International price discrimination, imperfect pass-through and deviations from the Law of One Price

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1 Introduction

The early debate between PCP and LCP stresses 'pass-through' as a fundamental structural feature for the design of optimal monetary policy. Indeed, the LCP model solved in previous lecture provides an analytically important example of international dimension of monetary policy.

However, one can write models where incomplete pass-through has no implications for monetary policy. On the other hand, the general principle for an international dimension of optimal monetary policy may be more general than the example.

In this lecture, we move beyond the PCP-LCP debate.

What do we know about exchange rate pass-through (ERPT)?

- ERPT is different for border and consumer prices
  - far from complete for international (import) prices,
  - drops substantially for consumer prices

- ERPT different across industries

- ERPT changes over different time horizons
  - incomplete ERPT is not only a short-run phenomenon; ERPT remains incomplete over long horizon.
- ERPT may reflects different mechanisms
  - Optimal price discrimination (preferences, technology, market structure etc.)
  - Nominal rigidities

The key issue: To what extent local currency price stability of imports can be explained by nominal rigidities?

- It is well understood that the low elasticity of import prices with respect to the exchange rate is in large part due to the incidence of distribution (Burstein, Eichenbaum and Rebelo 2006).

- Several macro and micro contributions have emphasized the role of optimal destination-specific markup adjustment by monopolistic firms depending on market structure (Dornbusch 1997, Goldberg and Verboven 2001), or vertical interactions between producers and retailers (Corsetti and Dedola 2005).

The main point is that low pass-through is not necessarily incompatible with expenditure switching effects (see e.g. Obstfeld 2002).

The Obstfeld and Rogoff hurdle

Obstfeld and Rogoff 2000 emphasizes that, in the data (and consistent with the received wisdom), nominal depreciation does tend to be associated with deteriorating terms of trade. This piece of evidence clearly sets an empirical hurdle for LCP models assuming a high degree of price stickiness in local currency. In the model with LCP and one period preset price, a nominal depreciation appreciates the terms of trade.

Estimates of LCP models downplaying price discrimination, distribution and other real determinants of incomplete pass-through (see e.g. Lubik and Schorfeide 2006) predict that the degree of price stickiness is implausibly higher for imports than for domestic goods, a result suggesting model mis-specification and failing the OR hurdle above.

However, some degree of rigidities of exports in local prices may pass the test (see Corsetti, Dedola and Leduc 2005 for a quantitative assessment).

In models assuming CES utility, firms have no incentive to price discriminate in a flex price equilibrium

$$p = Ep^* = markup * E(mc)$$

Usually, these models make no distinction between consumer and import price. In what follows we explore one way to move away from the PCP and LCP debate, accounting for endogenous pricing to market and incomplete pass-through:

- Upstream firms with monopoly power sell tradables to competitive retailers situated in different locations.

- Because of local-input-intensive distribution services, the elasticity of demand differs across markets for the same good.

What do we get from this?

1. A model with realistic features – allowing for nontradability and distributive trade.

2. Deviations from the law of one price (at both wholesale and retail level) derive *endogenously* from optimal pricing by monopolistic firms.

3. Because of optimal cross-border price discrimination, exchange rate pass-through is incomplete — its degree depending on the type of shocks hitting the economy.

2 The economy

Same setup as in the model of the previous lectures (two countries, two types of tradable goods H and F, many brands supplied by imperfectly competitive firms, no capital accumulation. It also works with firms entry). Two new features:

- *Nontraded goods* (denoted by N) so that consumption is now

$$
\begin{aligned}
C_t(j) &\equiv \frac{C_{\mathrm{T},t}(j)^{\xi} C_{\mathrm{N},t}(j)^{1-\xi}}{\xi^{\xi}(1-\xi)^{1-\xi}} \\
C_{\mathrm{T},t}(j) &\equiv 2 C_{\mathrm{H},t}(j)^{1/2} C_{\mathrm{F},t}(j)^{1/2} \\
C_{\mathrm{N},t}(j) &\equiv \left[\int_0^1 C_t(n,j)^{\frac{\theta-1}{\theta}} dn\right]^{\frac{\theta}{\theta-1}}.
\end{aligned}
$$

- *Distribution services* .As in Erceg and Levin [1995] and Burstein, Neves and Rebelo [2001], bringing one unit of traded goods to consumers requires η units of a basket of differentiated nontraded goods

$$\eta = \left[\int_0^1 \eta(n)^{\frac{\theta-1}{\theta}} dn \right]^{\frac{\theta}{\theta-1}} .$$

  for simplicity, this is the same Dixit-Stiglitz index of tradable consumption.

2.1 Optimal price discrimination

Consider first **optimal prices of nontraded goods.** Since here we abstract from distribution, we derive the familiar expression

$$p_t(n) = P_{\mathsf{N},t} = \frac{\theta}{\theta - 1}\frac{W_t}{Z_{\mathsf{N},t}} = mk \cdot MC.$$

Optimal pricing is instead different for **traded goods.** Let $\bar{p}_t(h)$ denote the price of brand h expressed in the Home currency, at *producer* level. With a competitive distribution sector, the consumer price of good h is simply

$$p_t(h) = \bar{p}_t(h) + \eta P_{\mathsf{N},t}.$$

In the tradable sector, the Home representative firm maximizes

$$[\bar{p}_t(h)C_t(h) + \mathcal{E}_t\bar{p}_t^*(h)C_t^*(h)] - \frac{W_t}{Z_{\mathsf{H},t}}[C_t(h) + C_t^*(h)]$$

where

$$\begin{aligned} C_t(h) &= \left(\frac{\bar{p}_t(h) + \eta P_{\mathsf{N},t}}{P_{\mathsf{H},t}}\right)^{-\theta} C_{\mathsf{H},t}, \\ C_t^*(h) &= \left(\frac{\bar{p}_t^*(h) + \eta P_{\mathsf{N},t}^*}{P_{\mathsf{H},t}^*}\right)^{-\theta} C_{\mathsf{H},t}^*. \end{aligned}$$

Monopolistic firms take account of the implications of distributive trade on the demand elasticity for their product, and find it optimal to charge different prices to firms distributing in the Home and in the Foreign market.

Different Demand Elasticities

The price elasticity of the demand for the good h will depend:

- relative productivity across domestic sectors *in the Home market*

$$\xi_{C_t(h),\bar{p}_t(h)} \equiv -\frac{\partial C_t(h)}{\partial \bar{p}(h)} \frac{\bar{p}_t(h)}{C_t(h)} = \theta \frac{1 + \frac{\eta}{\theta - 1} \frac{Z_{\mathsf{H},t}}{Z_{\mathsf{N},t}}}{1 + \eta \frac{\theta}{\theta - 1} \frac{Z_{\mathsf{H},t}}{Z_{\mathsf{N},t}}}.$$

- on productivity in the nontraded goods at Home and abroad, relative wages and the exchange rate *in the export market:*

$$\xi_{C_t^*(h),\bar{p}_t^*(h)} \equiv -\frac{\partial C_t^*(h)}{\partial \bar{p}^*(h)} \frac{\bar{p}^*(h)}{C_t^*(h)} = \theta \frac{1 + \frac{\eta}{\theta - 1} \frac{\mathcal{E}_t W_t^*}{W_t} \frac{Z_{\mathsf{H},t}}{Z_{\mathsf{N},t}^*}}{1 + \eta \frac{\theta}{\theta - 1} \frac{\mathcal{E}_t W_t^*}{W_t} \frac{Z_{\mathsf{H},t}}{Z_{\mathsf{N},t}^*}}.$$

Important properties of elasticies

- the elasticity of foreign demand for h goods $\xi_{C_t^*(h),\bar{p}_t^*(h)}$ with respect to its foreign wholesale price is non linear in the exchange rate: a relatively appreciated Home currency (a low $\mathcal{E}_t$) corresponds to a relatively large price elasticity.

- $\xi_{C_t^*(h),\bar{p}_t^*(h)}$ is increasing in the wholesale price — as shown by the literature on international trade (e.g., see Marston [1990]), this is a sufficient condition for incomplete exchange rate pass-through (we will discuss this topic in detail below).

Elasticities fall with distribution margins

Moreover, consider the 'distribution margin,' i.e., the share of distributive trade in the consumer price of the good h in the Home (Foreign) market. Then:

$$
\begin{aligned}
\xi_{C_t(h),\bar{p}_t(h)} &= \theta\left(1-\frac{\eta P_{\mathsf{N},t}}{p_t(h)}\right), \\
\xi_{C_t^*(h),\bar{p}_t^*(h)} &= \theta\left(1-\frac{\eta P_{\mathsf{N},t}^*}{p_t^*(h)}\right).
\end{aligned}
$$

The demand elasticities to the wholesale prices are monotonic functions of the distribution margins: distributive trade lowers price elasticities below the constant preference parameter θ.

Optimal pricing and market-specific markups,...

Making use of P_N the optimal wholesale prices $\bar{p}(h)$ and $\bar{p}^*(h)$ are:

$$\bar{p}_t(h) = \overbrace{\frac{\theta}{\theta - 1}\left(1 + \frac{\eta}{\theta - 1}\frac{Z_{\mathsf{H},t}}{Z_{\mathsf{N},t}}\right)}^{mk_{\mathsf{H},t}}\frac{W_t}{Z_{\mathsf{H},t}},$$

$$\mathcal{E}_t\bar{p}_t^*(h) = \overbrace{\frac{\theta}{\theta - 1}\left(1 + \frac{\eta}{\theta - 1}\frac{\mathcal{E}_t W_t^*}{W_t}\frac{Z_{\mathsf{H},t}}{Z_{\mathsf{N},t}^*}\right)}^{mk_{\mathsf{H}^*,t}}\frac{W_t}{Z_{\mathsf{H},t}}.$$

Markups $mk_{\mathsf{H},t}$ and $mk_{\mathsf{H}^*,t}$ include a state-contingent component — in brackets in the above expression — that varies as a function of productivity shocks, monetary innovations (affecting the exchange rate) and relative wages.

... implying deviations from the law of one price;

Since in general

$$mk_{\mathsf{H},t} \neq mk_{\mathsf{H}^*,t}$$

the optimal wholesale price of tradable goods will not obey the law of one price

$$\bar{p}_t(h) \neq \mathcal{E}_t \bar{p}_t^*(h)$$

- Despite CES preferences, the elasticity of the demand for the Home goods faced by the upstream monopolist will be different at Home and abroad, reflecting any asymmetry in relative productivity and/or relative wages.

2.2 On the role of arbitrage across national markets

Most open macro models with monopolistic competition assume that firms have the power to segment markets across national borders — ruling out arbitrage across wholesale markets.

Yet, there is no reason to exclude the possibility that domestic retailers buy goods from foreign retailers, rather than from monopolistic producers in the wholesale market.

Study of the constrained optimal pricing problem for the firms.

No arbitrage constraint (1)

If the representative Home firm sets the wholesale price in the Foreign country above the consumer price of its own good in the Home country, firms distributing good h in the Foreign country would find it profitable to buy it from Home retailers rather than in the wholesale market. This implies that optimal price discrimination is possible only as long as the following no-arbitrage conditions are verified:

$$\begin{aligned} \mathcal{E}_t p_t^*(h) &= \mathcal{E}_t \left(\bar{p}_t^*(h) + \eta P_{\mathsf{N},t}^* \right) \geq \bar{p}_t(h) \\ p_t(h) &= \bar{p}_t(h) + \eta P_{\mathsf{N},t} \geq \mathcal{E}_t \bar{p}_t^*(h). \end{aligned}$$

No arbitrage constraint (2)

Using optimal prices, these conditions can be synthetically written as:

$$\frac{1}{\theta} \leq \frac{\mathcal{E}_t W_t^*}{W_t} \frac{Z_{\mathsf{N},t}}{Z_{\mathsf{N},t}^*} \leq \theta.$$

A large depreciation of the nominal exchange rate could reduce the Home consumer price of h in Foreign currency below the optimal export price $\bar{p}_t^*(h)$ — violating the second inequality above. In that case, arbitrage in the goods market would force firms to set the foreign wholesale price and the domestic price equal to each other: $\mathcal{E}_t \bar{p}_t^*(h) = p_t(h)$.

By the same token, a large nominal appreciation could reduce the foreign retail price of h in the Home currency below the wholesale price at Home. In this case, ruling out arbitrage requires firms to set $\bar{p}_t(h) = \mathcal{E}_t p_t^*(h)$.

Intuitive account of arbitrage-constrained pricing

Suppose that to rule out arbitrage Home firms must set: $p_t(h) = \mathcal{E}_t \bar{p}_t^*(h)$. The firms problem must now allow for this constraint. Results are as follows:

When the constraint is binding, Home firms will now raise $\bar{p}_t(h)$ somewhat while lowering $\bar{p}_t^*(h)$ somewhat, relative to their optimal level in the absence of arbitrage. As the two prices cannot be set independently, the drop in the markup in the foreign market is partly offset by a higher markup at home.

Note however that, even when the no-arbitrage condition is binding, *wholesale* prices will be different in the Home and Foreign markets because of distribution margins: with $\eta > 0$, the law of one price cannot hold.

3 In general equilibrium

With **complete markets**, Backus-Smith implies that the exchange rate is

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

With **incomplete markets**, the exchange rate is a direct function of productivity shocks. For instance, in financial autarky

$$\mathcal{E}_t \mu_t^* \frac{1 + \frac{\eta}{\theta - 1} \frac{\mathcal{E}_t W_t^*}{W_t} \frac{Z_{\mathsf{H},t}}{Z_{\mathsf{N},t}^*}}{1 + \frac{\eta\theta}{\theta - 1} \frac{\mathcal{E}_t W_t^*}{W_t} \frac{Z_{\mathsf{H},t}}{Z_{\mathsf{N},t}^*}} = \mu_t \frac{\mathcal{E}_t + \frac{\eta}{\theta - 1} \frac{W_t}{W_t^*} \frac{Z_{\mathsf{F},t}}{Z_{\mathsf{N},t}}}{\mathcal{E}_t + \frac{\eta\theta}{\theta - 1} \frac{W_t}{W_t^*} \frac{Z_{\mathsf{F},t}}{Z_{\mathsf{N},t}}}.$$

Note that full insurance requires $\eta = 0$ (no distribution costs). In general, one can have multiple equilibrium. See Corsetti and Dedola for Details.

How much local currency price stability can the model explain?

Table 2: Impact Responses of Selected Variables to Nominal and Real Shocks[a]
(Percentage deviations from steady-state values and elasticities)

	Monetary Shock	*Shock to Tradables*		*Shock to Nontradables*		*Economy-wide Shock*	
		Temporary	Permanent	Temporary	Permanent	Temporary	Permanent
Nominal exchange rate	1.5%	0.2%	5.9%	0.2%	5.7%	0.4%	11.8%
Real exchange rate	1.2%	0.2%	4.7%	1.0%	5.3%	1.6%	10.2%
Terms of trade	0.9%	1.0%	4.3%	-0.1%	3.2%	0.9%	7.6%
Producer import price	1.2%	0.2%	4.7%	-0.01%	4.3%	0.2%	9.3%
Consumer import price	0.6%	0.1%	2.4%	-0.5%	1.7%	-0.4%	4.1%
CPI	0.2%	-0.1%	0.5%	-0.8%	-0.2%	-0.8%	0.3%
ERPT ξ:							
Producer import price $\xi_{\overline{P}_{F,t},\mathcal{E}_t}$	0.80	0.81	0.82	-0.06	0.76	0.36	0.78
Consumer import price $\xi_{P_{F,t},\mathcal{E}_t}$	0.40	0.41	0.35	-2.20	0.30	-0.99	0.35
CPI $\xi_{P_t,\mathcal{E}_t}$	0.12	-0.32	0.08	-3.34	-0.03	-1.87	0.02

[a] From Corsetti, Giancarlo, and Luca Dedola (2005). "A macroeconomic model of international price discrimination", *Journal of International Economics* 67, 129-156. See this text for explanation.

On modelling:

- Local cost components may reflect more than distribution: for instance, assembling of imported input and local input..

- There are two elements that drive the results on local currency price stability

  - Local inputs dampen the response of consumer prices to changes in the prices of imported components; this works also with perfect competition (Burstein, Neves and Rebelo)

  - Low elasticity of substitution between imported and local component affects trade elasticity. Hence, assuming imperfect competition, we obtain markup adjustment (Corsetti and Dedola, Rebelo et al. GEM etc.)