Lecture 1:
Introduction to Empirical Macroeconomics

Kunal Sangani

ECON 416-1

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Case study of empirical macroeconomics: The Phillips curve

- Perhaps no idea in macroeconomics has had more influence on prediction and policymaking than the Phillips curve.
  - Larry Summers, in WaPo op-ed (Feb 2021): *"The proposed stimulus will total in the neighborhood of $150 billion a month, even before consideration of any follow-on measures. That is at least three times the size of the output shortfall. [....] There is a chance that macroeconomic stimulus on a scale closer to World War II levels than normal recession levels will set off inflationary pressures of a kind we have not seen in a generation, with consequences for the value of the dollar and financial stability."*
- Today: A brief history of the Phillips curve.
- Interplay between theory and empirics, identification, and aggregation.

Phillips (1958): UK unemployment and wage inflation

- Phillips curve begins with relationship of unemployment and wage inflation in UK.

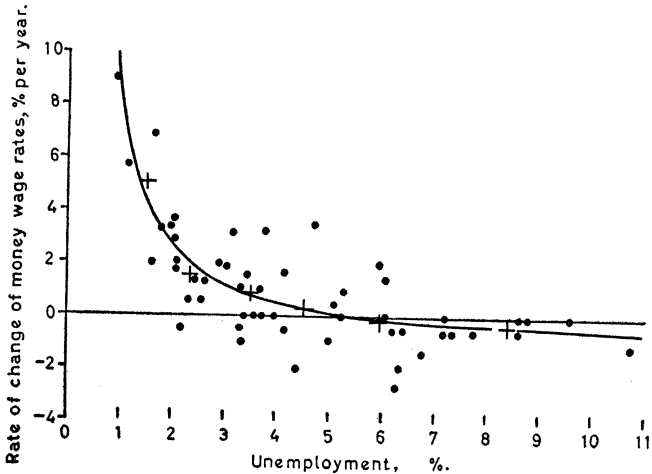


Fig.1. 1861 – 1913

Phillips (1958): UK unemployment and wage inflation

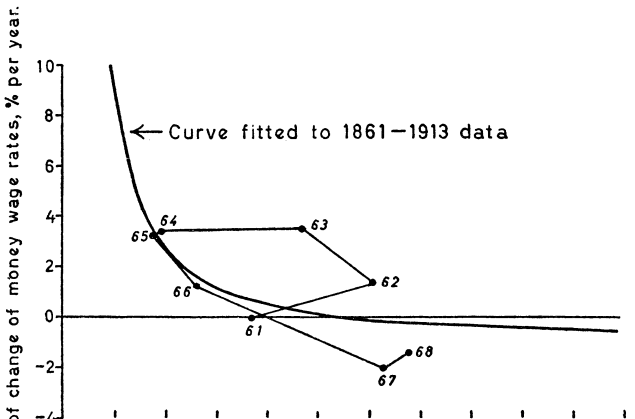


Fig. 2. 1861 — 1868

Source: Phillips (1958)

Phillips (1958): UK unemployment and wage inflation

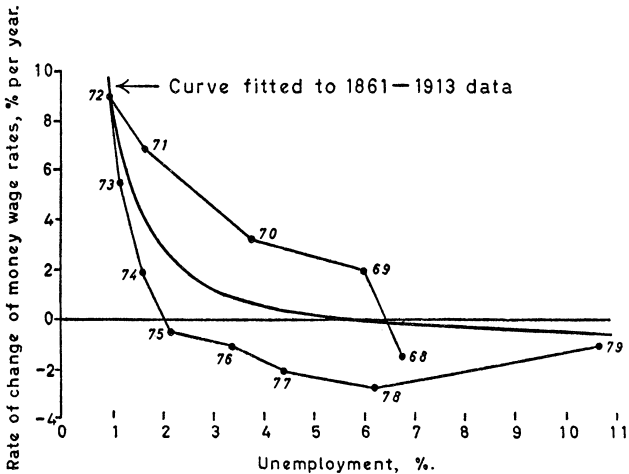


Fig. 3. 1868 —1879

Source: Phillips (1958)

Phillips (1958): UK unemployment and wage inflation

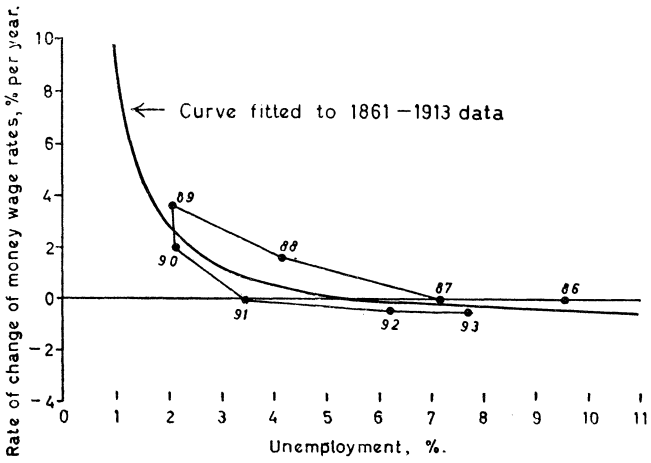


Fig.5. 1886 − 1893

Source: Phillips (1958)

Phillips (1958): UK unemployment and wage inflation

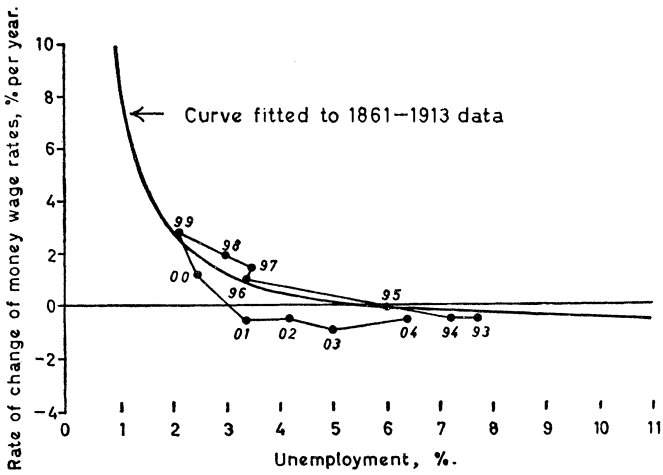


Fig.6. 1893—1904

Source: Phillips (1958)

Samuelson and Solow (1960): A menu of choice

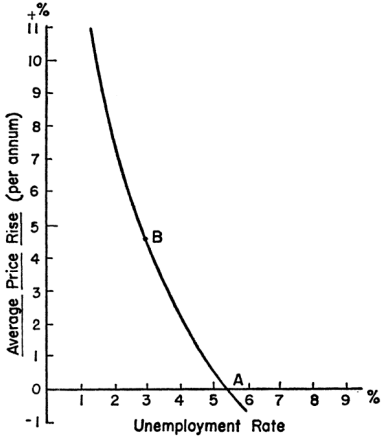


FIGURE 2

MODIFIED PHILLIPS CURVE FOR U.S.
This shows the menu of choice between different degrees of unemployment and price stability, as roughly estimated from last twenty-five years of American data.

- Samuelson and Solow (1960) popularize idea in U.S.
- Policymakers' "menu": lower unemployment, but at cost of inflation.
- Sacrifice ratio: Loss in GDP / employment required to reduce inflation.
- *"It would be wrong, though, to think that our Figure 2 menu that relates obtainable price and unemployment behavior will maintain its same shape in the longer run."*

View in the 1960s

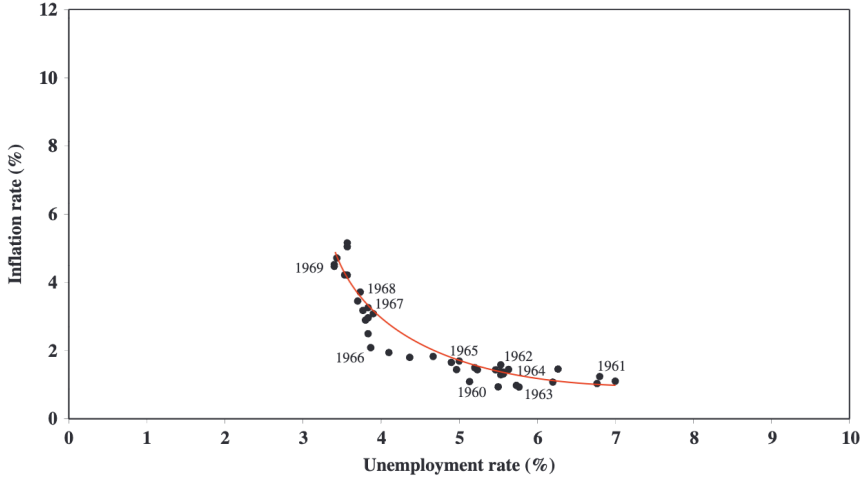


FIGURE 2. Scatter plot of the unemployment and inflation rates, quarterly data, 1960–80.

Figure: US inflation and unemployment, 1960–1969 (adapted from Gordon 2011).

Friedman AEA address

- In 1968 AEA address, Friedman critiques possibility of stable, long-run Phillips curve.
- Workers will demand wage increases in excess of expected inflation.
- As inflation rises, expectations of inflation will rise.
- Changes in expected inflation will shift the Phillips curve.
- Friedman: *"There is always a temporary trade-off between inflation and unemployment; there is no permanent trade-off. The temporary trade-off comes not from inflation per se, but from unanticipated inflation, which generally means, from a rising rate of inflation."*
- (Also concurrently discussed by Phelps 1967).

At the time of AEA address

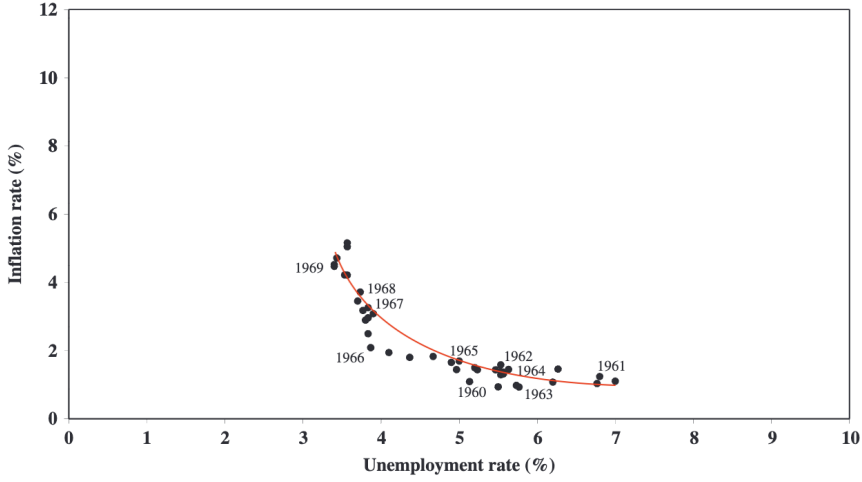


FIGURE 2. Scatter plot of the unemployment and inflation rates, quarterly data, 1960–80.

Figure: US inflation and unemployment, 1960–1969 (adapted from Gordon 2011).

Friedman was right!

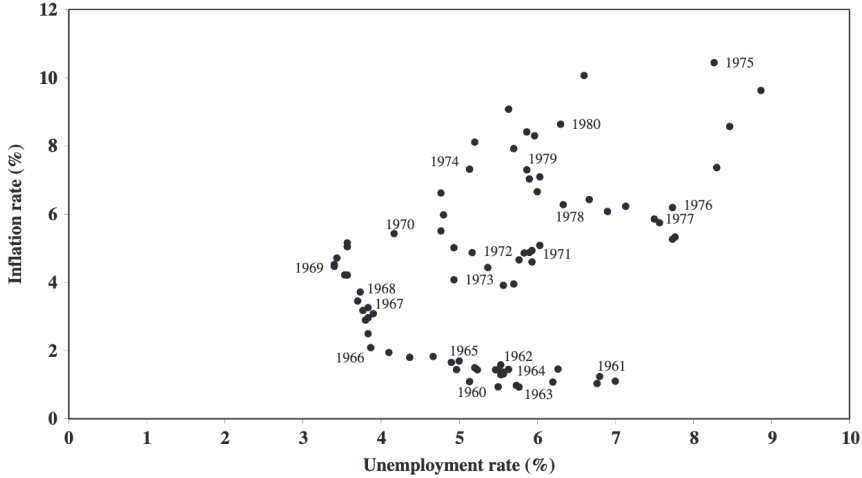


FIGURE 2. Scatter plot of the unemployment and inflation rates, quarterly data, 1960–80.

Figure: US inflation and unemployment, 1960–1980 (adapted from Gordon 2011).

Changes to the Phillips curve

- Mankiw and Reis (2018): *"The stagflation of the 1970s, when both inflation and unemployment rose, is one of the greatest successes of out-of-sample forecasting by a macroeconomist."*

- Before Friedman/Phelps:
$$\pi_t = \pi_0 + \kappa\left(y_t - y_t^n\right).$$

- One reaction: Phillips curve with adaptive expectations:
$$\pi_t = \pi_{t-1} + \kappa\left(y_t - y_t^n\right).$$
If monetary authority attempts to target unemployment rate below natural rate (NAIRU), leads to inflationary spiral.

Sargent (1982): The Ends of Four Big Inflations

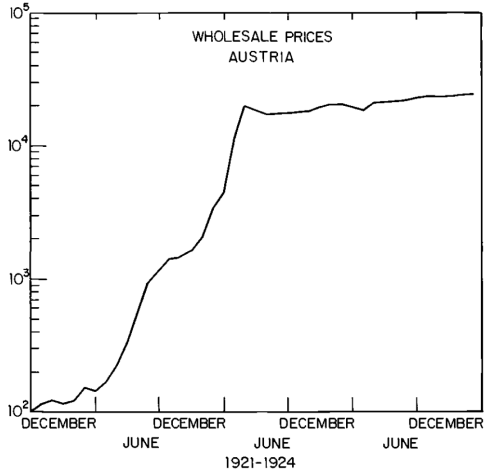


Fig. 2.1 Wholesale prices in Austria.

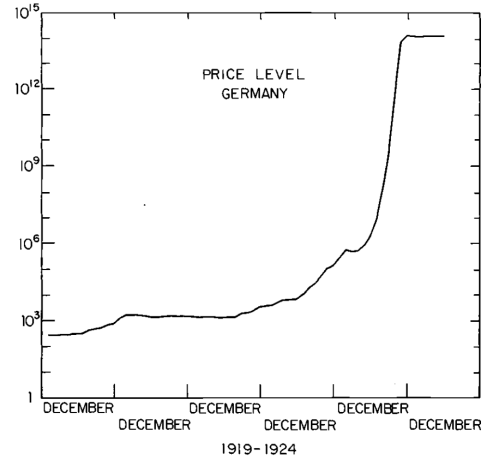


Fig. 2.4 Wholesale prices in Germany.

Sargent (1982): The Ends of Four Big Inflations

- Sargent: *"It is often claimed that there is an underlying rate of inflation which responds slowly, if at all, to restrictive monetary and fiscal measures. Evidently, this underlying rate of inflation is the rate of inflation that firms and workers have come to expect will prevail in the future. There is momentum in this process because firms and workers supposedly form their expectations by extrapolating past rates of inflation into the future. [...]*

  An alternative 'rational expectations' view denies that there is any inherent momentum in the present process of inflation[....] People expect high rates of inflation in the future precisely because the government's current and prospective monetary and fiscal policies warrant those expectations[....] Inflation only seems to have a momentum of its own; it is actually the long-term government policy of persistently running large deficits and creating money at high rates which imparts the momentum to the inflation rate."

- Inflation ending without large output loss discriminates between classes of models.

Sargent (1982): The Ends of Four Big Inflations

By all available measures, the stabilization of the German mark was accompanied by increases in output and employment and decreases in unemployment.[34] While 1924 was not a good year for German business, it was much better than 1923. Table G6 is representative of the figures assembled by Graham, and shows that 1924 suffers in comparison with 1922 but that 1925 was a good year. In these figures one cannot find much convincing evidence of a favorable trade-off between inflation and out-

Table G6 **Index of Physical Volume of Production per Capita in Germany**

Year	Index of Production	Year	Index of Production
1920	61	1924	77
1921	77	1925	90
1922	86	1926	86
1923	54	1927	111

Source: Graham [7, p. 287].

Modern Phillips Curve

- Using Calvo (1983) sticky prices, New Keynesian Phillips curve takes the form,

$$d\log\pi_t = \kappa d\log Y_t + \beta\mathbb{E}_t[d\log\pi_{t+1}] + \eta_t.$$

  Inflation due to expected (future) inflation, output gap, and cost-push shocks.

- Perfectly credible, unexpected disinflation can occur without output loss (Sargent).

- Yet attended by some empirical challenges:
  - Expected inflation unobserved.
  - Natural rate of output unobserved.
  - Cost-push shocks unobserved.

Modern Phillips Curve

$$d \log \pi_t = \kappa d \log Y_t + \beta \mathbb{E}_t[d \log \pi_{t+1}] + \eta_t.$$

- Unobserved, omitted variables makes estimating κ difficult:
  - Even if output gap moves during inflation, what fraction was due to shift in natural rate / cost-push shocks?
  - Even if output gap moves during disinflation, what fraction of disinflation due to shift in expected inflation?
- Three approaches:
  1. Estimate deep structural parameters.
  2. Use macro data and identifying restrictions.
  3. Exploit cross-sectional variation in micro data.

Estimating κ: Deep structural parameters

$$d\log \pi_t = \kappa d\log Y_t + \beta \mathbb{E}_t[d\log \pi_{t+1}] + \eta_t,$$

- In canonical formulation (e.g., Gali 2015), the slope of the Phillips curve κ is

$$\kappa = (\sigma + \varphi)\frac{(1-\theta)(1-\beta\theta)}{\theta},$$

  where
  - σ is the inverse elasticity of intertemporal substitution,
  - φ is the inverse Frisch elasticity,
  - θ is the degree of price flexibility, and
  - β is the discount rate.

- One option: Estimate each of these "deep structural parameters" using micro data.

Estimating κ: Deep structural parameters

- Let's take some of the best evidence available on each structural parameter:

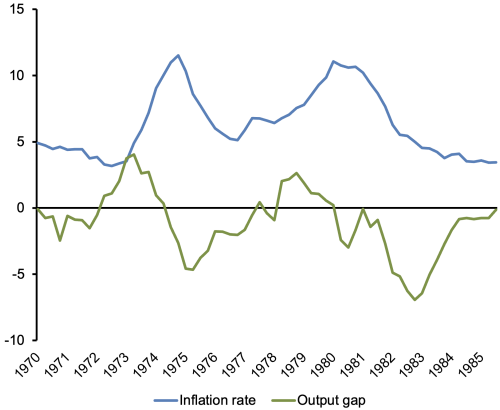
Parameter		Estimate	Source
IES	$1/\sigma$	0.1	Best, Cloyne, Ilzetzki & Kleven (RESTUD, 2020)
Frisch elasticity	$1/\varphi$	0.025–0.2	Martínez, Saez & Siegenthaler (AER, 2021)
Avg. price spell duration	$1/\theta$	7–9 months	Nakamura & Steinsson (QJE, 2008)
Discount rate	β	0.96	Interest rate

- Using quarterly values,

$$\kappa = \left(\frac{1}{0.1} + \frac{1}{0.2}\right) \frac{(1-0.5)(1-0.5(0.96)^{1/4})}{0.5} \approx 7.6.$$

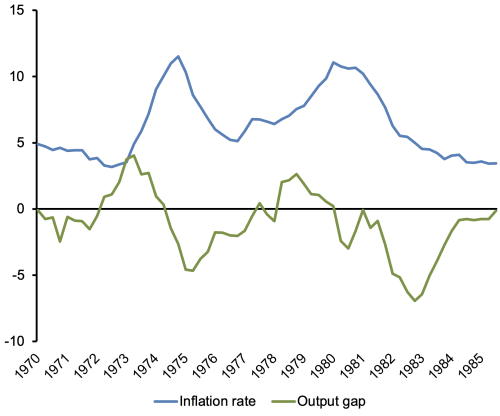
Estimating κ: Deep structural parameters

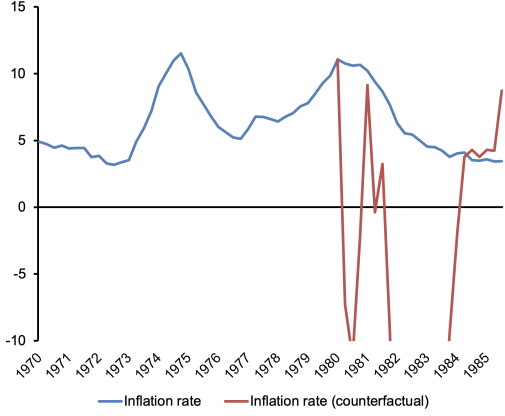
- Applying $\kappa = 7.6$ to inflation and output gap over Volcker disinflation (1980–1982)...



Estimating κ: Deep structural parameters

- Applying $\kappa = 7.6$ to inflation and output gap over Volcker disinflation (1980–1982)...
- Would need huge rise in expected inflation or cost-push shocks (in fact, both falling over this period).





A deep-dive into one potential problem: Aggregation

- Clearly, part of the problem is that the IES and Frisch elasticity are very low.
- Let us take labor supply as an example.
- Micro estimates of labor supply elasticity typically measured at individual level.
- Suppose we introduce an extensive margin of work:
  - Labor is indivisible. Each individual can work fraction h of time or zero.
  - Individuals participate in employment lotteries (Rogerson 1948, 1988; Hansen 1985).
  - With probability p, agent gets to work, and with probability $1-p$ the agent is unemployment.
  - Agents have access to insurance markets to share risk.

A deep-dive into one potential problem: Aggregation

- Suppose agent utility,

$$U(c, 1-\ell) = \log(c) + \log v(1-\ell).$$

- Given perfect risk-sharing, there is a representative agent whose preferences are

$$U^{\text{rep}}(C, 1-L) = \max_{p, c_E, c_U} pU(c_E, 1-h) + (1-p)U(c_U, 1).$$

$$\text{s.t.} \qquad L = ph, \qquad \text{and} \qquad pc_E + (1-p)c_U = C.$$

- Optimality: $U_c(c_E, 1-h) = U_c(c_U, 1)$, so we get $c_E = c_U = C$.

$$U^{\text{rep}}(C, 1-L) = \log(C) - L\left[\frac{1}{h}\log\left(\frac{v(1)}{v(1-h)}\right)\right] + \log(v(1)).$$

(Equivalent: household is a "family" that decides how many members to send to work.)

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(Equivalent: household is a "family" that decides how many members to send to work.)

- Bottom line: Individual labor supply elasticity is 0, but rep agent has ∞ labor supply (disutility of labor is linear).

A deep-dive into one potential problem: Aggregation

- Turns out, even the extensive margin doesn't help us here.
- Martínez et al. (2021): *"We find significant but quantitatively very small responses of wage earnings with an intertemporal elasticity of 0.025 overall.*

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TABLE 1—MICRO VS. MACRO LABOR SUPPLY ELASTICITIES

		Intensive Margin	Extensive Margin	Aggregate Hours
Steady State (Hicksian)	micro	0.33	0.26	0.59
	macro	0.33	0.17	0.50
Intertemporal Substitution (Frisch)	micro	0.54	0.28	0.82
	macro	[0.54]	[2.30]	2.84

Note: Each cell shows a point estimate of the relevant elasticity based on meta analyses of existing micro and macro evidence. Micro estimates are identified from quasi-experimental studies; macro estimates are identified from cross-country variation in tax rates (steady state elasticities) and business cycle fluctuations (intertemporal substitution elasticities). The aggregate hours elasticity is the sum of the extensive and intensive elasticities. Macro studies do not always decompose intertemporal aggregate hours elasticities into extensive and intensive elasticities. Therefore, the estimates in brackets show the values implied by the macro aggregate hours elasticity if the intensive Frisch elasticity is chosen to match the micro estimate of 0.54. Sources are described in the appendix.

Figure: Chetty, Guren, Manoli, and Weber (2011).

Estimating κ: Deep structural parameters

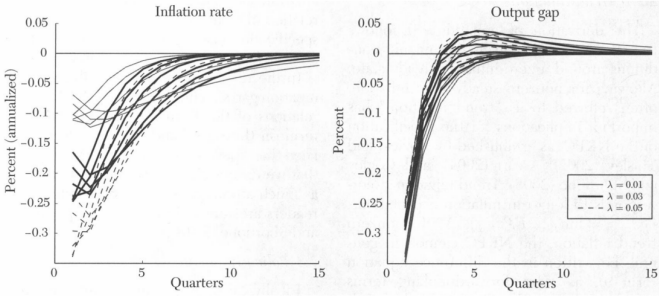


Figure 1. Impulse Responses to Monetary Policy Shock

Notes: Impulse responses of inflation and the output gap to a 25 basis point monetary policy shock in a standard three-equation New Keynesian model with $\gamma_f = 0.3, 0.4, \ldots 0.8$ and $\lambda = 0.01, 0.03, 0.05$. The other parameters are calibrated to the benchmark values listed in Appendix A.1. More sluggish responses correspond to lower values of γ_f. The figure was generated using Dynare (Adjemian et al. 2011).

- Mavroeidis, Plagborg-Møller & Stock (2014) simulate classic New Keynesian model with parameter estimates spanning literature.
- Most negative cumulative inflation/output responses 5x larger than least.

Estimating κ: Are deep structural parameters really that?

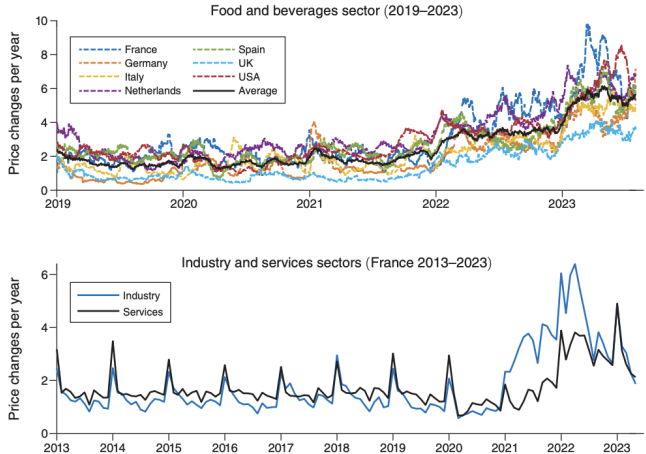


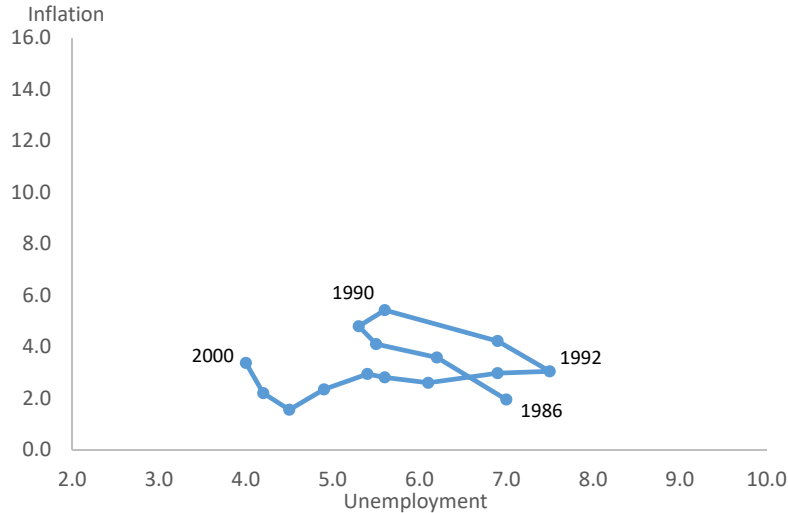
FIGURE 1. FREQUENCY OF PRICE CHANGES

Figure: Cavallo, Lippi, and Miyahara (2024): "Large Shocks Travel Fast."

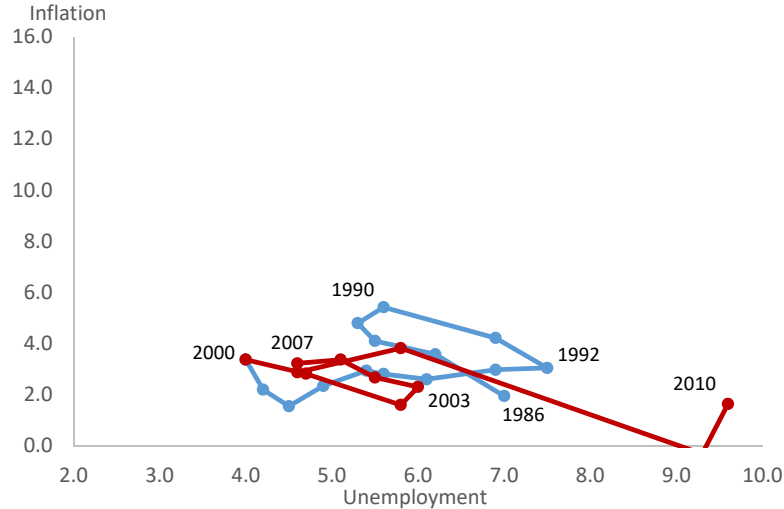
Estimating κ: Macro data

- What if we instead discipline slope of the Phillips curve using macro data?
- Inference from scatterplot of inflation vs. unemployment complicated by omitted variables.
- From Jón Steinsson: Phillips curve often pronounced dead.
  - Missing inflation in late 1990s.
  - Missing disinflation in the Great Recession.
  - Missing reinflation in the subsequent recovery.
  - Missing disinflation in the COVID crisis.
- Seems like inflation is always going missing...

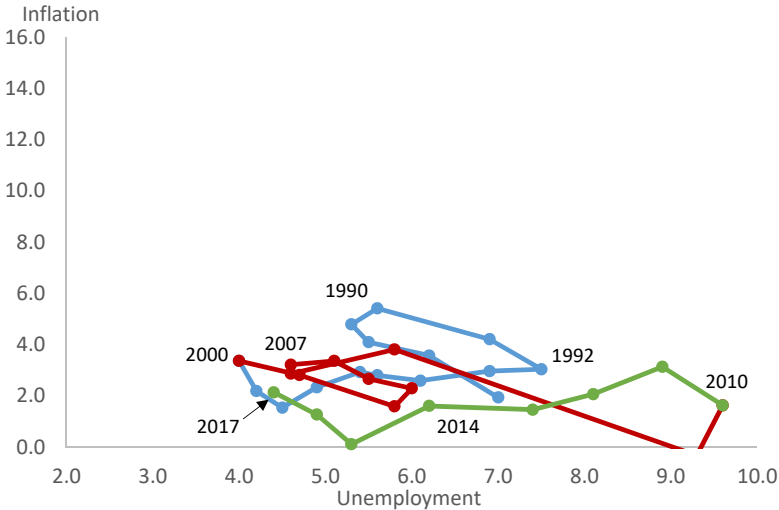
Missing Inflation in Late 1990s



Missing Disinflation in the Great Recession



Missing Reinflation since Great Recession



Flattening Phillips Curve

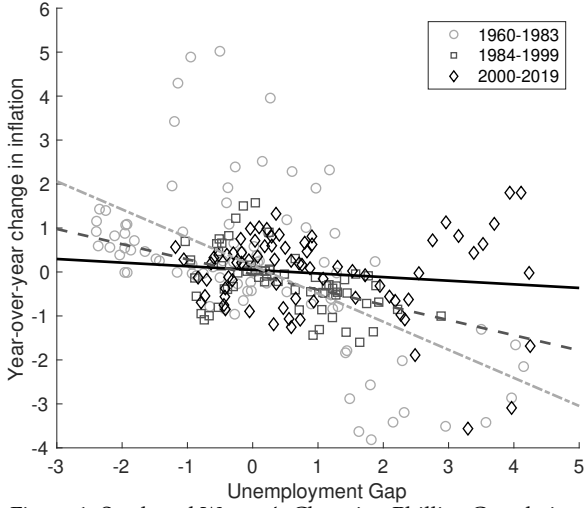
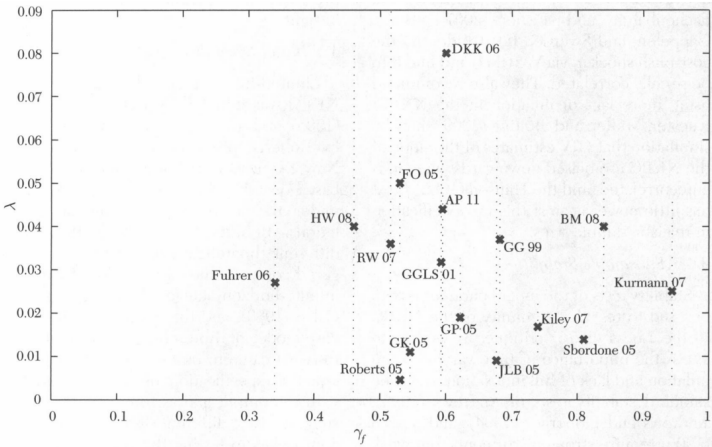


Figure 1: Stock and Watson's Changing Phillips Correlation

Source: Hazell, Herreño, Nakamura, and Steinsson (2022).

Estimating κ: Macro data

- Mavroeidis, Plagborg-Møller & Stock (2014) survey of literature estimates of coefficients on output gap (λ) and on expected future inflation (γ_f).



Estimating κ: Macro data

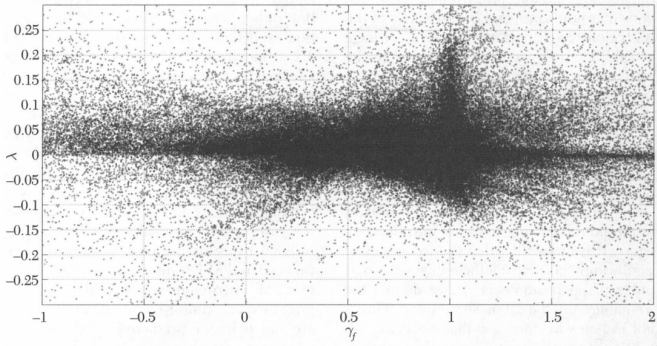


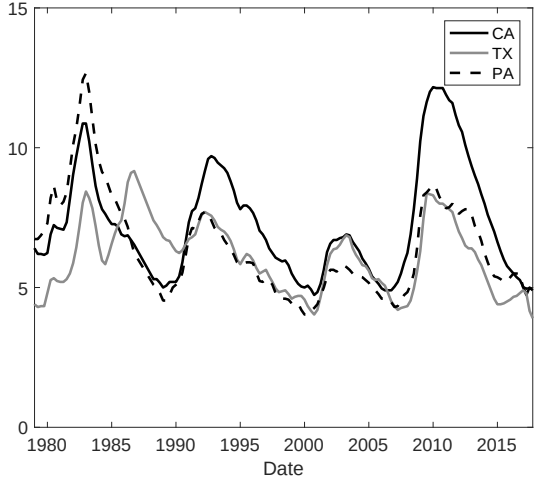
Figure 5. Point Estimates: Output Gap Specifications
Notes: Point estimates of λ, γ_f from the various specifications listed in table 4 that use the output gap as forcing variable, excluding real-time and survey instrument sets.

- Mavroeidis, Plagborg-Møller & Stock (2014): *"We conclude that the literature has reached a limit on how much can be learned about the New Keynesian Phillips curve from aggregate macroeconomic time series. New identification approaches and new datasets are needed to reach an empirical consensus."*

Estimating κ: Cross-sectional variation in micro data

- Another approach: Exploit variation across regions, industries, or firms.
- Exploiting variation across regions: Fitzgerald and Nicolini (2014), McLeay and Tenreyro (2019), Hooper Mishkin and Sufi (2019), Beraja Hurst and Ospina (2019), Hazell Herreño Nakamura and Steinsson (2022).
- Idea: Takes care of endogeneity of unemployment.
  - If inflation expectations common, absorbed in time fixed effects.
  - Supply shocks lead to positive comovement between inflation and unemployment, and monetary policy counteracts demand variation leaving only supply variation.
  - But monetary policy cannot eliminate regional demand shocks.

Estimating κ: Cross-sectional variation in micro data



- Hazell et al (2022): Use differences in state-level demand to estimate effect of local unemployment on non-tradeables inflation.

Estimating κ: Cross-sectional variation in micro data

- Construct multi-region model with tradeable and non-tradeable goods.
- Regional Phillips curve for non-tradeables:

$$\pi_t^N = \beta E_t[\pi_{t+1}^N] - \kappa u_t - \lambda p_t^N + \nu_t^N.$$

- Aggregate Phillips curve:

$$\pi_t = \beta E_t[\pi_{t+1}] - \kappa u_t + \nu_t.$$

- κ in regional non-tradeable Phillips curve is same as aggregate PC (in this model)!
- Iterating forward,

$$\begin{aligned}\pi_t^N &= -\kappa E_t \sum_{j=0}^{\infty} \beta^j u_{t+j} - \lambda E_t \sum_{j=0}^{\infty} \beta^j p_{t+j}^N + E_t \pi_{t+\infty} + \omega_t^N \\ &= -\psi u_t - \delta p_t + E_t \pi_{t+\infty} + \omega_t^N.\end{aligned}$$

where e.g., $\psi = \kappa/(1-\beta\rho_u)$ and ρ_u is persistence of unemployment.

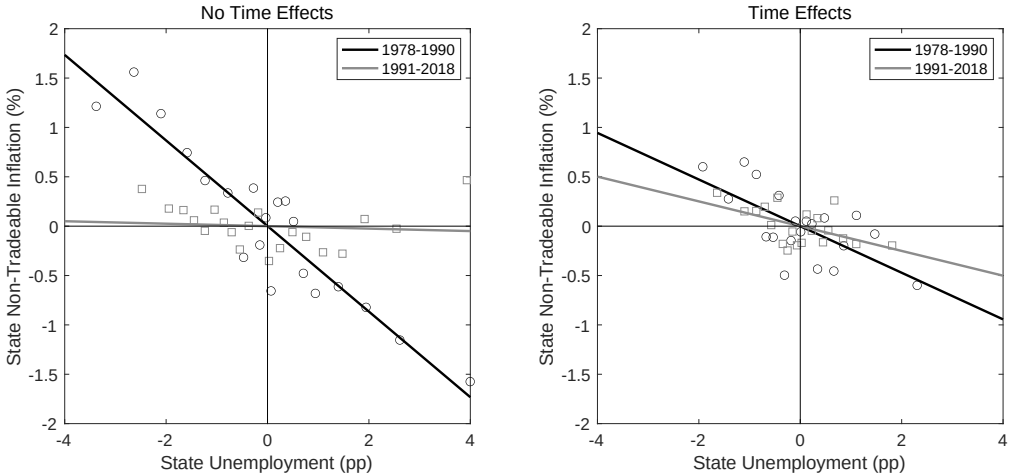
Estimating κ: Cross-sectional variation in micro data

	No State Effects	No Time Effects	Lagged unemp. IV	Tradeable Demand IV
	(1)	(2)	(3)	(4)
ψ	-0.103	0.017	0.112	0.339
	(0.036)	(0.027)	(0.057)	(0.126)
κ	-0.0037	0.0003	0.0062	0.0062
	(0.0013)	(0.0019)	(0.0028)	(0.0025)
State Effects		✓	✓	✓
Time Effects			✓	✓

Table: Hazell et al (2022) estimates of Phillips curve slope.

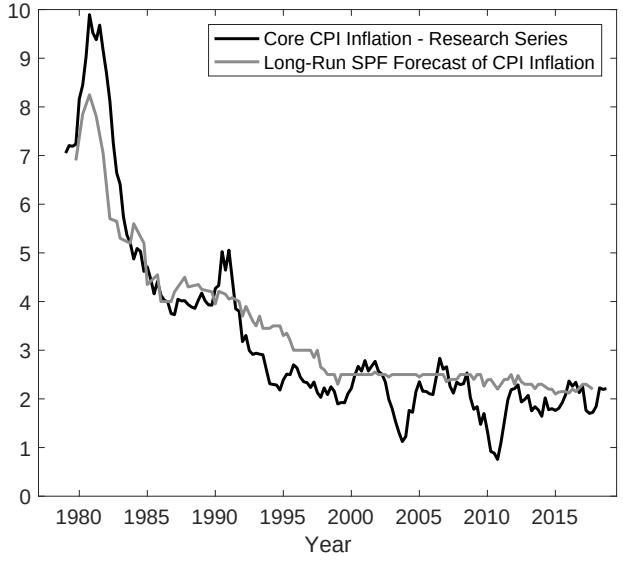
- Very flat: 5pp increase in unemployment decreases inflation by 2pp.

Argument: Much less flattening than thought

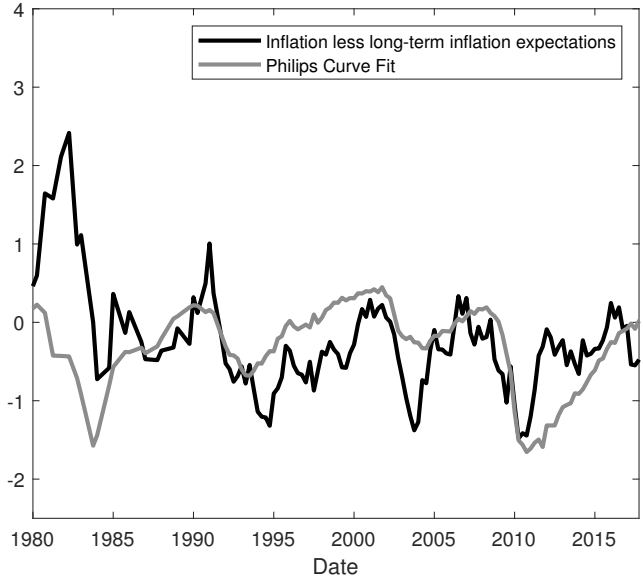


- Apparent flattening in aggregate data due to inflation expectations.

Argument: Steep Phillips curve during Volcker due to inflation expectations



Argument: No missing deflation during Great Recession



Some open questions

- Hazell et al (2022) provide a model in which regions face local demand shocks and differences in non-tradeables inflation tell us slope of the aggregate Phillips curve.

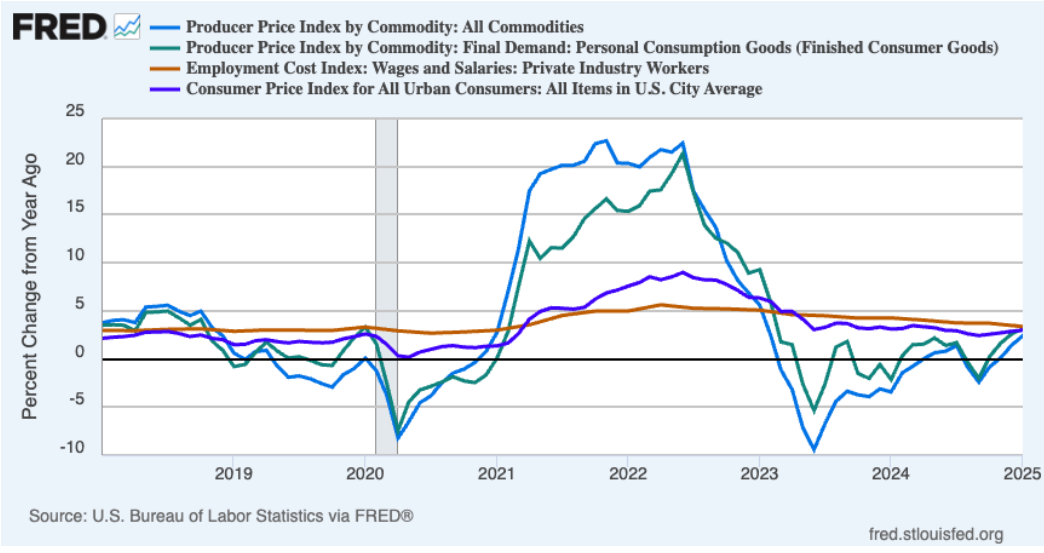
- Not clear this is necessarily the right model.

1. Heterogeneous price rigidity across regions?
    - Same aggregate demand shock $\Rightarrow$ more output response, less inflation response in regions with stickier prices.
    - This will bias Phillips curve slope toward being flatter.

2. Elasticity of supply for tradeable goods vs. non-tradeables?

3. Nonlinearities?

Some open questions: Elasticity of supply for tradeables vs. non-tradeables



Some open questions: Nonlinearities

Figure 12: Passthrough of costs into inflation

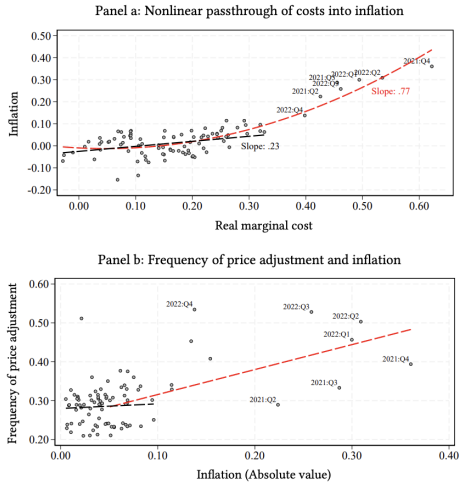


Figure: Gagliardone, Gertler, Lenzu, and Tielens (2025).

Some open questions: Nonlinearities

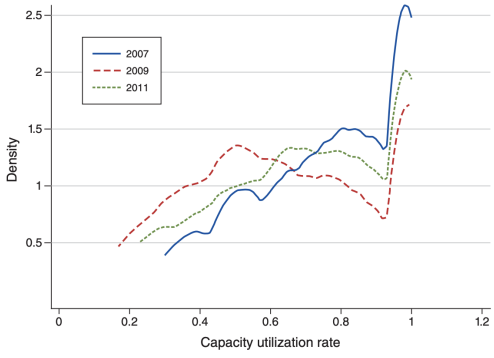


FIGURE 1. DENSITIES OF PLANT CAPACITY UTILIZATION

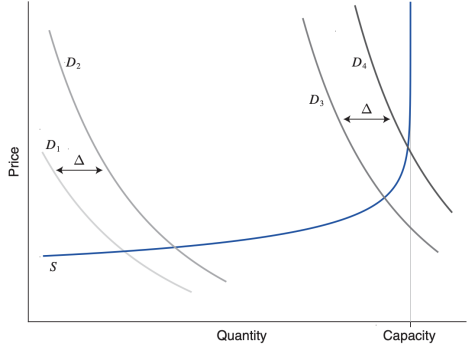


FIGURE 3. THE UTILIZATION RATE AS A SUFFICIENT STATISTIC FOR THE SUPPLY ELASTICITY

Figure: Boehm and Pandalai-Nayar (2022): “Convex Supply Curves.”

Past and future of the Phillips curve

- Phillips curve began as an empirical relationship.
- Refined with new theory, new data, and new identification strategies.
  - Deep parameters. (E.g., disconnect between micro- and macro- Frisch elasticities.)
  - Simple empirical observations (E.g., how hyperinflations end.)
  - Macro data and identifying restrictions.
  - Cross-sectional data and applied micro techniques.
- Friedman (1953): *"Viewed as a body of substantive hypotheses, theory is to be judged by its predictive power for the class of phenomena which it is intended to 'explain.' Only factual evidence can show whether it is 'right' or 'wrong' or, better, tentatively 'accepted' as valid or 'rejected.'"*

Table of Contents

Course outline

1. Theory.
    - Disaggregation, Hulten's Theorem, inter-industry interactions.
    - Distortions and misallocation.
    - Models of endogenous distortions.
    - Competition and market power.
    - Open questions on firms, industries, competition, and efficiency.
2. Empirics.
    - Sufficient statistics, identified moments, and structural parameters.
    - Measurement: Problems and strategies.
    - Aggregegation: Problems and strategies.

Course outline

1. Who is this course for?

2. Objectives.

3. Office hours: Monday afternoon, KGH 3445, sign-up online.
   Please bring slides or write-up if possible.
   Email sangani@northwestern.edu if we need to find another time.

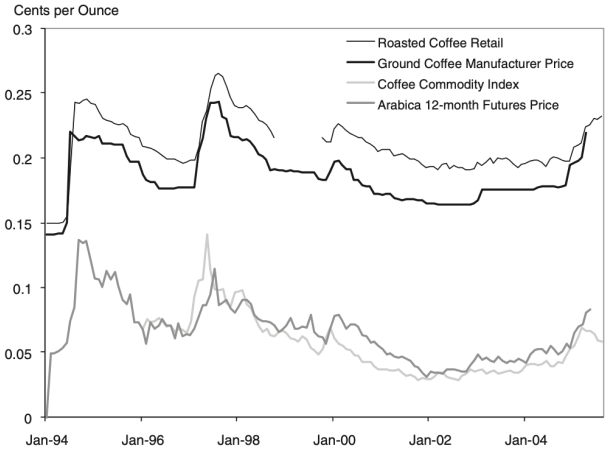
Course requirements

1. Empirical result presentations (Monday, September 29).
2. Problem set (due roughly October 15 – to be confirmed).
3. Problem set (due roughly November 12 – to be confirmed).
4. Final project: Presentation and proposal.
    - Please check intermediate deadlines on syllabus.

First assignment: Empirical result presentations

- Present one empirical result from a paper that is...
  1. Not on the course syllabus.
  2. Cited in Summers (1991), Ramey (2016), Romer (2016), Christiano, Eichenbaum, and Trabandt (2018), or Nakamura and Steinsson (2018).
- Five minute presentation with 1–2 slides (no more!) on **Monday, September 29**.
  - Upload to Canvas by **5pm on Sunday, September 28**.
- Describe the context, data, and methodology, and present the result.
- Do not need to present the entire paper or contextualize within the paper's argument.

Example: Nakamura and Zerom (2010)



- What explains incomplete pass-through of cost changes? Markups? Local costs? Price rigidity? Nakamura & Zerom study using coffee commodity costs and retail/wholesale prices.

Example: Nakamura and Zerom (2010)

TABLE 1
Pass-through regressions

	Log specification		Levels specification	
Variable	Retail	Wholesale	Retail	Wholesale
Δ Commodity cost (t)	0.063 (0.013)	0.115 (0.018)	0.142 (0.040)	0.218 (0.061)
Δ Commodity cost ($t-1$)	0.104 (0.008)	0.169 (0.013)	0.446 (0.024)	0.520 (0.043)
Δ Commodity cost ($t-2$)	0.013 (0.007)	−0.010 (0.010)	0.016 (0.019)	0.029 (0.028)
Δ Commodity cost ($t-3$)	0.031 (0.006)	−0.016 (0.009)	0.080 (0.018)	0.004 (0.026)
Δ Commodity cost ($t-4$)	0.048 (0.007)	0.007 (0.013)	0.144 (0.018)	0.023 (0.030)
Δ Commodity cost ($t-5$)	0.007 (0.006)	0.025 (0.011)	0.070 (0.017)	0.067 (0.031)
Δ Commodity cost ($t-6$)	−0.015 (0.008)	−0.026 (0.012)	0.017 (0.021)	−0.009 (0.029)
Constant	0.033 (0.003)	−0.004 (0.003)	0.007 (0.0004)	0.001 (0.0005)
Long-run pass-through	0.252 (0.007)	0.262 (0.018)	0.916 (0.023)	0.852 (0.052)
Number of observations	40,129	2867	40,129	2867
R-squared	0.079	0.141	0.088	0.134

- *"A 1% increase in coffee commodity costs leads to an increase in prices of approximately a third of a per cent."*
- Changes in commodity prices reflected roughly cent-for-cent in downstream prices.