t+1} - \frac{a_c}{1-a_i}\hat{v}_{t+1} + \hat{R}_t] \\ &+ \theta_B\beta z_2^x[\hat{z}_{2,t+1}^x + \hat{\eta}_{t+1}], \qquad x = C, I. \end{aligned} \tag{56}$$

Definition of z_1:

$$\hat{z}_{1,t}^x = \hat{\varrho}_{x,t} - \hat{\varrho}_{x,t-1} + \hat{z}_{2,t}^x, \qquad x = C, I. \tag{57}$$

Definition of z_2 for $x = C, I$:

$$\hat{z}^x_{2,t} = \frac{\pi_C}{(R^B_x - R)\varrho_x + R}[R^B_x \varrho_x[\hat{R}^B_{x,t} + \hat{\pi}_{C,t}] + \frac{R}{\pi_C}(1-\varrho_x)\hat{R}_{t-1} + (R^B_x \pi_C - R)\frac{\varrho_x}{\pi_C}\hat{\varrho}_{x,t-1}] - \hat{\pi}_{C,t}. \tag{58}$$

The leverage ratio:

$$\hat{\varrho}_{x,t} = \hat{\eta}_{x,t} + \frac{\nu}{\lambda_B - \nu}\hat{\nu}_{x,t}, \qquad x = C, I. \tag{59}$$

The leverage equation:

$$\hat{q}_{x,t} + \hat{s}_{x,t} = \hat{\varrho}_{x,t} + \hat{n}_{x,t}. \tag{60}$$

The bank's wealth accumulation equation

$$\begin{aligned}\hat{n}_{x,t} =& \theta_B \frac{\varrho_x}{\pi_C} e^{-g_a - \frac{a_c}{1-a_i}g_v}\Big[R^B_x \pi_C[\hat{R}^B_{x,t} + \hat{\pi}_{C,t}] + \Big(\frac{1}{\varrho_x} - 1\Big)R\hat{R}_{t-1} + (R^B_x\pi_C - R)\hat{\varrho}_{x,t-1}\Big] \\ &+ \frac{\theta_B}{\pi_C} e^{-g_a - \frac{a_c}{1-a_i}g_v}[(R^B_x\pi_C - R)\varrho_x + R]\Big[-\hat{z}_t - \frac{a_c}{1-a_i}\hat{v}_t + \hat{n}_{x,t-1} - \hat{\pi}_{C,t}\Big] \\ &+ (1 - \frac{\theta_B}{\pi_C} e^{-g_a - \frac{a_c}{1-a_i}g_v}[(R^B_x\pi_C - R)\varrho_x + R])[\hat{q}_{x,t} + \hat{s}_{x,t}], \qquad x = C, I.\end{aligned} \tag{61}$$

The borrow in advance constraint:

$$\hat{\bar{k}}_{x,t+1} = \hat{s}_{x,t}, \qquad x = C, I. \tag{62}$$

The bank's stochastic return on assets in sector $x = C, I$:

$$\hat{R}^B_{x,t} = \frac{1}{r^K_x + q_x(1-\delta_x)}[r^K_x(\hat{r}^K_{x,t} + \hat{u}_{x,t}) + q_x(1-\delta_x)\hat{q}_{x,t}] - \hat{q}_{x,t-1} + \xi^K_{x,t} + \hat{z}_t - \frac{1-a_c}{1-a_i}\hat{v}_t. \tag{63}$$

Excess (nominal) return:

$$\hat{R}^S_{x,t} = \frac{R^B_x\pi_C}{R^B_x\pi_C - R}(\hat{R}^B_{x,t+1} + \hat{\pi}_{C,t+1}) - \frac{R}{R^B_x\pi_C - R}\hat{R}_t, \qquad x = C, I. \tag{64}$$

C.7.7 Monetary policy and market clearing

Monetary policy rule:

$$\hat{R}_t = \rho_R\hat{R}_{t-1} + (1-\rho_R)\Big[\phi_\pi\hat{\pi}_{c,t} + \phi_{\Delta Y}(\hat{y}_t - \hat{y}_{t-1})\Big] + \hat{\eta}_{mp,t} \tag{65}$$

Resource constraint in the consumption sector:

$$\hat{c}_t + \left(r_C^K \frac{\bar{k}_C}{c}\hat{u}_{C,t} + r_I^K \frac{\bar{k}_I}{c}\hat{u}_{I,t}\right)e^{-\frac{1}{1-a_i}g_v} = \frac{c+F_c}{c}[a_c\hat{k}_{C,t} + (1-a_c)\hat{L}_{C,t}] \tag{66}$$

Resource constraint in the investment sector:

$$\hat{i}_t = \frac{i+F_I}{i}[a_i\hat{k}_{I,t} + (1-a_i)\hat{L}_{I,t}] \tag{67}$$

Definition of GDP:

$$\hat{y}_t = \frac{c}{c+p_i i}\hat{c}_t + \frac{p_i i}{c+p_i i}(\hat{i}_t + \hat{p}_{i,t}) + \hat{g}_t. \tag{68}$$

Market clearing:

$$\frac{L_C}{L}\hat{L}_{C,t} + \frac{L_I}{L}\hat{L}_{I,t} = \hat{L}_t, \quad \frac{i_C}{i}\hat{i}_{C,t} + \frac{i_I}{i}\hat{i}_{I,t} = \hat{i}_t, \quad \frac{n_C}{n}\hat{n}_{C,t} + \frac{n_I}{n}\hat{n}_{I,t} = \hat{n}_t. \tag{69}$$

C.7.8 Exogenous processes

The 10 exogenous processes of the model can be written in log-linearized form as follows:

Price markup in sector $x = C, I$:

$$\hat{\lambda}^x_{p,t} = \rho_{\lambda^x_p}\hat{\lambda}^x_{p,t-1} + \varepsilon^x_{p,t}. \tag{70}$$

The TFP growth (consumption sector):

$$\hat{z}_t = \rho_z\hat{z}_{t-1} + \varepsilon^z_t. \tag{71}$$

The TFP growth (investment sector):

$$\hat{v}_t = \rho_v\hat{v}_{t-1} + \varepsilon^v_t. \tag{72}$$

Wage markup:

$$\hat{\lambda}_{w,t} = \rho_w\hat{\lambda}_{w,t-1} + \varepsilon_{w,t}. \tag{73}$$

Preference:

$$\hat{b}_t = \rho_b\hat{b}_{t-1} + \varepsilon^b_t. \tag{74}$$

Monetary policy:

$$\hat{\eta}_{mp,t} = \varepsilon^{mp}_t. \tag{75}$$

Government spending:

$$\hat{g}_t = \rho_g \hat{g}_{t-1} + \varepsilon_t^g. \tag{76}$$

Capital quality in sector $x = C, I$:

$$\hat{\xi}_{x,t}^K = \rho_{\xi^K,x} \hat{\xi}_{x,t-1}^K + \varepsilon_{x,t}^{\xi^K} \tag{77}$$

The entire log-linear model is summarized by equations (39) - (49) and (53) - (69) as well as the shock processes (70) - (77).

C.8 Measurement equations

For estimation, model variables are linked with observables using measurement equations. Letting a superscript "d" denote observable series, then the model's measurement equations are as follows:

Real consumption growth,

$$\Delta C_t^d \equiv \log\left(\frac{C_t}{C_{t-1}}\right) = \log\left(\frac{c_t}{c_{t-1}}\right) + \hat{z}_t + \frac{a_c}{1-a_i}\hat{v}_t,$$

Real investment growth,

$$\Delta I_t^d \equiv \log\left(\frac{I_t}{I_{t-1}}\right) = \log\left(\frac{i_t}{i_{t-1}}\right) + \frac{1}{1-a_i}\hat{v}_t,$$

Real wage growth,

$$\Delta W_t^d \equiv \log\left(\frac{W_t}{W_{t-1}}\right) = \log\left(\frac{w_t}{w_{t-1}}\right) + \hat{z}_t + \frac{a_c}{1-a_i}\hat{v}_t,$$

Real output growth,

$$\Delta Y_t^d \equiv \log\left(\frac{Y_t}{Y_{t-1}}\right) = \log\left(\frac{y_t}{y_{t-1}}\right) + \hat{z}_t + \frac{a_c}{1-a_i}\hat{v}_t,$$

Consumption sector inflation,

$$\pi_{C,t}^d \equiv \pi_{C,t} = \hat{\pi}_{C,t} \quad \text{and} \quad \hat{\pi}_{C,t} = \log(\pi_{C,t}) - \log(\pi_C),$$

Investment sector inflation,

$$\pi_{I,t}^d \equiv \pi_{I,t} = \hat{\pi}_{I,t} \quad \text{and} \quad \hat{\pi}_{I,t} = \log(\pi_{I,t}) - \log(\pi_I),$$

Total hours worked,

$$L_t^d \equiv \log L_t = \hat{L}_t,$$

Nominal interest rate (federal funds rate),

$$R_t^d \equiv \log R_t = \log \hat{R}_t,$$

Consumption sector corporate spread,

$$R_{C,t}^{S,d} \equiv \log R_{C,t}^S = \frac{R_x^B \pi_C}{R_x^B \pi_C - R}(\log \hat{R}_{C,t+1}^B + \log \hat{\pi}_{C,t+1}) - \frac{R}{R_x^B \pi_C - R} \log \hat{R}_t,$$

Investment sector corporate spread,

$$R_{I,t}^{S,d} \equiv \log R_{I,t}^S = \frac{R_x^B \pi_C}{R_x^B \pi_C - R}(\log \hat{R}_{I,t+1}^B + \log \hat{\pi}_{C,t+1}) - \frac{R}{R_x^B \pi_C - R} \log \hat{R}_t,$$

Real total equity capital growth,

$$\begin{aligned} \Delta N_t^d \equiv& \log\left(\frac{N_t}{N_{t-1}}\right) \\ =& e^{g_a + \frac{a_c}{1-a_i} g_v} \left(\frac{n_C}{n_C + n_I}(\hat{n}_{C,t} - \hat{n}_{C,t-1}) + \frac{n_I}{n_C + n_I}(\hat{n}_{I,t} - \hat{n}_{I,t-1}) + \hat{z}_t + \frac{a_c}{1-a_i}\hat{v}_t\right). \end{aligned}$$

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