Lecture 2: A primer in open economy macro and policy

Rhys Bidder

University of Oxford - MFE - International Finance

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Disclaimer

The views expressed in this presentation, and all errors and omissions, should be regarded as those solely of the authors, and are not necessarily those of the Federal Reserve Bank of San Francisco, the Federal Reserve Board of Governors or the Federal Reserve System.

From last week. . .

Course Admin

- Practical group assignment (25% of overall grade)
  - $\approx$ 5 groups of 3
  - Choose a country (not G7 or China)
  - Inform me of groups and countries this week
  - Submit slides by noon, Monday 17^{th} June
  - Present during usual class time, Wednesday 19^{th} June
  - Each group presents only to me - will be recorded

Course Admin

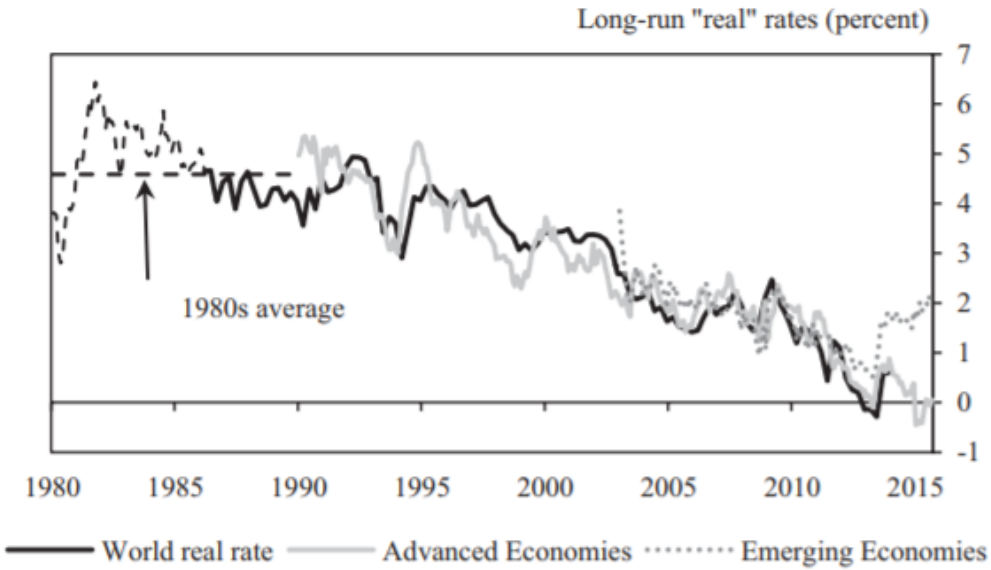
- Group presentation should focus on...
  - Current macro/financial outlook
  - Evolution over coming 1-3 years
- Use analytical/policy models developed in class
  - Avoid journalistic chatter (or marketing!)
  - If tools from core courses are useful - feel free...
- Choose your favored slides software
  - I recommend Powerpoint or Beamer (LaTex)

Cross country ZLB

- I was asked about movements in r^* across countries
- Some good references for this are
  - Rachel and Smith 2015
  - Del Negro *et al* 2018
  - Rachel and Summers 2019

Cross country ZLB

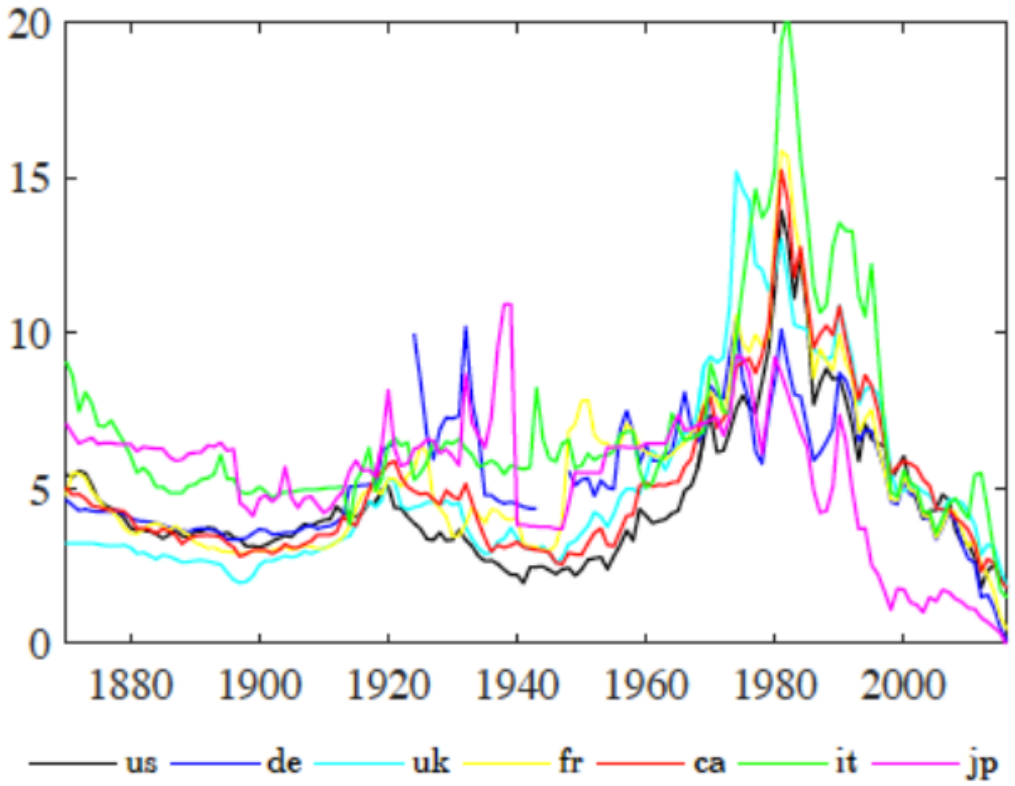
Figure 1. Comparison of Real Interest Rates



Notes: The "world" real rate (solid black line) is taken from King and Low (2014) and shows the average ten-year yield of inflation-linked bonds in the G7 countries (excluding Italy) over the period 1985 2013. This line has been extended back to the start of the 1980s (dashed black line) using a simple regression linking it to movements in UK ten-year nominal yields and RPI inflation. The solid and dotted grey lines show simpler measures of real rates for different country groups, calculated as the nominal yield on ten-year sovereign bonds minus one-year-ahead inflation expectations from Consensus Economics. Figures have been GDP-weighted together for twenty advanced economies (solid grey) and seventeen emerging markets (dotted grey).

Cross country ZLB

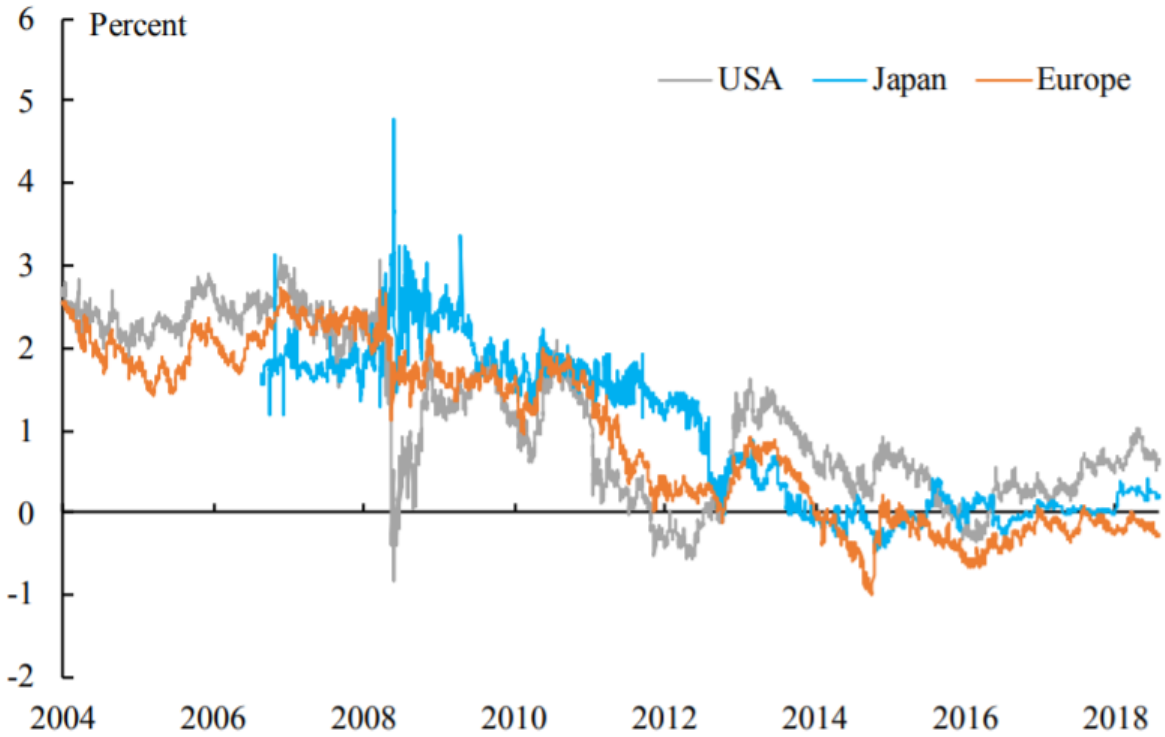
Figure 1 Nominal yields on long term government bonds over the past 150 years



Source: Jorda, Schularick, and Taylor, Macrohistory Database (www.macrohistory.net/data)

Cross country ZLB

Figure 2: Real 5-year/5-year swap rates



Note: Five- and ten-year nominal and inflation swap rates data are from Bloomberg. Real swap rates are nominal minus inflation.

Introduction

Roadmap

- Short-run and medium-run dynamics of a small open economy
  - Labor market equilibrium (Phillips curve)
  - Goods market equilibrium (IS curve)
  - Forex market equilibrium (UIP condition)
- Policy responses to shocks
  - Monetary - standard case and in ZLB
  - Fiscal
- Unconventional tools

Roadmap

- Benchmark model will follow Carlin and Soskice (Ch. 1, 2 and 9)
- Very simplified model but more useful than IS-LM and Mundell-Fleming models for our purposes
  - IS-LM: money supply as policy tool - interest rates now favored
  - Mundell-Fleming: constant price assumption
- Related to New Keynesian model (see Gali textbook) but without explicit microfoundations
  - Monopolistic competition in labor and goods markets
  - Nominal price and wage rigidity
  - Adaptive expectations of inflation rate by some participants
  - Deviations from 'full' employment feed into inflation (accelerationist Phillips curve)
  - Inflation targeting central bank trades off output and inflation
  - Integrated world markets implies PPP and UIP hold

Roadmap

- Unconventional policy
  - Discussion of concepts
  - Channels through which policy may act

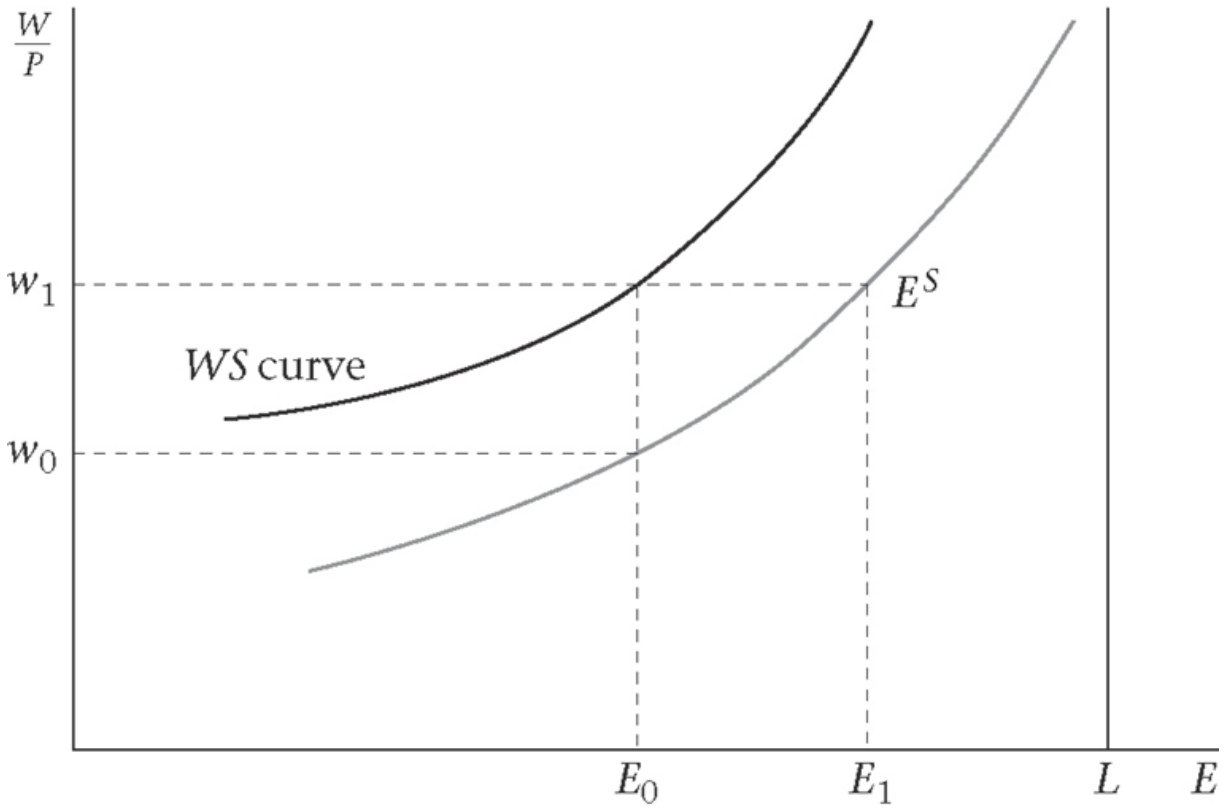
Benchmark open economy model

Labor market - wage/price setting

- Labor supply schedule (ES) in a competitive (price taking) market increases in the real wage
  - Implied by FOC for optimal labor supply
  - Trade-off: disutility of labor vs. utility from consumption
- But we assume that labor is supplied in a non-competitive market...
  - Wages are set by 'unions' with pricing power - perhaps through bargaining with employers
  - Unions set a wage function (WS) that increases in the employment level E, but which are a 'markup' over ES
- Alternative theories might also justify markups
  - Efficiency wages
  - Search frictions

Labor market - wage/price setting

$$w^{WS} \equiv \frac{W}{P} = b(E)$$



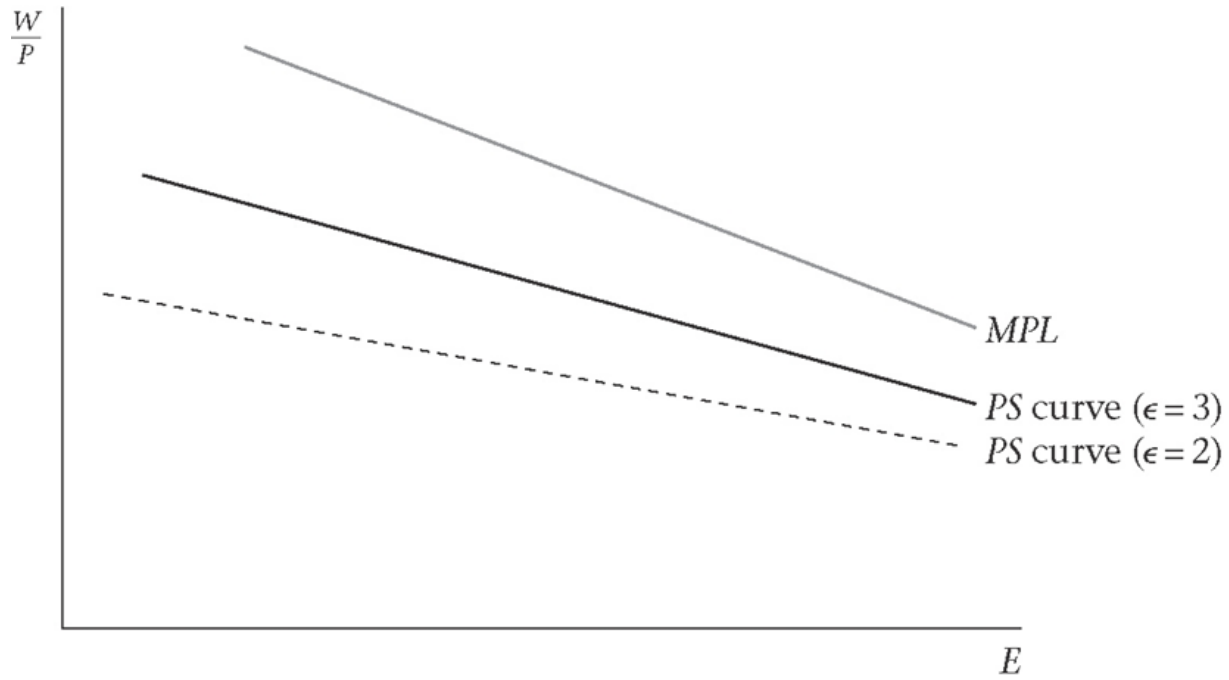
Labor market - wage/price setting

- Firms assumed to set prices *after* wages are set
- Under perfect competition (price taking)
  - Profit maximization implies $P = MC = \frac{W}{MPL}$
  - Alternatively the real wage is equal to marginal product
- Under imperfect (monopolistic) competition price is a markup over marginal cost
  - $P = (1 + \mu)\frac{W}{MPL}$
  - $\mu \geq 0$, is decreasing in the price elasticity of demand, ε

Labor market - wage/price setting

$$w^{PS} = \frac{1}{1+\mu} MPL < MPL$$

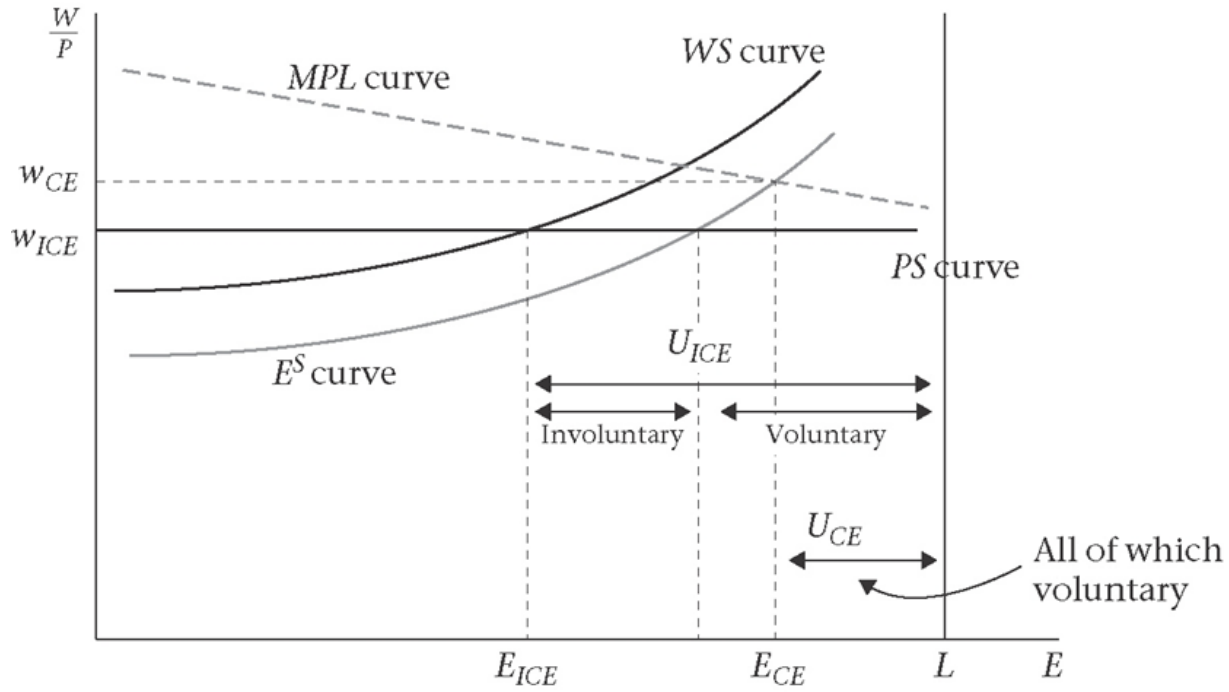
$$\mu = \frac{1}{\varepsilon - 1}$$



Labor market - medium run equilibrium

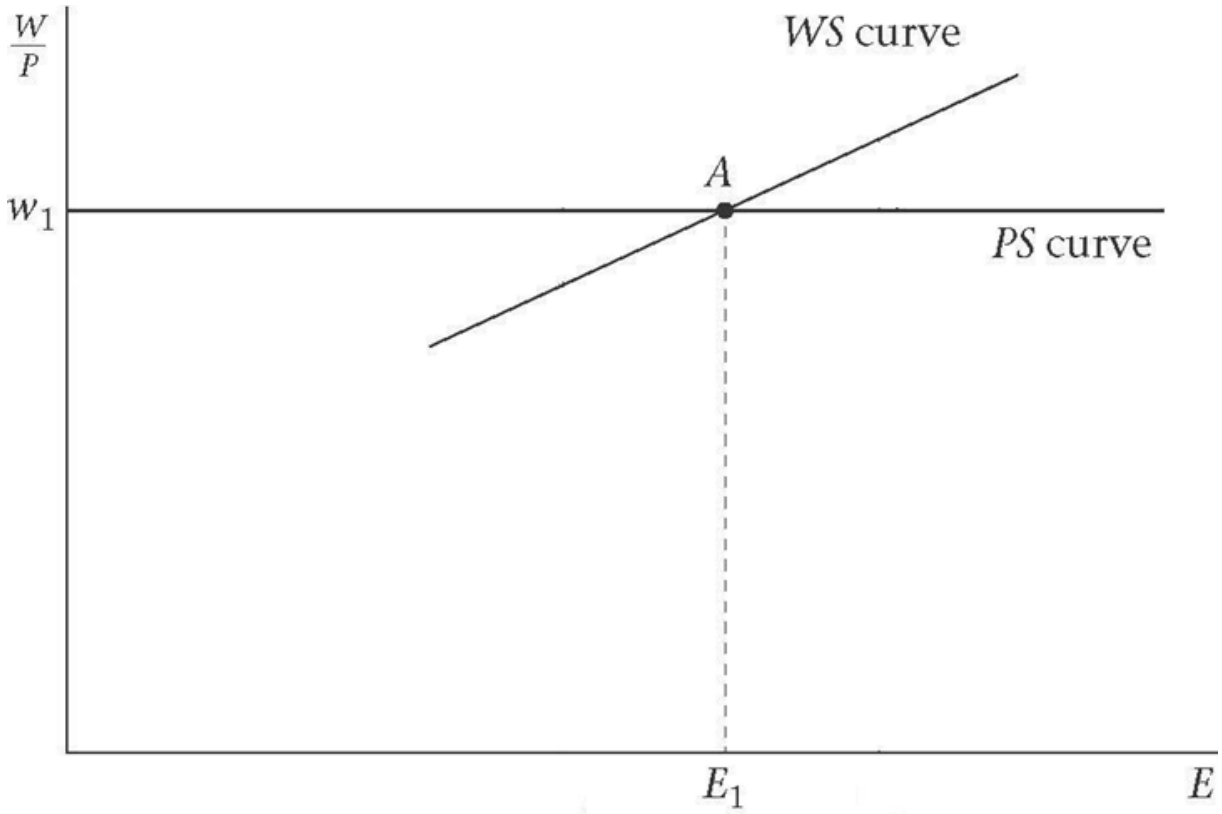
- Competitive labor market $\Rightarrow$ not everyone employed, but all unemployment is voluntary
- Imperfect competition $\Rightarrow$ involuntary unemployment
- Unemployment is inefficiently high due to wage and price mark-ups
- Factors that push up the WS schedule:
  - More activist trade unions, a higher wedge of consumer, income and employers' taxes,...
- Implies reductions in equilibrium levels of employment and output and boosts involuntary unemployment

Labor market - medium run equilibrium



- Voluntary: Not willing to supply at prevailing wage
- Involuntary: Willing to supply at prevailing wage but not employed (inefficiency - why?)
- Note: PS curve assumed horizontal for simplicity (CRS and price mark-ups independent of economic activity)

Labor market - medium run equilibrium



- Intersection of WS and PS curves yield the medium-run equilibrium
- Pins down employment (thus output) and real wage rate

Inflation, employment and real wages

- When bargaining over wages, the 'union' has an inflation rate in mind
- Suppose, initially, we are in equilibrium, the inflation rate is 4% and that is expected to continue
- To maintain their purchasing power (real wage), unions bargain for, and achieve, a 4% increase in *nominal* wage
- Given the increase in their marginal costs and our assumption of constant markup, this is passed through to prices by firms
- Ultimately the real wage and inflation are unchanged and the economy remains in equilibrium (point A)

Accelerationist Phillips curve(s)

- 'Accelerationist' means that if employment is above (below) M-R equilibrium value, inflation will increase (decrease)
- Employment above (below) equilib. $\Leftrightarrow$ output above (below) equilib.
- Expectations feature in relationship between inflation and output:
  - Workers are forward looking when demanding nominal wage increases
  - Concerned with real wage so must form expectations of inflation
  - Simplification: basic form of *adaptive* expectations
  - Assume expected inflation = previous period inflation

Accelerationist Phillips curve(s)

- Inflation = expectations $\Leftrightarrow$ output/employment at M-R equilibrium
  - No long run tradeoff between a (constant) rate of inflation and output
- Under our specification this implies constant inflation
  - $\pi_t = \pi_t^e = \pi_{t-1}$ so $\Delta\pi_t = 0$
- These insights are captured in the 'Phillips Curve' (PC)...

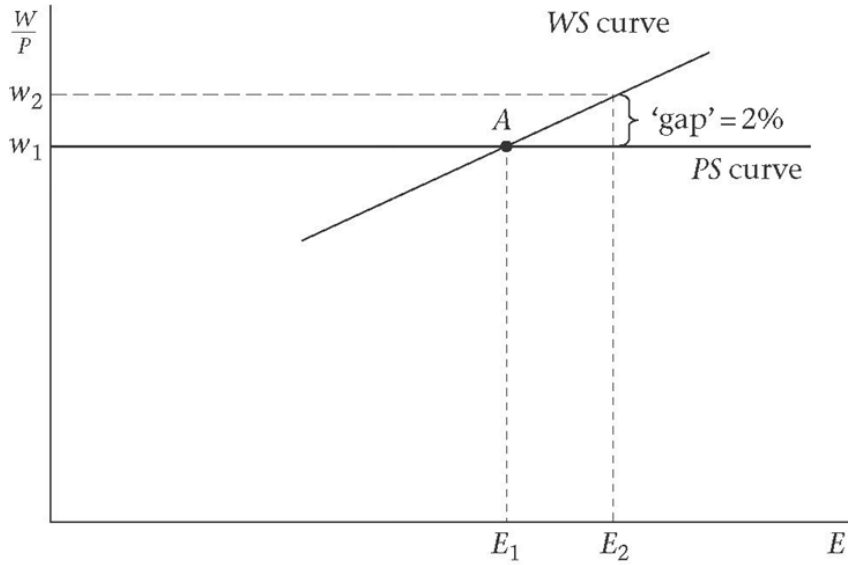
$$\pi_t = \pi_{t-1} + \alpha\left(y_t - y_e\right)$$

Accelerationist Phillips curve(s)

$$\pi_t = \pi_{t-1} + \alpha (y_t - y_e)$$

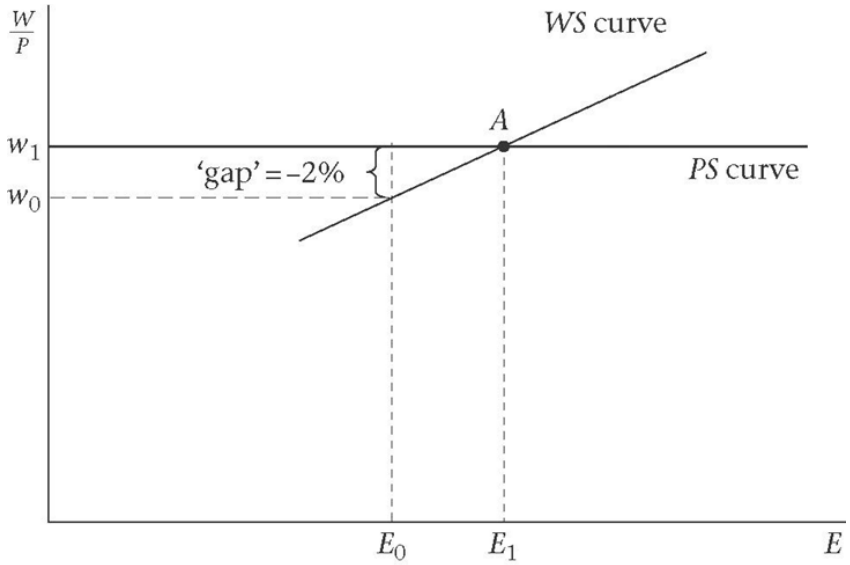
- $y_t = y_e$ iff $\pi_t = \pi_{t-1}$
  - Labor market in equilibrium: constant inflation and zero output gap
  - Sometimes referred to as 'vertical Phillips curve'
  - *Any* rate of inflation is consistent with equilibrium in the medium-long run
- Slope of PC (α) is positive and determined by slopes of WS and PS
- Richer models have a different specification of expectations
  - NK model features rational expectations $\pi_t^e = E_{t-1}[\pi_t]$
  - Presence of *some* 'backward looking' agents $\Rightarrow$ lagged inflation in the Phillips curve (Gali and Gertler 1999)
  - Sticky information models (e.g. Mankiw and Reiss 2002) are akin to our setup in some of their implications

Labor market - SR fluctuations



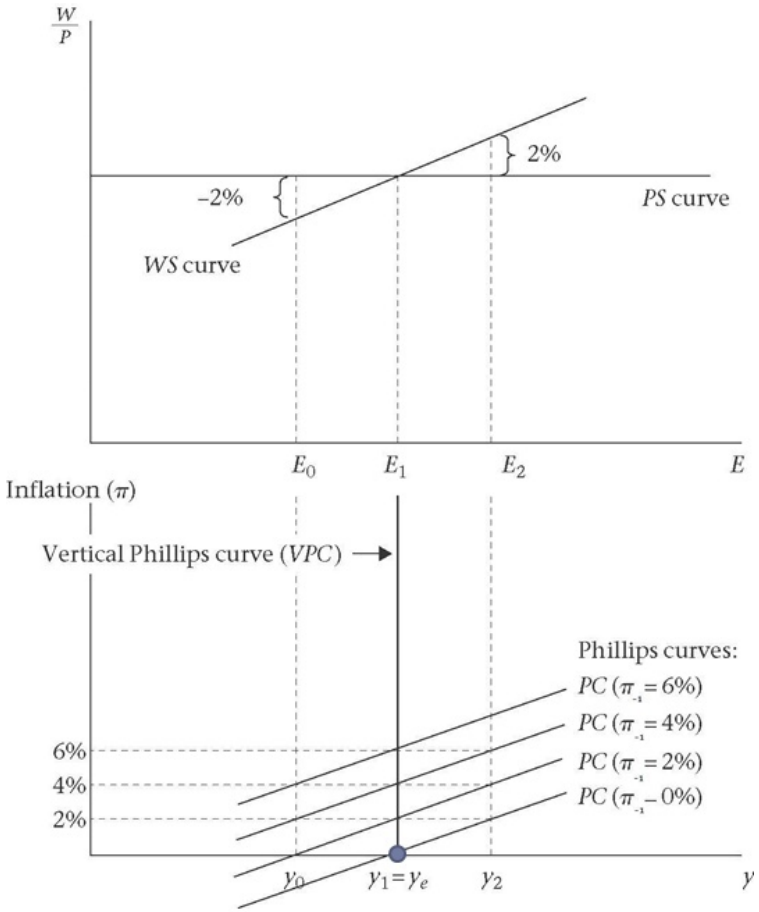
- E_1 is M-R equilibrium employment so $E_2 > E_1 \Rightarrow \pi \uparrow$
- Bargaining power of union is high - seeks to raise real wage
- Union demands higher nominal wage growth than π_{t-1} by, say, 2%
- Firms set prices higher by 2% than otherwise, to restore markup
- Real wage does not attain the desired level but inflation now higher
- Incorporated into inflation expectations next period

Labor market - SR fluctuations



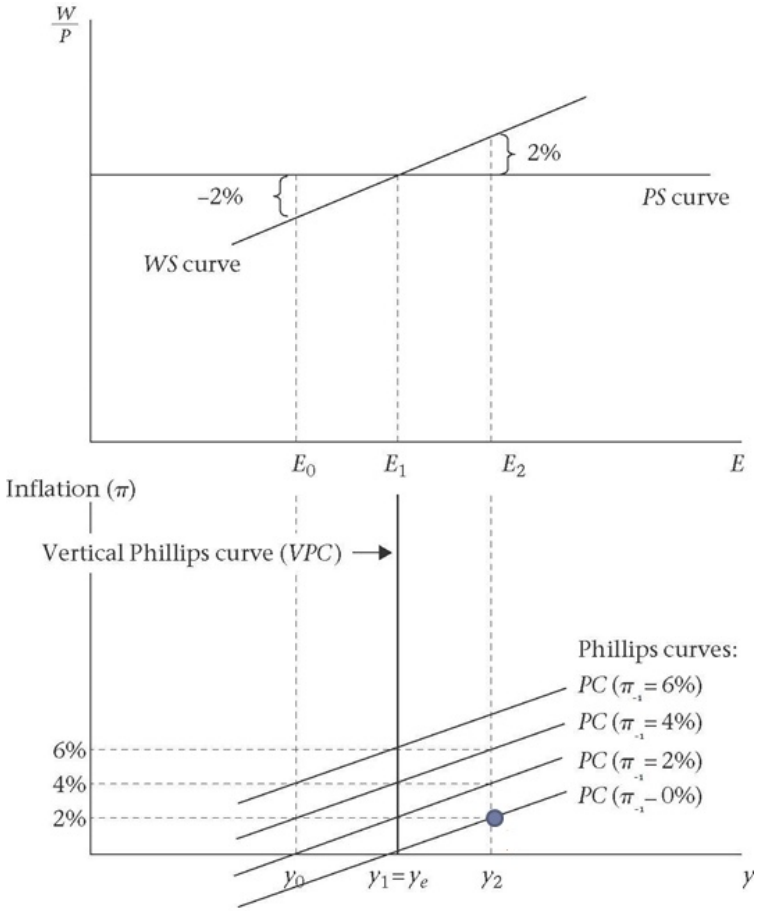
- E_1 is M-R equilibrium employment so $E_0 < E_1 \Rightarrow \pi \downarrow$
- Bargaining power of union is low - prepared to accept lower real wage
- Lower nominal wage growth than π_{t-1} by, say, 2%
- Firms set prices lower by 2% than otherwise, to restore markup
- Real wage does not attain the desired level but inflation now lower
- Incorporated into inflation expectations next period

Labor market - Inflation spiral



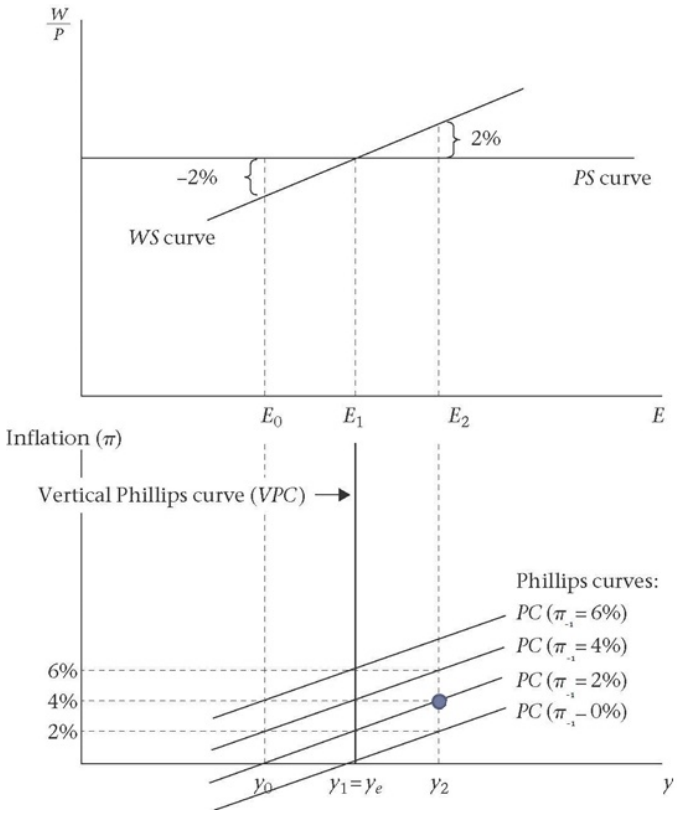
- Start at zero inflation medium-run equilibrium
- Output is at y_e and inflation is constant at zero, as expected

Labor market - Inflation spiral



- Imagine 'something' (policy error?) raises output to y_2
- As discussed, this raises inflation to 2%

Labor market - Inflation spiral



- Expectations of 2% inflation imply a different 'short run' Phillips curve
- Output still at $y_2 \Rightarrow$ inflationary wage demands and firm response raise inflation further, to 4% - and so on...

Introducing open economy elements

- We assume a 'small' (price taking) economy
- Medium-run
  - Equilibrium real interest rate is determined by global factors
  - Real exchange rate (RER) adjusts in response to permanent aggregate demand and supply shocks
  - Abstract from any impact on equilibrium output of change in RER
- Short run
  - Domestic central bank (CB) chooses a domestic real interest rate that deviates from the world rate

Goods market equilibrium

- Goods market (SR or LR) equilibrium $\Rightarrow AD = AS$
  - Firms supply what is demanded - technology pins down employment

$$Y^d = C + I + G + \underbrace{(X - M)}_{NX}$$

- Domestic components of aggregate demand (AD)
  - Consumption is forward looking and depends on current financial wealth and PV of future income
  - Investment depends on expected stream of payoffs from capital
  - Both are suppressed, all else equal, by higher interest rates
  - Government spending driven by policy (and maybe auto stabilizers)
- Net exports depend positively on real exchange rate, q ($q \uparrow$ is depreciation), and negatively on income, all else equal
  - Assume Marshall-Lerner condition holds
  - Quantity effect on exports and imports overwhelms price effect

Goods market equilibrium

- We can express the combinations of r, q and y that clear the goods market as follows

$$y_t = A - ar_{t-1} + bq_{t-1}$$

- a and b are > 0 (functions of deep parameters)
- A is related to wealth, confidence, expectations, govt. expenditure...
- In medium-run we obtain equilibrium RER

$$\bar{q} \equiv \frac{y_e - A + r^*}{b}$$

IS Curve

- Rearranging, we obtain the IS curve...

$$r_{t-1} = r^{IS}(y_t; q_{t-1})$$

- Represents, *in output and real interest rate space*, combinations of the two variables consistent with goods market clearing, *given* q
- The RER acts as a 'shifter' for the IS curve (along with the determinants of A)

Modeling the FX market

- Three parity conditions
  - Purchasing Power Parity (PPP)
  - Covered Interest Parity (CIP)
  - Uncovered Interest Parity (UIP)

- Recall: RER is price of foreign consumption in domestic currency
  - $q = p^* + e - p$
  - $e \uparrow$ represents a nominal depreciation of home currency
  - p and p^* are price indices for a basket of goods in both countries
  - Note: Lower case letters represent logs (e.g. $q \equiv \log Q$)

PPP

The general idea behind purchasing power parity is that a unit of currency should be able to buy the same basket of goods in one country as the equivalent amount of foreign currency, at the going exchange rate, can buy in a foreign country, so that there is parity in the purchasing power of the unit of currency across the two economies.

- A. Taylor and M. Taylor, *Journal of Economic Perspectives*, 2004

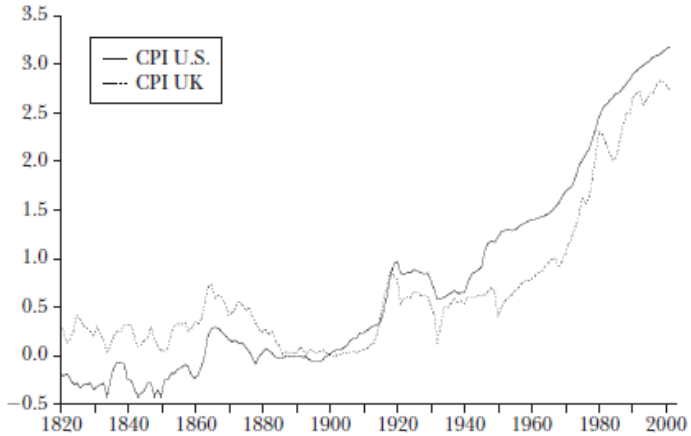
PPP

- Many reasons why 'absolute' PPP ($Q = 1$) may not hold
  - Trading costs, non-tradables, differing baskets of goods (or weights in basket), differing good definitions (quality), pricing to market...
- Even 'relative' PPP ($\Delta q = \pi - \pi^*$) is not strongly supported in the data (but more so at long horizons)
  - Sticky prices + monetary shocks $\Rightarrow$ substantial SR deviations
  - Changes over time in 'long run' equilibrium RER also at play

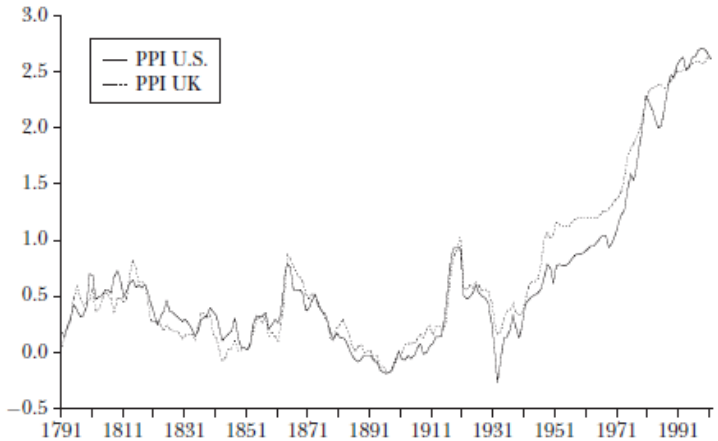
PPP

Figure 1
Dollar-Sterling PPP Over Two Centuries

(a) U.S. and UK CPIs in dollar terms



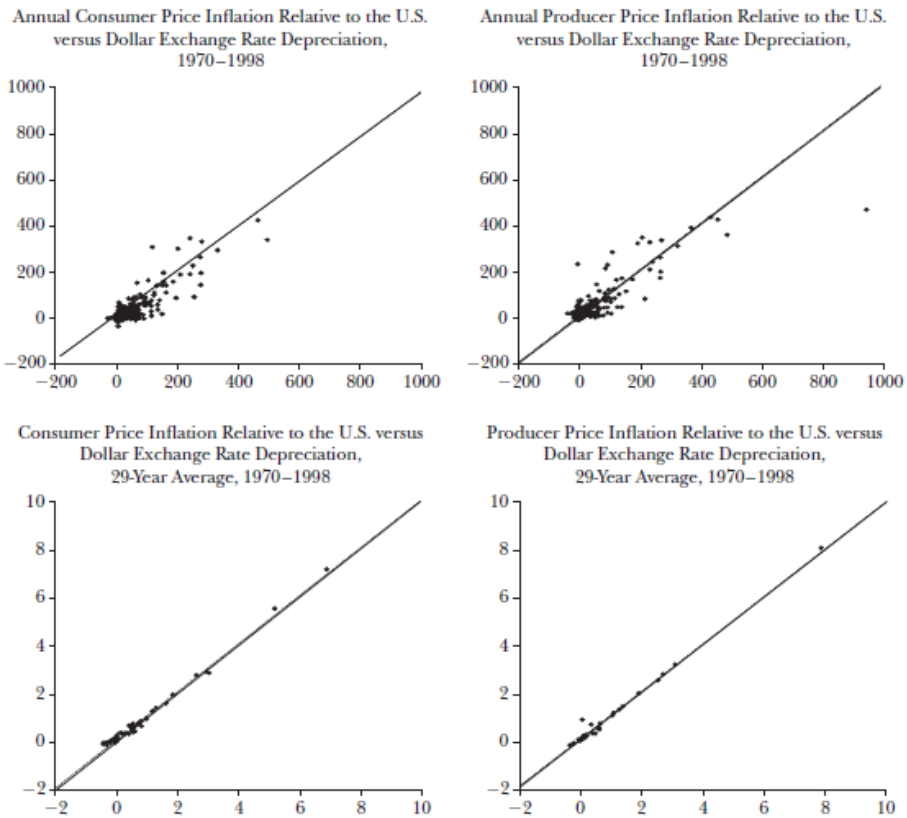
(b) U.S. and UK PPIs in dollar terms



Notes: This figure shows U.S. and UK consumer and producer price indices expressed in U.S. dollar terms over roughly the last two centuries using a log scale with a base of 1900 = 0.

PPP

Figure 2
PPP at Various Time Horizons



Notes: This figure shows countries' cumulative inflation rate differentials against the United States in percent (vertical axis) plotted against their cumulative depreciation rates against the U.S. dollar in percent (horizontal axis). The charts on the left show CPI inflation, those on the right PPI inflation. The charts in the top row show annual rates, those in the bottom row 29-year average rates from 1970 to 1998.

Parity Conditions - CIP

- Covered interest parity
  - Holds 'exactly' (almost - though less than it used to) due to elimination of arbitrage opportunity
  - Forward position eliminates currency risk in exploiting interest rate differences (adjusted for forward premium)
  - $i_t - i_t^* \approx f_{t+1} - e_t$

CIP deviations - post crisis

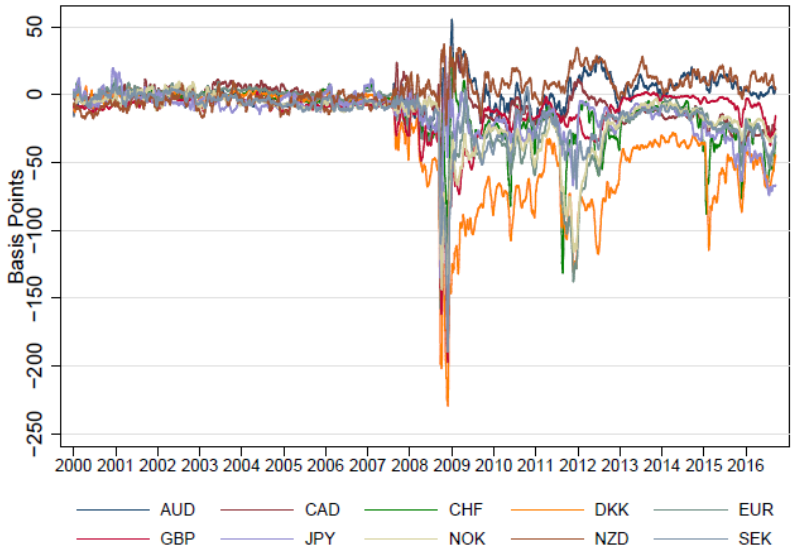


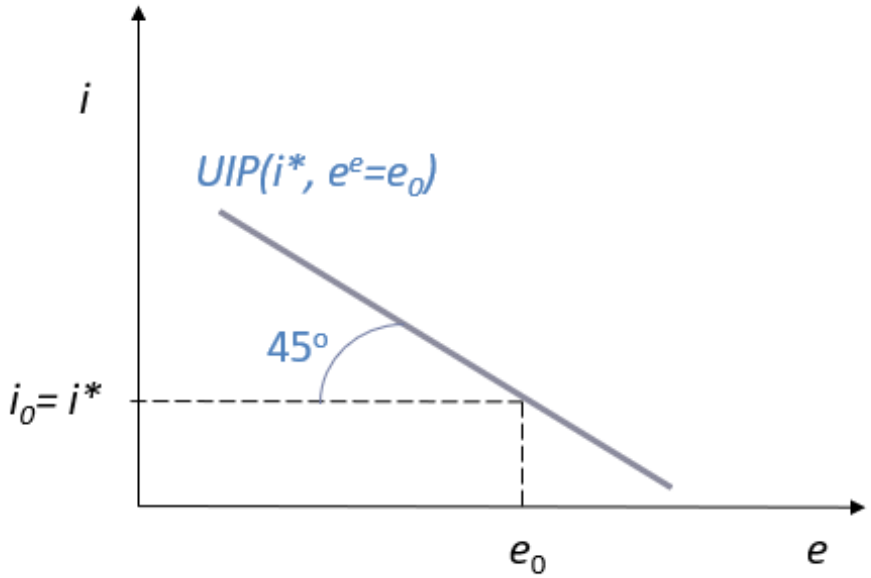
Figure 2: **Short-Term Libor-Based Deviations from Covered Interest Rate Parity:** This figure plots the 10-day moving averages of the three-month Libor cross-currency basis, measured in basis points, for G10 currencies. The covered interest rate parity implies that the basis should be zero. One-hundred basis points equal one percent. The Libor basis is equal to $y^{\$,Libor}_{t,t+n} - (y^{Libor}_{t,t+n} - \rho_{t,t+n})$, where n = three months, $y^{\$,Libor}_{t,t+n}$ and $y^{Libor}_{t,t+n}$ denote the U.S. and foreign three-month Libor rates, and $\rho_{t,t+n} \equiv \frac{1}{n}(f_{t,t+n} - s_t)$ denotes the forward premium obtained from the forward $f_{t,t+n}$ and spot s_t exchange rates.

- Du *et al* (2018) document greater CIP deviations post crisis
- Possibly regulation-driven, hindering arbitrage

Parity Conditions - UIP

- Uncovered interest parity
  - Holds if, among other things, marginal investor is risk neutral
  - Connects expected depreciation to interest rate gap
  - $i_t - i_t^* \approx e_{t+1}^e - e_t$
- *In expectation*, implies return from depositing in domestic account = return from depositing abroad and then converting back to domestic currency
  - Risk aversion and time varying risk premia cause violations (even in frictionless world)
- But for now we will assume that it holds (but note this is a *big* simplification)

Parity Conditions - UIP



- Rearrange UIP condition to obtain

$$i_t = \underbrace{-e_t}_{\text{Negative } 45^\circ} + \underbrace{i_t^* + e_{t+1}^e}_{\text{Curve Shifters}}$$

- We can convert UIP condition to real terms (QQ schedule)

$$r_t - r^* \approx E_t[\Delta q_{t+1}]$$

Monetary policy

$$L\left(y_{t+1}, \pi_{t+1}; y_e, \bar{\pi}, \beta\right) = (y_{t+1} - y_e)^2 + \beta(\pi_{t+1} - \bar{\pi})^2$$

- Standard to assume the CB has a quadratic loss function
  - Dislikes (squared) deviations of output from y^e
  - Dislikes (squared) deviations of output from inflation target, $\bar{\pi}$
  - β controls the relative weighting (large β - inflation 'nutter')
- Timing meant to capture government's acknowledgement that CB can only influence economy with a lag

Solving the central bank's problem

$$\begin{aligned} \min_{y} L \quad &\equiv \quad (y - y_e)^2 + \beta(\pi - \bar{\pi})^2 \\ s.t. \quad \pi &= \quad \pi_{-1} + \alpha(y - y_e) \end{aligned}$$

- This yields a FOC for optimality...

$$y - y_e = -\alpha\beta(\pi - \bar{\pi})$$

- Implies relationship between output and inflation capturing a 'monetary rule' (MR)

Summary of open economy model

- IS (Aggregate demand)

$$y_{t+1} = A - ar_t + bq_t$$

- PC (Phillips curve)

$$\pi_{t+1} = \pi_t + \alpha(y_{t+1} - y_e)$$

- MR (Monetary policy)

$$y_{t+1} - y_e = -\alpha\beta(\pi_{t+1} - \bar{\pi})$$

- Real UIP

$$r_t - r^* = E[q_{t+1}] - q_t$$

Solving the model - inflation and monetary policy

- Substituting MR into PC we obtain

$$\pi_{t+1} = \frac{\pi_t + \alpha^2 \beta \bar{\pi}}{1 + \alpha^2 \beta}$$

- Yields a stable backwards looking diff. equation in inflation gaps

$$\begin{aligned} \pi_{t+1} - \bar{\pi} &= \lambda(\pi_t - \bar{\pi}) \\ \lambda &\equiv (1 + \alpha^2 \beta)^{-1} \end{aligned}$$

- Since $\lambda \in (0, 1)$ we have

$$\pi_t = \bar{\pi} + \lambda^t(\pi_0 - \bar{\pi}) \to \bar{\pi} \text{ as } t \to \infty$$

- Thus, under optimal policy, inflation reverts to target

Solving the model - inflation and monetary policy

- We also have $y_t \rightarrow y_e$ and $r_t \rightarrow r^*$
- Thus, faced with excessive inflation the CB raises rates
  - Curbs aggregate demand...
  - Raises unemployment...
  - Gradually restores inflation to target
- Interest rate is initially raised and gradually reduced over time
- This approach reflects the accelerationist PC
  - Note current debate on 'flattening' of the PC
- Note: λ only depends on parameters of PC and CB loss function, not on open economy elements
  - However, those elements do influence the path of the economy
  - The CB does 'whatever it takes' and open economy influences 'what it takes'

Solving the model - RX schedule

- Real UIP implies that the deiviation of RER from its equilibrium value is given by

$$\bar{q} - q_0 = \sum_{t=0}^{\infty}(r_t - r^*) = \frac{r_0 - r^*}{1-\lambda}$$

- The IS curve gives

$$y_1 - y_e = -a(r_0 - r^*) + b(q_0 - \bar{q})$$

- Substituting real UIP into IS yields the RX curve

$$\begin{aligned} r_{t-1} &= r^* - \frac{y_t - y_e}{a + \frac{b}{1-\lambda}} \\ &\equiv r^* + \Gamma(a,b,\lambda)y_e - \overbrace{\Gamma(a,b,\lambda)}^{\text{Flatter than IS}-\textit{why}?} y_t \end{aligned}$$

- The RX schedule pins down the interest rate needed to implement the CB's desired outcome - to eliminate output gap (note: CB affects with lag)

Solving the model - 'Taylor rule'

- One can re-express behavior of real interest rate in a 'familiar' form
- Substitute MR and solution for inflation gap (from earlier) into RX

$$\begin{aligned} r_t &= r^* + \alpha\beta\lambda \times \Gamma(a, b, \lambda)(\pi_t - \bar{\pi}) \\ &\equiv r^* + \zeta(\alpha, \beta, a, b, \lambda)(\pi_t - \bar{\pi}) \end{aligned}$$

- Stronger reaction if...
  - More inflation averse ($\beta \uparrow$)
  - PC steeper ($\alpha \uparrow$) as inflation more sensitive to output deviations
- Response can be weaker if economy more sensitive to policy
  - 'Directly' through AD responsiveness to r ($a \uparrow$)
  - 'Indirectly' through market expectations and Δq ($b \uparrow$)

Short vs. medium run behavior

- Short run
  - In economics, 'short-run' $\Rightarrow$ period over which some phemomenon of interest is fixed
  - Here, prices or expectations thereof are fixed/sticky in some way
  - Implies CB can influence r_t (or $\frac{M}{P}$) by (implicitly) varying i_t (or M)
  - The 'Classical Dichotomy' between real and nominal variables is broken
- Medium run
  - Prices are allowed to adjust
  - Real output, income employment etc. are determined by the economy's productive capacity/technology (AS)

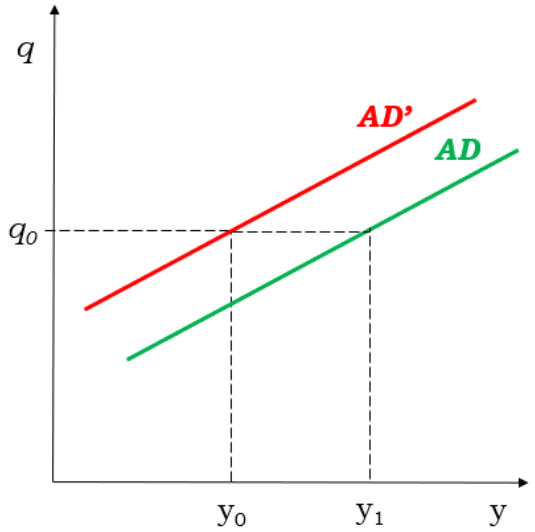
Short run analysis

- We want AD and AS schedules in exchange rate output space
- Substitute real UIP (QQ) condition into IS to eliminate r_t

$$y_{t+1} = A - ar^* - aE_t[q_{t+1}] + (a+b)q_t$$

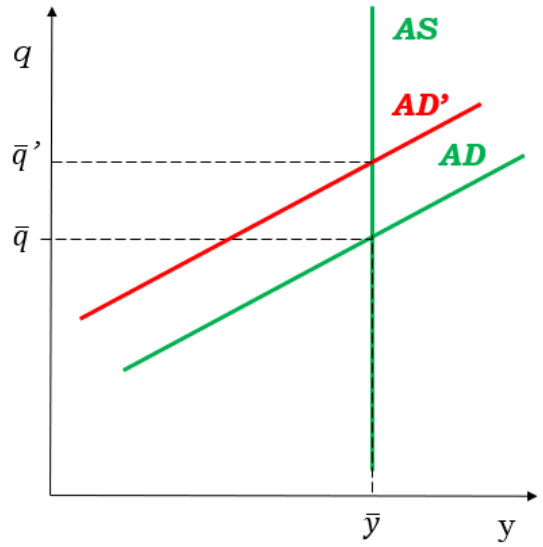
- For given expectations of the exchange rate (simplification) aggregate demand...
  - Increases with positive demand shock ($A \uparrow$ may be from, say, expansionary fiscal policy - or 'confidence')
  - Decreases with world interest rate
  - Increases as exchange rate depreciates
- We will abstract from any effect of q on AS (though there could be a channel through CPI)
  - Implies a vertical AS curve

Aggregate demand side



- We will be on an AD curve in short-run equilibrium
  - Monetary policy changes induce moves *along* curve (why?)
  - Fiscal or confidence shocks 'shift' curve (more confident - more demand for given q)
- Along the curve the goods, bond and FX markets are in 'equilibrium'
  - Equations that capture these markets' equilibrium conditions were used to derive the AD
  - Employment (and thus output) will *not* necessarily be at its medium-run equilibrium value

Aggregate supply side



- Medium-run equilibrium at intersection of AD and medium-run AS
- Vertical AS assumption (invariant to q) abstracts from phenomena such as...
  - Effects on prices of imported goods in CPI $\Rightarrow$ real wage effect through hhold. labor supply optimality
  - Similarly, effects of relative price changes (via imported production goods) on firms' profit maximizing factor mix decisions
- But not a ridiculous assumption in SR (another way to define short run) - why?

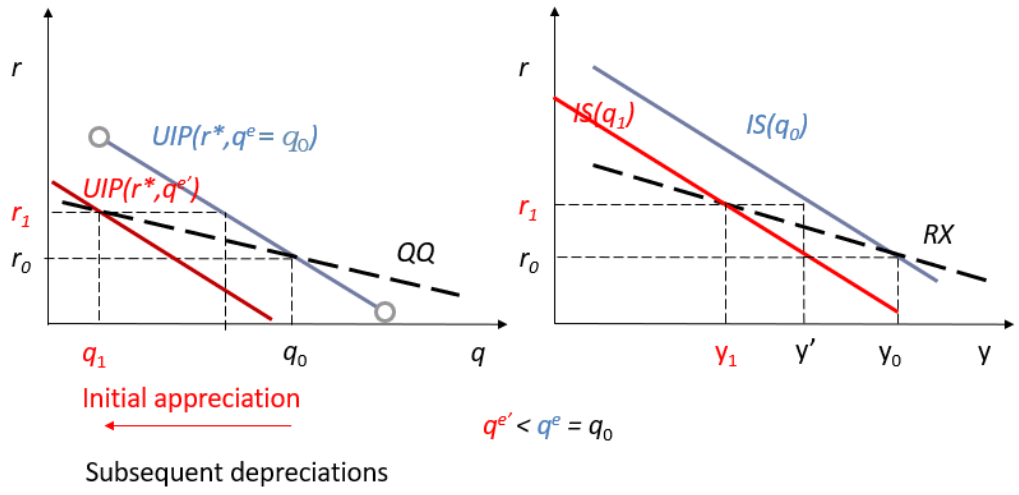
Aggregate supply side

- Other assumptions...
  - Recall, we are in a floating rate world (fixed rate later in course)
    - Nominal exchange rate restricted by UIP
    - Note: UIP does not hold in reality (risk premia etc.) but hey...- compare to linearizing DSGE models (though approximation error is not the only problem)
  - Small open economy - takes r^* as given
    - In long run $r_t = r^*$
    - Short run deviations allowed though
    - So role for monetary policy in S-R
- For stable nominal exchange rate in medium-long-run
  - Assume $\bar{\pi} = \bar{\pi}^*$
  - Otherwise perpetual (nominal) appreciation or depreciation
  - This isn't really necessary or, actually, realistic

Response to an inflation shock

- Start with medium-run equilibrium and inflation at target then 'news' of an inflation shock
- CB and FX market anticipate a prolonged period with higher inflation and interest rates (to restore inflation to target)
  - CB raises interest rates and real exchange rate jumps (appreciates)
- Output and inflation fall
  - CB gradually reduces interest rates
  - Exchange rate gradually depreciates
  - NB: Depreciation (expected) allowed initially higher rates to satisfy UIP
- Long-run real exchange rate unaffected
  - Prices sticky in S-R but ultimately rise to higher L-R value
  - Nominal exchange rate: appreciates on impact, depreciates in L-R

RX and QQ - shifting curves



- Initially CB raises r_t to raise unemp. and suppress infl.
  - UIP shifts left reflecting future expected depreciation
- After initial period, UIP gradually shifts back to the right as expected (remaining) depreciation declines (implicit in expected q next period, given by generic $q^{e'}$)
  - Point on each UIP curve associated with the prevailing r_t traces out QQ
  - Throughout, the expected exch. rate loss from holding domestic bonds = interest rate gains from $r_t > r^*$
- As q depreciates, the IS curve shifts $\rightarrow$ (traces out RX)

RX and QQ - shifting curves

- Dornbusch (1976) called this 'exchange rate overshooting'
  - Helps explain why exchange rates are so volatile, namely relative to prices
  - 'Smart' speculators and naive price and wage setters

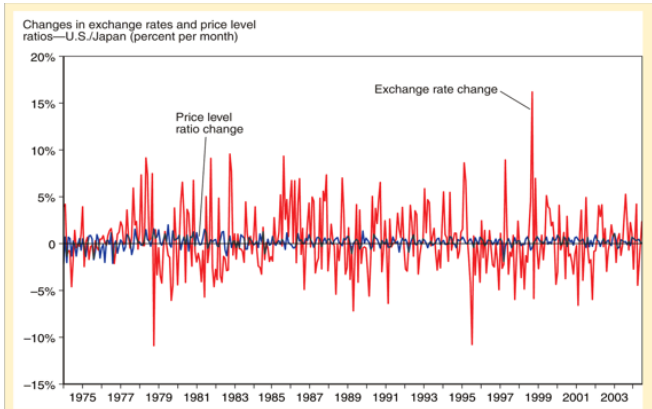


Figure 14-11

Month-to-Month Variability of the Dollar/Yen Exchange Rate and of the U.S./Japan Price Level Ratio, 1974–2004

The much greater month-to-month variability of the exchange rate suggests that price levels are relatively sticky in the short run.

Source: International Monetary Fund, *International Financial Statistics*.

- Direct consequence of UIP and price rigidity
  - Expectations adjust quickly, but prices adjust slowly
  - q must overshoot initially to clear the FX market

Overshooting following permanent demand shock ($A \uparrow$)

- Initial $\bar{q}$ (given initial A) clears goods market when $r_t = r^*$ and $y_t = y_e$
- Hence, real appreciation necessary if $A \uparrow$
  - Why? To choke off NX to restore $y_t = y_e$
- q_t increases in expected future $\pi_t - \bar{\pi}$
  - Or, from alternative perspective (using MR), decreases in future $y_t - y_e$
- But then the current q_t must appreciate as markets anticipate tighter monetary policy to choke off demand shock ΔA (before eventually $r_t = r^*$ is restored)
  - We know that q must appreciate in the L-R (higher $\bar{q}$) to be consistent with the higher A, even once $r_t = r^*$ in equilibrium
  - Therefore it must appreciate *even more* in the S-R to account *also* for periods of $r_t > r^*$ along the transition path

Overshooting following permanent demand shock ($A \uparrow$)

- For another perspective we can use the IS and MR in the real UIP (QQ) condition...

$$E[q_{t+1}] = (1 + \frac{b}{a})q_t + \frac{A - y_e + \alpha\beta(\pi_{t+1} - \bar{\pi})}{a} - r^*$$

- But this can be solved forward (repeated lead and substitute q_{t+j}), yielding

$$q_t = \frac{y_e - A + ar^*}{b} - \frac{1 + \frac{b}{a}}{a(1 + \frac{b}{a} + \lambda}(y_t - y_e)$$

- First term: Permanently elevated A similar to permanently reduced r^* (intuition?) though magnitudes differ
- Second term captures overshooting
  - Higher A induces positive output gaps for a while
  - Induces 'extra' appreciation

Zero lower bound and policy responses

Zero lower bound

- We have discussed a positive demand shock
- A large negative AD shock can drive the r_t desired by the CB below zero
- Loosely, this was experienced by the U.S. and other economies in the GFC
- Problem if inflation is too low to allow $r_t < 0$ while $i_t \geq 0$
  - Why is it typically thought $i_t \geq 0$?
- In a low inflation world - and with a low r^* - this may not be the case
- During Great Recession and afterwards, standard policy rules $\Rightarrow$ negative nominal rates were necessary
- U.S. and other countries hit the *Zero Lower Bound*

Zero lower bound - short rates constrained

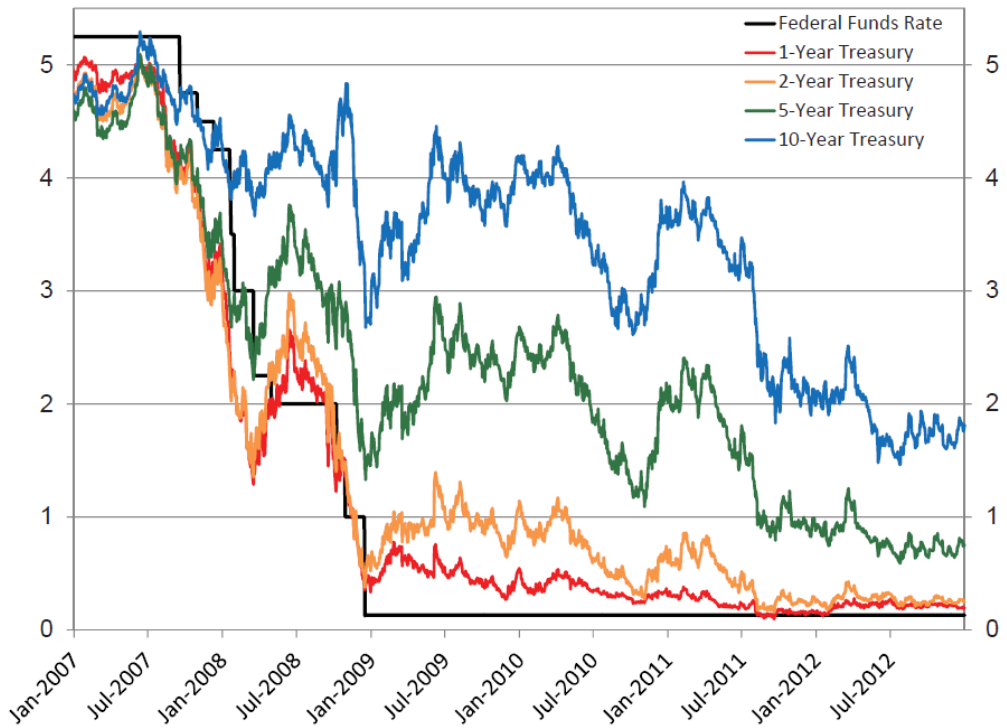


Figure 1. Federal funds rate target and 1-, 2-, 5-, and 10-year zero-coupon Treasury yields from January 2007 through December 2012. Data are from the Federal Reserve Board and the Gürkaynak, Sack, and Wright (2007) online dataset.

Zero lower bound - short rates constrained

- Suppose $i_{t+1} \geq 0$ and $\pi_t \leq \pi_{low}$
- Then real rate is constrained: $r_t \geq -\pi_{low}$
- Imagine $\pi_{low} = 0$ then cannot set real rate negative (which has frequently helped stimulated the economy in other recessions)
- Intuitively, monetary policy remains tight when it should be loose
- CB cannot implement the responses in r_t that we discussed earlier
- Theoretical possibility of being trapped in a deflationary spiral/equilbrium!
- Scary. Stuff.

Is there anything we can do?

- Yes, maybe
  - Ask the Japanese how hard it is, and the current Fed and ECB policymakers how they feel about the situation right now...
  - See last Friday's newsflow from the Hoover conference at Stanford with a lot of discussion of possible new operating frameworks for Fed (e.g. price level targeting)
- Various possibilities - a few are...
  - Forward guidance
  - QE
  - Fiscal expansion

Forward guidance

- Setting ZLB aside, forward guidance is in some sense always at play under effective monetary policy
- Consider an IS equation (a more standard one than from our simple model above)

$$y_t - y_e = -\alpha(i_t - E_t[\pi_{t+1}] - r_t^*) + E_t[y_{t+1} - y_e]$$

- Iterate forwards / re-express

$$\begin{aligned} y_t - y_e &= -\alpha(i_t - E_t[\pi_{t+1}] - r_t^*) + E_t[y_{t+1} - y_e] \\ &= -\alpha E_t \sum_{j=0}^{\infty} (i_{t+j} - \pi_{t+j+1} - r_{t+j}^*) \end{aligned}$$

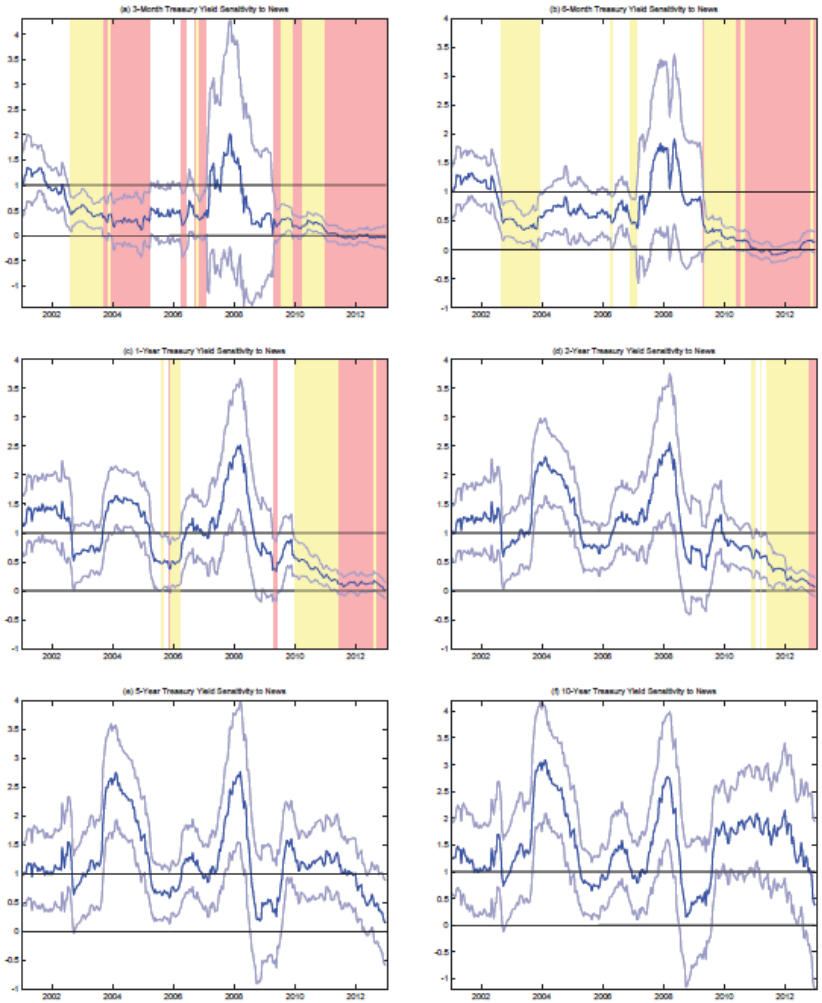
- Current output gap depends on expected future path of short rate, inflation and the (possibly time varying) 'natural' rate of interest

Forward guidance

$$y_t - y_e = -\alpha E_t \sum_{j=0}^{\infty} (i_{t+j} - \pi_{t+j+1} - r^*_{t+j})$$

- A brief 'pulse' in i_t for a single or small number of periods will not have an enormous effect on the economy
- The same move will be powerful if it is part of a systematic, sustained and **credibly communicated** course of policy action
- If CB can affect expectations of i_{t+j} and π_{t+j} *in the future* then can influence economy even if in the S-R i_t can't be used
- One channel: many borrowing rates (e.g. mortgages) are at longer maturities and perhaps can be influenced
- Theory is subtle: Often relies on information asymmetries, commitments to be 'irresponsible' (e.g. 'lower for longer')

Williams and Swanson 2013 - Long rate sensitivity to news



Fed date-based guidance - powerful effect in 2011

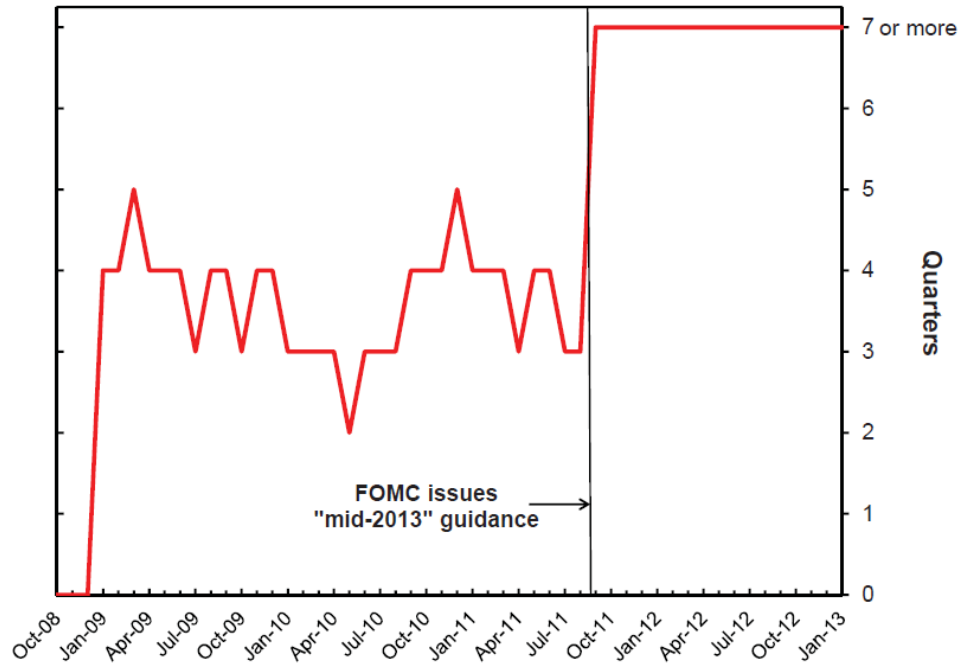
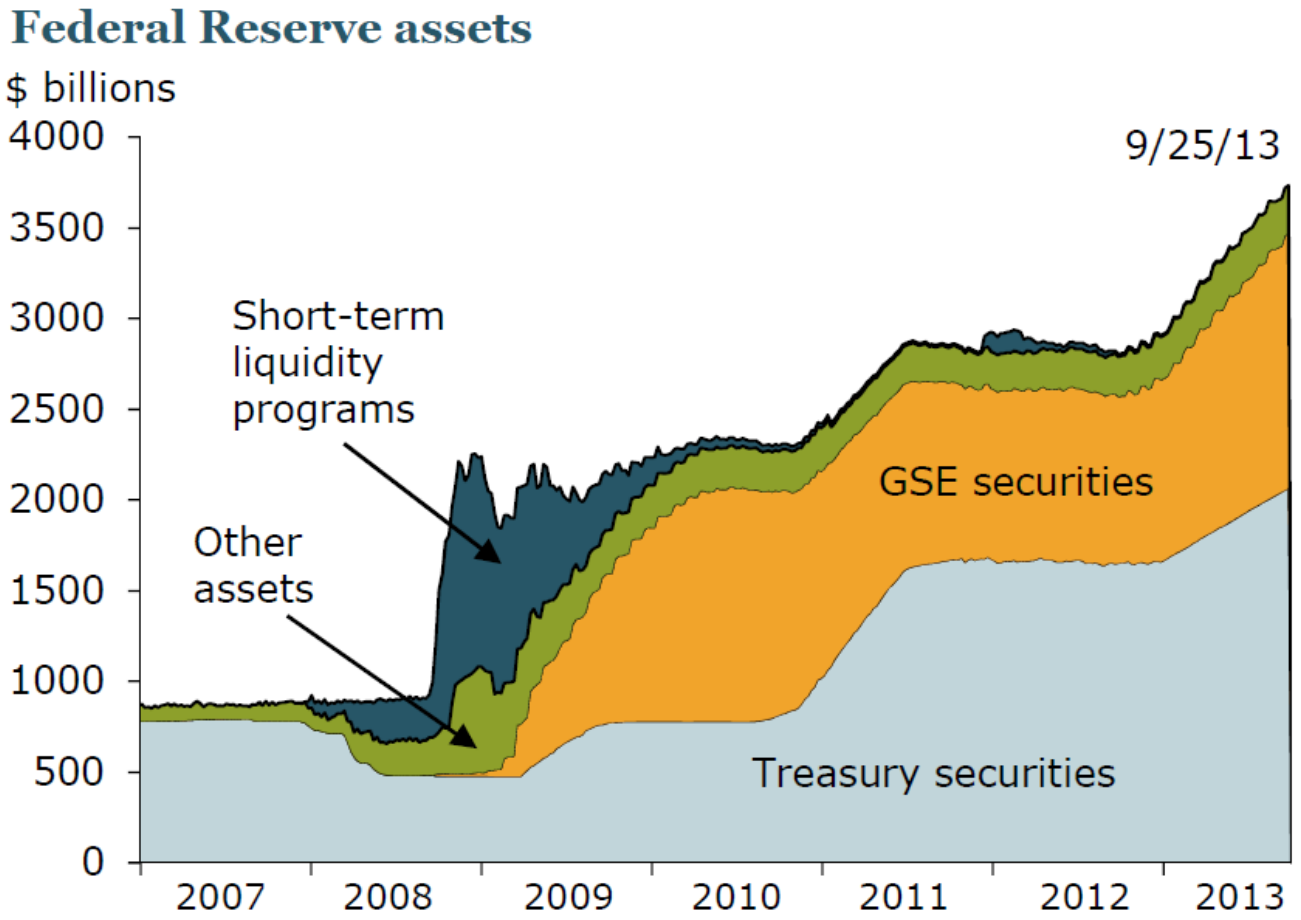


Figure 5. Expected number of quarters until the first federal funds rate increase above 25 bp, from the monthly Blue Chip survey of forecasters. Data are top-coded at "7 or more" quarters due to the forecast horizon length published by Blue Chip.

- In 2011, economic conditions, *'likely to warrant exceptionally low levels for the federal funds rate at least through mid-2013'*
- Compare with, less explicit, 'indications that rates were likely to stay low *'for some time'*

Quantitative Easing

- Fed (and other central banks) also massively expanded their balance sheets to purchase assets



Source: Federal Reserve Board of Governors.

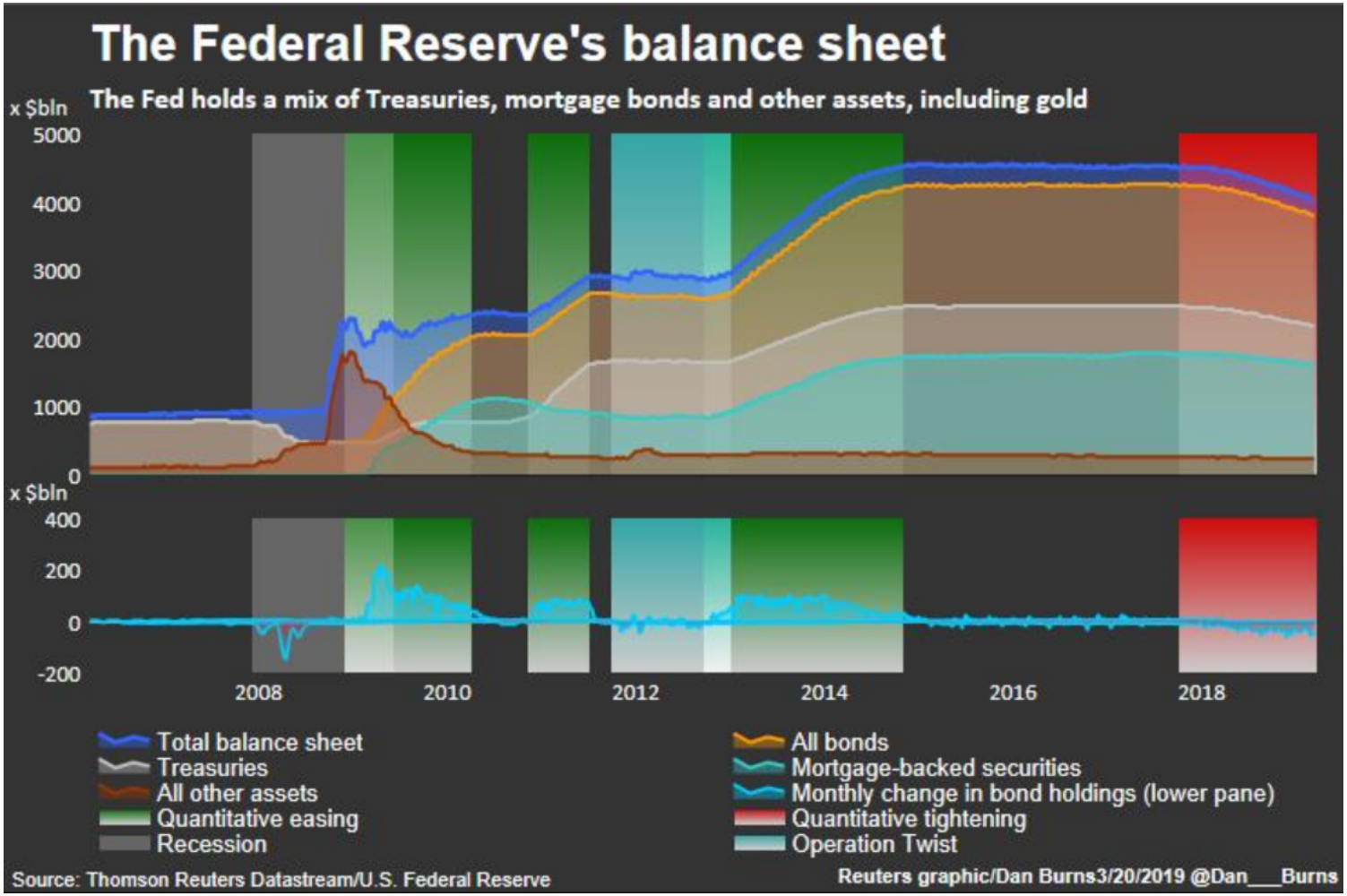
Quantitative Easing

- QE1 (December 2008)
  - $\$600bn$ of agency MBS and debt - initially sterilized
  - Later $\$750bn$ more + $\$300bn$ Treasuries - not sterilized so $BS \uparrow$ (QE up and running)
- QE2 (November 2010)
  - $\$600bn$ of long-dated Treasuries ($BS \uparrow$)

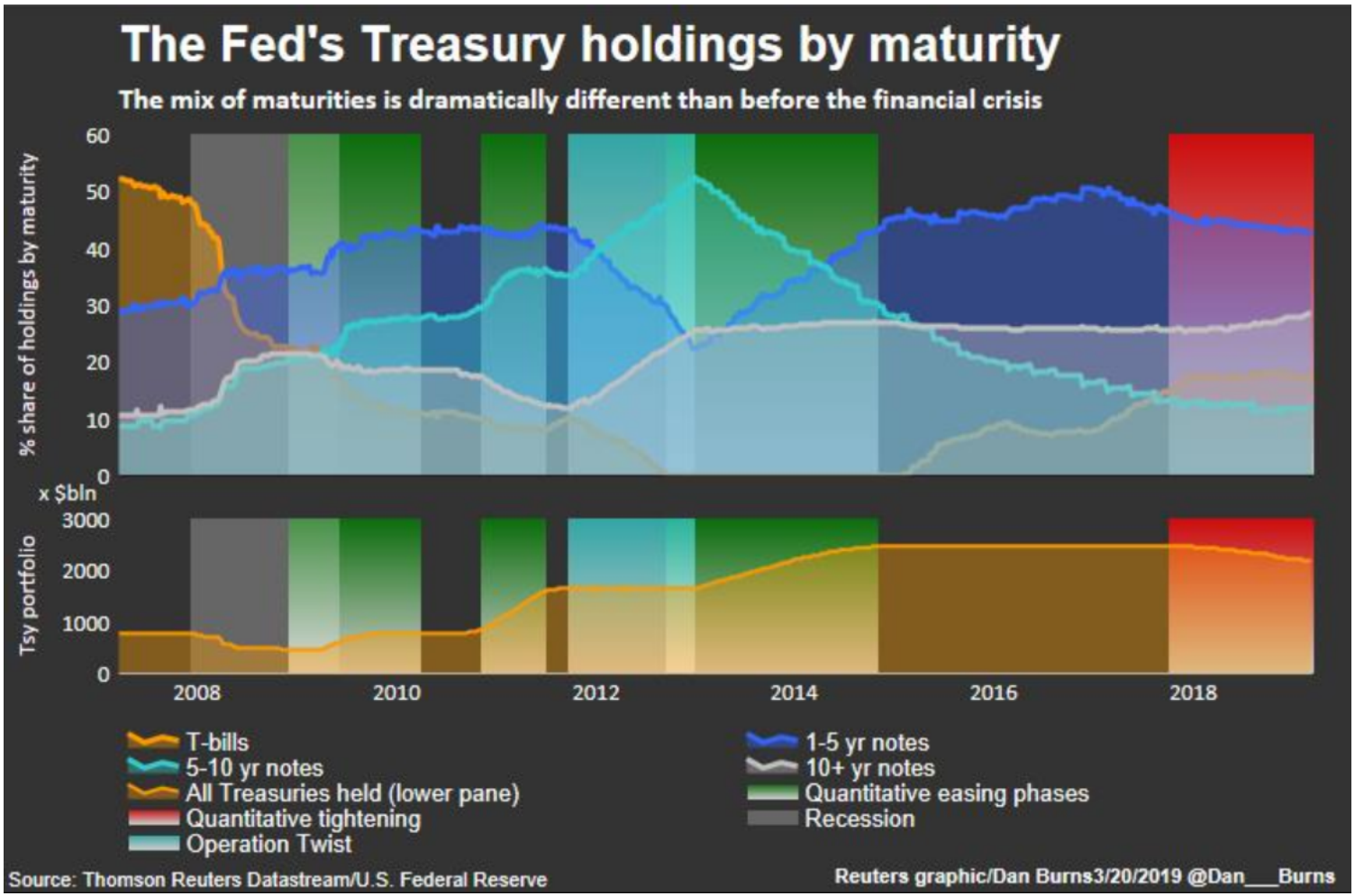
Quantitative Easing

- Operation Twist (2011)
  - Purchase $\$400bn$ bonds with maturities 6 to 30 years, using proceeds from selling bonds with maturities less than 3 years
  - Limited impact on size of balance sheet - changing composition
  - Lengthened average maturity and 'removed duration' from market
  - Later extended with further $\$267bn$
  - Eventually ran out of short dated to sell
- QE3 (2012)
  - Open ended commitment to purchase $\$40bn$ agency MBS until labor market improved
  - Later added up $\$45bn$ long dated Treasury purchases per month

Balance sheet decomposition - asset class



Balance sheet decomposition - maturity



Channels

- Main intended channels
  - Drive down long rates
  - Induce substitution into other - riskier - assets like lending (esp. mortgages)
  - Stimulate stock market (aiding wealth and confidence)
- Theoretical basis somewhat unclear (still)
  - But empirically, rates did seem to drop - at least around impact and in periods after
  - VAR analysis an other approaches also suggest effect on economy
- Possible additional channels
  - Conveying commitment
  - Perhaps even signaling future interest rate policy (as discussed earlier)
  - Weakening exchange rate (though not primary aim)
  - Induce bank lending by solidifying bank balance sheets (from rising asset prices)

Stimulating risk assets? Dow Jones

Fiscal policy?

- Big increase in 'G' can shift the IS curve far to the 'right'
- Effectively a large demand shock that raises the r_t that should be sought by the CB
- Blasts the economy out of the ZLB (see diagrams earlier for $A \uparrow$
- Is it that easy?
  - Not necessarily
  - Ricardian equivalence and expectations of future taxes (if spending is deficit financed)
  - May mean a loss of confidence or leave expected effect on permanent income $\approx$ zero
  - Might be accompanied by a drop in other determinants of A
  - Countries already in a bad fiscal position (eps. if they've bailed out banks) may not be 'allowed' by the markets to borrow to fund spending - and raising taxes is difficult in recession