Recessions, Recoveries, and Leverage

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Abstract

When leverage is low, recoveries from recessions are likely to eventually return the economy to its pre-recession growth path. When leverage is high, recoveries are likely to leave the economy below its pre-recession growth path. In other words, low-leverage recessions are likely to be U-shaped while high-leverage recessions are likely to be L-shaped. The increase in leverage over the post-War period that recent recessions are much more likely to be L-shaped. In particular, there is strong evidence that the Great Recession was L-shaped. We find similar effects of leverage for a number of other countries, but not all.

Keywords: Recession, recovery, leverage

JEL codes: E3, E32

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1 Introduction

There has been an increase in business-cycle asymmetry in the latter part of the post-War period that is associated with a rise in financial leverage, as is extensively documented in Jensen et al. (2020). We provide here a Markov-switching model of the business-cycle in which leverage affects the probability that an expansion will end with an L-shaped recession versus a U-shaped recession. As illustrated in Figure 1, in a U-shaped recession the economy eventually recovers all the way to the pre-recession growth path. In contrast, in an L-shaped recession there is a permanent loss as the economy eventually recovers to the pre-recession rate of growth but never fully recovers to the level projected from the previous expansion. Because high leverage is associated with L-shaped recessions, recessions during periods of high-leverage are much more damaging to the economy. While initial losses from recessions are larger when leverage is low, by 10 periods after the onset of recession we estimate that the cumulative loss to the economy will be 10 percentage points of GDP greater when leverage is high.

We find that post-1984 recessions are much more likely to be L-shaped. When we compare high-leverage to low-leverage situations our point estimate is that the probability of entering an L-shaped recession as compared to the probability of entering a U-shaped recession is greater by a factor of 24. When leverage is low, the probability of entering a U-shaped recession is greater by a factor of 4. When we apply the same model to a number of other developed countries we find that leverage helps explain recession shapes for most countries, but not for all.

Jensen et al. (2020) show the rise in financial leverage in the post-War period. We show our version of the leverage data in Figure 2.[1] In the model offered in Jensen et al. (2020), the operative mechanism is that shocks during high-leverage periods are likely to result in constraints on investment. Reduced investment has a long-lasting negative effect

[1] We use the credit-to-GDP ratio for easier comparison across countries, as in the international results in Jensen et al. (2020). We obtain similar results for the U.S. with the loan-to-asset ratio and loan-to-GDP ratio used by Jensen et al. (2020).

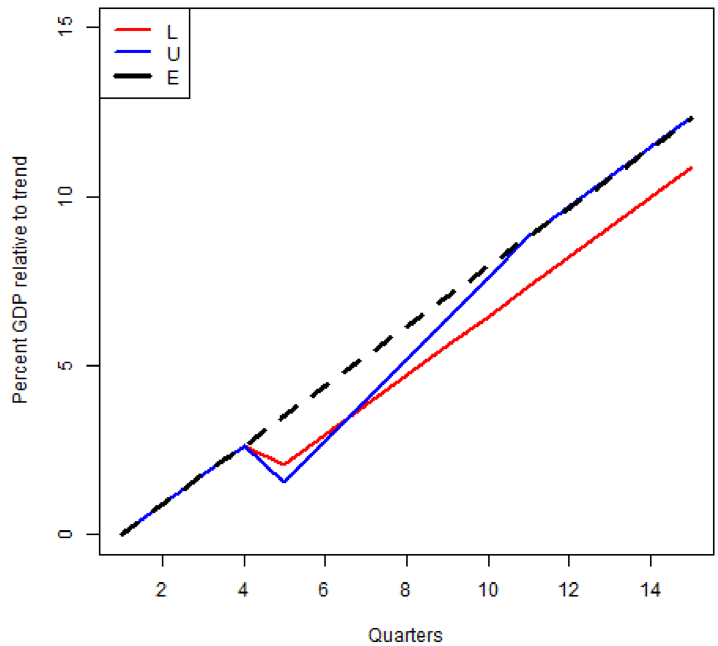

Figure 1: L-shaped versus U-shaped Recessions

on the capital stock. Long-lasting reduced capital stock means less production, which in our empirical work is modeled as an L-shaped recession.

Our paper also makes one other contribution to the literature on the shape of recessions—we find strong evidence that the Great Recession was L-shaped. The literature on recession shapes has taken two approaches. Luo et al. (2021) begins with accepting the NBER recession chronology as correctly identifying recessions. The authors then allow each recession to take on either shape and use Bayesian model averaging to compute the probability that a given recession took should be classified as L-shaped or U-shaped. Notably, the authors find very strong evidence that the Great Recession was L-shaped. In a different approach, rather than accept NBER recession dates Eo and Morley (2022) develop a univariate Markov-switching model of real GDP growth that accommodates two different types of recessions, i.e., L- and U-shaped. (Their estimated recession dates turn out to be quite close to the NBER chronology.) One can think of the Eo and Morley (2022) model

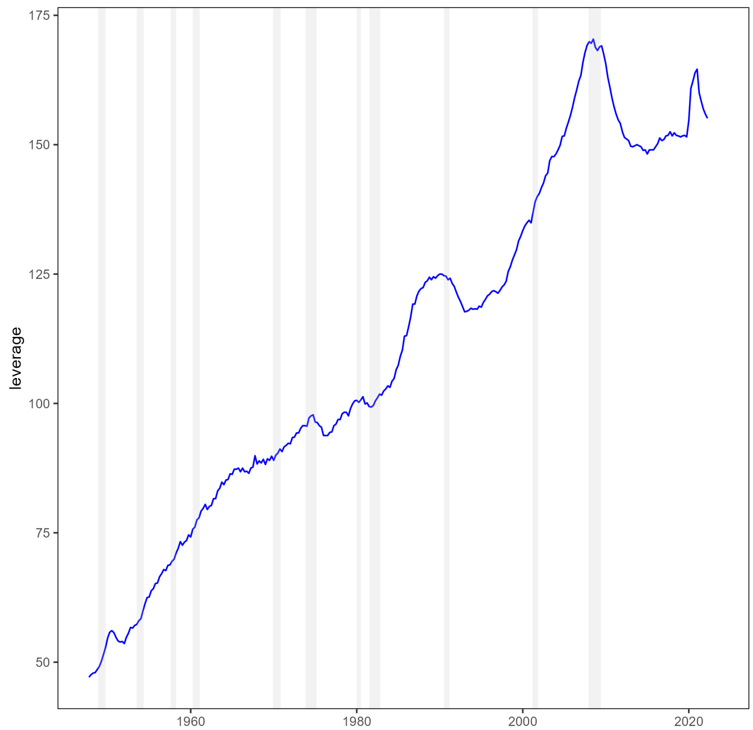

Figure 2: Financial Leverage

as an extension of Hamilton (1989) (see also Chauvet (1998)) in which there are three Markov states: expansions, U-shaped recessions, and L-shaped recessions. Switches are allowed between expansions and either recession state, but direct switches between the recession states are not allowed. In contrast to the Luo et al. 2021 finding, the authors find very strong evidence that the Great Recession was U-shaped. In our empirical approach we extend the Eo-Morley model to allow state probabilities to be leverage-dependent. Our extended model offers strong support for the Great Recession to be L-shaped.

2 Model and Results

The Eo and Morley (2022) model assumes that log output growth, Δy_t, has the following time-varying process based on three regimes.

$$\Delta y_t = \mu_E + \mu_L \times I(S_t = L) + \mu_U \times I(S_t = U) + \lambda_U \times \sum_{k=1}^{m} I(S_{t-k} = U) + \delta \times I(t > \tau) + e_t, \quad (1)$$

where $e_t \sim N(0, \sigma_t^2)$, with $\sigma_t^2 = \sigma_{\nu 0}^2 \times I(t \leq \tau_\nu) + \sigma_{\nu 1}^2 \times I(t > \tau_\nu)$, and $I(\cdot)$ is an indicator function. S_t is a latent Markov-switching state variable that takes on discrete values such that $S_t = E$ for the expansionary regime, $S_t = L$ for the L-shaped contractionary regime, and $S_t = U$ for the U-shaped contractionary regime according to transition probabilities $Pr[S_t = j | S_{t-1} = i] = p_{ij}$ for $i, j = E, L, U$. We maintain three assumptions from Eo and Morley (2022). First we assume the break dates $\tau = 2006Q1$ for trend growth and $\tau_\nu = 1984Q2$ for residual volatility. Second, we impose two identification assumptions. The first identifying assumption is that the economy does not switch between contractionary regimes without going through an expansionary regime first. That is, $p_{LU} = 0$ and $p_{UL} = 0$. The second identifying assumption is that the U-shaped regime does not have permanent effects on the level of output and imposes the restriction $\mu_U + m \times \lambda_U = 0$, so that in a U-shaped recession the economy recovers fully after m periods, and we follow Eo and Morley (2022) by setting $m = 6$.

Figure 3 shows the main results from the our re-estimation of the Eo and Morley (2022) model. The Great Recession is classified as U-shaped, with only a small probability of an L-shaped regime at the beginning of the recession.

We start with the Eo and Morley (2022) model and augment it by allowing regime-switching probabilities to depend on leverage. We use the exact model developed by Eo and Morley (2022) but let the transition probabilities correlate with the credit to GDP ratio constructed by the BIS.[2] Specifically, let v_t be the credit to GDP ratio, and we assume that the transition probabilities from regime E (expansion) to regime L (L-shaped

[2] We obtain the credit to GDP ratio from BIS website at https://www.bis.org/statistics/c_gaps.htm. Real GDP is measured by the quarterly real GDP index from the OECD Main Economic Indicator database under descriptor ID: LORSGPOR.

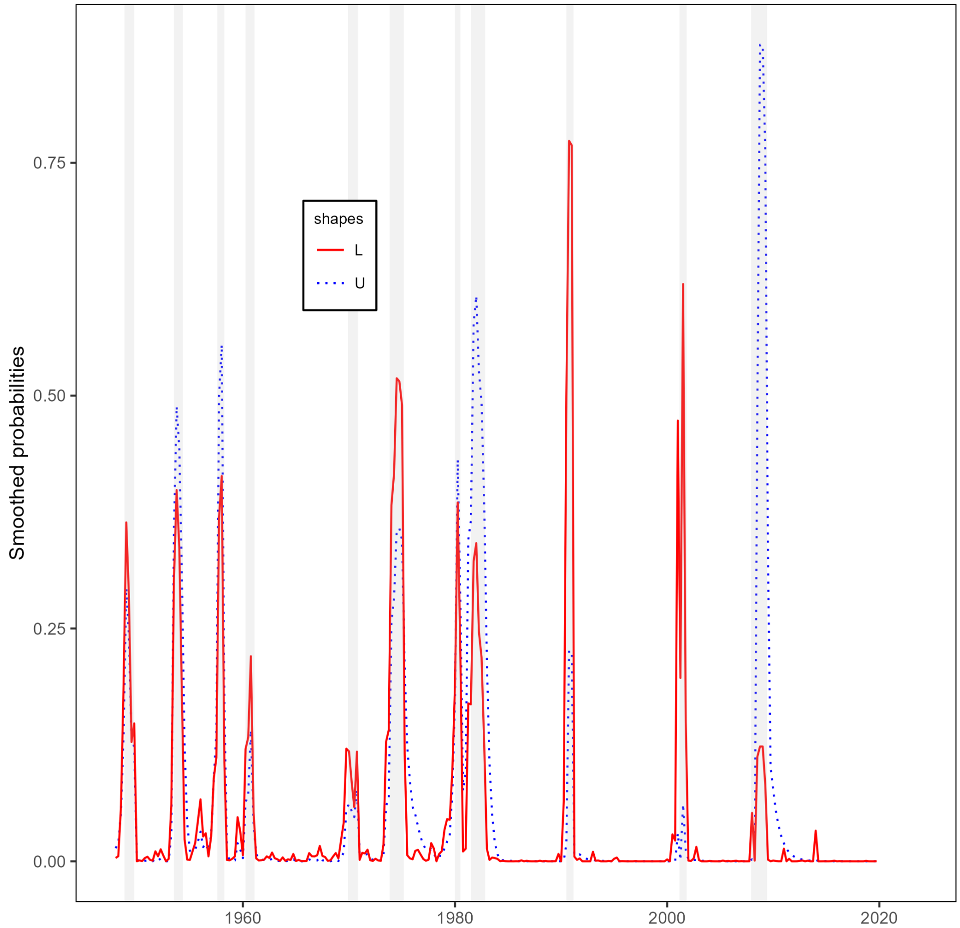

Figure 3: Probabilities of L- and U-shaped Regimes Ignoring Leverage

recession) and from regime E to regime U (U-shaped recession) vary with v_t:[3]

$$Pr[S_t = j|S_{t-1} = E] = \frac{\exp(\alpha_{c,j} + \alpha_{v,j} v_{t-1})}{1 + \exp(\alpha_{c,L} + \alpha_{v,L} v_{t-1}) + \exp(\alpha_{c,U} + \alpha_{v,U} v_{t-1})}, \quad j = L, U. \quad (2)$$

We assume that the level of leverage will affect the probability of entering an L- or U-shaped contractionary regime but not the probability of leaving a contractionary regime.[4] That is, $Pr[S_t = L|S_{t-1} = L]$ and $Pr[S_t = U|S_{t-1} = U]$ are constant over time.

[3] To mitigate concerns over simultaneity, we use lagged leverage throughout.

[4] As a check, we also estimated a model that allowed the probability of exiting a recession to depend on leverage. The coefficients on leverage for the exit probabilities were not significant and classification into U-shaped and L-shaped was unchanged.

Table 1: Parameter Estimates for Leverage and Restricted Models

	Leverage Model		Restricted Model	
Parameter	Estimate	S.E.	Estimate	S.E.
$p_{EL}^{high}(\%)$	2.90	(1.98)	2.27	(1.45)
$p_{EU}^{high}(\%)$	0.12	(0.23)	1.51	(0.99)
$p_{EL}^{low}(\%)$	0.90	(1.47)	2.27	(1.45)
$p_{EU}^{low}(\%)$	3.63	(2.07)	1.51	(0.99)
$p_{LL}(\%)$	60.79	(19.76)	60.19	(18.57)
$p_{UU}(\%)$	70.39	(11.67)	74.65	(13.95)
μ_E	0.88	(0.05)	0.89	(0.05)
μ_L	-1.46	(0.29)	-1.45	(0.32)
μ_U	-1.96	(0.26)	2.02	(0.27)
λ_U	0.33	(0.04)	0.34	(0.04)
δ	-0.35	(0.08)	-0.36	(0.08)
$\alpha_{c,L}$	-6.00	(3.44)		
$\alpha_{v,L}$	0.02	(0.02)		
$\alpha_{c,U}$	0.65	(1.69)		
$\alpha_{v,U}$	-0.05	(0.02)		
$\sigma_{\nu 0}$	0.90	(0.07)	0.91	(0.07)
$\sigma_{\nu 1}$	0.42	(0.03)	0.42	(0.03)
log-like	-310.27		-314.78	

The leverage model is given by equation (2) with transition probabilities specified by equation (2). The restricted model is based on the restrictions that $\alpha_{v,j} = 0$ for $j = L, U$ in equation (2).

Table 1 reports maximum likelihood estimates for the leverage model and for the restricted (i.e., the original Eo and Morley (2022)) model. We report here two transition probabilities. The high-leverage level is computed assuming a leverage level at the 80$^{\text{th}}$ percentile of observed leverage levels and the low-leverage level is computed assuming a leverage level at the 20$^{\text{th}}$ percentile. When leverage is high, the probability that a booming economy will enter an L-shaped contractionary regime is estimated to be 2.90%, far higher than the probability of entering a U-shaped contractionary regime (0.12%). On the other hand, when leverage is low, a U-shaped contractionary regime is more likely to occur than an L-shaped contractionary regime (3.63% v.s. 0.90%). In either case, expansions are much more persistent than either type of recession. The expected duration of the expansionary regime is estimated to be 22 (33) quarters when leverage is low (high), while that of the L-shaped (U-shaped) regime is 2.6 (3.4) quarters. Because the confidence intervals on duration are quite large, we would not put great weight on these implied durations. With that caveat, our results are largely consistent with the findings in Jensen et al. (2020). We find that the probability of entering a recession (either L-shaped or U-shaped) is lower when leverage is high, about three percent when leverage is high as compared to four-and-a-half percent when leverage is low. We also find that the expected duration of expansions is longer when leverage is high. Our estimates of the duration of recessions shows only a trivial difference associated with the extent of leverage.

Figure 4 shows the estimated probabilities of entering an L-shaped or U-shaped recession as a function of leverage, with the 20$^{\text{th}}$ and 80$^{\text{th}}$ percentiles of leverage denoted with dashed lines. The estimates are consistent with the frequent U-shaped recessions before 1970 and the less frequent L-shaped recessions more recently.

Jensen et al. (2020) find that higher leverage is associated with deeper recessions. Our estimates are that the initial drop in output is somewhat larger in U-shaped recessions, which are generally associated with low leverage, and that U-shaped recessions last a little longer. Of course, the recovery from U-shaped recessions is much more robust. See Figure 6 below.

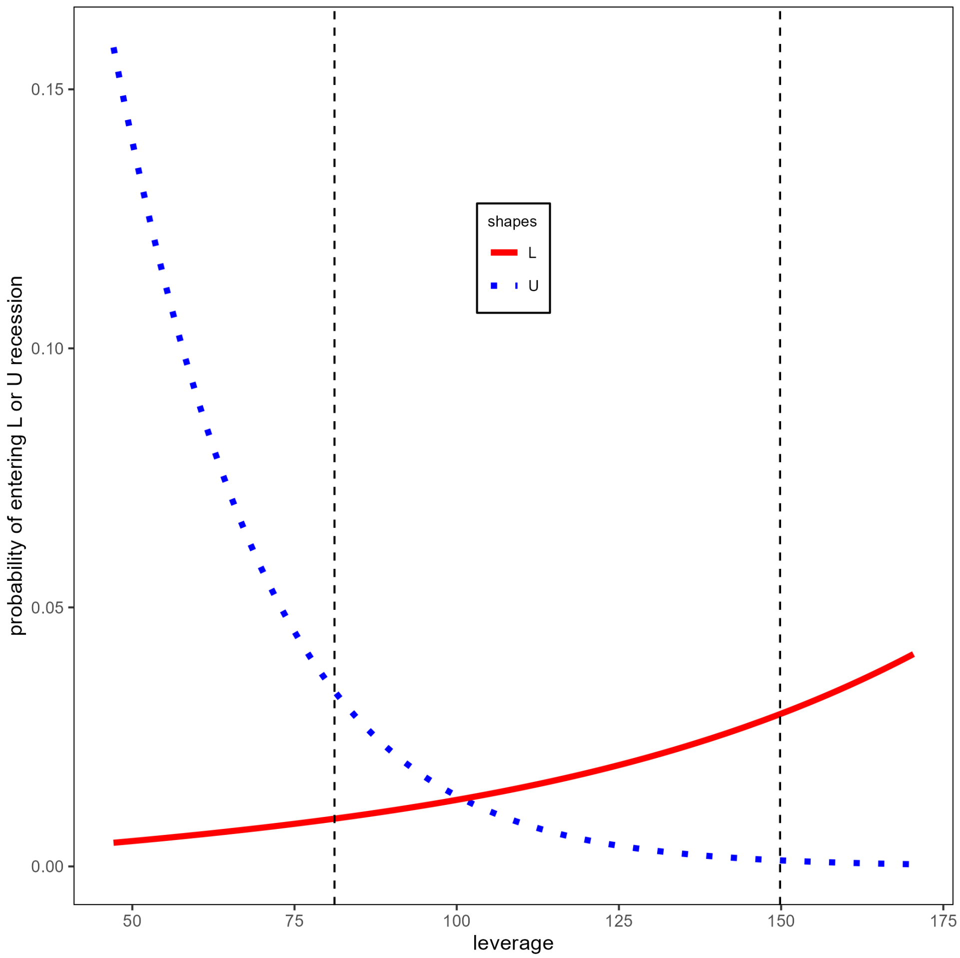

Figure 4: Association of leverage with the probability of entering an L-shaped or U-shaped recession

In the restricted model (smoothed probabilities shown in Figure 3), we impose the restriction that the transition probabilities do not vary with leverage, i.e., $\alpha_{v,L} = \alpha_{v,U} = 0$ in equation (2), in other words, the model used by Eo and Morley (2022). When these restrictions are imposed, the fit of the model noticeably deteriorates, with the log-likelihood dropping to -314.78 from -310.27 for our leverage model. The likelihood ratio statistic is 9.02 which corresponds to a p-value of 0.01, so we can reject the null hypothesis that the transition probabilities do not vary with leverage.

Figure 5 plots the smoothed probabilities of the L-shaped and U-shaped regimes separately. Comparing with Figure 3, the most striking difference is the classification of the

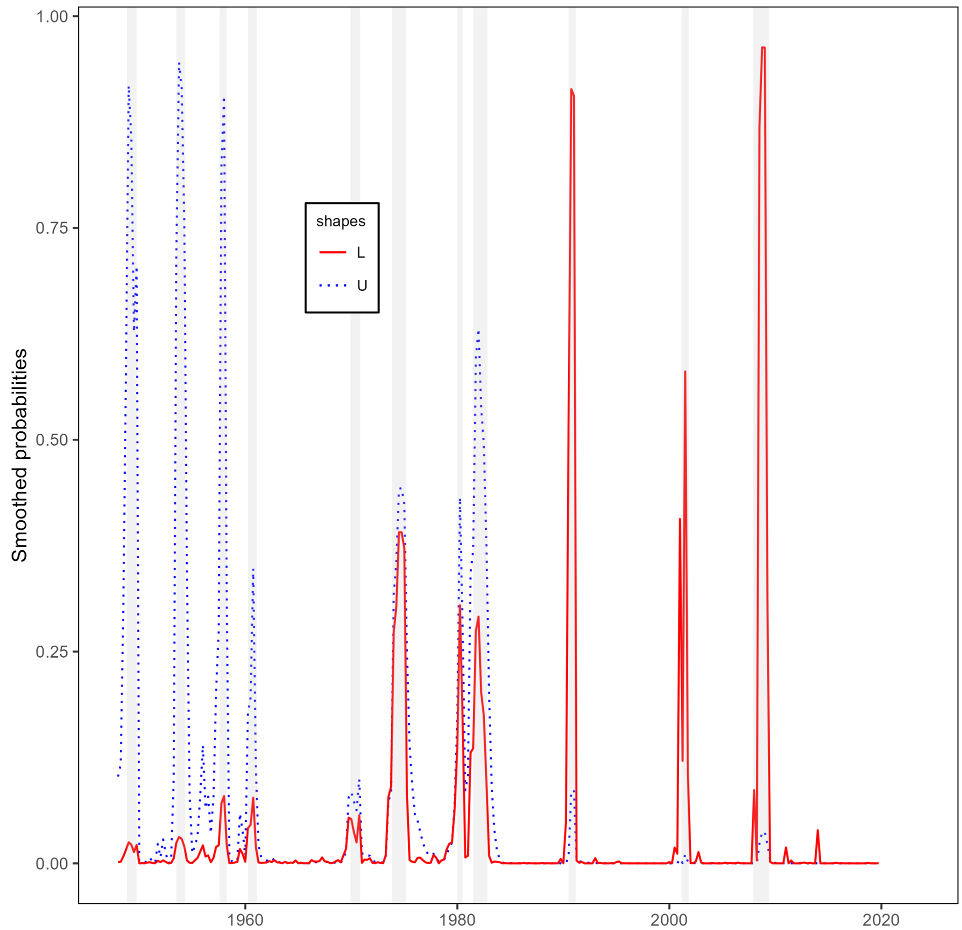

Figure 5: Smoothed Probabilities of Contractionary Regime Accounting for Leverage

2007-2009 recession. Our results indicate that the Great Recession is almost surely an L-shaped recession, consistent with Luo et al. (2021).

The paths of recession and recovery depend on the shape of the recession and the duration of the recession. Figure 1 shows the expected paths based on our parameter estimates from a one-period recession. In Figure 6 we use our estimated parameters to show the expected value of the paths including both the probability of shape and of duration at both high- and low-leverage. Because the probabilities of recession shapes are so different at different leverage values, the picture is not much different from a picture plotting shapes. While a low-leverage recession is initially slightly deeper and slightly longer lasting, recovery is essentially full and relatively rapid, while the effect of a high-leverage recession is nearly recession is nearly permanent. As a consequence, a high-leverage) (likely L-shaped) recession is much worse for the economy. As stated in the Introduction, the cumulative loss 10 periods after the onset of a recession is 10 percentage points of GDP greater when leverage is high than when leverage is low.

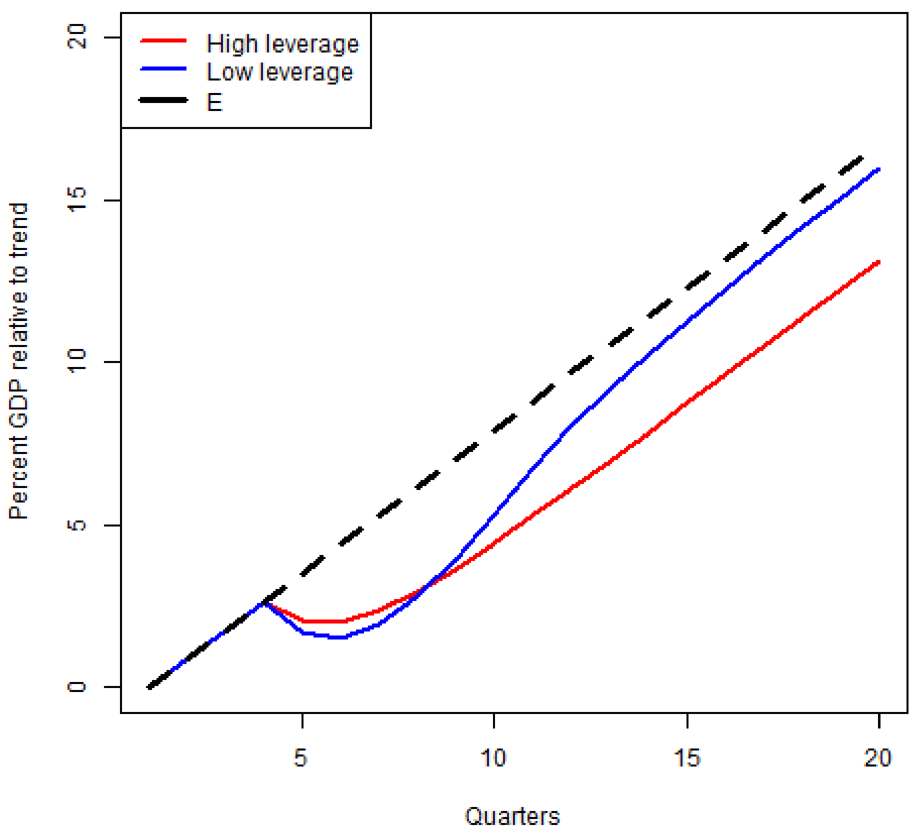

Figure 6: Expected Paths of Recession and Recovery Accounting for Leverage

3 Trend and cycle model

The model estimated above might be thought of as the reduced form of a more general unobserved components model. Because an unobserved components model includes an explicitly transitory component, it allows for a different form of U-shaped recessions. In particular, recovery can be asymptotic rather than requiring full recovery after m periods. Kim et al. (2007) propose a model (see also Kim and Murray (2002)) that allows for regime shifts in the mean growth rate of the stochastic trend and in the mean of the transitory component as in Kim and Nelson (1999), with separate regime indicator variables used for the two components. We augment their model by adding recession shapes to a multivariate unobserved component model of log U.S. real GDP (y_t) and log nondurable goods and services consumption (c_t), which are driven by a common stochastic trend (x_t), a common transitory component (z_t), and idiosyncratic transitory components ($e_{i,t}$) specified as

$$\begin{bmatrix} y_t \\ c_t \end{bmatrix} = \begin{bmatrix} 0 \\ \alpha \end{bmatrix} + \begin{bmatrix} 1 \\ \gamma_x \end{bmatrix} x_t + \begin{bmatrix} 1 \\ \gamma_z \end{bmatrix} z_t + \begin{bmatrix} e_{y,t} \\ e_{c,t} \end{bmatrix} \tag{3}$$

$$x_t = \mu_E + \mu_L \times I(S_t = L) + x_{t-1} + \delta \times I(t > \tau) + \eta_t, \tag{4}$$

$$\psi(L) z_t = \epsilon_t, \tag{5}$$

$$\rho_y(L) e_{y,t} = \mu_{U,y} \times I(S_t = U) + \omega_{y,t}, \tag{6}$$

$$\rho_c(L) e_{c,t} = \mu_{U,c} \times I(S_t = U) + \omega_{c,t}. \tag{7}$$

The $S_t = L$ and $S_t = U$ again indicate the state of the economy for the trend and transitory component, respectively. τ is set to 2006q1. If the trend component enters the contractionary state ($S_t = L$), the growth rate of the trend is reduced by μ_L for one period. This reduction in trend leaves output permanently lower than if the recession had never occurred. If the transitory component enters the contractionary state ($S_T = U$), $e_{y,t}$ is reduced by $\mu_{U,y}$. Once the transitory shock ends and the economy resumes an expansion, the path of the expansion is governed by the autoregressive dynamics of the error term in the GDP equation. If ρ_y is large, then the "bounce back" is slow. Note that this formulation provides for separate dynamics for transitory shocks during expansions which are governed by ψ, and U-shaped recessions which are governed by ρ_y. As above, regime-switching is governed by equation (2) and we follow Eo and Morley (2022) and assume that the economy does not switch between contractionary regimes without going through an expansionary regime first. That is, $p_{UL} = 0$ and $p_{LU} = 0$.

Table 2: Parameter Estimates for Trend/Cycle Model

	Leverage Model		Restricted Model	
Parameter	Estimate	S.E.	Estimate	S.E.
$p_{EL}^{high}(\%)$	4.03	(2.17)	4.41	(2.42)
$p_{EU}^{high}(\%)$	0.06	(0.17)	3.72	(1.51)
$p_{EL}^{low}(\%)$	1.44	(1.33)	4.41	(2.42)
$p_{EU}^{low}(\%)$	3.08	(2.40)	3.72	(1.51)
$p_{LL}(\%)$	65.22	(13.51)	53.14	(21.49)
$p_{UU}(\%)$	69.43	(13.18)	93.28	(2.60)
μ_E	0.90	(0.05)	0.92	(0.07)
μ_L	-1.39	(0.18)	-1.20	(0.34)
τ_y	-1.66	(0.28)	-1.67	(0.17)
τ_c	-0.73	(0.28)	-0.96	(0.20)
log-like	-565.71		-570.97	

The leverage model is given by equations (4) through (7) with transition probabilities specified by equation (2). The restricted model is based on the restrictions that $\alpha_{v,j} = 0$ for $j = L, U$ in equations (4), (6), and (7).

Finally, we assume $[\eta_t, \epsilon_t, \omega_{y,t}, \omega_{c,t}]$ are uncorrelated and normally distributed. To account for this volatility reduction we define:

$$\sigma_\eta^* = \sigma_{\eta 0} \times I(t <= \tau_\eta) + \sigma_{\eta 1} \times I(t > \tau_\eta)$$
$$\sigma_\epsilon^* = \sigma_{\epsilon 0} \times I(t <= \tau_\epsilon) + \sigma_{\epsilon 1} \times I(t > \tau_\epsilon)$$

where $\tau_\eta = \tau_\epsilon$ equals 1984q1.

Table 2 reports maximum likelihood estimates for the leverage model. We set an AR(2) process for the common transitory component and idiosyncratic transitory components. When leverage is high, the probability that a booming economy will enter an L-shaped

Table 3: Parameter Estimates for Trend/Cycle Model, Cont.

	Leverage Model		Restricted Model	
Parameter	Estimate	S.E.	Estimate	S.E.
$\rho_{y,1}$	1.17	(0.11)	1.13	(0.06)
$\rho_{y,2}$	-0.44	(0.09)	-0.46	(0.06)
$\rho_{c,1}$	0.97	(0.32)	1.07	(0.15)
$\rho_{c,2}$	-0.32	(0.36)	-0.42	(0.14)
ψ_1	0.79	(0.06)	0.83	(0.07)
ψ_2	0.20	(0.06)	0.17	(0.06)
γ_x	0.81	(0.04)	0.81	(0.12)
γ_z	-1.66	(0.37)	-1.76	(0.60)
δ	-0.40	(0.08)	-0.41	(0.08)
$\sigma_{\epsilon 0}$	0.38	(0.06)	0.37	(0.10)
$\sigma_{\epsilon 1}$	0.20	(0.03)	0.66	(0.07)
$\sigma_{\eta 0}$	0.70	(0.05)	0.20	(0.04)
$\sigma_{\eta 1}$	0.41	(0.03)	0.38	(0.03)
$\alpha_{c,1}$	-5.47	(2.13)	-3.20	(0.42)
$\alpha_{v,1}$	0.02	(0.02)	0	-
$\alpha_{c,2}$	1.46	(2.56)	3.04	(0.57)
$\alpha_{v,2}$	-0.06	(0.04)	0	-
log-like	-565.71		-570.97	

The leverage model is given by equations (4) through (7) with transition probabilities specified by equation (2). The restricted model is based on the restrictions that $\alpha_{v,j} = 0$ for $j = L, U$ in equations (4), (6), and (7).

contractionary regime is estimated to be 4.03%, while it is very unlikely to enter a U-shaped contractionary regime (0.06%). On the other hand, when leverage is low, a U-shaped contractionary regime is more likely to occur than an L-shaped contractionary regime (3.08% v.s. 1.44%). These estimates are roughly in line with the estimates from our leverage-augmented version of the Eo and Morley (2022) model above. The forecasted drops on entering a recession are also similar, with the size of U-shaped drop being a bit less than the estimate above. When the leverage-doesn't-matter restrictions are imposed, the fit of the model noticeably deteriorates, with the log-likelihood dropping to -570.97 from -565.71 for our leverage model. The likelihood ratio statistics is 10.52 which has a p-value less than 0.01, so we can reject the null hypothesis that the transition probabilities do not vary with leverage.

The results from the unobserved components model are quite similar to those from the previous model. Figure 7 plots the smoothed probabilities of the L-shaped and U-shaped regimes separately. Our results again indicate that the Great Recession is essentially an L-shaped recession, consistent with Luo et al. (2021). Figure 8 compares the mean responses to a one-quarter U-shaped recession as estimated by the augmented Eo and Morley (2022) model to those from the unobserved components model. For all interesting purposes the responses are the same, which suggests that the restrictions on recoveries from U-shaped recessions in Eo and Morley (2022) are reasonable.

4 International evidence

Jensen et al. (2020) find a relation between leverage and business cycle characteristics for the G7 countries. We applied our augmented Eo-Morley model to the G7 plus Australia, less Germany (due to East/West versus reunified data issues).[5] In general, we find that higher leverage is associated with L-shaped recessions. But the evidence is not uniform

[5] We obtain the credit to GDP ratio from BIS website at `https://www.bis.org/statistics/c_gaps.htm`. The real GDP is measured by the quarterly real GDP index from the OECD Main Economic Indicator database under descriptor ID: LORSGPOR.

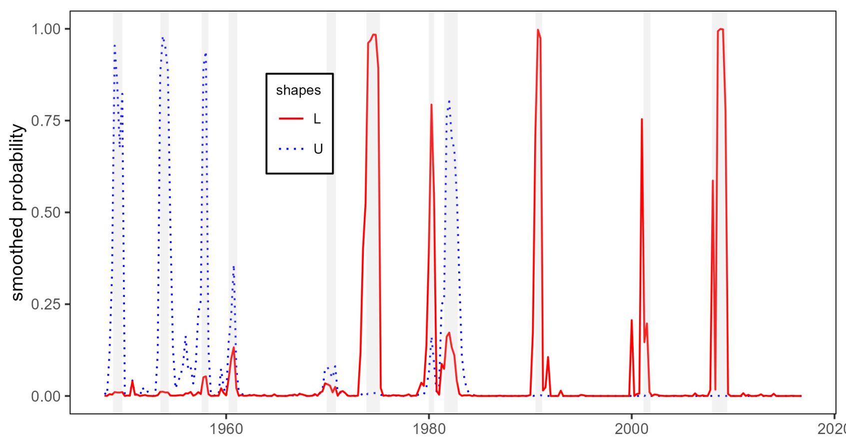

Figure 7: Smoothed Probabilities of Contractionary Regimes from Unobserved Components Model

across countries. Data for most of the G7 starts somewhat later than for the United States. As a result, periods in which the United States experienced the most U-shaped recessions are excluded from much of the data. This limits the ability of the estimation algorithm to well-identify U-shaped recessions. What does remain clear is that the Great Recession was L-shaped around the world.

Figure 9 shows that growth in leverage is generally similar to leverage in the United States. The two exceptions are Japan, which had a significant drop in leverage, and Italy, where leverage rose but at noticeably lower overall level.

Table 4 gives the smoothed probability that a country was in an L-shaped recession in the first quarter of 2009. (We illustrate with 2009q1 because the Great Recession internationally lagged events in the United States. The probability of an L-shaped Great Recession in Australia was above 0.8 in both 2008q4 and 2009q2.) Essentially, the Great Recession was L-shaped for all countries in our sample. Table 4 also gives the p-value against leverage not mattering. For the majority of countries, it is clear that leverage matters. The first exception is Italy, where leverage never became very high. The second exception is France, where leverage eventually became considerably higher than in the United States.

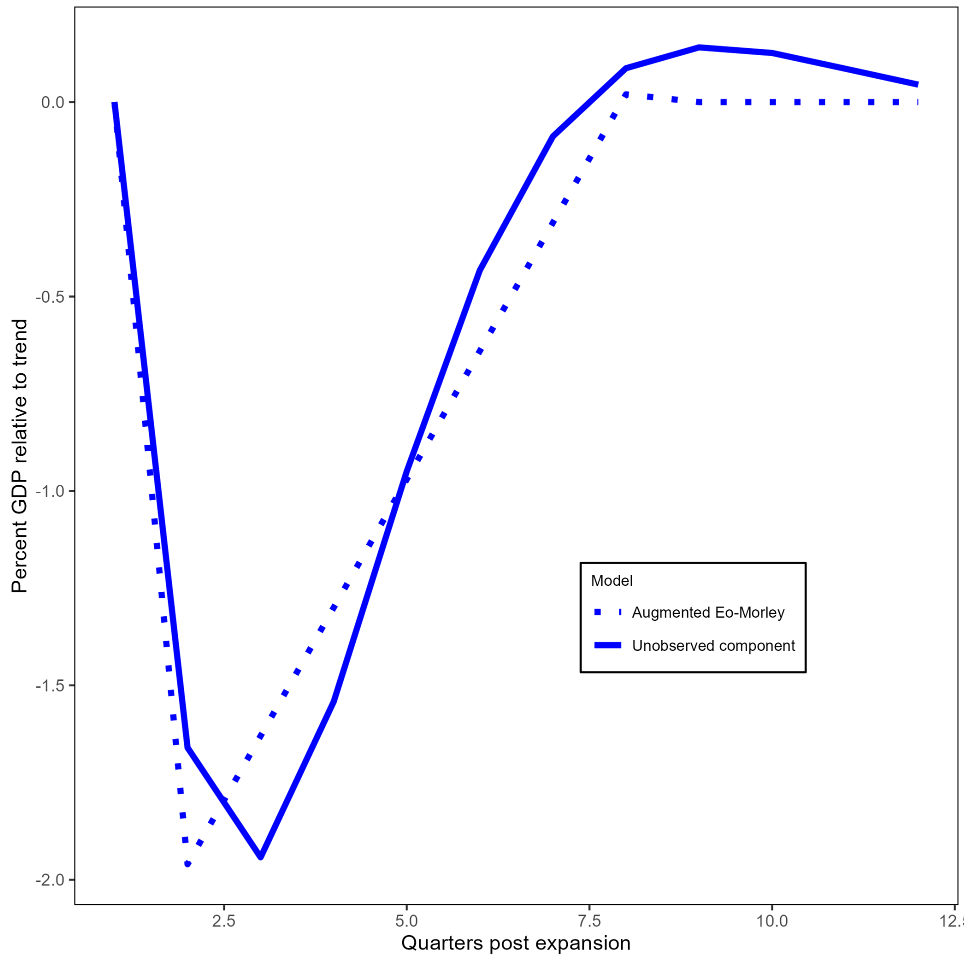

Figure 8: Mean estimated response to one-quarter U-shaped recession comparing the augmented Eo-Morley and the unobserved components models

5 Robustness check

The credit-to-GDP (CTG) ratio exhibits an upward trend in our sample period. Therefore, it is possible that the association between the leverage and transition probabilities is driven by other factors that exhibit a similar time trend. To investigate the role of leverage over the business cycle, we detrend the credit-to-GDP ratio using novel techniques developed recently. (See notes to Table 5.) Table 5 shows the log-likelihood of the leverage model using detrended CTG ratio. It is notable that using CTG gap based on the Boosted HP filter, the model generates a similar level of log-likelihood to that using

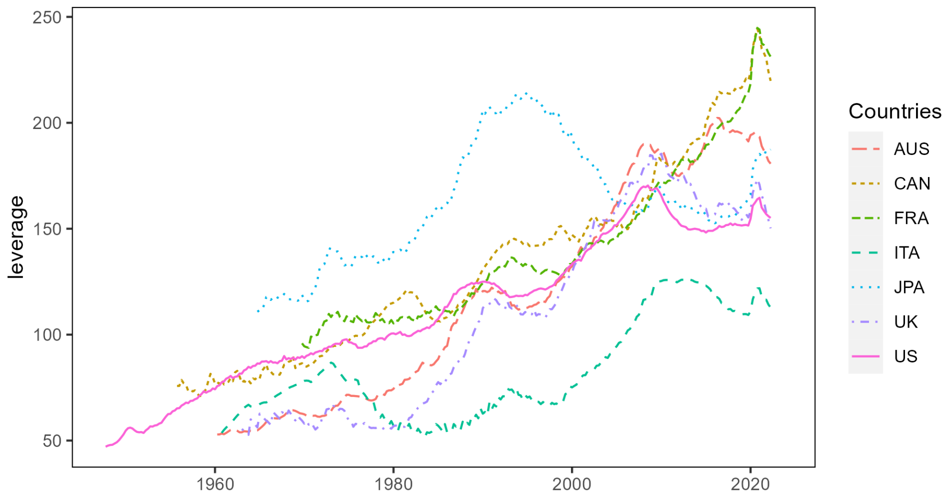

Figure 9: Leverage across countries

CTG ratio. Because all models have the same number of parameters, the difference in log-likelihoods between models is exactly the difference in BICs. Based on the criteria proposed by Kass and Raftery (1995), the model using CTG gap based on the Boosted HP filter is strongly favored against models using other detrending techniques. Figure 10 plots the smoothed probabilities of the L-shaped and U-shaped regimes from the model using CTG gap based on the Boosted HP filter. We reach the same conclusion that the Great Recession is L-shaped.

6 Conclusion

Jensen et al. (2020) demonstrate a number of ways in which increasing leverage affects the business cycle. We show here, first, that increased leverage is associated with L-shaped recessions and, second, that once leverage is accounted for the Great Recession was clearly L-shaped. The evidence for this for the United States is very strong across a variety of models. The evidence is similarly strong internationally, although not for all countries. Because L-shaped recessions are particularly damaging, our findings add to arguments that policymakers should be concerned with high leverage rates.

Table 4: G7 results

Country	Probability L-shaped 2009q1	p-value against leverage not mattering.
Australia	0.61	0.009
Canada	1.0	0.000
France	1.0	0.432
Italy	1.0	0.631
Japan	1.0	0.006
UK	1.0	0.000
US	0.96	0.011

Table 5: Log-likelihood of the Leverage Model using Detrended CTG ratio

		level	Modified H.	Boosted HP	Max-BN	Log-diff
log-lik	unrestricted	-310.2703	-314.2710	-311.0032	-314.1626	-314.7398
	restricted			-314.7760		

The Modified H. stands for the modified Hamilton filter (Quast and Wolters 2022). Boosted HP is the boosted HP filter proposed by Phillips and Shi (2021). Max-BN is a modified Beveridge-Nelson filter that maximizes the signal-to-noise ratio (Kamber et al. 2018). Log-diff is the first difference in the log CTG ratio.

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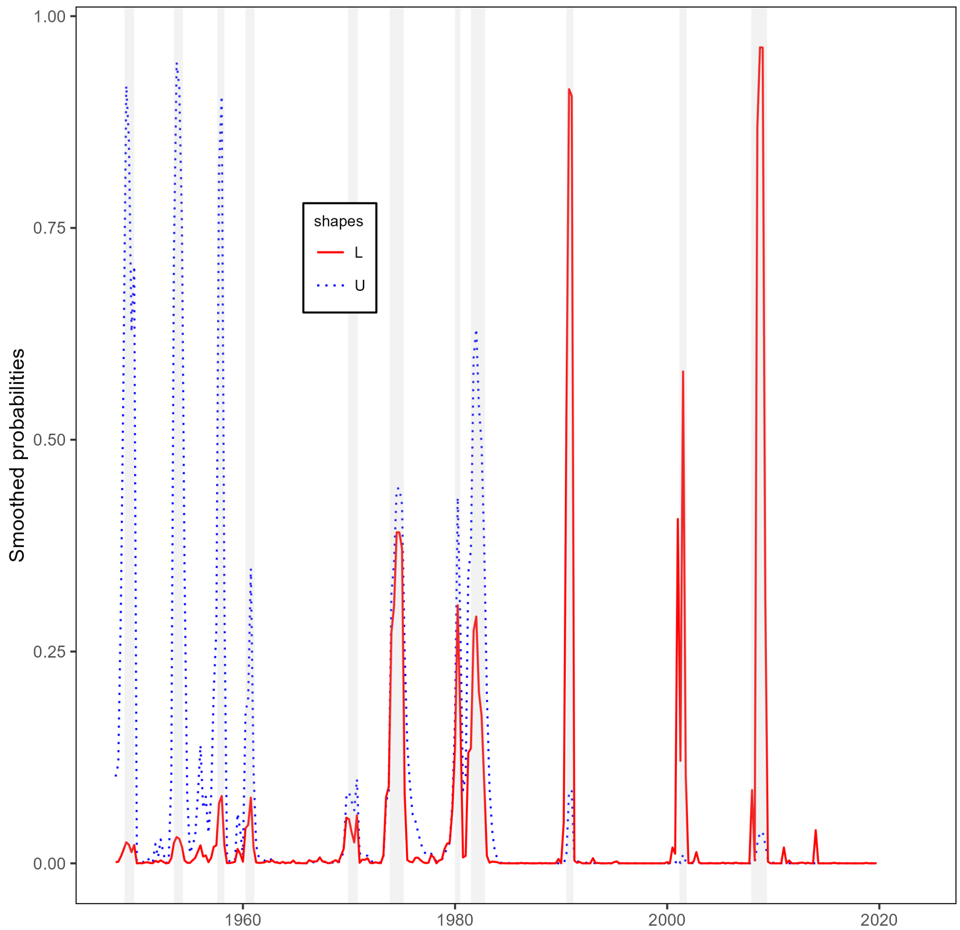

Figure 10: Smoothed Probabilities Using Boosted HP Leverage

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