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# A re-examination on dissecting the purchasing power parity puzzle

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A B S T R A C T

The purpose of this paper is to examine the source of a real exchange-rate adjustment based on the impulse-response function constructed from local projections when the true data-generating process (DGP) is unknown. This work extends the local-projection method proposed by Jordà [2005. Estimation and inference of impulse responses by local projections. American Economic Review 95, 161–182] to allow for variables that are $I(1)$ and exhibit cointegration. Our paper shows that nominal exchange-rate adjustments dominate in the reversion toward PPP regardless of a nominal exchange-rate shock or a price shock. It is also shown that the half-life of real exchange rates is close to that of nominal exchange rates. Since these results are consistent with those of Cheung et al. [Cheung, Y.W., Lai, K.S., Bergman, M., 2004. Dissecting the PPP puzzle: the unconventional roles of nominal exchange rate and price adjustments. Journal of International Economics 64, 135–150], we therefore conclude that their main findings are robust to possible misspecifications in the true DGP.



## 1. Introduction

For decades, the purchasing power parity (PPP) hypothesis has been a major research field within empirical international finance. Existing empirical evidence based on unit-root tests provided mixed results for the long-run validity of PPP (Mark, 1990; Abuaf and Jorion, 1990; Taylor and Sarno, 1998;

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O'Connell, 1998; Cheung and Lai, 1993; Michael et al., 1997). Although several articles appear to support the mean reversion of real exchange rates, their estimates of the half-life range from 3 to 5 years (Rogoff, 1996). These half-life estimates seem too long to be explained by sticky-price models which predict a half-life of 1–2 years. This is the PPP puzzle outlined by Rogoff (1996).

Since the seminal work of Rogoff (1996), the adjustment mechanism of PPP deviations has become an interesting issue in literature. Some articles examine the dynamic adjustment of real exchange rates, but the literature about the adjustment mechanism of nominal exchange rates and prices resulting from PPP deviations is limited. Two articles investigate the adjustment mechanism of PPP deviations. First, Engel and Morley (2001) use a state-space model to show that, while it takes years for nominal exchange rates to converge, it only takes a few months for prices to do so. Next, Cheung et al. (2004) use a linear vector error-correction model (VECM) to reach a similar conclusion. Cheung et al. (2004) also conclude that "about 60–90% of real exchange-rate convergence is driven by nominal exchange rates and the contribution of prices to PPP convergence is relatively minor". Their findings sharply contrast with conventional explanations based on nominal rigidities and therefore offer a new look at theoretical modeling of real exchange-rate dynamics.

Cheung et al. (2004) apply a VECM model to construct impulse-response functions (IRFs) given that nominal exchange rates and prices are $I(1)$ but cointegrated. The conventional VAR-VECM approach assumes that the true data-generating process (DGP) follows a vector autoregressive (VAR) process. A reduced rank VAR specification may also be misspecified in a set of cointegrated variables, since an error-correction model may be formed by a reduced rank vector autoregressive moving average (VARMA) specification (Engle and Granger, 1987).[1] Hence, the construction of IRFs based on the VAR-VECM model is not robust to misspecifications in the true DGP.

Jordà (2005) proposes a local-projection approach that uses multi-step direct forecasts as an alternative to a VARMA transformation.[2] Furthermore, he shows that IRF estimates derived from local projections are consistent and asymptotically normal. One advantage of Jordà's local projections is that they allow IRFs to be constructed without knowing the true DGP.[3] In other words, the IRFs constructed from local projections are robust to misspecifications in the true DGP.

Unfortunately, Jordà's local-projection method cannot be directly applied to cases where variables are $I(1)$, since the standard multi-step forecast and projection theorem requires the existence of the second moment of variables.[4] Lin and Tsay (1996) find, based on monthly financial and macroeconomic data of six major economies, that direct forecasting outperforms VECM-based forecasting in the presence of unknown unit roots and cointegration – even though unit roots and cointegration are ignored in direct forecasting. Theoretically, cointegration implies the existence of a long-run equilibrium among the variables, which could be exploited to improve the accuracy of long-term forecasts. The simulations of Lin and Tsay (1996) show the long-term forecasting benefit of modeling cointegrating relationships among variables, if they exist. Therefore, having the correct knowledge of cointegrating relationships among variables improves the accuracy of forecasts.

The purpose of our paper is to re-examine the adjustment mechanism of prices and nominal exchange rates based on IRFs constructed from local projections. This paper extends Jordà's local-projection method to obtain IRFs in a model where variables are integrated of order one, $I(1)$, but with

1 Let $\mathbf{y}_t$ be an $n \times 1$ random vector such that all components of $\mathbf{y}_t$ are $I(1)$ and that there exists a vector $\boldsymbol{\beta}$ such that $\boldsymbol{\beta}'\mathbf{y}_t \sim I(0)$. Engle and Granger (1987) show that there exists an error-correction representation with $\mathbf{z}_t = \boldsymbol{\beta}'\mathbf{y}_t$, an $r \times 1$ vector of stationary random variables:$\mathbf{A}^*(L)(1-L)\mathbf{y}_t = -\boldsymbol{\alpha}\boldsymbol{\beta}'\mathbf{y}_{t-1} + \mathbf{d}(L)\epsilon_t$.It is worth noting that the above vector error-correction model is not a VAR model unless $\mathbf{d}(L) = \mathbf{I}$.

2 Jordà (2005) establishes the equivalence of IRFs calculated by local projections and VAR, respectively, when the true DGP follows a VAR process.

3 When variables under investigation are $I(0)$, a standard VAR approach is applied to construct an IRF. The conventional approach may not be appropriate if one is interested in the true dynamics of underlying process. This is because VAR specifications are typical parsimonious and likely misspecified and hence a VAR($k$) model is not likely to be the exact representation of the process under study (Chang and Sakata, 2007). In addition, an unappealing feature of conventional IRF estimates is that these estimates are constructed by extrapolating the parsimonious VAR model which will typically impose smooth decay in the estimated IRF and therefore excludes potentially high-order dynamics of underlying process.

4 To be specific, it requires that variables are in a Hilbert space, $L^2(\Omega, \mathcal{F}, P)$ (Weiss, 1991; Brockwell and Davis, 1991, Chapter 2; Ing, 2003).