Intermediate macroeconomics
Aggregate supply[1]

Kamil Kovar

IES - Summer Semester 2025

[1] Acknowledgment: These slides are partly based on slides of Tomas Lichard

Outline

Introduction

Outline

Introduction

We started with AS-AD model, but then proceeded to talk about AD only.

- IS-LM is a model of aggregate demand.
- IS-LM tells us how much and why does *demand* increase in response to shocks.

What happens to output in response to demand shocks?

Thought experiment: Microeconomics

Consider standard microeconomic model of supply and demand for apples.

Imagine that demand for apples increases.

How much does quantity increase?

In microeconomics **the response of quantity to demand shocks is entirely determined by shape of supply curve.**

Thought experiment: Macroeconomics

Imagine that there is large increase in aggregate demand due to increase in government spending on defense.

How much does output increase?

In macroeocnomics **the response of output crucially is entirely determined by shape of aggregate supply curve.**

Slope of aggregate supply curve

Classical model: Aggregate supply cure is vertical.

- Demand shocks do not lead to fluctuation in output (good and bad news).
- Possibly good description of long run.

Short-run supply curve: Aggregate supply curve is upward sloping but not vertical.

Crucial question: Why isn't aggregate supply curve vertical in short-run?

Defining Short Run vs. Long Run

Short Run:

- Period where some prices (especially wages) are sticky/inflexible
- Output can deviate from its natural level
- Monetary policy can affect real variables

Long Run:

- All prices and wages are fully flexible
- Economy operates at natural level (potential output)
- Classical dichotomy holds

The distinction between short and long run is central to understanding macroeconomic fluctuations

Aggregate Supply

Outline

Aggregate Supply Models

Sticky price models

- Firms do not adjust instantly due to transaction costs

Sticky wage models

- long-term wage contracts

Imperfect information models

- Firms and/or workers confuse an increase in the price level with own prices
- Firms and/or workers confuse nominal and real wage
- Rational inattention models

Sticky price models

Sources of price stickiness

Why are prices sticky?

- Existence of long-term contracts
- Consumer relationship considerations
- Menu costs and managerial costs of price changes

Empirical evidence of price stickiness

Roughly 1/10 of prices are changed every months, implying that given price typically will be valid around 10 months.

TABLE I
FREQUENCY OF PRICE CHANGE IN THE CPI

	Median frequency		Median implied duration		Mean frequency		Mean implied duration	
	1988–1997 (%)	1998–2005 (%)	1988–1997 (months)	1998–2005 (months)	1988–1997 (%)	1998–2005 (%)	1988–1997 (months)	1998–2005 (months)
A. Including sales								
Excluding substitutions	20.3	19.4	4.4	4.6	23.9	26.5	8.3	9.0
Including substitutions	21.7	20.5	4.1	4.4	25.2	27.7	7.5	7.7
B. Excluding sales and substitutions								
Contiguous observations	11.1	8.7	8.5	11.0	18.7	21.1	11.6	13.0
Carry regular price forward during sales and stockouts	11.2	9.0	8.4	10.6	18.6	20.9	11.0	12.3
Estimate frequency of price change during sales	11.5	9.6	8.2	9.9	19.0	21.3	11.2	12.5
Estimate frequency of price change during sales and stockouts	11.9	9.9	7.9	9.6	18.9	21.5	10.8	11.7
C. Excluding sales, including substitutions								
Contiguous observations	12.7	10.9	7.4	8.7	20.4	22.8	9.3	9.8
Carry regular price forward during sales and stockouts	12.3	10.6	7.6	8.9	19.7	22.0	9.6	10.4
Estimate frequency of price change during sales	12.8	11.3	7.3	8.3	20.8	22.8	9.2	9.8
Estimate frequency of price change during sales and stockouts	13.0	11.8	7.2	8.0	20.7	23.1	9.0	9.3

Notes. All frequencies are reported in percent per month. Implied durations are reported in months. "Median frequency" denotes the weighted median frequency of price change. It is calculated by first calculating the mean frequency of price change for each ELI and then taking a weighted median across ELIs within the major group using CPI expenditure weights. The "Median implied duration" is equal to $-1/\ln(1-f)$, where f is the median frequency of price change. "Mean frequency" denotes the weighted mean frequency of price change. "Mean implied duration" denotes the weighted implied duration of price change. It is calculated by first calculating the implied duration for each ELI as $-1/\ln(1-f)$, where f is the frequency of price change for a particular ELI, and then taking a weighted mean across ELIs using CPI expenditure weights.

Price setting

Goal: Simple model of price setting by firms.

- Assumption: Firms are setting prices (i.e. absence of perfect competition)

What do firms care about when setting prices?

- Firm's costs $\Rightarrow$ determined by aggregate price level.
- Demand for firm's goods $\Rightarrow$ determined by aggregate demand.

Price setting equation:

$$p_t = P_t + a\Big(y_t - \overline{y}_t\Big).$$

where p_t is price set by firm, P_t is price level and y_t is output and $\overline{y}_t$ is natural level of output.

- a is a parameter governing by how much do firms increase prices when demand is strong.

Price settings: Flexible price firms)

Type 1 firms have flexible prices and can set prices optimally:

$$p_{1,t} = P_t + a\Big(y_t - \overline{y}_t\Big).$$

Why do firms set higher prices when is demand stronger? $\rightarrow$ because stronger demand gives that opportunity to do so while still selling high output.

Price settings: Sticky price firms)

Type 2 firms face sticky prices $\leftrightarrow$ they have to set prices in advance according to their *expectations* of future demand and prices:

$$p_{2,t} = P_t^e + a\left(y_t^e - \overline{y}_t^e\right)$$

where p_t^e is firms' expectation of period t's price level formed at period $t-1$ (similarly for y_t^e and $\overline{y}_t^e$).

If we assume that

$$y_t^e = \overline{y}_t^e.$$

then we get

$$p_{2,t} = P_t^e$$

Aggregate prices

- If the share of firms with sticky prices is s, the overall price level in the economy is then:

$$P_t = sp_{2,t} + (1-s)p_{1,t} = s\,P_t^e + (1-s)\Big[P_t + a\Big(y_t - \overline{y}_t\Big)\Big].$$

- This implies:

$$P_t = P_t^e + \Big[\Big(1-s\Big)\frac{a}{s}\Big]\Big(y_t - \overline{y}_t\Big).$$

- Higher expected price level leads to higher actual price level, *for both types of firms*.
- Higher demand/output leads firms with flexible prices to set higher prices.
- Prices respond to output more when prices are more flexible.

The presence of sticky price firms is crucial - otherwise prices react infinitely to output deviation.

- Sticky price firms cannot increase prices.
- Flexible price firms know this, so also react less (input prices, relative prices).

Aggregate supply

The aggregate pricing equation relates prices to output.

We can re-arrange to relate output to prices:

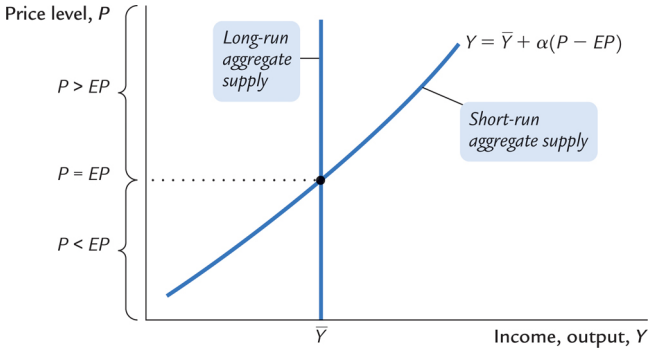
$$y_t = \overline{y}_t + \alpha\Big(P_t - P_t^e\Big).$$

This is our aggregate supply curve.

- Gives aggregate output as function of price level.
- Higher price level is associated with higher output (not "leads to").
- Aggreate supply is steeper if prices are more flexible (and vertical when they are fully flexible).
- Other parameters: natural output, expected price level.

Aggregate supply curve

The aggregate supply can be represented as upward sloping curve in graph of output and prices.



Staggered price setting

How long does it take for shock to be fully reflected in aggregate supply? $\rightarrow$ when sticky price firms set prices (i.e. after one period).

What if sticky price firms set prices every two periods?

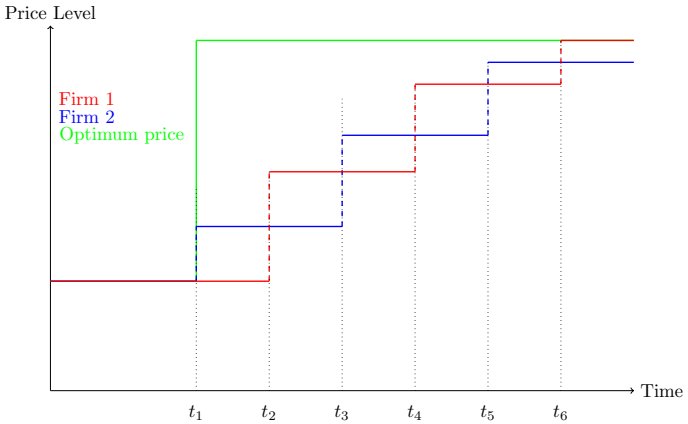
Imagine two types of firms setting prices in alternating periods and exogenous jump in equilibrium prices. Do all prices reach equilibrium after two period?

No!

- Consumers care about relative prices, so firms do not want to set prices too different from other firms.
- When one type of firms have option to set prices they do not adjust fully in order to remain competitive.
- When other type of firms have option to set prices they do not adjust fully in order to remain competitive.
- ...

Staggered price setting: Illustration

When price setting is staggered then prices take long time to adjust. (What if there is a common shock?)



Five facts about price stickiness

1. Prices are moderately sticky.
2. There is large heterogeneity in frequency of price changes across categories.
3. Price changes are more frequent when inflation is higher.
4. Frequency of price changes is seasonal.
5. Many prices are updated once every year in specified month.

Five facts about price stickiness: Frequency across categories

Fuel prices change constantly, fresh food prices are changed frequently, processed food prices change moderately frequently, and service or goods prices infrequently.

TABLE II
FREQUENCY OF PRICE CHANGE BY MAJOR GROUP IN 1998–2005

		Regular prices				Prices				Sales	
		Median		Mean		Median		Mean			
Major group	Weight	Freq.	Impl. dur.	freq.	Frac. up	Freq.	Impl. dur.	freq.	Frac. up	Frac. price ch.	Frac. obs.
Processed food	8.2	10.5	9.0	10.6	65.4	25.9	3.3	25.5	54.7	57.9	16.6
Unprocessed food	5.9	25.0	3.5	25.4	61.2	37.3	2.1	39.5	53.3	37.9	17.1
Household furnishing	5.0	6.0	16.1	6.5	62.9	19.4	4.6	20.6	49.0	66.8	21.2
Apparel	6.5	3.6	27.3	3.6	57.1	31.0	2.7	30.1	36.1	87.1	34.5
Transportation goods	8.3	31.3	2.7	21.3	45.9	31.3	2.7	22.2	44.0	8.0	2.7
Recreation goods	3.6	6.0	16.3	6.1	62.0	11.9	7.9	13.7	51.3	49.1	10.9
Other goods	5.4	15.0	6.1	13.9	73.7	15.5	5.9	20.6	61.3	32.6	15.3
Utilities	5.3	38.1	2.1	49.4	53.1	38.1	2.1	49.4	53.1	0.0	0.0
Vehicle fuel	5.1	87.6	0.5	87.4	53.5	87.6	0.5	87.5	53.4	0.0	0.3
Travel	5.5	41.7	1.9	43.7	52.8	42.8	1.8	44.4	52.2	1.5	2.1
Services (excl. travel)	38.5	6.1	15.8	8.8	79.0	6.6	14.6	9.1	76.8	3.1	0.5
All sectors	100.0	8.7	11.0	21.1	64.8	19.4	4.6	26.5	57.1	21.5	7.4

Notes. All frequencies are reported in percent per month. Durations are reported in months. Fractions are reported as percentages. Regular prices denote prices excluding sales. "Weight" denotes the CPI expenditure weight of the major group; "median freq." denotes the weighted median frequency of price change. It is calculated by first calculating the mean frequency of price change for each ELI and then taking a weighted median across ELIs within the major group using CPI expenditure weights. The other median statistics in this table are calculated in an analogous manner: "median impl. dur." is equal to $-1/\ln(1-f)$, where f is the median frequency of price change. "Mean freq." denotes the expenditure weighted mean frequency of price change; "frac. up" denotes the median fraction of price changes that are price increases; "frac. price ch." and "frac. obs." denote the expenditure weighted mean fraction of price changes that are due to sales and fraction of observations that are sales. The sector weights add up to 97.4% because used cars are not included in any sector.

FIVE FACTS ABOUT PRICES 1.

Five facts about price stickiness: Frequency over time

Years with higher inflation see more frequent price increases (but no change in frequency of price decreases).

- Variation in inflation is both due to size of price increases and due to their frequency.

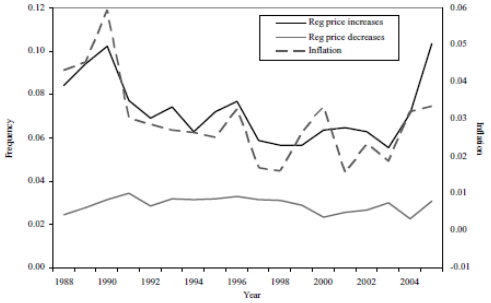


FIGURE II
Inflation and the Frequency of Regular Price Change for Consumer Prices
Note. The figure plots the annual evolution of the weighted median frequency of regular price increases and decreases along with the CPI inflation rate.

Five facts about price stickiness: Seasonality

Largest share of price changes occurs in January, the first quarter in general, and first month of each quarter.

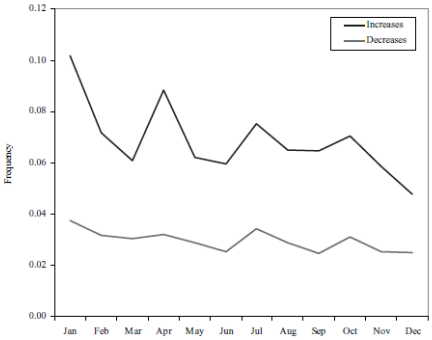


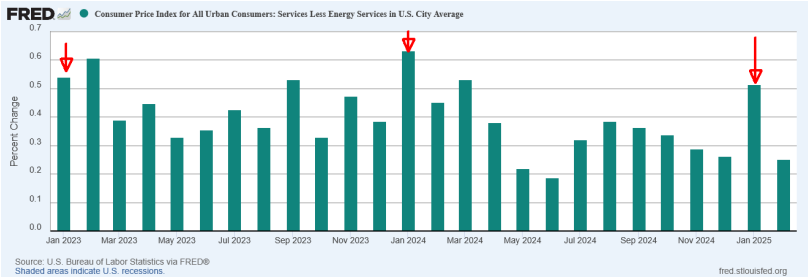
FIGURE V
Frequency of Regular Price Increases and Decreases by Month for Consumer Prices

Note. The figure plots the weighted median frequency of regular price increase and decrease by month.

Five facts about price stickiness: Seasonality II

During the recent inflationary surge January saw larger jumps in inflation (even after seasonal adjustment).

- Many firms do update their prices in January (called January re-pricing).



Five facts about price stickiness: Annual updates

The likelihood of price being updated (i.e. the hazard function) spikes at 12 moths.

- Many firms do update their prices in regularly once a year (e.g. school fees, football ticket prices, entrance fees).

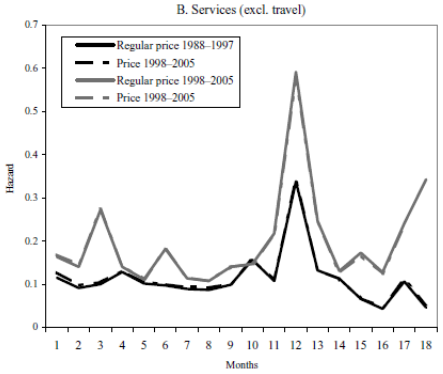


FIGURE VIII
Hazard Function for Consumer Prices

Sticky wages

Sticky wages

A closely related to sticky prices are sticky wages.

Why are wages sticky?

- Long-term labor contracts
- Efficiency wages (productivity concerns)
- Implicit contracts and morale concerns
- Social norms and fairness considerations

Sticky wages: Empirical evidence

Wages are typically adjusted once a year.

Table 4: **Quarterly Frequency of Wage Adjustment, Hourly Workers**

Period	Reported	Adjusted	CEE 05	SW 07	HLM 08	Gottschalk 05
96-99	0.481	0.178				
65-95			0.36			
66-04				0.26		
98-05					0.35	
86-93						0.11

Sticky wages: Relationship to aggregate supply

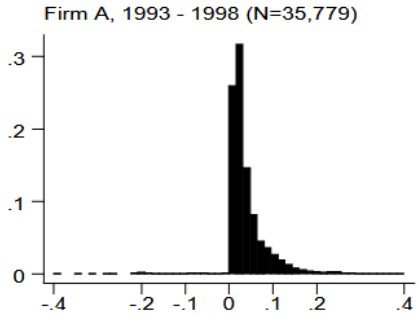
If nominal wages adjust slowly to economic changes, then

- when price level rises but nominal wages remain fixed
- Real wages fall (W/P decreases)
- Labor becomes cheaper for firms
- Firms hire more workers and increase output

If prices are higher firms are willing to produce more $\Leftrightarrow$ higher price level leads to higher output.

Downward nominal rigidity in wages

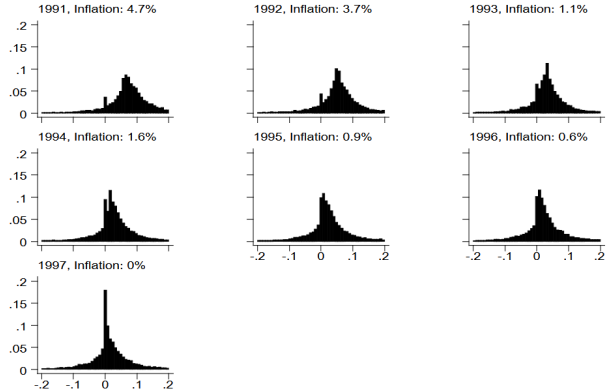
One aspect of sticky wages is downward nominal rigidity: firms avoid lowering nominal wages for morale reasons.



Downward nominal rigidity in wages: Role of inflation

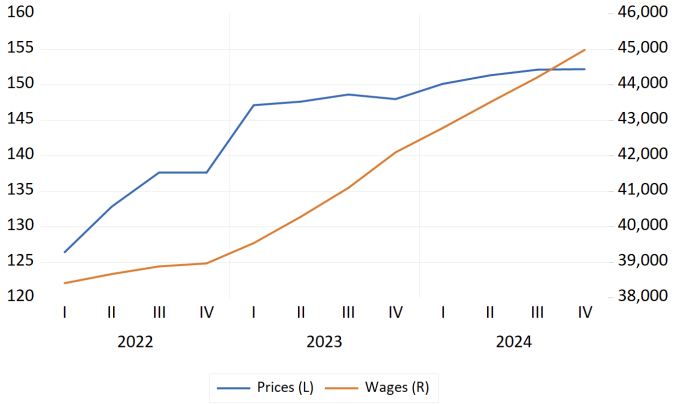
Downward nominal rigidity can become problematic in environment of low inflation.

- Main argument for positive inflation target.



Sticky prices or wages

Are prices or wages stickier? Recent experience would suggest that prices can become non-sticky much easier than wages, and wages catch up only slowly.



Sticky wages: Implications

Sticky wages has important implications.

- Prevents market clearing in labor markets
- Firms seek to reduce costs through layoffs rather than wage cuts
- Creates involuntary unemployment

Imperfect information models

Basic Idea

Alternative to sticky price/wage models.

Key idea: Agents have imperfect knowledge of broad economic developments.

Example: Distinguishing between increase in price level and increase in prices for firm's products.

Individual supply curve

Imagine deciding on your quantity of production. This depends on *real* prices for your product.

- You know price for your product.
- You know only imperfectly the prices for other products (aka the price level).
- Hence you have only imperfect information about *real* price of your product.

Overall, you may confuse a rise in the overall price level with a rise in the real price of your product.

Consequence: if they see an *unexpected* rise in price level, you will partly assign it to increase in real price of your product and will increase your supply.

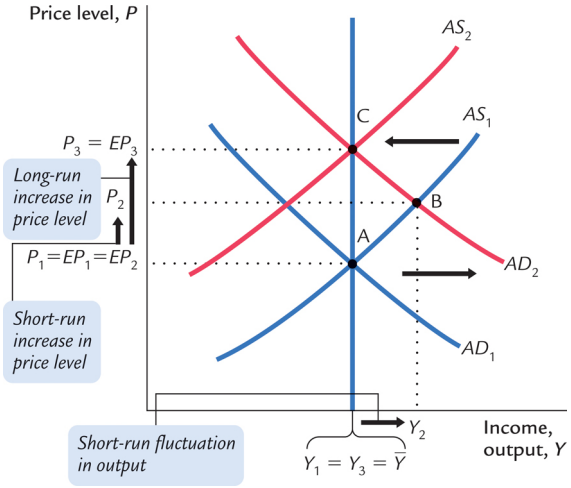
- This yield following production function:

$$y_t = \overline{y}_t + \alpha \left(p_t - p_t^e \right)$$

AS and responses to shocks

Outline

Positive shock to AD



Positive shock to AD: Short-run and long-run effects

Short-run effect: Higher output and higher prices.

- Higher prices are not expected and allow for higher output (and/or higher output causes higher prices).
- Increase in AD increases output, but less than the increase in AD due to increase in interest rate.

The economy is in short-run equilibrium but this equilibrium is not stable $\Leftrightarrow$ inflationary positive output gap.

- Reset of prices: At given level of output firms will increase prices when they can.
- Catch-up of wages: Workers will demand increase in wages to compensate for increase in prices.
- Update of information: Firms update their information about the relative prices.
  $\Rightarrow$ Short-run AS shifts left because firm prices are now higher for any given output.

Long-run effect: Same output, higher prices.

Positive shock to AD: Dynamics

How do we get from short-run equilibrium to long-run equilibrium?

- Price reset/wage catch-up/information update all lead to decline in AS: for given price level lower quantity produced.
- Decline in AS leads to lower output and higher prices.

Overall dynamics:

- Output initially increases and then declines back to initial level.
- Prices increase initially and again later on, before stabilizing.

  $\Rightarrow$ Inflationary boom.

[S] Negative shock to AD

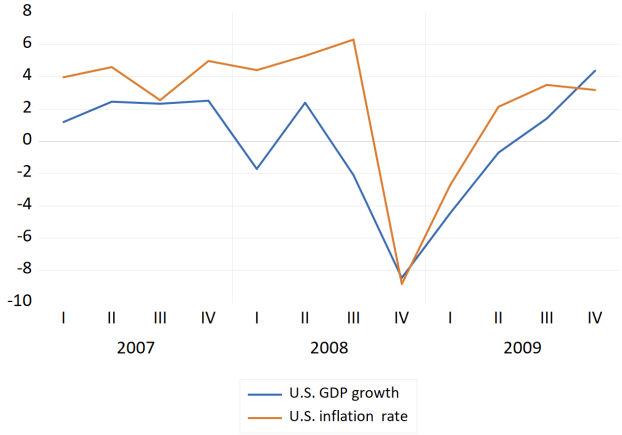
Negative AD shock has the reverse effects from positive AD shock.

- Prices decrease.
- Output decreases.

  $\Rightarrow$ Deflationary recession.

Negative shock to AD: Empirical illustration

Following the financial crisis the output and inflation dropped.



Shocks to AD and slope of AS

How are things different with vertical AS?

- Positive/negative AD leads to higher/lower prices but the level of output is unchanged.

How are things different with horizontal AS?

- Positive/negative AD leads to higher/lower output but the level of prices is unchanged.

Conclusion: Steepness of AS determines whether AD shocks have bigger impact on prices of output.

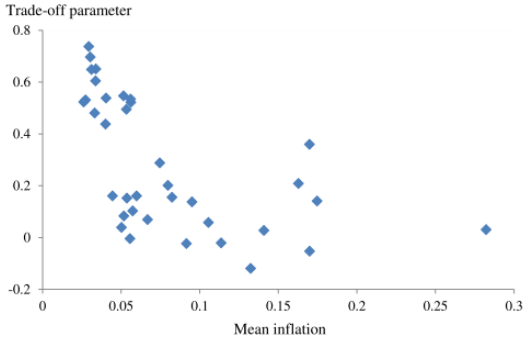
Determinants of slope of AS

What determines slope of the AS curve?

- More sticky prices/wages means price/wages react less or slower to demand shocks $\Rightarrow$ smaller reaction of prices and larger reaction of output.
- Generally more stable prices means that firms interpret higher nominal prices for their goods are higher real prices $\Rightarrow$ larger reaction of output for same increase in prices.
- Trivial determinant: Time horizon - longer horizon means longer for price/wage/information adjustment and hence more reaction of prices to output.

Determinants of slope of AS: Empirics I

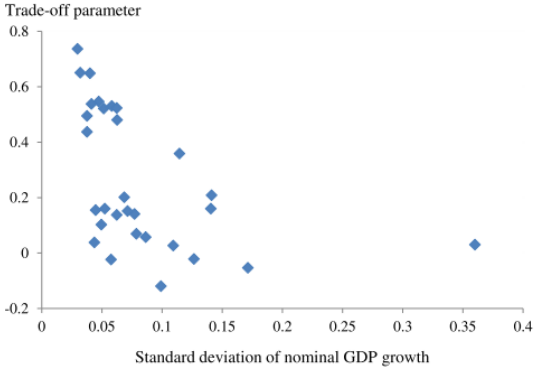
In countries with long-term high average inflation it is more costly for firms to not change prices, so AS is steeper $\Leftrightarrow$ shocks lead to less output response than inflation response (output/inflation trade off is higher) .



Source: Rongrong. 2014. "Nominal Rigidity and Some New Evidence on the New Keynesian Theory of the Output-Inflation Tradeoff."

Determinants of slope of AS: Empirics II

In countries with more variation in prices firms increase output less to in response to increase in prices, so AS is steeper.



Source: Rongrong. 2014. "Nominal Rigidity and Some New Evidence on the New Keynesian Theory of the Output-Inflation Tradeoff."

Aggregate supply curve: Sources of shifts

What causes AS curve to change?

AS curve relates prices and output, so shifts in AS curve have to be caused by other factors.

- There are three possible factors in our AS equation: P^e, $\bar{y}_t$ and the unexplained residual, call it v_t.

Examples:

- Expectations about future prices, e.g. future monetary or fiscal shocks.
- Natural output $\bar{y}$ changes, e.g. productivity shocks (broadly defined).
- Input costs changes, e.g. oil price shocks or labour cost shocks.
- Firm mark-up shocks ("greedflation").

Positive shock to AS: Short-run effect

Consider permanent improvement in productivity.

- For any given price level firms are willing to produce more $\Rightarrow$ AS shifts to right.

Short-run effect: Higher output and lower prices.

- Lower prices are not expected and lead to lower output - but still higher than previous period.

Positive shock to AS: Long run

The economy is in short-run equilibrium but this equilibrium is not stable $\Leftrightarrow$ deflationary negative output gap.

- Reset of prices: At given level of output firms will decrease prices when they can.
- Catch-up of wages: Workers will be ok with lower *nominal* wages, as real wages have increased.
- Update of information: Firms update their information about the real price for their product.

  $\Rightarrow$ There is further "increase" in short-run AS.

Long-run effect: Higher output, lower prices.

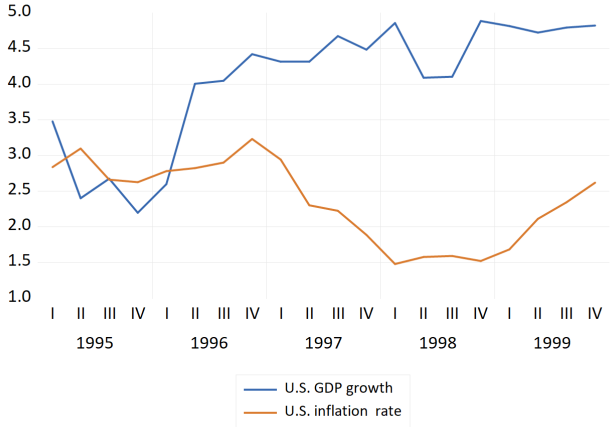
Dynamics:

- Output initially increases and then increases further.
- Prices decrease initially and again later on, before stabilizing.

  $\Rightarrow$ Deflationary boom.

Positive shock to AS: 1990s IT boom

In 1990s U.S. economy experienced rapid growth and stable inflation.



Negative shock to AS: Short-run effect

Consider commodity price shock (oil in 1973 and 1979, gas in 2022), that leads to *temporary* decrease in AS.

Short-run effect: Lower output and higher prices.

- Output decreases less than size of shock.

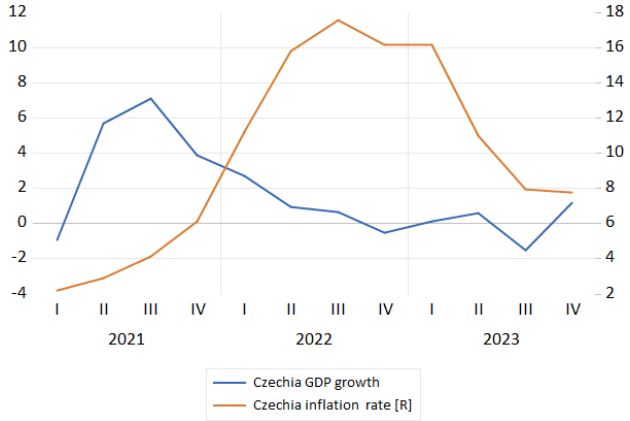
The economy is in short-run equilibrium but this equilibrium is not stable.

- Prices will decline and we return to original equilibrium.

  $\Rightarrow$ Inflationary recession

Negative shock to AS: 2022 gas price shock

The price of gas (and electricity) has skyrocketed in Europe after invasion, causing high inflation and low growth.



Phillips curve

Outline

Introduction

Aggregate supply curve is relationship between output and prices.

We can change this into relationship between unemployment rate and inflation.

This highlights an inflation-unemployment rate trade-off, called the Phillips curve.

- Key aspect of many policy discussions.

Basic idea

Aggregate supply is relationship between output and prices.

$$y_t = \overline{y}_t + \alpha \left(p_t - p_t^e \right)$$

Modern macro has been build around Phillips curve, that is relationship between unemployment rate and inflation.

We can move from AS to Phillips curve: relationship between *level* of unemployment rate and *change* in prices gives inflation.

- Its modern form is:

$$\pi_t = \pi_t^e - \beta \left(u_t - u^n \right) + \nu_t$$

- It's linked to aggregate supply equation

[S] From AS to PC I

Start with the aggregate supply equation:

$$P_t = P_t^e + \frac{1}{\alpha}(Y_t - \bar{Y}) + \nu_t$$

Subtract last year's price level P_{t-1}:

$$P_t - P_{t-1} = P_t^e - P_{t-1}) + \frac{1}{\alpha}(Y_t - \bar{Y}) + \nu_t$$

Define:

- $\pi_t = P_t - P_{t-1}$: actual inflation
- $\pi_t^e = P_t^e - P_{t-1}$: expected inflation

Then:

$$\pi_t = \pi_t^e + \frac{1}{\alpha}(Y_t - \bar{Y}) + \nu_t$$

[S] From AS to PC II

Okun's Law relates output and unemployment:

$$\frac{1}{\alpha}(Y_t - \bar{Y}) = -\beta(u_t - u^n)$$

Substitute into the inflation equation:

$$\pi_t = \pi_t^e - \beta(u_t - u^n) + \nu_t$$

This is the expectations-augmented Phillips Curve.

History excursion

Phillips curve went through few changes over the history of macroeconomics.

- Started as relationship between wage growth and unemployment rate:

$$wage_t^{\pi} = -\beta(u_t)$$

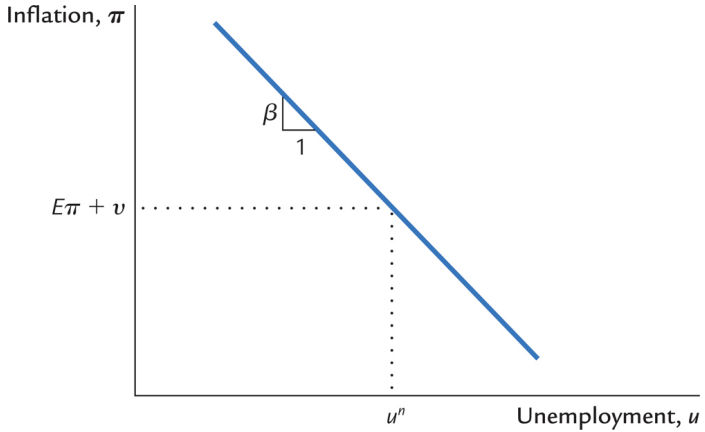
  No a fundamental difference (but probably for the change for worse).
- It did not include expected inflation - crucial improvement, lesson of 1970s.
- It did not include cost-push shock - important improvement.
- It used unemployment rate rather than unemployment rate gap - moderate improvement.

Inflation-unemployment trade-off

Phillips curve and short-run tradeoff

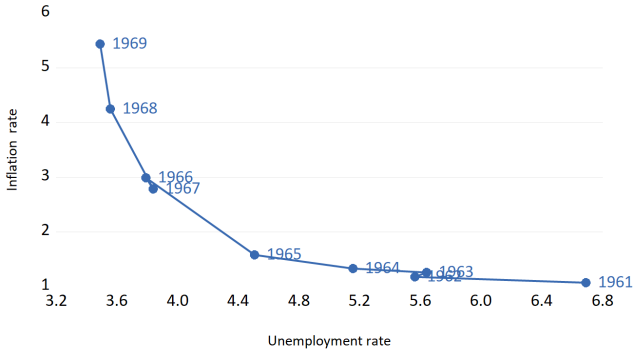
Philips curve is a negative relationship between inflation and output.

- There is a trade-off between inflation and unemployment rate, at least in the short-run.



Phillips curve and macro history I: Successful 1960s

The original Phillips curve was a huge success in 1960s, with inflation and unemployment rate drawing it out and demonstrating apparent inflation-unemployment rate trade-off.



Sources of inflation

Sources of inflation

Phillips curve is relationship that aims to explain inflation.

There are three factors that can explain inflation:

- Expectations of inflation π_t^e.
- Unemployment rate: $-\beta\left(u_t - u^n\right)$.
  - Low unemployment pulls inflation up, high unemployment down - **demand-pull inflation**.
- Other unexplained factors ν.
  - Residual category: everything that is not expectations or demand.
  - Supply (cost) shocks that push inflation up/down.

Phillips curve and inflation expectations I

To make Phillips curve practical we need to know how people form inflation expectations.

Option 1: **Adaptive expectations** $\Leftrightarrow$ people think that inflation will be the same as in past: $\pi_t^e = \pi_{t-1}$

$$\pi_t = \pi_{t-1} - \beta\left(u_t - u^n\right) + \nu_t$$

- This would imply that there is *inflation inertia*: Jump in inflation will sustain itself and only demand or supply shocks would pull it down.

$$\pi_t - \pi_{t-1} = -\beta\left(u_t - u^n\right) + \nu_t$$

Phillips curve and macro history II: Expectations strike back

By 1970s the relationship started breaking down, as inflation expectations started to increase.

- Main lesson: Inflation-unemployment trade-off is not stable, it is a short/medium run phenomenon.

Phillips curve and macro history III: Oil price shocks add to the fire

Two oil shocks during 1970s acted as large cost push shocks and shifted Phillips curve further out.

- Main lesson: Cost-push shocks can interact with anchored inflation expectations and make *everything* worse.

Costs of disinflation

Costs of disinflation

The existence trade-off between inflation and unemployment rate raises the question of how costly are disinflations.

Does disinflation have to be costly?

- The argument of costly disinflation relies on the demand-pull part of Phillips curve.
- Another channel for disinflation is the expectations term π_t^e.
- If a change in policy is credible, it can change people's predictions of inflation.
- Crucial question: How much inertia is there in inflation expectations?

Big discussion in early 1980s whether disinflation will be very costly or just costly.

Phillips curve and inflation expectations II

Option 2: Forward looking expectations $\Leftrightarrow$ People form expectations based on some model of economy.

- Typically the same model $\Rightarrow$ model-consistent expectations.
- Also called rational expectations: expectations are formed optimally based on all available information.

Inflation does not have inertia.

- Inflation can drop because expectations change: e.g. expected inflation 'might be equal to central banks target $\pi_t^e = \pi^*$
- Costless disinflation: inflation can drop *immediately* without increase in unemployment rate if central banks *credibly* changes inflation target.

Phillips curve and macro history IV: Volcker disinflation

Following monetary restriction inflation drops first along the steep Phillips curve, but then along flat Phillips curve.

- Main lesson: Disinflation can be (and was) less costly if expectations can be shifted by credible policy.

Phillips curve and inflation expectations III

Adaptive and rational expectations are two extreme assumptions ⇒ Option 3: Anchored inflation expectations.

- Central banks have inflation target ⇒ people should naturally expect inflation to be equal to target.
- It is natural that inflation shocks are not eliminated right away ⇒ inflation should reflect recent inflation.

Phillips curve with anchored expectations:

$$\pi_t - \pi^* = \psi(\pi_{t-1} - \pi^*) - \beta\left(u_t - u^n\right) + \nu_t$$

Inflation has some inertia, but not much.

- $\pi_t - \pi^*$ is deviation of inflation from target.
- ψ measures how persistent do people expect inflation deviations to be.

Phillips curve and inflation expectations III: Implications

Anchored inflation expectations have important implications for costs of disinflations.

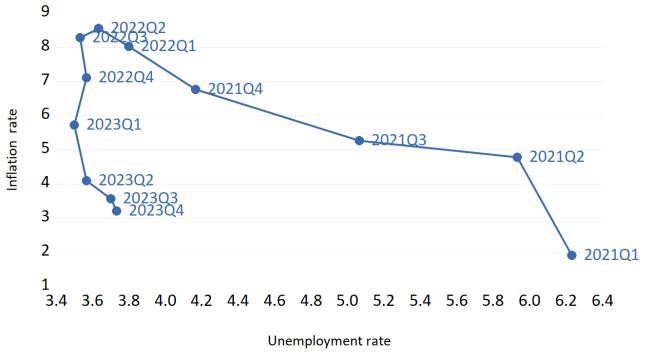
- In absence of shocks inflation will tend back towards target.
- If ρ is relatively small then disinflation can be relatively quick and costless.
- If ρ is large then disinflation will be long.

Big discussion in 2022 whether disinflation will require increase in unemployment rate or whether inflation will decline on its own.

Phillips curve and macro history V: Painless disinflation magic

After pandemic inflation has surged (while unemployment rate has dropped). However, afterwards inflation dropped without any increase in unemployment rate!

- Interpretation: Increase in inflation came when inflation expectations were **anchored** (and monetary policy kept them so, in contrast to 1970s).

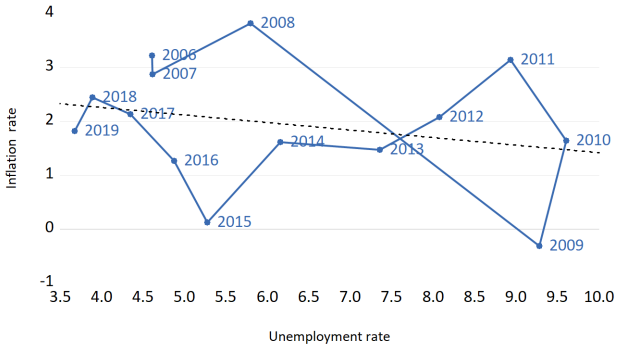


Shape of Phillips curve

Phillips curve and macro history VI: Missing disinflation in 2010s

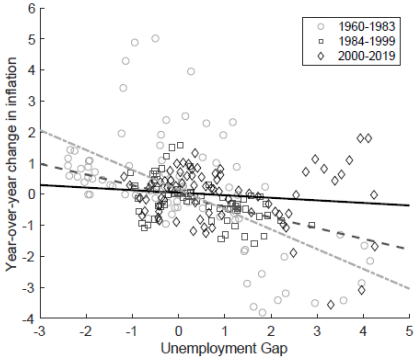
Following Great recession the inflation was barely changed when unemployment rate was high or when it was low.

- Interpretation: Is Phillips curve flat?



Slope of Phillips curve

It is possible that Phillips curve became flatter over time, and very flat by 2010s.



Shape of Phillips curve

Alternative explanation: Phillips curve is non-linear and we were on the flat part.

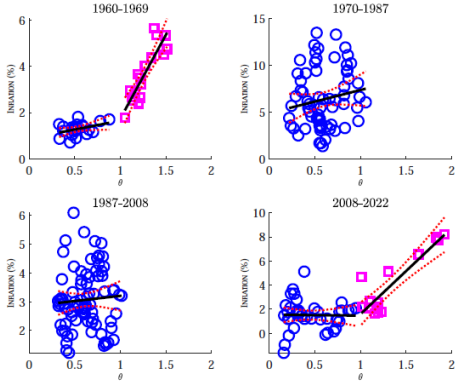


Figure 4: Inflation: CPI inflation rate at annual rates. θ: vacancy-to-unemployed ratio.

Long-Run Effects of AD on output

Outline

Long-run irrelevance of demand

Basic theory: Long-run aggregate supply is vertical $\Rightarrow$ AD shocks do not affect output *in the long run.*

Long-run irrelevance of demand - only supply matters in the long run.

- Recessions are just temporary painful periods - and that's great news!

Is this true?

Hysteresis concept

Alternative view: Temporary shocks can have permanent effects on output and unemployment.

- Hysteresis: Economic downturns may permanently lower potential output.
- The economy may not fully recover to its pre-recession trend.

  $\Rightarrow$ Recessions leave a permanent scar on the economy.

AD shock with conventional vs. hysteresis view

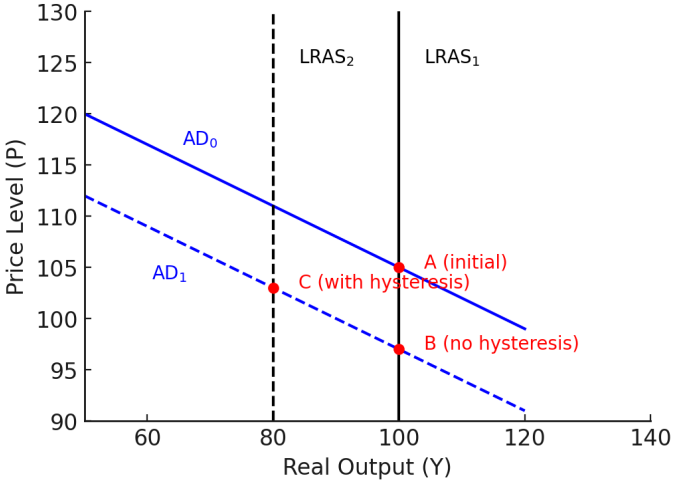
Standard AS: Negative AD shocks reduce output in short run, but output returns to Y^* in the long run.

- SRAS shifts over time as wages and prices adjust.
- LRAS remains fixed at full-employment output.
- Prices adjust to reach new long-run equilibrium.

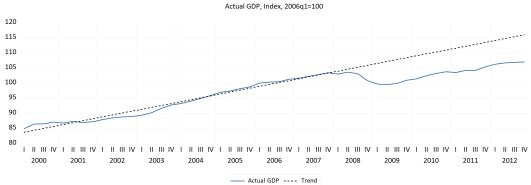
Hysteresis view: Negative AD shocks reduces output now, but also in the long-run.

- Shift in SRAS *and* LRAS.

Theoretical illustration



Empirical illustration



Mechanisms of Hysteresis and Graphical Illustration

Why might recessions have permanent effects?

Labour market: Structural unemployment/under-employment/non-participation.

- Discouraged workers exit labor force, people end up in jobs below their skills.

Productivity: Loss of "technology".

- Firms go bankrupt, new technology is developed with delay, skills are lost.

Middle ground: AD shocks take *years* to fade away, but eventually do.

- For example structural unemployment that does not get cleared away in span of few years.

Policy implications

If AD shocks have permanent effects then there is a stronger case for stabilization policy.

- Timely fiscal and monetary stimulus can prevent permanent output loss.

  $\Rightarrow$ Avoid deep or prolonged recessions to prevent scarring.

There is also argument for labor market policies: training, reemployment incentives, attachment programs to avoid people dropping out of workforce.

Conclusion

Outline

Short-run AS

Aggregate supply curve is vertical in long-run but only upward-sloping in the short-run.

- Sticky prices/sticky wages/misperceptions lead to higher prices when output is higher and/or higher output when prices are higher.

Non-vertical SRAS allows aggregate demand shocks to affect output (and not just prices).

- Slope of SRAS determined whether AD shocks affect more prices of output.

Phillips curve

SRAS is typically expressed as Phillips-curve: negative relationship between inflation and unemployment rate (trade-off).

- Prices are change in inflation, and output and unemployment rate are two sides of the same coin.
- SRAS and PC are the same thing.

Phillips curve says that inflation can shift for demand or supply reasons, but also expectations.

- Demand pull inflation in 1960s, demand pull disinflation in 1980s.
- Supply shock in 1970s (and 2020s?).
- Expectations shift in early 1970s and during Volcker disinflation, but not in 2020s.

Open questions

Is Phillips-curve real? Is it flat, vertical or both?

What matters in Phillips curve, unemployment rate or something else?

How are inflation expectations formed? What determines when they become un-anchored?

Is there a natural rate of unemployment, and how stable is it over time?

Do demand shocks lead to permanent scarring of the economy?