Can AI Understand Inflation?

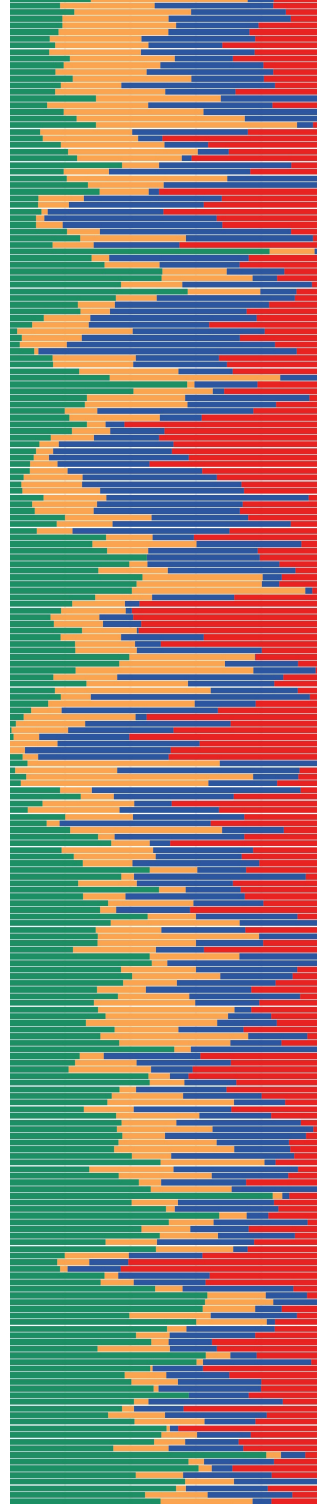
Philippe Goulet Coulombe, PhD

goulet_coulombe.philippe@uqam.ca

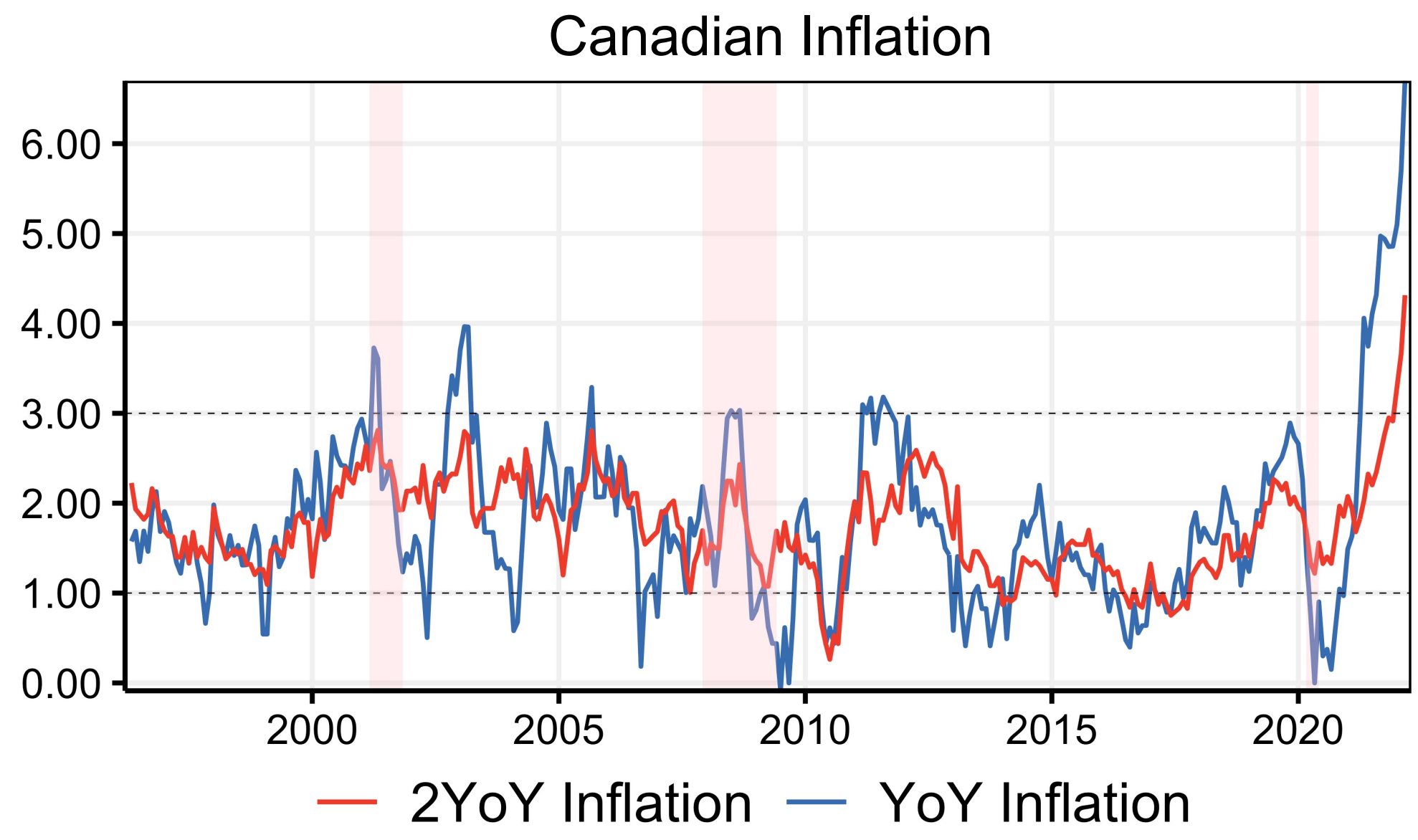
ESG UQÀM

Chaire en Macroéconomie et Prévisions

May 6th, 2022, TimeWorld



In case you've been living under a rock



Inflation forecasting is difficult

- Models fail to surpass the simplest and mostly uninformative benchmark

- Not great: it means that monetary policy, which has a very delayed effect on inflation, will always be behind the curve.

Generally, learning macroeconomic relationships from data is hard.

- Interdependence between aggregates (like GDP, interest rates) are complex.
- They are likely ever-changing.
- The relevant historical record is short.

And interpretability is *everything*. Most central bankers don't care so much for the forecast as what's behind it.

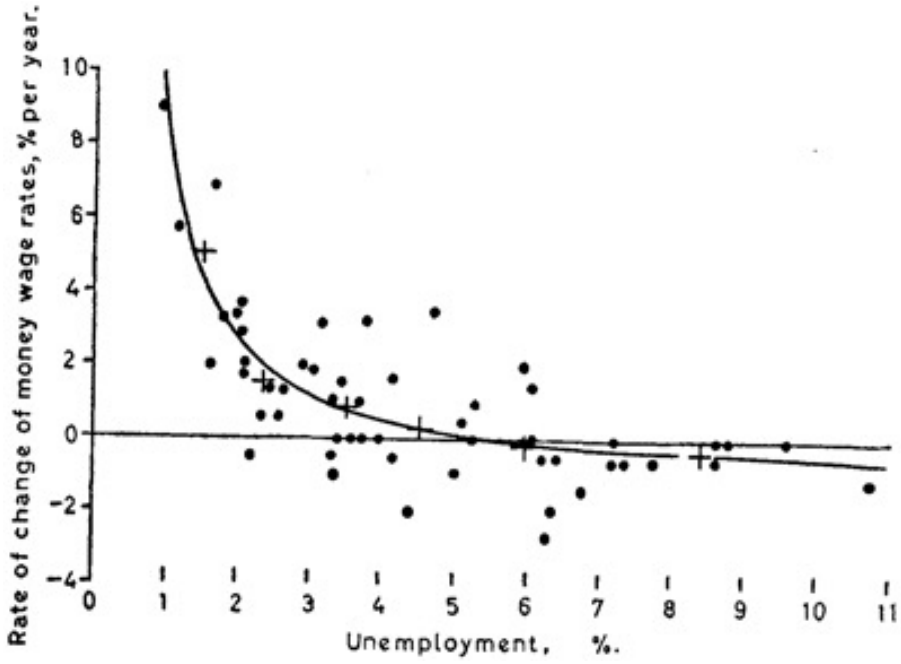
The Good Ol' Days

The Phillips' curve, from Phillips (1958), is a mapping describing how economic activity translates into increasing prices.

Unemployment → Inflation

"→" has forecasting and (monetary) policy implications.

- "→" looked obvious in 1958:



- "→" never looked so obvious again.

A Research Agenda

- 2021 and 2022 suggests some form of Phillips Curve is alive and well.
- How come statistical models have pronounced it dead?
- AI has the virtue of being particularly agnostic, but its opacity is notorious, making it difficult for economists and policymakers to use.

Solution

- Nest minimal macroeconomic theory within machine learning models.

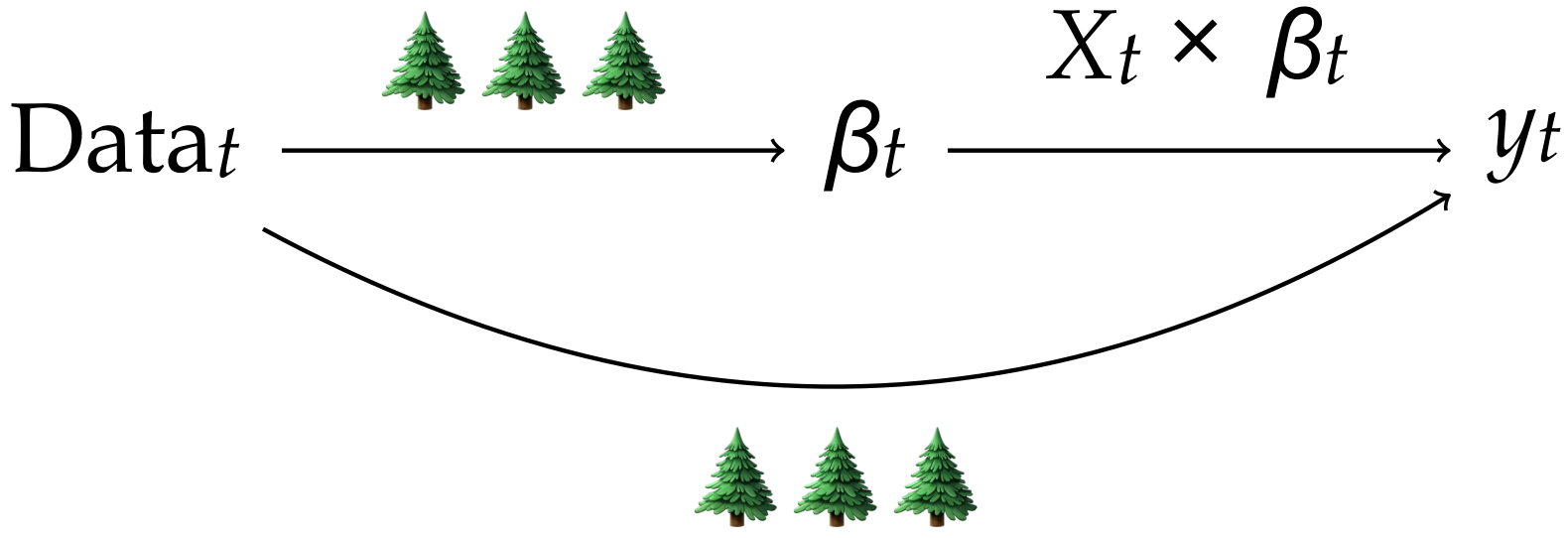
Benefits

- Better forecasts
- Actually learn something about macroeconomics

New algorithms

1. Macroeconomic Random Forest (Goulet Coulombe, 2020)
2. Hemisphere Neural Network (Goulet Coulombe, 2022)

(Machine) Learning β_t's via **Macro Random Forest**



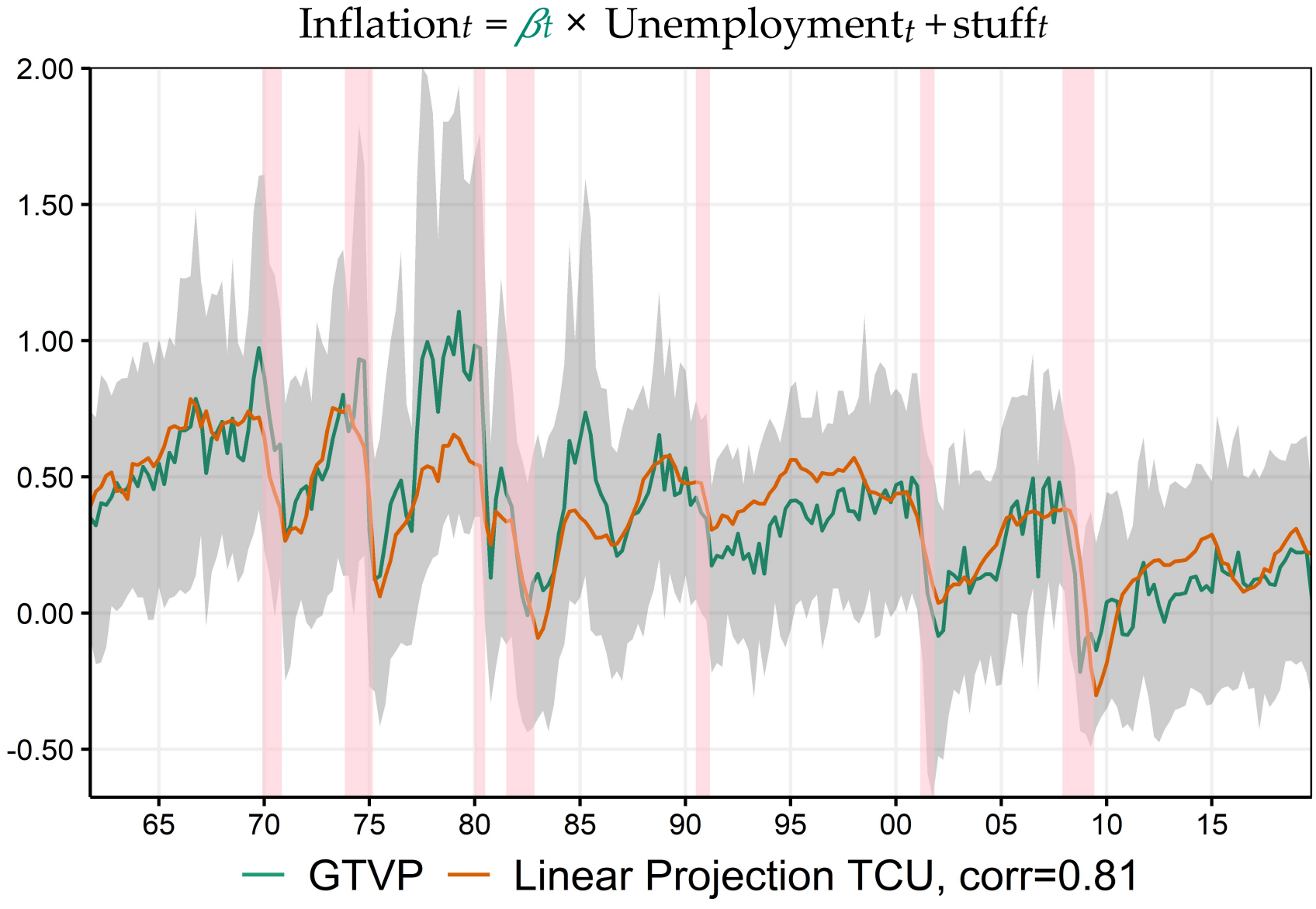
- 🌲🌲🌲 is a Random Forest
- What are βt's? They are time-varying *coefficients* guiding a linear relationship between X and y. For instance, a Phillips Curve

$$\text{Inflation}_t = \beta t \times \text{Unemployment}_t + \text{noise}_t$$

- A single βt, when fixing t, has a straightforward interpretation.

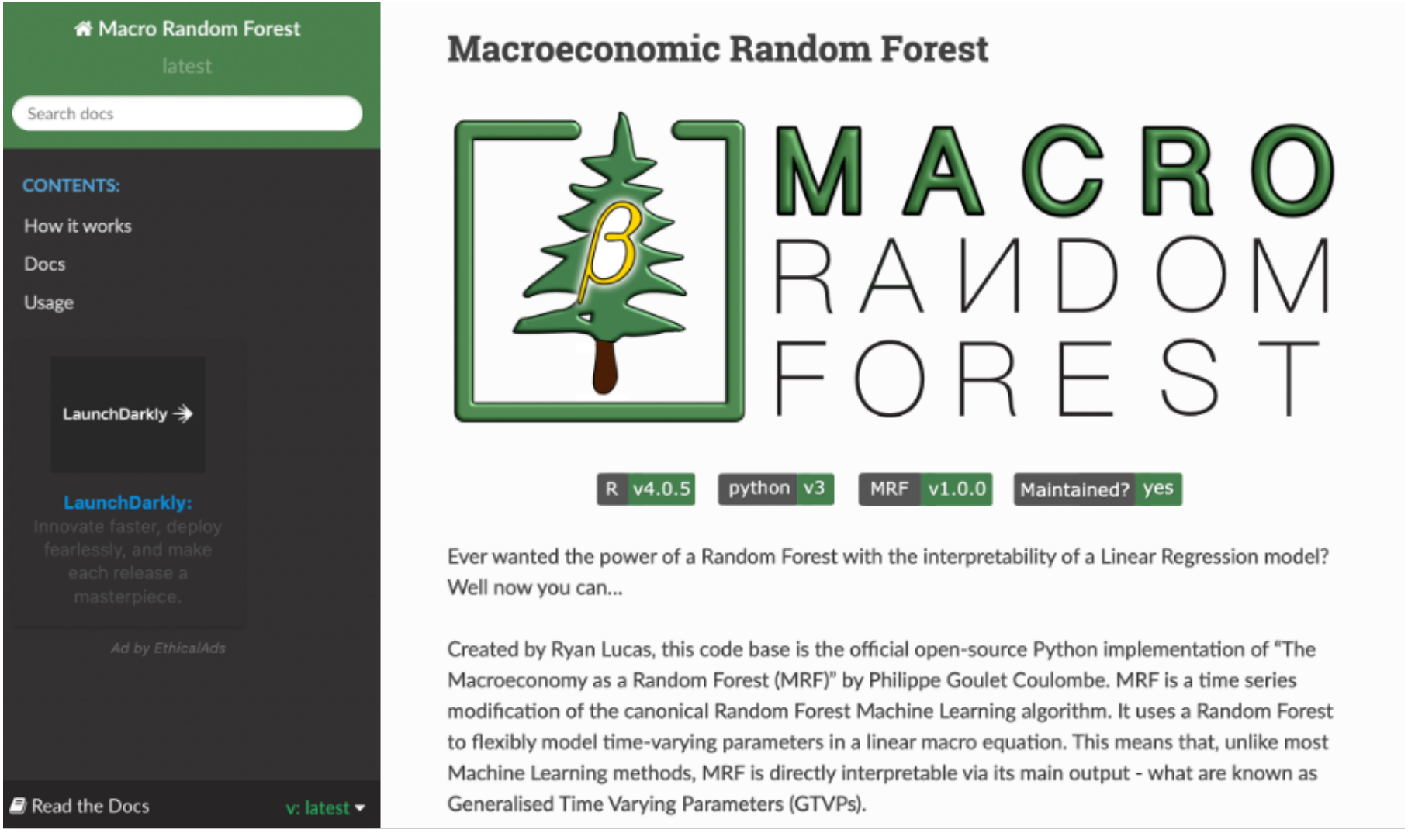
Some Inflation Insights From Pre-Covid Data

βt looks like Total Capacity Utilization (TCU)



Packages

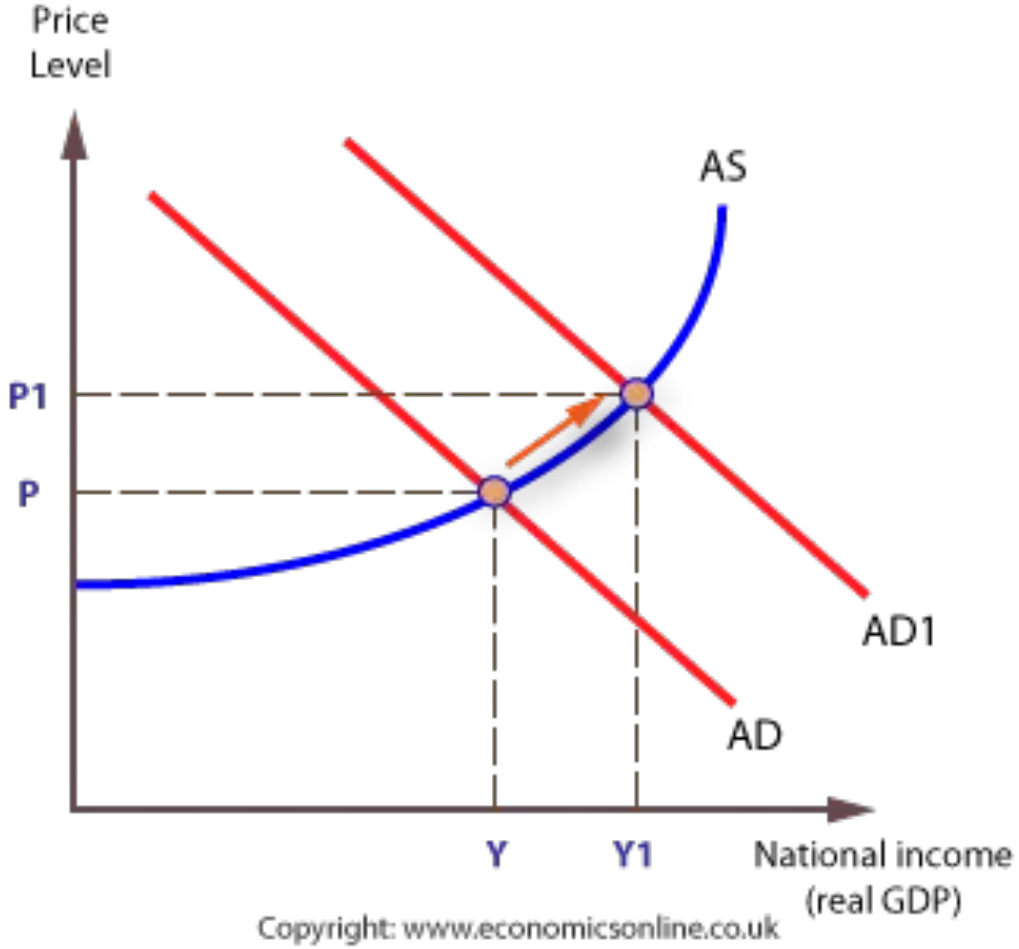
There is a `R package` available, as well as a `Python` one.



Back to Macro 101

- What economic theory actually says is that an abstract concept coined "economic slack" or the output gap (gt) is what drives inflation (πt).

- gt is essentially the difference between aggregate demand (AD) and aggregate supply (AS). If AD>AS (i.e., $gt > 0$), we get inflation.



The Road to Hell is Paved with ***Unknowns Unknowns***

- Unemployment and GDP, including statistical transformations of them, are widely used proxies for *gt*.
- **Those may or may not be adequate proxies of economic slack.**
- Symptoms would include inflation forecasts being repeatedly biased downward. Sounds familiar?

Deep Learning at Work

- **Ingredient 1:** a well-known database of about 250 macroeconomic predictors for the US, available quarterly starting from 1960.
- **Ingredient 2:** *Hemisphere Neural Network,* a new deep architecture
- Its peculiar structure allows the interpretation of certain parts of the network as key macroeconomic latent states, like the very desirable $gt.$
- **The AI's job is precisely to figure out which indicators of economic health, and what sophisticated transformation of them, have most explanatory power for inflation. In other words, it will extract** $gt.$

A Neural Phillips Curve

- The Phillips' Curve can be written as a sum of (i) inflation expectations, (ii) output gap, and (iii) commodity prices, and (iv) unpredictable noise.

$$\pi_{t+1} = \theta_t \mathcal{E}_t^{\pi} + \gamma_t g_t + \zeta_t c_t + \nu_{t+1}$$

- This macroeconomic equation can be seen as three outputs from « hemispheres » in a very specific form of neural network with

$$h_{t,1} = \theta_t \mathcal{E}_t^{\pi} \qquad h_{t,2} = \gamma_t g_t \qquad h_{t,3} = \zeta_t c_t$$

- Putting it together

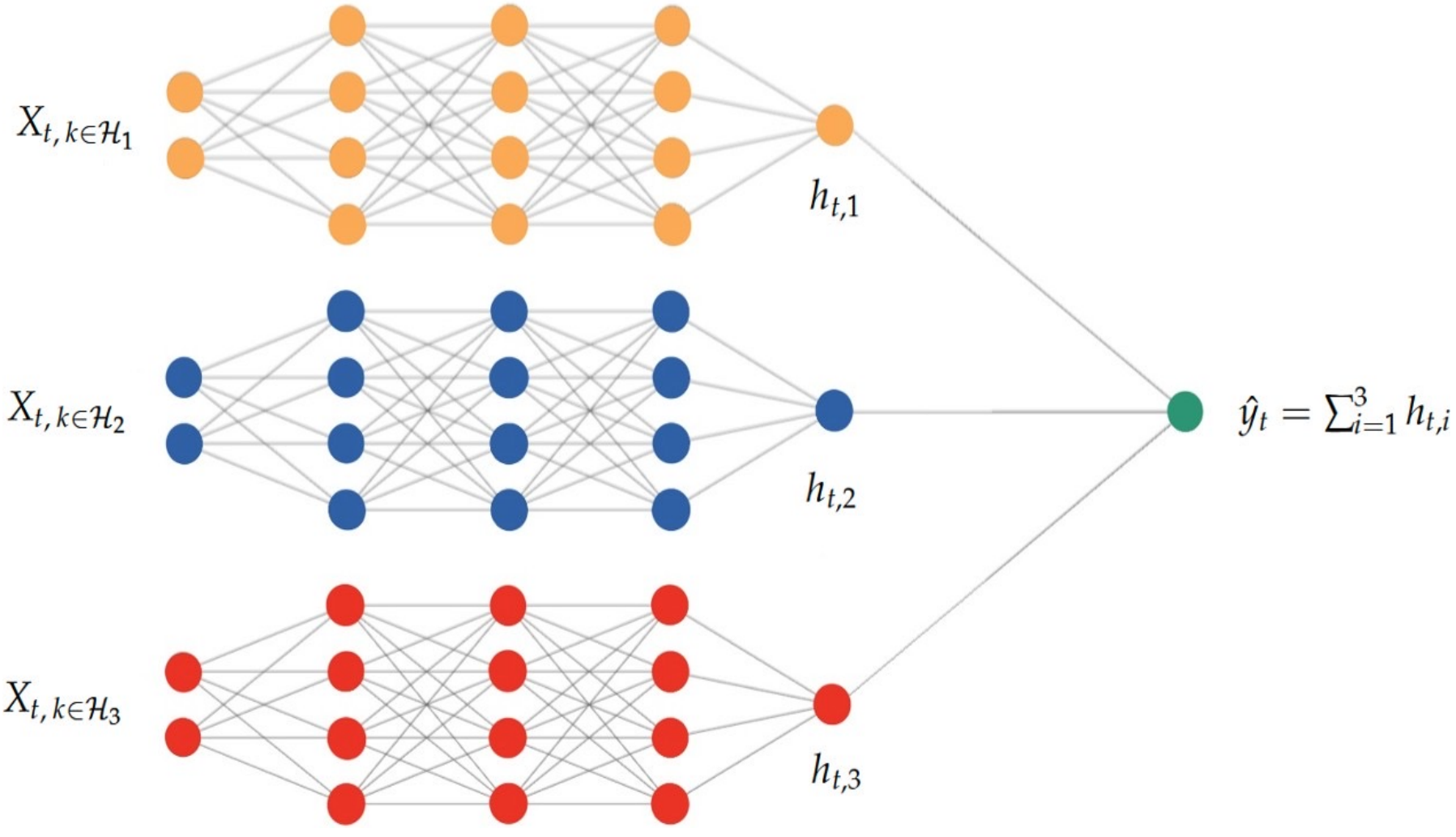
$$\pi_{t+1} = h_{t,1} + h_{t,2} + h_{t,3} + \nu_{t+1}$$

- How can we tell an AI system to model inflation as such?

.

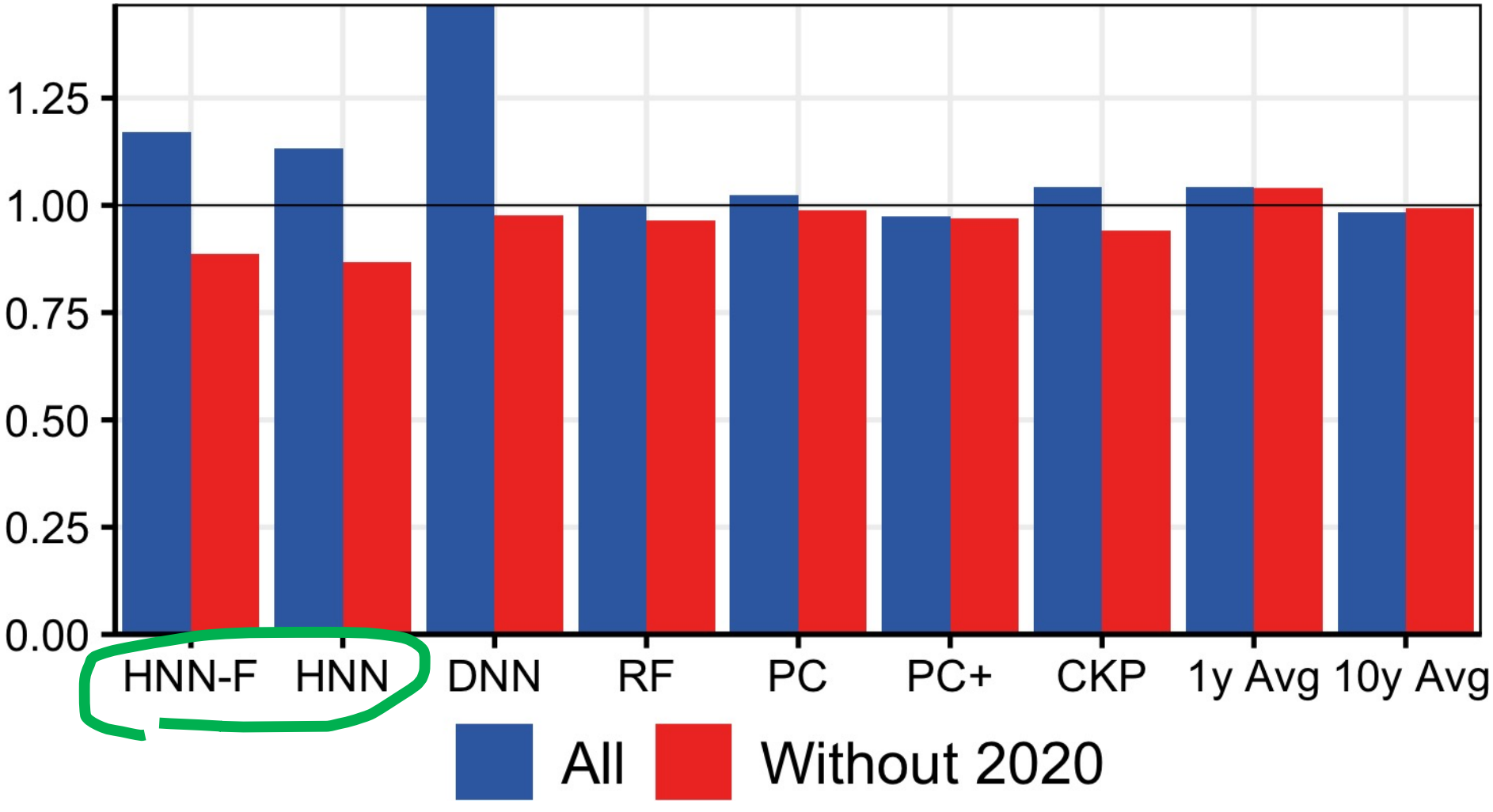
Hemisphere Neural Network

- Let H_1, H_2, and H_3 be the expectations , real activity, and commoditiy prices hemispheres, respectively.



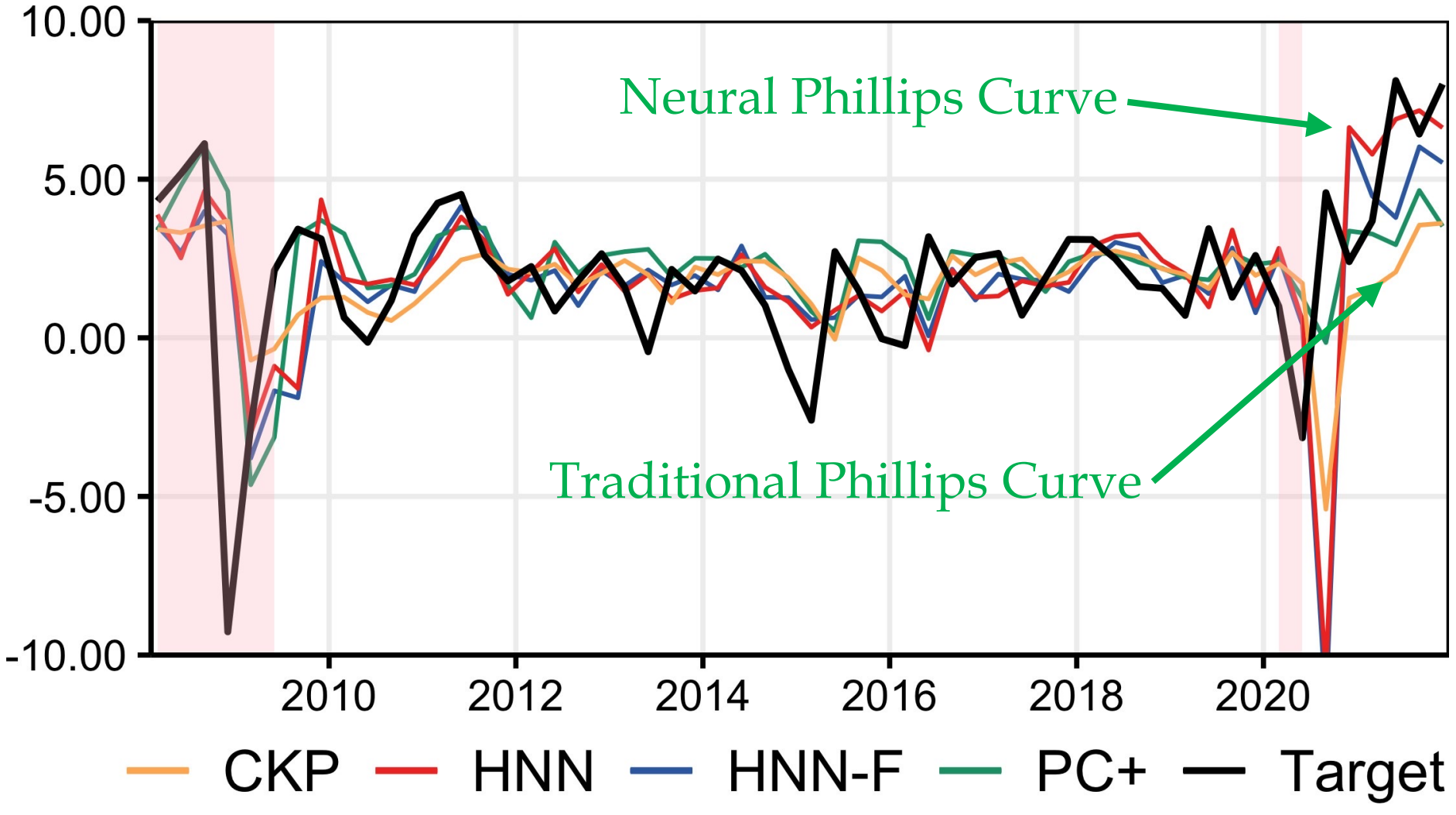
Forecasting Performance (MSEs, so **lower the better**)

Quarterly inflation, one quarter ahead, from 2007



Forecasts

Quarterly inflation, one quarter ahead, from 2007



Understanding Inflation

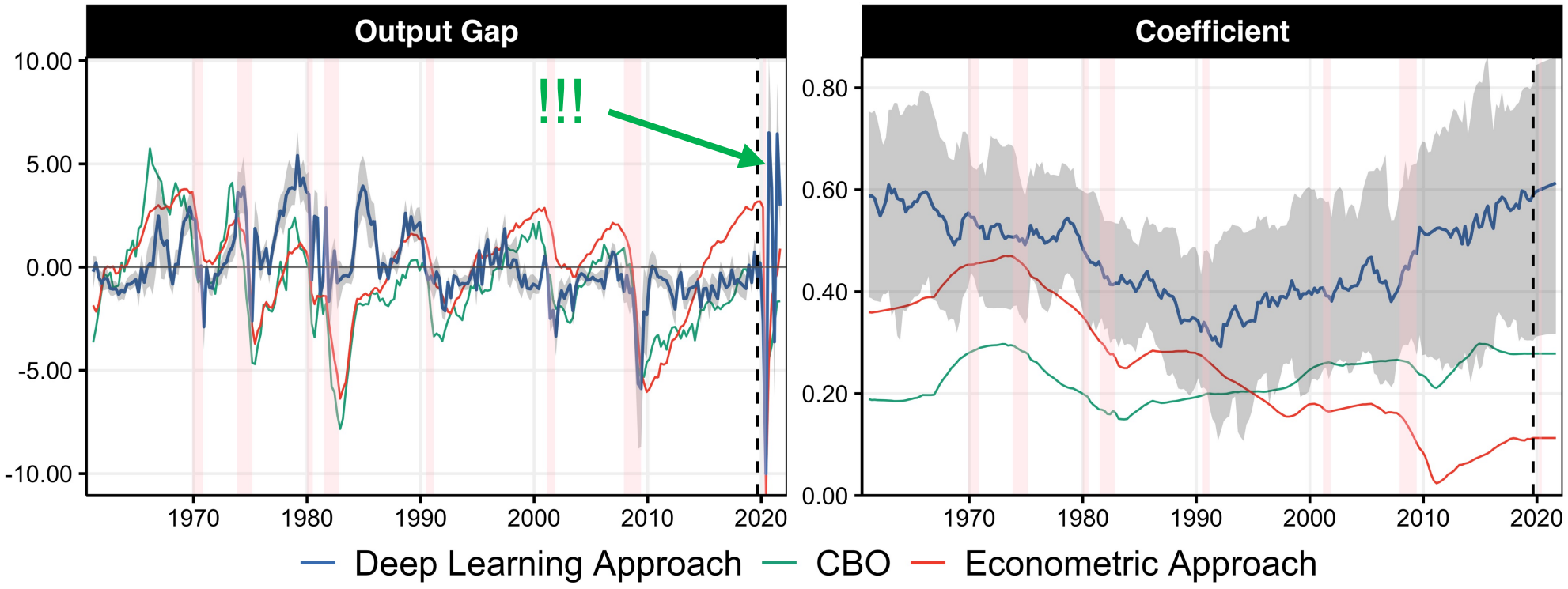
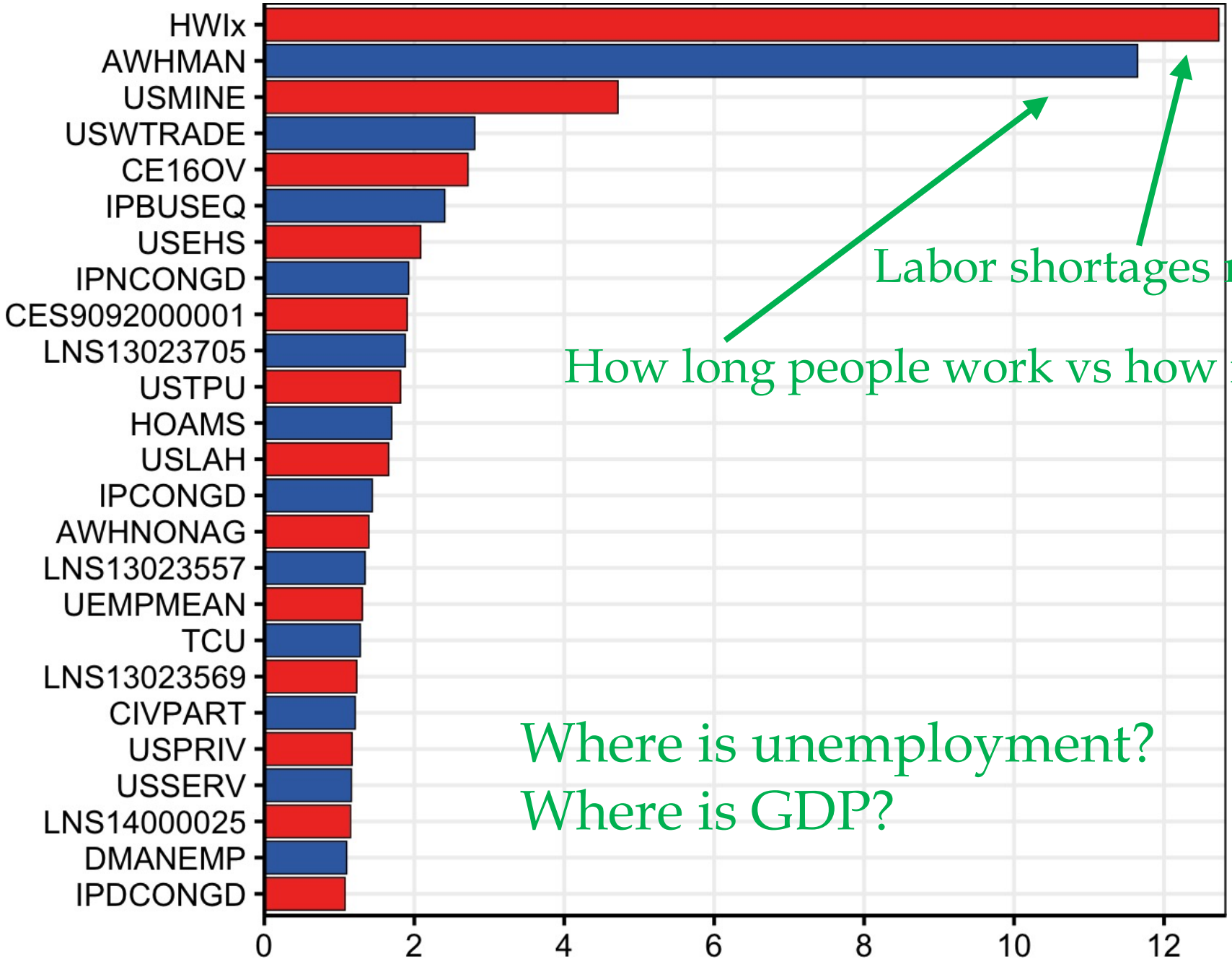


Figure: HNN-F's output gap (g_t) and associated coefficient (γ_t). Notes: Dashed line is the beginning of the out-of-sample. NBER recessions are in pink shadowing.

- Unlike what unemployment suggests, inflationary pressures are skyrocketing in 2021.
- Unlike results from standard approaches, the Phillips' Curve coefficient is *not* found to decline further following 2008.

What is g_t made of? Top 25 most relevant indicators



So, Can AI Understand Inflation?

- Can use AI to extract a data-driven "output gap" that does not bear the important shortcomings of traditional econometric approaches.
- Can use AI to think about the Phillips Curve and its evolution.
- Can use AI to construct economically interpretable forecasts that can be used to inform policy.

So, that's already that.

But given that AI applications to macroeconomics are still in their infancy, I confidently forecast that this understanding is poised to deepen in coming years.

Parting Words

All models are wrong, but some are useful. - G. Box

And AI-based ones, to *understand* inflation, appear particularly useful.