International Economics, Lecture 5
Monetary Policy

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Plan

- Closed Economy
- Two Country Model
- Nominal Rigidities
- International Transmission Mechanism
- Optimal Monetary Policy
- Summary

Introduction

- Monetary policy decisions in one country affect other countries.
- Today: transmission through demand channels via terms of trade.
- Overarching Theme: Introduce an intuitive, simple, graphical apparatus. Simplification to enhance geometric analysis.
- Largely ignore intertemporal considerations.

Open Questions

- What are the international aspects of monetary policy transmission?
- How should monetary policy be conducted in an open economy?
- In particular, should monetary policy have an international dimension?
- When is international cooperation desirable?

New Open-Economy Macroeconomics

- NOEM aims to answer these questions, and more.
- Begins with Obstfeld and Rogoff (1995).
- Highlights the importances of firm's pricing decisions.
  - Are prices preset in home or foreign currency?
- Highlights the monopoly power of a country on its own terms of trade.
  - Should policies be "inward looking" focussing on domestic output and inflation only, or also include an international component?
- Highlights the potential gains from international monetary policy coordination.
  - ... or a lack thereof.

Closed Economy Model Set-Up

- Begin with a **closed economy**.
- No trade in international goods or financial assets.
- Understand the **transmission** of productivity shocks.
- Understand how monetary policy may help **mitigate** adverse consequences.
- Then we will extend to open economy analysis.

Households

- Normalise population size (aggregate = per capita).
- Representative household derives utility from consumption, C_t, and disutility from labour supply (hours worked), ℓ_t:

$$U_t = \ln C_t - \kappa \ell_t.$$

- Consumption is taken to be an aggregate of many varieties, supplied by firms.
- κ measures discomfort from labour, such that MRS_{C_t,ℓ_t}:

$$\left.\frac{\partial C_t}{\partial \ell_t}\right|_{\partial U_t = 0} = \kappa C_t.$$

Firms

- Many firms, with identical production technology.
- Imperfect competition between firms, each producing a single variety.
  - Firms have some (limited) market pricing power.
  - Households own firms, and therefore receive any profits.
- Abstract from capital, with labour as only input.
- Perfect competition in factor market (labour).
  - In equilibrium, real wage equals productivity.

Two Possible Shocks

- **Productivity** shocks. (Real shocks).
  - These will be economy-wide, simultaneously affecting all firms.
  - Summarised in the labour productivity variable, Z_t.
- **Monetary** shocks. (Nominal shocks).
  - Exogenous changes in the monetary stance, μ_t.

Three Key Relationships I - Aggregate Demand

- Monetary policymakers may also be able to respond to shocks.
- μ_t will synthesise the effect of current and expected future monetary policy on nominal spending, with aggregate monetary stance:

$$\mu_t = P_t C_t \quad \text{such that} \quad C_t = \frac{\mu_t}{P_t}. \tag{AD}$$

- Monetary easing (higher μ_t) increases nominal spending through two plausible mechanisms:
  - In SR (price level fixed) higher real consumption.
  - In LR (flexible price levels) through higher price level. Monetary neutrality.

Three Key Relationships II - Aggregate Supply

- Linear aggregate production function:

$$Y_t = Z_t \ell_t.$$

- Goods market clearing $Y_t = C_t$ infers:

$$C_t = Z_t \ell_t. \qquad \text{(AS)}$$

- Intersection with AD determines $\{C_t, \ell_t\}$ as a function of $\{Z_t, \mu_t, P_t\}$.
- Aggregate price level is endogenous, thus one further relationship required to fully characterise the system.
  - Study firm pricing behaviour and recall symmetry assumption.

Firms Pricing Behaviour

- Assume prices are **flexible**.
- Imperfectly competitive firms set prices as a markup over their marginal costs. As labour is the only input, this infers:

$$P_t^{\text{Flex}} = \underbrace{\frac{\theta}{\theta - 1}}_{\text{markup}} \underbrace{\frac{W_t}{Z_t}}_{\text{mc}},$$

  where $\theta > 1$ represents the elasticity of substitution between varieties.
- Low values of θ (low substitutability between varieties) increase market power, and hence the aggregate price level.

Three Key Relationships III - Natural Rate [NR]

- Under perfect competition in the labour market, the real wage is equal to the MRS_{C_t,ℓ_t}:

$$\frac{W_t}{P_t} = \kappa C_t.$$

- Hence:

$$P_t^{\text{Flex}} = \frac{\theta}{\theta - 1} \frac{\kappa P_t^{\text{Flex}} C_t}{Z_t} = \frac{\theta}{\theta - 1} \frac{\kappa P_t^{\text{Flex}} Z_t \ell_t}{Z_t}.$$

- Thus:

$$\ell_t = \frac{\theta - 1}{\theta \kappa} \equiv \bar{\ell}, \qquad \text{(NR)}$$

  where $\bar{\ell}$ may be taken to be the natural rate of employment.

- Natural rate coincides with the **flexible price** allocation.
- Natural rate of output, $Z_t \bar{\ell}$, fluctuates with productivity.

Graphically

- Rather than the standard, (Y_t, P_t)-space, set up the economy in (ℓ_t, C_t)-space.
- Recall equilibrium relationships:
  - AD is a horizontal line:

$$C_t = \frac{\mu_t}{P_t}. \tag{AD}$$

  - AS is a ray from the origin.

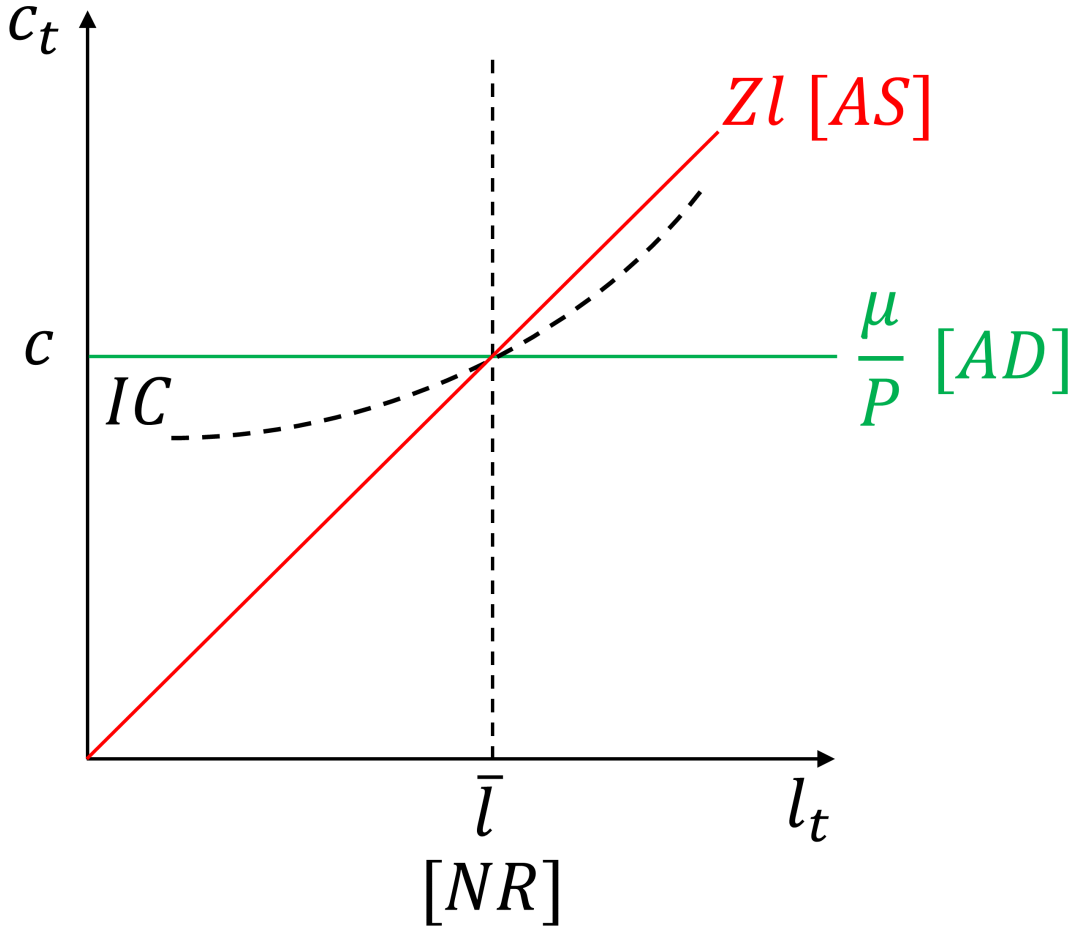
$$C_t = Z_t \ell_t. \tag{AS}$$

  - NR is a vertical line.

$$\ell_t = \frac{\theta - 1}{\theta \kappa} \equiv \bar{\ell}, \tag{NR}$$

Graphical Representation - Closed Economy

- Flexible price allocation.



Source: Corsetti and Pesenti (2007).

Flexible Price Transmission

- A fixed employment rate, $\bar{\ell}$, ensures AD adjusts to match the natural rate.

  1. NR determines $\ell_t = \bar{\ell}$.
  2. AS then uses, Z_t to determine C_t.
  3. Finally AD adjusts (via P_t^{Flex}), given the monetary stance μ_t, to ensure equilibrium.

- Monetary policy has no impact on real allocations.

Nominal Rigidities

- Consider instead fixed one-period ahead "**sticky**" prices.
- Firms preset prices before productivity shocks realised.
- Imperfectly competitive firms set prices as a markup over their **expected** marginal costs:

$$P_t = \frac{\theta}{\theta - 1} \mathbb{E}_{t-1} \left[\frac{W_t}{Z_t} \right].$$

- Then, meet realised demand at these prices.
- **Expected employment** is equal to the natural rate.
- On average firms hit the flexible price supply curve.

Expected Employment is Equal to the Natural Rate

- Begin with the "sticky" price setting.

$$P_t = \frac{\theta}{\theta - 1} \mathbb{E}_{t-1} \left[\frac{W_t}{Z_t} \right].$$

- Use labour market clearing condition and AD schedule.

$$P_t = \frac{\theta\kappa}{\theta - 1} \mathbb{E}_{t-1} \left[\frac{P_t C_t}{Z_t} \right] = \frac{\theta\kappa}{\theta - 1} \mathbb{E}_{t-1} \left[\frac{\mu_t}{Z_t} \right].$$

- Multiply by C_t and use AD and AS schedules:

$$\mu_t = \frac{\theta\kappa}{\theta - 1} \mathbb{E}_{t-1} \left[\frac{\mu_t}{Z_t} \right] Z_t \ell_t.$$

- Rearrange:

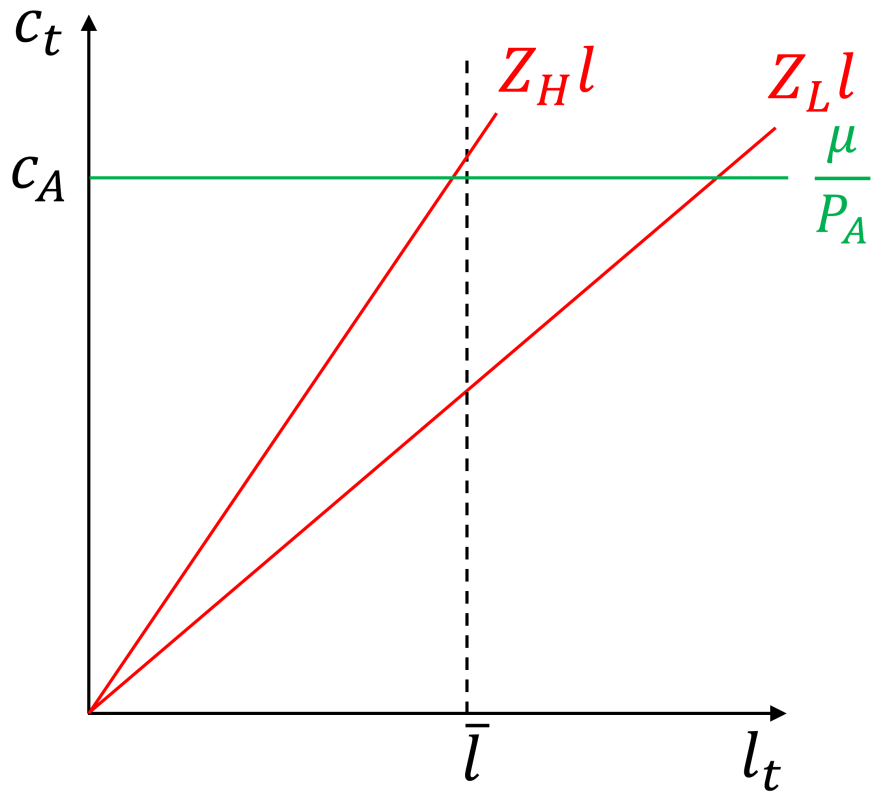
$$\ell_t = \frac{\theta - 1}{\theta\kappa} \frac{\mu_t / Z_t}{\mathbb{E}_{t-1}[\mu_t / Z_t]}.$$

- Take expectations:

$$\mathbb{E}_{t-1}[\ell_t] = \mathbb{E}_{t-1} \left[\frac{\theta - 1}{\theta\kappa} \frac{\mu_t / Z_t}{\mathbb{E}_{t-1}[\mu_t / Z_t]} \right] = \frac{\theta - 1}{\theta\kappa} = \bar{\ell}.$$

Price Setting Under Uncertainty I

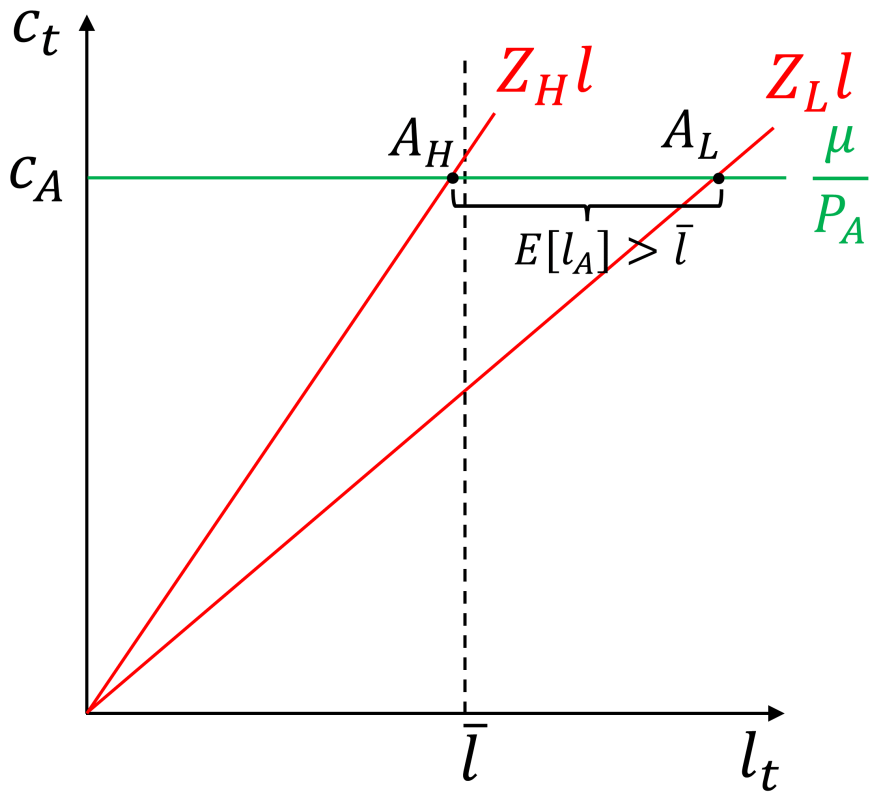
- Consider two possible productivity realisations, Z_H and Z_L.
- Assume they occur with the same probability.



Source: Corsetti and Pesenti (2007).

Price Setting Under Uncertainty II

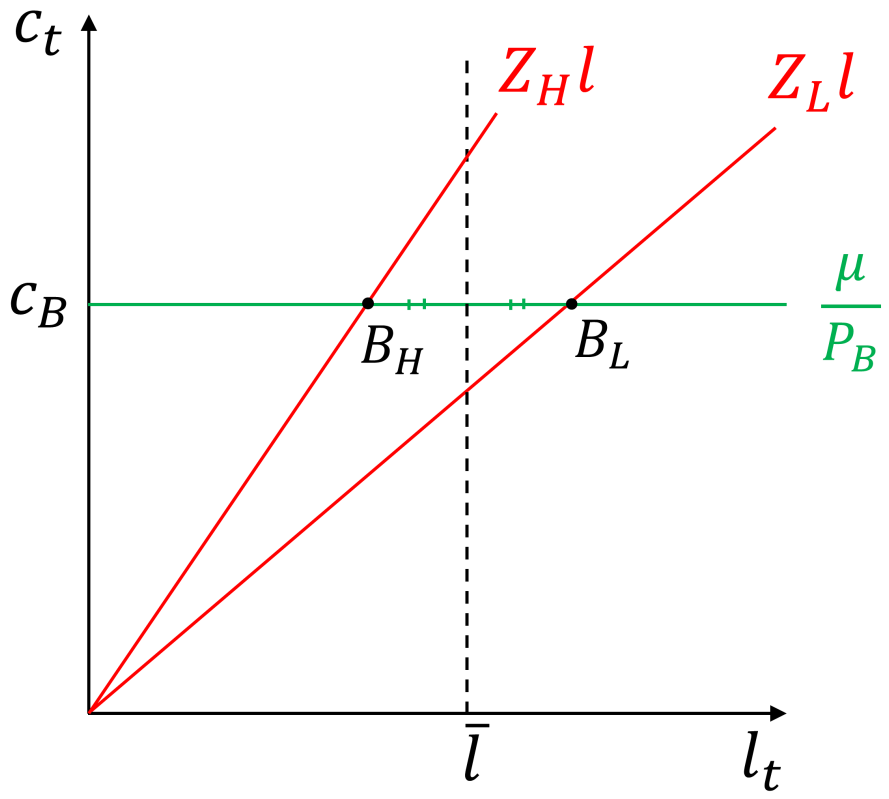
- Conjecture an initial price level, P_A.
- Clear that this generates $\mathbb{E}[\ell_A] > \bar{\ell}$.



Source: Corsetti and Pesenti (2007).

Price Setting Under Uncertainty III

- Given μ_t, price level should be higher.
- Until we reach the condition $\mathbb{E}[\ell_A] = \bar{\ell}$.



Source: Corsetti and Pesenti (2007).

Welfare

- Utility increases to the north-west of the graph.
  - Higher consumption, lower labour supply.

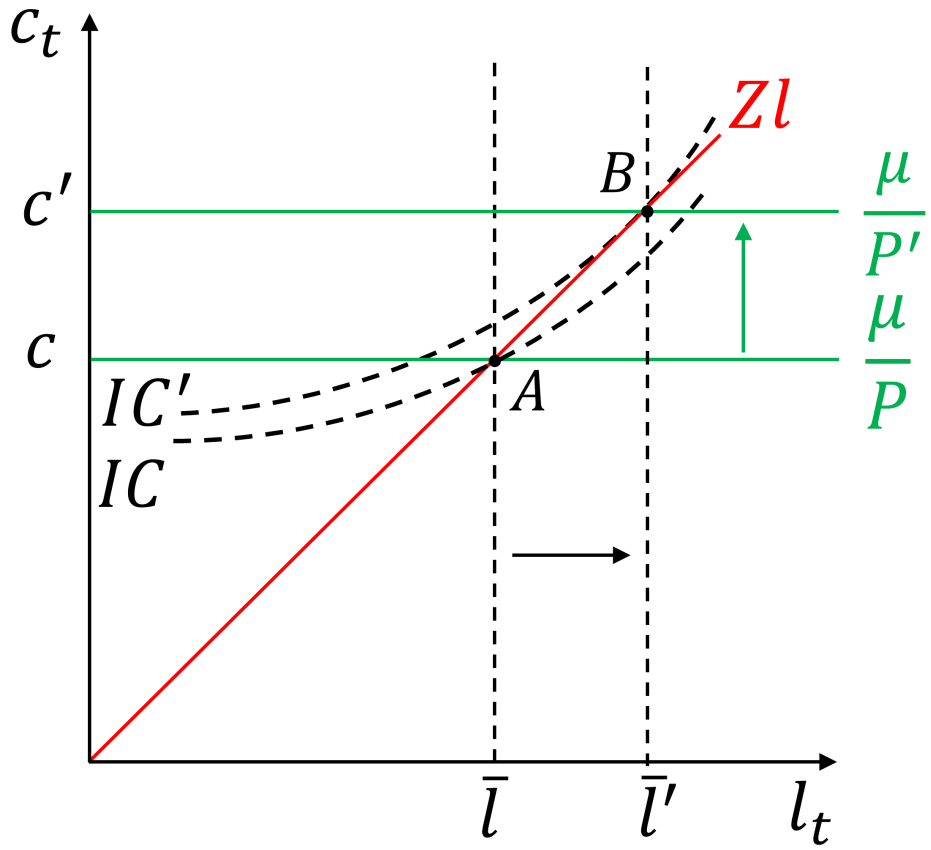
- Since monopolistic distortions, competitive equilibrium is not Pareto efficient.

$$MRS_{C_t,\ell_t} = \kappa C_t = \kappa Z_t \frac{\theta - 1}{\theta \kappa} < Z_t = MRT_{C_t,\ell_t}.$$

- Firms set:
  - Prices sub-optimally high.
  - Output (and employment) sub-optimally low.
  - Generating excess profits.

Structural Reforms

- Remove the monopolistic competition: $P_t \downarrow$, $C_t \uparrow$, $\ell_t \uparrow$.
- Point B is Pareto efficient, IC is tangent to BC.



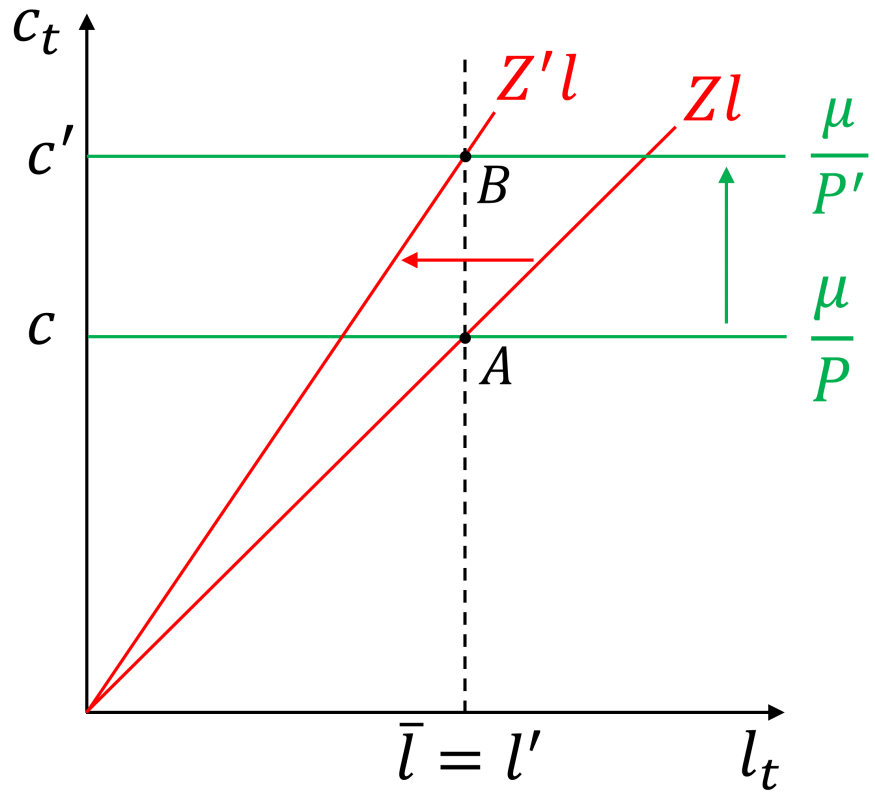
Source: Corsetti and Pesenti (2007).

Response to Shocks Under Flexible Prices

- Monetary policy shock.
  - Monetary policy stance, μ_t, and price level, P_t simultaneously move to re-establish the natural rate equilibrium.
- Positive productivity shock.
  - Natural rate is unchanged.
  - Increase in productivity rotates the AS curve upwards.
  - With no change in nominal spending (μ_t fixed) the price level falls to boost aggregate consumption.
  - Output and consumption increase, employment unchanged. Price level falls.

Positive Productivity Shock - Flexible Prices

- Remain at natural employment rate.
- Price level responds to higher productivity level.



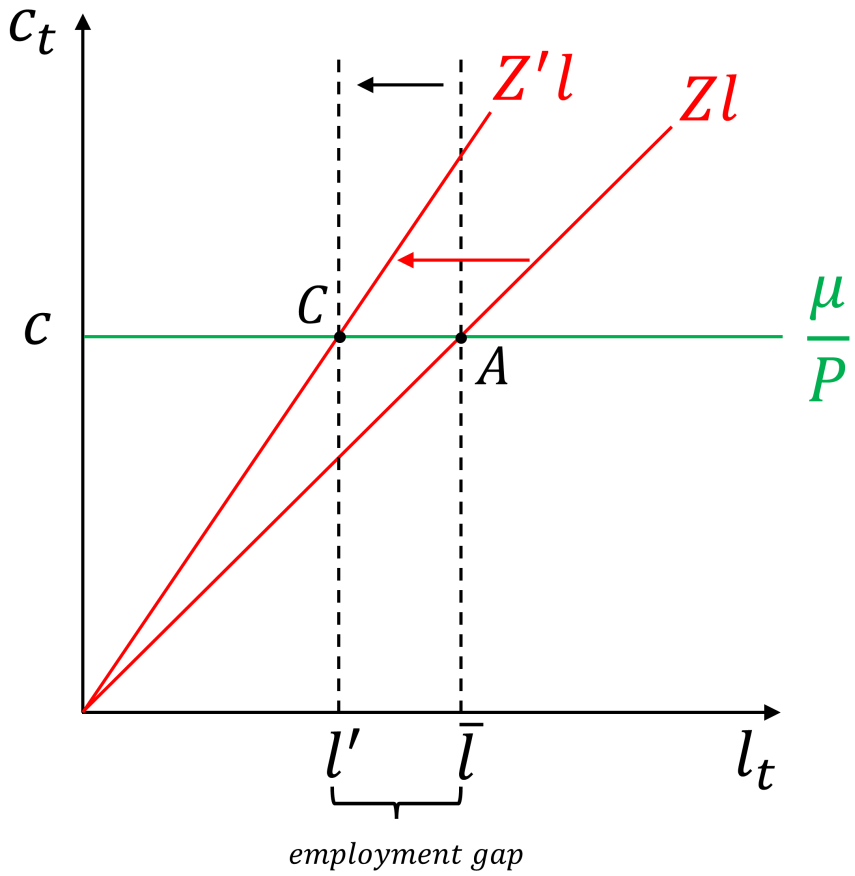
Source: Corsetti and Pesenti (2007).

Response to Productivity Shock Under Sticky Prices

- Price level is fixed.
- A positive productivity shock still rotates AS curve.
- With no change in the monetary stance, μ_t, consumption must fall to maintain current expenditure.
- Employment falls below the flexible price allocation: employment gap opens.
- Output falls below the flexible price allocation: output gap opens.

Positive Productivity Shock - Sticky Prices

- Price level unable to respond.
- Positive output and employment gaps, with $\ell' < \bar{\ell}$.



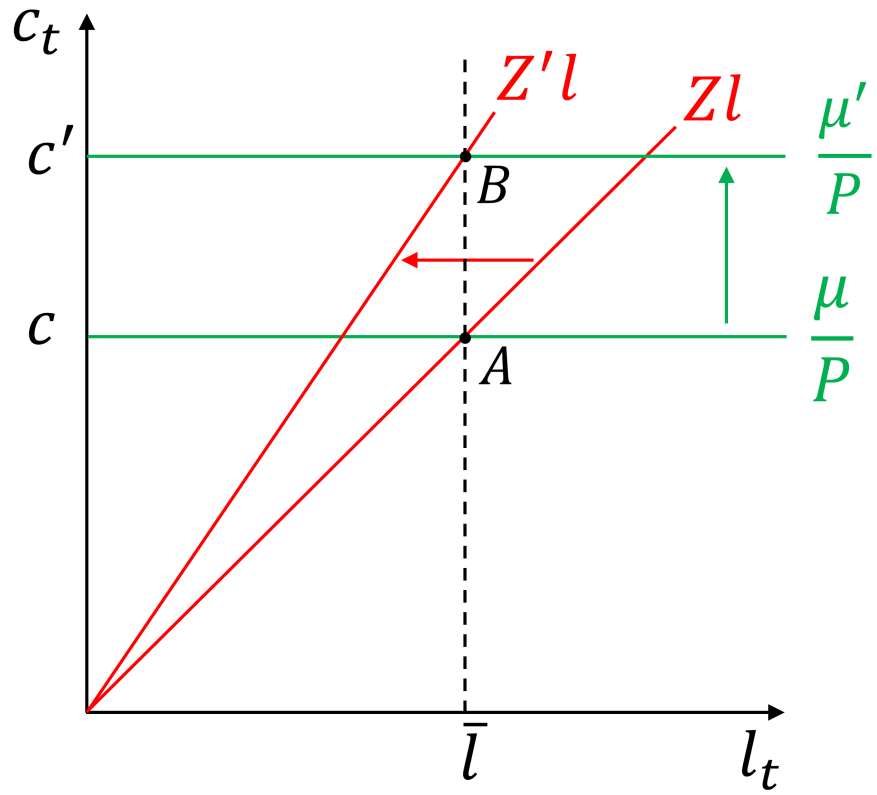
Source: Corsetti and Pesenti (2007).

Monetary Policy Stabilisation Role

- Assume monetary policymakers observe productivity.
- By altering the monetary policy stance, we can do better.
- After the positive productivity shock, enact expansionary monetary policy.
- Engineer higher nominal spending.
- Recover the flexible price allocations.
- Unambiguously higher utility level.

Positive Productivity Shock - Optimal Response

- Central bank replicates the flexible price allocation.
- $\mu \uparrow$ to avoid an output gap and welfare losses.



Source: Corsetti and Pesenti (2007).

Prelude

- Now move to a two-country setting.
- Builds on work from basic Cole and Obstfeld (1991) style economies.
- Follows Corsetti and Pesenti (2001, 2005) and in particular Corsetti and Pesenti (2007) closely.
- When we specify preferences as log + Cobb-Douglas aggregator of domestic and foreign consumption, we simplify the analysis and are able to derive closed-form solutions.

New Features

- Firms now sell in two markets, at home and abroad.
  - Are prices pre-set in the domestic currency?
  - Do firms fix two sets of prices?
- Terms of trade distortions.
  - Already have two potential distortions (monopolistic competition and sticky prices).
  - Now add: country with monopoly power over terms of trade.
  - Individual firms ignore this distortion.

Two Country Model

- Much of the same intuition, but will need to derive once more.
- Countries of equal size.
- Countries produce one specific type of good, denoted H and F.
- Monopolistic competition between varieties with each country.
- Linear production technology.
- Households consume both H and F goods with unitary elasticity (Cobb-Douglas aggregator).
- Foreign variables denoted with an asterisk.

Three International Prices

- As in Lecture 3.
- Nominal exchange rate defined as Home currency per unit of Foreign:

$$\mathcal{E}_t.$$

- Real exchange rate:

$$Q_t = \frac{\mathcal{E}_t P_t^*}{P_t}.$$

- Terms of trade:

$$ToT_t = \frac{P_{F,t}}{\mathcal{E}_t P_{H,t}^*}.$$

Current Account?

- No.
- No capital or investment, so will be little to say.
- Instead, assume balanced trade:

$$P_{F,t} C_{F,t} = \mathcal{E}_t P^*_{H,t} C^*_{H,t}.$$

Consumption [AD Block]

- Consumption is taken to be a Cobb-Douglas aggregator of Home and Foreign goods:

$$C_t = C_{H,t}^{\frac{1}{2}} C_{F,t}^{\frac{1}{2}}.$$

such that consumption is symmetric in both goods, with equal weights.

- The utility-based consumer price index (CPI-measure) - price associated with the minimum expenditure associated with $C_t = 1$ - is then given as:

$$P_t = 2P_{H,t}^{\frac{1}{2}} P_{F,t}^{\frac{1}{2}}.$$

- Using this, demand equations are given as:

$$P_{H,t} C_{H,t} = \frac{1}{2} P_t C_t = P_{F,t} C_{F,t}.$$

Price Level and Demand Equations

- As always, set up the problem as a Lagrangian:

$$\mathcal{L}_t = P_{H,t}C_{H,t} + P_{F,t}C_{F,t} + \lambda_t(1 - C_{H,t}^{\frac{1}{2}}C_{F,t}^{\frac{1}{2}})$$

- The two first order conditions (+ rearranged):

$$P_{H,t} = \lambda_t \frac{1}{2} C_{H,t}^{\frac{1}{2}} C_{F,t}^{\frac{1}{2}} C_{H,t}^{-1} \quad \rightarrow \quad C_{H,t} = \lambda_t \frac{1}{2} C_t P_{H,t}^{-1},$$
$$P_{F,t} = \lambda_t \frac{1}{2} C_{H,t}^{\frac{1}{2}} C_{F,t}^{\frac{1}{2}} C_{F,t}^{-1} \quad \rightarrow \quad C_{F,t} = \lambda_t \frac{1}{2} C_t P_{F,t}^{-1}.$$

- Use in the consumption constraint:

$$\lambda_t = 2P_{H,t}^{\frac{1}{2}} P_{F,t}^{\frac{1}{2}}.$$

- Equate expenditure:

$$P_t = 2P_{H,t}^{\frac{1}{2}} P_{F,t}^{\frac{1}{2}} = \lambda_t.$$

- Hence demand equations are constant expenditure shares.

Production [AS Block]

- Consider the resource constraint:

$$Z_t \ell_t = C_{H,t} + C^*_{H,t}.$$

- Use demand equations:

$$Z_t \ell_t = \frac{1}{2}\left(\frac{P_t C_t}{P_{H,t}} + \frac{P^*_t C^*_t}{P^*_{H,t}}\right).$$

- Complete asset markets infers risk sharing condition:

$$\mathcal{E}_t = \frac{\mu_t}{\mu^*_t} \quad \rightarrow \quad P_t C_t = \mathcal{E}_t P^*_t C^*_t.$$

- Hence, rewrite the resource constraint as:

$$Z_t \ell_t = \frac{P_t}{2}\left(\frac{1}{P_{H,t}} + \frac{1}{\mathcal{E}_t P^*_{H,t}}\right) C_t \quad \rightarrow \quad Z_t \ell_t \tau_t = C_t.$$

where we define a consumption-output terms of trade:

$$\tau_t \equiv \left[\frac{P_t}{2}\left(\frac{1}{P_{H,t}} + \frac{1}{\mathcal{E}_t P^*_{H,t}}\right)\right]^{-1}.$$

Open-Economy Model

	Home Country	Foreign Country
AD	$C_t = \mu_t / P_t$	$C_t^* = \mu_t^* / P_t^*$
	$P_{H,t} C_{H,t} = \frac{1}{2} P_t C_t$	$P_{H,t}^* C_{H,t}^* = \frac{1}{2} P_t^* C_t^*$
	$P_{F,t} C_{F,t} = \frac{1}{2} P_t C_t$	$P_{F,t}^* C_{F,t}^* = \frac{1}{2} P_t^* C_t^*$
	$P_t = 2 P_{H,t}^{1/2} P_{F,t}^{1/2}$	$P_t^* = 2 P_{H,t}^{*,1/2} P_{F,t}^{*,1/2}$
AS	$C_t = Z_t \ell_t \tau_t$	$C_t^* = Z_t^* \ell_t^* \tau_t^*$
	$\tau_t \equiv \left[\frac{P_t}{2} \left(\frac{1}{P_{H,t}} + \frac{1}{\mathcal{E}_t P_{H,t}^*} \right) \right]^{-1}$	$\tau_t^* \equiv \left[\frac{P_t^*}{2} \left(\frac{1}{P_{F,t}^*} + \frac{\mathcal{E}_t}{P_{F,t}} \right) \right]^{-1}$
NR	$\bar{\ell} = \frac{\theta - 1}{\theta \kappa}$	$\bar{\ell}^* = \frac{\theta - 1}{\theta \kappa}$
XR	$\mathcal{E}_t = \mu_t / \mu_t^*$	

Source: Corsetti and Pesenti (2007), Table 2.1.

Main Differences: Closed Economy vs. Two Country

- Although monetary stance still determines nominal spending, this is now split (equally) between two goods.
- AS equation now translates production into expenditure on both home and foreign products.
- At current prices it now takes $\frac{1}{\tau}$ units of home output for households to purchase one unit of the consumption good.

Closing the Model

- As for the closed economy case, the model is closed by analysing firm's pricing decisions.
- Four distinct possibilities:
  - Flexible prices.
  - Producer Country Pricing (PCP).
  - Local Country Pricing (LCP).
  - Dollar Country Pricing (DCP).

ERPT Theory

- Two critical stages of Exchange Rate Pass-Through (ERPT).

Stage 1. Import prices fluctuate with the exchange rate.

  - Up to some elasticity value changes in exchange rates are reflected in import prices.
  - Depends critically on firm's pricing.
  - Evidence: Campa and Goldberg (2005), Gopinath and Rigobon (2008).

Stage 2. Then, changes in import prices play an important role in driving domestic inflation (ERPT stage 2).

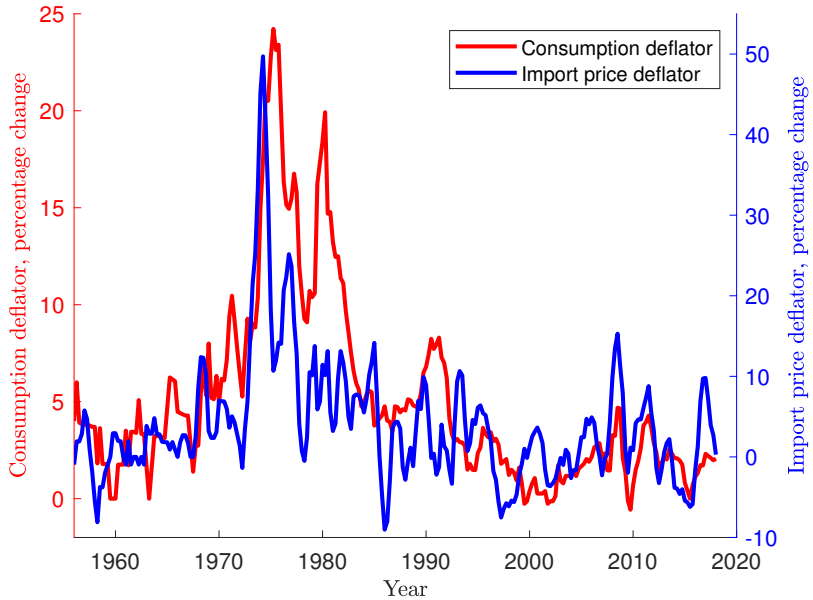
  - ERPT stage 1 depends critically on firm's pricing behaviour.

- Relationship depends critically on specific exogenous shocks. Forbes et al. (2018) (i.e. ERPT is not a structural parameter, rather a price co-movement).

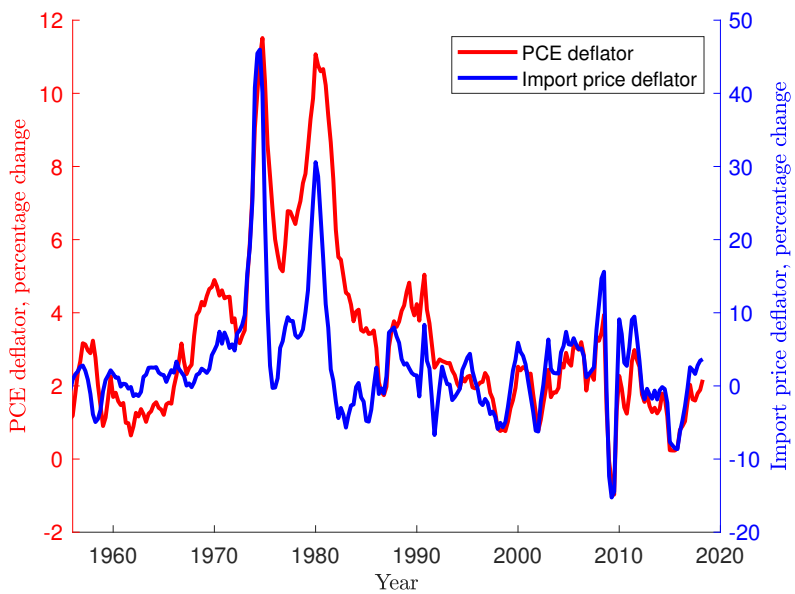
ERPT Evidence

- Strong relationship in aggregate data.
- Here show ERPT stage 2.

UK



US



Sources: ONS and BEA.

Flexible Prices

- In absence of nominal rigidities firms again charge an optimal markup over marginal costs:

$$P_{H,t}^{\text{Flex}} = \mathcal{E}_t P_{H,t}^{*,\text{Flex}} = \frac{\theta\kappa}{\theta - 1}\frac{\mu_t}{Z_t},$$

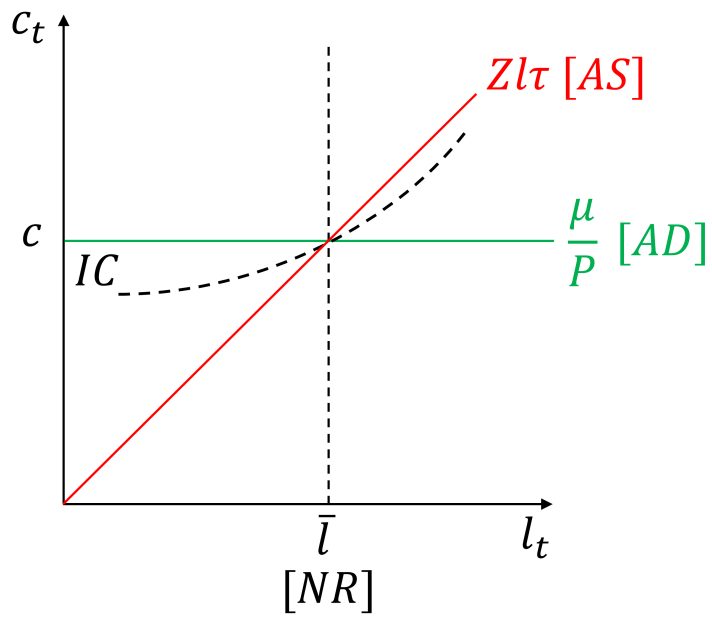
$$P_{F,t}^{*,\text{Flex}} = \frac{P_{F,t}^{\text{Flex}}}{\mathcal{E}_t} = \frac{\theta\kappa}{\theta - 1}\frac{\mu_t^*}{Z_t^*}.$$

- Again, these give rise to the definition of natural rate of employment, and output.

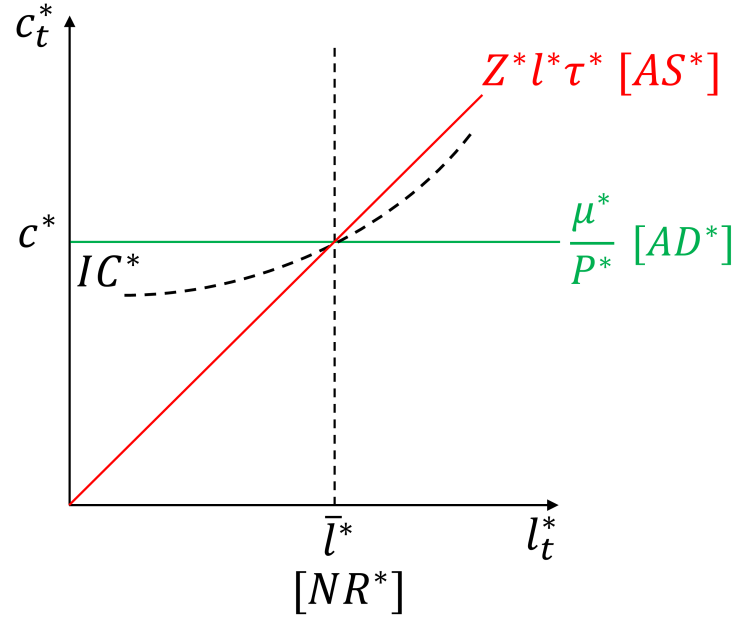
Global Economy Model

- Similar graphical representation.
- Important role for terms of trade, τ.

Home



Foreign



Source: Corsetti and Pesenti (2007).

Nominal Rigidities - I

- Producer Currency Pricing (PCP)
- Firms pre-set prices in their own currency.
- After any shock, prices abroad move one-for-one with the exchange rate.
- $P_{H,t}$ and $P^*_{F,t}$ are "sticky" but $P^*_{H,t}$ and $P_{F,t}$ are not:

$$P_{H,t} = \mathcal{E}_t P^*_{H,t} = \frac{\theta\kappa}{\theta - 1} \mathbb{E}_{t-1}\left[\frac{\mu_t}{Z_t}\right],$$

$$P^*_{F,t} = \frac{P_{F,t}}{\mathcal{E}_t} = \frac{\theta\kappa}{\theta - 1} \mathbb{E}_{t-1}\left[\frac{\mu^*_t}{Z^*_t}\right].$$

- LOOP always holds, with full ERPT.

Nominal Rigidities - II

- Local Currency Pricing (LCP)
- Firms pre-set prices in domestic currency for the domestic market, and foreign currency for the foreign market.
- All prices are "sticky", with no ERPT.

$$P_{H,t} = \frac{\theta\kappa}{\theta - 1}\,\mathbb{E}_{t-1}\left[\frac{\mu_t}{Z_t}\right], \quad \text{and} \quad P^*_{H,t} = \frac{\theta\kappa}{\theta - 1}\,\mathbb{E}_{t-1}\left[\frac{\mu_t}{\mathcal{E}_t Z_t}\right],$$

$$P^*_{F,t} = \frac{\theta\kappa}{\theta - 1}\,\mathbb{E}_{t-1}\left[\frac{\mu^*_t}{Z^*_t}\right], \quad \text{and} \quad P_{F,t} = \frac{\theta\kappa}{\theta - 1}\,\mathbb{E}_{t-1}\left[\frac{\mathcal{E}_t\mu^*_t}{Z^*_t}\right].$$

- Ex post LOOP may fail.

Nominal Rigidities - III

- Dollar Currency Pricing (DCP)
- All internationally traded prices are set in a global currency.
- Here, assume Home country is US, such that the Home country does PCP, while the Foreign country does LCP.
- Asymmetric impact of exchange rate movements.

$$P_{H,t} = \mathcal{E}_t P^*_{H,t} = \frac{\theta\kappa}{\theta - 1}\,\mathbb{E}_{t-1}\left[\frac{\mu_t}{Z_t}\right],$$

$$P^*_{F,t} = \frac{\theta\kappa}{\theta - 1}\,\mathbb{E}_{t-1}\left[\frac{\mu^*_t}{Z^*_t}\right], \quad \text{and} \quad P_{F,t} = \frac{\theta\kappa}{\theta - 1}\,\mathbb{E}_{t-1}\left[\frac{\mathcal{E}_t\mu^*_t}{Z^*_t}\right].$$

- LOOP holds for Home country but may fail ex post in Foreign.

Summary: 4 Modelling Frameworks

- Flexible Prices:

$$P_{H,t}^{\text{Flex}} = \mathcal{E}_t P_{H,t}^{*,\text{Flex}} = \frac{\theta\kappa}{\theta-1}\frac{\mu_t}{Z_t}, \quad \text{and} \quad P_{F,t}^{*,\text{Flex}} = \frac{P_{F,t}^{\text{Flex}}}{\mathcal{E}_t} = \frac{\theta\kappa}{\theta-1}\frac{\mu_t^*}{Z_t^*}.$$

- Producer Currency Pricing (PCP):

$$P_{H,t} = \mathcal{E}_t P_{H,t}^* = \frac{\theta\kappa}{\theta-1}\mathbb{E}_{t-1}\left[\frac{\mu_t}{Z_t}\right], \quad \text{and} \quad P_{F,t}^* = \frac{P_{F,t}}{\mathcal{E}_t} = \frac{\theta\kappa}{\theta-1}\mathbb{E}_{t-1}\left[\frac{\mu_t^*}{Z_t^*}\right].$$

- Local Currency Pricing (LCP):

$$P_{H,t} = \frac{\theta\kappa}{\theta-1}\mathbb{E}_{t-1}\left[\frac{\mu_t}{Z_t}\right], \quad \text{and} \quad P_{H,t}^* = \frac{\theta\kappa}{\theta-1}\mathbb{E}_{t-1}\left[\frac{\mu_t}{\mathcal{E}_t Z_t}\right],$$
$$P_{F,t}^* = \frac{\theta\kappa}{\theta-1}\mathbb{E}_{t-1}\left[\frac{\mu_t^*}{Z_t^*}\right], \quad \text{and} \quad P_{F,t} = \frac{\theta\kappa}{\theta-1}\mathbb{E}_{t-1}\left[\frac{\mathcal{E}_t\mu_t^*}{Z_t^*}\right].$$

- Dollar Currency Pricing (DCP):

$$P_{H,t} = \mathcal{E}_t P_{H,t}^* = \frac{\theta\kappa}{\theta-1}\mathbb{E}_{t-1}\left[\frac{\mu_t}{Z_t}\right],$$
$$P_{F,t}^* = \frac{\theta\kappa}{\theta-1}\mathbb{E}_{t-1}\left[\frac{\mu_t^*}{Z_t^*}\right], \quad \text{and} \quad P_{F,t} = \frac{\theta\kappa}{\theta-1}\mathbb{E}_{t-1}\left[\frac{\mathcal{E}_t\mu_t^*}{Z_t^*}\right].$$

International Transmission Mechanism

- Having detailed four versions of the model, now consider shocks and the international transmission mechanism.
- How do productivity shocks transmit?
- Is there a role for the terms of trade?
- How may transmission be influenced by monetary policy?
- Given a productivity shock, in all models natural rates are unchanged. $\mathbb{E}_{t-1}[\ell_t] = \bar{\ell}$.
- Responses may differ between countries. Source of the shock matters (Home or Foreign).

Productivity Shock ($Z_t \uparrow$) - Flexible Prices (Maths)

- Labour supply:

$$\ell_t = \bar{\ell} \rightarrow Y_{H,t} = Z_t \bar{\ell}.$$

- Consumption:

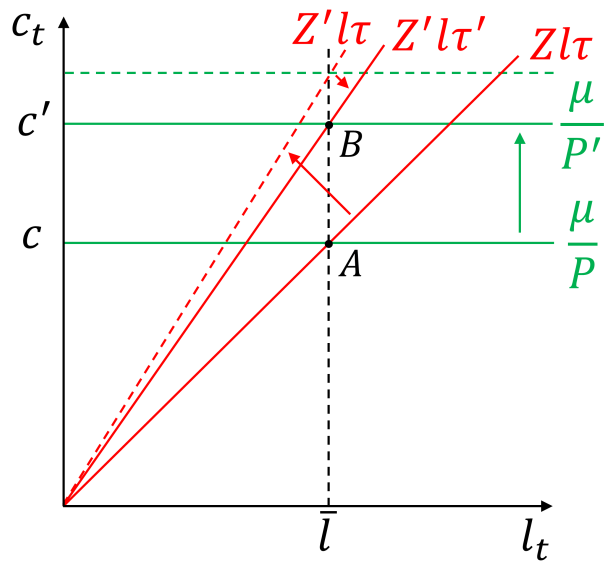
$$C_t = Z_t \bar{\ell} \tau_t = Z_t \bar{\ell} \left(\frac{P_{H,t}}{P_{F,t}} \right)^{\frac{1}{2}} = Z_t \bar{\ell} \left(\frac{Z_t^*}{Z_t} \right)^{\frac{1}{2}} = Z_t^{\frac{1}{2}} Z_t^{*,\frac{1}{2}} \bar{\ell} = C_t^*.$$

- Transmission of productivity shocks is **positive**. Both countries benefit from productivity increases.
- Two components to the shock. Primary (direct) effect via $Z_t \uparrow$ and secondary effect via $\tau_t \downarrow$.
- Policy, μ_t, does not matter. An increase in nominal spending is matched by an adjustment in nominal prices.

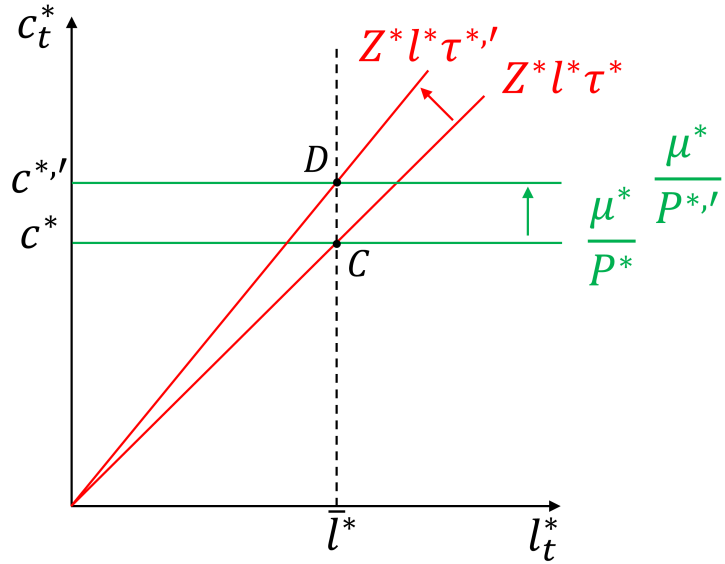
Productivity Shock ($Z_t \uparrow$) - Flexible Prices (Graph)

- In Home, $\tau_t \downarrow$ partially offsets the initial shock.
- In Foreign, $\tau_t^* \uparrow$ causes movement.

Home



Foreign



Source: Corsetti and Pesenti (2007).

Productivity Shock ($Z_t \uparrow$) - Flexible Prices (Intuition I)

- Primary Effects for Home:
  - Productivity increase rotates the AS curve upwards.
- Secondary Effects for Home:
  - Higher $Y_{H,t}$ supply deteriorates τ_t (lower international price).
  - AS curve rotates downwards, partially offsetting initial movement (Secondary).
  - Given the monetary stance, μ_t, $P_{H,t}$ falls one-to-one with the productivity increase.
  - Home CPI also falls, but by less, as part of Home price level reflects consumption of Foreign goods.
  - AD shifts upwards.
  - As $\tau_t \downarrow$ partially offsets initial $Z_t \uparrow$, equilibrium changes are smaller than in the closed-economy setting.

Productivity Shock ($Z_t \uparrow$) - Flexible Prices (Intuition II)

- Home productivity change **spills over** to Foreign country.
- When production of Home good increases, Foreign import prices fall and, Foreign terms of trade improve $\tau_t^* \uparrow$.
- AS curve rotates upwards.
- Unambiguous utility **gain** for the Foreign country.

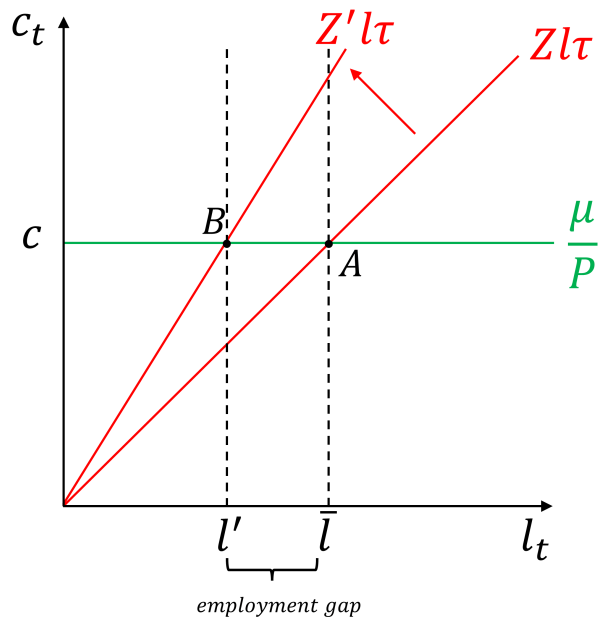
Productivity Shock ($Z_t \uparrow$) - Sticky Prices (Intuition)

- The nominal exchange rate does not move with productivity shift, only monetary factors.
- Thus the shock (itself) has no impact on import prices, which are either sticky themselves (LCP), or move with the nominal exchange rate (PCP).
- Without price changes, aggregate demand is constant and higher productivity generates an employment and output gap - as in the closed-economy setting.

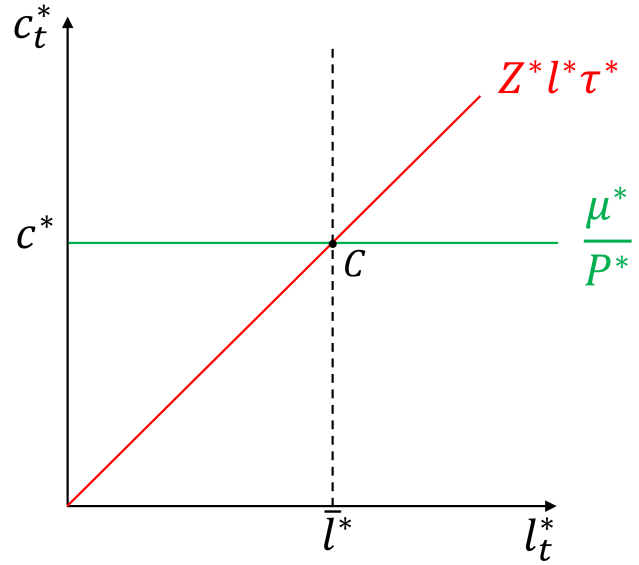
Productivity Shock ($Z_t \uparrow$) - Sticky Prices (Graph)

- In Home, sticky prices causes a positive output gap.
- International non-transmission of shock (as $\mathcal{E}_t$ unchanged).

Home



Foreign



Source: Corsetti and Pesenti (2007).

Stabilisation Policy from $Z_t \uparrow$ Under PCP (Maths)

- Allocations:

$$\ell_t = \frac{\mu_t / Z_t}{\mathbb{E}_{t-1}[\mu_t / Z_t]} \bar{\ell}, \qquad \ell_t^* = \frac{\mu_t^* / Z_t^*}{\mathbb{E}_{t-1}[\mu_t^* / Z_t^*]} \bar{\ell},$$

$$\tau_t = \frac{1}{2} \left(\frac{\mathbb{E}_{t-1}[\mu_t / Z_t]}{\mathbb{E}_{t-1}[\mu_t^* / Z_t^*]} \frac{1}{\mathcal{E}_t} \right)^{\frac{1}{2}}, \qquad \tau_t^* = \frac{1}{2} \left(\frac{\mathbb{E}_{t-1}[\mu_t^* / Z_t^*]}{\mathbb{E}_{t-1}[\mu_t / Z_t]} \mathcal{E}_t \right)^{\frac{1}{2}},$$

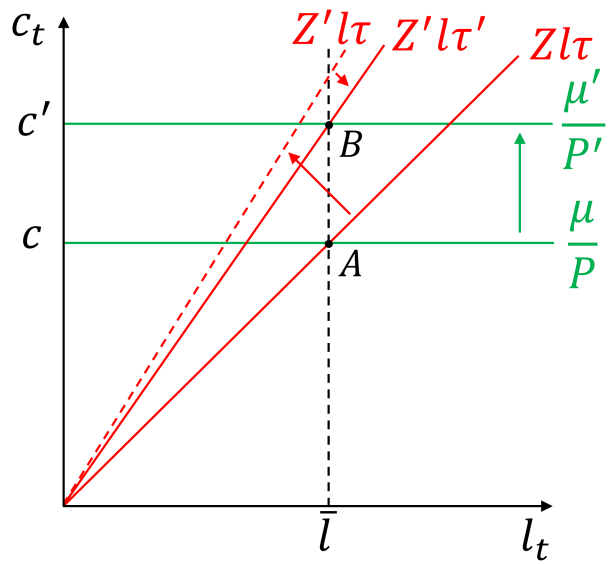
$$C_t = \bar{\ell} \frac{\mu_t^{\frac{1}{2}} \mu_t^{*,\frac{1}{2}}}{2 \, \mathbb{E}_{t-1}[\mu_t / Z_t]^{\frac{1}{2}} \, \mathbb{E}_{t-1}[\mu_t^* / Z_t^*]^{\frac{1}{2}}} = C_t^*,$$

- Home productivity shocks only affect Home employment.
- AD shocks have spillovers on C_t^*, but not on output abroad.
- Monetary response: an expansion, $\mu_t \uparrow$, causes a nominal depreciation, $\mathcal{E}_t \uparrow$, and terms of trade **deterioration**, $\tau_t \downarrow$.
- Monetary transmission is **positive**, as it raises consumption abroad for any level of labour effort.

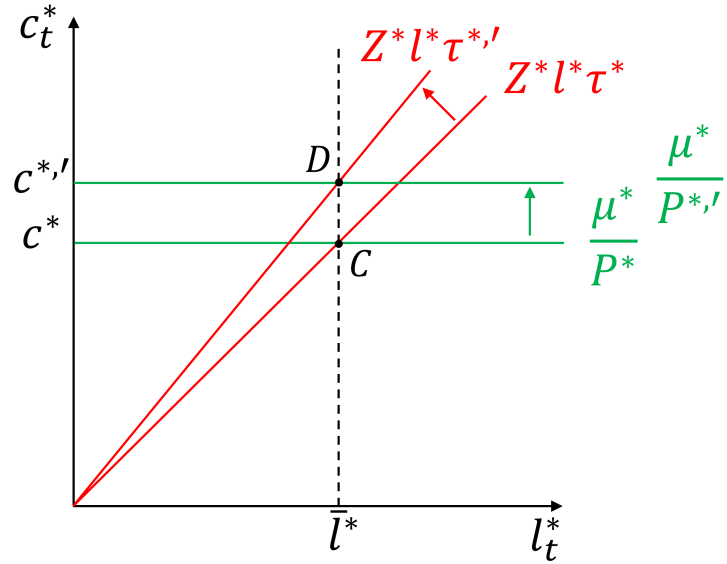
Stabilisation Policy from $Z_t \uparrow$ Under PCP (Graph)

- Home CB responds to remove output gap.
- $\tau_t \downarrow$ as deteriorating Home ToT, while $\tau_t^* \uparrow$.

Home



Foreign



Source: Corsetti and Pesenti (2007).

Productivity Shock ($Z_t \uparrow$) - PCP (Intuition)

- Under PCP the policy prescription is the same as closed-economy case: world (relative) price of home goods must fall.
- Stabilisation is achieved via exchange rate manipulation (depreciation here), flexible exchange rate is desirable.
- **Expenditure switching** effects with PCP:
  - LOOP holds: $ToT_t = P_{F,t}/\mathcal{E}_t P^*_{H,t} = P^*_{F,t}\mathcal{E}_t/P_{H,t} = ToT^*_t$.
  - As $P_{H,t}$ and $P^*_{F,t}$ are preset, the $ToT_t \uparrow$ (worsens) with a nominal depreciation of the Home currency (i,e. a higher $\mathcal{E}_t$). When the Home currency weakens, Home goods are cheaper relative to Foreign goods in both the Home and the Foreign country.
  - Demand shifts in favour of the good with the lowest relative price: world consumption of Home goods increases relative to consumption of Foreign goods.

Stabilisation Policy from $Z_t \uparrow$ Under LCP (Maths)

- Allocations:

$$\ell_t = \frac{1}{2}\Big(\frac{\mu_t/Z_t}{\mathbb{E}_{t-1}[\mu_t/Z_t]} + \frac{\mu_t^*/Z_t}{\mathbb{E}_{t-1}[\mu_t^*/Z_t]}\Big)\bar{\ell}, \qquad \ell_t^* = \frac{1}{2}\Big(\frac{\mu_t^*/Z_t^*}{\mathbb{E}_{t-1}[\mu_t^*/Z_t^*]} + \frac{\mu_t/Z_t^*}{\mathbb{E}_{t-1}[\mu_t/Z_t^*]}\Big)\bar{\ell},$$

$$\tau_t = \frac{\Big(\frac{\mathbb{E}_{t-1}[\mu_t/Z_t]}{\mathbb{E}_{t-1}[\mu_t/Z_t^*]}\Big)^{\frac{1}{2}}}{1 + \frac{\mathbb{E}_{t-1}[\mu_t/Z_t]}{\mathbb{E}_{t-1}[\mu_t^*/Z_t]}\frac{1}{\mathcal{E}_t}} \qquad \tau_t^* = \frac{\Big(\frac{\mathbb{E}_{t-1}[\mu_t^*/Z_t^*]}{\mathbb{E}_{t-1}[\mu_t^*/Z_t]}\Big)^{\frac{1}{2}}}{1 + \frac{\mathbb{E}_{t-1}[\mu_t^*/Z_t^*]}{\mathbb{E}_{t-1}[\mu_t/Z_t^*]}\mathcal{E}_t},$$

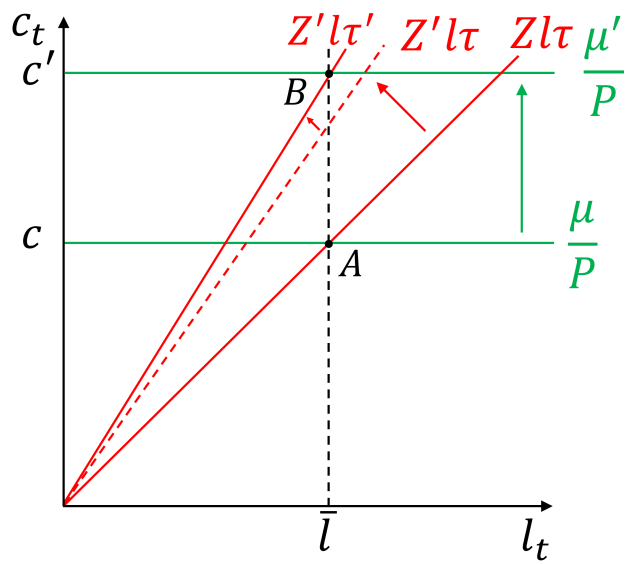
$$C_t = \frac{\mu_t}{2(\mathbb{E}_{t-1}[\mu_t/Z_t])^{1/2}(\mathbb{E}_{t-1}[\mu_t/Z_t^*])^{1/2}}\bar{\ell}, \qquad C_t^* = \frac{\mu_t^*}{2(\mathbb{E}_{t-1}[\mu_t^*/Z_t^*])^{1/2}(\mathbb{E}_{t-1}[\mu_t^*/Z_t])^{1/2}}\bar{\ell}^*.$$

- Current productivity only affects Home employment.
- AD shocks have spillovers on output and employment abroad.
- Monetary response: an expansion, $\mu_t \uparrow$, causes a nominal depreciation, $\mathcal{E}_t \uparrow$, and terms of trade **improvement**, $\tau_t \uparrow$.
- Monetary transmission is **negative**, as it raises labour effort abroad for a given level of consumption.
- Again, it is the stabilisation policy (rather than the shock) which causes international transmission.

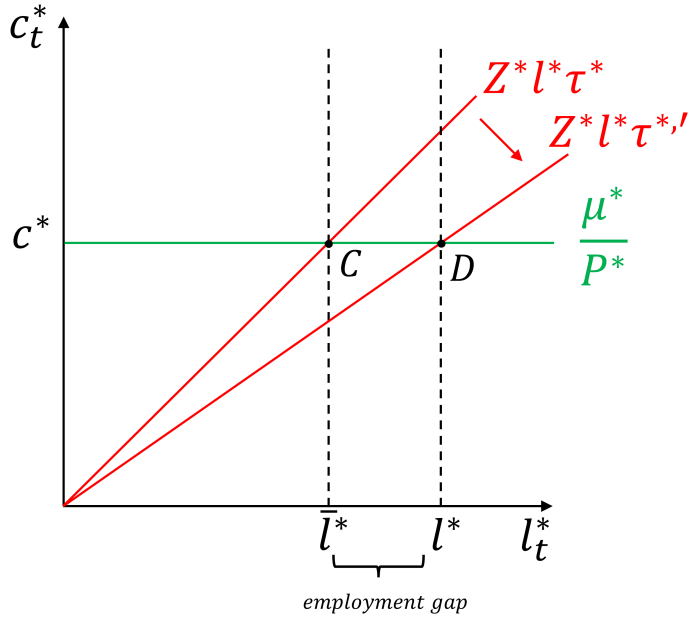
Stabilisation Policy from $Z_t \uparrow$ Under LCP (Graph)

- Home CB responds to remove output gap.
- $\tau_t \uparrow$ as improving Home ToT, while $\tau_t^* \downarrow$.

Home



Foreign



Source: Corsetti and Pesenti (2007).

Productivity Shock ($Z_t \uparrow$) - LCP (Intuition)

- Under LCP prices are preset in local currency.
- A depreciation, $\mathcal{E}_t \uparrow$, improves the Home TOT, $P_{F,t}/\mathcal{E}_t P^*_{H,t}$. (Increase Home exporters' sales revenue and reduces Foreign exporters' sales revenue without impact on relative prices).
- No **expenditure switching** (relative prices are preset).
- Depreciation now has a positive impact on τ_t and negative on τ^*_t - the opposite of the PCP case. A positive Home productivity shock may be very nasty for the Foreign country.
- **Beggar–thy-neighbour** transmission of monetary policy, as C_t and ℓ^*_t increase.
- No monetary spillovers on consumption.

Stabilisation Policy from $Z_t \uparrow$ Under DCP (Maths)

- Allocations:

$$\ell_t = \frac{\mu_t / Z_t}{\mathbb{E}_{t-1}[\mu_t / Z_t]}\bar{\ell}, \qquad \ell_t^* = \frac{1}{2}\Big(\frac{\mu_t^* / Z_t^*}{\mathbb{E}_{t-1}[\mu_t^* / Z_t^*]} + \frac{\mu_t / Z_t^*}{\mathbb{E}_{t-1}[\mu_t / Z_t^*]}\Big)\bar{\ell},$$

$$\tau_t = \frac{1}{2}\Big(\frac{\mathbb{E}_{t-1}[\mu_t / Z_t]}{\mathbb{E}_{t-1}[\mu_t / Z_t^*]}\Big)^{\frac{1}{2}}, \qquad \tau_t^* = \frac{\Big(\mathcal{E}_t \frac{\mathbb{E}_{t-1}[\mu_t^* / Z_t^*]}{\mathbb{E}_{t-1}[\mu_t / Z_t]}\Big)^{\frac{1}{2}}}{1 + \frac{\mathbb{E}_{t-1}[\mu_t^* / Z_t^*]}{\mathbb{E}_{t-1}[\mu_t / Z_t^*]}\mathcal{E}_t}$$

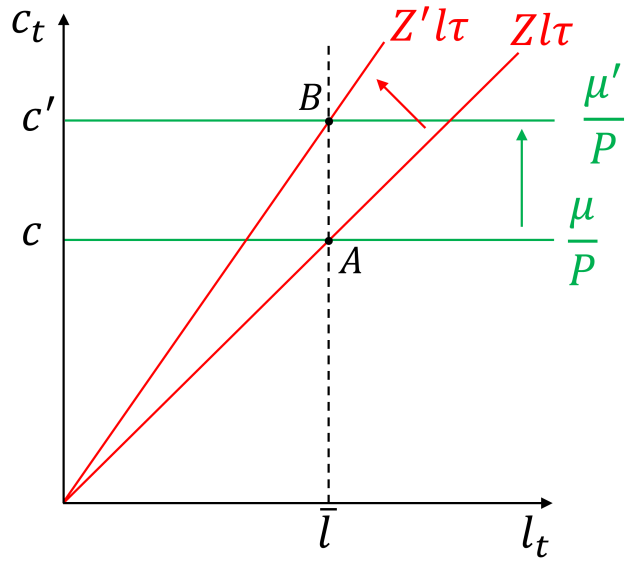
$$C_t = \bar{\ell}\frac{\mu_t}{2\,\mathbb{E}_{t-1}[\mu_t / Z_t]^{\frac{1}{2}}\,\mathbb{E}_{t-1}[\mu_t / Z_t^*]^{\frac{1}{2}}}, \qquad C_t^* = \bar{\ell}\frac{\mu_t^{1/2}\mu_t^{*,1/2}}{2(\mathbb{E}_{t-1}[\mu_t^* / Z_t^*])^{1/2}(\mathbb{E}_{t-1}[\mu_t / Z_t])^{1/2}}.$$

- Current productivity only affects Home employment.
- Home allocations are **completely insulated** from external shocks (asymmetric).
- Monetary response: an expansion, $\mu_t \uparrow$, causes a nominal depreciation, $\mathcal{E}_t \uparrow$, but **no terms of trade impact** at Home.

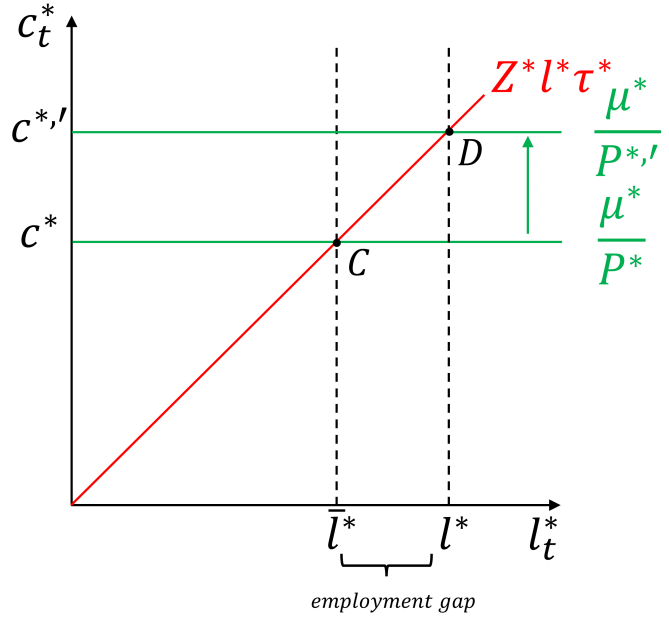
Stabilisation Policy from $Z_t \uparrow$ Under DCP (Graph)

- Home CB responds to remove output gap.
- τ_t unchanged. Assume τ_t^* also unchanged.

Home



Foreign



Source: Corsetti and Pesenti (2007).

Productivity Shock ($Z_t \uparrow$) - DCP (Intuition)

- No reaction in Home prices to exchange rate.
- Home depreciation has two effects on the Foreign country:
  1. Lowers import prices in the Foreign country, improving τ^*.
  2. Reduces sales revenue for Foreign exporters, lowering τ^*.
- Which effect prevails depends on the sign of:

$$\mathcal{E}_t^{-1/2} - \mathcal{E}_t^{-1/2}\, \mathbb{E}_{t-1}[\mu_t^*/Z_t^*]/\, \mathbb{E}_{t-1}[\mu_t/Z_t^*].$$

- When evaluated around a non-stochastic equilibrium, this expression is zero. I.e. a home depreciation has no first-order effects on τ^*.
- Yet, Home monetary policy has spillovers for both Foreign output and consumption.
- If labour increases by, say, $\delta\bar{\ell}$, consumption increases by $Z_t^*\delta\bar{\ell}$.

Optimal Monetary Policy

- Previous discussion was ad hoc.
- Fundamental question: given these effects, what response of monetary policymakers can be considered **optimal**?

Optimal Monetary Policy - Non-cooperative Optimal Policy

- Assume monetary authorities have **perfect commitment**.
- Define the welfare functions:

$$\mathcal{W}_t \equiv \mathbb{E}_{t-1}[U_t] \quad \text{and} \quad \mathcal{W}_t^* \equiv \mathbb{E}_{t-1}[U_t^*].$$

- In the absence of international coordination, Home policymakers determine their optimal monetary stance by maximising W_t, with respect to μ_t, while taking μ_t^* as given.
- Foreign monetary policymakers behave in the same way.
- The two optimal monetary policy stances then define the following **Nash equilibrium**:

$$\mu_{t,\text{Non-coop}} = \arg\max_{\mu_t} \mathcal{W}_t,$$

$$\mu_{t,\text{Non-coop}}^* = \arg\max_{\mu_t^*} \mathcal{W}_t^*.$$

Optimal Monetary Policy - Cooperation

- Instead, to characterise cooperative policymaking we posit that policymakers jointly maximise an equally weighted average of Home and Foreign welfare:

$$\{\mu_{t,\text{Coop}}, \mu^*_{t,\text{Coop}}\} = \arg\max_{\mu_t, \mu^*_t} \frac{1}{2}\mathcal{W}_t + \frac{1}{2}\mathcal{W}^*_t.$$

  where the weights coincide with the size of each country.

- In all our models, recall that $\mathbb{E}_{t-1}[\ell_t] = \bar{\ell}$, so that the second term in the utility function is independent of monetary policy and we need to focus on consumption only.

- In fact, welfare can be written as:

$$\mathcal{W}_t = \mathbb{E}_{t-1} \ln C_t + \text{constant (independent of } \mu_t).$$

Recall: Distortions in the Economy

- Monopoly power in production.
- Monopoly power on the terms of trade: atomistic firms disregard the effect of their supply / pricing decision on the aggregate terms of trade for their country.
- Nominal rigidities.

Flexible Price Model

- No role for monetary policy, because we have flexible prices:
- Price level:

$$P_{H,t} = \frac{\theta\kappa}{\theta - 1}\Gamma_t.$$

- Labour supply:

$$\ell_t = \bar{\ell} = \frac{\theta - 1}{\theta\kappa} \rightarrow Y_{H,t} = Z_t\bar{\ell}.$$

- Consumption:

$$C_t = Z_t^{\frac{1}{2}} Z_t^{*,\frac{1}{2}} \bar{\ell} = C_t^*.$$

where Γ_t is the nominal scale of the economy.

Optimal Policy Under PCP I

- Formulate the policy problem:

$$\max_{\mu_t} \mathbb{E}_{t-1} \ln C_t = \mathbb{E}_{t-1} \ln \frac{\theta - 1}{\theta \kappa} \frac{\mu_t^{1/2} \mu_t^{*,1/2}}{2(\mathbb{E}_{t-1}[\mu_t / Z_t])^{1/2} (\mathbb{E}_{t-1}[\mu_t^* / Z_t^*])^{1/2}},$$

$$\max_{\mu_t} \mathbb{E}_{t-1} \ln C_t = \frac{1}{2} \mathbb{E}_{t-1} \ln \mu_t + \frac{1}{2} \mathbb{E}_t \ln \mu_t^* - \frac{1}{2} \ln \mathbb{E}_{t-1} \mu_t / Z_t - \frac{1}{2} \mathbb{E}_{t-1}[\mu_t^* / Z_t^*].$$

- First order condition:

$$\frac{1}{2} \frac{1}{\mu_t} - \frac{1}{2} \frac{1/Z_t}{\mathbb{E}_{t-1}[\mu_t / Z_t]} = 0.$$

- This is precisely the same expression as in a closed economy.
- Home monetary policy responds to real shocks one-for-one, stabilising Home firms' marginal costs.
- The FOC is solved by

$$\mu_t = \Gamma_t Z_t.$$

Optimal Policy Under PCP II

- Substituting into optimal pricing:

$$P_{H,t} = \frac{\theta\kappa}{\theta - 1}\mathbb{E}_{t-1}\left[\frac{\mu_t}{Z_t}\right] = \frac{\theta\kappa}{\theta - 1}\Gamma_t.$$

- Optimal policy is a commitment to provide a nominal anchor for the economy, Γ_t, (nominal trend).
- Only deviate when:
  1. Current productivity shocks threaten to destabilise marginal costs.
  2. Anticipated shocks threaten to raise demand for a given current productivity.

  Both move employment and output away from potential.
- Optimal policy is **inward looking**.

Non-Cooperative vs. Cooperative Policy Under PCP

- Under PCP, the national objective function for the Foreign policy makers is **identical** to the Home objective function $\mathcal{W} = \mathcal{W}^*$.
- Maximising an average of $\mathcal{W}$ and $\mathcal{W}^*$ yields exactly the same optimal policy prescriptions as the Nash optimal rule.
- The non-cooperative rules remain the best policy rules.
- Implies: international policy cooperation is **redundant**.
- By "*keeping ones own house in order*" policymakers are already able to achieve economic efficiency.

Arguments Against Cooperation

1. Cooperation is not sustainable.

2. Cooperation is not effective.

3. By the time you cooperate, it's too little too late. You can't cooperate quickly enough.

4. Cooperation is irrelevant for these shocks.

Optimal Policy Under LCP I

- Formulate the policy problem, for Home:

$$\max_{\mu_t} \mathbb{E}_{t-1} \ln C_t = \mathbb{E}_{t-1} \ln \frac{\theta - 1}{\theta \kappa} \frac{\mu_t}{2(\mathbb{E}_{t-1}[\mu_t / Z_t])^{1/2} (\mathbb{E}_{t-1}[\mu_t / Z_t^*])^{1/2}},$$

$$\max_{\mu_t} \mathbb{E}_{t-1} \ln C_t = \mathbb{E}_{t-1} \ln \mu_t - \frac{1}{2} \ln \mathbb{E}_{t-1} \mu_t / Z_t - \frac{1}{2} \mathbb{E}_{t-1}[\mu_t / Z_t^*].$$

- First order condition, for Home:

$$\frac{1}{\mu_t} - \frac{1}{2} \frac{1/Z_t}{\mathbb{E}_{t-1}[\mu_t / Z_t]} - \frac{1}{2} \frac{1/Z_t^*}{\mathbb{E}_{t-1}[\mu_t / Z_t^*]} = 0.$$

- For Foreign:

$$\frac{1}{\mu_t^*} - \frac{1}{2} \frac{1/Z_t^*}{\mathbb{E}_{t-1}[\mu_t^* / Z_t^*]} - \frac{1}{2} \frac{1/Z_t}{\mathbb{E}_{t-1}[\mu_t^* / Z_t]} = 0.$$

- Highlights an international dimension in monetary policy.
- Respond to **both** Z_t and Z_t^*, with weights given by the relative importance of domestic and foreign goods in consumption.

Optimal Policy Under LCP II

- Home policymakers face a trade-off:
  - Stabilise the markups of domestic producers' (lower Home goods prices).
  - Stabilise the markups of Foreign producers' (lower import prices).
- Optimal policy balances these two effects and is therefore not "*inward looking*".
- Optimal policy prescribes a move towards targetting CPI, instead of the GDP deflator (as in PCP).

Non-Cooperative vs. Cooperative Policy Under LCP

- **No gains** from monetary coordination under LCP!
- In PCP this was as decisions were **already efficient**, with LCP this arises due to **limited gains** from monetary policy action.
- Under LCP, home monetary policy shocks have **large spillovers** on employment and output abroad.
- Yet, in our parameterisation there are no gains from international policy coordination, because there are **no spillovers** on Foreign consumption.
- $C_t^* = \mu_t^* P_t^*$ does not move with μ_t as P_t^* is predetermined.
- Coordinating monetary policy is useless in addressing the labour and output inefficiency spillovers due to the **natural rate** property of the model:

$$\mathbb{E}_{t-1}[\ell_t] = \bar{\ell}.$$

Optimal Policy Under DCP

- When world exports are priced in Home currency, Home optimal monetary policy is still described by Nash LCP.
- Instead, in the Foreign country welfare is:

$$\max_{\mu_t^*} \mathbb{E}_{t-1} \ln C_t^* = \mathbb{E}_{t-1} \ln \frac{\theta - 1}{\theta \kappa} \frac{\mu_t^{1/2} \mu_t^{*,1/2}}{2(\mathbb{E}_{t-1}[\mu_t^*/Z_t^*])^{1/2}(\mathbb{E}_{t-1}[\mu_t/Z_t])^{1/2}},$$

$$\max_{\mu_t^*} \mathbb{E}_{t-1} \ln C_t^* = \frac{1}{2} \mathbb{E}_{t-1} \ln \mu_t + \frac{1}{2} \mathbb{E}_{t-1} \ln \mu_t^* - \frac{1}{2} \ln \mathbb{E}_t[\mu_t^*/Z_t^*] - \frac{1}{2} \ln \mathbb{E}_{t-1}[\mu_t/Z_t].$$

- Optimal policy satisfies the FOC:

$$\frac{1}{2} \frac{1}{\mu_t^*} - \frac{1}{2} \frac{1/Z_t^*}{\mathbb{E}_{t-1}[\mu_t^*/Z_t^*]} = 0$$

- In a Nash equilibrium, the country that issues the vehicle currency (here Home) optimally responds to shocks hitting the global economy.
- The country that uses the vehicle currency (here Foreign) only needs to stabilise domestic prices and markups.

Non-Cooperative vs. Cooperative Policy Under DCP

- Incentive for cooperation with DCP, as under cooperation **world welfare increases**.
- But is this desirable for both countries?
- Both cooperative and non-cooperative optimal policy rules coincide for the Foreign country, but not for Home.
- This suggests that the gains from cooperation are **one-way**.
- The **contribution** to cooperation is therefore unilateral: only the Home country is expected to modify its rules.
- So what is the incentive for this country to enter any binding cooperative agreement for stabilisation policy?

Optimal Policy: Summary

- PCP: target **GDP deflator** (let exchange rate movements correct relative prices).
- LCP: target **CPI** (minimise overall consumption price movements).
- Under DCP gains from cooperation are **unilateral**.
- Large caveats. Cost-push shocks? Rigidities in the labour market?

Discretion vs. Commitment

- Under discretion, Home policymakers maximise utility wrt μ_t after observing Z_t and Z_t^*. Prices and Foreign policy are given.
- The Foreign policymaker solves a similar problem.
- Incentive for policymaker to **deviate** ex post, after prices have been set, to undo distortionary losses (expand / contract monetary policy relative to private expectations).
- Discretion **may not have a solution**; commitment does.
- Strength of this motive depends on the trade-off between the terms of trade and monopolistic competition distortions.
- In a closed economy (no ToT distortions) unambiguous inflationary bias.

Summary

- Simplified a vast body of literature with a tractable model.
- Clear that many questions on monetary transmission depend crucially on firms' pricing decisions.
- Next lecture: uncertainty and portfolio diversification (Emile).

- Thanks for a fun five weeks!

References I

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