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Sticky prices and deviations from the Law of One Price: Evidence from Mexican micro-price data☆,☆☆

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ABSTRACT

This paper uses a novel dataset of weekly sampled store-level prices to study the impact of sticky prices on the volatility and persistence of intranational deviations from the Law of One Price (LOP). The volatility of LOP deviations is found to be increasing both on the distance separating two locations and on the degree of price stickiness. Sticky prices are also found to be systematically related to the persistence of LOP deviations: Half-lives of LOP deviations are systematically larger for goods with stickier prices. These observations are shown to accord well with the predictions of a dynamic general equilibrium model featuring real market segmentation and Calvo pricing. I also find evidence of remarkably fast convergence to the LOP (average half-lives of LOP deviations are in the order of 3–6 weeks) and show that previously reported convergence estimates may be afflicted by a positive temporal aggregation bias.

1. Introduction

A long-standing question in international economics concerns the nature of the large, volatile, and persistent deviations from the Law of One Price (LOP) observed in the data. In an important contribution to this literature, Engel and Rogers (1996) showed that the volatility of LOP deviations is systematically related to trade costs (proxied by physical distance) and advanced the hypothesis that LOP deviations could also be explained by price stickiness.[1]

Recent theoretical work by Kehoe and Midrigan (2007) and Crucini et al. (2010, 2013) formalize Engel and Rogers' (1996) hypothesis and show that the volatility and persistence of LOP deviations can be partly explained by nominal price rigidities. This research finds that the persistence of LOP deviations is increasing in the degree of price stickiness, regardless of whether the analysis is cast in an intranational or an international setting. The relationship between the volatility of LOP deviations and sticky prices is more complex and is found to depend crucially on the nature of the shocks affecting (good-level) real exchange rates. In the intranational context, where relative prices are only affected by real shocks, greater degrees of price stickiness are unambiguously associated with less volatile LOP deviations (Crucini et al. 2010, henceforth CST). When real exchange rates are only affected by monetary shocks instead (as in Kehoe and Midrigan's (2007) model of cross-border real exchange rates), then greater price stickiness is associated with more volatile LOP deviations.[2] The empirical evidence supporting the theory is still sparse and incomplete.[3]

This article empirically addresses the role of price rigidities in explaining both the volatility and persistence of intranational LOP deviations using a unique dataset of store-level prices. A major advantage of focusing the analysis in the intranational (as opposed to the international) context is that the predictions of the theory are starker in this setting.

☆ This paper is based on my PhD dissertation at the University of California Berkeley. Portions of this paper circulated in an earlier working paper entitled "Temporal Aggregation and Convergence to the Law of One Price: Evidence from Micro Data."

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1 Engel and Rogers (1996) found that price stickiness could partially explain the border-effect (the fact that the variability of LOP deviations is substantially larger for two cities located in different countries than for two equidistant cities in the same country) and tentatively concluded that sticky prices could help explain the variability of LOP deviations.

2 Crucini et al. (2013) provide a synthesis of the work of CST and Kehoe and Midrigan (2007) and show that in the presence of both real and nominal shocks the relationship between the volatility of LOP deviations and the degree of price stickiness has a U-shape.

3 Kehoe and Midrigan (2007) find no support for the predicted effects of price stickiness on the volatility of cross-border real exchange rates and partial support for their effects on the persistence of LOP deviations. CST find support for the predicted effects of price stickiness on the volatility of intranational LOP deviations but does not address the impact of price stickiness on the persistence of intranational LOP deviations.

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The CST model predicts that sticky prices give rise to more persistent LOP deviations and, controlling for distance, less volatile LOP deviations. Using the frequency of price adjustment at the individual good level as a proxy for price stickiness I find strong evidence for both of these predictions.

The data include store-level prices for a set of 40 narrowly defined products[4] sampled weekly from outlets located across 11 urban centers[5] in Mexico. Prices in the sample are surveyed from about 1800 outlets over the 2001–2011 period. The dataset includes both perishable (e.g., "1 kg. of ham San Rafael, 16 percent protein") and nonperishable (e.g., "355 ml can of Coca-Cola") products which are primarily foodstuffs and health and beauty products.

A number of distinctive features of the data are worth emphasizing. First, the data are at the store and product level, which allows me to obtain direct calculations of frequencies of price adjustment. Prior work on the relationship between intranational LOP deviations and price stickiness by CST used city-level prices, and hence had to rely on estimates instead of direct calculations of frequencies of price adjustment. Second, the data include prices that are sampled at a higher frequency (weekly) than prices used in most previous studies examining deviations from the LOP. This feature allows me to compute more precise measures of price stickiness and to obtain estimates of the speed of convergence to the LOP which are unlikely to be subject to temporal aggregation bias (see Taylor (2001)).[6] Third, the data include prices for exactly identical products across locations.

The evidence presented in this paper indicates that price stickiness is strongly related to the persistence and volatility of intranational LOP deviations, as the theory predicts. Increases in the infrequency of price adjustments are shown to be associated to more persistent LOP deviations: I estimate that doubling the frequency of price adjustment for the average good in the sample reduces the half-life of LOP deviations by about two-thirds. Furthermore, I find that the CST model does a reasonably good job at predicting half-lives based on the observed frequencies of price adjustment. The absolute difference between predicted and estimated half-lives is, on average, about 0.37 as a fraction of the estimated half-life. This contrasts with the difficulty found by Kehoe and Midrigan (2007) of reconciling the predictions of their model with observed half-lives in the international context.[7] The volatility of LOP deviations is found to be increasing in physical distance and decreasing in the degree of price stickiness. Using the implied distance equivalent of an increase in the infrequency of price changes as a metric of the quantitative importance of price stickiness, I find that a 0.01 increase in the infrequency of price adjustments is equivalent to an increase of approximately 20 miles in the distance between two cities relative to the average distance in the sample. This is very similar to the estimate reported by CST using data for Japan.

Finally, I find evidence that convergence to the LOP occurs at a faster speed than previously reported in the literature. The average half-life of deviations from the LOP is estimated at 3.4 weeks (6.3 weeks) based on posted (regular) prices. Half-life estimates appear to be robust to small sample bias and to measurement error, both of which may induce an underestimation of convergence speed. I show that part of the discrepancy between the persistence estimates in this paper and some of those reported in the literature can be explained by the type of temporal aggregation bias emphasized by Taylor (2001).

The remainder of the paper is organized as follows. Section 2 presents the theoretical framework for the study. Section 3 describes the data and reports summary statistics on price dispersion and frequencies of price adjustment. Section 4 examines the magnitude, volatility and persistence of LOP deviations in the data. Section 5 studies the empirical relationship between sticky prices and the volatility and persistence of intranational LOP deviations. Section 6 concludes.

2. Theoretical framework

This section presents an outline of the sticky price model of intranational LOP deviations developed in CST and derives its implications for the relationship between price stickiness and the persistence of deviations from the LOP.[8] In the model, price stickiness is introduced through a Calvo (1983) mechanism and is assumed to be heterogeneous across goods. The model generates deviations from the LOP through a combination of trade costs (which give rise to home bias in consumption) and labor productivity shocks.

The model considers two cities, A and B, located in the same country. The relative price of good i (in logs) between the two cities is defined as:

$$q_t(i) = \ln P_{B,t}(i) - \ln P_{A,t}(i)$$

where $P_{j,t}(i)$ is the price of good i in city $j \in \{A, B\}$. Households in the two cities are assumed to hold complete state-contingent money claims and have a period utility function given by: $\ln C_{j,t} - L_{j,t}$, where $C_{j,t}$ and $L_{j,t}$ denote consumption and labor supply. The combination of a binding cash-in-advance constrain and a standard intratemporal optimality condition imply that the nominal wage rate and nominal money demand are equal to each other.[9]

Monopolistically competitive firms use a production technology which is linear in labor and subject to productivity shocks: $Y_{j,t}(i, v) = Z_{j,t}(i)L_{j,t}(i, v)$, where $Y_{j,t}(i, v)$, $L_{j,t}(i, v)$ and $Z_{j,t}(i)$ denote output, labor demand and labor productivity, respectively, of brand v of product i in city j.[10] Firms in city j must incur an iceberg cost τ to sell in city k. Firms reset their prices under Calvo-type pricing: Each period a random fraction $(1 - \lambda_i)$ of firms selling good i is allowed to reset prices.

In this setting, the relative price of good i between the two cities (normalized[11] and expressed as deviations from the steady state) follows an AR(2) process given by:[12]

$$\hat{q}_t(i) = (\lambda_i + \rho)\hat{q}_{t-1}(i) - \lambda_i\rho\hat{q}_{t-2}(i) + (S_A(i) + S_B(i) - 1) \times \left[\frac{(1-\lambda_i)(1-\lambda_i\beta)}{1-\lambda_i\beta\rho}\right]\xi_t(i) \tag{1}$$

where ρ measures the persistence of productivity shocks, β is the household discount factor, $S_j(i)$ $(j = A, B)$ is the steady-state expenditure share on home brands of good i for city j and $\xi_t(i)$ is the productivity differential across cities (relative to its unconditional mean).[13]

CST demonstrate that the volatility of $\hat{q}_t(i)$ is decreasing in the infrequency or price adjustments λ_i and increasing in the iceberg transportation cost τ (see Proposition 1 in CST). To examine the relationship

4 In what follows I use the terms *product* and *good* indistinctively.

5 Urban centers correspond to 10 cities and Tlaxcala, the smallest state in Mexico.

6 Taylor (2001) shows that estimating convergence to the LOP or PPP using temporally aggregate data (i.e., low-frequency averages of prices generated at higher frequencies) leads to upwardly biased persistence estimates.

7 Kehoe and Midrigan (2007) report cases for which the estimated half-life of LOP deviations is about 30 times the half-life implied by the model.

8 The reader is referred to CST as well as to the working paper version of CST, Crucini et al. (2009), for further details on the model.

9 In equilibrium, nominal money demand is equal to the money supply which is assumed to follow the process:

$$\ln M_{j,t} = \mu_j^M + \eta_t^M$$

where μ_j^M is a fixed effect and η_t^M is a random walk component.

10 Labor productivity is assumed to follow the process:

$$\ln Z_{j,t}(i) = \mu_j^Z(i) + \eta_t^Z + \varepsilon_{j,t}(i)$$
$$\varepsilon_{j,t}(i) = \rho\varepsilon_{j,t-1}(i) + \xi_{j,t}(i), \xi_{j,t}(i) \sim i.i.d.\left(0, \sigma_\xi^2\right)$$

where $\mu_j^Z(i)$ is a fixed effect and η_t^Z is a random walk component.

11 The normalized LOP deviation uses the following normalization for the price of good i in city j: $\overline{P}_{j,t}(i) = Z_{j,t}P_{j,t}(i)/M_{j,t}$.

12 See Appendix in Crucini et al. (2009).

13 The equation simplifies to the following AR(1) process in the special case in which the productivity shocks are i.i.d.:

$$\hat{q}_t(i) = \lambda_i\hat{q}_{t-1}(i) + (S_A(i) + S_B(i) - 1)(1-\lambda_i)(1-\lambda_i\beta)\xi_t(i)$$