International Evidence on Sticky Consumption Growth

Christopher Carroll[1] Jirka Slacalek[2] Martin Sommer[3]

[1]Johns Hopkins and NBER
ccarroll@jhu.edu

[2]European Central Bank
jiri.slacalek@ecb.int

[3]International Monetary Fund
msommer@imf.org

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Consumption Habits Are Pervasive

- Equity premium puzzle
- Hump-shaped response of consumption to income shocks
- Dynamic effects of fiscal policy
- Persistence in current account balances
- ...

BUT

- No consensus on whether the Hall (1978) random walk model is in line with data
- Few estimates of how sluggish C growth is (in particular in international data)
- Estimates of habits often smaller than required by theory

The Hall Model and The Data

The Hall (1978) Random Walk Model

Consumption Growth Is Unpredictable and Thus Serially Uncorrelated

$$\mathbf{E}_t \Delta C_{t+1} = 0 \Rightarrow \mathbf{E}_t \left(\Delta C_t \times \Delta C_{t+1} \right) = 0$$

Existing Empirical Work Reveals Predictability...

with stock prices, income, consumer sentiment...

- Flavin (1981), Campbell and Mankiw (1989) and many others

...But Not as much as in Most Calibrated Models with Habits

- First autocorrelation of C growth in aggregate US data ≈ 0.35

Explanations of the "Excess Sensitivity" of Consumption

- Time Aggregation
  Cannot Explain Strong AC in C Growth
- Precautionary Savings
  Aggregate Uncertainty Is Small $\Rightarrow$ Limited Relevance in Macro Data
- Data Construction Methods [e.g., interpolation and imputation]
  We Argue This Is Important
- Rule-of-Thumb Consumers
  We Argue This Is Less Important Than Typically Believed

Our Contribution

- Estimate the role "stickiness in aggregate C growth" (which can be interpreted as habits or sticky expectations) correcting for the presence of measurement error and transitory consumption (IV and the Kalman filter)
- Data from 13 countries

Our Findings

- Strong Evidence of C Growth **"Stickiness"**
- The Weight of Habits/Sticky Expectations Is about 70 Percent
- Typically Reject Rule-of-Thumb Consumers in Favor of Stickiness

Theories of Stickiness I.: Habit Formation

- Muellbauer (1988):

$$\max \mathbf{E}_s \sum_{t=s}^{\infty} \beta^{t-s} \mathbf{u}(C_t - \chi C_{t-1})$$
$$\text{s.t. } B_{t+1} = (B_t - C_t)R + Y_{t+1}$$

- χ : Weight of Habits (Represented with C_{t-1})
- Both Level of C and Growth Matter:

$$\mathbf{u}(C_t - \chi C_{t-1}) = \mathbf{u}\big((1-\chi)C_t - \chi \Delta C_{t-1}\big)$$

- Linearized FOC for CRRA Utility:

$$\Delta \log C_t = \chi \Delta \log C_{t-1} + \varepsilon_t$$

Theories of Stickiness II.: Sticky Expectations

- Carroll and Slacalek (2006), Reis (2006): Consumers are inattentive: know accurately their personal circumstances but follow macroeconomic developments only once in a while.
- Consumers update their info about permanent income with probability Π each period
- Individual consumption growth is dominated by idiosyncratic shocks and is white noise.
- Aggregate consumption growth is AR(1) with autocorrelation $1 - \Pi$

$$\Delta \log C_t = (1 - \Pi)\Delta \log C_{t-1} + \varepsilon_t$$

- Both habits and sticky expectations have identical implications in aggregate data (but not in micro data)

Estimation Methods à la Sommer (2007)

Instrumental Variables

$$\Delta \log C_t = \varsigma + \chi \mathbf{E}_{t-2}[\Delta \log C_{t-1}] + \eta \mathbf{E}_{t-2}[\Delta \log Y_t] + \alpha \mathbf{E}_{t-2}[A_{t-1}] + \varepsilon_t$$

Kalman filter

$$\Delta \log C_t = \Delta \log C_t^* + u_t + (\theta - 1)u_{t-1} - \theta u_{t-2},$$
$$\Delta \log C_t^* = c_0 + \chi \Delta \log C_{t-1}^* + v_t + \lambda_1(\chi)v_{t-1} + \lambda_2(\chi)v_{t-2},$$

where C^* is unobserved "true" consumption

OLS Is Biased

- Measurement error
- Transitory consumption (eg, hurricane Katrina)
- Time aggregation

Instrumental Variables

$$\Delta \log C_t = \varsigma + \chi \mathbf{E}_{t-2}[\Delta \log C_{t-1}] + \eta \mathbf{E}_{t-2}[\Delta \log Y_t] + \alpha \mathbf{E}_{t-2}[A_{t-1}] + \varepsilon_t$$

- Nests three alternatives:
  - $\chi = 0$ and $\eta = 0$: Random walk
  - $\chi = 0$: Rule-of-thumb consumers (with $C_t = Y_t$)
  - $\eta = 0$: C Stickiness (Habits/Sticky Expectations)
- Financial assets (A_{t-1}) included to account for precautionary savings and/or time-variation in interest rates
- With appropriate (ie, uncorrelated with measurement error and correlated with endogenous variables) instruments no need to specify the stochastic structure of measurement error.

Kalman Filter

Two-stage procedure

1. Kalman filter—MA(1) measurement error in log-level of C

$$\Delta \log C_t = \Delta \log C_t^* + u_t + (\theta - 1)u_{t-1} - \theta u_{t-2},$$
$$\Delta \log C_t^* = c_0 + \chi \Delta \log C_{t-1}^* + v_t + \lambda_1(\chi)v_{t-1} + \lambda_2(\chi)v_{t-2},$$

   where C^* is unobserved "true" consumption

   - λs are nonlinear functions of χ
   - MA(2) coefficient λ_2 is close to zero for reasonable $\chi \in (0, 1)$, so that $\Delta \log C_t^*$ is approximately ARMA(1,1).

2. Instrumental variables on

$$\Delta \log C_t^* = \varsigma + \chi \mathbf{E}_{t-2}[\Delta \log C_{t-1}^*] + \eta \mathbf{E}_{t-2}[\Delta \log Y_t] + \alpha \mathbf{E}_{t-2}[A_{t-1}] + \varepsilon_t$$

Data

- 13 advanced economies
- Quarterly data roughly over past 40 years
- Consumption: Ideally, sum of nondurables and services (available only for Can, Fra, Ger, Ita, UK, US), else total personal consumption expenditures
- Income: Disposable income
- Assets (A): Ratio of financial assets to disposable income
- Instruments: Various sets; baseline: unemployment rate, long-term interest rate, index of price volatility and consumer sentiment

Baseline IV Results

$$\Delta \log C_t = \varsigma + \chi \mathbf{E}_{t-2}[\Delta \log C_{t-1}] + \eta \mathbf{E}_{t-2}[\Delta \log Y_t] + \alpha \mathbf{E}_{t-2}[A_{t-1}]$$

	One regressor only			All three regressors—Horse-race		
Country	χ	η	α	χ	η	α
Canada	0.72^{***}	0.32^{***}	0.33	0.64^{***}	0.05	0.11
France	0.61^{***}	0.29^{***}	0.04	0.44	0.19	−0.04
Germany	0.40^{*}	0.72^{***}	−0.36	0.16	0.66^{***}	−0.17
Italy	0.65^{***}	0.20^{**}	−0.05	0.53^{**}	0.13	−0.02
United Kingdom	0.83^{***}	0.10	0.27^{*}	1.00^{***}	−0.17	0.01
United States	0.83^{***}	0.54^{***}	0.26^{*}	0.55^{***}	0.27^{*}	0.02
Australia	0.54^{***}	0.12	0.10	0.51^{**}	0.03	0.01
Belgium	0.64^{***}	0.34^{**}	0.11	0.56^{**}	0.12	0.01
Denmark	0.86^{***}	0.43	−0.34	0.78^{***}	0.27	−0.32
Finland	0.90^{***}	0.61^{**}	0.53	0.86^{***}	0.07	−0.13
Netherlands	0.70^{***}	0.09	0.21	0.53	−0.14	0.10
Spain	0.94^{***}	0.79^{***}	0.83^{***}	0.71^{**}	0.04	0.21
Sweden	0.83^{***}	0.37^{**}	0.58^{***}	0.88^{***}	0.32^{*}	−0.25
Mean	0.73^{***}	0.38^{**}	0.19	0.63^{**}	0.14	−0.03

Baseline IV Summary

Univariate Regressions

- Clear rejection of random walk
- C Stickyness χ significant and around 0.7
- Income share of rule-of-thumb consumers $\eta \approx 0.4$, less significant
- Coefficient on wealth α typically insignificant
- First-stage $\bar{R}^2$ for C typically ranges between 0.1 and 0.2

Horse-race Regressions

- Past C beats other regressors
- χ drops only slightly (from 0.7 to 0.6) and remains significant in 10 countries
- η insignificant (except for Germany)
- OID test does not reject instrument exogeneity

IV Results for Country Groups (Averages)

$$\Delta \log \mathbf{C}_t = \varsigma + \chi \mathbf{E}_{t-2}[\Delta \log C_{t-1}] + \eta \mathbf{E}_{t-2}[\Delta \log Y_t] + \alpha \mathbf{E}_{t-2}[A_{t-1}]$$

	Estimation with one regressor only			Estimation with all three regressors		
Country	χ	η	α	χ	η	α
All Countries	0.73^{***}	0.38^{**}	0.19	0.63^{**}	0.14	−0.03
	(0.18)	(0.18)	(0.19)	(0.25)	(0.21)	(0.16)
G7 Countries	0.67^{***}	0.36^{***}	0.08	0.55^{**}	0.19	−0.01
	(0.18)	(0.11)	(0.19)	(0.23)	(0.14)	(0.12)
Anglo–Saxon	0.73^{***}	0.27^{**}	0.24	0.68^{***}	0.04	0.04
	(0.16)	(0.11)	(0.18)	(0.22)	(0.14)	(0.12)
Euro Area	0.69^{***}	0.43^{**}	0.19	0.54^{**}	0.15	−0.01
	(0.18)	(0.20)	(0.18)	(0.27)	(0.22)	(0.13)
European Union	0.73^{***}	0.39^{*}	0.18	0.65^{**}	0.15	−0.06
	(0.18)	(0.20)	(0.20)	(0.26)	(0.23)	(0.17)

Instruments: `L(2/4).un L(2/4).lr L(2/4).pceinfvol L(2/4).sent`

Alternative Instrument Set [Un, Inc, IR Spread, Sent]

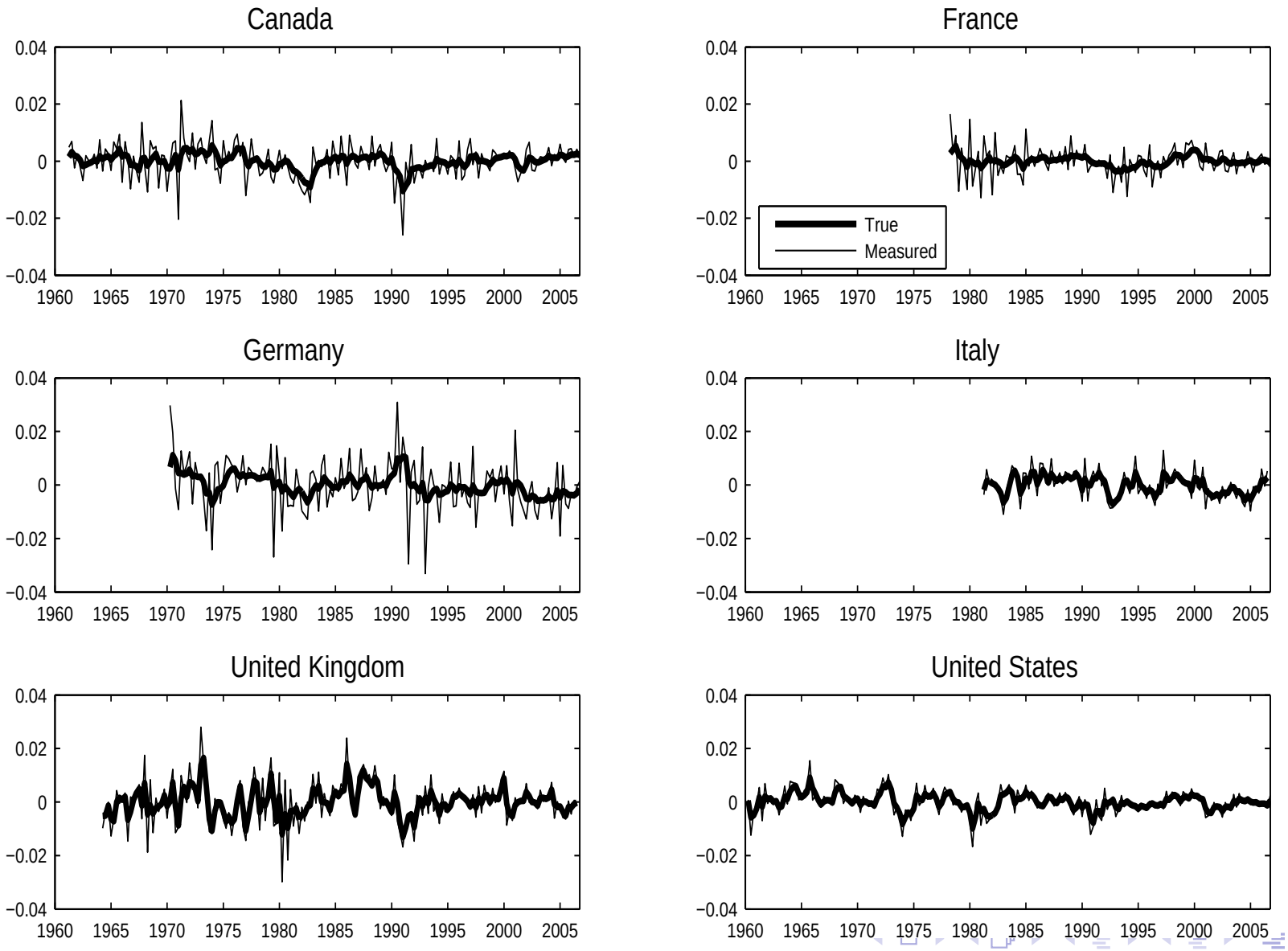
$$\Delta \log C_t = \varsigma + \chi \mathbf{E}_{t-2}[\Delta \log C_{t-1}] + \eta \mathbf{E}_{t-2}[\Delta \log Y_t] + \alpha \mathbf{E}_{t-2}[A_{t-1}]$$

	One regressor only			All three regressors—Horse-race		
Country	χ	η	α	χ	η	α
Canada	0.69^{***}	0.33^{***}	0.91^{**}	0.40	0.16	0.35
France	0.03	0.23^{*}	0.08	−0.31	0.36	0.09
Germany	0.02	0.88^{***}	−0.29	−0.14	0.89^{***}	−0.18
Italy	0.62^{***}	0.29^{*}	−0.06	0.55^{***}	0.10	−0.02
United Kingdom	0.41^{**}	0.07	0.24	0.58^{**}	−0.20	0.13
United States	0.74^{***}	0.41^{***}	0.23	0.53^{**}	0.16	0.04
Australia	0.71^{***}	0.18	0.11	0.73^{***}	−0.05	0.02
Belgium	0.71^{***}	0.27^{*}	0.09	0.77^{**}	0.13	−0.09
Denmark	0.35	0.10	-1.26^{**}	0.19	−0.00	-1.14^{*}
Finland	0.88^{***}	0.49^{***}	2.86^{***}	0.56^{*}	0.15	0.82
Netherlands	0.75^{***}	0.16	0.12	0.71^{***}	0.14	0.02
Spain	0.94^{***}	0.58^{***}	0.97^{***}	0.67^{**}	0.18	0.15
Sweden	0.86^{***}	0.05	0.81^{***}	0.85^{**}	−0.03	0.04
Mean	0.59^{***}	0.31^{**}	0.37	0.47	0.15	0.02

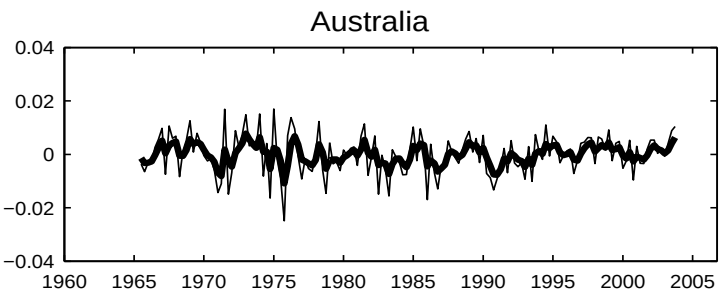
Kalman Filter—First-Stage Results

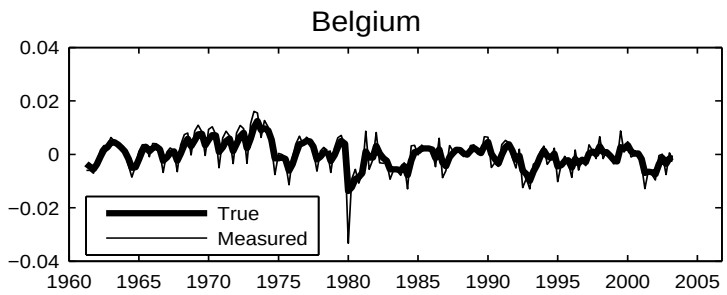
Country	Parameter Estimates				
	χ	θ	$\log \sigma_u^2$	$\log \sigma_v^2$	$\frac{\text{var}(\Delta \log \mathbf{C}_t^*)}{\text{var}(\Delta \log \mathbf{C}_t)}$
G7 Countries					
Canada	0.78^{***}	0.25^{**}	-11.03^{***}	-13.02^{***}	0.18
France	0.81^{***}	-0.01	-11.42^{***}	-14.00^{***}	0.10
Germany	0.83^{***}	0.25^{*}	-9.97^{***}	-12.49^{***}	0.14
Italy	0.62^{***}	-0.08	-12.04^{***}	-12.26^{***}	0.37
United Kingdom	0.36^{***}	-1.00	-12.21^{***}	-10.79^{***}	0.39
United States	0.67^{***}	0.30^{**}	-12.26^{***}	-12.58^{***}	0.44
Other Countries					
Australia	0.49^{*}	0.23	-10.78^{***}	-11.50^{***}	0.21
Belgium	0.70^{***}	0.39^{***}	-11.44^{***}	-11.83^{***}	0.45
Denmark	0.39^{*}	-0.23	-10.38^{***}	-9.85^{***}	0.38
Finland	0.72^{***}	0.20	-10.95^{***}	-11.00^{***}	0.55
Netherlands	0.90^{***}	-0.08	-9.85^{***}	-12.64^{***}	0.18
Spain	0.84^{***}	0.23	-12.08^{***}	-11.39^{***}	0.82
Sweden	0.67^{***}	0.27^{*}	-11.71^{***}	-11.40^{***}	0.60

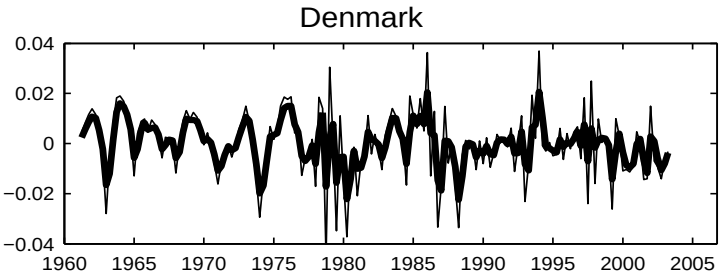
"True" Consumption Growth (Kalman smoother, G7, demeaned, per cap)

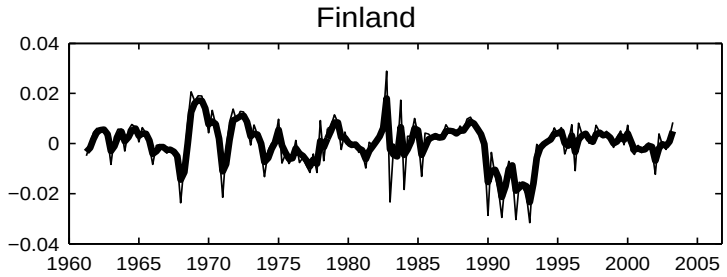


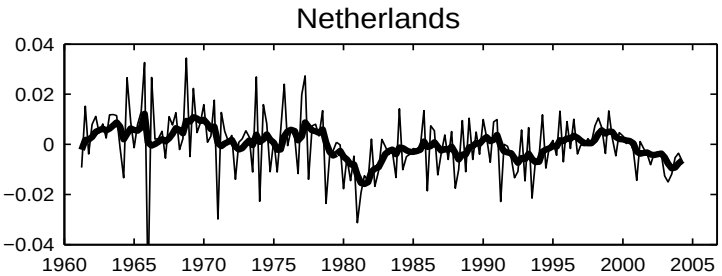
"True" Consumption Growth (Kalman smoother, other countries)

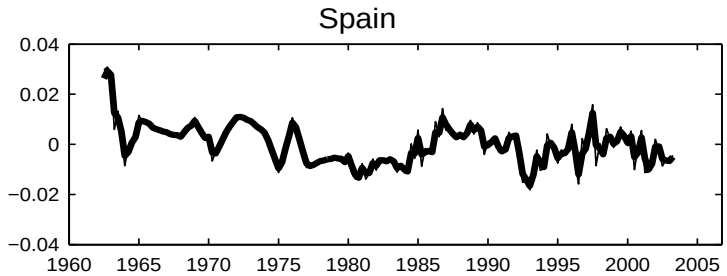


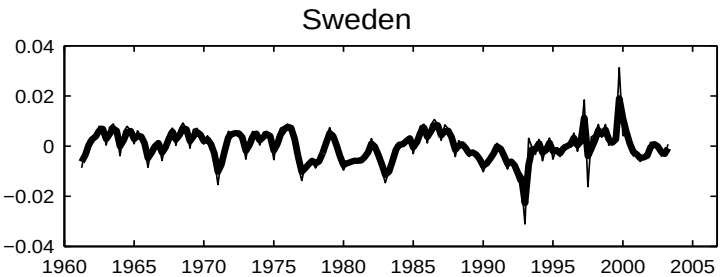












Kalman Filter—Second-Stage Results

$$\Delta \log C_t^* = \varsigma + \chi \mathbf{E}_{t-2}[\Delta \log C_{t-1}^*] + \eta \mathbf{E}_{t-2}[\Delta \log Y_t] + \alpha \mathbf{E}_{t-2}[A_{t-1}]$$

	One regressor only			All three regressors—Horse-race		
Country	χ	η	α	χ	η	α
Canada	0.92^{***}	0.32^{***}	0.28	0.91^{***}	0.00	0.02
France	0.91^{***}	0.21^{***}	0.08	0.84^{***}	0.05^{**}	−0.00
Germany	0.92^{***}	0.34^{***}	−0.33	0.81^{***}	0.12^{***}	−0.00
Italy	0.84^{***}	0.16^{*}	−0.04	0.82^{***}	0.01	−0.01
United Kingdom	0.89^{***}	0.14^{*}	0.24^{*}	1.00^{***}	−0.08	−0.00
United States	0.89^{***}	0.43^{***}	0.24^{**}	0.72^{***}	0.15^{**}	0.01
Australia	0.76^{***}	0.11^{*}	0.11^{*}	0.73^{***}	0.03	0.00
Belgium	0.80^{***}	0.35^{***}	0.12	0.82^{***}	−0.02	−0.00
Denmark	0.97^{***}	0.31	−0.29	0.92^{***}	0.20	-0.32^{*}
Finland	0.91^{***}	0.56^{***}	0.47	0.96^{***}	−0.04	−0.10
Netherlands	0.93^{***}	0.11	0.22^{**}	0.92^{***}	0.01	0.00
Spain	0.99^{***}	0.77^{***}	0.79^{***}	0.97^{***}	−0.03	0.05
Sweden	0.89^{***}	0.26^{*}	0.51^{***}	0.96^{***}	0.14	−0.17
Mean	0.89^{***}	0.31^{**}	0.19	0.88^{***}	0.04	−0.04

Kalman Filter Summary

- Clear rejection of random walk
- C Stickiness χ highly significant and around 0.8 (in both panels)
- χ generally close to IV estimates
- Large fraction of transitory components in C growth (around 50 percent in US)
- Little correlation between C and instrumented Y in univariate regressions, none in horse-race

Structural Interpretation

The Kalman filter model fits into the structural DSGE framework of Ireland (2004): $\mathbf{f}_t = \mathbf{C}\mathbf{s}_t + \mathbf{u}_t$
$\mathbf{f}_t$: control variables, $\mathbf{s}_t$: state variables, $\mathbf{u}_t$: residuals

Ireland: "the residuals [$\mathbf{u}_t$] may ... soak up both measurement errors, but they can be interpreted more liberally as capturing all of the movements and co-movements in the data that the real business cycle model, because of its elegance and simplicity, cannot explain."

- For our model: $\mathbf{f}_t = \Delta \log C_t$, $\mathbf{s}_t = \Delta \log C^*_{t-1}$, $\mathbf{C} = \chi$, $\mathbf{u}_t = u_t + (\theta - 1)u_{t-1} - \theta u_{t-2} + v_t + \lambda_1(\chi)v_{t-1} + \lambda_2(\chi)v_{t-2}$
- Our model is simple and can be estimated with classical techniques. $\Rightarrow$
  Data have complete control over the estimates of χ.
- Our estimates can be use to calibrate priors in larger-scale Bayesian DSGE models.

Conclusion

Aggregate Consumption Growth Is Sticky.

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