

A Neural Phillips Curve & a Deep Output Gap

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The Road to Hell is Paved with *Unknown Unknowns*



- Unemployment and GDP, and statistical transformations of them, are widely used proxies for economic slack (gt).
- **Those may or may not be adequate.**

What now?

- 2021/2022 suggests some form of Phillips Curve (PC) to be alive and well.
- Yet, econometric models had mostly pronounced it dead.
- AI has the virtue of being particularly agnostic
 - Drawback: black box

Solution

- Nest a very flexible and general PC within a deep neural network.

Benefits

- Better forecasts
- Interpretability — i.e., actually learn something about macroeconomics

A Neural Phillips Curve

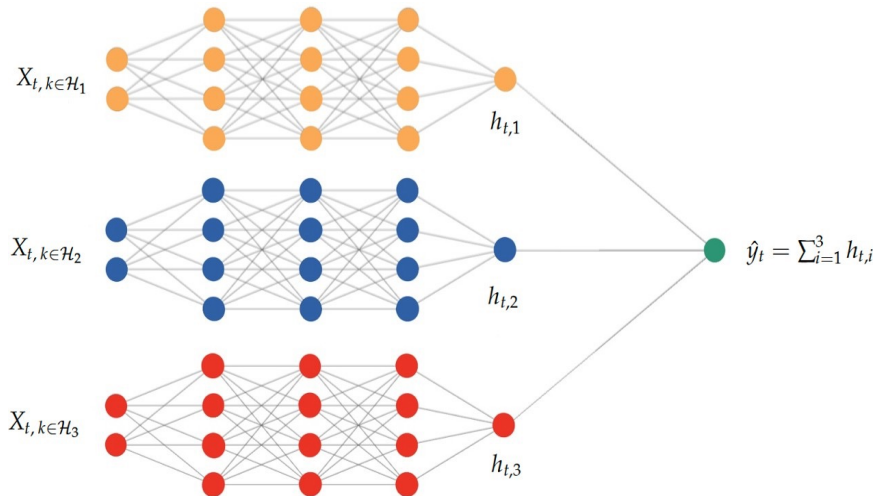
- A modern PC can be written as a sum of (i) expectations, (ii) output gap, and (iii) commodity prices, and (iv) noise.

$$\pi_{t+1} = \underbrace{\theta_t \mathcal{E}_t^\pi}_{h_{t,1}} + \underbrace{\gamma_t g_t}_{h_{t,2}} + \underbrace{\zeta_t c_t}_{h_{t,3}} + \nu_{t+1}$$

- This macroeconomic equation can be seen as the sum of outputs from three « hemispheres » obtained with restricted form of neural network

Hemisphere Neural Network

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



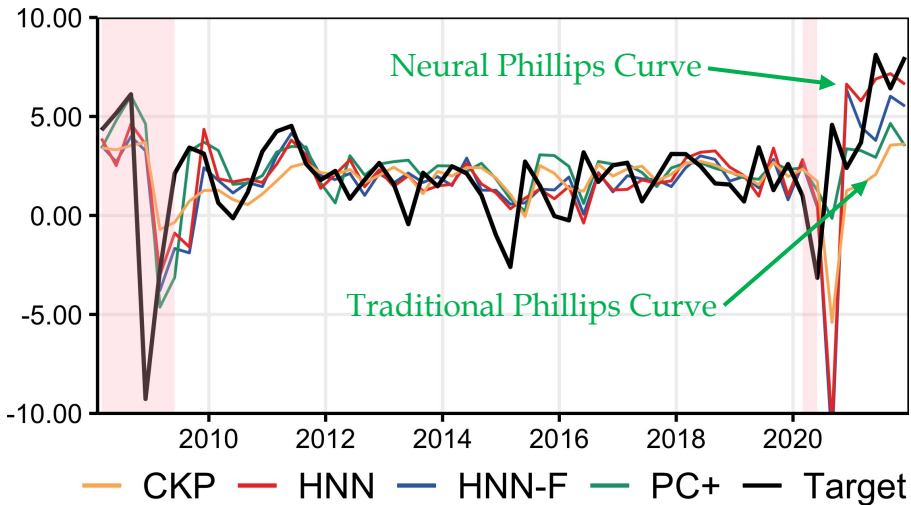
Deep Learning at Work

- **Ingredient 1:** FRED-QD database of about 250 macroeconomic predictors for the US, available quarterly starting from 1960.
- **Ingredient 2:** *Hemisphere Neural Network* (HNN), a novel architecture

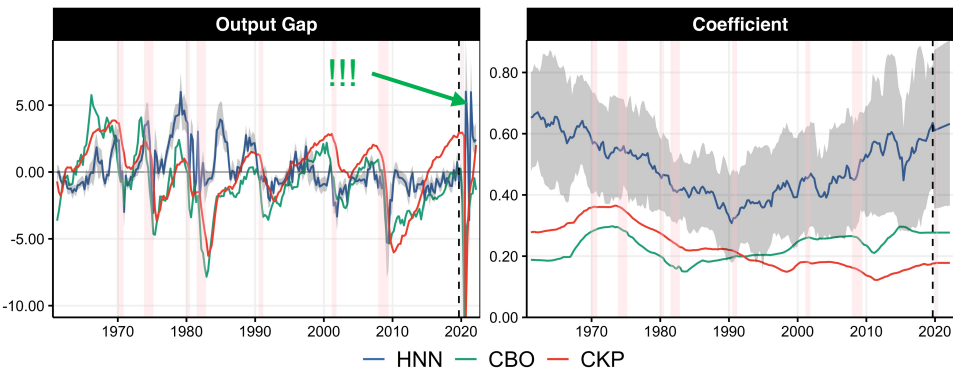
- HNN's job is to
 - i. learn which indicators of economic slack/pressure are pertinent;
 - ii. learn what sophisticated transformation of them should be applied;
 - iii. create a time series with explanatory power for inflation:
→ extraction of latent states like inflation expectations and g_t

Forecasts

Quarterly US inflation, one quarter ahead, from 2007 to 2021Q4

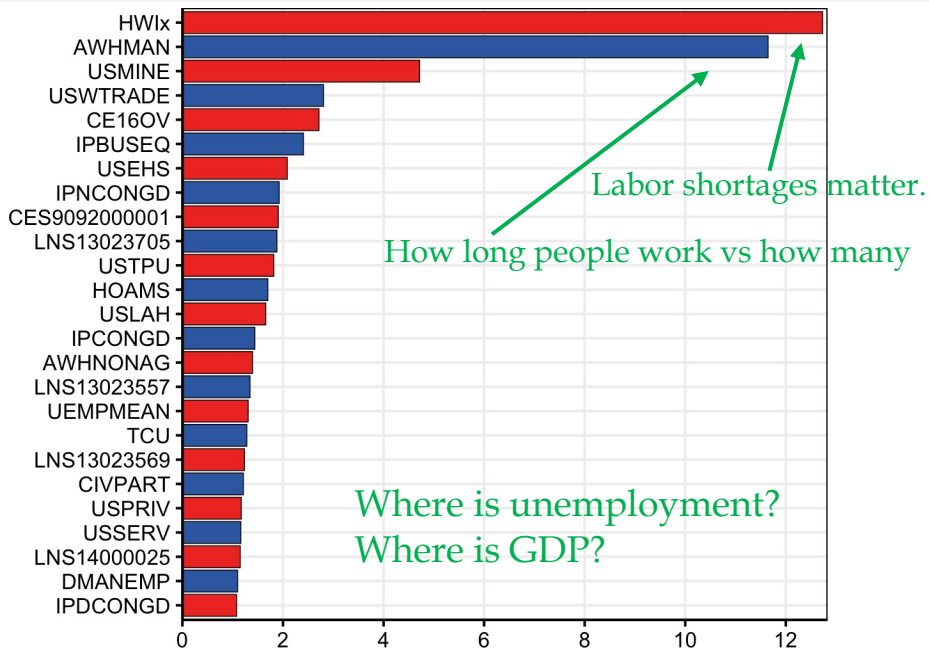


A look at the gap and its coefficient



- Unlike what unemployment suggests, inflationary pressures are skyrocketing in 2021 and remain high in early 2022.
- 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



Lessons Learned

- Economic slack that is relevant for inflation may not be captured adequately by the usual suspects
- A HNN estimated with data through 2019Q1 sees considerable inflationary pressures in 2021 (and 2022), whereas filtered unemployment or GDP do not.
- Of course, it now aligns with some recent papers revising (ex-post) the natural rate of unemployment upward ([Crump et al., 2022](#)) or arguing for alternative measures of slack more aligned with the supply side of the labor market ([Domash and Summers, 2022](#)).
- More generally, this work shows economists can use deep learning to construct economically interpretable forecasts which can inform policy.