KIEP Working Paper 08-06

Real Exchange Rate Dynamics in the Presence of Nontraded Goods and Transaction Costs

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Executive Summary

The Purchasing Price Parity states that international relative price differentials should be arbitraged away so that identical goods in different countries should sell for the same price, when expressed in a common currency. Yet the evidence from the empirical literature shows that not only are relative prices quite different across countries, but also such deviations are highly volatile and persistent. These characteristics of the real exchange rate have been the central puzzle in international macroeconomics literature, with the source of the puzzling behavior remaining unclear.

In this paper, we study the role of transaction costs and nontraded goods to account for the puzzling behavior of the real exchange rate. In particular, we develop a simple general equilibrium model and evaluate the quantitative performance of the model in replicating the dynamic properties of the real exchange rate. The simulation results show that introducing both the transaction costs and nontraded goods in an otherwise standard model dramatically improve its ability to rationalize observed real exchange rate dynamic properties. The benchmark model matches 95% of the persistence and 90% of the volatility of the real exchange rate. In addition, the sensitivity analysis shows that our model can rationalize more than 97% of both persistence and volatility of the real exchange rate.

Our analysis suggests that the purchasing price parity puzzle can naturally arise in the presence of transaction costs and nontraded goods, even under the assumption of a flexible price market.

Keywords: Real exchange rate, persistence, volatility, nontraded goods, transaction costs

JEL classification: F31, F41, F47

국문요약

현대 국제거시경제학 모형의 기본적 가정인 law of one price와 purchasing power parity는 국가별 상대가격의 격차가 시차를 거치며 축소될 것으로 가정하고 있다. 하지만 실제로는 실질환율, 즉 국가간 상대가격의 격차가 매우 지속적(persistent)일 뿐만 아니라 변동적(volatile)으로 움직이는 것으로 관찰된다. 따라서 기존의 국제거시모형은 실질환율의 동태적인 지속성과 변동성을 동시에 설명하지 못하는 한계를 지니고 있다. 본 연구에서는 비교역재와 거래비용을 고려한 일반균형 모형을 발전시키고 이로부터 실질환율의 동태적 움직임을 설명하고자 한다. 시뮬레이션 결과에 따르면 본 모형은 실질환율 지속성의 95%, 변동성의 90% 이상을 설명할 수 있는 것으로 나타난다. 이러한 결과는 가격경직성을 가정하지 않더라도 비교역재와 거래비용이 존재하는 한 실질환율의 지속성과 변동성이 유지된다는 사실을 의미한다.

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Contents

Real Exchange Rate Dynamics in the Presence of Nontraded Goods and Transaction Costs

Inkoo Lee[1] and Jonghyup Shin[2]

Abstract

This paper studies the role of nontraded goods and transaction costs in accounting for the puzzling behavior of the real exchange rate. In particular, we develop a simple general equilibrium model and evaluate the quantitative performance of the model in replicating the dynamic properties of the real exchange rate.

The simulation results show that introducing both the transaction costs and nontraded goods in an otherwise standard model dramatically improve its ability to rationalize observed real exchange rate dynamic properties. The benchmark model matches 95% of the persistence and 90% of the volatility of the real exchange rate. In addition, the sensitivity analysis shows that our model can rationalize more than 97% of both persistence and volatility of the real exchange rate.

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Our analysis suggests that the purchasing price parity puzzle can naturally arise in the presence of transaction costs and nontraded goods, even under the assumption of a flexible price market.

I. Introduction

Obstfeld and Rogoff (2000) advanced the hypothesis that trade costs in goods markets in an otherwise neoclassical and competitive environment could resolve the six major puzzles in international macroeconomics, with two exceptions. The exceptions were the purchasing power parity puzzle and the exchange rate disconnect puzzle. They claimed that accounting for these two puzzles would require additional frictions: "among other things, elements of monopoly and sticky nominal prices for goods and labor."

In this paper, we offer an alternative explanation of not only the puzzling facts that motivated Obstfeld and Rogoff to chart the course of the New Open Economy Models paradigm, but an explanation that also attempts to capture the time series behavior of real exchange rate. In doing so, we impose empirical discipline on the model based on its micro foundations and leave the macroeconomic implications to be determined endogenously.

The essence of our story is the recognition that consumers purchase bundles of commodities and services, not individual commodities. This is what retail markets offer. Some bundles are simple, such as bananas sold at a grocery store, while others are rather complex, such as the 30,000-mile warranty that comes with the purchase of a Honda Accord at a local car dealership. Our focus is on the distinctions between local goods and traded goods, and on the role of the transaction costs. We assume that traded goods fluctuate in price, but their relative prices are bound above and below international arbitrage costs. The supply of local goods and their prices are basically determined locally. We explicitly rule out any role for monopoly power or price stickiness to focus on the channels we wish to emphasize.

We adopt a simple two-country-endowment model that does not rely on price stickiness, market incompleteness, or wage stickiness. The results, however, on average, accord very well with the statistics obtained from the data. Using the same value for risk aversion as Chari et al. (2002) with iceberg-type transaction costs, we match almost exactly the persistence of the real exchange rate and explain more than 90% of the volatility, on average.

The remainder of this paper is organized as follows. We begin in Section 2 by describing the model that extends the stochastic trade arbitrage model by Sercu et al. (1995). In Section 3, we use the model as a quantitative laboratory to explore its implications for the dynamic properties of the real exchange rate, restricting our attention to the case of real endowment shocks. Section 4 concludes the paper.

II. The Model

The model has three basic building blocks: (i) all items are perishable; (ii) the supply of each perishable good in each location is exogenous and random; and (iii) trade is subject to costs of the iceberg variety.

1. The Economic Environment

We make two assumptions regarding consumer preferences to keep things tractable. First, utility function is separable across time and goods. The reason we maintain separability across time and goods is that, when combined with perishability of endowments, it allows us to describe the arbitrage conditions on a period-by-period and good-by-good basis. The second assumption we make about preferences is that the level of the endowment of the nontraded good in a particular location enhances the utility of the traded good that is consumed in that location. This is the only device we have come up with that allows us to preserve the desirable empirical implications of the partial equilibrium retail model employed by Crucini et al. (2005) in a general equilibrium setting. There are plausible stories one can tell to justify the assumption: it has the favor of the non-rivalry assumption, a pure public good, or a utility valuation of location that has spillovers for the utility consumers attain for other goods and services.

Getting to the particulars, our consumers have preferences given by:

(1) $E_0 \sum_{t=0}^{\infty} \beta^t U(c_{jt}, z_{jt}) = \sum_{t=0}^{\infty} \beta^t \frac{(z_{jt}^{\alpha} c_{jt}^{1-\alpha})^{1-\alpha}}{1-\sigma}$

where z_j is the endowment of the nontraded good in location *j*, and c_j is the consumption of the traded good in location *j*. We fix the number of locations at two and work with bilateral relationships across locations *j* and *k*.

The model is solved as a social planning problem:

(2) $\underset{\{x_{jt}, x_{kt}\}}{Max}\ E_0(U(c_{jt}, z_{jt}) + U(c_{kt}, z_{kt}))$

such that

(2a) $c_{jt} = y_{jt} - x_{jt} + \frac{x_{kt}}{1+\tau}$

(2b) $c_{kt} = y_{kt} - x_{kt} + \frac{x_{jt}}{1+\tau}$

(2c) $0 \leq x_{jt} \leq y_{jt}$

(2d) $0 \leq x_{kt} \leq y_{kt}$

(2e) $0 \leq z_{jt}$

(2f) $0 \leq z_{kt}$

where x_j is the exports of the good from location *j* to *k*, and $x_k / 1+\tau$ is the imports of the good from location *k* to location *j*. The appearance of the transaction cost factor in the denominator of the import flow is the essence of the iceberg cost assumption: proportion of the physical shipment of the traded good is lost in transit. y_j is the endowment of the traded good in location *j*.

The implication of the model for real exchange rates is easily described by describing the determination of the relative prices of the traded and nontraded goods prices. It is important to keep in mind that the planner is choosing the amount of trade (x_{jt}, x_{kt}) that determines the amount of consumption (c_{jt}, c_{kt}), given the endowment (y_{jt}, y_{kt}). z_{jt} are exogenous supplies of nontraded goods that serve effectively as taste shocks.

2. The Relative Prices of the Traded and Nontraded Goods

From the first order conditions, the equilibrium values of the relative price of the traded good (q_{jk}^{T}) are given by

$$(3)\quad q_{ijk}^{T} = \begin{cases} \dfrac{1}{1+\tau} & if \quad \left(\dfrac{y_k}{y_j}\right)^{a}\left(\dfrac{z_k}{z_j}\right)^{b} < \dfrac{1}{1+\tau} \\ \left(\dfrac{y_k}{y_j}\right)^{a}\left(\dfrac{z_k}{z_j}\right)^{b} & \text{otherwise} \\ 1+\tau & if \quad \left(\dfrac{y_k}{y_j}\right)^{a}\left(\dfrac{z_k}{z_j}\right)^{b} > 1+\tau \end{cases}$$

where $a = \sigma(1-\alpha)+\alpha$ and $b = \alpha(\sigma-1)$. We suppress the time subscript, because these conditions apply period-by-period.

In the first (third) row location j exports (imports), and in the middle row the regions do not trade because the gains from trade due to diverse endowments are not sufficiently large to compensate for the loss due to transaction cost.

The equilibrium values of the relative price of the nontraded good are given by:

$$(4)\quad q_{ijk}^{NT} = \begin{cases} \left(\dfrac{1}{1+\tau}\right)^{\frac{a-1}{a}} \left(\dfrac{z_k}{z_j}\right)^{\frac{\sigma}{a}} & \text{if} \quad \left(\dfrac{y_k}{y_j}\right)^{a} \left(\dfrac{z_k}{z_j}\right)^{b} < \dfrac{1}{1+\tau} \\ \left(\dfrac{y_k}{y_j}\right)^{a-1} \left(\dfrac{z_k}{z_j}\right)^{b+1} & \text{otherwise} \\ (1+\tau)^{\frac{a-1}{a}} \left(\dfrac{z_k}{z_j}\right)^{\frac{\sigma}{a}} & \text{if} \quad \left(\dfrac{y_k}{y_j}\right)^{a} \left(\dfrac{z_k}{z_j}\right)^{b} > 1+\tau \end{cases}$$

3. The Real Exchange Rate

The real exchange rate is determined as a relative price of the composite price index between locations. Assuming a common level of risk aversion and expenditure share across countries, the resulting real exchange rate is a Cobb-Douglas aggregate of the traded and nontraded relative prices as follows:

$$(5)\quad q_{ijk}=\left\{\begin{array}{ll}\left(\frac{1}{1+\tau}\right)^{\frac{a-\alpha}{a}}\left(\frac{z_k}{z_j}\right)^{\frac{\alpha\sigma}{a}} & if\quad \left(\frac{y_k}{y_j}\right)^{a}\left(\frac{z_k}{z_j}\right)^{b}<\frac{1}{1+\tau}\\ \left(\frac{y_k}{y_j}\right)^{a-\alpha}\left(\frac{z_k}{z_j}\right)^{b+\alpha} & \text{otherwise}\\ (1+\tau)^{\frac{a-\alpha}{a}}\left(\frac{z_k}{z_j}\right)^{\frac{\alpha\sigma}{a}} & if\quad \left(\frac{y_k}{y_j}\right)^{a}\left(\frac{z_k}{z_j}\right)^{b}>1+\tau\end{array}\right\}$$

Equation (5) shows that the dynamic behavior of this model hinges on three key features: (i) transaction cost for the traded good; (ii) endowment ratio of the traded good; and (iii) endowment ratio of the nontraded good. The transaction cost and endowment ratio drive a natural wedge between relative prices in different locations, leading to deviations from the law of one price for the traded good. More specifically, there are three possible trade and price pairings. First, when the endowment ratio is sufficiently close across countries that the gains from trade are not large enough to offset the transaction cost, there will be a no-trade equilibrium. Second, when the home endowment is sufficiently large relative to the foreign endowment, goods flow from the home country to the foreign country, and the price in the home country is τ less than the foreign price. Third, when the foreign endowment is sufficiently large relative to the home endowment, goods flow from the foreign country to the home country, and the price in the home country is τ greater than the foreign price

The movements of the nontraded input augment the threshold generated by transaction cost and trade patterns, and affect the deviations in the real exchange rate through a difference in the aggregate price index of each country.

III. Quantitative Evaluation

1. Calibration

Having specified the model, we shall now turn to the quantitative evaluation of its properties. More specifically, we examine whether our model can account for the observed movements in real exchange rates. In conducting our experiments, the specifics depend on the choice of parameters.

With the functional form of preferences, $\frac{(Z_{jt}^{\alpha} C_{jt}^{1-\alpha})^{1-\alpha}}{1-\sigma}$, the curvature properties of the utility function are determined by the intertemporal substitution parameter (σ) and the expenditure share of non-traded good (α). We set the first parameter (α) equal to 5, as suggested by Chari et al. (2002). The expenditure share on the nontraded sector is obtained from US Bureau of Labor Statistics and set to 0.7.[3]

Turning to the transaction cost, the most natural measure from a theoretical point of view is the difference between imports evaluated at price which include freight and insurance (c.i.f.) and exports evaluated free on board (f.o.b.). In principle this could be estimated from import and export unit values defined as the ratio of nominal value to physical quantity imported. For example, Hummels (2001) estimates trade costs based on direct measurement of the freight rate, which is defined as

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[3] The expenditure share on the nontraded sector in the US does not vary much, ranging between 69.0% and 71.6% during 1989–2006. The nontraded sector includes housing, insurance and pension, vehicle-related service costs, health, entertainment, education, etc.

the ratio of transportation expenditure to the value of imports exclusive of freight and insurance charges. The all-commodities trade-weighted average freight rate ranges from 3.8% for the US to 13.3% for Paraguay. Across commodities in the US, the freight rate ranges from a low of 0.9% for transport equipment to a high of 27% for crude fertilizer. In their extensive survey of the measurement of trade costs, Anderson and van Wincoop (2004) show that the 170% of "representative" trade costs in industrialized countries breaks down into 21% of transportation costs, 44% of border-related trade barriers, and 55% of retail and wholesale distribution costs. Burstein et al. show that distribution costs for Canada, Germany, and UK amount to 41.2%, 41.5%, and 45.4%, respectively, which are similar to those for the US (43.4%). We consider the transaction cost as a transport cost, and choose 0.1 as a benchmark case.

The propagation mechanism for the shocks is described as by the following process:

(6) $y_{t+1} = \Pi^{y} y_t + \Psi_t^{y}$

(7) $z_{t+1} = \Pi^{z} z_t + \Psi_t^{z}$

where $y = \left[\ln(y_k), \ln(y_j)\right]'$ and $z = \left[\ln(z_k), \ln(z_j)\right]'$. Π^y and Π^z are the matrices of coefficients, and Ψ^y and Ψ^z are the vectors of mean zero normal random variables with the contemporaneous variance-covariance matrix given by Σ^y and Σ^z, corresponding to the innovations to endowment shocks for traded goods and non-traded goods, respectively.

$$(8)\quad \Pi^{y} = \begin{pmatrix} \pi_{11}^{y} & \pi_{12}^{y} \\ \pi_{21}^{y} & \pi_{22}^{y} \end{pmatrix}, \quad \Sigma^{y} = \begin{pmatrix} \sigma_{11}^{y} & \sigma_{12}^{y} \\ \sigma_{21}^{y} & \sigma_{22}^{y} \end{pmatrix}$$

$$(9)\quad \Pi^{z} = \begin{pmatrix} \pi_{11}^{z} & \pi_{12}^{z} \\ \pi_{21}^{z} & \pi_{22}^{z} \end{pmatrix}, \quad \Sigma^{y} = \begin{pmatrix} \sigma_{11}^{z} & \sigma_{12}^{z} \\ \sigma_{21}^{z} & \sigma_{22}^{z} \end{pmatrix}$$

We use these autocorrelation coefficients and variance-covariance matrices to generate the traded and nontraded endowments, and then simulate the real exchange rates based on equation (5). To avoid the initial value problem, we generate 5,000 observations for the real exchange rate, discard the first 1,000 values, and choose the final 4,000 periods of simulated data for analysis. We calibrate the stochastic process of the traded (total manufacturing) and nontraded (total service) endowments for 12 OECD countries using the OECD Structural Analysis Database.[4]

While we view our baseline parameterization as a plausible benchmark, there is substantial uncertainty about individual parameter values. For this reason we run numerous experiments to test the sensitivity of the model.

4 In the STAN 2003 database, 14 countries are available for the sectoral output data during 1970–2000 that is required to generate real exchange rates in the simulation. The real exchange rate in Italy, however, is too volatile (almost ten times more volatile than that of other countries), and the persistence of the real exchange rate in the Netherlands is too low (almost half of the average of other countries). Therefore, we exclude these two outliers from the sample.

2. The Results

We now evaluate the performance of the model in matching the time series properties of the observed data. To do this, we examine the ability of the model to match key moments in the data, that is, the volatility and persistence of the real exchange rates. We measure the persistence and volatility by standard deviation and autocorrelation coefficient of the AR(1), respectively.

Regarding the data, we estimate the persistence and volatility of the (log) real exchange rates for 12 OECD countries against the US using an AR(1) process without a constant term.[5] Here, HP filtered real exchange rates are used because we are interested in the business cycle properties of the exchange rates. The volatility of the real exchange rate in the observed data ranges from a low of 0.058 for Canada to a high of 0.139 for Belgium, with the average value being 0.107. The persistence ranges from a low of 0.595 for Australia to a high of 0.775 for Canada, with the average value being 0.656.

Table 2 describes the dynamics of the real exchange rate observed in the data in the model without nontraded goods, and in the benchmark model ($\alpha = 0.7$, $\tau = 0.1$, $\sigma = 5$). As shown in the fourth and fifth columns, when the nontraded good does not exist ($\alpha = 0$), the model performs very poorly in matching the moments of the real exchange rate. However, as is evident from the last two columns, introducing

[5] The simulation results from the AR process with a constant term are rarely different from those from the AR process without a constant term.

both the transaction cost and nontraded good in an otherwise standard model dramatically improve its ability to rationalize observed real exchange rate dynamics. We see that the benchmark produces substantial volatility (0.069–0.155) and persistence (0.486–0.784), which are close to those in the data. The benchmark model, on average, matches 95% of the persistence and 90% of the volatility of the real exchange rate. Across the countries, the benchmark model performs well in replicating the dynamic properties for Australia, Finland, Greece, and the UK, while it does relatively poorly for Canada, Denmark, France, and Sweden.

Considering the simplicity of the model, we can arguably say that the model shows exceptional performance in explaining the dynamic properties of the real exchange rate. For example, Chari et al. (2002) relies heavily on price stickiness to get the appropriate volatility of the real exchange rate, but their model can explain only 75% of the persistence. As Chari et al. point out, the intertemporal substitution parameter (σ) plays a critical role in generating the proper volatility in the real exchange rate, but they still lack the ability to match the right persistence. We use the same intertemporal substitution parameter value as in Chari et al., and it turns out that introducing the transaction cost and nontraded good in the model substantially improves its ability to explain the puzzling behavior of the real exchange rate.

3. Sensitivity Analysis

There are four parameters in the model: risk aversion σ (inverse of intertemporal elasticity of substitution), transaction cost τ, and the expenditure share on nontraded good α. The intertemporal substitution parameter affects the curvature of the utility function and determines the level of risk aversion. The transaction cost affects the size of the fixed limit of arbitrage for the traded good.

The simulation results for various risk aversion values are presented in Table 3. The upper panel shows the sensitivity analysis for the volatility, and the lower panel provides the results for the persistence. As risk aversion increases (as intertemporal elasticity of substitution decreases), the volatility of the real exchange rate in each country also increases. Note that the volatility is a concave function of the risk aversion parameter. The average volatility increases by 0.024 when σ rises from 3 to 5, while it increases by only 0.014 when σ changes from 5 to 7. This implies that a risk aversion parameter of around 6.5 is the most fitting value for matching the volatility with the data. On the other hand, the persistence of the real exchange rate tends to decrease in the risk aversion. It is a convex function of the risk aversion parameter, but the curvature is less steep than that of the volatility function. The persistence matches better with the data when $\sigma = 3$ (0.627). Therefore, there is a conflict between volatility and persistence as we try to match these values with the observed data. This is why most theoretical models fail to account for empirical evidence related to high volatility and high persistence of the real exchange rate.

Since the volatility responds to the risk aversion in a way opposite to that of the persistence, we contemplate the mechanism behind this phenomenon intuitively. As risk aversion increases, intertemporal elasticity of substitution decreases in a typical CRRA utility function. So the higher σ is, the larger relative prices change when agents alter their consumption plans over time. That is, the agents confront with more difficulty in smoothing consumption over time as the intertemporal elasticity of substitution gets smaller. Hence, less substitutability leads to higher volatility of relative prices. On the other hand, as volatility increases in σ, the possibility for the real exchange rate to hit the upper or lower bounds of the band also increases. As a result, the persistence moves in a direction opposite to that of the volatility when σ changes.

We also vary transaction costs between 0.1 and 0.5 and show the results in Table 4. We consider $\tau = 0.1$ as a benchmark, but it also may be reasonable to define a transaction cost as a combination of the transport cost and distribution cost as emphasized by Burstein et al. (2003). The result shows that real exchange rate volatility increases as transaction cost rises. This is because, when other things remain constant, higher transaction cost makes goods less likely to be arbitraged and therefore increases the extent of exchange rate fluctuations.

Lastly, both volatility and persistence of the real exchange rate increase as the expenditure share on the nontraded good rises. Table 5 shows that when α equals 0.8, the model, on average, matches as much as 99% of the persistence and 97% of the volatility of the real exchange rate. Again, this represents the importance of the nontraded goods in accounting for dynamic properties of the real exchange rate.

IV. Conclusions

The Purchasing Price Parity states that international relative price differentials should be arbitraged away so that identical goods in different countries should sell for the same price, when expressed in a common currency. Yet the evidence from the empirical literature shows that not only are relative prices quite different across countries, but such deviations are highly volatile and persistent. These characteristics of the real exchange rate have been the central puzzle in international macroeconomics literature, with the source of the puzzling behavior remaining unclear.

In this paper, we study the role of transaction cost and nontraded goods to account for the puzzling behavior of the real exchange rate. In particular, we develop a simple general equilibrium model in the presence of transaction cost and nontraded good and evaluate the quantitative performance of the model in replicating the dynamic properties of the real exchange rate. The simulation results show that introducing both the transaction cost and nontraded good in an otherwise standard model dramatically improves its ability to rationalize observed real exchange rate dynamic properties. The benchmark model matches 95% of the persistence and 90% of the volatility of the real exchange rate. In addition, the sensitivity analysis shows that our model can rationalize more than 97% of both persistence and volatility of the real exchange rate. Our analysis suggests that the purchasing price parity puzzle can naturally arise in the presence of transaction cost and nontraded goods, even under the assumption of a flexible price market.

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Appendix

Table 1. Parameter Values

Benchmark model	
Inverse of intertemporal elasticity of substitution	$\sigma = 5.0$
Expenditure share on the nontraded good	$\alpha = 0.7$
Transaction cost	$\tau = 0.1$

Table 2. Simulation Results for The Model

	Observed data		Model without nontraded good		Model with nontraded good	
	Volatility	Persistence	Volatility	Persistence	Volatility	Persistence
Australia	0.096	0.595	0.017	0.341	0.107	0.688
Belgium	0.139	0.687	0.017	0.323	0.090	0.698
Canada	0.058	0.775	0.017	0.504	0.080	0.595
Denmark	0.124	0.671	0.016	0.372	0.077	0.560
Finland	0.119	0.644	0.018	0.319	0.106	0.589
France	0.118	0.602	0.016	0.375	0.069	0.486
Greece	0.102	0.632	0.017	0.362	0.104	0.626
Japan	0.108	0.556	0.017	0.406	0.106	0.780
Korea	0.102	0.716	0.018	0.530	0.155	0.784
Norway	0.096	0.669	0.017	0.503	0.081	0.554
Sweden	0.123	0.690	0.018	0.487	0.078	0.539
U.K.	0.104	0.640	0.017	0.430	0.095	0.540
Average	0.107	0.656	0.017	0.412	0.096	0.620

Table 3. The Sensitivity Analysis for Intertemporal Elasticity of Substitution

		Data	$\sigma = 3$	$\sigma = 4$	$\sigma = 5$	$\sigma = 6$	$\sigma = 7$
Volatility	Australia	0.096	0.080	0.096	0.107	0.116	0.122
	Belgium	0.139	0.067	0.080	0.090	0.097	0.104
	Canada	0.058	0.060	0.072	0.080	0.087	0.093
	Denmark	0.124	0.056	0.068	0.077	0.084	0.090
	Finland	0.119	0.081	0.095	0.106	0.114	0.120
	France	0.118	0.049	0.060	0.069	0.076	0.081
	Greece	0.102	0.079	0.094	0.104	0.112	0.119
	Japan	0.108	0.081	0.095	0.106	0.115	0.121
	Korea	0.102	0.122	0.141	0.155	0.166	0.174
	Norway	0.096	0.060	0.072	0.081	0.089	0.094
	Sweden	0.123	0.059	0.069	0.078	0.084	0.089
	U.K.	0.104	0.070	0.084	0.095	0.103	0.109
	Average	0.107	0.072	0.086	0.096	0.104	0.110
Persistence	Australia	0.595	0.692	0.691	0.688	0.684	0.680
	Belgium	0.687	0.694	0.698	0.698	0.698	0.698
	Canada	0.775	0.607	0.601	0.595	0.590	0.586
	Denmark	0.671	0.569	0.565	0.560	0.557	0.554
	Finland	0.644	0.591	0.591	0.589	0.588	0.587
	France	0.602	0.492	0.490	0.486	0.481	0.475
	Greece	0.632	0.632	0.629	0.626	0.622	0.619
	Japan	0.556	0.783	0.781	0.780	0.779	0.778
	Korea	0.716	0.788	0.787	0.784	0.783	0.781
	Norway	0.669	0.569	0.560	0.554	0.549	0.546
	Sweden	0.690	0.553	0.546	0.539	0.534	0.530
	U.K.	0.640	0.551	0.545	0.540	0.535	0.531
	Average	0.656	0.627	0.624	0.620	0.617	0.614

Table 4. The Sensitivity Analysis for Transaction Cost

		Data	$\tau = 0.1$	$\tau = 0.3$	$\tau = 0.5$
Volatility	Australia	0.096	0.107	0.146	0.152
	Belgium	0.139	0.090	0.127	0.132
	Canada	0.058	0.080	0.122	0.128
	Denmark	0.124	0.077	0.104	0.106
	Finland	0.119	0.106	0.161	0.179
	France	0.118	0.069	0.087	0.088
	Greece	0.102	0.104	0.151	0.161
	Japan	0.108	0.106	0.151	0.161
	Korea	0.102	0.155	0.218	0.245
	Norway	0.096	0.081	0.116	0.121
	Sweden	0.123	0.078	0.126	0.137
	U.K.	0.104	0.095	0.131	0.136
	Average	0.107	0.096	0.137	0.146
Persistence	Australia	0.595	0.688	0.686	0.686
	Belgium	0.687	0.698	0.671	0.668
	Canada	0.775	0.595	0.620	0.621
	Denmark	0.671	0.560	0.571	0.571
	Finland	0.644	0.589	0.566	0.568
	France	0.602	0.486	0.494	0.493
	Greece	0.632	0.626	0.631	0.635
	Japan	0.556	0.780	0.773	0.777
	Korea	0.716	0.784	0.776	0.779
	Norway	0.669	0.554	0.585	0.590
	Sweden	0.690	0.539	0.573	0.582
	U.K.	0.640	0.540	0.557	0.561
	Average	0.656	0.620	0.625	0.628

Table 5. The Sensitivity Analysis for The Expenditure Share on The Nontraded Goods

		Data	$\alpha = 0.6$	$\alpha = 0.7$	$\alpha = 0.8$
Volatility	Australia	0.096	0.095	0.107	0.125
	Belgium	0.139	0.082	0.090	0.102
	Canada	0.058	0.077	0.080	0.088
	Denmark	0.124	0.074	0.077	0.085
	Finland	0.119	0.094	0.106	0.125
	France	0.118	0.068	0.069	0.073
	Greece	0.102	0.093	0.104	0.122
	Japan	0.108	0.094	0.106	0.125
	Korea	0.102	0.130	0.155	0.192
	Norway	0.096	0.077	0.081	0.091
	Sweden	0.123	0.076	0.078	0.0.84
	U.K.	0.104	0.086	0.095	0.109
	Average	0.107	0.087	0.096	0.110
Persistence	Australia	0.595	0.641	0.688	0.718
	Belgium	0.687	0.611	0.698	0.761
	Canada	0.775	0.575	0.595	0.612
	Denmark	0.671	0.519	0.560	0.595
	Finland	0.644	0.526	0.589	0.636
	France	0.602	0.458	0.486	0.510
	Greece	0.632	0.579	0.626	0.655
	Japan	0.556	0.713	0.780	0.824
	Korea	0.716	0.758	0.784	0.798
	Norway	0.669	0.536	0.554	0.572
	Sweden	0.690	0.511	0.539	0.564
	U.K.	0.640	0.514	0.540	0.562
	Average	0.656	0.578	0.620	0.651

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Real Exchange Rate Dynamics in the Presence of Nontraded Goods and Transaction Costs

Inkoo Lee and Jonghyup Shin

This paper studies the role of nontraded goods and transaction costs in accounting for the puzzling behavior of the real exchange rate. In particular, we develop a simple general equilibrium model and evaluate the quantitative performance of the model in replicating the dynamic properties of the real exchange rate.

The simulation results show that introducing both the transaction costs and nontraded goods in an otherwise standard model dramatically improve its ability to rationalize observed real exchange rate dynamic properties. The benchmark model matches 95% of the persistence and 90% of the volatility of the real exchange rate. In addition, the sensitivity analysis shows that our model can rationalize more than 97% of both persistence and volatility of the real exchange rate.

Our analysis suggests that the purchasing price parity puzzle can naturally arise in the presence of transaction costs and nontraded goods, even under the assumption of a flexible price market.

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