The Shifts in Lead-Lag Properties of the US Business Cycle: Online Appendix Not for Publication

March 1, 2019

1 Cross-correlations across filters

Table 1 reports the baseline cross-correlations discussed in the paper. Cyclical components are obtained using the HP filter with a smoothing parameter of 1600. Table 2 are the cross-correlations when obtaining the cyclical components using Hamilton (2018)'s filter, using $h = 8$ and $p = 4$. Table 3 reports the cross-correlations obtained using Baxter and King (1999)'s filter examining the 6-32 quarter frequency. Table 4 reports the cross-correlations obtained using Christiano and Fitzgerald (2003) filter obtaining cyclical components between 6-32 quarter frequencies.

2 Standard errors of the cross-correlations

In the paper we compute standard errors for cross-correlations using the Delta method and generalized method of moments (see, for example (Cochrane 2005, pg. 207)),

$$\rho_{i,j}(\mu) = \frac{\mu_{yx} - \mu_x \mu_y}{(\mu_y - \mu_y^2)^{1/2}(\mu_{xx} - \mu_x^2)^{1/2}} \tag{1}$$

$$var(\hat{\rho_{i,j}}) = \frac{1}{T}\left\{\frac{\partial \rho}{\partial \mu}\right\}' \sum_{j=-\infty}^{\infty} cov(\mathbf{x}_t, \mathbf{x}'_{t-j})\left\{\frac{\partial \rho}{\partial \mu}\right\} \tag{2}$$

where $\rho_{i,j}(\mu)$ is the standard correlation coefficient formula. Then the variance can be computed using (2) where $\mu = [\mu_y \ \mu_x \ \mu_{yy} \ \mu_{xx} \ \mu_{yx}]$ are the sample moments of the two variables of interest. Then $\partial\rho/\partial\mu$ is a 5×1 vector of derivatives (e.g. $\partial\rho/\partial\mu_{xy} = \frac{1}{\sigma_x \sigma_y}$). The variance covariance matrix is estimated using a Newey-West estimator with 10 lags.

Figures 1-4 present cross-correlations discussed in the paper with their associated one standard deviation confidence bands.

3 Literature studying business cycle cross-correlations

As discussed in the introduction, a long literature has used cross-correlations in studying business cycles. Contributions in the case of real interest rates-output cross-correlations, for example, are Fiorito and Kollintzas (1994), Chari, Christiano and Eichenbaum (1995), King and Watson (1996), Beaudry and Guay (1996), Boldrin, Christiano and Fisher (2001), Mertens (2010), and Dotsey et al. (2003). For cross-correlations related to investment see Hornstein and Praschnik (1997), Gomme, Kydland and Rupert (2001), Fisher (2007), Kydland, Rupert and Sustek (2016), Khan and Rouillard (2017), Khan and Rouillard (2018), among others). For labour productivity-output and labour productivity-hours cross-correlations see Burnside and Eichenbaum (1993). In the case of net exports, terms of trade, and balance of payments cross-correlations see Backus, Kehoe and Kydland (1992), Backus, Kehoe and Kydland (1994), among others. Christiano, Motto and Rostagno (2014) for cross-correlations between output and investment, consumption, credit risk, and equity. Azariadis, Kaas and Wen (2016) examine cross-correlations in unsecured firm credit to motivate their model of self-fulfilling credit cycles. Beaudry, Galizia and Portier (2017) discuss the positive correlation between their measure of capital over-accumulation prior to a recession and the subsequent severity of the recession over the period 1959-2015 in motivating their theoretical model. Barsky and Sims (2012) discuss the cross-correlations between consumer confidence and output.

4 Replication codes

The replication code for Smets and Wouters (2007) is available from the *American Economic Review*'s website `https://www.aeaweb.org/articles?id=10.1257/aer.97.3.586`. The replication code for Iacoviello (2005) is available at Matteo Iacoviello's website `https://www2.bc.edu/matteo-iacoviello/research.htm`. The replication code for Basu and Bundick (2017) is available at Brent Bundick's website `http://www.brentbundick.com/research.html` and Johannes Pfeifer's github page `https://github.com/JohannesPfeifer/DSGE_mod`. The replication code for Galí and van Rens (2017) is available from Thijs van Rens's website `http://www.thijsvanrens.com/VPLP/`.

	SD(%)	Rel Vol	ϕ_1	x(-5)	x(-4)	x(-3)	x(-2)	x(-1)	x	x(+1)	x(+2)	x(+3)	x(+4)	x(+5)
								Cross-correlations with real GDP						
1948Q1-1984Q4														
Real interest rate	2.02	1.02	.41	-.25	-.34	-.4	-.35	-.2	-.1	.01	.13	.15	.2	.14
Nominal interest rate	1.16	.59	.75	-.61	-.53	-.38	-.18	.1	.33	.42	.43	.39	.34	.29
Residential Inv	11.43	5.77	.88	.28	.44	.57	.67	.66	.53	.26	-.03	-.27	-.41	-.45
TFP	1.07	.54	.62	.21	.12	.03	-.09	-.2	-.19	-.22	-.17	-.1	.01	.07
W/R ratio	2.36	1.19	.48	.27	.37	.44	.4	.27	.18	.04	-.1	-.15	-.21	-.16
Ex-post inflation	2.01	1.02	.46	-.1	.04	.18	.25	.26	.29	.23	.12	.07	0	.02
Ex-ante inflation	1.35	.68	.65	-.3	-.19	-.01	.18	.29	.3	.28	.19	.11	.08	.03
1985Q1-2016Q4														
Real interest rate	1.06	.99	.62	-.05	.06	.16	.24	.31	.39	.46	.49	.53	.51	.43
Nominal interest rate	1.03	.96	.94	.07	.21	.35	.46	.55	.61	.62	.57	.51	.42	.3
Residential Inv	7.18	6.7	.93	.55	.62	.66	.68	.67	.61	.46	.29	.13	0	-.11
TFP	.84	.78	.69	.23	.15	.08	0	-.1	-.18	-.33	-.37	-.33	-.25	-.17
W/R ratio	1.74	1.62	.66	.11	.04	-.03	-.09	-.14	-.22	-.27	-.32	-.35	-.34	-.29
Ex-post inflation	.72	.67	.3	.18	.22	.26	.31	.33	.31	.2	.1	-.05	-.16	-.2
Ex-ante inflation	.59	.55	.54	.29	.33	.37	.4	.43	.43	.36	.22	.1	-.06	-.16
								Cross-correlations with non-farm output						
1948Q1-1984Q4														
Output per hour	1.22	.47	.7	.26	.42	.56	.67	.68	.64	.26	-.07	-.32	-.44	-.48
Output per person	1.58	.61	.77	.21	.4	.59	.74	.79	.77	.4	.04	-.25	-.42	-.49
Total hours	2.05	.79	.88	-.35	-.21	.02	.33	.65	.89	.9	.77	.55	.3	.08
1985Q1-2016Q4														
Output per hour	.85	.58	.74	.18	.15	.11	.07	.01	-.04	-.31	-.49	-.59	-.61	-.58
Output per person	.88	.6	.74	.27	.32	.36	.39	.36	.33	.02	-.23	-.44	-.57	-.63
Total hours	1.72	1.18	.94	.04	.22	.4	.59	.75	.87	.91	.86	.75	.59	.42
								Cross-correlations with output per hour						
1948Q1-1984Q4														
Total hours	2.05	1.68	.88	-.47	-.52	-.5	-.35	-.09	.21	.44	.59	.62	.56	.45
1985Q1-2016Q4														
Total hours	1.72	2.03	.94	-.5	-.58	-.65	-.67	-.63	-.53	-.36	-.2	-.05	.06	.15
								Cross-correlations with output per person						
1948Q1-1984Q4														
Total employment	1.72	1.09	.89	-.57	-.62	-.58	-.4	-.1	.24	.5	.65	.68	.62	.49
1985Q1-2016Q4														
Total employment	1.44	1.64	.96	-.59	-.62	-.62	-.55	-.43	-.27	-.08	.08	.2	.29	.34
								Cross-correlations with unemployment						
1948Q1-1984Q4														
Output per hour	1.22	1.34	.7	-.43	-.56	-.64	-.62	-.48	-.24	.09	.36	.5	.54	.46
Output per person	1.58	1.74	.77	-.41	-.57	-.7	-.73	-.62	-.39	-.03	.29	.5	.58	.54
1985Q1-2016Q4														
Output per hour	.85	1.25	.74	-.17	-.08	.04	.17	.33	.48	.61	.66	.65	.58	.48
Output per person	.88	1.29	.74	-.37	-.35	-.28	-.2	-.05	.14	.34	.49	.58	.61	.59

TABLE 1: Cross-correlations and volatilities using Hodrick-Prescott filter

	SD(%)	Rel Vol	ϕ_1	x(-5)	x(-4)	x(-3)	x(-2)	x(-1)	x	x(+1)	x(+2)	x(+3)	x(+4)	x(+5)
								Cross-correlations with real GDP						
1948Q1-1984Q4														
Real interest rate	2.5	.65	.63	-.26	-.33	-.35	-.31	-.23	-.17	-.11	-.06	-.02	.03	.02
Nominal interest rate	2.16	.56	.88	-.58	-.49	-.39	-.23	0	.2	.3	.34	.38	.38	.35
Residential Inv	20.75	5.38	.89	.39	.5	.55	.57	.54	.43	.18	-.03	-.21	-.36	-.42
TFP	1.95	.51	.83	.3	.21	.13	.02	-.09	-.14	-.16	-.12	-.08	.01	.07
W/R ratio	3.63	.94	.73	.27	.36	.4	.38	.33	.27	.18	.09	.01	-.07	-.08
Ex-post inflation	2.01	.52	.46	-.19	-.08	-.03	0	.04	.08	.07	.07	.1	.11	.17
Ex-ante inflation	1.35	.35	.65	-.25	-.19	-.08	0	.04	.08	.06	.02	.04	.08	.12
1985Q1-2016Q4														
Real interest rate	1.82	.68	.86	.03	.11	.21	.32	.41	.5	.56	.59	.6	.58	.54
Nominal interest rate	1.86	.69	.95	.16	.29	.41	.51	.58	.63	.62	.58	.53	.46	.38
Residential Inv	16.95	6.33	.94	.7	.73	.74	.73	.71	.67	.57	.48	.38	.29	.2
TFP	2.04	.76	.9	.3	.27	.23	.19	.15	.13	.08	.08	.11	.15	.18
W/R ratio	3.54	1.32	.88	.17	.14	.09	.03	-.01	-.07	-.09	-.11	-.1	-.06	-.02
Ex-post inflation	.72	.27	.3	.07	.15	.18	.22	.23	.2	.16	.1	.04	-.01	-.03
Ex-ante inflation	.59	.22	.54	.05	.15	.22	.28	.31	.32	.26	.21	.14	.08	.03
								Cross-correlations with non-farm output						
1948Q1-1984Q4														
Output per hour	2.43	.5	.88	.56	.66	.72	.72	.69	.62	.38	.13	-.06	-.19	-.27
Output per person	3.24	.66	.9	.51	.64	.73	.76	.76	.72	.48	.23	.02	-.15	-.27
Total hours	3.92	.8	.85	-.15	.03	.23	.45	.7	.88	.81	.72	.6	.41	.23
1985Q1-2016Q4														
Output per hour	2.07	.58	.91	.16	.14	.11	.05	-.01	-.03	-.13	-.19	-.2	-.19	-.17
Output per person	1.94	.54	.89	.3	.33	.34	.3	.26	.23	.06	-.06	-.15	-.22	-.27
Total hours	3.92	1.09	.93	.35	.48	.6	.71	.8	.87	.85	.79	.7	.58	.46
								Cross-correlations with output per hour						
1948Q1-1984Q4														
Total hours	3.92	1.61	.85	-.48	-.46	-.4	-.23	0	.22	.37	.48	.54	.53	.49
1985Q1-2016Q4														
Total hours	3.92	1.89	.93	-.43	-.5	-.55	-.58	-.56	-.5	-.42	-.35	-.27	-.2	-.13
								Cross-correlations with output per person						
1948Q1-1984Q4														
Total employment	3.51	1.08	.84	-.6	-.56	-.46	-.28	-.04	.21	.35	.45	.5	.46	.39
1985Q1-2016Q4														
Total employment	3.29	1.7	.94	-.5	-.52	-.5	-.45	-.36	-.25	-.14	-.05	.01	.07	.11
								Cross-correlations with unemployment						
1948Q1-1984Q4														
Output per hour	2.43	1.54	.88	-.6	-.65	-.69	-.67	-.58	-.45	-.22	0	.15	.25	.29
Output per person	3.24	2.06	.9	-.59	-.67	-.72	-.72	-.65	-.52	-.29	-.07	.11	.25	.32
1985Q1-2016Q4														
Output per hour	2.07	1.66	.91	-.06	-.02	.04	.1	.16	.22	.26	.27	.24	.19	.1
Output per person	1.94	1.55	.89	-.23	-.22	-.17	-.13	-.05	.04	.14	.22	.27	.29	.26

TABLE 2: Cross-correlations and volatilities using the *hp* filter (Hamilton (2018))

	SD(%)	Rel Vol	ϕ_1	x(-5)	x(-4)	x(-3)	x(-2)	x(-1)	x	x(+1)	x(+2)	x(+3)	x(+4)	x(+5)
								Cross-correlations with real GDP						
1948Q1-1984Q4														
Real interest rate	1.33	.73	.84	-.39	-.44	-.4	-.28	-.1	.07	.19	.19	.1	-.01	-.08
Nominal interest rate	1.06	.58	.92	-.73	-.64	-.44	-.16	.14	.39	.53	.55	.49	.37	.27
Residential Inv	11.02	6.07	.92	.33	.49	.64	.72	.69	.52	.27	0	-.24	-.39	-.45
TFP	.97	.53	.88	.34	.24	.09	-.07	-.2	-.28	-.26	-.18	-.07	.02	.08
W/R ratio	1.68	.92	.88	.34	.42	.43	.36	.23	.07	-.06	-.09	-.06	-.01	.02
Ex-post inflation	2.01	1.11	.46	-.16	-.07	.03	.11	.17	.2	.17	.2	.2	.28	.24
Ex-ante inflation	1.35	.74	.65	-.31	-.21	-.05	.1	.22	.26	.23	.16	.15	.16	.25
1985Q1-2016Q4														
Real interest rate	.89	.85	.93	-.09	.05	.16	.24	.32	.41	.5	.57	.61	.58	.5
Nominal interest rate	.99	.95	.95	.04	.21	.35	.47	.56	.62	.62	.58	.5	.39	.27
Residential Inv	6.78	6.47	.96	.53	.61	.68	.72	.7	.62	.48	.31	.15	.02	-.08
TFP	.81	.77	.91	.3	.23	.15	.04	-.08	-.21	-.31	-.35	-.32	-.24	-.11
W/R ratio	1.54	1.47	.92	.22	.13	.04	-.04	-.12	-.21	-.3	-.37	-.41	-.4	-.35
Ex-post inflation	.72	.69	.3	.2	.25	.31	.36	.38	.35	.25	.1	-.06	-.19	-.26
Ex-ante inflation	.59	.56	.54	.26	.34	.4	.45	.48	.47	.39	.27	.11	-.06	-.2
								Cross-correlations with non-farm output						
1948Q1-1984Q4														
Output per hour	1.13	.47	.89	.26	.44	.63	.76	.77	.61	.32	-.02	-.32	-.5	-.54
Output per person	1.47	.61	.9	.21	.42	.65	.83	.88	.75	.46	.1	-.24	-.47	-.55
Total hours	1.94	.8	.89	-.38	-.24	.01	.34	.66	.89	.92	.8	.57	.31	.08
1985Q1-2016Q4														
Output per hour	.79	.56	.91	.2	.18	.18	.16	.08	-.07	-.27	-.46	-.6	-.64	-.58
Output per person	.82	.58	.9	.28	.35	.44	.49	.47	.34	.1	-.19	-.45	-.62	-.67
Total hours	1.67	1.18	.95	0	.17	.37	.58	.75	.88	.92	.87	.74	.57	.37
								Cross-correlations with output per hour						
1948Q1-1984Q4														
Total hours	1.94	1.72	.89	-.51	-.58	-.53	-.37	-.11	.18	.45	.61	.65	.6	.49
1985Q1-2016Q4														
Total hours	1.67	2.11	.95	-.49	-.6	-.68	-.71	-.65	-.53	-.36	-.18	-.02	.1	.18
								Cross-correlations with output per person						
1948Q1-1984Q4														
Total employment	1.63	1.11	.9	-.61	-.67	-.62	-.42	-.13	.21	.5	.67	.71	.65	.52
1985Q1-2016Q4														
Total employment	1.38	1.68	.96	-.61	-.66	-.65	-.58	-.44	-.25	-.05	.13	.26	.34	.37
								Cross-correlations with unemployment						
1948Q1-1984Q4														
Output per hour	1.13	1.34	.89	-.46	-.6	-.68	-.67	-.53	-.28	.04	.33	.52	.57	.49
Output per person	1.47	1.74	.9	-.44	-.61	-.75	-.79	-.68	-.43	-.08	.25	.5	.6	.56
1985Q1-2016Q4														
Output per hour	.79	1.21	.91	-.19	-.11	.01	.16	.34	.5	.63	.69	.67	.59	.48
Output per person	.82	1.26	.9	-.39	-.38	-.34	-.24	-.07	.13	.34	.52	.63	.66	.63

TABLE 3: Cross-correlations and volatilities using Baxter and King (1999) filter

	SD(%)	Rel Vol	ϕ_1	x(-5)	x(-4)	x(-3)	x(-2)	x(-1)	x	x(+1)	x(+2)	x(+3)	x(+4)	x(+5)
Cross-correlations with real GDP														
1948Q1-1984Q4														
Real interest rate	1.61	.85	.84	-.3	-.42	-.48	-.44	-.31	-.13	.05	.17	.23	.21	.16
Nominal interest rate	1.05	.56	.91	-.71	-.61	-.41	-.14	.15	.4	.55	.59	.53	.43	.33
Residential Inv	11.79	6.26	.92	.33	.5	.66	.74	.71	.54	.26	-.06	-.33	-.5	-.56
TFP	.98	.52	.86	.33	.22	.07	-.08	-.2	-.27	-.27	-.23	-.16	-.07	.02
W/R ratio	2	1.06	.87	.35	.48	.54	.5	.38	.2	0	-.15	-.25	-.27	-.24
Ex-post inflation	2.01	1.07	.46	-.13	.02	.16	.27	.31	.3	.23	.15	.08	.05	.04
Ex-ante inflation	1.35	.72	.65	-.3	-.17	.01	.19	.32	.37	.32	.24	.16	.1	.08
1985Q1-2016Q4														
Real interest rate	.84	.85	.91	-.18	-.05	.06	.15	.24	.32	.4	.46	.48	.44	.35
Nominal interest rate	.92	.93	.94	-.07	.08	.23	.35	.44	.49	.49	.45	.36	.24	.12
Residential Inv	5.4	5.46	.93	.32	.48	.63	.75	.79	.75	.62	.44	.26	.11	-.02
TFP	.76	.77	.89	.33	.24	.12	-.01	-.16	-.3	-.43	-.5	-.5	-.43	-.32
W/R ratio	1.59	1.61	.93	.29	.22	.15	.08	0	-.08	-.15	-.21	-.26	-.27	-.24
Ex-post inflation	.72	.73	.3	.15	.18	.21	.25	.25	.21	.12	-.01	-.15	-.25	-.3
Ex-ante inflation	.59	.6	.54	.22	.27	.31	.35	.36	.33	.22	.11	-.04	-.19	-.3
Cross-correlations with non-farm output														
1948Q1-1984Q4														
Output per hour	1.14	.45	.89	.26	.46	.67	.8	.8	.63	.33	-.02	-.33	-.52	-.57
Output per person	1.5	.59	.9	.2	.44	.68	.87	.91	.78	.48	.11	-.24	-.48	-.57
Total hours	2.02	.8	.91	-.44	-.27	.01	.35	.68	.9	.94	.82	.57	.28	.03
1985Q1-2016Q4														
Output per hour	.75	.56	.9	.4	.39	.39	.36	.26	.09	-.15	-.38	-.56	-.65	-.63
Output per person	.83	.62	.9	.44	.53	.62	.68	.65	.5	.24	-.08	-.38	-.6	-.69
Total hours	1.47	1.1	.94	-.22	-.01	.23	.48	.7	.86	.91	.85	.71	.52	.3
Cross-correlations with output per hour														
1948Q1-1984Q4														
Total hours	2.02	1.77	.91	-.54	-.6	-.55	-.37	-.09	.22	.49	.67	.71	.64	.5
1985Q1-2016Q4														
Total hours	1.47	1.96	.94	-.51	-.61	-.67	-.67	-.59	-.43	-.22	0	.19	.33	.43
Cross-correlations with output per person														
1948Q1-1984Q4														
Total employment	1.66	1.11	.91	-.63	-.68	-.61	-.39	-.07	.28	.58	.76	.8	.71	.55
1985Q1-2016Q4														
Total employment	1.17	1.42	.94	-.68	-.7	-.66	-.55	-.37	-.14	.1	.32	.49	.58	.61
Cross-correlations with unemployment														
1948Q1-1984Q4														
Output per hour	1.14	1.28	.89	-.48	-.63	-.71	-.68	-.51	-.23	.1	.4	.59	.64	.56
Output per person	1.5	1.68	.9	-.45	-.64	-.78	-.81	-.68	-.41	-.05	.3	.55	.66	.63
1985Q1-2016Q4														
Output per hour	.75	1.3	.9	-.39	-.3	-.16	.01	.22	.42	.58	.65	.65	.58	.48
Output per person	.83	1.44	.9	-.57	-.57	-.53	-.41	-.23	.01	.25	.46	.6	.66	.66

TABLE 4: Cross-correlations and volatilities using Christiano and Fitzgerald (2003) filter

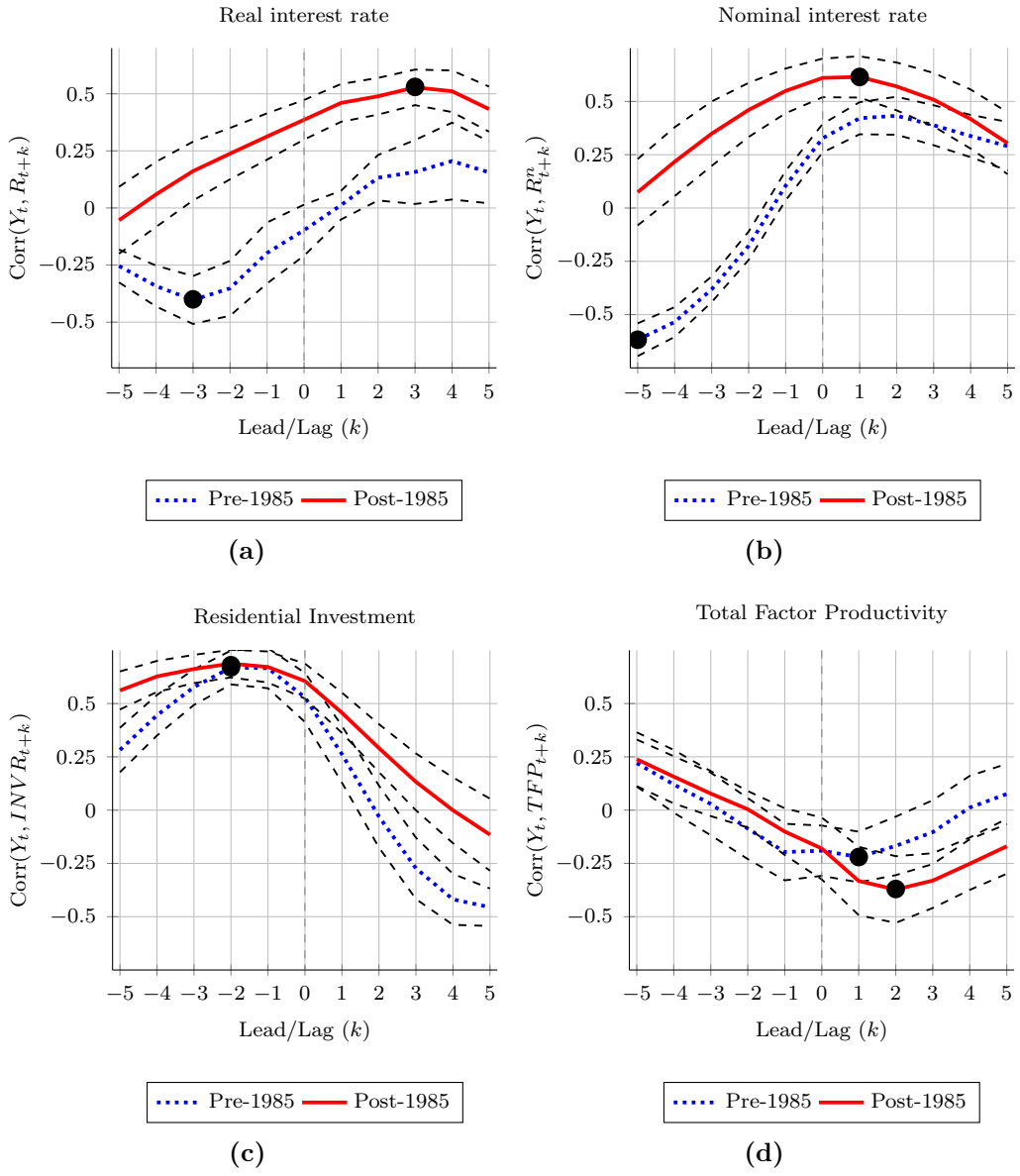


Figure 1: Cross-correlations with 1 standard deviation confidence bands

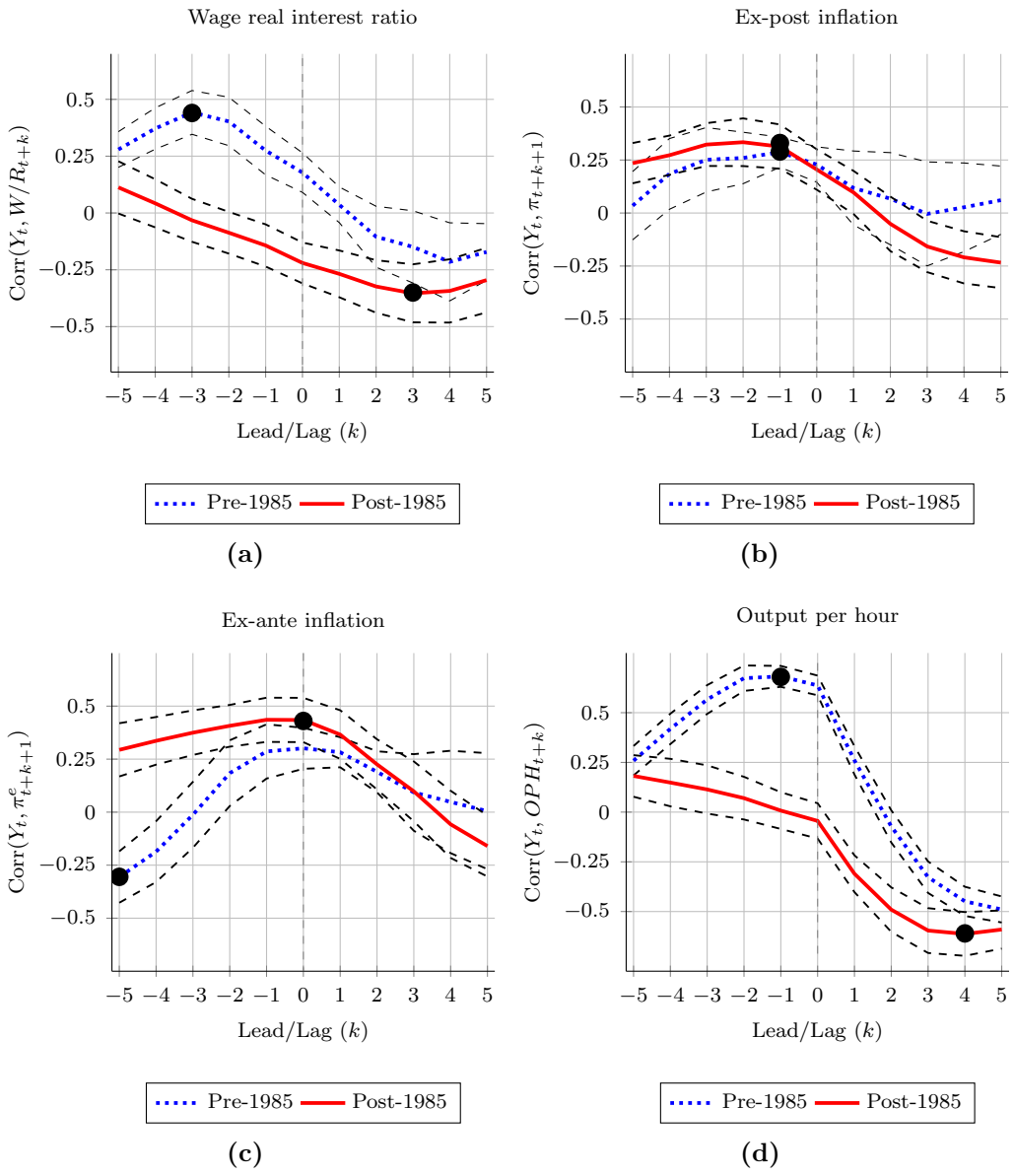


Figure 2: Cross-correlations with 1 standard deviation confidence bands

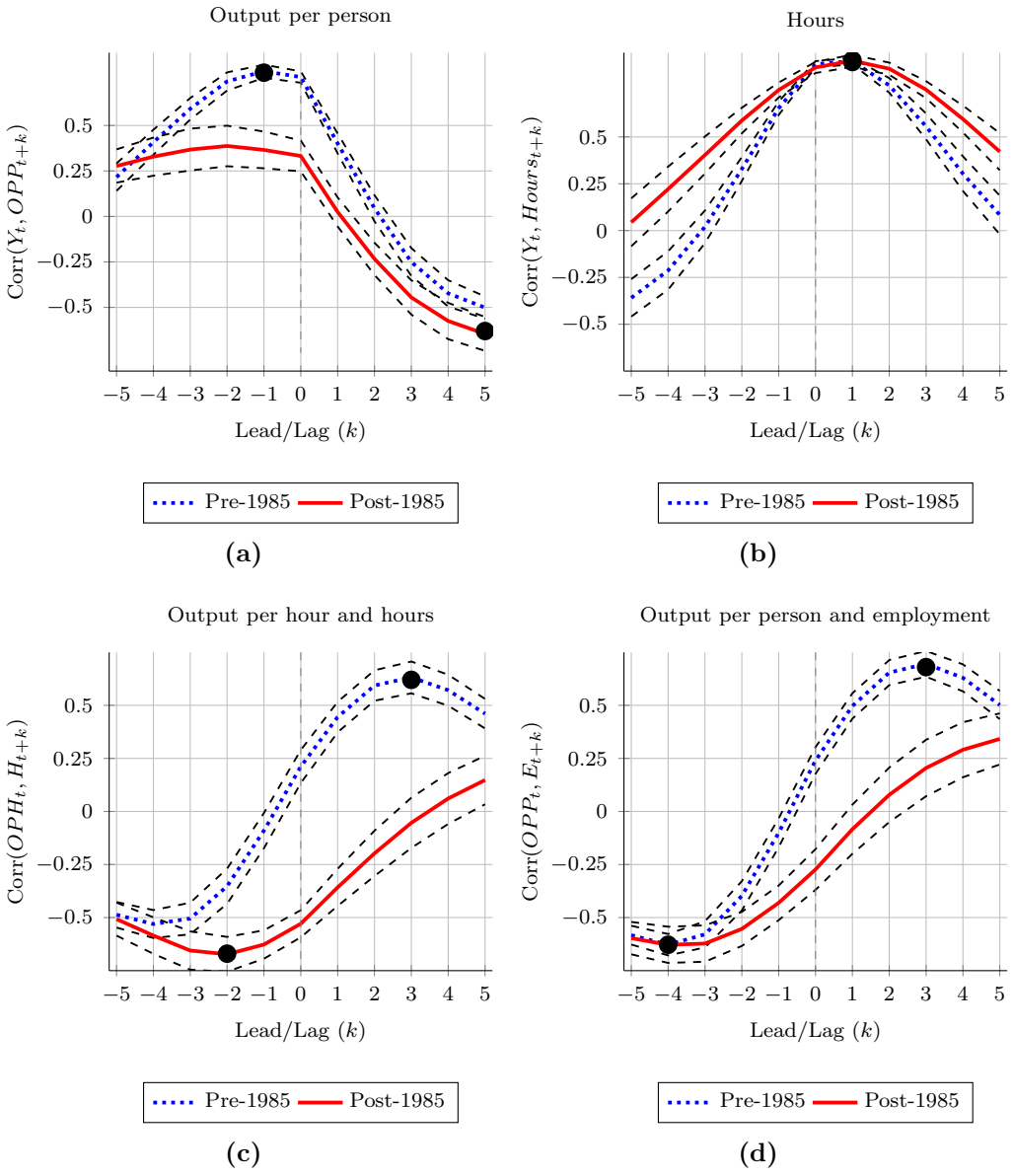
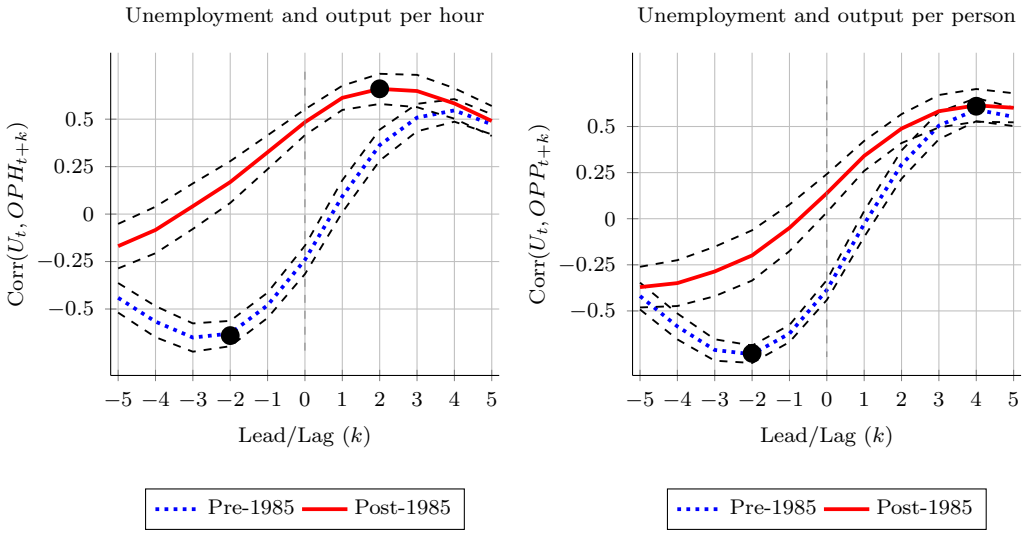


Figure 3: Cross-correlations with 1 standard deviation confidence bands



(a) **(b)**

Figure 4: Cross-correlations with 1 standard deviation confidence bands

5 Data and Definitions

The data series used in the paper are described below:

Variable	Data source	Sample	Notes
Real GDP	FRED	1947:I-2017:I	FRED code (GDPC1)
Nonfarm output	FRED	1947:I-2017:I	FRED code (OUTNFB)
GDP Deflator	FRED	1947:I-2017:I	FRED code (GDPDEF)
Federal funds rate	FRED	1954I:2017I	FRED code (FEDFUNDS)
3-month treasury bill	FRED	1947I:2017I	FRED code (TB3MS)
Total hours worked	FRED	1947:I-2017:I	FRED code (HOANBS)
Total employment	FRED	1947:I-2017:I	FRED code (PRS85006013)
Unemployment rate	FRED	1948:I-2017:I	FRED code (UNRATE)
Output per person	FRED	1947:I-2017:I	FRED code (PRS85006163)
Output per hour	FRED	1947:I-2017:I	FRED code (OPHNFB)
Residential investment	FRED	1947:I-2017:I	FRED code (A011RA3Q086SBEA)
Shadow federal funds rate	Wu and Xia (2016)	1960:I-2015:III	No zero lower bound
Consumer price index	FRED	1947:I-2017:I	FRED code (CPIAUCSL)
Core CPI	FRED	1957:I-2017:I	FRED code (CPILFESL)
PCE Deflator	FRED	1947:I-2017:I	FRED code (DPCERD3Q086SBEA)
Total factor productivity	Fernald (2014)	1947:I-2017:I	Level 1947:I=1
Forecasted inflation	SPF	1981:III-2017:I	One quarter ahead forecast
Demographic adj. hours	Wolters (2018)	1948I:2017I	Demographics purged
Real compensation	FRED	1947:I-2017:I	FRED code (COMPRNFB)

TABLE 5: Data sources

In compiling the data sources, any variables in monthly format are converted to quarterly by averaging. In the paper we defined additional variables via the following formulas:

$$\pi_t = (\ln(\text{Price}_t) - \ln(\text{Price}_{t-1})) * 400$$
$$r_t = R_t - \pi_{t+1}$$
$$\frac{W}{R} = \frac{\text{Real compensation}}{1 + \text{Real interest rate}}$$

Where π_t is the inflation rate, r_t is the real interest rate, R_t is the nominal interest rate, and W is the real compensation per hour, respectively. We log transform all of the variables prior to filtering, excluding interest rates and the unemployment rate. We use a smoothing parameter of $\lambda = 1600$ for the Hodrick-Prescott filter. Applying the Hamilton filter, we use $h = 8$ and $p = 4$, Hamilton's suggested parametric specification for detrending quarterly data.

We compute the cross-correlations as follows. Cross-covariance is defined as,

$$Cov\{x_1(t), x_2(t+k)\} = R_{12}(k)$$

and cross-correlation is computed as,

$$\rho_{ij}(k) = \text{Corr}\{x_i(t), x_j(t+k)\} = \frac{R_{ij}(k)}{\sqrt{R_{ii}(k)R_{jj}(k)}}$$

where $R_{ii}(k)$ and $R_{jj}(k)$ are the variances of the corresponding series.

6 Alternative definitions of real interest rate

The baseline real interest rate defined in the paper is the 3-month treasury bill rate minus ex-post inflation defined as the annualized log difference in the GDP deflator in $t+1$. Below we consider a variety of ex-ante and ex-post measures for the real interest rate from alternative price indexes (also we consider whether the real interest rate series is stationary or non-stationary). Table 6 reports cross-correlations for real interest rate using alternative definitions for the pre-1985 period. Table 7 reports the real interest rate cross-correlations for the same definitions in the post-1985 period.

Note: Ex-post measures of real interest rate are calculated using actual inflation at $t+1$. ISVAR computes expected inflation using an in-sample VAR. REVAR computes expected inflation using a recursive VAR forecast (using all information up to time t to forecast inflation at time $t+1$). ROVAR computes expected inflation using a rolling VAR forecast where the window is 40 quarters. Finally, in brackets (U) or (F) indicates whether the real interest rate series was passed through the Hodrick-Prescott filter with a smoothing parameter of 1600 (U for unfiltered and F for filtered). We begin the pre-1985 subsamples in 1956Q3 for all measures in this table to ensure the VAR has enough observations to generate reliable forecasts. We also consider the estimated nominal interest series from Wu and Xia (2016), which estimates the nominal interest rate in the absence of the zero lower bound (this is only relevant for the post-1985 sample). Finally, we consider expected inflation from the Survey of Profession Forecasters obtained through the Federal Reserve Bank of Philadelphia. Our measure of expected inflation is the median response for expected CPI growth in $t+1$ (CPI3 in the data). Since this data is only available from 1981:III onwards, we consider this measure for the post-1985 subsample only.

	SD(%)	Rel Vol	ϕ_1	x(-5)	x(-4)	x(-3)	x(-2)	x(-1)	x	x(+1)	x(+2)	x(+3)	x(+4)	x(+5)
1956Q3-1984Q4														
Ex-post (U)														
GDP Deflator	2.45	1.31	.84	-.23	-.27	-.27	-.21	-.1	-.06	-.07	-.11	-.16	-.16	-.14
CPI Deflator	2.69	1.44	.85	-.18	-.25	-.28	-.33	-.33	-.33	-.32	-.34	-.33	-.26	-.21
PCE Deflator	2.5	1.34	.86	-.23	-.26	-.27	-.26	-.2	-.17	-.16	-.17	-.21	-.16	-.11
Core CPI	2.3	1.23	.79	-.18	-.18	-.14	-.21	-.2	-.15	-.15	-.2	-.21	-.24	-.25
Ex-post (F)														
GDP Deflator	1.38	.74	.3	-.25	-.32	-.31	-.21	-.01	.07	.05	-.02	-.1	-.12	-.12
CPI Deflator	1.59	.85	.47	-.12	-.22	-.27	-.34	-.34	-.33	-.32	-.35	-.33	-.24	-.18
PCE Deflator	1.45	.78	.43	-.23	-.29	-.29	-.27	-.17	-.13	-.11	-.14	-.21	-.13	-.08
Core CPI	1.47	.79	.34	-.13	-.13	-.06	-.16	-.13	-.06	-.05	-.13	-.16	-.21	-.25
Ex-ante ISVAR (U)														
GDP Deflator	1.99	1.07	.93	-.27	-.24	-.22	-.19	-.08	.04	.07	.07	0	-.07	-.09
CPI Deflator	1.9	1.02	.92	-.18	-.24	-.29	-.32	-.33	-.27	-.23	-.21	-.23	-.23	-.19
PCE Deflator	1.98	1.06	.94	-.27	-.25	-.24	-.22	-.13	-.05	-.01	0	-.05	-.11	-.09
Core CPI	1.91	1.02	.91	-.23	-.24	-.21	-.15	-.14	-.09	-.08	-.12	-.16	-.19	-.2
Ex-ante ISVAR (F)														
GDP Deflator	1	.54	.43	-.37	-.32	-.28	-.23	0	.24	.3	.29	.16	.01	-.06
CPI Deflator	1.01	.54	.47	-.15	-.25	-.33	-.37	-.39	-.27	-.19	-.16	-.2	-.21	-.17
PCE Deflator	1.05	.56	.5	-.33	-.31	-.29	-.25	-.1	.06	.12	.14	.04	-.08	-.09
Core CPI	1.11	.59	.54	-.19	-.2	-.13	-.05	-.05	.03	.04	-.02	-.09	-.15	-.18
Ex-ante REVAR (U)														
GDP Deflator	1.8	.96	.91	-.22	-.21	-.22	-.19	-.1	.03	.12	.13	.07	0	-.08
CPI Deflator	1.97	1.06	.83	-.1	-.14	-.2	-.23	-.27	-.26	-.23	-.2	-.22	-.23	-.23
PCE Deflator	1.89	1.01	.92	-.23	-.22	-.24	-.23	-.16	-.08	-.02	.02	-.01	-.07	-.08
Core CPI	2.41	1.29	.8	-.12	-.15	-.18	-.13	-.2	-.22	-.24	-.27	-.33	-.33	-.33
Ex-ante REVAR (F)														
GDP Deflator	1.01	.54	.45	-.31	-.29	-.29	-.24	-.08	.15	.31	.33	.23	.1	-.06
CPI Deflator	1.14	.61	.35	-.11	-.15	-.22	-.26	-.31	-.27	-.2	-.15	-.17	-.19	-.21
PCE Deflator	1.01	.54	.49	-.34	-.31	-.34	-.31	-.18	-.03	.09	.16	.11	-.02	-.06
Core CPI	1.61	.86	.42	-.01	-.04	-.07	.02	-.08	-.12	-.13	-.17	-.26	-.26	-.29
Ex-ante ROVAR (U)														
GDP Deflator	2.02	1.08	.92	-.2	-.22	-.24	-.24	-.18	-.1	-.05	-.04	-.09	-.13	-.14
CPI Deflator	2.64	1.41	.86	-.13	-.18	-.24	-.27	-.32	-.31	-.28	-.27	-.27	-.26	-.21
PCE Deflator	2.26	1.21	.9	-.17	-.16	-.21	-.22	-.19	-.16	-.12	-.1	-.13	-.17	-.14
Core CPI	2.47	1.32	.81	-.19	-.22	-.26	-.23	-.29	-.34	-.33	-.33	-.34	-.3	-.25
Ex-ante ROVAR (F)														
GDP Deflator	1.07	.57	.49	-.26	-.28	-.32	-.32	-.19	-.04	.06	.07	-.01	-.12	-.16
CPI Deflator	1.66	.89	.56	-.1	-.16	-.24	-.29	-.34	-.32	-.28	-.26	-.26	-.26	-.21
PCE Deflator	1.27	.68	.5	-.18	-.17	-.24	-.27	-.21	-.14	-.08	-.04	-.1	-.2	-.17
Core CPI	1.73	.93	.53	-.09	-.12	-.17	-.12	-.21	-.28	-.27	-.28	-.3	-.26	-.22
Nominal rates														
3M Tbill (U)	3.12	1.67	1	-.35	-.3	-.22	-.11	.03	.15	.21	.23	.22	.21	.21
3M Tbill (F)	1.31	.7	.75	-.7	-.61	-.44	-.22	.1	.35	.46	.48	.44	.4	.35
Fed funds (U)	3.84	2.06	.99	-.38	-.33	-.25	-.15	.02	.16	.25	.28	.28	.27	.27
Fed funds (F)	1.81	.97	.79	-.68	-.61	-.47	-.27	.06	.34	.49	.53	.51	.47	.43

TABLE 6: Cross-correlations using alternative measures of real interest rate, pre-1985.

	SD(%)	Rel Vol	ϕ_1	x(-5)	x(-4)	x(-3)	x(-2)	x(-1)	x	x(+1)	x(+2)	x(+3)	x(+4)	x(+5)
1985Q1-2016Q4														
Ex-post (U)														
GDP Deflator	2.32	2.16	.93	.04	.12	.19	.24	.29	.34	.38	.39	.4	.38	.34
CPI Deflator	2.6	2.43	.62	.06	.07	.09	.12	.17	.28	.33	.33	.33	.33	.27
PCE Deflator	2.42	2.26	.82	.06	.09	.12	.17	.23	.34	.39	.4	.38	.36	.29
Core CPI	1.89	1.76	.93	.16	.24	.31	.36	.39	.41	.39	.35	.31	.27	.23
Ex-post (F)														
GDP Deflator	1.06	.99	.62	-.05	.06	.16	.24	.31	.39	.46	.49	.53	.51	.43
CPI Deflator	1.89	1.76	.21	-.02	-.02	-.01	-.01	.06	.19	.27	.27	.27	.29	.23
PCE Deflator	1.49	1.39	.4	-.02	0	.03	.07	.15	.31	.4	.41	.39	.38	.28
Core CPI	.92	.86	.71	.13	.26	.35	.42	.45	.47	.44	.37	.32	.27	.21
Ex-ante ISVAR (U)														
GDP Deflator	2.07	1.93	.95	.03	.11	.19	.26	.31	.36	.38	.4	.39	.38	.35
CPI Deflator	2	1.87	.78	.03	.08	.1	.16	.18	.24	.33	.39	.41	.4	.38
PCE Deflator	2.04	1.9	.9	.06	.12	.16	.21	.25	.31	.38	.43	.43	.4	.36
Core CPI	1.76	1.64	.94	.08	.18	.26	.33	.38	.41	.42	.39	.35	.31	.27
Ex-ante ISVAR (F)														
GDP Deflator	.83	.77	.75	-.11	.03	.17	.28	.37	.45	.51	.55	.56	.56	.49
CPI Deflator	1.18	1.1	.33	-.08	-.02	-.02	.04	.05	.13	.28	.37	.42	.41	.39
PCE Deflator	1.04	.97	.62	-.04	.04	.08	.13	.18	.27	.42	.51	.54	.49	.42
Core CPI	.79	.74	.81	0	.16	.28	.39	.47	.51	.53	.48	.41	.35	.28
Ex-ante REVAR (U)														
GDP Deflator	1.99	1.86	.96	.03	.11	.19	.26	.3	.35	.37	.38	.39	.38	.36
CPI Deflator	1.99	1.86	.81	0	.06	.1	.13	.15	.21	.3	.38	.4	.39	.39
PCE Deflator	2.04	1.9	.9	.05	.1	.15	.18	.22	.28	.36	.42	.43	.4	.38
Core CPI	1.73	1.61	.95	.06	.16	.24	.32	.36	.4	.41	.39	.35	.31	.28
Ex-ante REVAR (F)														
GDP Deflator	.8	.75	.8	-.1	.06	.18	.29	.37	.43	.48	.52	.54	.54	.51
CPI Deflator	1.23	1.15	.48	-.09	-.04	-.01	0	.02	.08	.23	.35	.39	.39	.39
PCE Deflator	1.08	1.01	.63	-.04	.02	.07	.09	.13	.22	.37	.48	.51	.47	.44
Core CPI	.78	.73	.86	-.04	.13	.26	.37	.44	.48	.51	.48	.41	.35	.29
Ex-ante ROVAR (U)														
GDP Deflator	2.21	2.06	.96	.06	.14	.21	.27	.31	.37	.4	.42	.43	.4	.37
CPI Deflator	2.39	2.23	.82	0	.05	.11	.14	.17	.27	.39	.52	.57	.53	.49
PCE Deflator	2.29	2.14	.89	.05	.13	.2	.25	.29	.37	.46	.54	.54	.5	.44
Core CPI	1.79	1.67	.95	.11	.2	.28	.34	.37	.41	.42	.41	.37	.32	.26
Ex-ante ROVAR (F)														
GDP Deflator	.92	.86	.8	-.02	.1	.21	.29	.36	.45	.51	.56	.58	.54	.47
CPI Deflator	1.55	1.45	.57	-.11	-.06	-.02	-.01	.01	.13	.3	.49	.57	.52	.46
PCE Deflator	1.28	1.19	.64	-.06	.04	.11	.15	.19	.32	.47	.61	.62	.55	.47
Core CPI	.92	.86	.86	.06	.21	.31	.38	.43	.48	.5	.49	.42	.35	.26
Wu & Xia (2016)														
Unfiltered	2.97	2.77	.95	.02	.09	.16	.22	.27	.33	.38	.41	.44	.43	.4
Filtered	1.21	1.13	.7	-.11	0	.11	.21	.3	.4	.5	.56	.6	.57	.5
SPF														
Unfiltered	1.9	1.77	.96	.15	.24	.31	.36	.41	.43	.44	.42	.38	.34	.29
Filtered	.84	.78	.85	.12	.26	.37	.45	.51	.54	.56	.53	.48	.4	.32
Nominal rates														
3M Tbill (U)	2.59	2.42	.98	.12	.2	.27	.34	.4	.43	.43	.41	.38	.33	.28
3M Tbill (F)	1.03	.96	.94	.07	.21	.35	.46	.55	.61	.62	.57	.51	.42	.3
Fed funds (U)	2.85	2.66	.98	.1	.19	.28	.35	.41	.45	.46	.44	.4	.35	.3
Fed funds (F)	1.13	1.05	.94	.03	.19	.34	.46	.56	.63	.65	.61	.54	.44	.33

TABLE 7: Cross-correlations using alternative measures of real interest rate, post-1985.

7 Alternative sample periods

In the paper we consider two subsamples, the pre-1985 and post-1985 periods. Below we report two alternative subsamples to assess how sensitive the shifts are to alternative subsamples. Table 8 reports post-1985 cross-correlations and volatilities when excluding the Great Recession. This table highlights that the Positive Lagging Property reported in the paper is not driven by the nominal interest rate binding at the zero lower bound. Table 9 reports cross-correlations and volatilities when we consider the post-1983 time period as the onset of the Great Moderation.

8 Extending the definition of the business cycle to 8-50 quarters

Tables 10 and 11 report cross-correlations when we examine the 8-50 frequency range using the Christiano and Fitzgerald (2003) and Baxter and King (1999) filters.

	SD(%)	Rel Vol	ϕ_1	x(-5)	x(-4)	x(-3)	x(-2)	x(-1)	x	x(+1)	x(+2)	x(+3)	x(+4)	x(+5)
							Cross-correlations with real GDP							
1985Q1-2007Q4														
Real interest rate	1.16	1.12	.71	-.1	-.02	.1	.25	.4	.47	.54	.57	.56	.54	.47
Nominal interest rate	1.18	1.13	.95	-.02	.11	.26	.41	.54	.64	.68	.66	.62	.54	.43
Residential inv	6.62	6.37	.94	.61	.65	.68	.69	.65	.55	.38	.21	.06	-.07	-.18
TFP	.82	.79	.67	.18	.09	.03	.02	-.05	-.09	-.2	-.21	-.22	-.19	-.17
W/R ratio	1.86	1.79	.77	.12	.06	0	-.08	-.15	-.22	-.29	-.35	-.35	-.35	-.3
Ex-post inflation	.67	.64	.3	.15	.24	.27	.27	.26	.31	.26	.19	.12	.01	-.06
Ex-ante inflation	.59	.57	.57	.23	.26	.35	.41	.43	.43	.44	.34	.27	.16	.04
							Cross-correlations with non-farm output							
1985Q1-2007Q4														
Output per hour	.82	.59	.73	.13	.06	-.01	-.03	-.04	-.03	-.22	-.34	-.43	-.44	-.44
Output per person	.81	.59	.73	.26	.27	.26	.29	.3	.32	.07	-.12	-.29	-.38	-.43
Total hours	1.63	1.18	.98	.17	.34	.49	.64	.76	.86	.85	.79	.7	.59	.46
							Cross-correlations with output per hour							
1985Q1-2007Q4														
Total hours	1.63	1.98	.98	-.4	-.45	-.51	-.55	-.56	-.53	-.41	-.29	-.15	-.02	.09
							Cross-correlations with output per person							
1985Q1-2007Q4														
Total employment	1.36	1.68	.99	-.42	-.44	-.45	-.43	-.37	-.27	-.13	-.01	.11	.21	.28
							Cross-correlations with unemployment							
1985Q1-2007Q4														
Output per hour	.82	1.38	.73	-.15	-.04	.12	.26	.38	.47	.55	.53	.5	.45	.39
Output per person	.81	1.36	.73	-.34	-.29	-.19	-.08	.04	.16	.31	.37	.4	.41	.4

TABLE 8: Cross-correlations and volatilities using Hodrick-Prescott filter, excluding the Great Recession

	SD(%)	Rel Vol	ϕ_1	x(-5)	x(-4)	x(-3)	x(-2)	x(-1)	x	x(+1)	x(+2)	x(+3)	x(+4)	x(+5)
								Cross-correlations with real GDP						
1948Q1-1982Q4														
Real interest rate	2.06	1.04	.42	-.23	-.32	-.41	-.37	-.22	-.11	0	.13	.16	.21	.16
Nominal interest rate	1.16	.59	.76	-.59	-.52	-.4	-.24	.04	.29	.38	.39	.35	.31	.29
Residential Inv	11.6	5.87	.9	.22	.37	.51	.62	.64	.53	.26	-.02	-.25	-.39	-.42
TFP	1.05	.53	.6	.26	.16	.05	-.08	-.21	-.23	-.29	-.26	-.22	-.1	-.03
W/R ratio	2.4	1.21	.48	.26	.36	.45	.43	.31	.2	.05	-.11	-.16	-.24	-.2
Ex-post inflation	2.06	1.04	.46	-.1	.03	.18	.24	.25	.28	.21	.09	.04	-.03	.01
Ex-ante inflation	1.37	.69	.65	-.31	-.2	-.03	.17	.27	.29	.26	.16	.07	.04	.01
1983Q1-2016Q4														
Real interest rate	1.07	.93	.57	-.04	.06	.15	.22	.3	.37	.44	.41	.45	.4	.32
Nominal interest rate	1.04	.9	.91	.05	.18	.31	.44	.54	.64	.61	.52	.44	.32	.2
Residential Inv	7.2	6.24	.88	.5	.57	.61	.65	.64	.58	.38	.19	.04	-.07	-.15
TFP	.87	.75	.72	.14	.07	.01	-.03	-.08	-.09	-.18	-.18	-.16	-.13	-.1
W/R ratio	1.73	1.5	.65	.07	.01	-.05	-.1	-.16	-.23	-.26	-.26	-.29	-.24	-.19
Ex-post inflation	.74	.64	.31	.12	.17	.23	.29	.34	.36	.21	.13	-.05	-.12	-.18
Ex-ante inflation	.61	.53	.55	.19	.25	.3	.37	.43	.48	.36	.21	.1	-.06	-.12
								Cross-correlations with non-farm output						
1948Q1-1982Q4														
Output per hour	1.24	.48	.71	.23	.37	.52	.64	.67	.65	.26	-.06	-.31	-.42	-.45
Output per person	1.59	.61	.78	.19	.36	.55	.71	.78	.78	.41	.06	-.23	-.39	-.45
Total hours	2.04	.78	.89	-.36	-.23	0	.3	.63	.88	.88	.73	.51	.26	.06
1983Q1-2016Q4														
Output per hour	.84	.54	.72	.17	.15	.13	.1	.04	0	-.31	-.49	-.58	-.58	-.54
Output per person	.9	.58	.73	.26	.32	.37	.39	.38	.36	.01	-.26	-.44	-.55	-.6
Total hours	1.76	1.14	.92	0	.16	.34	.53	.71	.88	.88	.81	.68	.51	.35
								Cross-correlations with output per hour						
1948Q1-1982Q4														
Total hours	2.04	1.64	.89	-.46	-.51	-.49	-.35	-.09	.22	.43	.55	.57	.51	.42
1983Q1-2016Q4														
Total hours	1.76	2.09	.92	-.48	-.57	-.64	-.67	-.62	-.48	-.31	-.16	-.02	.07	.15
								Cross-correlations with output per person						
1948Q1-1982Q4														
Total employment	1.69	1.06	.9	-.54	-.6	-.56	-.38	-.09	.26	.49	.62	.64	.55	.43
1983Q1-2016Q4														
Total employment	1.49	1.65	.94	-.58	-.63	-.63	-.57	-.44	-.24	-.05	.1	.21	.28	.32
								Cross-correlations with unemployment						
1948Q1-1982Q4														
Output per hour	1.24	1.38	.71	-.39	-.5	-.59	-.58	-.46	-.25	.09	.36	.49	.52	.44
Output per person	1.59	1.77	.78	-.36	-.51	-.65	-.69	-.61	-.4	-.03	.28	.48	.55	.5
1983Q1-2016Q4														
Output per hour	.84	1.17	.72	-.16	-.09	.01	.12	.27	.42	.6	.65	.63	.56	.46
Output per person	.9	1.26	.73	-.33	-.33	-.29	-.23	-.1	.09	.34	.5	.58	.6	.57

TABLE 9: Cross-correlations and volatilities using Hodrick-Prescott filter, alternative onset of Great Moderation 1983Q1

	SD(%)	Rel Vol	ϕ_1	x(-5)	x(-4)	x(-3)	x(-2)	x(-1)	x	x(+1)	x(+2)	x(+3)	x(+4)	x(+5)
								Cross-correlations with real GDP						
1948Q1-1984Q4														
Real interest rate	1.26	.67	.9	-.45	-.45	-.39	-.28	-.13	.03	.15	.19	.16	.08	.01
Nominal interest rate	1.11	.59	.94	-.77	-.64	-.43	-.15	.13	.38	.53	.59	.56	.47	.36
Residential Inv	11.46	6.09	.94	.42	.58	.71	.75	.69	.52	.28	.02	-.21	-.39	-.49
TFP	1	.53	.91	.36	.25	.09	-.07	-.21	-.3	-.3	-.25	-.14	-.02	.09
W/R ratio	1.64	.87	.92	.38	.43	.43	.38	.27	.12	0	-.08	-.1	-.08	-.06
Ex-post inflation	2.01	1.07	.46	-.16	-.07	.02	.11	.17	.2	.17	.2	.21	.29	.25
Ex-ante inflation	1.35	.72	.65	-.28	-.19	-.05	.08	.2	.25	.23	.18	.17	.18	.25
1985Q1-2016Q4														
Real interest rate	.93	.85	.95	-.14	0	.14	.26	.37	.47	.54	.59	.6	.57	.51
Nominal interest rate	1.05	.96	.95	.03	.21	.37	.51	.6	.65	.64	.59	.5	.39	.27
Residential Inv	7.05	6.43	.97	.58	.66	.71	.72	.69	.61	.48	.34	.19	.04	-.09
TFP	.85	.78	.93	.37	.27	.15	.01	-.13	-.25	-.33	-.36	-.33	-.25	-.13
W/R ratio	1.59	1.45	.94	.26	.18	.08	-.03	-.14	-.26	-.34	-.41	-.44	-.43	-.37
Ex-post inflation	.72	.66	.3	.23	.29	.35	.39	.38	.33	.23	.1	-.05	-.17	-.26
Ex-ante inflation	.59	.54	.54	.26	.36	.44	.49	.51	.48	.38	.26	.11	-.05	-.19
								Cross-correlations with non-farm output						
1948Q1-1984Q4														
Output per hour	1.14	.46	.91	.4	.6	.75	.83	.77	.59	.31	-.01	-.29	-.49	-.57
Output per person	1.51	.61	.92	.33	.57	.77	.89	.89	.74	.46	.13	-.19	-.44	-.57
Total hours	2.04	.82	.91	-.39	-.19	.08	.39	.68	.89	.94	.86	.66	.41	.15
1985Q1-2016Q4														
Output per hour	.79	.53	.94	.31	.29	.24	.16	.03	-.14	-.32	-.48	-.61	-.66	-.63
Output per person	.83	.56	.93	.39	.48	.53	.54	.46	.3	.07	-.19	-.43	-.61	-.71
Total hours	1.78	1.19	.95	-.03	.17	.39	.6	.78	.9	.93	.89	.77	.59	.39
								Cross-correlations with output per hour						
1948Q1-1984Q4														
Total hours	2.04	1.79	.91	-.57	-.62	-.56	-.39	-.14	.16	.43	.63	.72	.7	.61
1985Q1-2016Q4														
Total hours	1.78	2.25	.95	-.56	-.68	-.74	-.74	-.68	-.56	-.39	-.21	-.04	.12	.23
								Cross-correlations with output per person						
1948Q1-1984Q4														
Total employment	1.72	1.14	.91	-.67	-.71	-.63	-.43	-.14	.19	.48	.68	.77	.75	.64
1985Q1-2016Q4														
Total employment	1.47	1.77	.96	-.68	-.72	-.7	-.6	-.45	-.26	-.06	.13	.28	.38	.43
								Cross-correlations with unemployment						
1948Q1-1984Q4														
Output per hour	1.14	1.3	.91	-.61	-.73	-.77	-.7	-.52	-.25	.05	.33	.52	.6	.57
Output per person	1.51	1.72	.92	-.58	-.75	-.84	-.82	-.67	-.41	-.09	.23	.48	.62	.64
1985Q1-2016Q4														
Output per hour	.79	1.14	.94	-.25	-.13	.02	.2	.38	.54	.66	.73	.72	.66	.54
Output per person	.83	1.2	.93	-.47	-.44	-.37	-.24	-.06	.14	.35	.53	.66	.71	.7

TABLE 10: Cross-correlations and volatilities using Baxter and King (1999) filter, 8-50 quarters

	SD(%)	Rel Vol	ϕ_1	x(-5)	x(-4)	x(-3)	x(-2)	x(-1)	x	x(+1)	x(+2)	x(+3)	x(+4)	x(+5)
								Cross-correlations with real GDP						
1948Q1-1984Q4														
Real interest rate	1.61	.69	.89	-.4	-.51	-.57	-.54	-.45	-.31	-.17	-.05	.02	.04	.03
Nominal interest rate	1.23	.53	.95	-.76	-.67	-.51	-.29	-.07	.13	.27	.34	.36	.34	.3
Residential Inv	12.58	5.38	.94	.36	.5	.62	.68	.64	.5	.29	.05	-.16	-.31	-.39
TFP	1.04	.45	.91	.21	.14	.05	-.04	-.11	-.13	-.12	-.08	-.01	.07	.15
W/R ratio	2.1	.9	.92	.4	.52	.6	.59	.52	.4	.26	.14	.05	.01	.01
Ex-post inflation	2.01	.86	.46	-.11	.02	.15	.24	.28	.27	.22	.17	.12	.08	.07
Ex-ante inflation	1.35	.58	.65	-.28	-.18	-.03	.13	.24	.29	.27	.2	.12	.07	.05
1985Q1-2016Q4														
Real interest rate	1.17	.82	.96	.03	.17	.3	.41	.51	.59	.64	.67	.67	.64	.58
Nominal interest rate	1.33	.93	.97	.12	.27	.41	.52	.61	.67	.69	.67	.62	.54	.45
Residential Inv	11.02	7.71	.98	.7	.71	.69	.66	.58	.48	.34	.19	.02	-.13	-.27
TFP	.8	.56	.93	.1	.03	-.06	-.15	-.24	-.31	-.36	-.37	-.35	-.28	-.19
W/R ratio	1.81	1.27	.96	-.06	-.13	-.2	-.27	-.32	-.37	-.4	-.41	-.41	-.38	-.33
Ex-post inflation	.72	.5	.3	.16	.2	.25	.27	.28	.25	.2	.11	.02	-.07	-.14
Ex-ante inflation	.59	.41	.54	.22	.3	.35	.38	.39	.37	.31	.23	.13	.02	-.08
								Cross-correlations with non-farm output						
1948Q1-1984Q4														
Output per hour	1.32	.45	.92	.48	.63	.76	.83	.79	.64	.39	.1	-.17	-.36	-.44
Output per person	1.82	.61	.93	.45	.62	.78	.87	.86	.74	.51	.22	-.06	-.28	-.4
Total hours	2.36	.8	.94	-.21	-.04	.2	.48	.73	.9	.96	.89	.72	.51	.3
1985Q1-2016Q4														
Output per hour	.92	.47	.95	.13	.06	-.01	-.09	-.19	-.32	-.45	-.58	-.67	-.71	-.68
Output per person	.96	.49	.94	.34	.34	.34	.31	.23	.09	-.09	-.28	-.46	-.59	-.66
Total hours	2.4	1.24	.97	.26	.43	.59	.74	.85	.93	.95	.92	.84	.72	.57
								Cross-correlations with output per hour						
1948Q1-1984Q4														
Total hours	2.36	1.79	.94	-.53	-.54	-.45	-.27	-.02	.24	.48	.64	.72	.71	.63
1985Q1-2016Q4														
Total hours	2.4	2.61	.97	-.62	-.72	-.78	-.78	-.73	-.64	-.52	-.38	-.24	-.1	.03
								Cross-correlations with output per person						
1948Q1-1984Q4														
Total employment	2.03	1.12	.94	-.63	-.63	-.54	-.35	-.09	.18	.43	.6	.68	.68	.61
1985Q1-2016Q4														
Total employment	2.08	2.18	.98	-.65	-.69	-.68	-.61	-.51	-.37	-.22	-.06	.07	.19	.28
								Cross-correlations with unemployment						
1948Q1-1984Q4														
Output per hour	1.32	1.27	.92	-.64	-.72	-.74	-.67	-.51	-.26	.02	.28	.47	.56	.55
Output per person	1.82	1.75	.93	-.61	-.72	-.78	-.75	-.61	-.38	-.1	.18	.41	.54	.57
1985Q1-2016Q4														
Output per hour	.92	.96	.95	-.08	.06	.2	.34	.49	.62	.72	.78	.79	.74	.65
Output per person	.96	1.01	.94	-.37	-.3	-.2	-.07	.08	.25	.41	.55	.64	.69	.68

TABLE 11: Cross-correlations and volatilities using Christiano and Fitzgerald (2003) filter, 8-50 quarters

9 Robustness to standardized volatility

Forbes and Rigobon (2002) highlighted that correlation coefficients may be biased if significant changes in volatility occur over time. Since we are examining subsamples consisting of pre- and post Great Moderation which coincides with declining macroeconomic volatility, we provide a robustness check to ensure that the shifts we highlight are not driven by this potential bias.

To address these concerns, we follow a procedure highlighted in Stock and Watson (2002). First, we standardize the volatility of all variables such that they have a variance equal to $1 \rightarrow X_t = \frac{x_t}{\sigma_x^2}$. In Table 12 we standardize the volatility of the entire sample and recompute the cross-correlations.

In Table 13 we again standardize the volatility, but in this instance we standardize each subsample (1948I:1984IV and 1985I:2016IV) to have unit variance. If the shifts in cross-correlations were the result of volatility changes these patterns would differ from those discussed in the results of the paper. These results suggest that the changes in cross-correlations are not the result of changes in volatility.

	SD(%)	Rel Vol	ϕ_1	x(-5)	x(-4)	x(-3)	x(-2)	x(-1)	x	x(+1)	x(+2)	x(+3)	x(+4)	x(+5)
								Cross-correlations with real GDP						
1948Q1-1984Q4														
Real interest rate	1.21	.99	.41	-.25	-.34	-.4	-.35	-.2	-.1	.01	.13	.15	.2	.14
Nominal interest rate	1.06	.86	.75	-.61	-.53	-.38	-.18	.1	.33	.42	.43	.39	.34	.29
Residential Inv	1.18	.96	.88	.28	.44	.57	.67	.66	.53	.26	-.03	-.27	-.41	-.45
TFP	1.1	.9	.62	.21	.12	.03	-.09	-.2	-.19	-.22	-.17	-.1	.01	.07
W/R ratio	1.11	.9	.48	.27	.37	.44	.4	.27	.18	.04	-.1	-.15	-.21	-.16
Ex-post inflation	1.28	1.04	.46	-.1	.04	.18	.25	.26	.29	.23	.12	.07	0	.02
Ex-ante inflation	1.27	1.03	.65	-.3	-.19	-.01	.18	.29	.3	.28	.19	.11	.08	.03
1985Q1-2016Q4														
Real interest rate	.64	.96	.62	-.05	.06	.16	.24	.31	.39	.46	.49	.53	.51	.43
Nominal interest rate	.95	1.43	.94	.07	.21	.35	.46	.55	.61	.62	.57	.51	.42	.3
Residential Inv	.74	1.11	.93	.55	.62	.66	.68	.67	.61	.46	.29	.13	0	-.11
TFP	.86	1.29	.69	.23	.15	.08	0	-.1	-.18	-.33	-.37	-.33	-.25	-.17
W/R ratio	.82	1.23	.66	.11	.04	-.03	-.09	-.14	-.22	-.27	-.32	-.35	-.34	-.29
Ex-post inflation	.46	.69	.3	.18	.22	.26	.31	.33	.31	.2	.1	-.05	-.16	-.2
Ex-ante inflation	.56	.84	.54	.29	.33	.37	.4	.43	.43	.36	.22	.1	-.06	-.16
								Cross-correlations with non-farm output						
1948Q1-1984Q4														
Output per hour	1.15	.94	.7	.26	.42	.56	.67	.68	.64	.26	-.07	-.32	-.44	-.48
Output per person	1.21	.99	.77	.21	.4	.59	.74	.79	.77	.4	.04	-.25	-.42	-.49
Total hours	1.09	.9	.88	-.35	-.21	.02	.33	.65	.89	.9	.77	.55	.3	.08
1985Q1-2016Q4														
Output per hour	.79	1.15	.74	.18	.15	.11	.07	.01	-.04	-.31	-.49	-.59	-.61	-.58
Output per person	.67	.98	.74	.27	.32	.36	.39	.36	.33	.02	-.23	-.44	-.57	-.63
Total hours	.91	1.33	.94	.04	.22	.4	.59	.75	.87	.91	.86	.75	.59	.42
								Cross-correlations with output per hour						
1948Q1-1984Q4														
Total hours	1.09	.95	.88	-.47	-.52	-.5	-.35	-.09	.21	.44	.59	.62	.56	.45
1985Q1-2016Q4														
Total hours	.91	1.15	.94	-.5	-.58	-.65	-.67	-.63	-.53	-.36	-.2	-.05	.06	.15
								Cross-correlations with output per person						
1948Q1-1984Q4														
Total employment	1.09	.9	.89	-.57	-.62	-.58	-.4	-.1	.24	.5	.65	.68	.62	.49
1985Q1-2016Q4														
Total employment	.91	1.35	.96	-.59	-.62	-.62	-.55	-.43	-.27	-.08	.08	.2	.29	.34
								Cross-correlations with unemployment						
1948Q1-1984Q4														
Output per hour	1.15	1.02	.7	-.43	-.56	-.64	-.62	-.48	-.24	.09	.36	.5	.54	.46
Output per person	1.21	1.07	.77	-.41	-.57	-.7	-.73	-.62	-.39	-.03	.29	.5	.58	.54
1985Q1-2016Q4														
Output per hour	.79	.94	.74	-.17	-.08	.04	.17	.33	.48	.61	.66	.65	.58	.48
Output per person	.67	.79	.74	-.37	-.35	-.28	-.2	-.05	.14	.34	.49	.58	.61	.59

TABLE 12: Cross-correlations and volatilities using Hodrick-Prescott filter, standardizing entire sample

	SD(%)	Rel Vol	ϕ_1	x(-5)	x(-4)	x(-3)	x(-2)	x(-1)	x	x(+1)	x(+2)	x(+3)	x(+4)	x(+5)
								Cross-correlations with real GDP						
1948Q1-1984Q4														
Real interest rate	1	1	.41	-.25	-.34	-.4	-.35	-.2	-.1	.01	.13	.15	.2	.14
Nominal interest rate	1	1	.75	-.61	-.53	-.38	-.18	.1	.33	.42	.43	.39	.34	.29
Residential Inv	1	1	.52	.28	.44	.57	.67	.66	.53	.26	-.03	-.27	-.41	-.45
TFP	1	1	.62	.21	.12	.03	-.09	-.2	-.19	-.22	-.17	-.1	.01	.07
W/R ratio	1	1	.48	.27	.37	.44	.4	.27	.18	.04	-.1	-.15	-.21	-.16
Ex-post inflation	1	1	.46	-.1	.04	.18	.25	.26	.29	.23	.12	.07	0	.02
Ex-ante inflation	1	1	.65	-.3	-.19	-.01	.18	.29	.3	.28	.19	.11	.08	.03
1985Q1-2016Q4														
Real interest rate	1	1	.62	-.05	.06	.16	.24	.31	.39	.46	.49	.53	.51	.43
Nominal interest rate	1	1	.94	.07	.21	.35	.46	.55	.61	.62	.57	.51	.42	.3
Residential Inv	1	1	.93	.55	.62	.66	.68	.67	.61	.46	.29	.13	0	-.11
TFP	1	1	.7	.23	.15	.08	0	-.1	-.18	-.33	-.37	-.33	-.25	-.17
W/R ratio	1	1	.66	.11	.04	-.03	-.09	-.14	-.22	-.27	-.32	-.35	-.34	-.29
Ex-post inflation	1	1	.32	.18	.22	.26	.31	.33	.31	.2	.1	-.05	-.16	-.2
Ex-ante inflation	1	1	.56	.29	.33	.37	.4	.43	.43	.36	.22	.1	-.06	-.16
								Cross-correlations with non-farm output						
1948Q1-1984Q4														
Output per hour	1	1	.7	.26	.42	.56	.67	.68	.64	.26	-.07	-.32	-.44	-.48
Output per person	1	1	.77	.21	.4	.59	.74	.79	.77	.4	.04	-.25	-.42	-.49
Total hours	1	1	.88	-.35	-.21	.02	.33	.65	.89	.9	.77	.55	.3	.08
1985Q1-2016Q4														
Output per hour	1	1	.74	.18	.15	.11	.07	.01	-.04	-.31	-.49	-.59	-.61	-.58
Output per person	1	1	.75	.27	.32	.36	.39	.36	.33	.02	-.23	-.44	-.57	-.63
Total hours	1	1	.95	.04	.22	.4	.59	.75	.87	.91	.86	.75	.59	.42
								Cross-correlations with output per hour						
1948Q1-1984Q4														
Total hours	1	1	.88	-.47	-.52	-.5	-.35	-.09	.21	.44	.59	.62	.56	.45
1985Q1-2016Q4														
Total hours	1	1	.95	-.5	-.58	-.65	-.67	-.63	-.53	-.36	-.2	-.05	.06	.15
								Cross-correlations with output per person						
1948Q1-1984Q4														
Total employment	1	1	.89	-.57	-.62	-.58	-.4	-.1	.24	.5	.65	.68	.62	.49
1985Q1-2016Q4														
Total employment	1	1	.96	-.59	-.62	-.62	-.55	-.43	-.27	-.08	.08	.2	.29	.34
								Cross-correlations with unemployment						
1948Q1-1984Q4														
Output per hour	1	1	.7	-.43	-.56	-.64	-.62	-.48	-.24	.09	.36	.5	.54	.46
Output per person	1	1	.77	-.41	-.57	-.7	-.73	-.62	-.39	-.03	.29	.5	.58	.54
1985Q1-2016Q4														
Output per hour	1	1	.74	-.17	-.08	.04	.17	.33	.48	.61	.66	.65	.58	.48
Output per person	1	1	.75	-.37	-.35	-.28	-.2	-.05	.14	.34	.49	.58	.61	.59

TABLE 13: Cross-correlations and volatilities using Hodrick-Prescott filter, standardizing each subsample

10 Filtering on subsamples

Table 14 reports cross-correlations when applying the Hodrick-Prescott filter to each subsample. The baseline case in the paper apply the HP-filter to the entire sample prior to examining cross-correlations in each subsample.

11 Demographic adjusted productivity

Table 15 reports cross-correlations when using demographic adjusted hours in computing output per hour.

	SD(%)	Rel Vol	ϕ_1	x(-5)	x(-4)	x(-3)	x(-2)	x(-1)	x	x(+1)	x(+2)	x(+3)	x(+4)	x(+5)
								Cross-correlations with real GDP						
1948Q1-1984Q4														
Real interest rate	2	1.02	.39	-.2	-.3	-.36	-.32	-.17	-.08	.03	.17	.2	.24	.18
Nominal interest rate	1.17	.59	.75	-.61	-.54	-.39	-.19	.1	.32	.42	.44	.41	.36	.32
Residential Inv	11.43	5.81	.89	.27	.45	.59	.68	.68	.55	.27	-.03	-.28	-.43	-.47
TFP	1.03	.52	.61	.27	.17	.06	-.07	-.19	-.19	-.23	-.19	-.14	-.04	.02
W/R ratio	2.3	1.17	.45	.22	.32	.4	.37	.25	.16	.01	-.15	-.21	-.27	-.22
Ex-post inflation	2.01	1.02	.46	-.12	.02	.17	.23	.24	.27	.21	.09	.04	-.03	.02
Ex-ante inflation	1.35	.69	.65	-.32	-.21	-.03	.17	.27	.28	.26	.17	.1	.07	.04
1985Q1-2016Q4														
Real interest rate	1.06	1	.58	-.05	.07	.17	.25	.32	.4	.48	.52	.56	.56	.49
Nominal interest rate	1.01	.95	.92	.09	.24	.38	.51	.6	.67	.68	.64	.57	.48	.37
Residential Inv	7.12	6.7	.9	.56	.62	.66	.68	.66	.6	.44	.26	.09	-.06	-.18
TFP	.84	.79	.69	.23	.15	.07	-.01	-.11	-.19	-.34	-.39	-.34	-.27	-.18
W/R ratio	1.73	1.63	.63	.11	.04	-.04	-.09	-.15	-.23	-.29	-.36	-.41	-.41	-.37
Ex-post inflation	.72	.68	.3	.22	.26	.31	.36	.39	.38	.27	.15	0	-.12	-.19
Ex-ante inflation	.59	.56	.54	.31	.36	.41	.45	.49	.49	.44	.3	.16	0	-.11
								Cross-correlations with non-farm output						
1948Q1-1984Q4														
Output per hour	1.22	.47	.7	.23	.4	.55	.66	.68	.64	.25	-.08	-.34	-.46	-.5
Output per person	1.57	.61	.77	.18	.38	.57	.73	.8	.77	.4	.04	-.26	-.43	-.5
Total hours	2.04	.79	.88	-.4	-.25	-.01	.3	.64	.89	.89	.75	.52	.26	.03
1985Q1-2016Q4														
Output per hour	.84	.58	.72	.17	.14	.1	.06	-.01	-.06	-.34	-.53	-.64	-.66	-.62
Output per person	.86	.59	.72	.27	.32	.35	.37	.35	.32	0	-.27	-.48	-.61	-.67
Total hours	1.72	1.18	.93	.04	.22	.4	.58	.75	.87	.91	.87	.76	.6	.43
								Cross-correlations with output per hour						
1948Q1-1984Q4														
Total hours	2.04	1.67	.88	-.49	-.54	-.52	-.36	-.1	.21	.44	.58	.61	.54	.43
1985Q1-2016Q4														
Total hours	1.72	2.05	.93	-.52	-.61	-.68	-.7	-.64	-.54	-.36	-.2	-.05	.07	.15
								Cross-correlations with output per person						
1948Q1-1984Q4														
Total employment	1.7	1.08	.89	-.58	-.63	-.59	-.4	-.1	.25	.51	.65	.68	.59	.45
1985Q1-2016Q4														
Total employment	1.44	1.67	.94	-.6	-.64	-.64	-.57	-.44	-.28	-.09	.08	.21	.3	.34
								Cross-correlations with unemployment						
1948Q1-1984Q4														
Output per hour	1.22	1.34	.7	-.4	-.54	-.63	-.62	-.49	-.25	.09	.36	.51	.55	.48
Output per person	1.57	1.72	.77	-.37	-.54	-.69	-.73	-.63	-.4	-.04	.29	.5	.58	.54
1985Q1-2016Q4														
Output per hour	.84	1.23	.72	-.17	-.08	.04	.17	.33	.49	.63	.68	.67	.6	.5
Output per person	.86	1.26	.72	-.37	-.35	-.29	-.2	-.05	.15	.36	.51	.6	.63	.6

TABLE 14: Cross-correlations and volatilities using Hodrick-Prescott filter, filtering pre- and post subsamples

	SD(%)	Rel Vol	ϕ_1	x(-5)	x(-4)	x(-3)	x(-2)	x(-1)	x	x(+1)	x(+2)	x(+3)	x(+4)	x(+5)
							Cross-correlations with non-farm output							
1948Q1-1984Q4														
Output per hour	.91	.35	.64	.15	.3	.46	.59	.59	.53	.18	-.13	-.36	-.44	-.41
1985Q1-2016Q4														
Output per hour	.71	.49	.75	.25	.19	.14	.08	.02	-.06	-.31	-.5	-.59	-.58	-.53
							Cross-correlations with output per hour							
1948Q1-1984Q4														
Total hours	2.05	2.24	.88	-.38	-.47	-.49	-.38	-.14	.13	.37	.51	.52	.44	.32
1985Q1-2016Q4														
Total hours	1.72	2.42	.94	-.51	-.59	-.65	-.67	-.61	-.51	-.34	-.18	-.03	.1	.2
							Cross-correlations with unemployment							
1948Q1-1984Q4														
Output per hour	.91	1	.64	-.27	-.4	-.52	-.54	-.4	-.17	.14	.39	.48	.47	.34
1985Q1-2016Q4														
Output per hour	.71	1.04	.75	-.23	-.12	.01	.14	.31	.47	.6	.66	.64	.57	.49

TABLE 15: Cross-correlations and volatilities using demographic adjusted hours in definition of output per hour

12 Jordá, Schularick, and Taylor (2016)

The following tables report cross-correlations by country using Jordà et al. (2016)'s dataset. We report cross-correlations for both growth rates and HP filtered data. We use real GDP per capita as our measure of output. We define credit as the total real loans per capita, which we compute by dividing total loans by the consumer price index and country population. Prior to filtering, we take the logs of both variables. We use a smoothing parameter of $\lambda = 6.25$ in detrending, as suggested by Ravn and Uhlig (2002). We examine two time periods, 1948-1984 and 1984-2013.

12.0.1 Cross-correlations for growth rates

	x(-2)	x(-1)	x	x(+1)	x(+2)
Australia	-.14	.14	.5	.21	-.31
Belgium	.17	.47	.23	.21	-.03
Canada	.03	.12	.56	.07	.02
Denmark	0	.26	.58	.27	.1
Finland	.1	-.03	.53	.38	-.18
France	.26	.52	.35	-.07	.06
Germany	.36	.37	.79	.5	.15
Italy	.17	.41	.43	.32	.24
Japan	.34	.52	.45	.25	.21
Netherlands	-.27	.31	.55	.28	.05
Norway	-.06	.37	.17	-.2	-.23
Portugal	.06	.43	.6	.35	.18
Spain	.31	.44	.65	.44	.3
Sweden	.04	.28	.44	-.02	-.11
Switzerland	.25	.4	.47	-.17	-.28
UK	-.44	.09	.48	-.03	-.45
USA	-.2	.23	.68	-.1	-.21

TABLE 16: Cross-correlations between growth rate of real gdp per capita and leads/lags of real credit per capita. Data from 1948-1984.

	x(-2)	x(-1)	x	x(+1)	x(+2)
Australia	-.48	-.41	.31	.4	.32
Belgium	-.25	.29	.61	.3	.15
Canada	-.42	-.07	.19	.04	-.01
Denmark	-.26	.15	.48	.51	.29
Finland	-.14	.18	.45	.53	.45
France	-.26	-.02	.46	.45	.09
Germany	.24	.19	.02	.04	-.07
Italy	-.09	.19	.59	.36	.37
Japan	.44	.34	.36	.4	.32
Netherlands	.47	.54	.47	.39	.15
Norway	-.37	-.11	.35	.51	.36
Portugal	-.14	.08	.3	.33	.25
Spain	.04	.41	.66	.6	.45
Sweden	-.27	-.03	.38	.46	.37
Switzerland	.14	.37	.47	.39	.06
UK	-.04	.29	.59	.81	.65
USA	.08	.32	.65	.42	.13

TABLE 17: Cross-correlations between growth rate of real gdp per capita and leads/lags of real credit per capita. Data from 1985-2013.

12.0.2 Cross-correlations for HP filtered data

	x(-2)	x(-1)	x	x(+1)	x(+2)
Australia	-.29	.14	.57	.21	-.44
Belgium	.16	.5	.28	.09	-.28
Canada	-.07	.12	.53	.04	-.15
Denmark	-.31	.13	.6	.23	-.13
Finland	-.03	.12	.6	.38	-.26
France	.18	.47	.12	-.52	-.44
Germany	-.19	-.08	.63	.24	-.3
Italy	-.31	.2	.41	.28	.1
Japan	-.1	.33	.38	.06	-.04
Netherlands	-.39	.32	.68	.29	-.19
Norway	-.02	.52	.35	-.07	-.18
Portugal	-.33	.23	.51	.26	.04
Spain	-.03	.25	.52	.13	-.17
Sweden	-.16	.36	.42	-.23	-.43
Switzerland	.28	.48	.44	-.21	-.47
UK	-.6	.07	.59	.13	-.37
USA	-.25	.34	.8	0	-.35

TABLE 18: Cross-correlations between HP filtered real gdp per capita and leads/lags of HP filtered real credit per capita. Data from 1948-1984.

	x(-2)	x(-1)	x	x(+1)	x(+2)
Australia	-.66	-.52	.34	.63	.32
Belgium	-.28	.34	.74	.4	.04
Canada	-.36	.18	.47	.25	-.04
Denmark	-.37	.08	.54	.64	.33
Finland	-.29	.13	.49	.56	.36
France	-.36	.04	.66	.66	.13
Germany	.24	.21	-.01	-.07	-.16
Italy	-.44	-.04	.43	.12	.07
Japan	-.02	-.24	-.33	-.03	.09
Netherlands	.44	.51	.3	.09	-.17
Norway	-.45	-.09	.54	.82	.5
Portugal	-.19	.15	.52	.56	.39
Spain	-.02	.52	.77	.51	.11
Sweden	-.33	-.02	.46	.53	.31
Switzerland	.15	.48	.55	.31	-.23
UK	-.6	-.12	.48	.85	.52
USA	.03	.42	.78	.47	-.05

TABLE 19: Cross-correlations between HP filtered real gdp per capita and leads/lags of HP filtered real credit per capita. Data from 1985-2013.

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