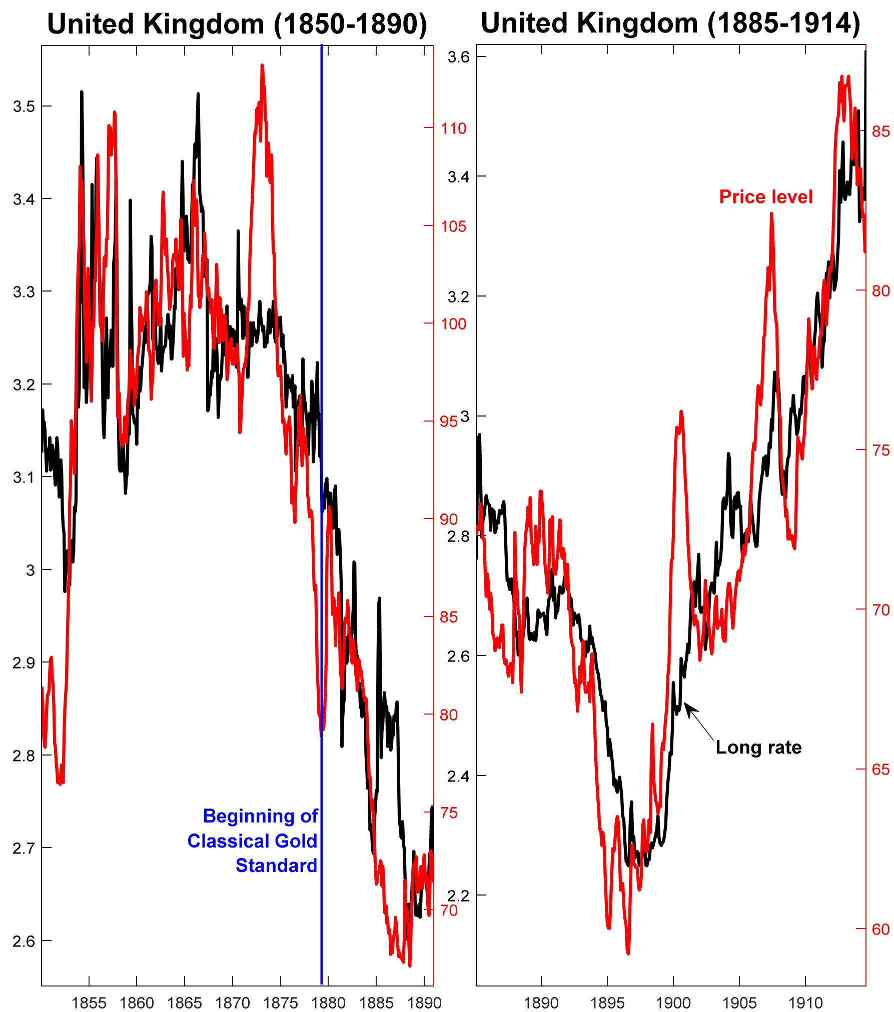
Gibson's Paradox and the Natural Rate of Interest

Luca Benati
University of Bern

Pierpaolo Benigno
University of Bern

EEA meeting, Barcelona, August 31, 2023

What is ‘Gibson’s Paradox’?



Strong correlation between **long-term** nominal **interest rates** and **price level** which had prevailed under **Gold Standard**, before World War I …

Left: evidence for U.K. …

Standard economic theory, specifically, **Fisher equation**,

$$R_t = \rho + \pi_t^e$$

predicts expected **inflation**, rather than price level, to be ‘priced in’ nominal interest rates …

Hence the ‘paradox’: at first sight it makes **no sense** …

Previous literature on Gibson's paradox

First discussed by Thomas Tooke in 1844 …

Wicksell, Fisher, and Keynes all proposed explanations for Gibson's paradox, which were subsequently all refuted …

Friedman and Schwartz (*EEH*, 1976): *'the Gibson paradox remains an empirical phenomenon without a theoretical explanation.'*

Friedman and Schwartz (*Monetary Trends*, 1982) highlighted Gibson's paradox temporal coincidence with the pre-WWI Gold Standard …

They suggested paradox originated from peculiar features of monetary regimes based on commodity money …

Subsequent literature—e.g. Barsky and Summers (*JPE*, 1988)—followed Friedman and Schwartz's suggestion, and proposed explanations focused on Gold Standard …

This paper

We argue Gibson's paradox has nothing to do with Gold Standard per se …

Rather, it originates from long-horizon variation in natural rate of interest under specific class of monetary regimes that make inflation stationary …

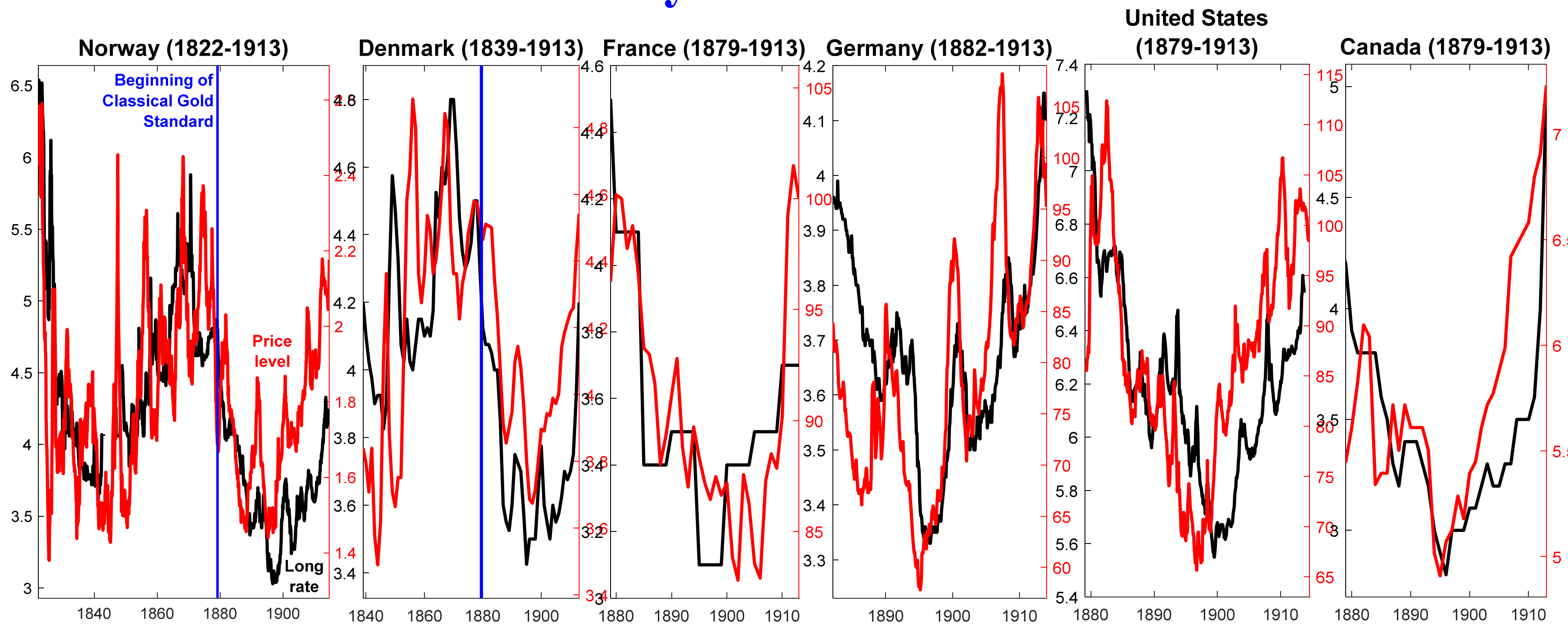
Gold Standard is only historical example of such class of monetary regimes, but in principle Gibson's paradox would appear (e.g.) under monetary targeting …

In fact, we show Gibson's paradox is 'hidden' in data from inflation-targeting regimes, and can be easily recovered …

Gibson's paradox is clear indication of sub-optimality of monetary policy: central bank is not tracking natural rate …

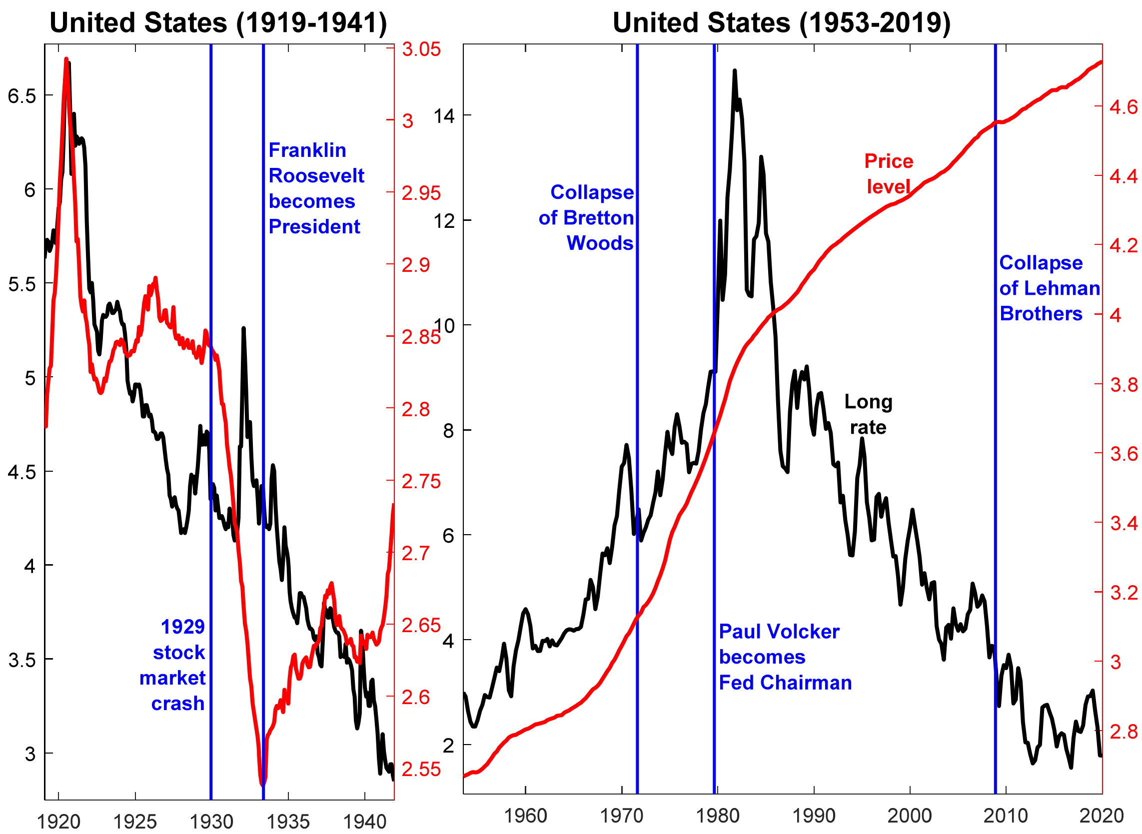
Propose simple metric for measuring sub-optimality of policy …

Stylized facts



<u>First</u>, under Gold Standard Gibson's paradox was ubiquitous …

<u>Second</u>, during interwar period (next slide, left) there was still evidence of it …



<u>Third</u>, since WWII it would seem to have disappeared …

In fact it has not: will show that it is still there, hidden in the data …

Let's turn to our proposed explanation, starting from a simple logical point …

A simple logical point about Gibson's paradox

Gibson's paradox pertains to long horizons (low frequencies) …

Therefore, to generate it we need shock with highly persistent impact on both prices and long rates …

What can it be?

For prices, many candidates: technology shocks, shocks to stock of gold, etc. …

However: under monetary regimes making inflation (close to) white noise such as Gold Standard and inflation targeting—see Benati (*QJE*, 2008)—long-horizon fluctuations in nominal interest rates can only be driven by low-frequency fluctuations in (real) natural rate of interest …

Therefore, as matter of logic, only long-horizon fluctuations in natural rate can generate Gibson's paradox …

The mechanism underlying Gibson's paradox

Model is variation of Sidrauski's: Representative agent maximizes utility function

$$E_{t_0}\left\{\sum_{t=t_0}^{\infty}\beta^{t-t_0}\left[U(C_t)+V(g_t)+L\left(\frac{M_t}{P_t}\right)\right]\right\}$$

where

$$\begin{aligned} U(C_t) &= \text{utility from consumption} \\ V(g_t) &= \text{utility from gold holdings} \\ L\left(\frac{M_t}{P_t}\right) &= \text{utility from real money holdings} \end{aligned}$$

subject to budget constraint

$$B_t+M_t+P_g g_t+P_t C_t=B_{t-1}(1+i_{t-1})+M_{t-1}+P_g g_{t-1}+P_t Y_t-T_t+P_g(G_t-G_{t-1})$$

where

$$\begin{aligned} G_t &= \text{overall stock of gold in the economy} \\ g_t &= \text{amount of gold held by representative agent} \\ P_g &= \text{nominal price of gold, pegged to 1 by monetary authority} \end{aligned}$$

Rest of notation is standard ...

Optimization produces two key equations: (1) Fisher equation,

$$\frac{1}{1+i_t} = E_t\left\{\frac{1}{R^n_{t,t+1}}\frac{1}{\Pi_{t+1}},\right\} \quad \Rightarrow \quad \hat{\imath}_t = r^n_t + E_t\pi_{t+1} \qquad (1)$$

and (2) asset pricing-type equation determining current value of money—which is inverse of price level—

$$\frac{1}{P_t} = \frac{V_g(g_t)}{U_c(C_t)} + E_t\left\{\frac{1}{R^n_{t,t+1}}\frac{1}{P_{t+1}}\right\} \quad \Rightarrow$$

$$\Rightarrow \quad \text{Current value of money} = \frac{1}{P_t} = E_t\left\{\sum_{\tau=t}^{\infty}\frac{1}{R^n_{t,\tau}}\frac{V_g(g_\tau)}{U_c(C_\tau)}\right\} \qquad (2)$$

Current value of money is expected discounted future flow of ratios between marginal utilities of gold and consumption ...

Key: in (2), natural rate of interest is discount factor for expected future flows ...

Now, consider <u>permanent</u> (or very highly persistent) <u>increase</u> in <u>natural rate</u> …

- **By <u>Fisher equation</u> (1), this causes corresponding <u>increase</u> in <u>nominal rates</u> at all maturities …**

  This is especially apparent for <u>long rates</u>, which behave as trend component of short rates ...

- **By <u>asset pricing</u>-type equation (2), this causes <u>decrease</u> in <u>current value</u> of <u>money</u>, which is achieved via <u>increase</u> in <u>price level</u> ...**

  Why? As we said, in (2) <u>natural rate</u> of interest is <u>discount factor</u> for expected future flows ...

This <u>positive long-horizon co-movement</u> between price level and long-term nominal rates is essence of <u>Gibson's paradox</u> ...

Gibson's paradox has nothing to do with Gold Standard per se

Our explanation implies Gibson's paradox has <u>nothing</u> to do with <u>Gold Standard</u> per se ...

<u>Why?</u>

We argued Gibson's paradox originates from <u>interaction</u> between (1) <u>Fisher equation</u> and (2) <u>asset pricing</u>-type equation determining current value of money:

- **<u>Fisher equation</u> features in <u>any meaningful macro model</u> ...**
- **As matter of logic, <u>any monetary regime</u> ought to feature <u>equation</u> determining <u>value of money</u> ...**

Therefore, since long-horizon fluctuations in natural rate have been ubiquitous—e.g. see evidence in Rogoff, Rossi and Schmelzing (2022, NBER WP)—in principle <u>Gibson's paradox</u> could appear under <u>any monetary regime</u> ...

<u>Key question</u>: Under what conditions is, or is not going to appear in raw data?

Necessary conditions for appearance of Gibson's paradox in raw data

For Gibson's paradox to be <u>visible</u> in raw data—as it was under Gold Standard—<u>nothing</u> must <u>perturb</u> interaction between Fisher equation and asset pricing condition …

<u>Example</u>: under <u>inflation targeting</u> positive <u>inflation target</u> introduces upward <u>drift</u> in price level, thus obscuring Gibson's paradox …

<u>Price level</u> has upward <u>trend</u>, <u>long rates</u> do <u>not</u>, thus hiding Gibson's paradox correlation …

Therefore, for Gibson's paradox to be visible in raw data, <u>inflation</u> must be

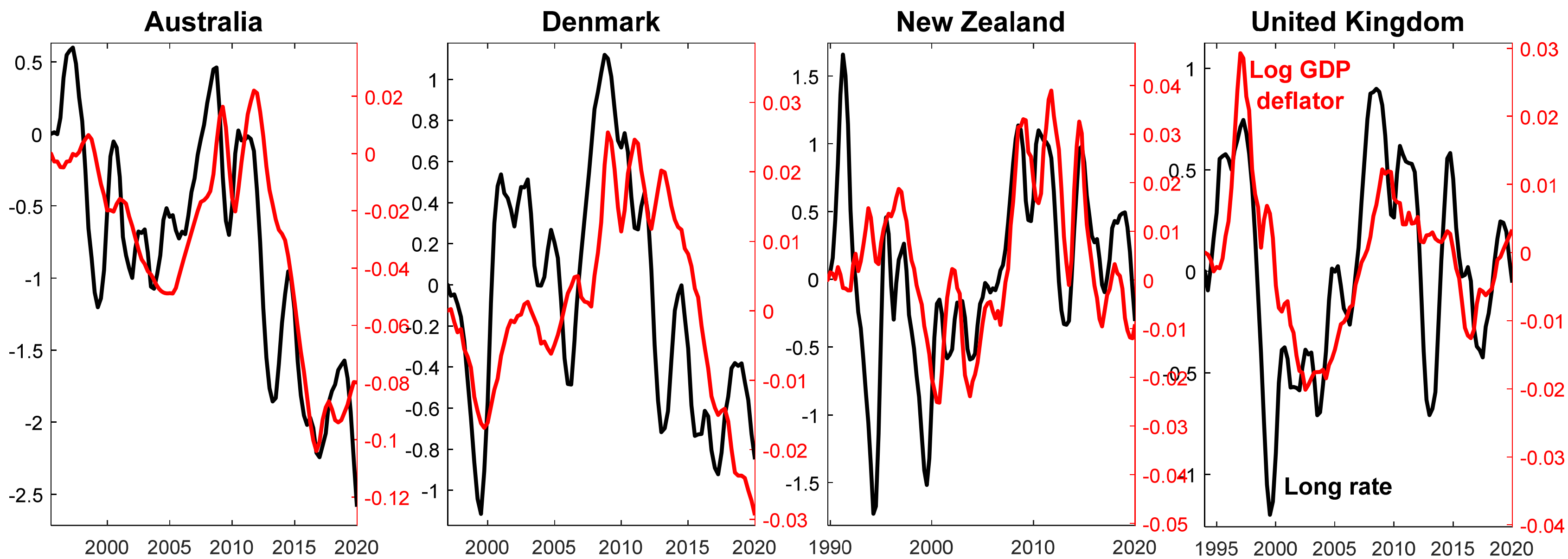
- **(close to) <u>white noise</u>, and**
- **essentially <u>zero-mean</u> (i.e., no drift in price level) …**

Under <u>Gold Standard</u> <u>both conditions</u> were <u>satisfied</u>: that's why Gibson's paradox was so starkly apparent …

Under inflation-targeting inflation is (close to) white noise, but it is not zero-mean: that's why correlation is hidden by drift in price level …

However, controlling for deterministic component of drift in price level allows to recover Gibson's paradox under inflation targeting …

Gibson’s paradox under inflation targeting



We estimate VAR, and then re-run history by

- **setting intercept to zero, so inflation becomes zero-mean by construction, and**
- **feeding VAR estimated residuals (i.e., all of the shocks) …**

Evidence is clear: removing deterministic component of drift in price level, Gibson’s paradox is revealed …

Gibson's paradox under alternative monetary regimes

What about other monetary regimes?

- **Price level targeting makes price level mean-reverting: therefore—as matter of logic—under this regime no shock can generate Gibson's paradox …**
- **We show Gibson's paradox would appear (e.g.) under money level targeting regime …**

Not surprising, in fact to be expected: Gold Standard was rule restricting dynamics of money stock, and therefore money level targeting should behave in same way as Gold Standard …

Implications for sub-optimality of monetary policy

Suppose central bank were able to track fluctuations in natural rate, and neutralize their impact on economy by appropriately moving monetary policy rate …

Then, natural rate would have no impact on economy, and there would be no Gibson's paradox …

Therefore, presence of Gibson's paradox implies central bank not neutralizing fluctuations in natural rate, i.e. monetary policy is sub-optimal in Woodford's sense…

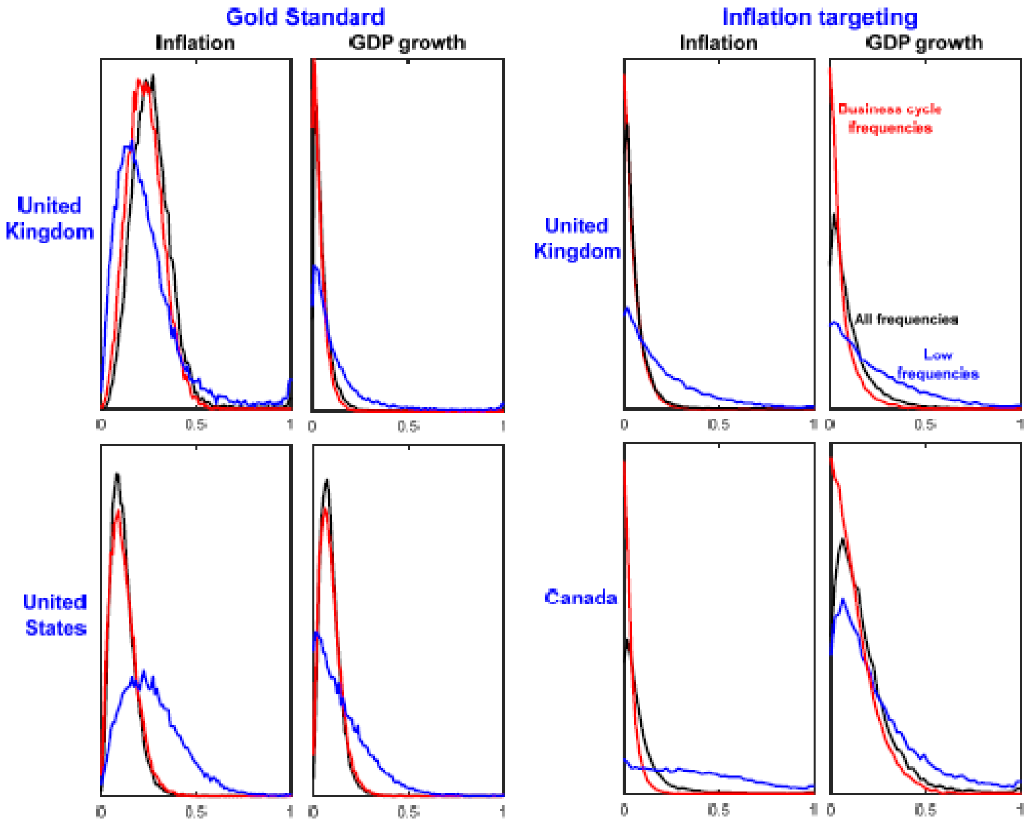
Propose metric to assess sub-optimality of monetary policy: fraction of variance of macro series explained by natural rate shocks …

Estimate VARs for inflation, real GDP growth, and short- and long-term nominal interest rates …

Identify natural rate shocks in frequency domain: disturbance explaining maximum fraction of variance of long rate at frequency $\omega = 0$ …

Under both Gold Standard and inflation targeting <u>inflation</u> had been, and is (close to) <u>white noise</u>: therefore, this is <u>natural</u> identifying restriction …

For each series compute fraction of variance explained by natural rate shocks at different frequencies …



Evidence points towards non-negligible extent of sub-optimality for both Gold Standard and inflation targeting …

What about other disturbances?

Bare-bones model I used features no random disturbances to (e.g.) marginal utility of gold or consumption …

New Keynesian model we estimate for U.S. and U.K. under Gold Standard features multiple disturbances:

- **to IS and Phillips curve,**
- **to marginal utility of consumption, gold and real money balances,**
- **etc. …**

Key result is that none of these shocks can generate Gibson's paradox: for all of them impulse-responses do not generate positive long-horizon co-movement between price level and long-term rate …

Fluctuations in natural rate are only possible explanation …

Summing up

Since Thomas Tooke (1844), Gibson's paradox has been *'an empirical phenomenon without a theoretical explanation.'* (Friedman and Schwartz, 1976) …

Following Friedman and Schwartz (1982), general consensus seems to be Gibson's paradox originated from peculiar features of regimes based on commodity money …

We argue this is not the case: Gibson's paradox has nothing to do with Gold Standard per se, and it can appear under a wide array of monetary arrangements—e.g., a regime targeting money stock …

As 'proof of concept' we recover Gibson's paradox from data generated by inflation targeting regimes …