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# The law of one price revisited: How do goods market frictions generate large and volatile price deviations?☆

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ABSTRACT

This paper analyzes the role of goods market frictions in accounting for the large and volatile deviations from the Law of One Price (LOP) in a framework of flexible prices. We draw a distinction between the goods market frictions that are required to consume tradable goods (e.g., distribution costs) and those that are necessary for international transactions (e.g., trade costs). We find that trade costs generate LOP deviations by introducing a no-arbitrage band, while distribution costs cause the price to deviate from the LOP by affecting the probability that trade will occur, given the band. We then conduct a Monte Carlo simulation to show that real exchange rate volatility is positively associated with trade costs, but negatively related to distribution costs. This effect depends on the interplay of trade costs and distribution costs, as they work in opposite directions when creating arbitrage opportunities.



## 1. Introduction

One of the most enduring puzzles in international macroeconomics, observed since the beginning of the post-Bretton Woods era, is that the deviations from the Law of One Price (LOP) and its generalization, Purchasing Power Parity (PPP), are not only large but also highly volatile and persistent. Rogoff (1996) refers to the juxtaposition of these observations and the predictions of structural models as the PPP puzzle. Traditionally, attempts to address this puzzle have been based on the distinction between tradable and non-tradable goods. However, since the influential work by Engel (1999), most studies have shed light on the LOP deviations of tradable goods as an empirically relevant foundation of the current theoretical approaches.[1] Two main branches of the literature have explored the LOP deviations of tradable goods. The first branch introduces nominal rigidities into dynamic equilibrium models (see, for example, Betts and Devereux (2000), Bergin and Feenstra (2001), Chari et al. (2002), Kehoe and Midrigan (2007), and Carvalho and Nechio (2011)). While useful in addressing monetary policy, such models lack the ability to provide a plausible mechanism for sustaining deviations from the LOP of the magnitude observed in the data. A second strand of the literature emphasizes the importance of transaction costs. These models predict that real exchange rates are bounded by the fixed limits of arbitrage costs, which are treated broadly to include transportation and other costs of bringing goods to final

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[1] Engel (1999) shows that almost all real exchange rate fluctuations are attributable to fluctuations in the relative prices of tradable goods between the U.S. and other industrialized countries.

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consumption markets (see, for example, Sercu et al. (1995), Obstfeld and Rogoff (2000), Burstein et al. (2003), Sercu and Uppal (2003), Crucini et al. (2005), and Corsetti et al. (2007)). This paper fits into the second strand of the literature.

Although the importance of *international* transaction costs in generating LOP deviations has been well documented, only a few papers have studied the role played by *domestic* transaction costs and their interplay with international costs in shaping the behavior of the real exchange rate. In this paper, we offer a new approach to explain the PPP puzzle in a framework of flexible prices. We specify a two-country world economy, allowing for two types of goods market frictions, namely, international trade costs and domestic distribution services. The inclusion of these frictions allows us to endogenously drive a natural wedge between the prices in different locations and thus account for the deviations from the LOP, even though all goods are tradable. Further, the distinction between domestic and international costs guides us to highlight two different channels through which these costs affect LOP deviations.

Our model thus encompasses the main elements of the standard models that study the role of transaction costs in explaining real exchange rate dynamics. However, our approach has three notable distinctions. First, we distinguish between domestic and international goods market frictions. Specifically, in addition to iceberg-type international trade costs, we incorporate domestic distribution costs by assuming that consuming a tradable good requires certain units of distribution services. Second, we elaborate on channels through which these costs and their interactions can affect the magnitude and volatility of LOP deviations. Third, we do not model nominal rigidities and deliberately focus on the role of goods market frictions. Our approach is meant to offer a framework to help understand the long-run real exchange rate by placing an emphasis on real frictions that drive large and volatile deviations from the LOP.

Our main findings are as follows. As widely known, trade costs appear to introduce the no-arbitrage band in which trade does not occur and hence directly generate the LOP deviations. We find that distribution costs also contribute to these deviations by affecting the direction of trade and the probability that trade will occur given the no-arbitrage band. By doing so, an increase in trade costs enlarges the deviations from the LOP by widening the no-arbitrage band, whereas a unilateral rise in distribution costs makes the real exchange rate more likely to move toward the boundary of the band generating the LOP deviations. The Monte Carlo Simulation shows that the volatility of LOP deviations is positively associated with trade costs, but negatively related to distribution costs. This effect depends on the interplay of trade costs and distribution costs, as they work in opposite directions when creating arbitrage opportunities.

The paper is organized as follows. Section 2 presents the model setup. Section 3 solves for the equilibrium real exchange rate and discusses how distribution costs and trade costs affect the deviations from the LOP. Section 4 carries out a Monte Carlo simulation to examine the effects of goods market frictions on the real exchange rate volatility. Section 5 concludes.

## 2. The model

Our framework builds on the model proposed by Sercu and Uppal (2003), which we generalize in two respects.[2] First, we introduce non-tradable goods. Second, we incorporate distribution services that are made up of non-tradable goods. The main differences arising from the existence of non-tradable goods and distribution services appear in the preference and resource constraints. The world economy consists of two countries of identical size: a home country (HC) and a foreign country (FC). We use an asterisk $(*)$ to denote the variables associated with the foreign country. Each country is populated by a large number of infinitely lived consumers who have utility defined over sequences of consumption of tradable $(C_t^T)$ and non-tradable goods $(C_t^{NT})$,

$$U = \sum_{t=0}^{\infty} \beta^t \frac{\left[\left(C_t^T\right)^{\alpha}\left(C_t^{NT}\right)^{1-\alpha}\right]^{1-\gamma}}{1-\gamma} \tag{1}$$

in the home country, and

$$U^* = \sum_{t=0}^{\infty} \beta^t \frac{\left[\left(C_t^{T*}\right)^{\alpha}\left(C_t^{NT*}\right)^{1-\alpha}\right]^{1-\gamma}}{1-\gamma} \tag{2}$$

in the foreign country, where $0 < \alpha < 1$ is the expenditure share of tradable goods, $0 < \beta < 1$ is the discount factor and $\gamma > 1$ is the inverse of the intertemporal elasticity of substitution. In every period, each economy is exogenously endowed with tradable $(Y_t^T)$ and non-tradable $(Y_t^{NT})$ goods that are non-storable. We assume that financial markets are perfectly integrated and complete such that financial claims are traded freely. Following Burstein et al. (2003), we introduce a distribution sector by assuming that consumption of a tradable good requires $\theta$ units of distribution services, which consist of non-tradable goods.[3] Distribution sectors are assumed to be heterogeneous across countries because wholesaling, retailing, and local transportation tend to be

[2] Sercu and Uppal (2003) analyze the relationship between exchange rate volatility and volume of trade, pointing out that a drop in shipment costs implies a decrease in exchange rate volatility.

[3] Noting that wholesaling, retailing, and transportation do not play significant roles in the most important non-tradable sectors (i.e., housing, health, and education expenditures), we assume that consumptions of non-tradables do not require distribution services, as suggested by Burstein et al. (2003).