"*Information-driven Business Cycles: Primal Approach*" Ryan Chahrour & Robert Ulbricht

Alexandre N. Kohlhas[1]

[1]Institute for International Economic Studies, Stockholm University

Madrid Workshop in Quantitative Macroeconomics, May 2017

Expectations, Information and Business Cycles

Motivation:

- *"Animal Spirits": Coordinated waves of mistaken optimism or pessimism are the source of business cycles (Pigou, 1927)*
- But, so far, most estimates of their relevance depend critically *on assumption about people's information sets*

Question: *What if we do not know people's information sets?*
Can we still quantify the role of Animal Spirits?

This paper: Proposes a novel theoretical resolution

Shows how *Animal Spirits* account for the bulk of US business cycles

Expectations, Information and Business Cycles

Motivation:

- *"Animal Spirits": Coordinated waves of mistaken optimism or pessimism are the source of business cycles (Pigou, 1927)*
- But, so far, most estimates of their relevance depend critically *on assumption about people's information sets*

Question: *What if we do not know people's information sets?*
Can we still quantify the role of Animal Spirits?

This paper: Proposes a novel theoretical resolution

Shows how *Animal Spirits* account for the bulk of US business cycles

A Bird's Eye View

The Importance of Information:

- Macroeconomic outcomes depend on preferences and beliefs
- *Estimates of imperfect information are thus necessary for...*
- *Business cycles, economic policy; most macroeconomic questions*

But *what information do people rely on when making their choices?*

$\sim$ *an inherently unobserved quantity*

Ryan and Robert show how *we can use simple tools from business cycle accounting for full-information rational expectation models*

$\Rightarrow$ *circumvent our own lack of knowledge*

$\Rightarrow$ *estimate the importance of imperfect information*

A Bird's Eye View

The Importance of Information:

- Macroeconomic outcomes depend on preferences and beliefs
- *Estimates of imperfect information are thus necessary for...*
- *Business cycles, economic policy; most macroeconomic questions*

But *what information do people rely on when making their choices?*

$\sim$ *an inherently unobserved quantity*

Ryan and Robert show how *we can use simple tools from business cycle accounting for full-information rational expectation models*

$\Rightarrow$ *circumvent our own lack of knowledge*

$\Rightarrow$ *estimate the importance of imperfect information*

A Bird's Eye View

The Importance of Information:

- Macroeconomic outcomes depend on preferences and beliefs
- *Estimates of imperfect information are thus necessary for...*
- *Business cycles, economic policy; most macroeconomic questions*

But *what information do people rely on when making their choices?*

$\sim$ *an inherently unobserved quantity*

Ryan and Robert show how *we can use simple tools from business cycle accounting for full-information rational expectation models*

$\Rightarrow$ *circumvent our own lack of knowledge*

$\Rightarrow$ *estimate the importance of imperfect information*

A Simple Example

Basic Setup:

- *Simplified imperfect information New Keynesian model*
- *Two-period version*: *(a)* Uncertainty about current realizations at s=t; *(b)* Then, flex-price full-information outcome for $s \geq t+1$.
- *Stark* information structure: $\Theta_t = a_t + \varepsilon_t^{\Theta}$, $\varepsilon_t^{\Theta} \sim N\left(0, \sigma_{\Theta}^2\right)$

Equilibrium Conditions:

1. *Demand Block:* $y_t = \mathbb{E}_t^c \left[y_{t+1} - i_t + \pi_{t+1} \right]$
2. *Supply Block:* $\pi_t = \mathbb{E}_t^f \left[\beta \pi_{t+1} + \kappa (y_t - a_t) \right]$
3. *Central Bank:* $i_t = \phi \pi_t$

A Simple Example

Basic Setup:

- *Simplified imperfect information New Keynesian model*
- *Two-period version*: *(a)* Uncertainty about current realizations at s=t; *(b)* Then, flex-price full-information outcome for $s \geq t+1$.
- *Stark* information structure: $\Theta_t = a_t + \varepsilon_t^{\Theta}$, $\varepsilon_t^{\Theta} \sim N\left(0, \sigma_{\Theta}^2\right)$

Equilibrium Conditions:

1. *Demand Block:* $y_t = \mathbb{E}_t^{\boldsymbol{c}}\left[y_{t+1} - i_t + \pi_{t+1}\right]$
2. *Supply Block*: $\pi_t = \mathbb{E}_t^{\boldsymbol{f}}\left[\beta\pi_{t+1} + \kappa(y_t - a_t)\right]$
3. *Central Bank*: $i_t = \phi\pi_t$

Imperfect Information and Information Wedges

Primal Approach:

$$\begin{aligned} y_t &= \mathbb{E}_t^c\left[\rho\, a_t - \phi\, \pi_t\right] = \rho\, a_t - \phi\, \pi_t + \tau_t^c \\ \pi_t &= \kappa \mathbb{E}_t^f\left[y_t - a_t\right] = \kappa\left(y_t - a_t\right) + \tau_t^f \end{aligned}$$

Information Wedges:

$\sim$ *Isomorphic to standard BCA wedges*

$$\tau_t^c \equiv \mathbb{E}_t^c\left[\rho\, a_t - \phi\, \pi_t\right] - \left(\rho\, a_t - \phi\, \pi_t\right) \quad \tau_t^f \equiv \kappa \mathbb{E}_t^f\left[y_t - a_t\right] - \kappa\left(y_t - a_t\right)$$

Implementability Conditions: *(a)* $\mathbb{E}\left[\underline{\tau}_t\right] = 0$ and *(b)* $\mathbb{C}ov\left[\underline{\tau}_t, \Theta_{t-j}\right] = \underline{0}$

Natural consequences of rational information use!

Imperfect Information and Information Wedges

Primal Approach:

$$\begin{aligned} y_t &= \mathbb{E}_t^c\left[\rho\, a_t - \phi\, \pi_t\right] = \rho\, a_t - \phi\, \pi_t + \tau_t^c \\ \pi_t &= \kappa \mathbb{E}_t^f\left[y_t - a_t\right] = \kappa\left(y_t - a_t\right) + \tau_t^f \end{aligned}$$

Information Wedges:

$\sim$ *Isomorphic to standard BCA wedges*

$$\tau_t^c \equiv \mathbb{E}_t^c\left[\rho\, a_t - \phi\, \pi_t\right] - \left(\rho\, a_t - \phi\, \pi_t\right) \quad \tau_t^f \equiv \kappa \mathbb{E}_t^f\left[y_t - a_t\right] - \kappa\left(y_t - a_t\right)$$

Implementability Conditions: *(a)* $\mathbb{E}\left[\underline{\tau}_t\right] = 0$ and *(b)* $\mathbb{C}ov\left[\underline{\tau}_t, \Theta_{t-j}\right] = \underline{0}$

Natural consequences of rational information use!

Imperfect Information and Information Wedges

Primal Approach:

$$\begin{aligned} y_t &= \mathbb{E}_t^c\left[\rho\, a_t - \phi\, \pi_t\right] = \rho\, a_t - \phi\, \pi_t + \tau_t^c \\ \pi_t &= \kappa \mathbb{E}_t^f\left[y_t - a_t\right] = \kappa\left(y_t - a_t\right) + \tau_t^f \end{aligned}$$

Information Wedges:

$\sim$ *Isomorphic to standard BCA wedges*

$$\tau_t^c \equiv \mathbb{E}_t^c\left[\rho\, a_t - \phi\, \pi_t\right] - \left(\rho\, a_t - \phi\, \pi_t\right) \quad \tau_t^f \equiv \kappa \mathbb{E}_t^f\left[y_t - a_t\right] - \kappa\left(y_t - a_t\right)$$

Implementability Conditions: *(a)* $\mathbb{E}\left[\underline{\tau}_t\right] = 0$ and *(b)* $\mathbb{C}ov\left[\underline{\tau}_t, \Theta_{t-j}\right] = \underline{0}$

Natural consequences of rational information use!

The Importance of Information Wedges

Properties of Information Wedges:

$$y_t = \rho a_t - \phi \pi_t + \tau_t^c \qquad \pi_t = \kappa (y_t - a_t) + \tau_t^f$$

- *Serially correlated*
- *Correlated across equations*

***(Extended Quantitative)* Model Meets Data:**

- BCA shows the *necessity of persistent, correlated wedges*
- Simple full Information models cannot account for this correlation
- *Dispersed imperfect information models can*!

Information Frictions Can Explain Business Cycle Dynamics

The Importance of Information Wedges

Properties of Information Wedges:

$$y_t = \rho a_t - \phi \pi_t + \tau_t^c \quad \pi_t = \kappa(y_t - a_t) + \tau_t^f$$

- *Serially correlated*
- *Correlated across equations*

***(Extended Quantitative)* Model Meets Data:**

- BCA shows the *necessity of persistent, correlated wedges*
- Simple full Information models cannot account for this correlation
- *Dispersed imperfect information models can*!

The Importance of Information Wedges

Properties of Information Wedges:

$$y_t = \rho a_t - \phi \pi_t + \tau_t^c \quad \pi_t = \kappa(y_t - a_t) + \tau_t^f$$

- *Serially correlated*
- *Correlated across equations*

***(Extended Quantitative)* Model Meets Data:**

- BCA shows the *necessity of persistent, correlated wedges*
- Simple full Information models cannot account for this correlation
- *Dispersed imperfect information models can*!

Information Frictions Can Explain Business Cycle Dynamics

A Maximal Estimate

A Residual Explanation:

$$y_t = \rho a_t - \phi \pi_t + \tau_t^c \quad \pi_t = \kappa(y_t - a_t) + \tau_t^f$$

- *Wedges create lots of degrees of freedom*
- *A better fit for macroeconomic data*

Composition of Wedges:

- *Expectation Errors*
- *Model Misspecification, Additional Shocks?*

Central Questions: *(a) Do orthogonality conditions constrain wedges?*
(b) Can we empirically test estimated wedges?

A Maximal Estimate

A Residual Explanation:

$$y_t = \rho a_t - \phi \pi_t + \tau_t^c \quad \pi_t = \kappa(y_t - a_t) + \tau_t^f$$

- *Wedges create lots of degrees of freedom*
- *A better fit for macroeconomic data*

Composition of Wedges:

- *Expectation Errors*
- *Model Misspecification, Additional Shocks?*

Central Questions: *(a) Do orthogonality conditions constrain wedges?*

(b) Can we empirically test estimated wedges?

A Maximal Estimate

A Residual Explanation:

$$y_t = \rho a_t - \phi \pi_t + \tau_t^c \quad \pi_t = \kappa(y_t - a_t) + \tau_t^f$$

- *Wedges create lots of degrees of freedom*
- *A better fit for macroeconomic data*

Composition of Wedges:

- *Expectation Errors*
- *Model Misspecification, Additional Shocks?*

Central Questions: *(a) Do orthogonality conditions constrain wedges?*

(b) Can we empirically test estimated wedges?

Empirically Credible Wedges?

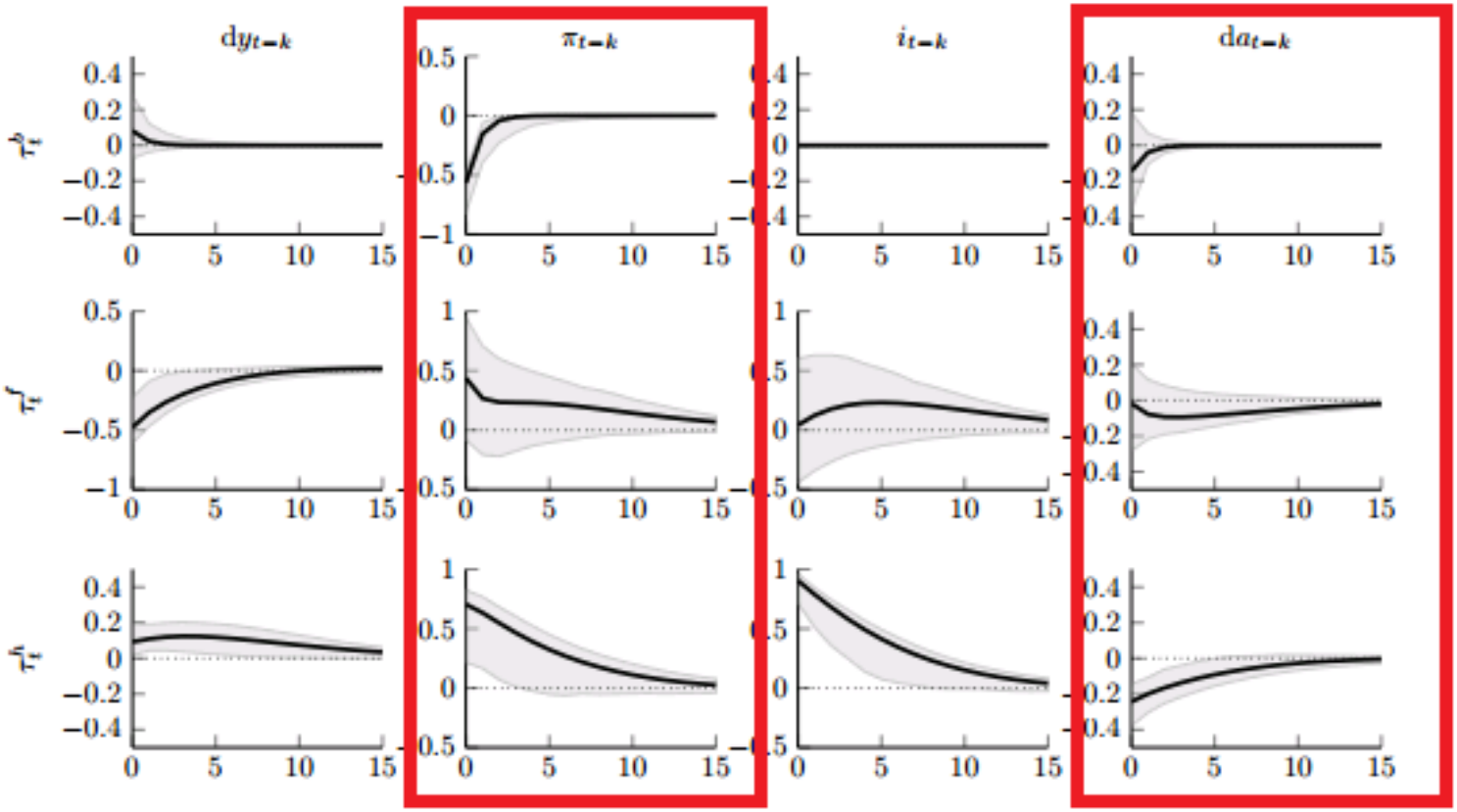


Figure 5: Correlation between information-wedges and aggregate statistics. Note.—The plot shows the (auto) correlation coefficients of the estimated information-wedges vis-à-vis output growth, inflation, the fed funds rate and productivity growth. The order of the autocorrelation is on the x-axis. Shaded areas depict

Construct Plausibility Test with Expectations Data

Micro-Consistent Expectations

Empirical Evidence: *Coibion and Gorodnichenko (2012, 2015)*

Inflation expectations appear consistent with noisy information models

Reduced Form Evidence in favor of *Animal Spirits?*

But...

- Expectations also seem extrapolative (Gennaioli et al, 2016)
- Revisions to fixed-term forecasts are *serially correlated*
- Inconsistent with rational information models

Imperfect Rational Expectations or Extrapolative Expectations?

Micro-Consistent Expectations

Empirical Evidence: *Coibion and Gorodnichenko (2012, 2015)*

Inflation expectations appear consistent with noisy information models

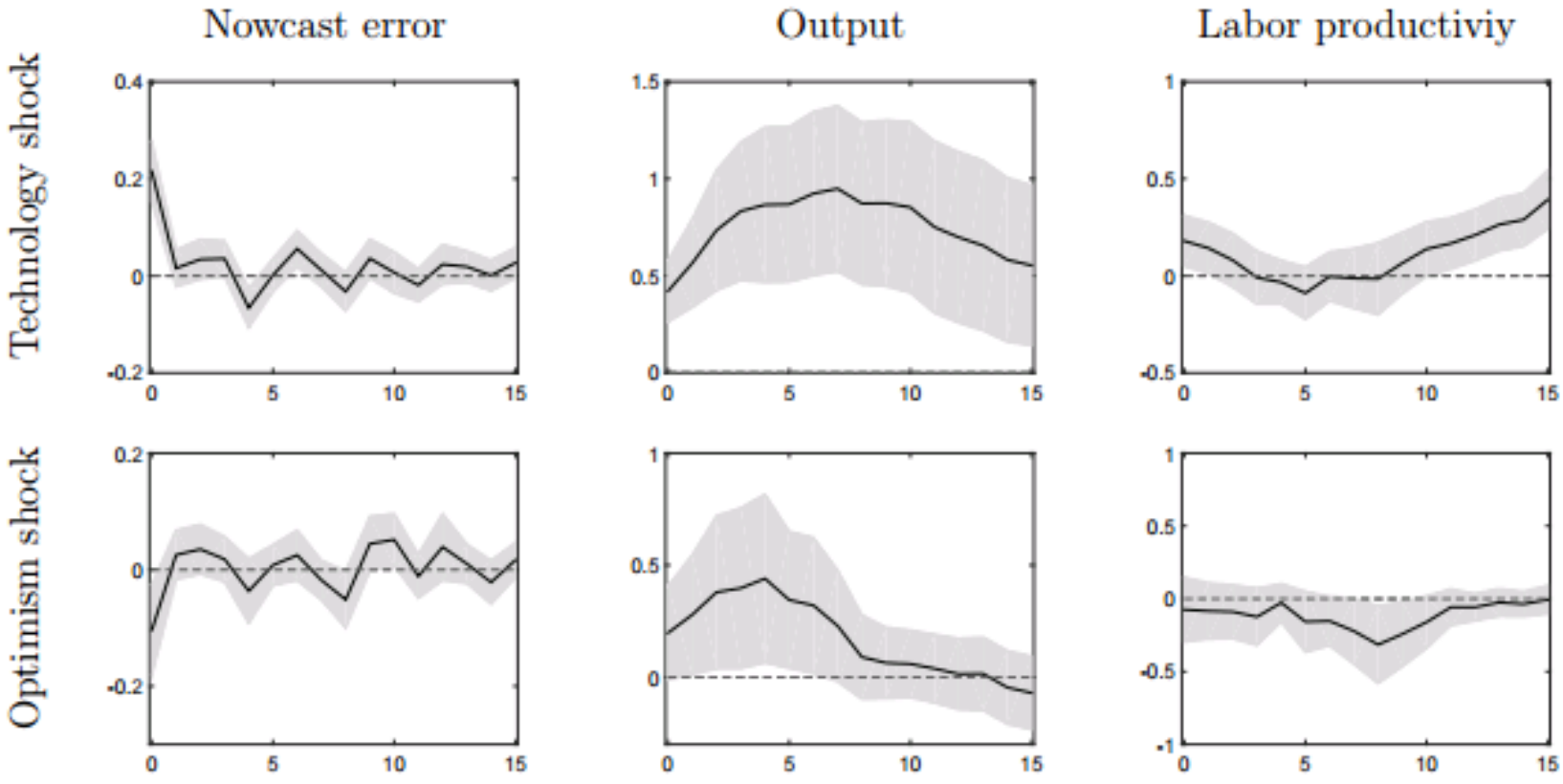
Reduced Form Evidence in favor of *Animal Spirits?*

But...

- Expectations also seem extrapolative (Gennaioli et al, 2016)
- Revisions to fixed-term forecasts are *serially correlated*
- Inconsistent with rational information models

Imperfect Rational Expectations or Extrapolative Expectations?

Micro-Consistent Reduced Form Evidence



Enders et al (2017): Growth Expectations and Short-run Fluctuations

Wedges with Endogenous Learning

Parametric Assumptions:

$$\tau_t = \psi \tau_{t-1} + \eta_t \sim VAR_2(1)$$

Extended Model with $\theta \to 1$

- Dispersed private information $s_t^i = a_t + \varepsilon_t^i$
- Endogenous public signal $\tilde{y}_t = y_t + \varepsilon_t^y$

Solutions & Reduced Form

$$y_t^{RR} = k a_t + \tau_t \sim ARMA(2,1) \qquad y_t^{MS} = \alpha' X_t^{(0:k)} \sim ARMA(k,k)$$

- $X_t^{(0:k)} = \left[\begin{array}{cccc} a_t & \bar{\mathbb{E}} a_t & \bar{\mathbb{E}}^{(2)} a_t & \dots & \bar{\mathbb{E}}^{(k)} a_t \end{array} \right]' \sim VAR_k(1)$

Rule Out *Ex-Ante* "*Plausible*" Information Structures?

Wedges with Endogenous Learning

Parametric Assumptions:

$$\tau_t = \psi \tau_{t-1} + \eta_t \sim VAR_2(1)$$

Extended Model with $\theta \to 1$

- Dispersed private information $s_t^i = a_t + \varepsilon_t^i$
- Endogenous public signal $\tilde{y}_t = y_t + \varepsilon_t^y$

Solutions & Reduced Form

$$y_t^{RR} = ka_t + \tau_t \sim ARMA(2,1) \qquad y_t^{MS} = \alpha' X_t^{(0:k)} \sim ARMA(k,k)$$

- $X_t^{(0:k)} = \left[\begin{array}{ccccc} a_t & \bar{\mathbb{E}} a_t & \bar{\mathbb{E}}^{(2)} a_t & \dots & \bar{\mathbb{E}}^{(k)} a_t \end{array} \right]' \sim VAR_k(1)$

Rule Out *Ex-Ante* "*Plausible*" Information Structures?

Final Remarks

Conclusion:

- Since **Arthur Pigou (1927)** focus on how erroneous coordinated waves of optimism and pessimism can create **business cycles**
- Yet the mere presence of **imperfect information** begs the question of what **information sets** people rely on?
- Robert and Ryan turn our attention to how simple **orthogonality conditions** allow us to estimate the role of imperfect information
- **....** without **any assumptions** about the **information structure**

A Key Step Forward that Asks the Correct Question!

Thank you for your time and attention!