International Monetary Economics

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Chapter 16 Price levels and the exchange rate in the long run

Outline

- 16.1 Law of One Price (LOP)
- 16.2 Absolute Purchasing Power Parity (APPP)
- 16.3 Relative Purchasing Power Parity (RPPP)
- 16.4 Big Mac Index

Introduction

- PPP is the oldest exchange rate theory,
- developed by Gustav Cassel.

Objective: Explaining

- the exchange rate level or
- changes in the exchange rate
- in the long run on the basis of
 - the domestic and foreign goods price or
 - the inflation differential.

Law of One Price (LOP)

If we assume

- free trade,
- no transaction costs,
- complete transparency for all agents,
- goods are homogeneous
 - geographical preferences
 - preferences in time,
 - personal preferences, and
 - goods are the same / have the same characteristics
- then price in all markets have to be the same (LOP).
- Good price in the home market (P) has to be the same as the good price in the foreign market (P*) after consideration of the exchange rate (E).

(1)
$$P = E \cdot P^*$$

Law of one price

In case that

(1)
$$P > EP^* \text{ or } P < EP^*$$

arbitrageurs will enter the market. Numerical example: $E = 0.8 \in /$ $P = 5 \in P^* = 10$

(2)
$$5 \in < 0.8 \in / \$ \cdot 10 \$$$

• German product cost 5€ while American product cost 8€.

Arbitrage: Buy low sell high!

 $5 \in < 0.8 \in /$ 10\$

- Arbitrageurs sell Dollars and buy Euros
- They buy the cheap German product
- and sell it in the US at a higher price \Rightarrow Profit per deal: $3 \in$
- Supply of Dollars increases $\Rightarrow E = 0.8 \in /$
- Demand for German products increases $\Rightarrow P = 5 \in \uparrow$
- Supply of American products increases \Rightarrow $P^* = 10\$\downarrow$

Law of one price and transaction costs

- Suppose that transaction cost amounts to $t = 1 \in$ for shipping etc.
- Hence, arbitrage will *only* take place when the price differential is larger than transaction cost:

$$(3) \qquad P - EP^* > t \text{ or } t < EP^* - P$$

• In our example, prices will not adjust completely until LoP holds! $5.9\,{\textcircled{\baselineskip}}<6.9\,{\textcircled{\baselineskip}}=0.75\,{\textcircled{\baselineskip}}/\$\cdot9.2\$$

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Absolute purchasing power parity (APPP)

- Due to different tastes and preferences LoP does not hold for a single item.
- Idea: Purchasing power is not the same for a single item but for an identical basket of goods.

	German Shopping cart		American Shopping cart	
Good 1 = Milk	3 Bottles á 5€	15€	3 Bottles á 6 \$	18 \$
Good 2 = Sausage	4 Units á 2.5€	10€	4 Units á 2.5 \$	10 \$
Good 3 = Cheese	5 Pieces á 1€	5€	5 Pieces á 1 \$	5\$
Good 4 = Beer	10 Cans á 4€	40€	10 Cans á 5 \$	50 \$
Good n = Jägermeister	2 Pülleken á 15€	30€	2 Pülleken á 21 \$	42 \$
	Total	100€	Total	125 \$

 Equilibrium exchange rate according to absolute purchasing power parity

$$\frac{100 \in}{125\$} = 0.8 \in /\$$$

Absolute purchasing power parity (APPP)

Equilibrium exchange rate according to absolute purchasing power parity

$$\frac{100 \in}{125\$} = 0.8 \in /\$$$

Lets assume that the actual exchange rate is indeed $E = 0.8 \in /$ \$.

- Law of one price only holds for product 4 (beer).
- Law of one price does not hold for all other items.
- BUT: Absolute purchasing power parity holds, since both carts have identical prices after consideration of the exchange rate.

Implications for the real exchange rate

If APPP holds:

 $\varepsilon = \frac{EP^*}{P} = \frac{0.8 \text{€}/\$ \cdot 125\$/\text{americ. Basket}}{100 \text{€}/\text{europ. Basket}} = 1 \text{ europ. Basket}/\text{americ. Basket}$

• Real exchange rate takes the value of one!

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Causes for deviations from APPP

Temporary causes

- incomplete information
- adjustment of prices takes time
- goods prices are sticky, due to long term contracts while exchange rate can jump instantaneously due to new information

Permanent causes

- trade barriers
- taxes and tariffs
- Quotas
- Transportation cost
- active price differentiation of the suppliers
- (perceived) differences in the quality

Relative Purchasing Power Parity (RPPP)

- If permanent causes exist, this will hinder a complete price adjustment even in the long run.
- Absolute purchasing power parity $P = EP^*$ will not hold.
- Hence, we get for the relationship between the domestic and foreign basket of goods prices

$$(3) \quad P = \frac{1}{\varepsilon} E P^*$$

• The parameter $1/\varepsilon$ considers all permanent causes that lead to a deviation of APPP.

Relative Purchasing Power Parity (RPPP)

(3)
$$P = \frac{1}{\varepsilon} EP^*$$

(4) $\varepsilon = \frac{EP^*}{P}$

- Parameter ε is labeled as the real exchange rate
- If APPP holds, the real exchange rate will take the value of one.
- Deviations from APPP can lead to a situation where the real exchange rate is smaller or larger than 1!

Relative PPP

(4)
$$\varepsilon = \frac{E \cdot P^*}{P}$$

• From equation (4) we get for the change of the real exchange rate:

(5)
$$\widehat{\varepsilon} = \widehat{E} + \widehat{P^*} - \widehat{P}$$

How do we get from (4) to (5)???

(4')
$$\varepsilon_t = \frac{E_t P_t^*}{P_t}$$
 (4") $\varepsilon_{t+1} = \frac{E_{t+1} P_{t+1}^*}{P_{t+1}}$

• Taking the natural logs of (4') and (4") one gets:

(5')
$$\ln \varepsilon_t = \ln E_t + \ln P_t^* - \ln P_t$$

(5")
$$\ln \varepsilon_{t+1} = \ln E_{t+1} + \ln P_{t+1}^* - \ln P_{t+1}$$

Relative PPP

• Subtracting (5') from (5") one gets:

$$(5''') \quad \ln \varepsilon_{t+1} - \ln \varepsilon_t = (\ln E_{t+1} - \ln E_t) + (\ln P_{t+1}^* - \ln P_t^*) - (\ln P_{t+1} - \ln P_t)$$

• Defining $\hat{\varepsilon} = \ln \varepsilon_{t+1} - \ln \varepsilon_t$ and so on...

(5)
$$\hat{\varepsilon} = \hat{E} + \widehat{P^*} - \widehat{P}$$

Relative PPP

(5)
$$\widehat{\varepsilon} = \widehat{E} + \widehat{P^*} - \widehat{P}$$

- If the permanent causes are constant ⇒ the real exchange rate (ε) does not change.
- The *change* in the real exchange rate is zero ($\hat{\varepsilon} = 0$).

$$(6) \quad 0 = \widehat{E} + \widehat{P^*} - \widehat{P}$$

Solving for the change in the nominal exchange rate yields:

(7)
$$\widehat{E} = \widehat{P} - \widehat{P^*}$$

• Equation (7) is labeled as the relative purchasing power parity.

Implications of RPPP

(7)
$$\widehat{E} = \widehat{P} - \widehat{P^*}$$

(7')
$$\frac{E_{t+1} - E_t}{E_t} = \frac{P_{t+1} - P_t}{P_t} - \frac{P_{t+1}^* - P_t^*}{P_t^*}$$

Relative PPP implies:

- Relative change in the nominal exchange rate is equal to the inflation differential between Euroland and the US.
- The real exchange rate is constant.
- If the domestic price level increases by 10 % while the foreign price level is constant, the nominal exchange rate increases by 10 %.
- Countries that have problems with their internal price stability,
- also have problems with their external price stability.

Testing RPPP

Time	$\pi_{ITA} - \pi^*_{BRD}$	$\frac{E_{t+1}-E_t}{E_t}$
1973	12%-8%	4 %
1974	25% - 5%	20 %
1975	11%-5%	6 %
1976	20% – 4%	16 %

Testing RPPP: Scatter diagram

	A	В	С	D	E	F		G	н	1	J	K		L
1														
2														
3														
4							5% _							
5						rate								
6						exchange	0%					•		
7						har								
8		pi_ITA	pi_BRD		(E_t+1 - E_t) / E_t	exc	.5%				•			
9		12.0%	8.0%	4%	4%	the	570							
10		25.0%	5.0%	20%	20%	. <u> </u>								
11		11.0%	5.0%	6%	6%	change	.0% -							
12		20.0%	4.0%	16%	16%	ch.								
13						tive	5%							
14						Relative o								
15							0% +							
16							0%	6	5%	10%	15%	20%	25%	
17										Inflation diff	erential			
18														

Testing RPPP

(4)
$$\frac{E_{t+1}-E_t}{E_t} = \alpha + \beta \cdot (\pi_t^{TA} - \pi_t^{BRD}) + u_{t+1}$$

2 pairs of Hypotheses:

- $H_0: \alpha = 0$ and $H_a: \alpha \neq 0$
- $H_0: \beta = 1 \text{ and } H_a: \beta \neq 1$
- Hence, we want to perform a two sided test!

We want to test on a 95 % confidence level and assume that we have enough observations so that the normal distribution is the appropriate choice!

• $t_{critical} \approx 2$ (in case you want to be precise: 1.96)

Testing RPPP Results for 1973 – 1995

	Coeff.	SE	t-Stat	P-val.	Low95	Up95
Intercept		2.12	2.32	0.03	0.50	9.31
$\pi_t^{ITA} - \pi_t^{BRD}$	0.42	0.24	1.76	0.09	-0.08	0.91

Interpretation confidence intervals

- Claimed value of $\alpha = 0$ is NOT included in the 95 % confidence interval. We reject H_0 .
- Claimed value of β = +1 is NOT included in the 95 % confidence interval. We reject H₀.
- Conclusions
 - Empirical evidence is not in line with RPPP. Beta is estimated to be +0.4, but should be equal to +1!
 - Both coefficients are significantly different from claimed values on a 95 % confidence level.
 - RPPP does NOT hold.

How to compute an estimated t-value (t_{est})

(5)
$$t_{est} = \frac{\text{estimated coefficient} - \text{claimed value}}{\text{standard error (SE)}}$$

• We claimed (in the hypotheses) that alpha should be zero:

(6)
$$t_{est} = \frac{4.91 - 0}{2.12} = 2.32$$

• We claimed (in the hypotheses) that beta should be one:

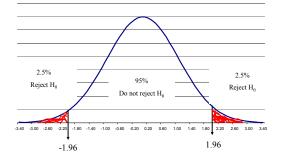
(7)
$$t_{est} = \frac{0.42 - 1}{0.2} = -2.46$$

NEW

(8)

$$t_{est} = \frac{0.417 - 1}{0.237} = -2.46$$

Interpretation t-values



Georg Stadtmann - Statistics - Slide No. 45

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Big Mac Index

Inicial currency Methods PPPF of the dollar exclual exclual additional exclual dollar exclual additional exclual dollar exclual dollar <thexclual dollar exclual dollar</thexclual 		Big M	lac prices	Implied		Under (- over(+) valuatio	
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Australia A53.45 3.36 0.97 1.03 -6 Brazii Real.750 4.73 2.10 1.58 4.33 Brazii Real.750 4.73 2.10 1.58 4.33 Brazii F2.29 4.75 1.58 4.30 4.42 Canada C54.09 4.08 1.15 1.00 4.42 Chile Pero 1,550 3.13 4.34 4.94 -12 China Vuan 12.5 1.83 3.50 6.83 -49 Exech Republic Koruna 65.1 4.56 1.85 1.45 2.48 Bommark DK28.0 5.95 7.84 4.70 -67 Hong Kong HK513.3 1.71 3.73 7.80 -52 Hungary Forint 670 4.64 187.7 144.3 +30 Indoresta Ruptah 18.700 2.04 5.23 9.152 -44 Malygia Ringstf.5.50 1.70 1.54 3.2 -52<	United States‡	\$3.57	3.57	-	-		
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Japan Yen 280 2.62 78.4 106.8 -27 Malaysia Ringgit 5.50 1.70 1.54 3.2 -52 Mexico Peso 32.0 3.15 8.96 10.2 -12 New Zealand NZ54.90 3.72 1.37 1.32 +4	Hungary	Forint 670	4.64	187.7	144.3	+30	
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Mexico Peso 32.0 3.15 8.96 10.2 -12 New Zealand NZ\$4.90 3.72 1.37 1.32 +4	Japan	Yen 280	2.62	78.4	106.8	-27	
New Zealand NZ\$4.90 3.72 1.37 1.32 +4	Malaysia	Ringgit 5.50	1.70	1.54	3.2	-52	
	Mexico	Peso 32.0	3.15	8.96	10.2	-12	
Norway Kroner 40.0 7.88 11.2 5.08 +121	New Zealand	NZ\$4.90	3.72	1.37	1.32	+4	
	Norway	Kroner 40.0	7.88	11.2	5.08	+121	

Big Mac Index

- A popular way of studying PPP is to use the Big Mac Index,
- developed by the journal *The Economist*

Why using the Big Mac for studying PPP?

- The Big Mac is more or less homogeneous around the world (no differences in quality).
- Preferences are the same.
- Unfortunately, the Big Mac is NOT an internationally traded good.
- However, the Big Mac price can be interpreted as a Producer Price Index (PPI), because factors of production (land, capital, labor) are used to produce a Big Mac

Big Mac Index: Example: Danish DKK/\$

- A BigMac sells in Denmark at 28DKK
- A BigMac sells in the US at 3.57\$
- IMPORTANT (IMPLICIT) ASSUMPTION: Goods prices do not adjust!
- The equilibrium exchange rate level is given by:

 $3.57\$ \cdot E = 28DKK$

Equilibrium exchange rate and degree of over-/undervaluation

$$3.57\$ \cdot E = 28DKK$$

 $E = \frac{28DKK}{3.57\$} = 7.84DKK/\$$

- However on July 24th, 2008 the actual exchange rate was at a level of 4.70 DKK/USD
- If one compares the actual exchange rate with the equilibrium exchange rate the Danish Krona to be overvalued.
- What is the degree of overvaluation?

$$\frac{equ-act}{act} = \frac{7.84 - 4.70}{4.70} = +0.668 \Rightarrow 67\%$$