TFP, News, and "Sentiments:" The International Transmission of Business Cycles

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Motivation

- International business cycle
  - Positive comovement between advanced countries
  - Studied (mostly) with models driven by surprise TFP shocks
    - International Real Business Cycle (Backus, Kehoe, Kydland, 1992)
- Domestic business cycle
  - Driven to a substantial extent by non-technology disturbances at short frequencies ("demand" shocks)
  - Blanchard and Quah (1989), Galí (1999), Canova and De Nicoló (2003), Basu, Fernald, Kimball (2006)
  - New theory: expectations-driven cycles (e.g. Angeletos and La'O 2013)

This Paper

- Provide an empirical account of international transmission of both technology and non-technology shocks
  - Structural VAR
  - From US to Canada
- Identify 3 shocks in the US:
  1. Surprise TFP (utilization-adjusted, ordered first)
  2. News of future TFP (Barsky and Sims, 2011)
  3. Sentiment: A shock orthogonal to both surprise and news TFP shocks that accounts for maximum of the forecast error variance of an expectational variable (GDP forecast or consumer confidence)
- Document their importance for both US and Canadian fluctuations at different frequencies

Preview of Results

- The sentiment shock generates a business cycle in the US
  - GDP, hours, consumption increase on impact, then revert to steady state
  - At short frequencies ($\leq$1 year), the sentiment shocks account for 60-75% of the forecast error variance in GDP, 60-70% in hours, and 20% in consumption
- News shocks become more important at longer frequencies: $\sim$50% of GDP and consumption
- Surprise TFP matters the least, at any frequency

Preview of Results

- The US sentiment shock drives a substantial share of the Canadian business cycle at short frequencies
  - On impact, Canadian GDP, consumption, hours, imports from, and exports to the US rise
  - Accounts for 20-40% of variation in Canadian GDP, 20-40% in Canadian hours, imports, and exports, and 10% in Canadian consumption
- US news shocks are more important for Canada at longer frequencies ($>$0.3 of output and hours)
- US surprise TFP shocks account for less than 10% of Canadian macro aggregates at any frequency.
- US sentiment and news shocks generate very high conditional correlations between US and Canadian variables

Literature

- Non-technology driven business cycles: Galí (1999), Beaudry and Portier (2006), Lorenzoni (2009), Barsky and Sims (2011), Angeletos and La'O (2013), Blanchard, L'Huillier, and Lorenzoni (2013), Benhabib, Liu, and Wang (2015), Huo and Takayama (2015)
- Measurement of sentiment shocks: Angeletos, Collard, and Dellas (2014), Milani (2014)
- International business cycle and demand shocks
  - Theory: Stockman and Tesar (1995), Wen (2007)
  - Measurement: Canova (2005), Corsetti, Dedola, and Leduc (2014)

Illustrative Model

- Angeletos and La'O (2013), Huo and Takayama (2015)
- US: a unit measure of islands indexed by $i \in [0,1]$, productivity $a_i \sim N\left(0, \tau_a^{-1}\right)$
- Canada: a single island c of measure zero
- Islands match with each other randomly and trade. Canada matches with a US island.
- Island i output:

$$y_{it} = \alpha_0 a_i + \alpha_1 E_{it}\left[y_{jt}\right], \qquad 0 < \alpha_1 < 1$$

Information and Sentiments

- A US island i receives signals:

$$x_{it}^1 = a_{jt} + \xi_t, \qquad \xi_t \sim N\left(0, \tau_\xi^{-1}\right),$$

$$x_{it}^2 = \xi_t + u_{it}, \qquad u_{it} \sim N\left(0, \tau_u^{-1}\right).$$

- The Canadian island receives signals:

$$x_{ct}^1 = a_{jt} + \xi_t,$$

$$x_{ct}^2 = \xi_t.$$

- Note: Canadians not subject to sentiment shocks. US island knows it is meeting a Canadian.

Equilibrium

- US island and aggregate output (Angeletos-La'O, Huo-Takayama):

$$y_{it} = h^a_{us} a_i + h^1_{us} x^1_{it} + h^2_{us} x^2_{it}.$$

$$y_t = \left(h^1_{us} + h^2_{us}\right) \xi_t.$$

- Canadian output:

$$y_{ct} = h^a_c a_c + h^1_c x^1_{ct} + h^2_c x^2_{ct},$$

with $h^1_c + h^2_c > 0$, therefore

$$\frac{dy_{ct}}{d\xi_t} > 0.$$

- Canadian output rises in response to US sentiment

Empirics

- A sentiment shock is something that moves expectations of (future) output:

$$y_{it} = \alpha_0 a_i + \alpha_1 E_{it}\left[y_{jt}\right]$$

- Challenge: in the data, expectations of future output may be driven by news of future TFP rather than "sentiment:"

$$TFP_t = \lambda_1 \epsilon_t^{sur} + \lambda_2 \epsilon_{t-s}^{news}$$

$$E_{it} = \lambda_1^E \epsilon_t^{sur} + \lambda_2^E \epsilon_{t-s}^{news} + \lambda_3^E \xi_t + \zeta_t$$

- Approach: still rely on expectations data, but net out the TFP news before identifying the sentiment shock

Preliminaries

- Reduced-form VAR:

$$Y_t = B(L)\,\mathbf{u}_t,$$

$$Y_t = \{TFP_t, GDP_t, C_t, Hours_t, E_t\}$$

- Structural representation:

$$Y_t = A(L)\,\boldsymbol{\epsilon}_t,$$

  with $A(L) = B(L)\,A$

- A identifies structural shocks, but is not unique: $\forall D$ s.t. $DD' = I$, AD is another identification.

- Forecast error h steps ahead:

$$Y_{t+h} - E_{t-1}Y_{t+h} = \sum_{\tau=0}^{h} B_\tau AD\boldsymbol{\epsilon}_{t+h-\tau},$$

Identification: Surprise and News

- Barsky and Sims (2011)
- Surprise TFP: reduced-form innovation in TFP ordered first
- News TFP:

$$\gamma^{news} = \text{argmax} \sum_{h=0}^{H^{news}} \left(\frac{\sum_{\tau=0}^{h} B_{1,\tau} \tilde{A} \gamma^{news} \gamma^{news\prime} \tilde{A}' B_{1,\tau}'}{\sum_{\tau=0}^{h} B_{1,\tau} \Sigma B_{1,\tau}'} \right)$$

subject to

$$D(1,i) = 0 \quad \forall i \neq 1$$

$$D \text{ is orthonormal}$$

- $H^{news} = 40$

Identification: Sentiment

- The shock orthogonal to the surprise TFP and the news TFP that maximizes the forecast error variance of the expectational variable (GDP forecast or consumer confidence)

$$\gamma^{sent} = \text{argmax} \sum_{h=0}^{H^{sent}} \left(\frac{\sum_{\tau=0}^{h} B_{5,\tau} \tilde{A} \gamma^{sent} \gamma^{sent\prime} \tilde{A}' B_{5,\tau}'}{\sum_{\tau=0}^{h} B_{5,\tau} \Sigma B_{5,\tau}'} \right)$$

subject to

$$D(1,i) = 0 \quad \forall i \neq 1$$

$$D \text{ is orthonormal}$$

$$D(:,2) = \gamma^{news}$$

- $H^{sent} = 2$

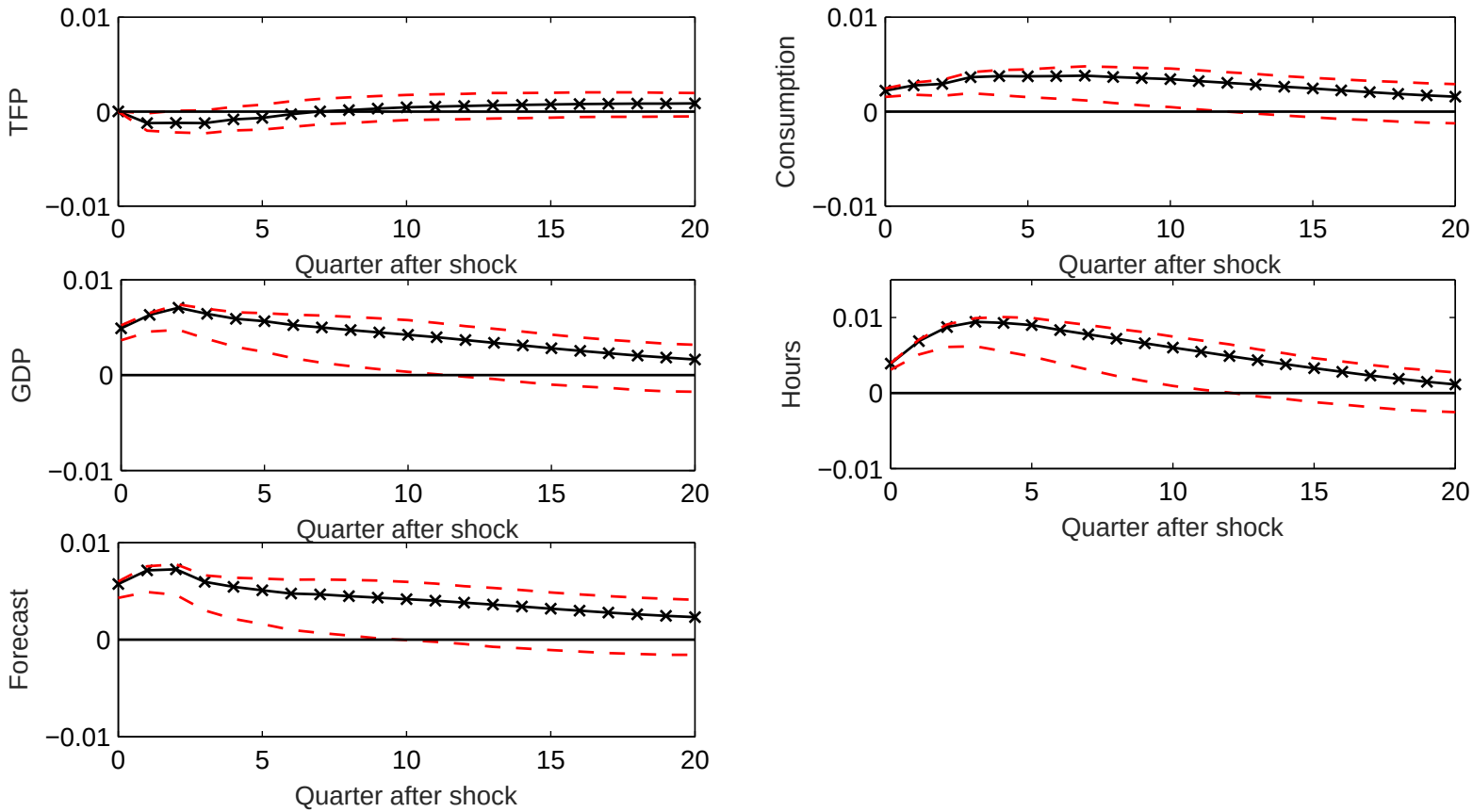
Implementation

- Canadian variables are included one-by-one as "non-core" variables in the VAR (Uhlig, 2003)
  - Cannot have a contemporaneous and lagged effects on any of the US variables
- Estimation in log-levels (Hamilton 1994, Barsky and Sims 2011) using Estimated GLS (Lütkepohl, 2005)
- Bias-corrected 2000 times bootstrapped standard errors (Kilian 1998)
- 4 lags (AIC)

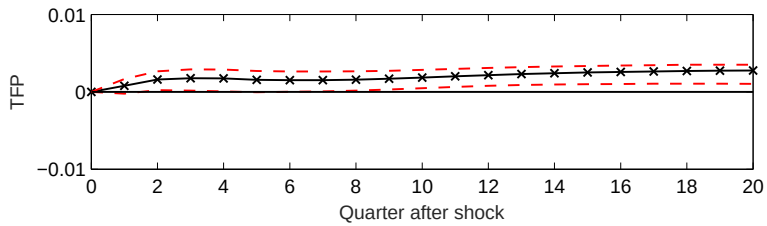
Data

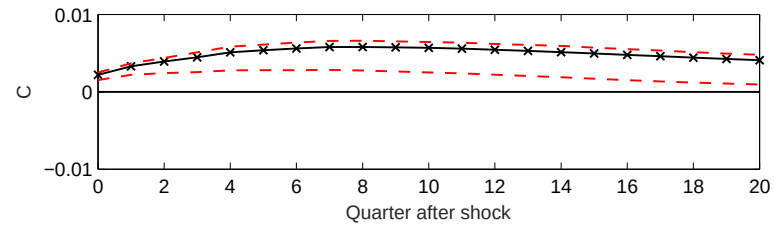
- 1968:Q4 to 2010:Q3
- US utilization-adjusted TFP from Fernald (2014) (Basu, Fernald, and Kimball, 2006)
- Expectational variables:
  - Philadelphia Fed's Survey of Professional Forecasters, average forecast of GDP one quarter ahead
  - Michigan Survey of Consumers, Confidence
    - *'And how about a year from now, do you expect that in the country as a whole, business conditions will be better, or worse than they are at present, or just about the same?'*
- Consumption: non-durables and services consumption
- Canadian utilization-adjusted TFP: constructed using the method in Imbs (1999)

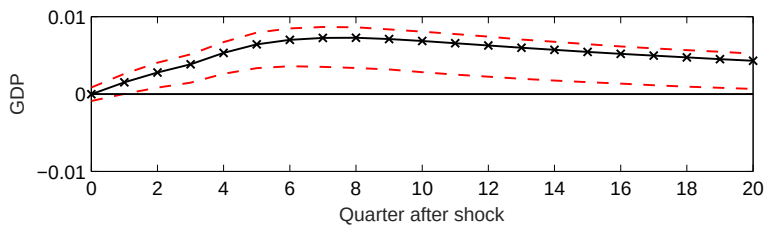
Sentiment Shock in the US

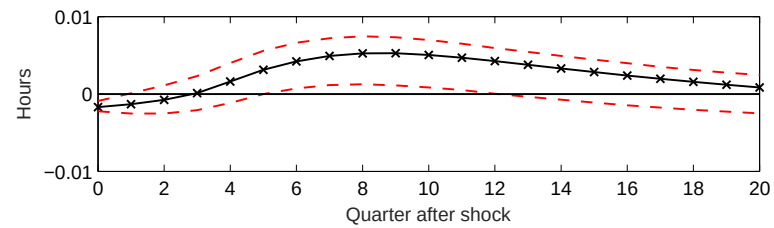


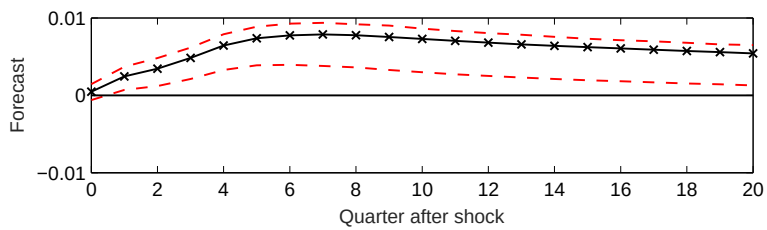
News TFP Shock in the US



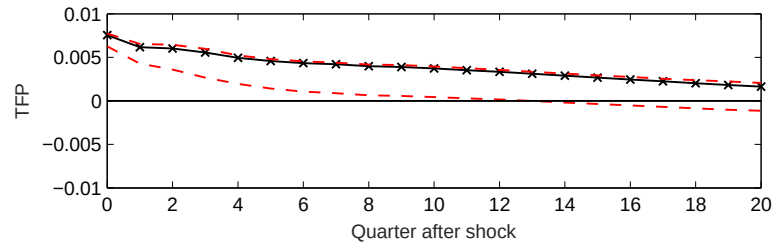


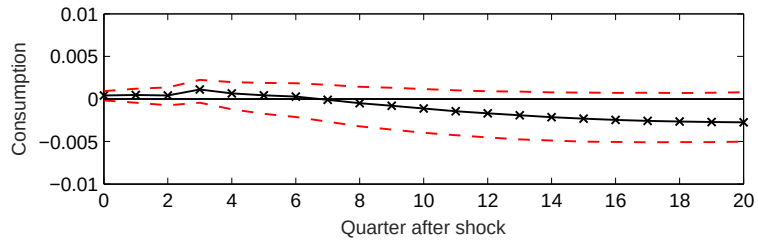


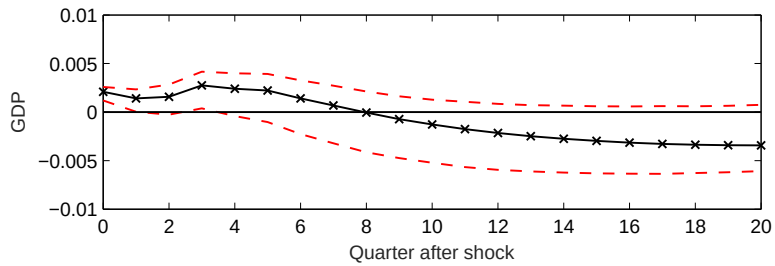


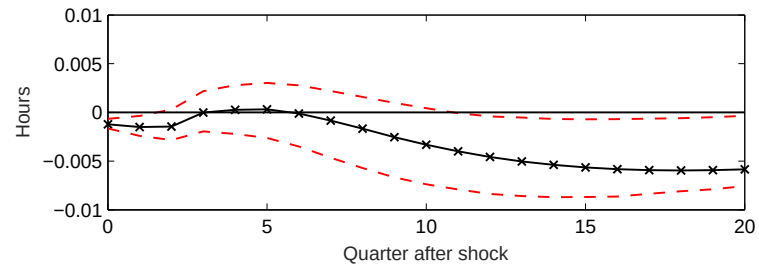


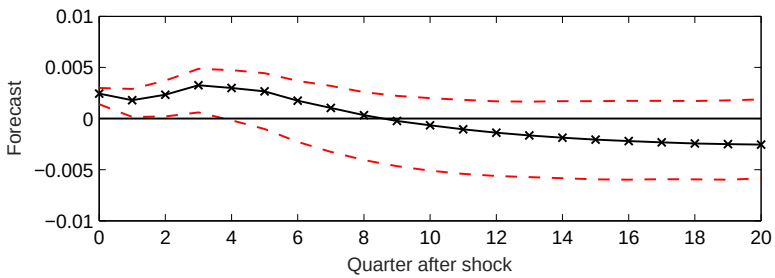
Surprise TFP Shock in the US











Forecast Error Variance: Sentiment

Horizon	TFP	Output	Consumption	Hours	Forecast
1Q	0.00	0.65	0.18	0.62	0.85
	(0.00)	(0.06)	(0.05)	(0.07)	(0.05)
2Q	0.02	0.75	0.21	0.71	0.81
	(0.02)	(0.06)	(0.06)	(0.07)	(0.06)
1Y	0.03	0.61	0.22	0.69	0.62
	(0.03)	(0.09)	(0.07)	(0.08)	(0.09)
2Y	0.02	0.36	0.21	0.52	0.35
	(0.04)	(0.10)	(0.09)	(0.12)	(0.10)
5Y	0.02	0.25	0.18	0.35	0.26
	(0.05)	(0.10)	(0.10)	(0.13)	(0.10)
10Y	0.03	0.21	0.15	0.29	0.22
	(0.05)	(0.10)	(0.10)	(0.12)	(0.10)

Forecast Error Variance: News TFP

Horizon	TFP	Output	Consumption	Hours	Forecast
1Q	0.00	0.00	0.36	0.14	0.00
	(0.00)	(0.01)	(0.07)	(0.06)	(0.02)
2Q	0.01	0.03	0.45	0.06	0.05
	(0.01)	(0.03)	(0.08)	(0.04)	(0.04)
1Y	0.04	0.11	0.48	0.02	0.15
	(0.04)	(0.07)	(0.09)	(0.03)	(0.07)
2Y	0.06	0.32	0.52	0.08	0.35
	(0.06)	(0.11)	(0.11)	(0.06)	(0.11)
5Y	0.18	0.45	0.56	0.13	0.46
	(0.11)	(0.12)	(0.13)	(0.08)	(0.12)
10Y	0.36	0.45	0.54	0.12	0.47
	(0.13)	(0.13)	(0.15)	(0.08)	(0.15)

Forecast Error Variance: Surprise TFP

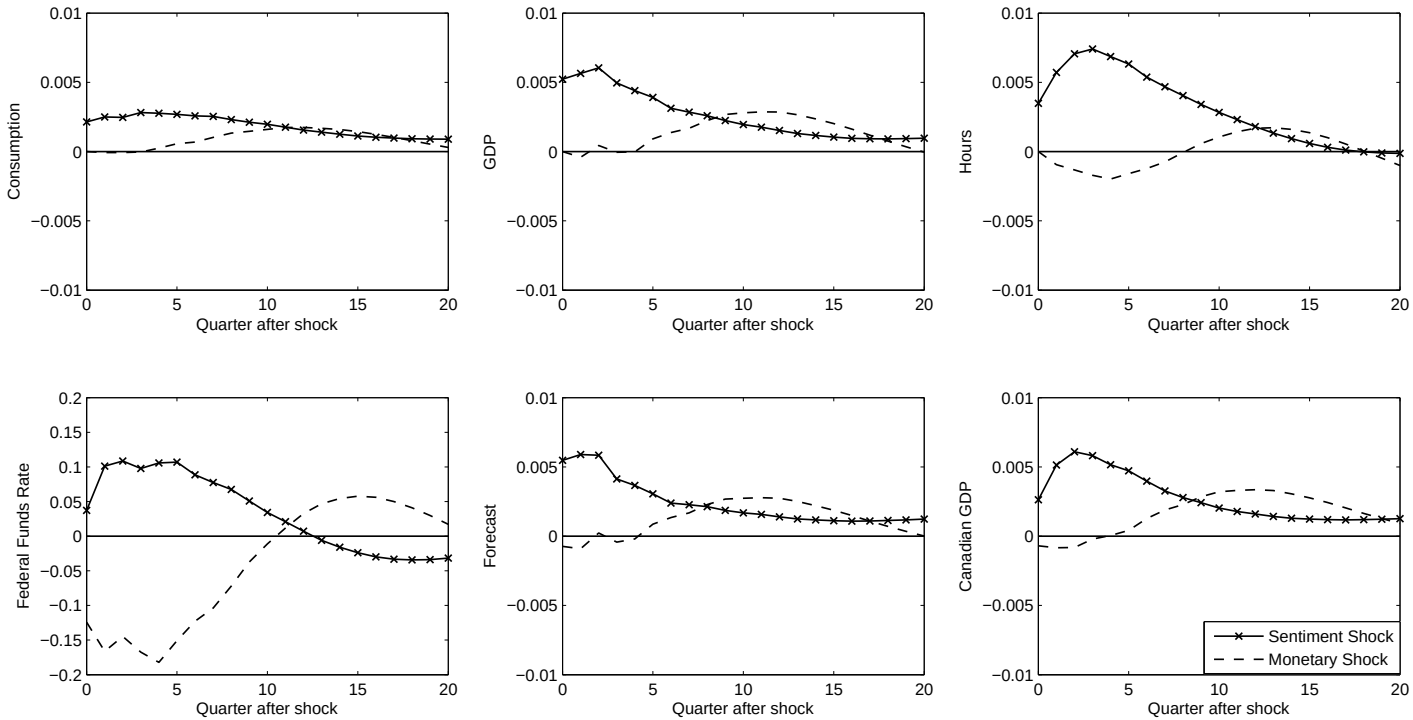
Horizon	TFP	Output	Consumption	Hours	Forecast
1Q	1.00	0.12	0.01	0.08	0.13
	(0.00)	(0.05)	(0.03)	(0.04)	(0.05)
2Q	0.98	0.08	0.01	0.05	0.08
	(0.02)	(0.04)	(0.03)	(0.04)	(0.04)
1Y	0.93	0.08	0.02	0.02	0.09
	(0.05)	(0.05)	(0.03)	(0.03)	(0.06)
2Y	0.91	0.05	0.01	0.01	0.06
	(0.07)	(0.05)	(0.04)	(0.03)	(0.05)
5Y	0.79	0.08	0.06	0.17	0.05
	(0.12)	(0.10)	(0.11)	(0.13)	(0.08)
10Y	0.59	0.13	0.12	0.28	0.07
	(0.13)	(0.12)	(0.13)	(0.14)	(0.10)

More on the Sentiment Shock

1. Sentiments vs. monetary shocks (Christiano-Eichenbaum-Evans)
2. Impact on prices
3. Additional controls

Sentiments vs. Monetary Policy

$-\times-$: sentiment $--$: monetary policy



Sentiments vs. Monetary Policy: Forecast Error Variance

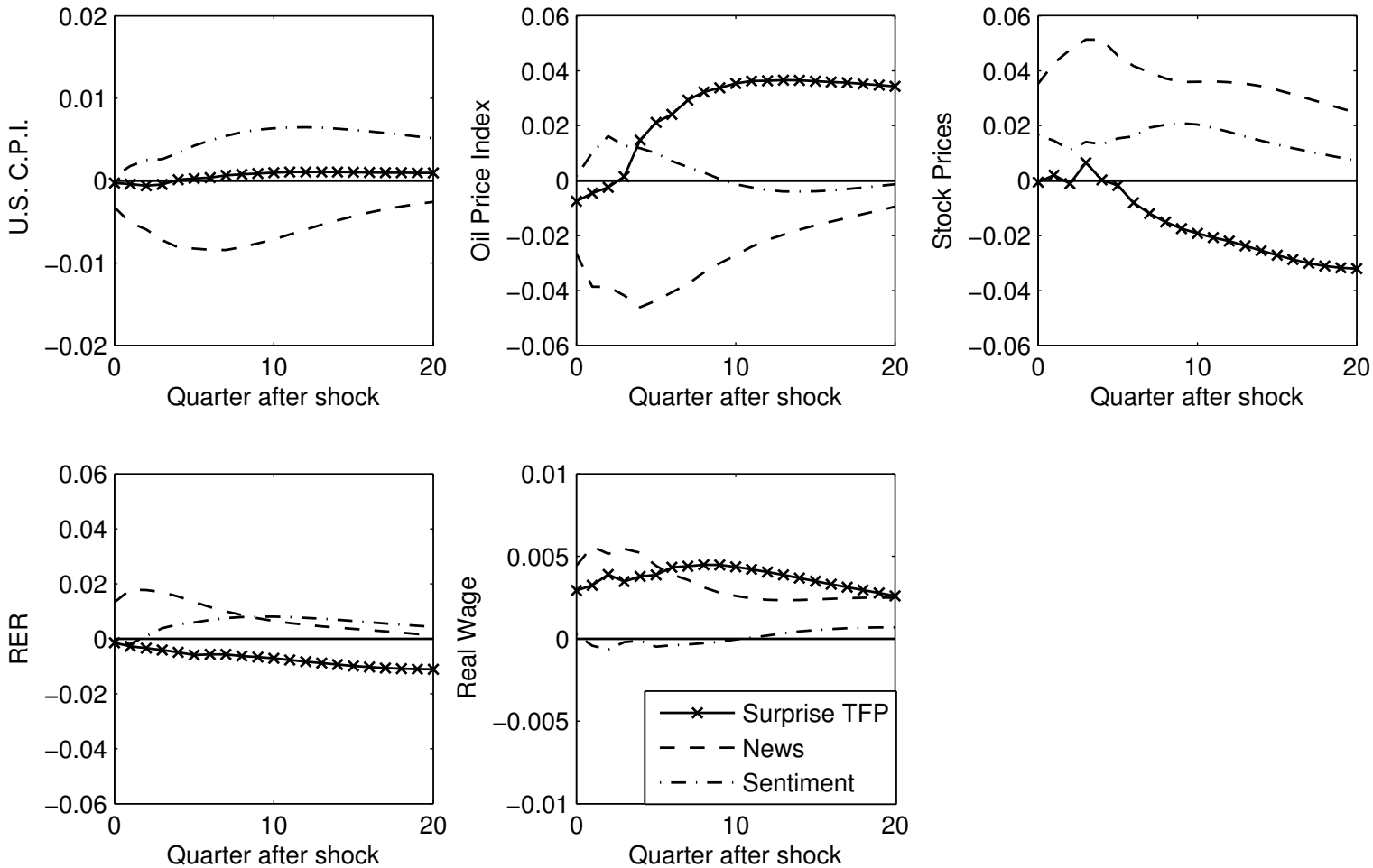
Panel A: Sentiment Shock

Horizon	TFP	C	GDP	H	FF	Forecast	Can GDP
1Q	0.00	0.36	0.83	0.64	0.08	0.70	0.18
2Q	0.02	0.32	0.83	0.64	0.20	0.62	0.33
1Y	0.02	0.25	0.64	0.61	0.23	0.47	0.42
2Y	0.02	0.18	0.34	0.42	0.22	0.23	0.33
5Y	0.02	0.10	0.17	0.23	0.20	0.12	0.21
10Y	0.03	0.08	0.12	0.17	0.18	0.08	0.17

Panel B: Monetary Policy Shock

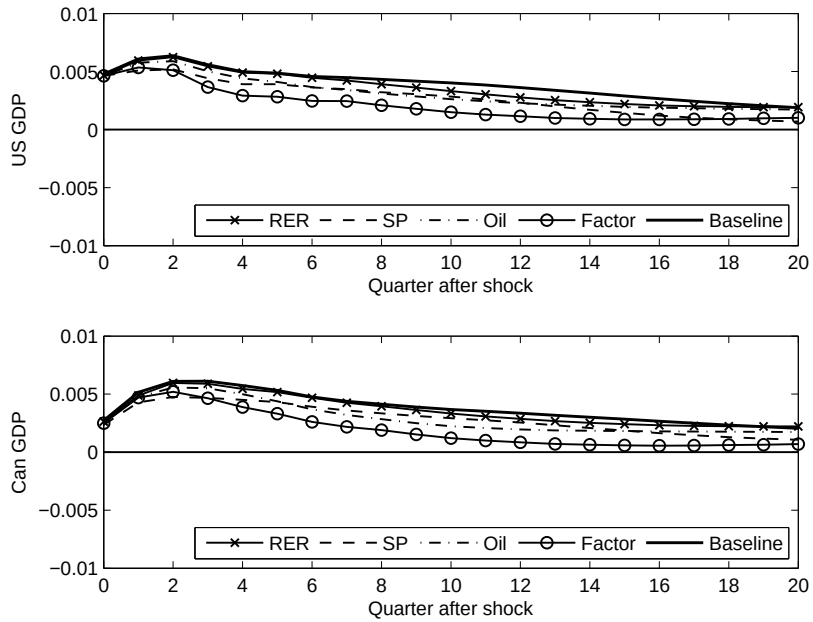
Horizon	TFP	C	GDP	H	FF	Forecast	Can GDP
1Q	0.00	0.00	0.00	0.00	0.88	0.01	0.01
2Q	0.01	0.00	0.00	0.01	0.75	0.01	0.01
1Y	0.04	0.00	0.00	0.02	0.65	0.01	0.01
2Y	0.10	0.01	0.01	0.02	0.55	0.01	0.01
5Y	0.14	0.03	0.05	0.02	0.47	0.04	0.09
10Y	0.12	0.03	0.04	0.07	0.45	0.03	0.07

Impact on Price Variables

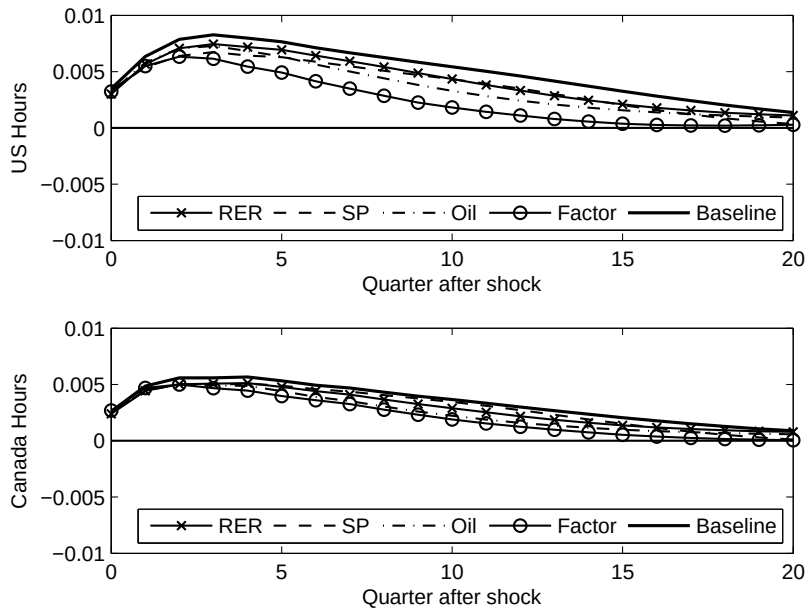


Additional Controls

GDP



Hours



Additional Controls: Sentiment Forecast Error Variance

Panel A: US GDP

Horizon	Factor	RER	Stock Prices	Oil
1Q	0.65	0.63	0.66	0.64
2Q	0.72	0.76	0.72	0.76
1Y	0.54	0.66	0.49	0.63
2Y	0.23	0.45	0.26	0.34
5Y	0.11	0.27	0.15	0.18
10Y	0.09	0.22	0.12	0.15

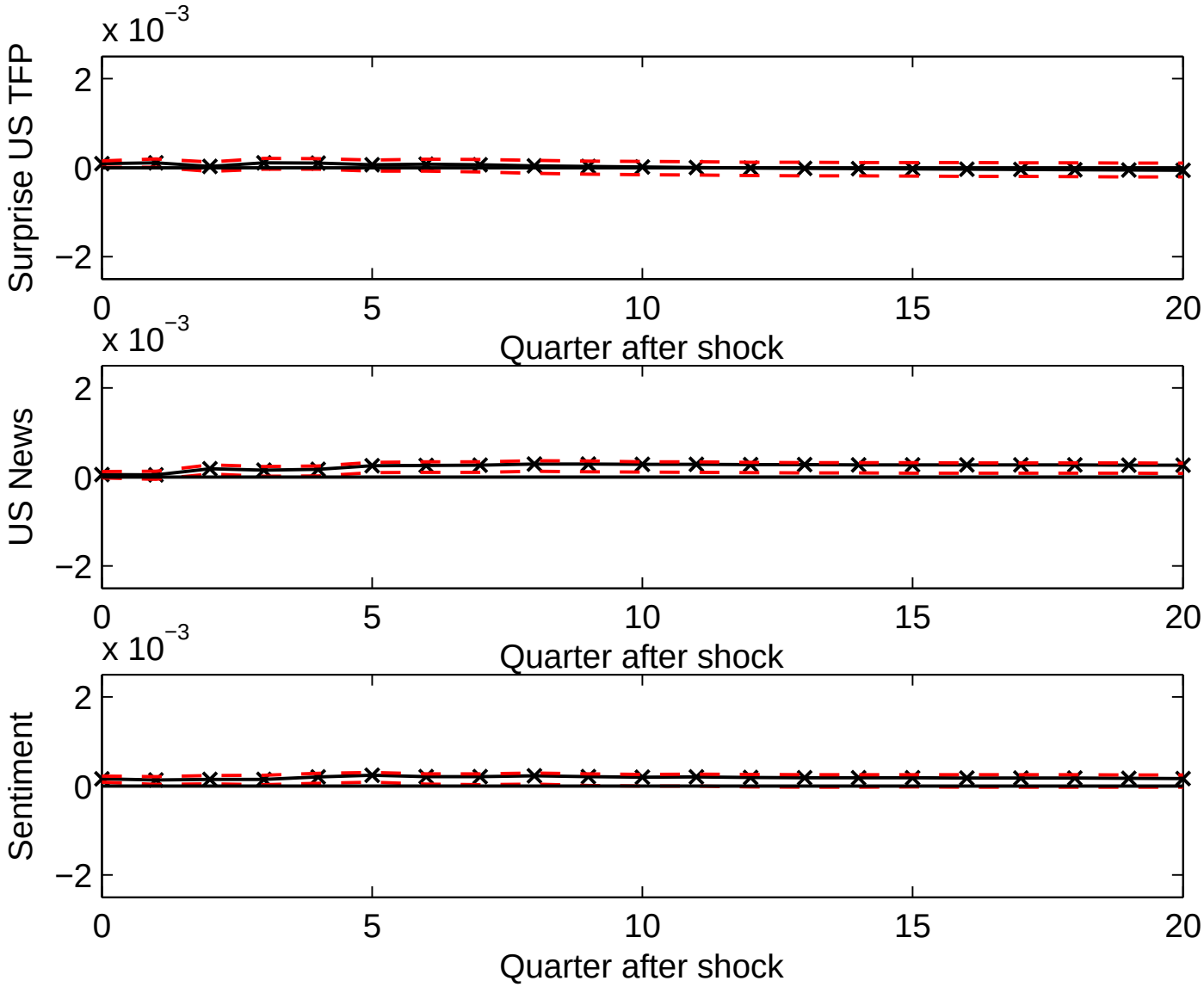
Panel B: US Hours

Horizon	Factor	RER	Stock Prices	Oil
1Q	0.59	0.47	0.66	0.53
2Q	0.70	0.58	0.70	0.65
1Y	0.66	0.58	0.57	0.66
2Y	0.37	0.48	0.36	0.47
5Y	0.14	0.30	0.23	0.24
10Y	0.11	0.24	0.19	0.18

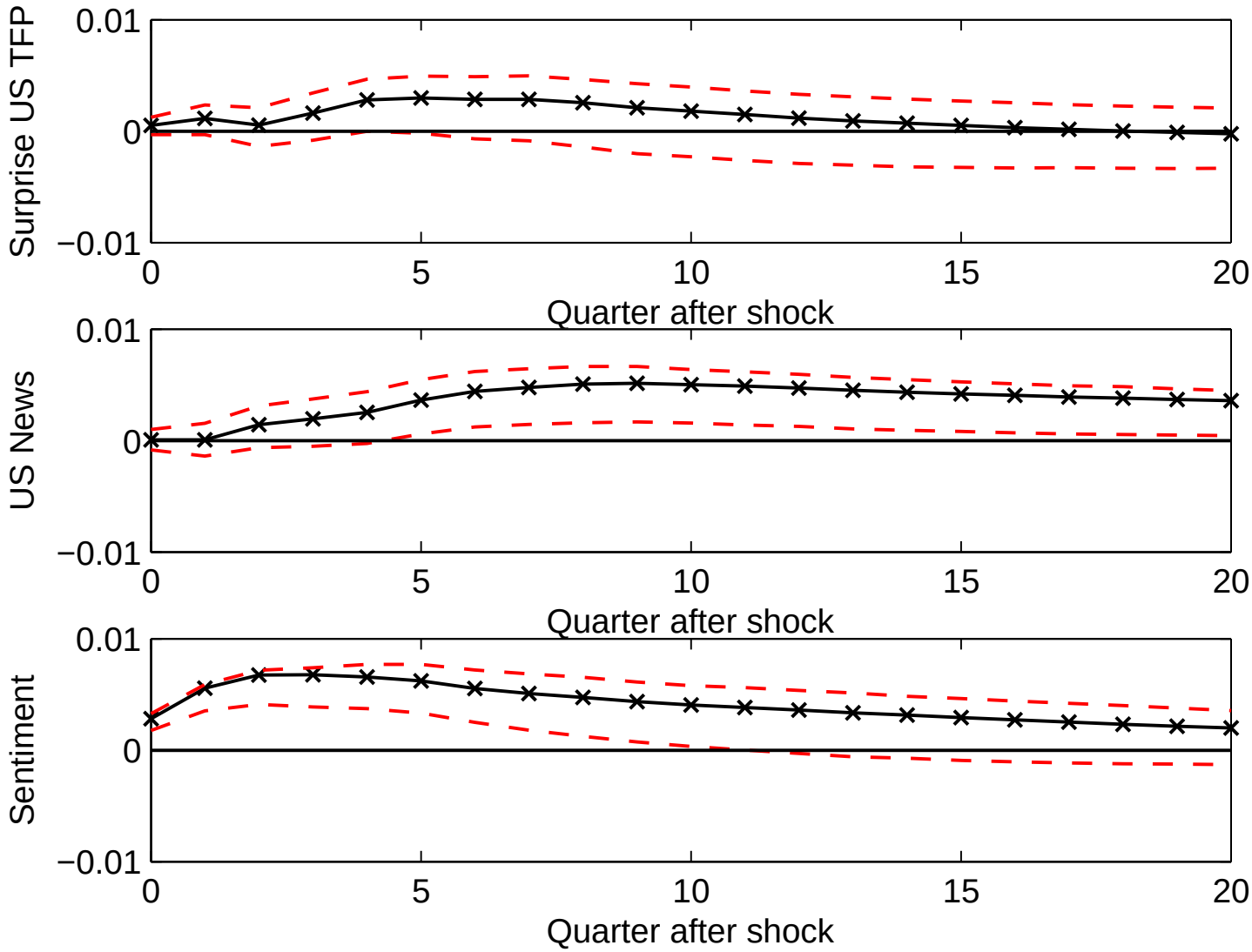
Panel C: Canadian GDP

Horizon	Factor	RER	Stock Prices	Oil
1Q	0.17	0.19	0.15	0.18
2Q	0.28	0.31	0.25	0.29
1Y	0.33	0.43	0.28	0.39
2Y	0.21	0.39	0.21	0.30
5Y	0.12	0.23	0.16	0.20
10Y	0.10	0.20	0.14	0.18

TFP: Canada


x 10^−3
Surprise US TFP
2
0
−2
0
5
10
15
20
Quarter after shock
x 10^−3
US News
2
0
−2
0
5
10
15
20
Quarter after shock
x 10^−3
Sentiment
2
0
−2
0
5
10
15
20
Quarter after shock

GDP: Canada


Surprise US TFP
0.01
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Quarter after shock
US News
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Quarter after shock
Sentiment
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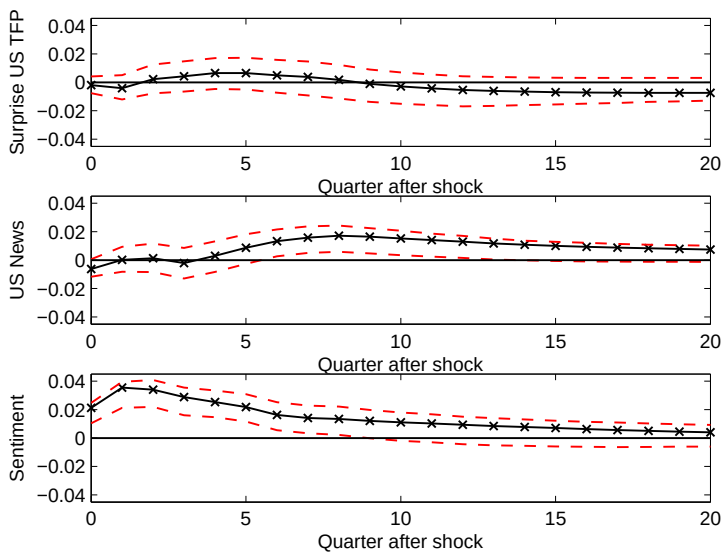
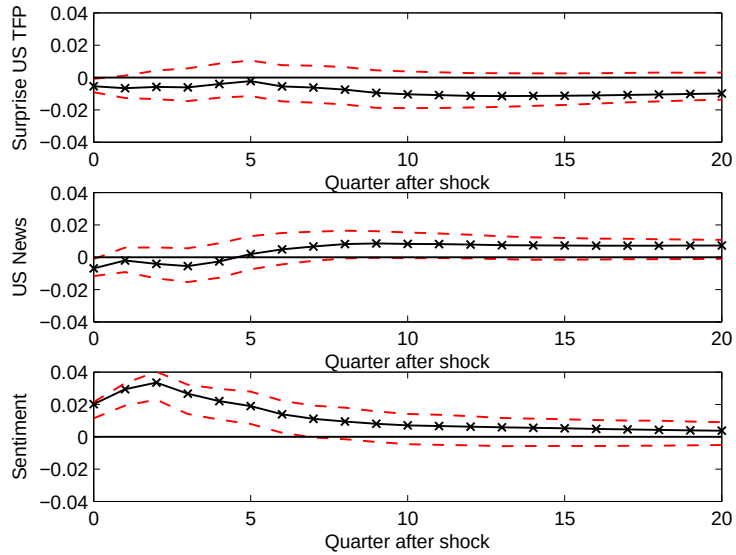
10
15
20
Quarter after shock

US-Canada Trade

Exports

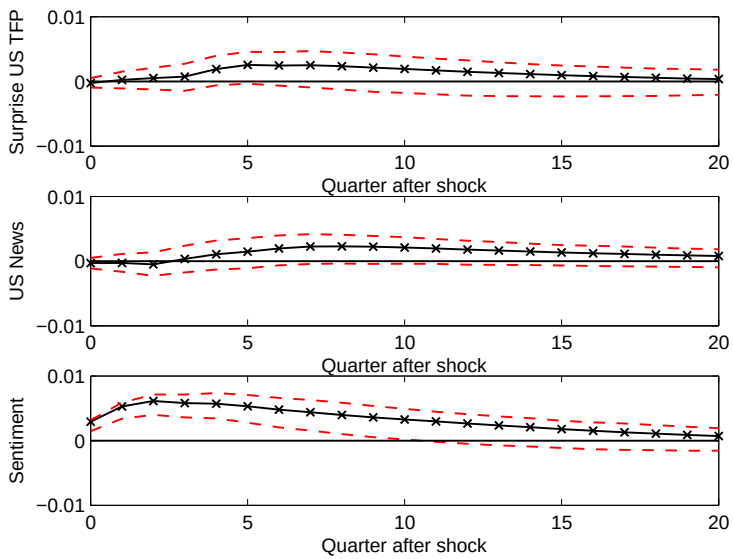


Imports

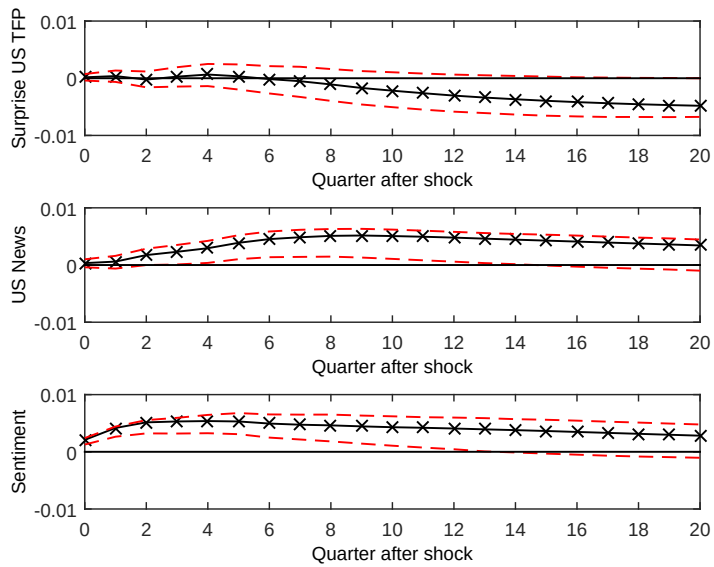


Canada Factor Usage

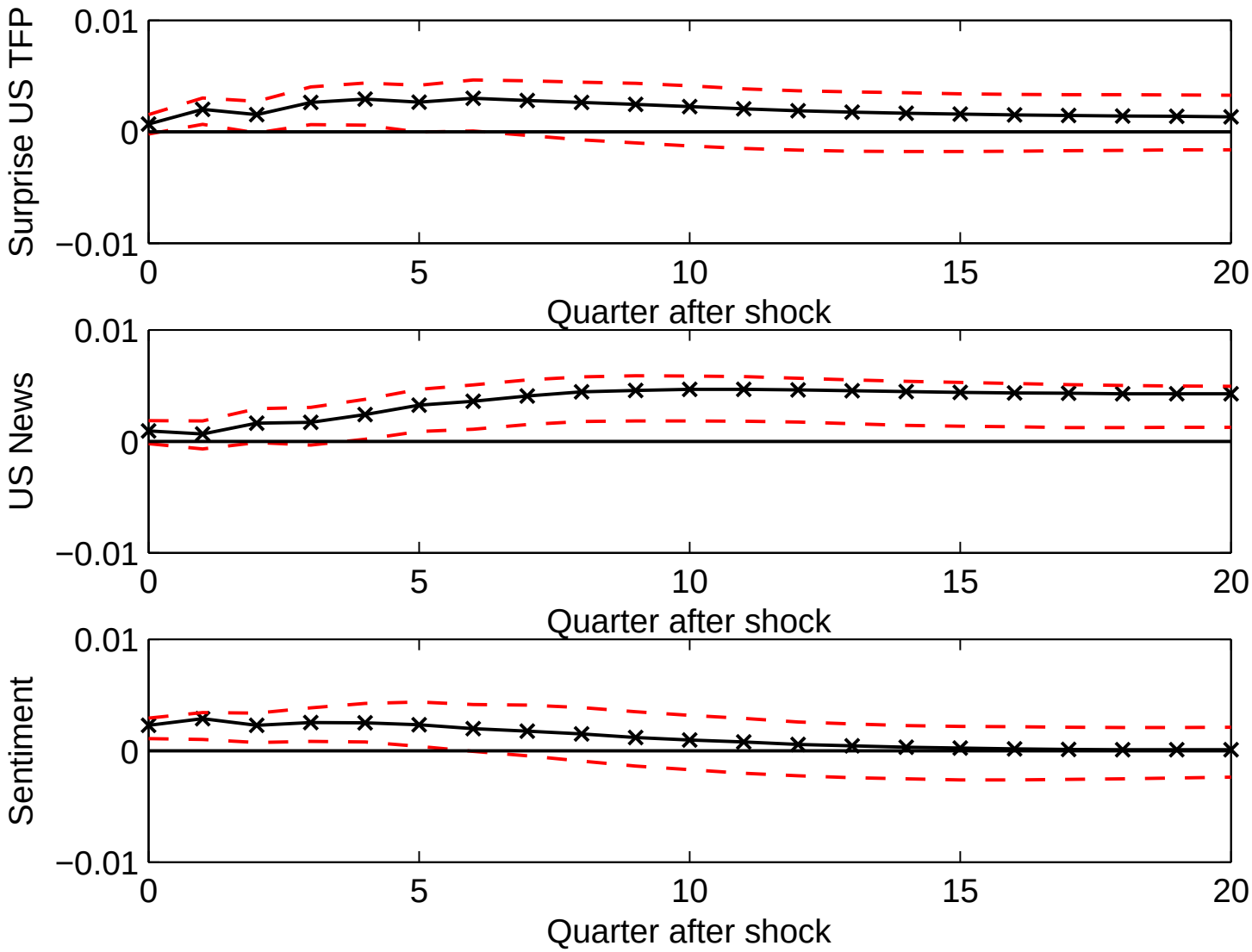
Hours



Utilization



Consumption: Canada



Canada Forecast Error Variance: Sentiment

Horizon	Output	Consumption	Hours	Exports	Imports	TFP	Utilization
1Q	0.19	0.08	0.19	0.25	0.25	0.01	0.18
	(0.06)	(0.05)	(0.06)	(0.07)	(0.07)	(0.01)	(0.06)
2Q	0.32	0.12	0.29	0.38	0.36	0.01	0.28
	(0.08)	(0.06)	(0.08)	(0.08)	(0.08)	(0.02)	(0.07)
1Y	0.41	0.09	0.35	0.44	0.41	0.04	0.33
	(0.09)	(0.06)	(0.10)	(0.09)	(0.09)	(0.04)	(0.09)
2Y	0.34	0.05	0.36	0.39	0.36	0.03	0.25
	(0.10)	(0.05)	(0.11)	(0.10)	(0.10)	(0.04)	(0.10)
5Y	0.29	0.03	0.37	0.32	0.29	0.06	0.17
	(0.10)	(0.05)	(0.12)	(0.10)	(0.10)	(0.06)	(0.10)
10Y	0.26	0.02	0.37	0.30	0.26	0.08	0.12
	(0.10)	(0.05)	(0.11)	(0.10)	(0.10)	(0.07)	(0.09)

Canada Forecast Error Variance: News TFP

Horizon	Output	Consumption	Hours	Exports	Imports	TFP	Utilization
1Q	0.00	0.02	0.00	0.02	0.03	0.01	0.01
	(0.01)	(0.03)	(0.01)	(0.03)	(0.03)	(0.02)	(0.02)
2Q	0.00	0.01	0.00	0.01	0.02	0.01	0.01
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
1Y	0.02	0.03	0.00	0.01	0.01	0.07	0.05
	(0.04)	(0.04)	(0.02)	(0.02)	(0.03)	(0.05)	(0.05)
2Y	0.11	0.12	0.02	0.05	0.02	0.18	0.16
	(0.08)	(0.08)	(0.05)	(0.04)	(0.03)	(0.09)	(0.09)
5Y	0.26	0.32	0.06	0.15	0.06	0.39	0.24
	(0.11)	(0.13)	(0.07)	(0.07)	(0.06)	(0.12)	(0.11)
10Y	0.33	0.51	0.06	0.17	0.10	0.47	0.20
	(0.13)	(0.14)	(0.07)	(0.08)	(0.08)	(0.14)	(0.11)

Canada Forecast Error Variance: Surprise TFP

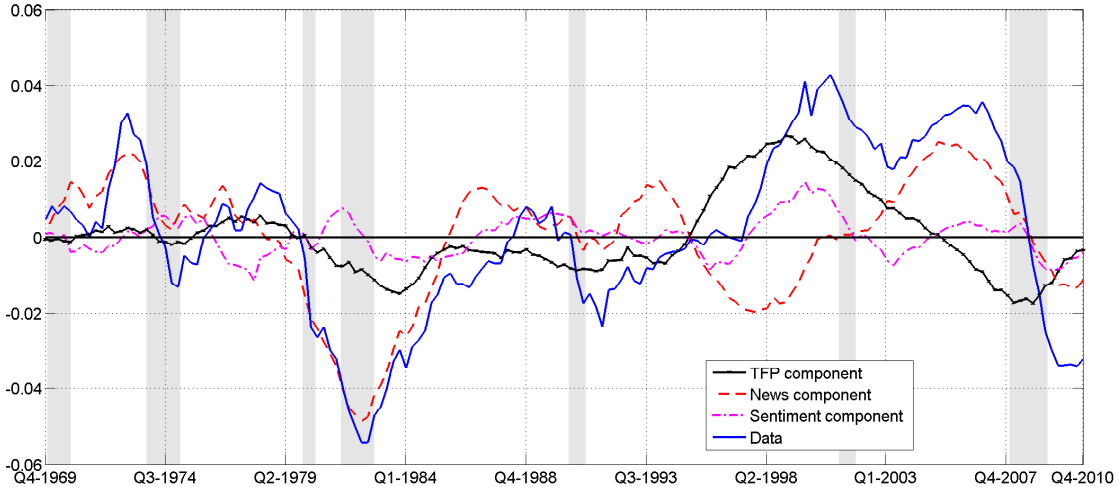
Horizon	Output	Consumption	Hours	Exports	Imports	TFP	Utilization
1Q	0.01	0.01	0.00	0.00	0.02	0.02	0.00
	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.03)	(0.01)
2Q	0.01	0.05	0.00	0.00	0.02	0.04	0.00
	(0.03)	(0.05)	(0.01)	(0.02)	(0.03)	(0.04)	(0.02)
1Y	0.02	0.07	0.00	0.01	0.02	0.04	0.00
	(0.03)	(0.07)	(0.02)	(0.02)	(0.03)	(0.04)	(0.02)
2Y	0.06	0.10	0.04	0.01	0.02	0.04	0.00
	(0.07)	(0.10)	(0.06)	(0.04)	(0.05)	(0.06)	(0.04)
5Y	0.05	0.10	0.06	0.04	0.11	0.02	0.11
	(0.08)	(0.11)	(0.09)	(0.07)	(0.10)	(0.07)	(0.12)
10Y	0.05	0.08	0.06	0.07	0.16	0.05	0.29
	(0.09)	(0.11)	(0.09)	(0.08)	(0.11)	(0.09)	(0.16)

Conditional Correlations Between US and Canada

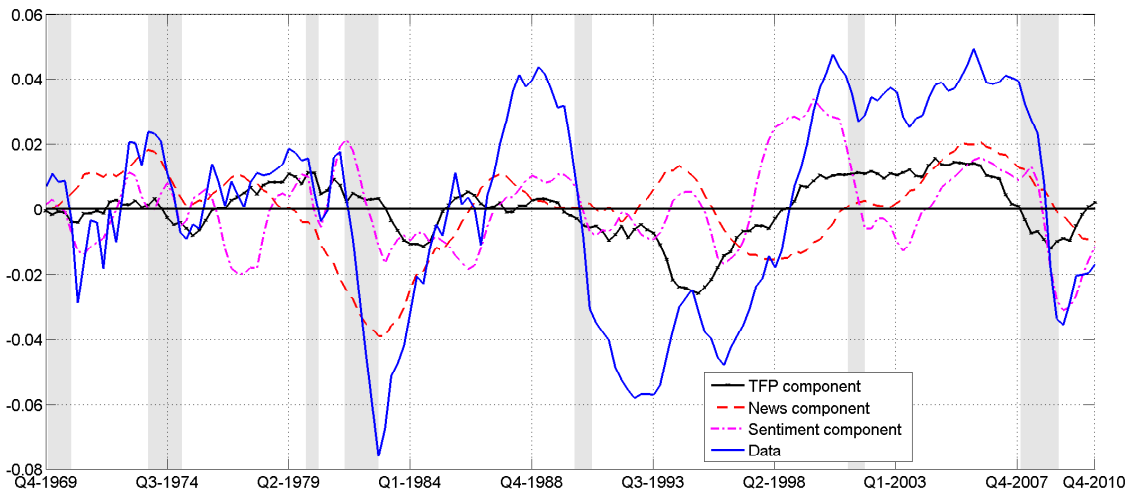
		Correlation Conditional on:		
	Data	TFP	News	Sentiment
US, Canada Output	0.73	0.47	0.99	0.99
		(0.28)	(0.07)	(0.05)
US, Canada Consumption	0.51	-0.13	0.94	0.80
		(0.47)	(0.13)	(0.23)
US, Canada Hours	0.68	-0.47	0.46	0.98
		(0.56)	(0.45)	(0.30)
Exports from Canada, US Output	0.66	0.95	0.97	0.89
		(0.19)	(0.16)	(0.09)
Canadian Imports, US Output	0.58	0.79	0.91	0.91
		(0.31)	(0.28)	(0.12)
US Output, US Consumption	0.84	0.97	0.99	0.96
		(0.05)	(0.03)	(0.04)
US Output, US Hours	0.87	0.81	0.20	0.73
		(0.39)	(0.44)	(0.31)

Historical Decompositions

US Output

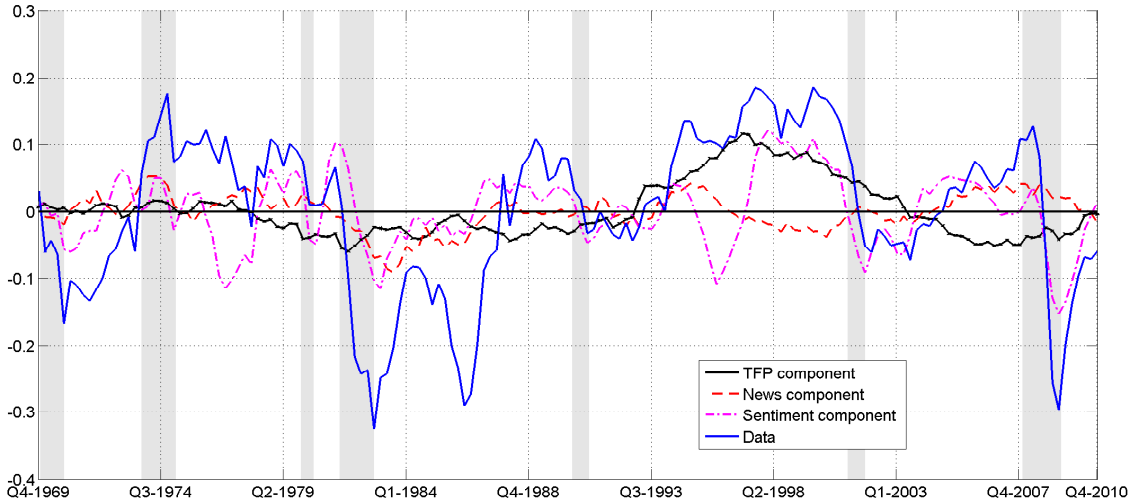


Canadian Output

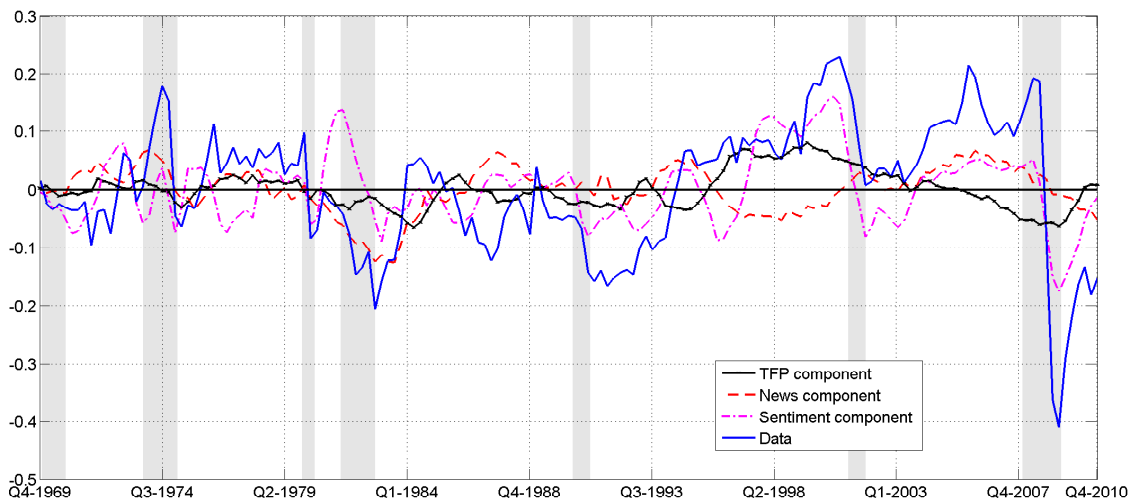


Historical Decompositions

Canadian Imports from the US



Canadian Exports to the US



Conclusion

- Novel identification of a non-technology shock in the US
- Transmission of both technology and non-technology shocks to Canada
- Sentiment shock:
  - Drives most of the short-run US fluctuations, and much of Canadian ones
  - Generates comovement in aggregates between US and Canada – "international business cycle"
- Technology shocks matter more as news rather than surprises