Aggregate real exchange rate persistence through the lens of sectoral data

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Microeconomic Sources of Real Exchange Rate Behavior

Motivation and Overview

- Most literature on PPP focuses on the analysis of aggregate RER data.

- General consensus:

  – Speed of convergence to PPP is extremely slow: HL ≈ 3 to 5 years.

  – Short run deviations from PPP are large and volatile.

PPP puzzle

The PPP-puzzle: one of the central puzzles in international economics (Rogoff and Obstfeld, 2000)

- Sectoral RERs data: Imbs et al. (QJE, 2005), Crucini et al. (AER, 2005), Crucini and Shintani (JME, 2008), Yang (1997), etc.

  – heterogeneity across sectoral RER persistence.

- But controversy on other issues.

  – Imbs et al. (QJE, 2005): average sectoral persistence is much smaller than aggregate one. HLs ≈1-1.5 years.
    PPP puzzle is due to an "aggregation bias"

  – Chen and Engel (PER, 2005), Crucini and Shintani (JME, 2008), Gadea and Mayoral (JAE, 2009) : similar persistence levels at the aggregate and at the sectoral levels.

The goal of this paper…

…is to shed further light on the causes of the slow reversion to parity of aggregate real exchange rates through the analysis of sectoral data.

We employ a novel metholody on a group of EU-15 real exchange rates (defined against the U.K. pound) for which highly disaggregate price data is available

Our starting point…

- Mayoral (2009) has established a direct link between aggregate and sectoral persistence:
  - The impulse response function (IRF) to an aggregate shock computed with aggregate data equals the average of the individual responses to this shock.
- This implies that
  - Either sectoral or aggregate data to estimate agg. persistence
  - Using sectoral data allows us to break down aggregate persistence into the persistence of its subcomponents.
  - Investigate sources of aggregate persistence

Our results show that…

- The distribution of sectoral persistence has a large variance and is highly skewed to the right
  - a few sectors (around 10%) are responsible for a large portion (around 40%) of the aggregate HL.
  - Why aggregate RERs is so persistent ≈why these few sectors are so persistent?
  - Tradable goods are heavily overrepresented in this 10% while services are underrepresented.

Our results suggest that, II

- Variables related to imperfect competition, pricing to market, and price stickiness have explanatory power to account for the behavior of the upper tails of the distribution of sectoral persistence

- …whereas variables associated with the tradability of the final goods or their inputs have not.

- The relevance of the explanatory variables tends to increase in the upper quantiles

Roadmap

I. Motivation and overview

II. Heterogeneity, aggregation and persistence in RERs

III. Data and preliminary analysis

IV. The distribution of sectoral persistence

V. Quantile regression analysis

VI. Concluding remarks

II. Heterogeneity, aggregation and persistence in RERs

Causal relation between
sectoral heterogeneity & RER persistence.

•**Imbs et al.** (QJE, 2005): Estimates of the persistence of sectoral RERs are, on average, considerably smaller than aggregate ones.

The failure to allow for heterogeneity
→ aggregation bias → PPP puzzle

.

• Consider a very simple set-up

$$q_{i,t} = \gamma_i + \alpha_i q_{i,t-1} + \nu_{i,t}$$

$$\nu_{i,t} = \rho_i u_t + \varepsilon_{i,t}$$

•The aggregate model can be obtained as the expected value of the sectors (Stoker, 1984; Lewbel, 1994).

.

$$Q_t = E_s\left(q_t\right) = E_s\left(\rho + \alpha\rho L + \alpha^2\rho L^2 ...\right) u_t$$

$$+E_s\left(1 + \alpha L + \alpha^2 L^2 ...\right) E_s(\varepsilon_{.,t}) = \sum_{j=0}^{\infty} E_s(\alpha^j \rho) u_{t-j},$$

Imbs et al., 2005

- Sectoral measures of persistence are computed from the IRF of

$$\bar{q}_t = \bar{\alpha}\bar{q}_{t-1} + a_t, \text{ where } \bar{\alpha} = E_s(\alpha),$$

$$IRF_{\bar{q}}(h) = \bar{\alpha}^h$$

- These measures and then compared with those obtained from the aggregate IRF given by

$$IRF_Q(h) = E_s(\alpha^h \rho).$$

Is the "Aggregation bias" a robust feature of the RER data?

• Chen and Engel (2005), Crucini and Shintani, (2008) and Gadea Mayoral (2009): the 'aggregation bias' is not a robust feature of the data.

• Gadea and Mayoral (2009): Sectoral IRF as the average of the sectoral IRFs to a unitary shock in ut.

$$IRF_{q_i}^{u}(h) = \alpha_i^h \rho_i,$$

$$\overline{IRF_q^u}(h) = E_s(\alpha^h \rho).$$

• Thus: $AB = IRF_Q(h) - \overline{IRF_q^u}(h) = 0,$ for all h.

Is the "Aggregation bias" a robust feature of the RER data?

- Carvalho and Nechio (2010):

$$THE = IRF_Q(h) - IRF_{\bar{q}}(h) = CE + AE,$$

Where

$$CE = \overline{IRF_q^v}(h) - IRF_{\bar{q}}(h),$$

$$AE = IRF_Q(h) - \overline{IRF_q^v}(h),$$

and

$$\overline{IRF_q^v}(h) = E_s\left(\alpha^h\right)$$

- Thus under independence of α and ρ, $\overline{IRF_q^v}(h) = \overline{IRF_q^u}(h)$

$$\overline{IRF_q^v}(h) = E_s\left(\alpha^h\right)$$

$$\overline{IRF_q^u}(h) = E_s(\alpha^h \rho).$$

And AB=AE=0!

III. Data

- Eurostat monthly Harmonized Index of Consumer Prices (HICP) for 11 EU-15 countries ranging from 1996:1 to 2007:12 has been employed.
- RERs are defined against the UK pound and are defined as

$$q_{c,i,t} = p_{c,i,t} - p_{uk,i,t} - s_{c,t},$$

- data on prices relative to 94 sectors

- Nominal exchange rates are obtained from Main Economic Indicators (OECD)

Data (II)

Data on trade, market structure and composition of final goods have been obtained from the following databases:

- Comtrade (United Nation Commodity Trade Statistic Database)

- OECD Structural Analysis Statistics (STAN, 2008)

- Input-output tables (IOT) from the OECD

Preliminary analysis, I

We have estimated $IRF_Q(h)$, $\overline{IRF_q^v}(h)$ and $\overline{IRF_q^u}(h)$

- AR(k) models to both aggregate and sectoral data; k: G-T-S, Kursteiner (2006)

- small sample bias: Kilian (1998) bootstrap-after-boostrap method

- Three different methods have been employed to estimate ut.

Preliminary analysis, II

TABLE I

RER Persistence with aggregate and sectoral data

		AU	BE	DK	FI	FR	GE	IT	NL	SP	SW
	Agg	37.52	40.18	44.08	36.04	37.21	31.32	60.51	44.19	118.53	22.38
HL	Sec^v	36.57	37.26	37.33	12.02	37.61	18.33	36.99	37.32	85.47	20.06
	Sec^u	36.75	37.32	36.99	12.06	37.66	18.39	37.23	37.42	91.11	20.30
	Agg	9.55	9.05	10.41	8.64	10.00	9.53	10.35	9.91	10.92	8.87
CIR(12)	Sec^v	8.60	8.59	9.10	8.03	9.03	8.29	8.61	8.93	9.25	8.15
	Sec^u	8.55	8.59	8.96	7.92	8.98	9.31	8.59	8.78	9.22	8.38
	Agg	16.02	15.37	18.55	13.90	17.11	15.54	19.60	17.64	21.48	15.94
CIR(24)	Sec^v	13.90	14.30	15.28	12.54	15.52	13.24	14.68	14.80	16.90	14.28
	Sec^u	13.87	14.30	14.99	12.36	15.49	13.32	14.74	14.64	16.95	14.81
	Agg	22.59	23.04	27.42	18.50	23.96	21.28	31.19	26.56	35.94	17.88
CIR(36)	Sec^v	18.99	20.22	21.24	16.56	22.04	18.04	20.96	21.02	25.97	17.48
	Sec^u	19.08	20.21	20.76	16.29	22.03	18.18	21.21	20.83	26.07	18.33
	Agg	27.91	31.82	37.80	18.48	28.11	24.33	48.88	37.52	67.57	15.65
CIR(60)	Sec^v	26.76	29.14	30.61	19.75	30.23	24.66	28.38	28.88	42.55	22.39
	Sec^u	27.08	29.14	29.86	19.51	30.31	24.89	29.20	28.91	43.09	23.35

Agg, Sec^v and Sec^u correspond to measures obtained from $\widehat{IRF_Q}$, $\widehat{\overline{IRF_q^v}}(h)$ and $\widehat{\overline{IRF_q^u}}(h)$, respectively.

Preliminary analysis, III

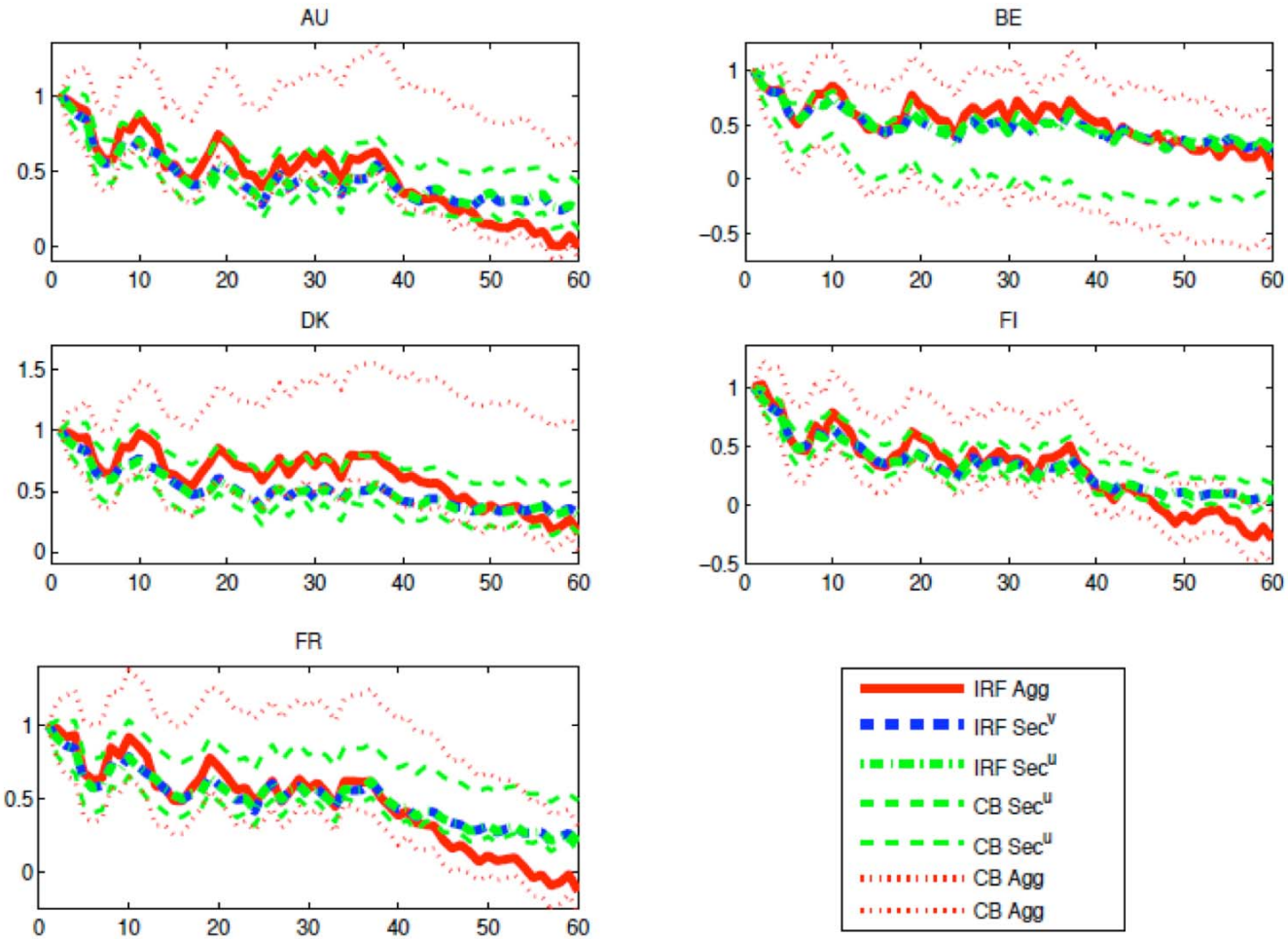
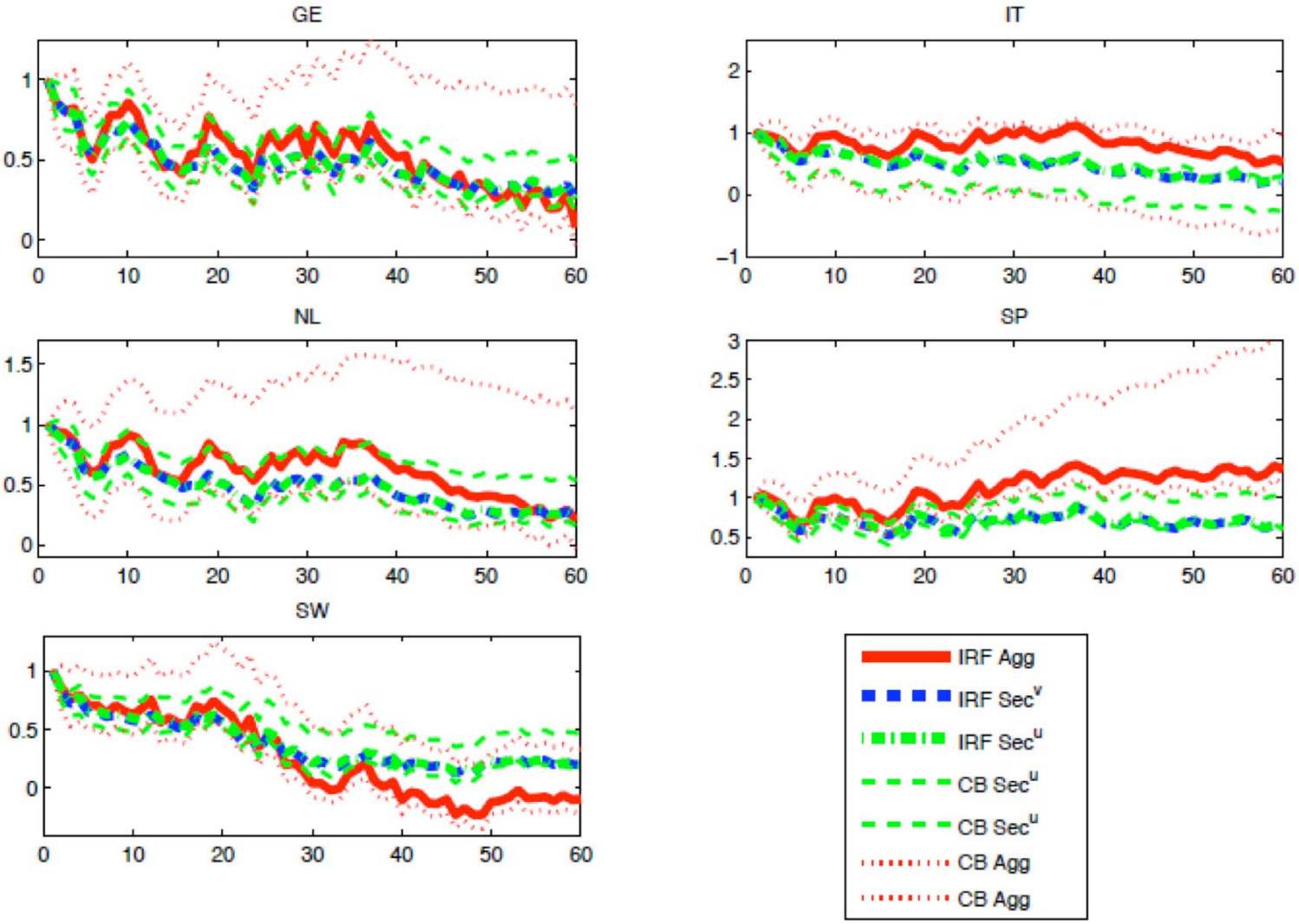


FIG. 1A. Estimated IRFs using aggregate and sectoral data.

Preliminary analysis, IV



Preliminary Analysis, V

- Bootstrap tests of the following hypotheses have been implemented

$$\text{Test A. } H_0^A : \sum_{h=0}^{G} (\overline{IRF_q^v}(h) - \overline{IRF_q^u}(h))^2 = 0$$

$$\text{Test B. } H_0^B : \sum_{h=0}^{G} (IRF_Q(h) - \overline{IRF_q^u}(h))^2 = 0$$

$$\text{Test C. } H_0^C : \sum_{h=0}^{G} (IRF_Q(h) - \overline{IRF_q^v}(h))^2 = 0$$

The null hypotheses could not be rejected for any of the countries in our dataset.

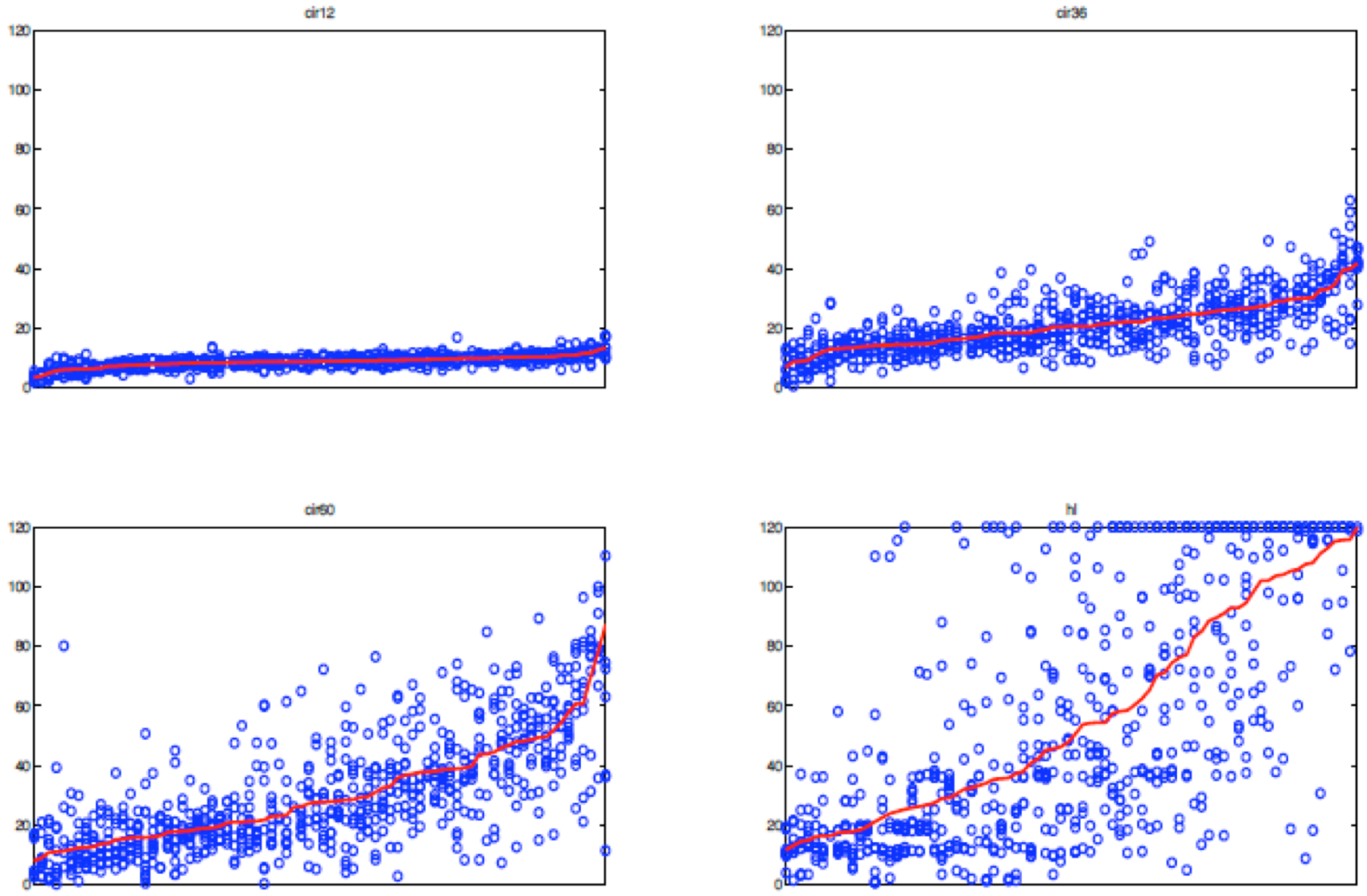
IV. The distribution of sectoral persistence

a. high degree of sectoral heterogeneity

b. Distributions are skewed to the right

c. Aggregate RER persistence is broken down by groups of sectors

a. Heterogeneity



b. Skewness

1. Sectors have been ranked by their contribution to the HL. The contribution of sector i to the HL:

$$\omega_i IRF_i \left(h = HL\right)$$

2. Sectors have been grouped in five categories, such that the contribution of each group amounts to 20% of the HL.

Thus, the first bin contains the first N1 sectors such that

$$\frac{\sum_{i=1}^{N_1} \omega_i IRF_{c,i}\left(t,h\right)}{\sum_{i=1}^{N} \omega_i IRF_{c,i}\left(t,h\right)} = 20\%.$$

Skewness, II

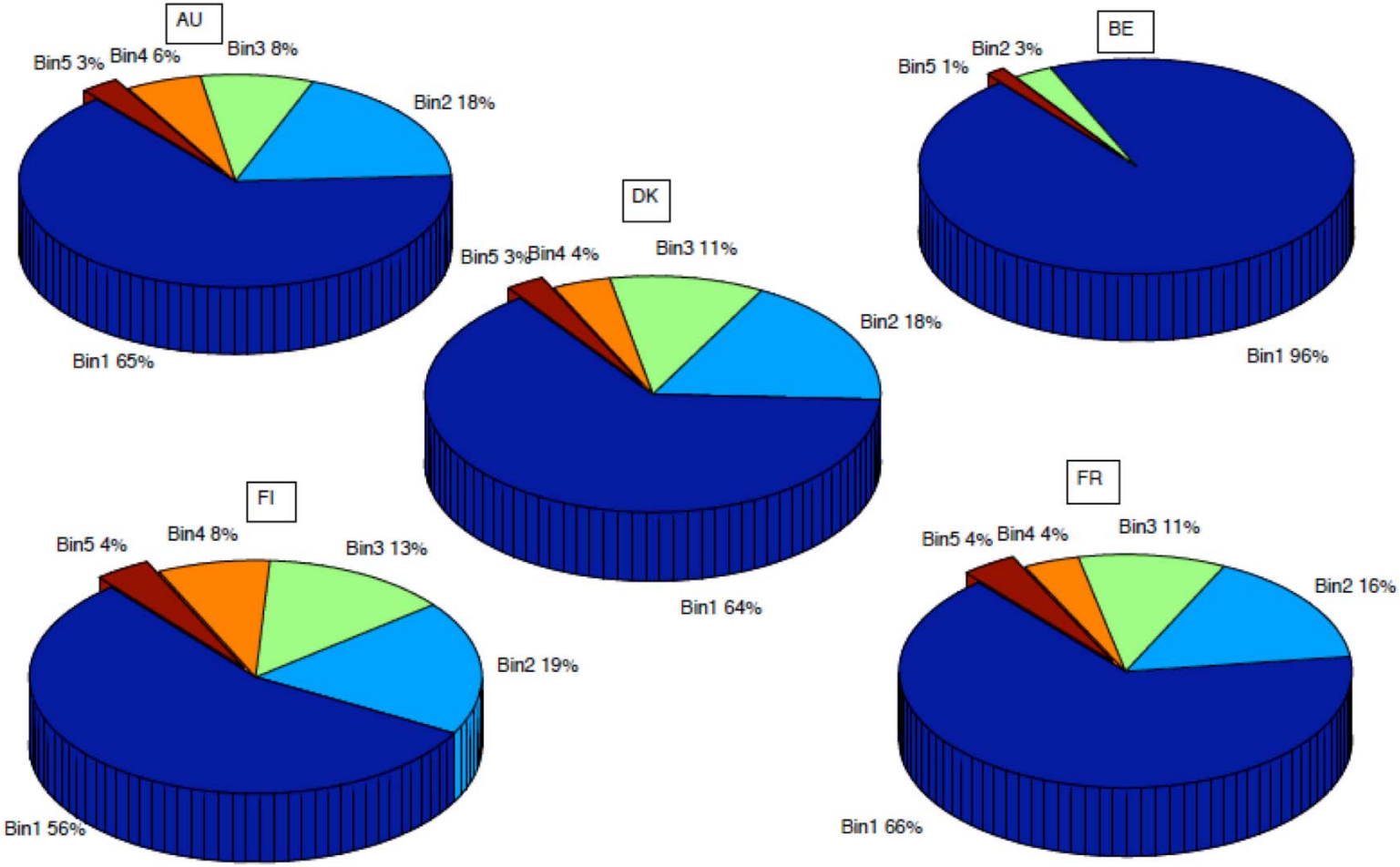
- 

FIGURE 3A. % of sectors in bins 1-5, ranked by contribution to the HL.

Skewness, III

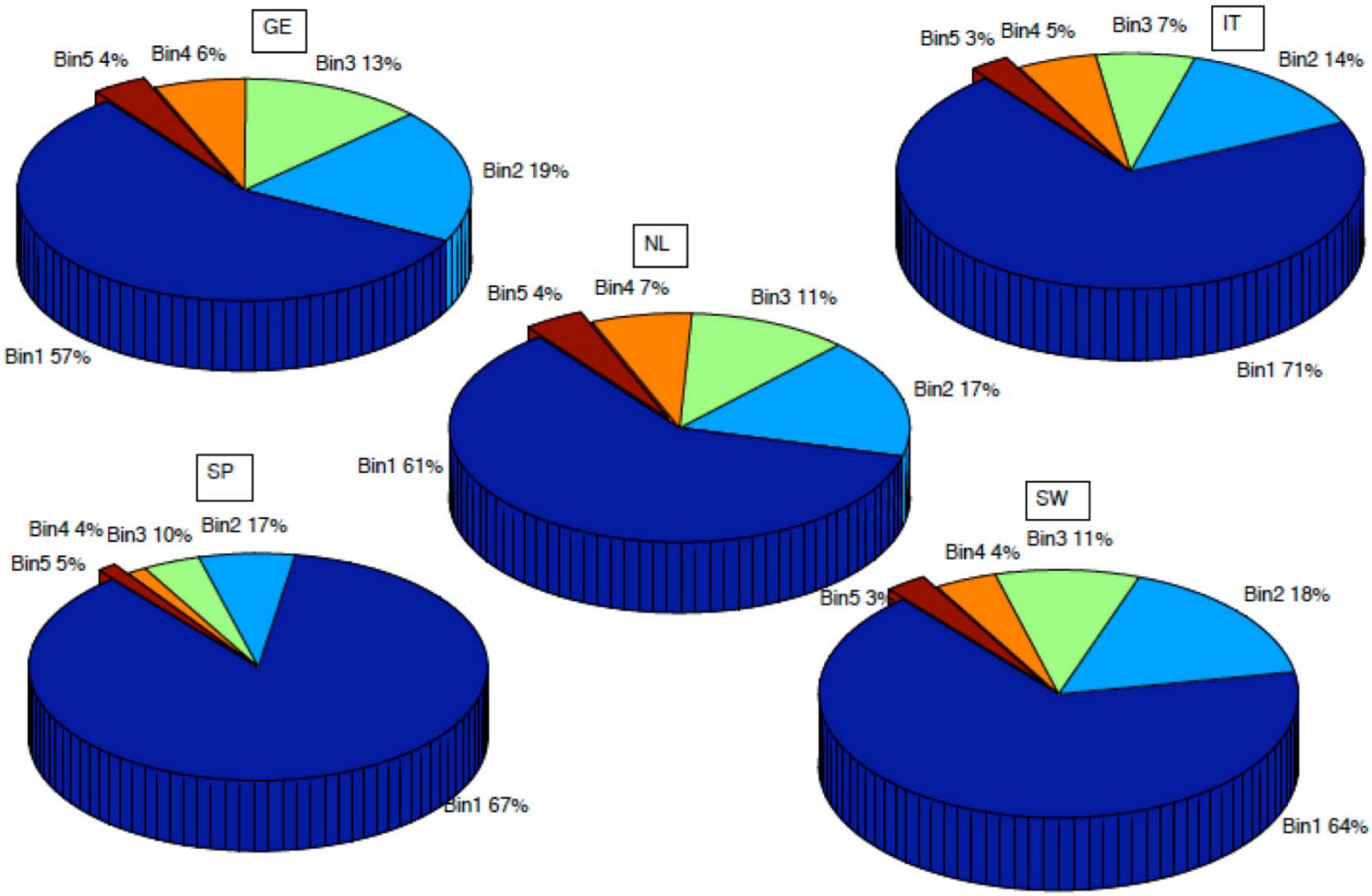
- 

FIGURE 3B. % of sectors in bins 1-5, ranked by contribution to the HL.

- The fith and the fourth bin only contain 3 and 5% of the sectors, on average. Thus

- 8% of the sectors account, on average, for 40% of the HL!

- Tradable goods are heavily overrepresented in the fourth and fith bins.

- Services are underepresented in the upper bins.

c. Breaking down aggregate persistence by group of sector

Two long-established categories:

1) food (F), durable (D), nondurable (ND), services (S) and energy (E).

2) traded (T) and nontraded (NT).

We have quantified the contribution of these group of sectors to aggregate persistence.

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Relative contributions of the groups.

$$IRF_Q(h) = \sum_{j=1}^{J} \sum_{i=1}^{N_j} \omega_i^j IRF_{q_i}^u(h)$$

The percentage contribution of group k, $C_{c,k}$ is

$$PC_j(h) = \frac{\sum_{i=1}^{N_j} \omega_i^j IRF_{q_i}(h)}{\sum_{i=1}^{N} \omega_i IRF_{q_i}(h)}.$$

The relative contribution of group k to $\mathrm{CIR}_{c,k}(h)$ or to the HL is

$$\text{PC-CIR}_j(h) = \sum_{r=1}^{h} PC_{c,j}(r). \qquad \text{PC-HL}_j = \frac{\sum_{i=1}^{N_j} \omega_i^j IRF_{c,i}(h = HL)}{\sum_{i=1}^{N} \omega_i IRF_{c,i}(h = HL)}.$$

TABLE III

CONTRIBUTION TO AGGREGATE PERSISTENCE BY GROUP OF SECTORS (IN % TERMS)

	Weights	PC-HL	PC-CIR(12)	PC-CIR(36)	PC-CIR(60)	PC-CIR(84)
1. FOOD	23	23	26	24	23	21
- Food	18	17	20	19	18	17
- Alcohol and Tobacco	5	0	6	5	5	5
2. ENERGY	10	6	9	8	6	5
3. NONDURABLES	6	8	6	7	8	8
4. DURABLES	27	41	25	31	38	43
- Clothing and personal effects	10	19	10	13	16	18
- Durables for the dwelling	6	8	5	6	8	9
- Motor vehicles	7	9	7	8	9	10
- Electronic products	2	3	2	2	3	4
- Recreational and cultural	2	2	1	2	2	2
5. SERVICES	34	23	34	29	26	21
- Services relating to the dwelling	10	7	9	9	7	6
- Transport	5	3	4	4	3	3
- Financial services	1	3	2	2	3	3
- Recreational and cultural services	15	8	16	12	11	9
- Other services	2	2	2	2	2	0
TOTAL	1	1	1	1	1	1
TRADED	62	74	61	66	71	74
NONTRADED	38	26	39	34	29	26
TOTAL	1	1	1	1	1	1

Results…

- In the short run [CIR(12)], the contribution of all groups to 'persistence' is very similar.
- As farther horizons are analyzed:
  - Durables are the most persistent sectors: 43% of the total cumulative effect of shocks in the long-term (CIR(84))
  - Their contribution to CIR(60) and CIR(80) exceeds their initial weight by 40% and 60%
  - The contribution of services and energy sectors to aggregate persistence decreases when longer horizons are considered.
  - The contribution of food and non-durables remains fairly constant over time and very similar to their initial weight

Results (II)

- Traded versus Non Traded:

  - NTs are less persistent than Ts: its contribution to CIR(60) and CIR(84) is only 0.76% and 0.68% of its initial weight.

  - The discrepancies between the traded and nontraded groups are not very large.

    The characteristics of these groups of goods might not be that different (Engel, 1999, Chari et al., 2002, Crucini and Shintani, 2008).

V. Quantile Regression (QR)

- Explanations of the slow convergence to PPP have traditionally been related to

1. nontraded goods in CPI
2. Imperfect competition, pricing to market techniques combined with nominal rigidities
3. Different consumption preferences across countries

QR is employed to test whether the theories above are able to account for sectoral persistence

Theories for RER persistence, I

1. Barriers to trade, such as tariffs or transportation costs impede trade; (Salter, 1959, Swan, 1960).

Since arbitrage is, at best, weak on these goods, volatile and persistent aggregate RERs are to be expected.

Mixed empirical support:

Engel (1999), Chari et al. (2002): nearly all the RER volatility can be attributed to the traded component.

Crucini and Shintani (2008) find very similar persistence across traded and nontraded goods.

Theories for RER persistence, II

2. Imperfect competition practices (pricing to market, PTM), combined with price stickiness, are able to create a wedge between the prices of the same good sold in different markets, violating the Law of One Price (LOP). (Betts and Deveraux, 1996, Chari et al, 2002, Hairault and Sopraseuth, 2003, Carvalho and Nechio, 2000).

With the exception of CN, these models are successful in replicating the volatility but not the persistence observed in RER data.

Theories for RER persistence, III

3. Different consumption preferences across countries

⇒ Inflation measurements are computed on different consumption baskets.

⇒ There is no reason for exchange rate changes to offset official measures of inflation differences

Since harmonized sectoral price data is used, different consumption preferences can be discarded as a source of deviations from PPP.

QR analysis: explanatory variables

1. variables related to market structure and imperfect competition.

- **PCM: price-cost margin**: approximates the degree of profitability of an industry.

The lower the value of the PCM, the fiercer the competition in this sector.

- **Input-PCM**: index that measures the degree of PCM associated with the intermediate items needed to produce good i.

The existence of PTM at the intermediate goods level can also have a big impact on the persistence of the final good i even when it is sold in a perfectly competitive market.

Variables related to market structure, II

IIT: intra-industry trade

Under IIT, domestic and foreign firms supply product varieties that are differentiated but still possess substitutability for one another. Thus, exporting firms have to maintain prices in line with local firms.

Faruque (1995) shows that more IIT leads to more PTM.

Input-IIT: intra-industry trade at the inputs level

Variables related to market structure, III

VOL: volatility of inflation

Without price stickiness, a model of PTM cannot generate persistence (Chang and Devereux, 1998).

We proxy price stickiness by the volatility of sectoral inflation.

Input-vol:

We have also computed an index that measures the price stickiness of intermediate inputs.

Definition of the variables,

explanatory variables: definitions

- IIT:

$$IIT_{c,i} = 1 - \frac{\sum_{i=1}^{N} |X_{c,i} - M_{c,i}|}{\sum_{i=1}^{N} (X_{c,i} + M_{c,i})},$$

- Input-IIT:

$$Input\text{-}IIT_{c,i} = \sum_{g=1}^{G} \omega_g IIT_{c,g}$$

- PCM:

$$PCM_{c,i} = \frac{VA_{c,i} - W_{c,i}}{VA_{c,i} + CM_{c,i}},$$

- Input-pcm.

$$Input\text{-}PCM_{c,i} = \sum_{g=1}^{G} \omega_g PCM_{c,g},$$

- Vol-infl: standard deviation inflation rate of sector i.

Variables related to the tradability of goods

Tradability

- op=openness

$$OP_{c,i} = \frac{X_{c,i} + M_{c,i}}{GDP_{c,i}}.$$

- Input-op: openness of intermediate inputs

$$Input\text{-}OP_i^c = \sum_{g=1}^{G} \omega_g OP_g^c,$$

Trade barriers

- tb=trade barriers, estimated following Anderson and Wincoop (2003, AER) and Nowy (2008)

Control variables

- **Inflation**: higher inflation can lead to a more rapid price adjustment and thus, to a lower degree of nominal rigidities.

Cheung and Lai (2000) find that higher inflation is related to less RER persitence.

Other controls

- Volatility of exchange rate
- Government spending
- …

Dependent variables

- Scalar measures of persistence used before:

  - CIR(h), h={12,36,60,84},

  - Sectoral HLs

Estimation

- Quantile panel regression, Koenker (2004)

- Standard panel: fixed effects .

Overview of the Results

1) The most important group of variables: those related to the market structure of the inputs: input-*iit* and input- *pcm*.

- Once the market structure of the intermediate inputs is considered, that of the final goods is no longer significant

2) A high degree of price stickiness is associated with a higher degree of persistence

Overview of the Results, II

3) The absolute value of the coefficients increases with both the horizon of the CIR and the quantile analyzed

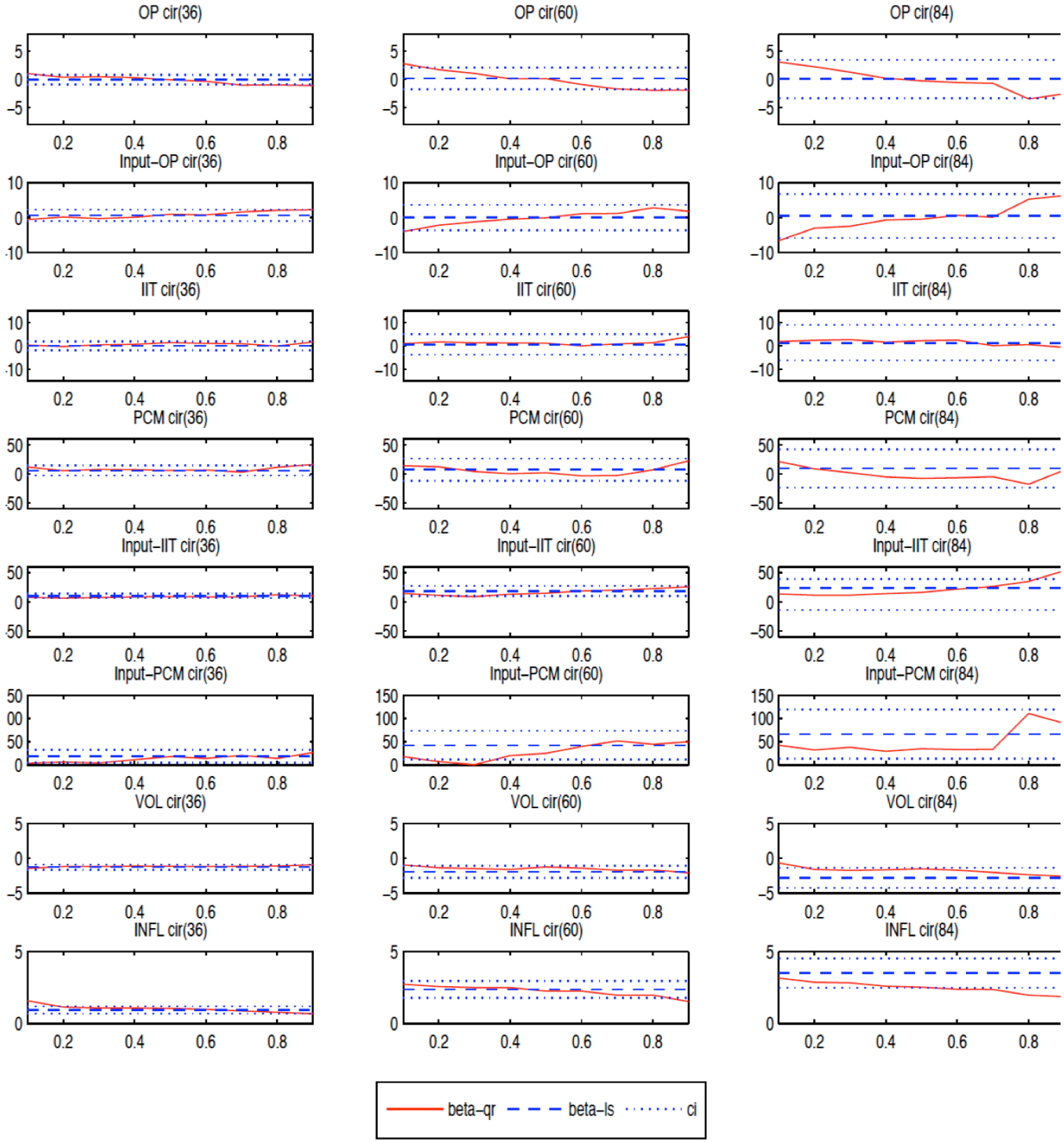
   – The impact of the variables increases when higher quantiles are considered, suggesting that their effect is more important, the more persistent the sectors are

4) Variables related to the tradability of the final goods or its inputs are not significant.

Overview of the Results, III

5) Goodness of fit of these models is high (around 50%)

6) A standard panel analysis yields similar results


OP cir(36)
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beta−qr
beta−ls
ci

TABLE IVa

Quantile Regression Results (I)

	τ_K	CIR, Short run		CIR, Medium Run		CIR, Long run				HL	
		CIR(12)		CIR(26)		CIR(60)		CIR(84)			
		M1	M2	M1	M2	M1	M2	M1	M2	M1	M2
	0.5	-0.02	-	-0.10	-	0.12	-	-0.29	-	0.49	-
OP	0.7	-0.00	-	-1.05	-	-1.71	-	-0.70	-	-0.78	-
	0.9	-0.11	-	-1.13	-	-1.96	-	-2.59	-	-1.74	-
	panel	0.00	-	-0.08	-	0.15	-	0.06	-	0.45	-
	0.5	0.23	-	0.92	-	-0.08	-	-0.48	-	2.11	-
Inputs-OP	0.7	0.20	-	1.64	-	1.14	-	0.12	-	3.51	-
	0.9	0.94	-	15.73	-	22.61	-	6.62	-	-5.38	-
	panel	1.66	-	5.57	-	7.13	-	9.15	-	-17.85	-

Notes: *, ** denote significance at the 10 and 5% level, respectively.

TABLE IVb

Quantile Regression Results (II)

		CIR,. Short run		CIR,Medium Run		CIR,Long run				HL	
		CIR(12)		CIR(36)		CIR(60)		CIR(84)			
	τ	M1	M2	M1	M2	M1	M2	M1	M2	M1	M2
IIT	0.5	0.52	-	1.37	-	1.14	-	2.18	-	-2.83	-
	0.7	0.45	-	0.86	-	0.76	-	0.02	-	-4.99	-
	0.9	0.71	-	1.69	-	3.94	-	-0.71	-	-28.43	-
	panel	0.33	-	-0.02	-	0.52	-	1.26	-	-6.29	-
Input -IIT	0.5	1.43**	1.40**	8.89**	8.83**	15.04**	15.41**	16.39**	17.56**	25.41**	22.41**
	0.7	0.97**	1.33**	8.60**	9.90**	20.10**	24.35**	26.56**	26.07**	31.77**	31.88**
	0.9	1.73*	1.53**	10.27**	9.06**	26.22**	27.13**	53.52**	50.90**	72.01**	55.60**
	panel	1.83**	1.66**	10.54**	9.90**	18.85**	18.96**	24.00**	24.04**	39.13**	35.53**
PCM	0.5	1.49	-	5.81	-	2.09	-	-7.97	-	-30.66**	-
	0.7	0.88	-	2.92	-	-2.82	-	-5.09	-	-37.32*	-
	0.9	0.94	-	15.73	-	22.61	-	6.62	-	-5.38	-
	panel	1.66	-	5.57	-	7.13	-	9.15	-	-17.85	-
Input -PCM	0.5	3.81*	4.34	18.01*	19.83*	25.15	28.59	35.00	29.41	87.16**	52.08**
	0.7	4.52*	5.13**	24.76**	23.08**	51.54**	60.86**	33.64*	33.33*	127.23**	107.13**
	0.9	11.04**	10.02**	256.57	34.12*	49.90	61.24**	89.26*	77.24*	201.00	308.75**
	panel	3.96*	4.53**	18.65*	21.82**	45.21*	49.02**	66.38*	74.22**	108.72**	105.67**
VOL	0.5	-0.39**	-0.38**	-1.15**	-1.12**	-1.24**	-1.39**	-1.51**	-1.52**	-1.04**	-1.02**
	0.7	-0.37**	-0.34**	-1.16**	-1.14**	-1.70**	-1.63**	-2.02**	-2.15**	-1.41**	-1.39**
	0.9	-0.22**	-0.26**	-0.92*	-0.98**	-2.08**	-2.14**	-2.59**	-2.91**	-0.78	0.48
	panel	-0.45**	-0.44**	-1.29**	-1.27**	-1.94**	-1.94**	-2.80**	-2.80**	-2.60*	-2.72**
INFL	0.5	0.08	0.07	1.04**	0.94**	2.25**	2.18**	2.52**	2.55**	3.98**	3.95**
	0.7	0.11	0.09	0.86**	0.94**	1.96**	2.16**	2.36**	2.49**	3.25**	3.32**
	0.9	0.04	0.03	0.67**	0.80**	1.52**	1.80**	1.85**	1.69**	2.76**	2.89**
	panel	0.05	0.05	0.92**	0.99**	2.35**	2.47**	3.50**	3.67**	2.91**	3.33**

* **

TABLE V

GOODNESS OF FIT (GOF)

	CIR(12)	CIR(24)	CIR(60)	CIR(84)	HL
R_G^*	0.435	0.433	0.440	0.422	0.452
$R_{\tau_\kappa}^*$, τ_k=0.5	0.432	0.458	0.467	0.455	0.538
$R_{\tau_\kappa}^*$, τ_k=0.7	0.411	0.467	0.479	0.474	0.523
$R_{\tau_\kappa}^*$, τ_k=0.9	0.355	0.418	0.438	0.421	0.510
$R^{2-}panel$	0.66	0.64	0.65	0.62	0.64

R_G^* denotes the GoF of the estimation of all quantiles, see (20)

$R_{\tau_\kappa}^*$ measures the GoF of the corresponding quantile τ_k, see (21)

Summarizing our contribution

1) Heterogeneity and skewness

2) As a consequence of the high skewness, the slow reversion to parity of aggregate RERs is driven by a few highly persistent sectors (around 10% account for 40 of the aggregate HL)

3) Sectors in the durable category are the most persistent ones and they alone account for more than 40% of the cumulative effect of shocks in the long run.

4) While Tradables are overrepresented in the upper 10%, services and other nontraded goods are surprisingly under-represented in this 10%

Summarizing… (and II)

- Imperfect competition and price stickiness at the intermediate good level are the most important factors to account for persistence at the upper quantiles
- Once the behavior of the intermediate goods has been taken into account, PTM at the final good level does not seem be important
- The traditional dichotomy that divides goods into $\mathcal{T}$ and $\mathcal{NT}$ seems not to have any explanatory power
- **We stress the importance of analyzing what happens in the upper quantiles of the distribution of sectoral persistence, rather than around the conditional mean to understand the forces that shape the slow reversion to parity of aggregate RERs.**