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Local-currency pricing and the choice of exchange-rate regime

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Abstract

Feldstein (1992, The Economist 19–22; 1997, Journal of Economic Perspectives 11, 23–42) invokes Friedman's (1953, Essays in Positive Economics. Chicago University Press, Chicago, pp. 157–203) classic case for flexible exchange rates to argue that the single currency of the European Monetary Union will hinder adjustments that might have occurred through real exchange rate movements under a more flexible exchange rate system. The extent of local-currency pricing among European countries undermines this view. The prices that consumers pay for imported goods are not much influenced by changes in nominal exchange rates in the short run. The channels for adjustment through relative price changes are considerably narrowed when local-currency pricing predominates. New evidence is presented that reaffirms the predominance of local-currency pricing for consumer prices in Europe. The optimum currency area analysis is reexamined in a Mundell–Fleming framework with local-currency pricing. © 2000 Elsevier Science B.V. All rights reserved.

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0. Introduction

There is little consensus among economists that Europe is well suited for a single currency. Frequently, commentators offer the opinion that the chief benefits of currency union for Europe are political, but that more flexible exchange rates are preferable if the choice of monetary system were based solely on economic considerations. Feldstein (1992, 1997) perhaps most prominently expresses those views.

The argument for more flexible rates in Europe is straightforward. Suppose there is some shock to the economy that requires prices of German goods to rise relative to the prices of French goods. For example, Eichengreen and Wyplosz (1993) argue that the fiscal expansion that followed German unification necessitated an increase in the price of German goods relative to other EMS countries. Such a relative price change has an automatic stabilizing effect on output. It leads to a trade balance deficit as Germans and other Europeans shift demand away from German goods toward goods produced in other countries.

How is this increase in the price of German goods to be achieved? In the traditional view of the macroeconomic adjustment process, the "law of one price" holds. Let P_G be the price of a good produced in Germany and sold in Germany. The price of that German-produced good sold in France is denoted $\Pi_G = P_G/E$, where E denotes the mark price of francs. According to the traditional view, if an increase in Π_G relative to the price of the French good (Π_F) is required, there are two means by which that could be achieved: P_G could increase (or Π_F could fall); or, the exchange rate could decline.

Feldstein (1992) makes the case that flexible exchange rates facilitate adjustment:

> A currency union means, of course, that nominal exchange rates cannot adjust to achieve a needed change in the real exchange rate. The local price level must, therefore, adjust to bring about the change in the real exchange rate. Thus a 10% fall in the real value of a currency can be achieved either by a 10% fall in the nominal exchange rate or by a 10% fall in local wages and prices.
>
> Either form of adjustment can bring the real exchange rate to its equilibrium value, but a decline in domestic prices is likely to require a period of increased unemployment. It would certainly be better to have a decline in the nominal exchange rate. The shift to a single currency in Europe would preclude such nominal exchange-rate adjustments and force real exchange-rate reductions to be achieved through lower local wages and prices.

The argument echoes Friedman's (1953) classic case for flexible exchange rates. In a similar vein, Obstfeld (1997) argues that Europe is not an optimum currency area, as defined by Mundell (1961). The Friedman–Feldstein analysis of the benefits of floating exchange rates is dependent on their view of how prices are set. In particular, it pays insufficient attention to the recent evidence of significant local-currency pricing.

Consider the simple law-of-one-price model that underlies the Friedman–Feldstein analysis. In this formulation, the German producer sets its price in deutschemarks. The price P_G is charged to German consumers and is unresponsive to changes in demand. When the mark appreciates the French franc price of the good sold to French consumers increases. The empirical evidence suggests that a better model of reality, at least for a large number of goods, is that German producers treat the German market for their goods separately from the French market. They choose a mark price, P_G, for the good sold in the German market, and a franc price, Π_G, for the good sold in the French market. Both of these prices are inflexible – neither responds when the exchange rate changes. The automatic stabilizing property of exchange rates vanishes when there is no "exchange-rate pass-through" to local prices. Likewise, the price of French goods does not fall for the German consumer, because the French firm sets a price in marks for selling its good to German consumers, at P_F (and a price in francs for French consumers, Π_F).

There are, of course, real effects of the nominal exchange rate changes. When the mark appreciates, but Π_G, the French franc price of German-produced goods, does not change, the revenue (in mark terms) for the German firm declines. Conversely, the franc revenue for the French firm selling goods in Germany increases. There can be a channel through which the changes in firms' profits stabilize swings in aggregate demand. The decline in profits of German firms, and increase in profits of French firms, will have the effect of lowering demand in Germany and raising it in France.

But this channel for stabilization is likely to be much weaker than the one posited by Friedman and Feldstein. The exchange rate change does not induce consumers to switch demand away from German goods toward French goods. Instead, there is an income effect. Lower profits for German firms reduce income for German owners of those firms, and conversely in France. To the extent that spending in each country is biased toward goods produced in that country, there will be a relative increase in demand for French products resulting from the mark appreciation. This effect is likely not to be strong unless profits are a relatively large fraction of income, and there is a strong home-country bias in spending.

In fact, there are several considerations that weaken this profit channel for influencing aggregate demand. First, firms can hedge their foreign exchange exposure. By selling francs forward for marks at a sufficient number of horizons into the future, or making use of other derivative markets, the German firm can insulate its profits from short-run fluctuations in the exchange rate. Second, the firms may not need to protect their bottom line from foreign exchange fluctuations because firm owners might do the diversification. Our assumption so far has been that German consumers own German firms and French consumers own French firms. In fact, while there is a home bias in asset holdings, there has been an increasing degree of internationalization of financial markets. Particularly within Europe, in which there are few barriers to capital flows, international diversification of portfolios is on the rise. The income of a German who owns shares of both German firms and French firms will not be affected much by exchange rate changes.

Another consideration is the fact that many of the firm's costs are incurred in the foreign currency. In order to sell its product in France, the German firm must pay for advertising, distribution and retailing in French francs. Particularly for consumer goods, these marketing and distribution costs can account for a significant fraction of the cost of the good. So the amount of exposure the German firm has to foreign exchange rate changes depends on the fraction of its costs that are in marks versus francs. Finally, a practical consideration is one of information. In the short run, the firm's foreign exchange profits or losses are not observed by shareholders who are not completely informed of the firm's foreign exchange exposure because the amount of hedging by the firm is not continuously reported. Frequently, the markets are not aware of significant gains or losses on foreign exchange markets until annual reports are compiled. So, even if the firm has not fully protected itself against foreign exchange fluctuations, the shareholders may not realize this and fail to adjust fully their assessment of the value of the firm.

Recent empirical studies suggest that consumer prices are not very responsive to exchange rate changes. For example, Engel (1993) finds that for differentiated consumer products, there is virtually no response of consumer prices to exchange rate changes, while the law of one price appears to hold much better for simple homogenous products such as fresh fruits and vegetables. Engel (1999) finds that well over 95% of real exchange rate movements among major industrialized countries are attributable to failures of the law of one price. However, studies of consumer prices suffer from the problem that the data do not distinguish the location of the producer of the products. Thus, the data do not account for the differences in the mix of products by location of producer in each buyer location. (That is, German consumer price indexes are likely to reflect a preponderance of German-produced goods, as compared to price indexes in other countries that give smaller weight to German-produced goods.) Keeping in mind that caveat, the greater unresponsiveness of consumer prices as compared to export prices suggests that the marketers and distributors of goods in the consumers' locale also must cushion the effect of exchange rate changes on prices by allowing their profit margins to vary with exchange rates.

To be clear, consideration of the implications of local-currency pricing do not constitute an argument for fixed exchange rates or for a single currency in Europe. It merely weakens the case for flexible exchange rates.

In Section 1, I present some new evidence on the failure of the law of one price in Europe. The evidence indicates there is local-currency pricing for consumer goods, and that consumer goods prices do not respond to exchange rate changes. Then, in Section 2, I formally review the argument for flexible exchange rates in the traditional Mundell–Fleming model, and demonstrate how that argument is refuted when there is little exchange-rate pass-through. The concluding section summarizes some of the shortcomings of this analysis and points to directions for future research.

1. Empirical evidence

How do consumer prices in Europe respond to exchange rate changes? Consider the log of the price of a good, call it good i, p_{it} in one country relative to the log of the price of the same good in another country, π_{it}. Under the law of one price assumption, changes in $p_{it} - \pi_{it}$ should exactly match changes in the log of the exchange rate, e_t. Here, we examine that proposition taking two different approaches. If exchange rate changes worked their way into prices relatively rapidly, then annual changes in $p_{it} - \pi_{it}$ should be highly correlated with annual changes in e_t; or, equivalently, annual changes in e_t should be nearly uncorrelated with annual changes in $e_t + \pi_{it} - p_{it}$. Alternatively, if there are short-term deviations from the law of one price that are eliminated over time, then $p_{it} - \pi_{it}$ should adjust when there are deviations from the law of one price.

We present evidence on both of these concepts of the law of one price using price index data for 22 categories of goods for nine European countries: Belgium, Denmark, Germany, Spain, France, Italy, the Netherlands, Portugal and the United Kingdom. The data are monthly. The length of the series varies. The longest runs from January 1977 to December 1995, and the shortest runs from April 1982 to July 1995. Many of the series are monthly from January 1981 to July 1995. The data were obtained from Eurostat's consumer price data base.[1]

The categories of consumer goods involve different levels of aggregation. Some of the series are highly aggregated: food, clothing and footwear, household

[1] There were quite a few data entry errors in the data set obtained from Eurostat. In cases where there were more than a few errors in one series, the series was dropped. Hence, there is not data for all nine countries for all of the goods. In cases where data entry errors were near the beginning or end of the series, the series were truncated. In some cases, the data was corrected from other sources. In some cases the entry error involved a transposition of digits which was corrected. In the remaining cases, the data points were replaced using interpolation from adjacent data points. The total number of data points used in the tables that are corrected data is 99 (out of a total of approximately 40,000 data points.) A list of corrections is available on request from the author. The original data is sold by Eurostat.

equipment. Other categories are substantially more disaggregated: fruit, books, hotels. Clearly, none of the data is so disaggregated that it actually compares prices of identical products across countries.

Another shortcoming of the data, for our purposes, is that the data are indexes rather than price level data. Hence, we cannot examine directly the degree of failure of the law of one price. Instead, we can only infer failures by examining changes in $p_{it} - \pi_{it}$ and e_t.

First, consider the behavior of nominal exchange rates and relative prices. If the law of one price holds, there should be no correlation of the nominal exchange rate and the relative price, $e_t + \pi_{it} - p_{it}$. No economist would expect instantaneous changes in nominal prices in response to market changes. We interpret the short-run law of one price as saying that annual changes in the exchange rate are uncorrelated with annual changes in $e_t + \pi_{it} - p_{it}$. The upper triangle of the matrices in Table 1 report these correlations. In fact, these correlations are generally very high. For all but a few goods, the vast majority of correlation coefficients are over 0.70. Approximately half are over 0.90 for most goods. So the pattern of correlations is much closer to what one would expect in the extreme case of no exchange-rate pass-through than to the zero correlation predicted by the law of one price.

For some simple goods sold in relatively competitive markets (fruit and fuel and energy being notable examples), the correlations are lower – in the neighborhood of 0.30–0.40 for many country pairs. But for the categories of goods that include differentiated products sold by monopolistically competitive firms – for example, domestic appliances, sound and photographic equipment, furniture, books – the correlations are extremely high. One exception to these generally high correlations is for relative prices between Germany and the Netherlands. Here, the correlations are much lower than for other country pairs, suggesting that the German–Dutch market is much more unified than other markets.

A different approach to the law of one price is that price differentials may crop up between locations, but they are eliminated over time through price adjustment. This approach can be expressed in the error-correction equation:

$$\Delta(p_{it} - \pi_{it}) = \alpha - \beta(p_{it} - \pi_{it} - e_t) + \sum_{j=0}^{k} \lambda_j \Delta e_{t-j} + \sum_{j=1}^{k} \gamma_j \Delta(p_{it-j} - \pi_{it-j}), \quad (1)$$

where Δ refers to the monthly change. This equation states that when the relative price, $e_t + \pi_{it} - p_{it}$ is above its mean or long-run value, $p_{it} - \pi_{it}$ adjusts to eliminate those deviations from the law of one price. The parameter β is a measure of how much of the deviation is eliminated after one month.

Table 1
Correlations of 12-month changes in relative prices and nominal exchange rates and estimated response of prices to deviations from the law of one price

	be	dk	de	es	fr	it	nl	pt	uk
Food – series 1110 (1/77–2/95)									
be		0.432	0.725	0.888	0.613	0.836	0.726	0.673	0.926
dk	0.461*		0.53	0.921	0.773	0.932	0.554	0.671	0.938
de	0.513*	0.383*		0.853	0.583	0.811	0.572	0.615	0.961
es	0.347*	0.273*	0.338*		0.919	0.891	0.843	0.728	0.896
fr	0.652*	0.334	0.329*	0.303*		0.945	0.597	0.725	0.934
it	0.219	0.106	0.18	0.279	0.121		0.827	0.76	0.936
nl	0.4*	0.228	1.94*	0.224*	0.101	0.0909		0.615	0.955
pt	0.189	0.178	0.174	0.318*	0.215	0.3*	0.111		0.754
uk	0.0999	0.0387	0.034	0.205	0.00791	0.0152	– 0.00188	0.103	
Bread and cereals – series 1111 (1/81–7/95)									
be		0.623	0.823	0.96	0.826	0.965		0.589	0.944
dk	0.729*		0.548	0.919	0.478	0.902		0.495	0.939
de	0.101	0.121		0.927	0.659	0.883		0.514	0.956
es	0.405*	0.424*	0.334*		0.954	0.958		0.461	0.927
fr	1.12*	0.314*	0.0883	0.566*		0.973		0.541	0.914
it	0.138	0.000481	– 0.0119	0.561*	0.0017			0.684	0.907
pt	0.935*	0.936*	0.885*	0.891*	0.843*	0.51*			0.641
uk	0.0916	0.102	0.0454	0.224	0.16	0.124		0.659*	
Meat – series 1112 (1/81–7/95)									
be		0.317	0.763	0.901	0.82	0.945	0.814	0.312	0.934
dk	0.513*		0.552	0.832	0.428	0.862	0.671	0.167	0.917
de	0.0352	0.426*		0.8	0.702	0.899	0.631	0.187	0.95
es	0.673*	0.468*	0.251		0.88	0.865	0.827	0.495	0.808
fr	0.276*	0.532*	0.0593	0.658*		0.973	0.764	0.192	0.934
it	0.0639	0.0832	0.0095	0.613*	0.0123		0.922	0.445	0.932
nl	0.0496	0.45*	1.11*	0.273	0.0416	0.0566		0.223	0.956
pt	0.21	0.389*	0.12	0.63*	0.264	0.0982	0.149		0.457
uk	0.0281	0.00224	– 0.014	0.242	0.0365	0.0727	0.0143	0.16	

Table 1
Continued

	be	dk	de	es	fr	it	nl	pt	uk
Dairy products – series 1114 (1/81–7/95)									
be		0.471	0.672	0.88	0.76	0.947	0.62		0.899
dk	0.67*		0.404	0.859	0.543	0.877	0.438		0.879
de	0.0713	0.544*		0.862	0.705	0.842	0.55		0.977
es	0.174	0.343*	0.105		0.909	0.896	0.848		0.833
fr	0.396*	0.957*	0.184*	0.311*		0.953	0.669		0.911
it	0.0226	0.295*	– 0.0026	0.169	0.0796		0.826		0.906
nl	0.108	0.728*	1.15*	0.137	0.18	0.0699			0.969
uk	0.0611	0.227	0.0642	0.0804	0.122	0.0658	0.132		
Fruit – series 1116 (1/81–7/95)									
be		0.18	0.169	0.544	0.344	0.527	0.257		0.74
dk	1.43*		0.0243	0.653	0.214	0.704	– 0.00169		0.753
de	2.73*	2.76*		0.603	0.237	0.515	0.176		0.67
es	1.74*	1.52*	2.56*		0.642	0.434	0.465		0.663
fr	2.67*	1.66*	2.58*	1.73*		0.678	0.0545		0.723
it	1.28*	0.699*	2.04*	1.21*	0.855*		0.636		0.612
nl	1.82*	1.11*	2.94*	1.25*	0.99*	0.577*			0.723
uk	1.47*	0.771*	1.55*	1.78*	0.987*	0.563*	0.531*		
Alcoholic and non-alcoholic drinks – series 1150 (1/81–7/95)									
be			0.803	0.916	0.817	0.973	0.788	0.647	0.968
de	0.169		0	0.909	0.731	0.926	0.416	0.65	0.947
es	0.13		0.111		0.896	0.912	0.886	0.402	0.917
fr	0.536*		0.0698	0.133*		0.98	0.693	0.592	0.959
it	0.0646		– 0.00168	0.0994	0.0138		0.915	0.649	0.964
nl	0.266		0.908*	0.102	0.261*	0.0687		0.639	0.944
pt	0.234*		0.218*	0.246*	0.242*	0.209*	0.251*		0.629
uk	0.124		0.107	0.144	0.135	0.0582	0.156	0.189*	

Clothing and footwear – series 1200 (1/77–10/95)									
be		0.675	0.862	0.834	0.631	0.833	0.794	0.797	0.942
dk	0.65*		0.744	0.889	0.764	0.868	0.772	0.858	0.954
de	0.195	0.413		0.867	0.722	0.845	0.225	0.818	0.957
es	0.0906	0.208	0.0302		0.924	0.939	0.916	0.912	0.903
fr	0.377*	0.598	0.0521	0.113		0.945	0.767	0.882	0.908
it	0.145	0.341	0.093	− 0.00299	0.212		0.902	0.909	0.877
nl	0.885*	1.01*	1.56*	0.269	0.876*	0.35		0.866	0.942
pt	0.076	0.101	0.0355	0.0702	0.154	− 0.0142	0.201		0.841
uk	0.136	0.147	0.0929	0.127	0.152	0.116	0.408*	0.131	
Clothing – series 1210 (1/81–7/95)									
be			0.882	0.956	0.737	0.932	0.877	0.778	0.952
de	0.209			0.939	0.708	0.902	0.122	0.759	0.97
es	0.195		0.00537		0.986	0.971	0.95	0.857	0.909
fr	1.07*		− 0.0125	0.0943		0.983	0.765	0.843	0.896
it	0.236*		0.0496	− 0.0411	0.172		0.924	0.892	0.904
nl	1.35*		1.9*	0.449	0.935*	0.356		0.827	0.941
pt	0.191		0.0614	0.0887	0.164	0.0387	0.275		0.816
uk	0.18		0.146	0.159	0.213	0.152	0.575*	0.118	
Footwear – series 1220 (1/81–7/95)									
be		0.617	0.946	0.966	0.769	0.969	0.813	0.784	0.937
dk	0.673*		0.863	0.893	0.195	0.888	0.779	0.736	0.959
de	0.118	0.405		0.932	0.763	0.898	0.617	0.832	0.956
es	0.0735	0.0936	0.0161		0.981	0.988	0.899	0.811	0.848
fr	0.325	0.233	0.0172	0.13		0.983	0.598	0.834	0.873
it	0.0598	0.136	0.015	− 0.0513	0.118		0.885	0.891	0.877
nl	1.06*	1.73*	3.15*	0.237	0.764*	0.377		0.782	0.911
pt	0.205	0.224	0.118	0.13	0.395*	0.089	0.438		0.817
uk	0.0625	0.0582	0.0418	0.0836	0.0729	0.0925	0.504	0.117	

Table 1
Continued

	be	dk	de	es	fr	it	nl	pt	uk
Rents – series 1300 (5/78–12/95)									
be		0.427	0.654	0.917	0.411	0.87	0.743	0.479	0.813
dk	0.668*		0.268	0.936	0.723	0.809	0.398	0.511	0.886
de	0.157	0.245		0.914	0.594	0.696	0.5	0.52	0.824
es	0.107	0.0991	0.101		0.939	0.856	0.936	0.458	0.791
fr	0.638*	0.639*	0.133	0.08		0.853	0.696	0.446	0.841
it	0.265	0.493*	0.149	0.266	0.196		0.771	0.757	0.738
nl	0.707*	0.455*	1.78*	0.279	0.482*	0.502*		0.552	0.833
pt	0.335	0.359	0.289	0.334	0.447*	0.487*	0.339		0.502
uk	0.382*	0.383*	0.314*	0.438*	0.38*	0.367*	0.456*	0.341*	
Fuel and energy – series 1330 (1/80–7/95)									
be		− 0.0855	0.383	0.567	0.159	0.766	0.452	0.0786	0.739
dk	0.67*		− 0.0371	0.535	0.311	0.59	0.0455	0.143	0.862
de	0.36	0.788*		0.664	0.265	0.627	0.0207	0.148	0.836
es	0.491*	0.365	0.326		0.665	0.811	0.737	0.0177	0.816
fr	0.955*	0.912*	0.435*	0.503*		0.852	0.431	0.286	0.846
it	0.515*	0.451*	0.35	0.592*	0.518*		0.663	0.599	0.866
nl	0.95*	0.48	1.42*	0.508*	0.785*	0.451*		0.299	0.809
pt	0.337	0.389*	0.284	0.49*	0.395	0.301	0.282		0.495
uk	0.203	0.294	0.0561	0.393*	0.243	0.3*	0.133	0.27	
Household equipment – series 1400 (1/77–12/95)									
be		0.525	0.84	0.841	0.657	0.847	0.824	0.863	0.946
dk	0.167		0.682	0.906	0.882	0.948	0.699	0.865	0.966
de	0.0294	0.126		0.841	0.707	0.848	0.822	0.841	0.964
es	0.0593	0.00753	0.0508		0.909	0.876	0.84	0.894	0.927
fr	0.0803	0.168	0.0614	0.0769*		0.966	0.702	0.843	0.949
it	0.0565	0.043	0.0449	0.0487	0.1		0.851	0.876	0.934
nl	0.0215	0.123	0.406*	0.0207	0.0289	0.0101		0.834	0.968
pt	0.227*	0.152	0.163	0.118	0.191	0.0637	0.101		0.874
uk	0.0421	0.0075	0.00384	0.0443	0.0812	0.0506	− 0.00208	0.0904	

Furniture – series 1410 (1/81–9/94)									
be		0.883	0.923	0.971	0.849	0.961	0.896	0.833	0.972
dk	0.5*		0.737	0.985	0.887	0.981	0.724	0.9	0.957
de	0.0407	0.0204		0.947	0.856	0.918	0.717	0.826	0.972
es	−0.0101	0.00363	0.013		0.991	0.981	0.938	0.906	0.922
fr	0.282	0.205	0.0369	0.0498		0.991	0.79	0.874	0.934
it	0.0703	−0.0456	0.0293	−0.0371	0.0587		0.895	0.932	0.932
nl	0.0837	0.0503	0.617*	0.0183	0.039	0.0267		0.817	0.979
pt	0.05	0.0688	0.0326	0.0325	0.0825	0.079	0.0437		0.864
uk	0.142	0.154	0.183	0.088	0.215*	0.155	0.145	0.0772	
Domestic appliances – series 1420 (1/81–9/94)									
be			0.818	0.963	0.823	0.956	0.849	0.681	0.957
de	0.122			0.893	0.694	0.848	0.457	0.625	0.981
es	0.00795		0.0391		0.974	0.96	0.904	0.592	0.894
fr	0.335*		0.0566	0.086		0.98	0.751	0.56	0.937
it	0.0865		0.0855	0.0682	0.0756		0.865	0.742	0.937
nl	0.0396		0.793*	0.0121	0.0515	0.0215		0.629	0.989
pt	0.137		0.0749	0.13	0.131	0.0586	0.0322		0.724
uk	−0.0362		−0.00274	0.0146	0.0393	0.0626	−0.000946	0.0239	
Transport and communications – series 1600 (1/77–12/95)									
be		0.607	0.933		0.859	0.97	0.936		0.972
dk	0.686*		0.819		0.846	0.975	0.853		0.979
de	0.161	0.231*			0.936	0.97	0.251		0.981
fr	0.334*	0.387*	0.137*			0.968	0.948		0.961
it	0.0689	0.0731	0.081		0.14		0.974		0.906
nl	0.122	0.227	1.01*		0.0885	0.053			0.982
uk	0.00739	0.0818	0.0593		0.0572	0.299*	0.0152		

Table 1
Continued

	be	dk	de	es	fr	it	nl	pt	uk
Vehicles – series 1610 (1/81–7/95)									
be			0.632	0.898	0.632	0.902	0.694		0.923
de	0.292*			0.912	0.618	0.75	0.287		0.97
es	0.36*		0.191		0.906	0.89	0.923		0.928
fr	0.439		0.276*	0.21		0.909	0.743		0.915
it	0.371		0.158	0.152	0.22		0.777		0.864
nl	0.132		0.989*	0.214	0.182	0.154			0.981
uk	0.178		− 0.0146	0.25	0.123	0.0698	0.128		
Public transport – series 1630 (4/82–7/95)									
dk			0.236	0.903	0.749	0.838	0.44		0.816
de		0.715*		0.909	0.659	0.779	− 0.492		0.935
es		0.196	0.124		0.94	0.938	0.938		0.83
fr		1.15*	0.285	0.193		0.894	0.784		0.88
it		0.466*	0.283	0.742*	0.287		0.852		0.791
nl		0.994*	0.905*	0.136	0.782*	0.189			0.869
uk		0.163	0.246*	0.133	0.158	0.261*	0.202*		
Recreation – series 1700 (1/77–12/95)									
be		0.697	0.837	0.913	0.74	0.899	0.886		0.951
dk	0.192		0.577	0.961	0.92	0.937	0.731		0.971
de	0.236	0.253*		0.889	0.689	0.836	0.417		0.961
es	0.126	0.108	0.168		0.962	0.933	0.92		0.952
fr	0.186	0.265	0.0874	0.134		0.949	0.766		0.963
it	0.11	0.201	0.113	0.0818	0.134		0.875		0.945
nl	0.291*	0.256	1.37*	0.128	0.132	0.109			0.969
uk	0.0414	0.00512	0.142	0.00887	0.0169	0.103	0.0654		

Sound and photographic equipment – series 1710 (1/81–7/95)									
be			0.672	0.933	0.775	0.956	0.806		0.955
de	0.41*			0.907	0.809	0.861	0.212		0.965
es	0.164		0.0742		0.96	0.958	0.934		0.947
fr	0.678*		0.0506	0.116		0.964	0.846		0.972
it	0.162		0.0551	0.0738	0.0321		0.914		0.943
nl	0.423*		0.861*	0.157	0.158	0.0438			0.971
uk	0.128		0.00923	0.0211	− 0.00159	0.0145	0.049		
Leisure – series 1720 (1/81–7/95)									
be				0.953	0.778		0.853	0.804	0.906
es	0.203				0.941		0.96	0.664	0.893
fr	0.683*			0.321*			0.734	0.695	0.875
nl	0.1			0.096	0.356*			0.734	0.954
pt	0.139			0.203	0.188		0.0396		0.712
uk	0.0214			0.0772	0.291		0.121	0.0789	
Books – series 1730 (1/81–7/95)									
be		0.785	0.892		0.696	0.889	0.907		0.952
dk	1.12*		0.589		0.629	0.89	0.593		0.961
de	0.225	0.21			0.695	0.8	0.239		0.944
fr	0.4*	0.655*	0.163			0.915	0.739		0.96
it	0.317	0.287	0.274		0.358*		0.833		0.89
nl	0.567*	0.396	1.47*		0.199	0.176			0.946
uk	− 0.00644	0.0361	0.0243		0.123	0.0465	0.148		

Table 1
Continued

	be	dk	de	es	fr	it	nl	pt	uk
Hotels – series 1830 (1/81–7/95)									
be		0.837	0.925	0.928	0.646	0.932	0.947	0.782	0.973
dk	1.05*		0.563	0.963	0.818	0.965	0.73	0.876	0.94
de	0.289	0.0416		0.91	0.75	0.87	0.536	0.806	0.984
es	0.155	0.167	0.0344		0.958	0.982	0.923	0.896	0.907
fr	0.433*	0.281	0.096	0.128		0.972	0.788	0.838	0.929
it	0.212	0.186	0.137	0.0872	0.112		0.903	0.945	0.919
nl	0.189	0.152	1.96*	0.12	0.114	0.228*		0.819	0.979
pt	0.305	0.281	0.14	0.164	0.267	0.177	0.157		0.877
uk	0.134	0.0597	0.0631	0.13	0.111*	0.179*	0.0867	0.137	

Note: be is Belgium, dk is Denmark, de is Germany, es is Spain, fr is France, it is Italy, nl is Netherlands, pt is Portugal and uk is United Kingdom. The upper triangle of the table is the correlation of the log of the nominal exchange rate between the indicated pair of countries, s_t, and the log of the relative price, $s_t + p^*_{it} - p_{it}$, where p^*_{it} and p_{it} are the nominal prices in each country. The lower triangle of the table reports the coefficient β from the error-correction regression:

$$\Delta(p_{it} - \pi_{it}) = \alpha - \beta(p_{it} - \pi_{it} - e_t) + \sum_{j=0}^{k} \lambda_j \Delta e_{t-j} + \sum_{j=1}^{k} \gamma_j \Delta(p_{it-j} - \pi_{it-j}).$$

The * next to the coefficients in the lower triangle means significant at 95% level.

Eq. (1) is estimated for each relative price series – for each good and each country pair. The lag length k was chosen by an iterative procedure. Initially, the equation is estimated with eight lags of Δe_{t-j} and $\Delta(p_{it-j} - \pi_{it-j})$. If the sixteen estimated lag parameters (λ_j and γ_j, $j = 1, 2, \dots, 8$) are not jointly significant, the eighth lag is dropped and the equation is reestimated with seven lags. This procedure is repeated until the k lags are jointly significant.[2]

The values of the estimated parameter β are reported in the bottom triangle of the matrices in Table 1. If adjustment to the law of one price were rapid, the estimated β coefficient would be close to unity. For a few goods – again, fruit and fuel and energy stand out – the estimated values of β are near to unity. In fact, many of the estimated coefficients in the fruit regression exceed one. But for most goods, the β coefficients are much smaller, frequently between 0.10 and 0.25. Again, exceptions to this general rule are the coefficients for the Germany–Netherlands regressions, which tend to be much closer to unity.

The table reports tests of the null hypothesis that $\beta = 0$. Under this null, there is no adjustment in prices toward the long-run law of one price. The relative price in this case has a unit root. The test of $\beta = 0$ is a test of cointegration between $p_{it} - \pi_{it}$ and e_t. Zivot (1995) develops this single-equation cointegration test (when the cointegration vector is known to be $(1, -1)$.) Critical values are derived in Hansen (1995).

The null that $p_{it} - \pi_{it}$ and e_t are not cointegrated should not be taken literally. Failure to reject the null should be interpreted as meaning that the test does not have sufficient power to reject the null in our samples. Still, Zivot (1995) shows his test has quite good power in general. So the surprising result is that convergence to the law of one price is so slow that we cannot reject the null of no cointegration for most relative prices even with 15–18 years of monthly data. For most relative price series, we fail to reject the null for a majority of country pairs. The exceptions to this are bread and cereal products, dairy products, fruit, fuel and energy, rent and public transportation.[3]

So for most categories of goods, there is not even evidence that deviations from the law of one price tend to be eliminated. The evidence from both types of tests for the law of one price demonstrate that, especially for categories of differentiated consumer products, price differentials do not respond much to exchange rate changes.

2. The model

We will demonstrate how local-currency pricing reduces the desirability of floating exchange rates in a simple Mundell–Fleming model. The fixed versus

[2] This is the procedure advocated by Ng and Perron (1995).

[3] Public transportation refers to transport that is shared, such as rail and air travel. It is generally a traded good.

floating debate for Europe has largely been carried out (sometimes implicitly) in the context of the Mundell–Fleming model, so this model is the appropriate venue to consider the implications of local-currency pricing. However, in this model, behavior is not based explicitly on optimization. Problems that arise with assessing the value of a floating exchange rate system in such a model are discussed in the concluding section. Recent models (for example, Obstfeld and Rogoff, 1995, 1998; Corsetti and Pesenti, 1998) replicate many of the features of the Mundell–Fleming model in optimizing frameworks. Betts and Devereux (1996, 2000) and Devereux and Engel (1998) examine some of the implications of pricing to market and sticky nominal prices in models of dynamic utility maximization.

We compare the short-run volatility of output in response to aggregate demand shocks in two models: the standard Mundell–Fleming model and the Mundell–Fleming model local-currency pricing. Feldstein and Friedman cast their argument in terms of short-run volatility; in the long run, nominal prices adjust so the choice of nominal exchange rate regime is immaterial.

The standard Mundell–Fleming model (under the law of one price) assumes that demand for domestic output, y, comes from consumption less imports $(c - m)$, exports (x), investment and an exogenous shift factor (g):

$$y = c(y) - qm(y, q) + f(i) + x(y^*, q) + g \tag{2}$$

with $0 < c' < 1$. The real exchange rate is defined as the relative price of foreign goods, so import demand falls as q rises (and import demand increases with income): $m_q < 0$; $0 < m_y < c' < 1$.

Investment demand depends inversely on the interest rate i: $f' < 0$.[4] Foreign demand for exports from the home country depends directly on foreign income and the real exchange rate: $x_y > 0; x_q > 0$.

The IS curve in the foreign country is analogous:

$$y^* = c^*(y^*) - \frac{1}{q}x(y^*, q) + m(y, q) + f^*(i^*) + g^*. \tag{3}$$

In financial markets, there is perfect capital mobility so uncovered interest parity holds:

$$i = i^* + \Delta e^e/e, \tag{4}$$

where e is the nominal exchange rate, so that $\Delta e^e/e$ is the expected percentage change in the exchange rate.

[4] Investment depends on the nominal interest rate for simplicity. In the examples we will look at, in which there are changes in relative demand, nominal prices turn out not to change in equilibrium. So, there is no difference between the real and nominal interest rates.

In each country, real money demand falls as the interest rate rises, and rises with increases in income. So, in the home country

$$h/p_h = \ell(i, y), \quad \ell_i < 0 \quad \text{and} \quad \ell_y > 0, \tag{5}$$

where h is the home money supply, and p_h is the home currency price of home goods. In the foreign country is an analogous money demand equation:

$$h^*/\pi_f = \ell^*(i^*, y^*), \quad \ell_i^* < 0 \quad \text{and} \quad \ell_y^* > 0, \tag{6}$$

where π_f is the foreign-currency price of foreign-produced goods.

The real exchange rate is defined as

$$q = e\pi_f/p_h. \tag{7}$$

There are two periods in the model. The second period represents the long run in which nominal prices are completely flexible and output is produced at the full-employment levels, which are exogenously given as $\bar{y}$ and $\bar{y}^*$. We will not consider changes in the money supply, so there is no permanent inflation or depreciation. There is no expected change in the exchange rate in the long run, so $i = i^*$. Eqs. (2) and (3) determine the long-run real exchange rate level and the long-run interest rate. Note, then, that money is neutral in the long run. From Eq. (5), p_h is proportional to h, and from Eq. (6), π_f is proportional to h^*. We will consider effects of shocks that affect the composition of aggregate demand between the home and foreign country, but not the level of aggregate demand. That is, we will assume

$$\mathrm{d}g + q\,\mathrm{d}g^* = 0, \tag{8}$$

where $\mathrm{d}x\,(x = g, g^*)$ refers to the differential of x.

First, we derive the change in the long-run exchange rate. In the long run there is no expected change in the exchange rate, so from Eq. (4), we have $\bar{i} = \bar{i}^*$.[5] (An overbar represents long-run values.) In the long run, output in both countries is at its full-employment levels. So, in taking the total differentials of Eqs. (2) and (3), $\mathrm{d}\bar{y} = 0$, $\mathrm{d}\bar{y}^* = 0$, and $\mathrm{d}i = \mathrm{d}i^*$. Initially $\bar{q} = 1$.

$$0 = -m \cdot \mathrm{d}\bar{q} - m_q\,\mathrm{d}\bar{q} + f_i\,\mathrm{d}\bar{i} + x_q\,\mathrm{d}\bar{q} + \mathrm{d}g, \tag{9}$$

$$0 = x \cdot \mathrm{d}\bar{q} - x_q\,\mathrm{d}\bar{q} + m_q\,\mathrm{d}\bar{q} + f_i^*\,\mathrm{d}\bar{i} + \mathrm{d}g^*. \tag{10}$$

Assume that trade is balanced initially, so that $x = m$. Using $\mathrm{d}g + \mathrm{d}g^* = 0$, we have, adding Eq. (10) to Eq. (9):

$$0 = (f_i + f_i^*)\,\mathrm{d}\bar{i},$$

[5] We assume money supplies are constant. Our interest is in real demand shocks, rather than monetary shocks.

which implies $\mathrm{d}\bar{i} = 0$ in the long run. Then, using (9) we have that the long-run change in the real exchange rate for the switch in demand from the foreign good toward the domestic good is given by

$$\frac{\mathrm{d}\bar{q}}{\mathrm{d}g} = \frac{-1}{x\Omega}, \tag{11}$$

where $\Omega = \varepsilon_x + \varepsilon_m - 1$, and $\varepsilon_x = x_q/x$ is the elasticity of demand for exports, and $\varepsilon_m = -m_q/m$ is the elasticity of import demand. We assume $\Omega > 0$ which is the Marshall–Lerner condition.

Since $\bar{y}$ and $\bar{i}$ do not change in the long run, and the money supply, $\bar{h}$, of the domestic country is constant, then from Eq. (5), $\bar{p}_h$ does not change in the long run when there is a change in aggregate demand. Likewise, from Eq. (6), $\bar{\pi}_f$ does not change. So the real exchange rate adjustment is achieved completely through an adjustment of the nominal exchange rate. The change in the long-run nominal exchange rate is given by

$$\frac{\mathrm{d}\bar{e}}{\mathrm{d}g} = \frac{-1}{x\Omega} < 0. \tag{12}$$

Now consider the short run in the standard Mundell–Fleming model. Nominal prices do not adjust immediately in response to changes in aggregate demand. But the key assumption in this type of model is that prices are fixed in the seller's currencies. That is, p_h and π_f are fixed. The law of one price holds for each good, so that the foreign currency price of domestic goods is p_h/e and the domestic currency price of foreign goods is $e\pi_f$. With p and π_f fixed, the real exchange rate q moves one-for-one with changes in the nominal exchange rate, e.

We assume that expectations are rational, so that investors expect the exchange rate to equal its long-run value next period:

$$\frac{\Delta e^e}{e} = \frac{\bar{e} - e}{e}. \tag{13}$$

Under this set of assumptions, we arrive at a standard result in the Mundell–Fleming model: the short-run change in the exchange rate is exactly the same as the long run (as given in Eq. (12)). When there are real demand shocks (subject to restriction (8)), there is no need for nominal prices to adjust. Nominal exchange rates by themselves achieve all of the needed price adjustment, and even in the short run we reach full equilibrium. So,

$$\frac{\mathrm{d}y}{\mathrm{d}g} = \frac{\mathrm{d}y^*}{\mathrm{d}g} = 0.$$

Next, consider the alternative view of short-run pricing behavior by firms. We take the opposite extreme from the Mundell model (which assumes 100% exchange rate pass through) and assume no exchange rate pass through. Prices are sticky in the buyer's currencies. So, import demand is a function of income, z, and the relative price of foreign goods:

$$m = m(z, p_f/p_h), \tag{14}$$

where p_f is the domestic currency price of the foreign good paid by home residents, and p_h is the domestic currency price of the home good paid by home residents. (Note that income, z, is not necessarily equal to the value of output, y. That will be discussed in more detail momentarily.) Since in the short run p_f and p_h are fixed, changes in the nominal exchange rate have no direct influence on import demand.[6] The real value of imports, expressed in terms of units of the home good, is given by $p_f m/p_h$, which also is not directly influenced by the nominal exchange rate.

Similarly, demand for exports from the home country are influenced by foreign income and the prices faced by foreigners:

$$x = x(z^*, \pi_f/\pi_h), \tag{15}$$

where z^* is foreign income, π_f is the foreign currency price of the foreign good paid by foreigners, and π_h is the foreign currency price of the home good paid by foreigners. Since π_f and π_h are fixed, there is no direct influence of changes in the exchange rate on foreigner's demand for exports.

The quantity of goods produced domestically is given by y. If the law of one price held, it would be simple to evaluate sales of goods in real terms. As in the Mundell model, the real value of sales is simply the quantity of goods sold. But, in our model, output sold to foreigners is sold at a different price than identical output sold to domestic residents. The domestic currency value of exports is equal to $e\pi_h x$, so the real value of exports, valued at domestic prices is $(e\pi_h/p_h)x$. But, for all of the reasons discussed in the introductory section, only a fraction k of foreign exchange earnings are considered to be part of income in the short run. Accordingly, real home income evaluated at domestic prices is

$$z = y - k\left(1 - \frac{e\pi_h}{p_h}\right)x, \tag{16}$$

where $0 < k < 1$. Foreign income is defined analogously:

$$z^* = y^* - k^*\left(1 - \frac{p_f}{e\pi_f}\right)m. \tag{17}$$

The equilibrium condition in the domestic goods market is now given by

$$y = c(z) - \frac{p_f}{p_h}\cdot m\left(z, \frac{p_f}{p_h}\right) + f(i) + x\left(z^*, \frac{\pi_f}{\pi_h}\right) + g. \tag{18}$$

[6] Though changes in the exchange rate directly influence income, z, as discussed below.

Similarly, the equation for the foreign IS curve is given by

$$y^* = c^*(z^*) - \frac{\pi_h}{\pi_f} x\left(z^*, \frac{\pi_f}{\pi_h}\right) + f^*(i^*) + m\left(z, \frac{p_f}{p_h}\right) + g^*. \tag{19}$$

The appendix derives the expression for the change in the exchange rate in this model in the case in which demand functions are symmetric. We find

$$\frac{\partial e}{\partial g} = \frac{-(\Sigma - \Omega x)}{x\Omega(\Sigma - kx)} < 0, \tag{20}$$

where $\Sigma = (\ell_1(1 - c_z + m_z + x_z) + f_i \ell_z)/2\ell_z < 0$ and Ω is defined above. Note that as long as $\Omega > k$ there is short-run overshooting of the exchange rate:

$$\frac{\partial e}{\partial g} - \frac{\partial \bar{e}}{\partial g} = \frac{\Omega - k}{\Omega(\Sigma - kx)} < 0.$$

Short-run overshooting of the exchange rate is consistent with the extreme volatility of modern floating exchange rate regimes. The exchange rate change has very little effect on the goods market in the short run. Hence, in order to achieve financial market equilibrium, large swings in the exchange rate are required.

In contrast to the Mundell model, both income and output are affected by demand shocks:

$$\frac{\partial z}{\partial g} = \frac{\ell_i(\Omega - k)}{2\ell_y \Omega(\Sigma - kx)} > 0 \tag{21}$$

and

$$\frac{\partial y}{\partial g} = \frac{\partial z}{\partial g} - kx\frac{\partial e}{\partial g} > \frac{\partial z}{\partial g} > 0. \tag{22}$$

In this model, Mundell's argument in favor of floating exchange rates is very much mitigated. The insulating properties of flexible exchange rates are much smaller when there is a substantial amount of local-currency pricing. In the Mundell model, exchange rate changes effectively completely offset the relative demand shock, so that there are no output effects. But, when there is local-currency pricing, and very little exchange-rate pass-through, floating exchange rates have only a small stabilizing effect. In this case, changes in the exchange rate have little effect on goods markets in the short run, so they are not a channel through which adjustment to shocks to the real sector can occur.

3. Conclusions

The Friedman–Feldstein case for flexible exchange rates must be reexamined in light of the evidence for local-currency pricing. The stabilizing role of flexible exchange rates may not be so strong when producers set prices in the consumer's currency.

In practice, exchange-rate pass-through is not the same for all goods, nor for producers in all countries. Even the limited evidence we have presented suggests there is more pass-through for simple, homogeneous goods than for complex goods produced by monopolists or monopolistic competitors. Evidence from Goldberg and Knetter (1997) seems to indicate there is more pass-through directly to export prices than there is to prices of finished goods sold to consumers. A complete analysis requires consideration of the causes of these varying pricing practices.

The Mundell–Fleming model assigns labor markets a secondary role. But many authors have noted that labor market behavior is key to the understanding of adjustment in European economies. It has been observed that Europe is characterized by a high degree of real-wage rigidity, which leads to very slow adjustment of Europe's labor markets. Obstfeld (1997), for one, investigates the implications of this real-wage rigidity for the choice of exchange-rate regime.

Our concern with the viability of floating exchange rates has been mainly with the stability of output. A more comprehensive analysis would compare overall economic welfare with varying degrees of pricing in local versus producer's currencies under fixed and floating exchange rates. Devereux and Engel (1998) have recently compared fixed and floating exchange rate regimes in intertemporal optimizing models with uncertainty. Their concern is how welfare comparisons between the two exchange-rate regimes are affected by price-setting behavior. They find that local-currency pricing strengthens the case for flexible exchange rates. However, their concern is solely with transmission of monetary shocks. They do not consider the goods-market shocks that Feldstein puts at the center of his analysis. Indeed, it would seem that monetary transmission is not so relevant an issue for the EMU, where it is generally presumed that overall monetary stability will be enhanced under the European central bank.

Devereux and Engel (1998) assume a complete market of state-contingent nominal bonds. When markets are complete in this way, the marginal utility of consumption relative to prices across countries are equalized:

$$\frac{u'(c)}{p} = \frac{u'(c^*)}{sp^*}. \tag{23}$$

Here, u represents the instantaneous utility function, c (c^*) is per capital consumption in the home (foreign) country, and p (p^*) is the price index for consumption in the home (foreign) country. When the law of one price holds, and under the assumption of identical preferences made by Devereux and Engel, purchasing power parity holds as well. In that case $p = sp^*$, and so Eq. (23) indicates that there is complete consumption insurance: $c = c^*$. On the other hand, when prices are set in consumers' currencies, the law of one price and purchasing power parity fail. In that case, consumption is not equalized across countries. This leads us to similar conclusions as we found in our ad hoc IS-LM model. We can conclude that under floating rates and the law of one price, consumption is stabilized across countries. In response to shocks, there is no idiosyncratic fluctuations in consumption across countries, only fluctuations in world consumption. This is exactly what we found in the IS-LM model, where we examined offsetting demand shocks at home and abroad so there were no fluctuations in world output. We found that local fluctuations in output (and hence consumption) are completely eliminated when PPP holds. On the other hand, if there is pricing in producers' currencies and the law of one price holds, Eq. (23) shows that there will be idiosyncratic differences in home and foreign consumption, which corresponds to the results we found in the IS-LM model with local-currency pricing.

There are some important differences in IS-LM models and the models based on intertemporal optimization of Obstfeld and Rogoff (1995,1998) and Devereux and Engel (1998). The IS-LM models are not genuinely forward-looking and ignore budget constraints facing consumers, firms and governments. Both sets of models, however, retain the central feature explored here: with local-currency pricing, nominal exchange rate changes do not affect relative prices faced by consumers.

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Appendix

We modify the money demand equations so they are function of income:

$$h/p_h = \ell(i, z), \tag{A.1}$$

$$h^*/\pi_f = \ell^*(i^*, z^*). \tag{A.2}$$

In this model, p_f, p_h, π_f and π_h are all fixed in the short run. For simplicity, we set those prices equal to one.

We totally differentiate Eqs. (4), (16)–(19), (A.1) and (A.2) evaluating the derivatives at $e = \bar{e} = p_h = p_f = \pi_h = \pi_f = 1$, and $x = m$:

$$\mathrm{d}i = \mathrm{d}i^* + \mathrm{d}\bar{e} - \mathrm{d}e, \tag{A.3}$$

$$\mathrm{d}z = \mathrm{d}y + xk\,\mathrm{d}e, \tag{A.4}$$

$$\mathrm{d}z^* = \mathrm{d}y^* - xk^*\,\mathrm{d}e, \tag{A.5}$$

$$\mathrm{d}y = c_z\,\mathrm{d}z - m_z\,\mathrm{d}z + f_i\,\mathrm{d}i + x_z\,\mathrm{d}z^* + \mathrm{d}g, \tag{A.6}$$

$$\mathrm{d}y^* = c_z^*\,\mathrm{d}z - x_z\,\mathrm{d}z^* + f_i^*\,\mathrm{d}i + m_z\,\mathrm{d}z + \mathrm{d}g^*, \tag{A.7}$$

$$0 = \ell_i\,\mathrm{d}i + \ell_z\,\mathrm{d}y + \ell_z xk\,\mathrm{d}e, \tag{A.8}$$

$$0 = \ell_i^*\,\mathrm{d}i^* + \ell_z^*\,\mathrm{d}y^* - \ell_z^* k^* x\,\mathrm{d}e. \tag{A.9}$$

For simplicity, consider the symmetrical case in which $c_z = c_z^*$, $f_i = f_i^*$, $\ell_i = \ell_i^*$, $\ell_z = \ell_z^*$ and $k = k^*$. Then, add Eqs. (A.4) and (A.5) together to get

$$\mathrm{d}z + \mathrm{d}z^* = \mathrm{d}y + \mathrm{d}y^*.$$

Then, recalling we are examining the case in which $\mathrm{d}g + \mathrm{d}g^* = 0$, add together Eqs. (A.6) and (A.7) to get

$$(1 - c_z)(\mathrm{d}y + \mathrm{d}y^*) = f_i(\mathrm{d}i + \mathrm{d}i^*). \tag{A.10}$$

Add Eqs. (A.8) and (A.9) to get

$$0 = \ell_i(\mathrm{d}i + \mathrm{d}i^*) + \ell_y(\mathrm{d}y + \mathrm{d}y^*). \tag{A.11}$$

Eqs. (A.10) and (A.11) imply $\mathrm{d}y + \mathrm{d}y^* = 0$, and $\mathrm{d}i + \mathrm{d}i^* = 0$, which in turn imply $\mathrm{d}z + \mathrm{d}z^* = 0$. So the effects on the two countries are symmetric – the change in output and interest rates in the home country are exactly the opposite of the change in the foreign country. We can then reduce the system to one of three equations that will solve for $\mathrm{d}z, \mathrm{d}e$ and $\mathrm{d}i$:

$$\mathrm{d}z - kx\,\mathrm{d}e = (c_z - m_z - x_z)\,\mathrm{d}z + f_i\,\mathrm{d}i + \mathrm{d}g. \tag{A.12}$$

$$2\,\mathrm{d}i = \mathrm{d}\bar{e} - \mathrm{d}e. \tag{A.13}$$

$$0 = \ell_i\,\mathrm{d}i + \ell_z\,\mathrm{d}z. \tag{A.14}$$

From these equations we find

$$\frac{\partial e}{\partial g} = \frac{-(\Sigma - \Omega x)}{x\Omega(\Sigma - kx)} < 0,$$

where $\Sigma = [\ell_i(1 - c_z + m_z + x_z) + f_i\ell_z]/2\ell_z < 0$ and Ω is defined above. Note that as long as $\Omega > k$ there is short-run overshooting of the exchange rate:

$$\frac{\partial e}{\partial g} - \frac{\partial \bar{e}}{\partial g} = \frac{\Omega - k}{\Omega(\Sigma - kx)} < 0.$$

In this case, income and output will increase:

$$\frac{\partial z}{\partial g} = \frac{\ell_i(\Omega - k)}{2\ell_y\Omega(\Sigma - kx)} > 0$$

and

$$\frac{\partial y}{\partial g} = \frac{\partial z}{\partial g} - kx\frac{\partial e}{\partial g} > \frac{\partial z}{\partial g} > 0.$$

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