



GLOBAL VERSUS LOCAL SHOCKS IN MICRO PRICE DYNAMICS

Philippe Andrade and Marios Zachariadis

Discussion Paper 10-2011

Global Versus Local Shocks in Micro Price Dynamics*

Philippe Andrade[†]
Banque de France & CREM

Marios Zachariadis[‡]
University of Cyprus

May 14, 2011

Abstract

A number of recent papers point to the importance of distinguishing between the price reaction to micro and macro shocks in order to reconcile the volatility of individual prices with the observed persistence of aggregate inflation. We emphasize instead the importance of distinguishing between *global* and *local* shocks. We exploit a panel of 276 micro price levels collected on a semi-annual frequency from 1990 to 2010 across 88 cities in 59 countries around the world, that enables us to distinguish between *different* types (local and global) of *micro* and *macro* shocks. The persistence associated with each of these components and its relation with volatility of the different components, provides a number of new facts. Prices respond more slowly to global shocks as compared to local ones – in particular, prices respond faster to local macro shocks than to global micro ones – implying that the relatively slow response of prices to macro shocks documented in recent studies comes from global rather than local sources. In addition, more volatility in *local* conditions leads to more persistent relative price distortions due to slower response of prices to *global* shocks, with this *local-global* link more than twice as large as the corresponding *micro-macro* link. Finally, global shocks account for half of the volatility in prices. Overall, our results imply that global shocks are important when analyzing price dynamics or assessing price-setting models.

Keywords: global shocks, local shocks, micro shocks, macro shocks, price adjustment, micro-macro gap, price-setting models, micro prices.

JEL Classification: E31, F4, C23

*We would like to thank Fernando Alvarez, Paul Bergin, Christian Hellwig, Hervé Le Bihan, and Xavier Ragot for useful comments and suggestions. All remaining errors are ours. The paper does not necessarily reflect the views of the Banque de France.

[†]Philippe Andrade, Banque de France, Monetary Policy Research Division, 31 rue Croix des Petits-Champs, 75049 Paris Cedex 1, France. Phone#: +33-142924995. Fax#: +33-149924818. E-mail: Philippe.Andrade@u-cergy.fr

[‡]Marios Zachariadis, Department of Economics, University of Cyprus, 1678 Nicosia, Cyprus. Phone#: 357-22893712, Fax#: 357-22892432. E-mail: zachariadis@ucy.ac.cy

1 Introduction

How fast do prices adjust to changes in economic conditions? Answering this is crucial in the assessment of the welfare costs of inflation and the real effects of nominal shocks. The literature provides apparently conflicting answers to this question: whereas aggregate price indices were found to be very persistent, more recent work starting with Bils & Klenow (2004) has shown that individual prices adjust frequently. Boivin, Giannoni and Mihov (2009) show that this puzzle can be resolved by distinguishing between the response of individual prices to *macroeconomic shocks* common to every sector or product, and their response to *microeconomic shocks* specific to a sector or product. They find that sectoral prices adjust sluggishly to the former but rapidly to the latter. This result has in turn spurred a debate on what theoretical model of price-setting could rationalize such different response of individual prices to different types of shocks.

In this paper, we emphasize the distinction between *global shocks* common to every location world-wide, and *local shocks* specific to a location. We find that, for both macro and micro shocks alike, global components are associated with a much slower speed of price adjustment than local ones. Furthermore, we find that the difference in the speed of price adjustment in response to local macro versus local micro shocks is smaller than the difference in the speed of price adjustment in response to global versus local shocks of any type. Moreover, global micro shocks are associated with a slower speed of price adjustment than local macro shocks. These findings imply that considering only a single type of micro or macro shock as in previous work hides important heterogeneity in their effects that could lead to misleading inferences about the relative persistence of local macro shocks (typically monetary ones) in micro prices. Finally, we find that more volatility in local conditions is associated with slower price adjustment in response to global shocks, with this local-global link more than twice as large as the one between volatility in micro conditions and price adjustment in response to macro shocks. Overall, our results suggest that the global-local distinction is a much more striking one and no less important in assessing models of price-setting, than the macro-micro split considered in previous work.

Our analysis relies on a panel of 276 micro price levels collected from 1990 to 2010 at a semi-annual frequency across 88 cities in 59 countries across the world. This dataset is non-standard and was especially compiled for us by the Economist Intelligence Unit (EIU) at a semiannual frequency for the complete sample of locations.¹ The three dimensions of our panel—time, location and

¹The standard EIU city prices edition typically used in work focusing on convergence in LOP deviations, e.g.

individual product—allow us to decompose the dynamics of the common currency micro price-level for each product in a given location at a given date into four different components: (1) a *global macro* component common to every good in every location, capturing for example global oil shocks; (2) a *global micro* component specific to a good and common to every location, related for example to technology shocks specific to a product but common across the globe; (3) a *local macro* component specific to a location and common to every good, related for example to monetary policy; and (4) a *local micro* or *idiosyncratic* component specific to a good and a location, capturing for example the idiosyncrasy of weather conditions facing vineyards in a certain location. Our identifying assumptions allow us to estimate each of these components from observed prices by applying simple average and difference transformations. We can then assess the convergence rates specific to each of these components allowing for different reaction of prices to these, as well as assess the link between persistence and volatility of the different components, and the share of price volatility attributed to each component.

Local micro shocks are the most rapidly corrected ones, followed by local macro shocks, and global micro shocks. More precisely, local micro shocks have a half-life estimate of about 7 months. The reaction to local macro shocks is of comparable order with a half-life of 10 months, while global micro shocks have a half-life that is about twice as long at 19 months. Finally, the response of prices to global macro shocks is found to be permanent so that international prices share this single global stochastic trend which is the main factor behind the observed drift in price levels.² Furthermore, we find that the global macro and micro components together account for half of the time-series volatility in prices in this sample. The above findings taken together suggest that global shocks cannot be ignored when analyzing the sources of persistence and volatility of prices. Our results confirm that prices react differently to different types of shocks, but stress that sorting shocks by geographic distance (global vs local) leads to more striking differences in the response of prices than sorting shocks by economic distance (macro vs micro).

The observed differences in persistence of the different price components could stem from differences in the persistence of the shocks driving the processes associated with these components rather than from differences in the reaction of prices to these shocks. We thus investigate further by considering the link between persistence and volatility of each price component. If persistence of the shocks was the main driver of the observed persistence in prices, then we would expect to see a positive

Crucini and Shintani (2008), is available only at the annual frequency.

²The absence of other stochastic trends validates the theoretical assumption by Golosov & Lucas (2007) that relative prices have no specific trend, ensuring that their time variance is bounded.

relation between own persistence and volatility. The estimated link between these turns out to be either negative or statistically indistinguishable to zero. This leads us to infer that price adjustment to different types of conditions does not stem from the mere persistence of the shocks. The link between persistence and volatility provides us with a couple of additional new facts. First, more volatility in micro conditions is associated with slower adjustment of prices, hence more persistent relative price distortions, in response to changes in macro conditions. Likewise, more volatility in local conditions is associated with slower price adjustment, hence more persistent relative price distortions, in response to changes in global conditions, with this link more than twice as large as the micro-macro one.

We propose that decomposing macro and micro shocks into finer categories provides a new more precise tool for gauging models of price-setting. The persistence associated with each of these components and its relation with volatility of the different components, provide new facts that price-setting models should be able to rationalize.³ First, price-setting models should be able to rationalize differences in the speed of adjustment to global versus local shocks in addition to macro versus micro shocks. They should also be able to explain why these differences are more striking when shocks are classified with respect to geographic distance (global vs local) rather than economic distance (macro vs micro). Second, models of price-setting should be able to cope with the estimated sign and size of the link between local volatility and the rate of price adjustment in response to global shocks.⁴ Again, they should also be able to explain why the volatility in local conditions seems to be more detrimental to the adjustment to global conditions, as compared to the effect of volatility in micro conditions for the adjustment to macro conditions.

One possibility would be to resort to models of endogenous imperfect perception of shocks, in the spirit of the recent contributions of Reis (2006), Maćkowiak and Wiederholt (2009), Woodford (2009) or Alvarez, Lippi and Paciello (2010), where the relative cost of observing global conditions would be greater than the one associated with monitoring local ones, and more so than the relative cost of observing macro conditions exceeds that for micro ones. Similarly, in the context of these models, the loss of processing capacities due to volatility in local conditions can be more detrimental

³There are three main competing approaches in terms of modelling price-setting behavior: time-dependent models of price setting developed by Calvo (1983); state-dependent models of price setting introduced by Sheshinski & Weiss (1977); and imperfect information models of price setting in the spirit of Lucas (1972). Recent developments along these lines includes Carvalho (2006) for time-dependent models, Golosov & Lucas (2007) and Gertler & Leahy (2008) for state-dependent ones, and Reis (2006), Hellwig & Veldkamp (2009) and Maćkowiak & Wiederholt (2009) for imperfect information ones.

⁴Maćkowiak et al. (2009) discuss how a similar link, between micro volatility and the persistence of the price reaction to macro shocks, can be used to dismiss a basic version of a Calvo price setting model.

to the monitoring of global conditions, as compared to the loss of processing capacities due to volatility in micro conditions for the monitoring of macro conditions. Yet another theoretical possibility would be to rely on labor market segmentation arguments, in the spirit of Carvalho and Lee (2010).⁵ Here, the segmentation would need to be greater between countries than within them in the same manner (but more so) that labor segmentation is greater across sectors than within them. However, this framework would have to incorporate a link between volatility of shocks and persistence of price reactions.

Our results on the differential response of prices to different types of shocks extend Clark (2006), Boivin et al. (2009), and Maćkowiak, Moench and Wiederholt (2009), to a global environment. These papers bridge the gap between measured persistence of macro price indices and the frequent adjustment observed in micro prices.⁶ In their setup, a macro shock is common to every sector in the US, potentially encompassing a shock common to every country worldwide (our global macro shock) and a shock specific to the US (our local macro shock). Likewise, their sectoral shock can be made of a worldwide sectoral shock (our global micro shock) and a US sector-specific one (our local micro shock). Our work points to the importance of disentangling global and local components to understand price dynamics. No study of micro price levels has looked at this global/local decomposition of micro and macro shocks.⁷ We show that whereas global macro shocks are highly persistent, prices react to local macro shocks much faster than to global micro ones. By contrast, Boivin et al. (2009) state that their “main finding is that disaggregated prices appear sticky in response to macroeconomic and monetary disturbances, but flexible in response to sector-specific shocks” and that “many prices fluctuate considerably in response to sector-specific shocks, but they respond only sluggishly to aggregate macroeconomic shocks such as monetary policy shocks”. To the extent that country-specific monetary policy is part of our local macro component, we find that this is much less persistent than in Boivin et al. (2009). Prices respond almost twice as fast to local macro shocks as they do to global micro shocks. This is also in contrast with the finding of

⁵Their mechanism relies on these along with sticky prices, pricing complementarities due to intermediate inputs, and endogenous monetary policy.

⁶They show that sectoral prices react rapidly to US sectoral shocks and sluggishly to US macro shocks, arguing that as the latter account for such a low share of sectoral price variance it is not surprising to observe sectoral prices that on average adjust rapidly. Altissimo, Mojon and Zaffaroni (2009) find similar results for the euro area.

⁷Using sectoral price indices, Beck, Hubrich & Marcellino (2010) also emphasize the variance of geographical components as an important part of what was previously thought to be micro shocks. The related literature on global shocks has found a large common component in international aggregate inflation indices in OECD countries (Ciccarelli & Mojon, 2010) or in disaggregated inflation at the CPI product level in OECD countries (Monacelli & Sala, 2008). As compared to these, we use a large number of micro-prices and global locations to further decompose the common component into macro and micro global components, stressing that the micro part accounts for a greater share of in-sample variance.

transitory micro shocks in Boivin et al. (2009).

Our results also relate to the literature on international price comparisons. Until recently, these were considered to be very persistent at the aggregate level. Deviations from PPP have a half-life of several years as documented in the surveys by Rogoff (1996) and Obstfeld and Rogoff (2000). The survey by Goldberg and Knetter (1997) stresses that the persistence is of comparable order when one considers deviations from the LOP using relatively aggregated sectoral price indices. Instead, the recent evidence relying on micro-data, such as Goldberg and Verboven (2005) using European car prices, Crucini and Shintani (2008) using annual EIU prices, and Broda and Weinstein (2008) or Burstein and Jaimovich (2009) using barcode prices, is that the persistence of LOP deviations is reduced sharply when based on micro prices with higher comparability across locations. Our estimated half-lives are even lower than in the recent micro-price literature on LOP deviations, in part due to the use of semiannual prices and a broader sample of locations across the world as compared to the previous studies. Bergin, Glick, and Wu (2010) argue that the differential importance and persistence of (local) macro versus (local) micro shocks can reconcile the macro with the micro evidence for international price convergence rates estimates.⁸ They show that idiosyncratic shocks at the individual good level, that dominate micro prices, are more volatile and have faster convergence than macro shocks that dominate at the aggregate level. Notwithstanding differences in the methodology being utilized and the sample under study, our estimate of a response of individual prices to idiosyncratic shocks that is comparable to the response to local macro shocks, appears to be somewhat at odds with their results. Our work implies that the micro/macro gap between the fast convergence in the deviations from the LOP (micro) and the very persistent deviations from PPP (macro) cannot be resolved by decomposing between macro and micro shocks in the LOP since there is not that much more persistence in local macro shocks as compared to local micro ones.

Next, we describe the data. We then present our statistical model, and proceed to discuss our results. Following that, we consider the link between volatility of shocks and persistence of prices before concluding in the final section.

⁸By contrast, Imbs *et al.* (2005) argue that the gap between the fast adjustment for LOP deviations and slow adjustment for aggregate price indices in the PPP literature comes from the aggregation of heterogeneous sectoral price dynamics, while Carvalho and Nechio (2008) rationalize the argument in a multi-sectoral two-country model proposing an aggregation effect arising in an economy characterized by heterogeneity in the degree of price stickiness across sectors that leads to heterogeneous dynamics in sectoral real exchange rates.

2 Data

2.1 Description and reliability

The main source of data utilized in our application comes from the Economist Intelligence Unit (EIU). EIU prices were provided to us for 327 items in 140 cities in 90 countries twice a year, where available, from 1990 to 2010. The semiannual (March and September) prices were especially compiled for us by the EIU upon request, as the standard historical data in the EIU “cityprices” publication contains prices gathered only once a year, every September. In the data appendix, we undertake a detailed description of how these prices are collected and put together, meant to help the reader understand the potential advantages and disadvantages of using this dataset to study international prices and to assist future users in appropriately handling these data. Although subsamples of these data have been used previously as described below, the information provided in the data appendix is largely new.

Engel and Rogers (2004), Crucini, Telmer, and Zachariadis (2005), Bergin and Glick (2007), Crucini and Shintani (2008), Crucini and Yilmazkuday (2009), and Bergin et. al. (2010) have all exploited sub-samples of these EIU prices. The first paper focuses on a sample of prices in 18 European cities for 101 traded and 38 non-traded products for the period from 1990 to 2003, to ask how much more integrated the EU has become after the introduction of the euro. The second paper utilizes the EIU data averaged over the period from 1990 to 2000, and focuses on the first and second moments of the cross-sectional distribution of bilateral country prices across goods, to assign a role to geographic variables. The paper by Bergin and Glick focuses on a sample of 101 tradeable goods in 108 cities in 70 countries for the period from 1990 to 2005, to assess global price convergence. Crucini and Shintani (2008) focus on a sample of 90 cities in 63 countries for the period from 1990 to 2005, to assess the rate of price convergence for the relative price of each good. Crucini and Yilmazkuday (2009) average the data over the period from 1990 to 2005 and explain this cross-sectional dimension with trade and distribution costs. Finally, Bergin et. al. (2010) study a subset of these data for traded goods price comparisons between the US and 20 cities in 20 industrial countries at a semiannual frequency from 1990 to 2007 in an attempt to resolve the macro-micro disconnect of PPP and the LOP.

As compared to the above papers, we have access to semiannual prices for the period from 1990 to 2010 for the great majority of locations. Restricting the sample to goods and locations always

present during this period, we end up with price levels for 276 goods and services across 88 cities in 59 countries. Table 1 provides a complete list of goods and locations (both cities and countries) that are present in our sample. It also provides a classification of cities between the less developed countries in our sample (LDC) with income per capita less than \$12,000 and more developed countries (DEV),⁹ and a classification of goods between traded (TR) and non-traded (NT). We note that there is a much lower number of NT items available as compared to TR products and a lower number of LDC locations. Most traded goods prices are observed in two types of stores, so that we end up with two price observations per date and location for 100 goods. In Table 1, we also report the type of store (supermarkets, chains, and mid-price or brand stores) each good was sampled in.

For some of our main results, we focus on a restricted sample of 49 countries, excluding EMU countries other than Germany, to address the fact that EMU countries do not undertake independent monetary policy so that local macro shocks would not be as related to monetary policy if these were included. Similarly, we have restricted our main analysis to countries rather than cities since the latter cannot undertake independent monetary policy. However, we also consider a more complete sample of 59 countries including EMU ones, as well as a city-level analysis for 88 cities in these 59 country sample.

All prices are converted in a common currency, the US dollar, using exchange rate data assembled by the EIU to match the sampling periods of the city price levels data. We also used the US dollar exchange rates to reconstruct exchange rate data for the British Pound and Yen relative to the national currencies of the locations in the sample, in order to consider the robustness of the results to the numeraire currency. We also obtained PPP-adjusted real GDP per worker from the Penn World Tables (up to 2007) and country-level population from the World Development Indicators.

2.2 Descriptive statistics

The EIU city price data include vastly different priced items. Some summary statistics regarding these EIU prices are presented in Table 6. There are much more cross-sectional differences, with a standard deviation equal to 2.57, as compared to time fluctuations that have a standard deviation of

⁹Our classification of less developed countries is based on the PPP adjusted GDP per capita from the Penn World Tables. These are countries with income per capita below \$12000 on average over the 1990–2007 period. This threshold corresponds to the average income per capita in the cross country distribution of the Penn World sample of countries.

0.33. The distribution of prices is skewed to the right, i.e. the distribution mass is more concentrated on small values. The autocorrelation coefficient averages around 0.81, implying persistent effects of shocks.

Moreover, we observe that more developed countries have higher price levels, less heterogeneity in each dimension, lower volatility, and more persistent effects of shocks. At the same time, traded goods in this sample have lower price levels on average than non-traded ones, as well as less heterogeneity in each dimension except for the speed of convergence. Traded goods are also characterized by comparable volatility with non-traded goods, and by less persistent effects of shocks on prices. The above suggest the absence of a systematic link between volatility and the speed of price convergence. That is, while more volatility in LDCs is associated with more rapid convergence, lower convergence for non-traded goods coexists along with similar degrees of volatility for traded and non-traded goods. A potential explanation for this might be that goods characteristics interact with location (city/country) characteristics so that prices react differently to these different components. We consider this decomposition in the following section.

3 A statistical model of goods prices in different locations

Let p_{ilt} be the common currency (log) price of good item i in location l at date t . We consider a decomposition of international prices into four components, namely

$$p_{ilt} = \alpha_{il}m_t + \beta_i m_{lt} + \gamma_l m_{it} + m_{ilt}.$$

The term m_t represents a component affecting *every price in every location*. We refer to this as the *global macroeconomic* component of prices. A typical example of a global macro component would be oil prices. Changes in oil prices have different impact on prices depending on the location considered, for instance because of the distance to production, or on the goods considered, for instance because of the composition of intermediate inputs. Such heterogeneity in price reactions is captured by the heterogeneity in the parameter α_{il} .

The second term, m_{lt} , denotes a component affecting the price of *every good for a given location*. We refer to this as the *local macroeconomic* component of international prices, typically monetary or fiscal policies. An aggregate demand shock specific to a location can induce different reaction in prices of different goods, according to markup determinants such as demand elasticities or the

cost of updating prices. We allow for such heterogeneous reaction of prices by allowing for heterogeneity in the parameter β_i . We could consider that the reaction of prices to local macro shocks differs according to both goods and locations. In that case, the effect of the local macroeconomic component on international prices would be described by a term $\tilde{\beta}_{il}\tilde{m}_{it}$. However, this turns out to be only a matter of normalization if we assume that one can separate the total impact between its location and good-specific components. For instance, if $\beta_{il} = \beta_i\beta_l$, one can rewrite such a term as $\beta_i m_{it}$ with $m_{it} = \beta_l \tilde{m}_{it}$.

The third term, m_{it} , represents a component affecting the price of a *given good in every location*. We refer to this as the *global microeconomic* component of international prices. A natural example would be an innovation specific to a given product. Such innovations can have a different impact on prices depending on the location to which the product is sold, typically due to the distance to the innovation frontier of the specific location considered. Such potential differences are captured in the heterogeneity of the parameters γ_l . As underlined in the previous paragraph, the heterogeneity of the reaction allowed for in our model encompasses the broader case where $\tilde{\gamma}_{il}\tilde{m}_{it}$ with $\tilde{\gamma}_{il} = \gamma_l\gamma_i$.

Lastly, the residual term, m_{ilt} , captures the component affecting the price of a *given good in a given location*. We refer to this as the *local microeconomic* or idiosyncratic component of prices. A typical example of a factor affecting this component would be a strike in a given sector and location.

We assume that each of these underlying components can be described by auto-regressive univariate processes so that

$$m_{*t} = c_* + \delta_*(L)m_{*t-1} + \epsilon_{*t},$$

where $* = \{\emptyset\}, i, l$ or il , the terms ϵ represent mutually independent white noise processes, and the operators $\delta(L)$ are polynomials in the lag operator satisfying standard invertibility conditions. The dynamics of prices are thus given by

$$p_{ilt} = \mu_{il} + \rho_{il}(L; m)m_{t-1} + \rho_{il}(L; m_l)m_{lt-1} + \rho_{il}(L; m_l)m_{lt-1} + \rho_{il}(L; m_{il})m_{ilt-1} + \varepsilon_{ilt} \quad (1)$$

with $\mu_{il} = \alpha_{il}c + \beta_i c_l + \gamma_l c_i + c_{il}$, $\rho_{il}(L; m) = \alpha_{il}\delta(L)$, $\rho_{il}(L; m_l) = \beta_i\delta_l(L)$, $\rho_{il}(L; m_i) = \gamma_l\delta_i(L)$, $\rho_{il}(L; m_{il}) = \delta_{il}(L)$, and $\varepsilon_{ilt} = \epsilon_t + \epsilon_{lt} + \epsilon_{it} + \epsilon_{ilt}$.

Lastly, we make two types of normalization assumptions. First, we assume that location-specific components average out across locations and that good-specific components average out across goods. More precisely, letting $E_z(x_{yz}|y)$ denote the expectation of x_{yz} conditional on y and over all possible values of z , we postulate that $E_l(m_{lt}|t) = E_l(m_{ilt}|it) = 0$ and $E_i(m_{it}|t) = E_i(m_{ilt}|lt) = 0$.

This obviously also implies that $E_{il}(m_{ilt}|t) = 0$. Second, as the coefficients α_{il} , β_i and γ_l give the impact of each component for a given good in a specific location relative to the average, we normalize this average reaction to unity, namely $E_{il}(\alpha_{il}) = E_i(\beta_i) = E_l(\gamma_l) = 1$.

Our model structure has some implications for two important measures of relative prices. First, the so-called deviations from the law of one price (LOP) widely discussed in the international economics literature, i.e. the price of a given good in a given location relative to the price of the same good in other locations. Letting $\bar{p}_{it} = \frac{1}{n_{l|i}} \sum_l p_{ilt}$, with $n_{l|i}$ the number of locations for which good i is sampled, deviations from the LOP are given as

$$q_{ilt} = p_{ilt} - \bar{p}_{it},$$

and under the assumptions of our econometric model, follow a process described by

$$q_{ilt} = \beta_i m_{lt} + m_{ilt} + u_{ilt},$$

with $u_{ilt} = (\alpha_{il} - \bar{\alpha}_i)m_t + (\gamma_l - 1)m_{it} + \{\bar{p}_{it} - E_l(p_{ilt}|it)\}$ and $\bar{\alpha}_i = E_l(\alpha_{il}|i)$. The relative price for a given good in a given location compared to other locations is therefore the combination of a common location-specific component, a good-location idiosyncratic term, and a residual resulting from the specific contribution of the global (both macro and micro) shocks to the price of that specific good in that specific location and an in-sample estimation error.

Our model structure also has implications for a second important measure of relative prices, pertaining to deviations from “pure inflation”¹⁰ within a country, i.e. the price of a given good in a given location relative to other goods in the same location. Letting $\bar{p}_{lt} = \frac{1}{n_{i|l}} \sum_i p_{ilt}$, with $n_{i|l}$ the number of goods sampled in location l , this relative price is given by

$$r_{ilt} = p_{ilt} - \bar{p}_{lt},$$

which, under our model’s assumptions follows a process described by

$$r_{ilt} = \gamma_l m_{it} + m_{ilt} + v_{ilt},$$

with $v_{ilt} = (\alpha_{il} - \bar{\alpha}_l)m_t + (\beta_i - 1)m_{it} + \{\bar{p}_{lt} - E_i(p_{ilt}|lt)\}$ and $\bar{\alpha}_l = E_i(\alpha_{il}|l)$. The relative price for a given good in a given location compared to other goods is therefore the combination of a common good-specific component, a good-location idiosyncratic term, and a residual resulting from the

¹⁰In the terminology of Reis and Watson (2009), “pure inflation” is the variation in prices that is common to every goods item in a given country so that it leaves relative prices constant.

specific contribution of the macro (both global and local) shocks to the price of that specific good in that specific location and an in-sample estimation error.

The price components m_t , m_{lt} , m_{it} , and m_{ilt} that appear in the dynamics of the last two relative prices are not directly observable. However, the model structure allows us to approximate them by linear combinations of the averages over the different indices. Indeed, letting $\bar{p}_t = \frac{1}{n} \sum_{il} p_{ilt}$, with $n = \sum_i n_{il} (= \sum_l n_{li})$ the number of individual units in the sample, $\bar{q}_{lt} = \frac{1}{n_{li}} \sum_i q_{ilt}$, and $\bar{r}_{it} = \frac{1}{n_{li}} \sum_{il} r_{ilt}$, then one can show that

$$\bar{p}_t \rightarrow m_t, \quad \bar{q}_{lt} = (\bar{p}_{lt} - \bar{p}_t) \rightarrow m_{lt} + (\bar{\alpha}_l - 1)m_t, \quad \text{and} \quad \bar{r}_{it} = (\bar{p}_{it} - \bar{p}_t) \rightarrow m_{it} + (\bar{\alpha}_i - 1)m_t,$$

where \rightarrow stands for convergence in probability. So m_{lt} can be estimated by projecting \bar{q}_{lt} over \bar{p}_t . Likewise, m_{it} can be estimated by projecting \bar{r}_{it} over \bar{p}_t . As a consequence, consistent estimates of the price dynamics properties can be obtained by resorting to the following regressions

$$\bar{p}_t = \nu + \rho(L)\bar{p}_{t-1} + \eta_t, \tag{2}$$

$$q_{ilt} = \nu_{il}^q + \bar{\rho}_{il}^q(L)\bar{q}_{ilt-1} + \tilde{\rho}_{il}^q(L)(q_{ilt-1} - \bar{q}_{ilt-1}) + \phi_{il}^q\bar{p}_t + \psi_{il}^q\bar{r}_{it} + \eta_{ilt}^q, \tag{3}$$

$$r_{ilt} = \nu_{il}^r + \bar{\rho}_{il}^r(L)\bar{r}_{ilt-1} + \tilde{\rho}_{il}^r(L)(r_{ilt-1} - \bar{r}_{ilt-1}) + \phi_{il}^r\bar{p}_t + \psi_{il}^r\bar{q}_{lt} + \eta_{ilt}^r. \tag{4}$$

Indeed, it follows from the previous analysis that $\rho(L) \rightarrow E_{il}\rho_{il}(L; m_l)$, $\bar{\rho}_{il}^q(L) \rightarrow \rho_{il}(L; m_l)$, $\bar{\rho}_{il}^r(L) \rightarrow \rho_{il}(L; m_i)$, $\tilde{\rho}_{il}^q(L) \rightarrow \rho_{il}(L; m_{il})$, and $\tilde{\rho}_{il}^r(L) \rightarrow \rho_{il}(L; m_{il})$, where $\rho_{il}(L; m_*)$ are the polynomials defined in equation (1), with $*$ being either $\{\emptyset\}$, i , l , or il .

To conclude this section, it is worth characterizing the type of bias induced by a split between the reaction of prices to macro and micro factors under the assumptions of our model. Because of data limitations, previous work, including Boivin, Giannoni and Mihov (2009), consider a price model of the following kind

$$p_{ilt} = \alpha_{il}f_{lt} + e_{ilt}.$$

Our postulated model structure gives insights on the type of bias this specification might imply. Indeed, a mapping between this model and our setup can be done by considering the macro component $f_{lt} = m_t + m_{lt}$ which obviously mixes the global and local macro components. The micro component is then given by $e_{ilt} = (\beta_i - \alpha_{il})m_{lt} + \gamma_l m_{it} + m_{ilt}$ and therefore mixes the global and local micro as well as the local macro components. Whenever the different components have different time-series properties, e.g. different persistence parameters, the macro/micro split will thus lead to biased estimates of these parameters.

4 Estimation results

4.1 Stationarity tests of components

For the global macro component of prices, m_t , we conduct a standard ADF unit-root test using a standard auto-regression of \bar{p}_t . For the other components, m_{lt} , m_{it} , and m_{ilt} , we implement the cross-sectional ADF (CADF) unit-root testing procedure of Pesaran (2007). We rely on individual auto-regressions of respectively, \bar{q}_{lt} , \bar{r}_{it} , and q_{ilt} or r_{ilt} , and calculate averages of individual ADF test statistics. However, as equations (3) and (4) make clear, these individual auto-regressions are correlated across units because of the common factors \bar{p}_t , \bar{q}_{lt} , and \bar{r}_{it} . We thus follow Pesaran (2007) and control for these common factors directly in these test regressions.

As shown in Table 7, the only stochastic trend is in the average price level. That is, global macro shocks constitute the single source of non-stationarity. Relative prices are stationary on average. As we can see in Table 7, deviations from the LOP are stationary at the location level, i.e. taking the average across goods, for 62 out of 88 locations, as well as at the individual product-location level for 74 out of 88 locations. Similarly, relative prices within a location are stationary both at the product level, i.e. taking the average across locations, for 183 out of 276 goods, and at the individual product-location level for 275 out of 276 goods.

The latter finding of stationarity in relative prices within a country differs from the finding of stochastic trends in relative sectoral prices within a country in Boivin et al. (2009) or Maćkowiak et al. (2009). That relative prices are found to be stationary on average is important for the calibration of price-setting models. Our finding is consistent with the assumption of stationary idiosyncratic shocks in the theoretical price-setting model of Golosov and Lucas (2007). By contrast Gertler and Leahy (2008) assume non-stationary idiosyncratic productivity shocks.

We note that we also find stationarity in the deviations from the LOP, confirming Crucini and Shintani (2008). As compared to the latter study, we use higher frequency (semiannual) and more recent (ending in year 2010 rather than 2005) data, and a modeling setup that allows for more heterogeneity across goods and locations. We also note that we find stationarity for the subset of non-traded goods, whereas Bergin et al. (2010) find stationarity only for traded goods in their sample of 20 locations with semiannual data extending to 2007.

4.2 Persistence of components

We now turn to the estimation of the persistence characterizing each of the components that are on average stationary. In Table 8, we report a measure of persistence estimates, namely the sum of the coefficients characterizing the dynamics of each of the stationary components, m_{lt} , m_{it} , and m_{ilt} . More specifically, using the notation from equation (1) in section 3, Table 8 gives estimates of $\rho_{il}(1; m_*)$ with $*$ being either i , l or il . We also report the half-life associated with each of these persistence parameters, namely the time it takes to correct half of the initial shock.

Estimates are obtained through the common correlated effect mean-group (CCEMG) estimation procedure proposed in Pesaran (2006). This involves estimating the individual auto-regressive equations (3) and (4) and then averaging the individual parameter estimates. The inclusion of the common factors, \bar{p}_t , \bar{q}_{lt} , and \bar{r}_{it} , in the individual auto-regressions, (3) and (4), allows to get rid of the contemporaneous correlation across individual regression errors that these common terms would otherwise imply.

For the results reported in Table 8, we have restricted the analysis to countries rather than cities for comparability to previous literature investigating macro shocks at the national level. For example, monetary policy is typically undertaken at the national rather than city level. Moreover, we treat the EMU as a single entity since EMU nations do not undertake independent monetary action. Thus, we restrict our sample to 49 countries, capturing the EMU entity by Germany.¹¹ Even though we do not exactly identify monetary policy shocks, excluding locations that do not exercise independent monetary policy ensures that our local macro shocks will be more closely related to monetary shocks than otherwise. We also consider the robustness of our findings for a more complete sample of 59 countries including all EMU nations, as well as a city-level analysis that exploits the full dimension of our dataset across 88 cities in Table 9.

As we can see in Table 8, prices react differently to different types of shocks. The response to local macro shocks in the first column of Table 8 is relatively fast with a mean reversion rate of less than 10 months which is comparable to the convergence rate of 7 months for local micro shocks, and faster than the convergence rate of prices in response to global micro shocks which is around 19 months long.¹² By contrast, as we saw in the previous section, the response of prices to global

¹¹Considering an average over EMU nations rather than capturing the EMU entity using Germany, does not affect our results.

¹²We note that a sample of homogeneous goods that are more highly comparable across countries, as explained in the data appendix, gives very similar results to those reported in Table 3 with half-lives of nearly 17 months for

macro shocks is permanent. Additional results, not reported in Table 8, show a substantial amount of heterogeneity of the persistence parameters.¹³

The fact that global macro and micro shocks have more persistent effects on prices than local ones is consistent with agents paying less attention to more distant shocks, not because they are macro rather than micro but because they are global rather than local. This is new and goes beyond the micro-macro distinction in Boivin et al. (2009) or Maćkowiak et al. (2009). In fact, abstracting from the global-local distinction, we find that macro shocks are more persistent than micro ones with associated respective convergence rates of 22 months versus 13 months as shown in the last couple of rows of Table 8, consistent with previous work on the micro-macro gap. Our results suggest that the global versus local distinction is crucial in order to uncover the reaction of prices to different types of shocks. For instance, our estimates show that prices are not that flexible in response to global micro shocks. Moreover, such micro shocks are in fact associated with slower price adjustment than local macro shocks that account for the effects of monetary policy.

Furthermore, the result that local macro shocks have only slightly more persistent but comparable effect on prices as compared to local micro shocks, differs from the main finding in Bergin et al. (2010). In the latter paper, local macro shocks are much more persistent than local micro shocks for a subsample of the locations considered here, and that finding is used to explain the micro-macro gap that arises due to the fast adjustment of micro-LOP deviations responding mostly to micro shocks as compared to the persistence of PPP aggregates responding mostly to macro shocks.¹⁴

The reaction to the shocks differs depending on goods' characteristics and the country's development level. As we show in Table 8, both global as well as local micro shocks are more rapidly corrected for traded as compared to non-traded goods, whereas the reaction to local macro shocks is identical for both types of goods. Moreover, the reaction to global-micro shocks is slower in the less developed countries in our sample. By contrast, both macro and micro local shocks are more rapidly corrected in less developed countries as compared to more developed countries in our sample. The latter findings suggests that LOP/PPP studies focusing on rich economies might infer a higher degree of

global micro shocks, 11 months for local macro shocks, and 7 months for local micro ones.

¹³For instance, the standard deviation of persistence estimates across different goods is equal to .23, .12 and .28 for the global micro, local macro and local micro shocks, respectively.

¹⁴We have traced the main difference in results to their use of the US as the comparison point relative to which they construct the LOP deviations for each country in their sample. Choosing one particular location as a comparison point introduces the statistical properties characterizing that location into the deviations from the LOP for every other location. Instead, we compare prices to the average across locations.

persistence than is actually the case in the larger sample of countries considered here.¹⁵

Robustness of persistence estimates

We now consider a number of robustness checks and report results in Table 9. First, we consider the complete sample of countries as compared to the restricted sample that treated Euro area countries as a single entity, results for which were reported in Table 8. Persistence estimates of prices in response to the different types of shocks and their relative ranking remain quantitatively and qualitatively the same to those reported in Table 8. As we can see in column (1) of Table 9, the half-life associated with the response of prices to local macro and local micro shocks remains about 10 and 7 months respectively. The half-life associated with the response of prices to global micro shocks is now 20 months as compared to 19 months for the restricted sample in column (1) of Table 8.

Second, we consider the issue of converting prices to a common currency other than the US dollar. More specifically, in columns (2) and (3) of Table 9 we consider the conversion of local currency prices into British Pound and Yen prices respectively. As we can see in column (2) of Table 9 using the British Pound, the half-life of the price adjustment in response to global micro shocks is now up to about two years. The half-life of the price adjustment in response to local micro shocks is now up to 8 months, very close to the half-life of 9 months for local macro shocks. Results using the Japanese Yen reported in column (3) of Table 9 suggest a half-life of 26 months in response to global micro shocks, 9 months for local micro shocks, and 10 months for local macro shocks. Overall, the ranking in terms of the relative persistence of prices in response to global micro, local macro, and local micro shocks does not change. However, price adjustment in response to global micro shocks reported in columns (2) and (3) of Table 9 is even slower than what was obtained using US dollar prices. Moreover, local micro shocks are now associated with somewhat slower speed of adjustment than was the case using US dollar prices. In fact, the speed of price adjustment in response to either local macro or local micro shocks is now very similar and differs only by a month.

The EIU samples only one price per good per type of store in a given city and period, which could lead to measurement error if this single price is used as the basic unit of analysis. To alleviate this source of measurement error, we now average prices across types of stores for a given good, city, and time period, which is possible since prices are available for two types of stores for most goods

¹⁵The finding of faster convergence for LOP deviations among less developed countries is consistent with the opportunity cost of time and search costs that are lower in poorer countries as in Alessandria and Kaboski (2010).

as shown in Table (1). In column (4) of Table 9, we report persistence estimates that utilize this average price as the basic unit of analysis. As we can see, the half-lives associated with local macro and global micro shocks remain unchanged relative to those reported in column (1), at about 10 and 20 months respectively. The half-life in response to local micro shocks is now up to 8.4 months.

Finally, we consider city-level analysis for the complete sample of locations, exploiting the full spatial dimension of our dataset across 88 cities. If this gives results that are similar to the country-level analysis, it would suggest that the response of prices in individual cities is driven by nationwide shocks like monetary policy ones that dominate any city-level shocks. In column (5) of Table 9, we show that local macro shocks are now associated with a price response of 11 months as compared to 10 months for the country-level analysis in column (1) of the Table. The half-life of the price adjustment in response to local micro shocks remains at 7 months. On the other hand, global micro shocks are now associated with a half-life of 17 months as compared to about 20 months for the country-level analysis. Once again, the relative ranking of persistence estimates of prices in response to the different types of shocks remains the same.

4.3 Time variance of components

We now turn to the time-series variance associated with the different components in order to begin to understand the sources of price volatility in this sample of goods and locations for the period from 1990 to 2010 at the semiannual frequency. More specifically, let $V(x_{yzt}|yz)$ denote the time variance of x_{yz} , Table 10 reports a decomposition of the average time-variance of prices $E_{il}\{V(p_{ilt}|il)\}$, into its four components: the average time-variance of global, location specific, good specific, and good-location idiosyncratic components of prices. We estimate each of these four variances by, respectively, $V(\bar{p}_t)$, $E_l\{V(\bar{q}_{lt}|l)\}$, $E_i\{V(\bar{r}_{it}|i)\}$ and $E_{il}\{V(p_{ilt} - \bar{p}_t - \bar{q}_{lt} - \bar{r}_{it}|il)\}$.

As we can see in Table 10, global shocks account on average for half of the time-series fluctuations of prices. In particular, global micro shocks account for almost forty percent of these fluctuations. Moreover, as we can see in Table 10 local micro shocks are more volatile than local macro shocks consistent with Boivin et al. (2009).

Considering different types of goods, we find that non-traded goods are associated with more volatile global micro shocks than traded goods. Moreover, less developed countries in our sample have more volatile local shocks. This is especially the case for local macro shocks exhibiting five times as much volatility in less developed countries than in more developed ones, perhaps due to the

relative stability of monetary policy in the latter group of countries. Less developed countries also exhibit twice as much volatility than more developed ones, in response to local micro shocks. This is perhaps due to the relative instability and higher degree of uncertainty facing particular markets in these countries, with shortages and sudden shifts in demand and supply a more common phenomenon in less developed economies where markets do not typically operate as smoothly.

5 Cross-section determinants of price persistence

Are global components of prices more persistent than local ones because global shocks are intrinsically more persistent than local ones, or because prices adjust at different speeds in response to changes in global and local conditions? Moreover, do more volatile economic conditions lead to less rapid price adjustment and therefore to distortions in relative prices that last longer?

To answer the first question, we investigate how the persistence of each price component is linked to its own volatility. As we explain below, if the persistence of shocks was the main driver of the observed persistence in price components, then we would expect to see a positive relation between own persistence and volatility for each price component. On the other hand, the absence of a positive estimated link would be evidence that price components have different adjustment rates because prices react differently to the shocks and not merely due to differences in the persistence of the shocks themselves. To answer the second question, we investigate how the persistence of each price component is linked to the volatility of other components. If volatility of, for instance, local conditions was detrimental to the adjustment to global conditions, then one would expect the persistence of the price response to global shocks to increase with the volatility of local shocks.

More precisely, letting $\rho_{il}(m_i)$, $\rho_{il}(m_l)$ and $\rho_{il}(m_{il})$ denote the (estimated) persistence parameters associated with, respectively, the good-specific, location-specific and idiosyncratic good-location specific components for each good and location pair in our sample¹⁶, and letting $\sigma(m_{it}|i)$, $\sigma(m_{lt}|l)$ and $\sigma(m_{ilt}|il)$ denote the (estimated) standard deviation over time of the good-specific (global micro), location-specific (local macro) and idiosyncratic good-location specific (local micro) components respectively, we estimate cross-sectional regressions of the following kind

$$\log \rho_{il}(m_*) = \mu + \theta_1 \log \sigma(m_{it}|i) + \theta_2 \log \sigma(m_{lt}|l) + \theta_3 \log \sigma(m_{ilt}|il) + \xi X_i + \zeta Z_l + u_{il} \quad (5)$$

¹⁶We recall that these persistence parameters are given by the sum of the coefficients characterizing the dynamics of each component, i.e. $\rho_{il}(1; m_*)$ with $*$ being either i , l or il , using the notation introduced in equation (1).

where $*$ is either i , l or il , X_i is a set of good-specific controls, and Z_l a set of location-specific controls. Results are provided in the three different panels of Table 11. In the first panel, we explain the persistence associated with local macro shocks, in the second panel we explain the persistence associated with global micro shocks, and in the last panel we consider persistence associated with local micro shocks.

Standard time series properties tell us that the volatility of a component in prices, $\sigma(m_{*t}|*)$, is positively related to the persistence of the shocks underlying this component and to the volatility of the innovations driving these shocks, $\sigma(\epsilon_{*t}|*)$. Thus, if the persistence of a price component, $\rho_{il}(m_*)$, was merely linked to the persistence of the shock driving that component, the estimated relationship between the persistence and volatility of each price component would be positive. Conversely, there is no *a priori* reason why the volatility of the innovations, $\sigma(\epsilon_{*t}|*)$, driving each price component should be negatively related to the persistence of the shock.

Column (1) of Table 11 reports estimates of the bivariate relationship between price persistence in response to a shock and volatility associated with that same type of shock. The link is clearly negative for the local macro and micro components and insignificant for the global micro one. These findings underline the negative effect of the volatility of innovations on price persistence. This conclusion holds even for the global micro component. The finding of a zero coefficient in the latter case implies that the natural positive link between persistence of the global-micro shocks and price persistence, is wiped off by a negative impact of the volatility of global-micro innovations on price persistence. All in all, prices adjust more rapidly to components that have more volatile innovations.

In column (2) of Table 11, we explain persistence associated with each type of shock with volatility associated with other types of shocks in addition to own volatility. Looking at the first panel of the table for the case of local macro shocks, we see that the negative estimated link between price persistence and own volatility is preserved when one controls for the volatility of other components in prices: more volatile macro shocks increase the speed of price adjustment in response to these local macro shocks. At the same time, higher volatility in the global micro or local micro components decreases the speed of adjustment of prices in response to local macro shocks, as witnessed by the positive estimated coefficients in the first and third row of the Table. Consistent with the imperfect information approach of price setting, more volatility in micro conditions leads to fuzzier perception and thus slower adjustment of prices to changes in macro conditions. Turning to the second panel

of the table for the case of global micro shocks, an increase in own volatility is still found to have a negative but insignificant impact on the price persistence associated with the response to global micro shocks. Moreover, higher volatility in the local macro or the local micro components increases the price persistence associated with the response to global micro shocks. That is, more volatility of local conditions is associated with slower adjustment of prices to global conditions, again consistent with imperfect information models of price setting. All in all, more volatile micro conditions lead to more persistent relative price distortions due to slower response of prices to macro shocks, and more volatile local conditions lead to more persistent relative price distortions due to slower response of prices to global shocks.

It is remarkable that the effect of a marginal increase in the volatility of the local (macro or micro) components on the persistence of the global micro component shown in the second panel of Table 11 is at least twice as large as the effect of a marginal increase in the volatility of the micro (global or local) components on the persistence of the local macro component shown in the first panel of Table 11. Increasing local volatility is quantitatively more detrimental to the speed of adjustment of prices to global shocks, than increasing micro volatility is to the speed of adjustment of prices to macro shocks.

Results are somewhat different in the case of idiosyncratic shocks estimates for which are reported in the last panel of Table 11. As we can see in column (2) of Table 11, own volatility has no significant impact on own persistence in this case. As previously explained, the finding of a non-significant link implies that the speed of reaction to idiosyncratic components increases with the volatility of their innovations, so that the conclusions from column (1) are not overturned. Moreover, volatility associated with global shocks does not impact on the speed of adjustment of idiosyncratic shocks. Finally, more volatility in the local macro component leads to faster adjustment of prices in response to idiosyncratic shocks. All in all, volatility has either no detrimental effect on the reaction of prices to local micro shocks, or even speeds this up in the case of local macro volatility.

In column (3) of Table 11, we consider additional explanatory variables that control for certain country and goods characteristics, such as real GDP per capita and the share of world population for each country to capture income and scale effects respectively, as well as the average price of each good across locations to capture one aspect of good-specific tradeability. The results of column (2) are not qualitatively affected by these controls.

Our results suggest that distinguishing between global and local components is important in char-

acterizing the link between persistence and volatility, and, more broadly speaking, useful in discriminating between different models of price setting. According to these results, price setting models should be able to rationalize differences between the price response to global versus local shocks that are more pronounced than between macro and micro shocks. Explaining these differences in the rate of price adjustment to different types of shocks, could be achieved by resorting to models of endogenous imperfect perception of shocks, in the spirit of the recent contributions of Reis (2006), Maćkowiak and Wiederholt (2009), Woodford (2009) or Alvarez, Lippi and Paciello (2010), where the relative cost of observing global conditions would be greater than the one associated with monitoring local ones, in the same manner (but more strikingly so) in which the relative cost of observing macro conditions is normally assumed to be greater than the one associated with monitoring micro ones. Another possibility would be to rely on labor market segmentation arguments, in the spirit of Carvalho and Lee (2010), with segmentation being greater between countries than within them in the same manner (but more strikingly so) that labor segmentation is greater across sectors than within sectors.

Furthermore, models of price setting have to explain the positive link between local volatility and the slowness of price adjustment to global shocks on the one hand, and between micro volatility and slowness of price adjustment to macro shocks on the other hand.¹⁷ A possibility is to rely on the rational inattention approach of Maćkowiak and Wiederholt (2009). When information capacity is fixed, an increase in the volatility of local (micro) components requires more attention devoted to the monitoring of local (micro) shocks which therefore hinders the monitoring of global (macro) ones. Thus, prices react more slowly to global (macro) shocks.¹⁸ If one resorts to this approach, then one would also have to explain why the loss of processing capacities due to volatility in local

¹⁷Maćkowiak et al. (2009) discuss how the empirical link they find between the volatility of micro and macro components in price dynamics and the persistence of the price reaction to macro shocks is evidence against simple Calvo models and the sticky information model of Mankiw and Reis (2002).

¹⁸This approach could also explain the additional interesting findings from Table 11 that pertain to the role of idiosyncratic local micro volatility and non-idiosyncratic price persistence. First, agents appear to allocate sufficient attention to idiosyncratic conditions, so that they have a good perception of it, no matter their volatility and the volatility of other components. However, an increase in the volatility of the idiosyncratic shock requires more attention capacity and therefore decreases the attention that can be allocated to the monitoring of non-idiosyncratic conditions. This explains why the persistence of both the global micro and local macro price components increases with the volatility of the idiosyncratic component. Second, for a given level of attention capacity allocated to monitoring non-idiosyncratic conditions, agents have to strike a balance between surveying global micro and local macro conditions. An increase in the volatility of local macro conditions raises the attention allocated to them but reduces the attention paid to global micro conditions. This would explain why an increase in the volatility of the local macro shock decreases the persistence of its own component in prices but raises the persistence of the global micro component. Likewise, an increase in the volatility of global micro conditions reduces the attention devoted to local macro conditions.

conditions is more detrimental to the monitoring of global conditions than the loss of processing capacities due to volatility in micro conditions is to the monitoring of macro conditions.

Finally, we note that sorting out local micro shocks from either global micro or local macro ones, reveals potential subtleties in the interaction between the volatility of shocks and the speed of adjustment of prices to shocks. In particular, the evidence that an increase in the volatility of local macro shocks decreases the persistence of the reaction to local micro shocks, while an increase in the variance of global micro shocks has no effect on the persistence of the reaction to local micro shocks, could signal that strategic complementarities in price-setting decisions are much more at stake across sectors within a country than for a given sector across countries.¹⁹ This could be rationalized by resorting to the fact that market segmentation is more significant between countries than between sectors.

6 Conclusions

We have used a unique global microeconomic dataset of semiannual prices observed over two decades ending in March 2010, to consider how fast prices and relative prices respond to different types of shocks. Previous work has emphasized the difference between the reaction of prices to macro and micro shocks. We have shown that macro shocks are not all alike and that different types of micro shocks do not necessarily resemble each other either. More precisely, we have emphasized the distinction between global and local shocks, and found that for both macro and micro shocks alike, global components are associated with a much slower speed of price adjustment than local ones. The difference in the speed of reaction of prices to different shocks is much more striking when decomposing between global and local shocks rather than merely considering macro versus micro shocks. Moreover, we have shown that the price response to some types of micro shocks is slower than for some types of macro shocks. More specifically, global micro shocks are associated with a slower speed of price adjustment than local macro shocks.

We also considered the relation between persistence of price adjustment and volatility for each type of shock. Our estimates imply that price adjustment to different types of changing conditions does not stem from the mere persistence of the shock driving the evolution of these conditions.

¹⁹The evidence that more variance in macro shocks increases the speed with which prices adjust is also reminiscent of the micro price studies showing that the frequency of price adjustment increases with the level of inflation, a result that is consistent with menu costs models of price setting. See e.g. Gagnon (2009) for Mexico and Alvarez et al. (2010) for Argentina.

Moreover, we found that more volatility in micro conditions is associated with slower adjustment of prices to macro shocks, and that more volatility in local conditions is associated with slower price adjustment to global shocks. In the latter case, the persistence-volatility link is at least twice as large as that in the micro-macro case.

Our methodology and resulting findings can be used to assess different models of price setting. Overall, our results are supportive of theoretical price-setting models that can explain differences in the speed of adjustment of prices in response to global versus local shocks, and differences in the link between persistence and volatility for global versus local components. Rational inattention models would be one potential candidate in that respect. The global-local distinction of macro and micro shocks also provides a new more precise tool for distinguishing among price setting models, as compared to a mere macro-micro breakdown. Models of price setting should be able to explain the exact ranking of the four different types of shocks in terms of how fast prices respond to these shocks, with local micro shocks associated with faster adjustment than local macro ones which are in turn associated with faster adjustment than global micro shocks that nevertheless have lower persistence than global macro ones.

Our work provides new facts that point towards the need of developing price-setting models with a spatial dimension. In particular, calibration exercises aiming at assessing the effectiveness of stabilization policies and the welfare cost of inflation should incorporate global shocks in their analysis. In such a context, geography could matter due to relative loss of information processing capacity or because of a higher degree of labor segmentation across as compared to within locations. By considering only a single type of micro or macro shock, the previous literature hides important heterogeneity in their effects and this would then possibly give rise to misleading inferences about the relative persistence of local macro shocks, typically monetary shocks, in micro prices.

A Data

The discussion below has benefitted greatly from systematic direct communication with the EIU office over the past few years, and in particular, from the insights and detailed explanations offered to us by Jon Copestake, Editor of the Worldwide Cost of Living Surveys.

Selection of stores and goods

Considerable care is taken by the EIU team to assess accurately the normal or average prices international executives and their families can expect to encounter in the cities surveyed. Survey prices are gathered from three types of stores: supermarkets, medium-priced retailers and more expensive specialty shops. Only outlets where items of internationally comparable quality are available for normal sale are visited. While the majority of cities provide a wide selection of goods and stores at different price levels, this range narrows considerably at several locations. In some cities the entire range of prices has to be collected at the few stores where goods of internationally comparable quality are found. Local markets and bazaars are visited only if the goods available are of standard quality and if shopping in these areas does not present any danger.

For certain items like monthly rent and clothing, there are many subjective factors, questions of personal preferences and taste at play, as well as a wide variety of choice. Therefore, price data given for certain items should be considered to be merely an indication of the general level of prices in these categories. In general, the degree of comparability across locations is high but varies with the general availability of goods in a given city. Given that the survey takes place in 140 cities worldwide, it is not always the case that an identical product is taken in all cities for all items. For example, it is more likely that while London has a quality Burberry raincoat available, Brussels does not have the same item or brand and the correspondent has taken a price based on the designer raincoats that are available. For such products, prices will reflect the general availability and local demand conditions in a location. Given these concerns, one would want to consider subsamples that exclude products likely to be less homogeneous across locations. The latter category includes pretty much all clothing items, automobiles, and a number of other products. As a result, we felt the need to create a sub-sample of goods that are more likely to be comparable across locations. This restricted sample of homogeneous goods excludes more than one third of our complete sample of goods and services, such as “Women’s raincoat Burberry type”, “personal computer”, “family car”, and “Furnished residential apartment: 1 bedroom, moderate”. However, convergence rates obtained (not reported in the Tables) based on this more highly comparable sub-sample of goods are very similar to what we obtain when using the full sample of goods and services.

The price range presented in the survey utilized in the current study is for supermarkets or chains, and for mid-priced outlets. The EIU takes one representative price per store, sampling only one price from each of two type of stores, and generally surveys two stores per item for most products.

As shown in Table 1, we use 100 distinct products that are reported at both a supermarket (or chain) and a mid-priced store and an additional 76 distinct products and services that are only sampled once, for a total of 276 price observations in each location and year.

In all cases, the EIU aims to keep the same stores and the same brands and sizes in obtaining the price for each item, so as to ensure ongoing consistency between surveys in each location. Store and product consistency has been an aim of the survey since its inception. The aim of sampling the same stores has remained consistent and the ability to do so has varied based on specific events in certain years relating to availability or specific situations affecting correspondents, like being refused entry to a store under new management. However, such consistency depends on and varies within individual markets. The surveyors seek to keep to the same stores, brands and weights between surveys. However, given that the survey takes place simultaneously in 140 cities over a period of twenty years, there may be substitutions or changes. This can occur in an evolutionary sense as certain brands or stores or sizes overtake others as the popular interpretation of a particular item changes over time. Alternatively, there may be sudden changes in brand, store or item based on availability in the market during a particular period. For example, a store may close and a certain brand may become temporarily or permanently unavailable. In these cases, substitutes are sought to reflect the price of obtaining the item in question at that particular time. This is more common in less developed markets where availability and price can fluctuate on a day to day basis, but even mature markets are prone to pricing or availability shocks and other changes of this kind especially over longer periods. We note that while the BLS adapts its basket of goods regularly and also changes the weighting system based on consumption trends, the EIU seeks to be more generally representative and has for the most part not changed in this manner, in an attempt to ensure a consistent dataset of like for like products going back over time.

The general conclusion from the discussion in this sub-section is that the EIU city-level prices are highly comparable across both space and time, and are thus suitable for the study of LOP deviations and their evolution over time. That is, one can use these prices to understand both the degree of market segmentation at any given point in time, and the process of market integration over time. The data appear less suitable for overall cost of living comparisons across locations since the goods sampled do not necessarily reflect local preferences as much as the shopping basket of executives and other multinational employees and their families.

Nominal exchange rate issues

Spot exchange rates are applied to the city data surveyed by the EIU, and are available along with the price data for each year. The post rates are FT rates taken on the Friday of the first week of each month of the survey. For the standard Cityprices data typically made available by the EIU, data overwrites old data each year, thus most of the exchange rate data supplied historically is September data except in a few instances where a city is only surveyed every March in which case

prices and exchange rates are from the first week of March. The exchange rate reported is the spot rate for the survey date when the data was gathered.

For pre-1999 price series, the conversion from legacy currencies to euros is made using the appropriate legacy currency, i.e. Ecu exchange rates prevailing at the time. Like Eurostat, the EIU has chosen to use the Ecu exchange rates because there is no universally agreed methodology for calculating a synthetic euro exchange rate. One Ecu was worth exactly one euro when the euro was launched at the beginning of 1999. The EIU used the September end-period rate from Eurostat to convert the legacy prices. Although surveys were completed for Euro cities at slightly different times in September, the EIU wanted to apply a standard rate to maintain relative prices between cities and also maintain distances between published Cost of Living indices.

Sampling, seasonality, and sales

The fieldwork for the Worldwide Cost of Living Surveys is carried out on location by the EIU researchers during the first week of March for the Spring edition and during the first week of September for the Autumn edition. These data was especially compiled for us, since the standard historical data in the “cityprices” EIU publication is only available at the annual frequency. Since the data overwrites old data each year, the standard data typically made available historically by the EIU is September data. There are two types of exception to this. First, are cities surveyed annually and only in March. These are: Baku, Bratislava, Calgary, Douala, Harare, Port Moresby, San Juan, and Tunis. For these cities, data is gathered since 2001 during the first week of March. Second, are cities where there are problems or delays in gathering data. These are individual cases and are not tracked, but it would generally be the case that such data is still gathered within a month or two, so that prices can still be relevant and comparable to other cities. Moreover, no such lags are allowed in high inflation locations.

The March and September dates for gathering data are specifically designed to avoid standard sales seasons, like traditional sales in December, January, May and June which take place in many countries. Correspondents are instructed not to take sale prices for items, but to take standard recommended retail prices. There is an element of common sense here as well though. That is, correspondents may take sales prices for general promotions if they feel the price reflects the “true worth” of an item. This might be the case for some items since retailers commonly use tactics of promoting an item by describing it as on “sale” when in fact they have previously artificially inflated the retail price of the item in order to later reduce it to a more reasonable price and make consumers think they are purchasing a bargain. This is true of items like CDs, wine, certain fresh food items, and other consumer goods. A few adjustments of the survey prices have been made in some cases where seasonal discount sales and changes in brand names, package sizes, and quality would have unduly distorted the index results. This procedure is limited to cases where it would not entail misrepresentation of actual prices in the EIU team’s judgement.

The conclusion from the above paragraph is that the astonishing price differences for specific items across cities observed by the EIU team, are not due to sales or discounting, as the EIU does not seek to include such seasonal data in the price survey.

Reliability of data

Given the above discussion, we have opted to be extremely conservative in removing entries that at first might appear to be price outliers. Moreover, we never opt to adjust prices for what might at first appear to be “obvious” mistakes, like misplacing a digit or otherwise using a wrong unit, or misplacing part of a price entry in previous or subsequent entries. In this respect, our treatment of the data is very different than Crucini and Shintani (2008).

We opted to treat the data as a rather reliable representation of actual prices since in our discussions with the EIU office it was convincingly explained to us that specifying for instance the price variance between surveys not to be less than half or more than twice the CPI rate would be an extremely narrow margin for highlighting outliers, as the EIU team has historically observed prices that regularly change by as much as four times or more the CPI rate, while other prices remain unchanged year after year or even move down. It was also explained to us, that every survey price is “sense checked” as it comes in compared to those returned six months ago and those returned one year ago. Sense checking is simply to ensure that prices look broadly comparable to those returned previously. However, the final prices reported in the EIU surveys are based on actual ones as returned from field correspondents in each city, and are never a calculation based on a ratio of expected price movement to reported inflation levels. As a result, prices of individual items in the basket the EIU surveys can fluctuate wildly based on the basket snapshot that is taken.

For instance, a seemingly wrong but actually correct price entry comes from Casablanca in the case of bread. The figures for years 1992 to 1995 seem to be missing the initial digit “1”. This example of bread in Casablanca between 1992 and 1996 is a prime example of how EIU prices should be considered valid even if they look peculiar relative to general price trends. Between 1992 and 1995, Morocco suffered from a period of drought which caused three harvests to fail (1992, 1993, and 1995). This had an impact on economic growth and prompted a recession. In response, the government will have extended price controls on staples. In the Moroccan diet, bread is considered to be the staple food of the poor and would have been the first and most heavily price-regulated item. Upon recovery and under external pressure the government pledged to relax such controls in 1996. In the case of the survey, we can clearly see this reflected. Lower priced bread in line with the 1992-1995 prices may have been widely available before and after this period, but during this period shortages, economic stagnation, suppressed demand for more expensive consumer goods, and price controls may have meant that these were the only prices available for bread. This situation was rectified as Morocco emerged from this period. Similarly, many prices could be flagged in developing countries during times of instability as these experience massive fluctuations in prices dependent

on localized supply and demand factors. Thus, the EIU suggests that users consider reasons why a particular price may deviate from expectation based on the political, social and economic market context, globally, nationally or at city level before removing a price entry.

Errors that emerge may be a currency issue where back-rates are recalculated to cater to currency redenominations caused by inflationary spikes, or where devalued/alternative exchange rates are in operation. It is possible that some prices might be entered in a sub-unit of currency (e.g. in pence or cents) then reported in standard units (e.g. in pounds, euros or dollars). However, this is something the EIU generally seeks to rectify on a rolling basis. Still, the EIU cannot double-check many of the prices since the citydata feed automatically takes from the source files. These are taken from surveys based on manually collected data by correspondents in each location. The price dataset is built as the accumulation of decades of data submitted from a variety of sources in a variety of formats. Any data collected before 1998, for example, would have been returned in paper format and manually input into the base files eventually used, and the original paper versions have long since been disposed of. Thus, the EIU may only be able to check sources for items after 1998 but such a process would be time-consuming and unnecessary according to the EIU office, since most of the price entries that appear at first to be errors are actually valid price entries.

Where a user has serious concerns, the EIU recommends removing a price rather than guessing at its original value. For instance, if we suspect that certain prices were simply misinput in error then this price would need to be removed from consideration as an outlier rather than tweaked into something resembling what it “should be”. While it is completely valid that a tiny proportion of the reported prices may include errors, the vast majority of prices are arguably valid snapshots at the time of the survey and most prices that vary disproportionately with the CPI can be explained simply by looking at the context in which the prices were taken. Finally, even if all prices that move very differently than the CPI were assumed to be errors, these would represent a proportion below 0.5% of the available data points.

References

- [1] Alessandria, George and Jo Kaboski (forthcoming) “Pricing to Market and the Failure of Absolute PPP.” forth. *American Economic Journal: Macroeconomics*.
- [2] Altissimo, Filippo and Mojon, Benoît and Zaffaroni, Paolo (2009) “Can Aggregation Explain the Persistence of Inflation?” *Journal of Monetary Economics* 56(2):231-241.
- [3] Alvarez, Fernando, Francesco Lippi, and Luigi Paciello (2011) “Optimal Price Setting with Observation and Menu Costs” forth. *Quarterly Journal of Economics*.
- [4] Alvarez, Fernando, Martin Gonzalez-Rozada, Andy Neumeyer, and Martin Beraja (2011) “From Hyper-Inflation to Stable Prices: Argentina’s Evidence on Menu Cost Models” Unpublished manuscript, University of Chicago and UTDT.
- [5] Beck, Guenter W. , Kristin Hubrich, and Massimiliano Marcellino (2010) “On the Importance of Sectoral Shocks for Price-setting” unpublished manuscript ECB and EUI.
- [6] Bergin, R. Paul and Reuven Glick (2007) “Global price dispersion: Are Prices Converging or Diverging?” *Journal of International Money and Finance* 26(5):703-729.
- [7] Bergin, R. Paul, Reuven Glick and Jyh-Lin Wu (2010) “The Micro-Macro Disconnect of Purchasing Power Parity” unpublished manuscript FRB San Francisco and UC-Davies.
- [8] Bills, Mark, and Peter J. Klenow (2004) “Some Evidence on the Importance of Sticky Prices.” *Journal of Political Economy*, 112(5):947-85.
- [9] Boivin, Jean, Giannoni, Marc P. and Mihov, Ilian (2009) “Sticky Prices and Monetary Policy: Evidence from Disaggregated Data” *The American Economic Review*, 99(1):350-384.
- [10] Broda Christian and David E. Weinstein (2008) “Understanding International Price Differences Using Barcode Data,” NBER Working Paper 14017.
- [11] Burstein, Ariel and Nir Jaimovich (2009) “Understanding Movements in Aggregate and Product-Level Real Exchange Rates,” unpublished manuscript Stanford and UCLA.
- [12] Carvalho, Carlos (2006) “Heterogeneity in Price Stickiness and the Real Effects of Monetary Shocks,” *The B.E. Journal of Macroeconomics (Frontiers)* 2(1).
- [13] Carvalho, Carlos and Fernanda Nechio (2008) “Aggregation and the PPP Puzzle in a Sticky Price Model” forth. *The American Economic Review*.
- [14] Carvalho, Carlos and Jae Won Lee (2010) “Sectoral Price Facts in a Sticky-Price Model” unpublished manuscript FRB New York and Rutgers.
- [15] Calvo, Guillermo (1983) “Staggered Prices and in a Utility-Maximizing Framework” *Journal of Monetary Economics* 12(3):383-98.
- [16] Ciccarelli, Matteo and Benoît Mojon (2010) “Global inflation” forth. *Review of Economics and Statistics* 92(3):524-535.
- [17] Clark, Todd E. (2006) “Disaggregate Evidence of the Persistence of Consumer Price Inflation,” *Journal of Applied Econometrics* 21(5):563-87.
- [18] Crucini, Mario, Chris Telmer, and Marios Zachariadis, (2005) “Price Dispersion: The Role of Borders, Distance, and Location,” unpublished manuscript.

- [19] Crucini, M.J. and Shintani, M. (2008). "Persistence in the Law of One Price deviations: Evidence from micro-data." *Journal of Monetary Economics* 55:629-644.
- [20] Crucini, Mario J. and Hakan Yilmazkuday (2009) "A Model of International Cities: Implications for Real Exchange Rates" NBER Working Paper No. 14834.
- [21] Engel C. and J. Rogers (2004) "European Product Market Integration After the Euro" *Economic Policy* 39:347-384.
- [22] Gertler, Mark and John Leahy (2008) "A Phillips Curve with an Ss Foundation" *Journal of Political Economy* 116(3):533-72.
- [23] Goldberg, P.K. and M. Knetter (1997) "Goods Prices and Exchange Rates: What Have We Learned?" *Journal of Economic Literature*, 35:1243-1272.
- [24] Gagnon, E. (2010) "Price Setting During Low and High Inflation: Evidence from Mexico" *Quarterly Journal of Economics* 124:1221-63.
- [25] Goldberg, P.K. and Verboven, F. (2005) "Market Integration and Convergence to the Law of One Price: Evidence from the European car market." *Journal of International Economics* 65:49-73.
- [26] Golosov, Mikhail and Robert E. Lucas Jr. (2007) "Menu Costs and Phillips Curves" *Journal of Political Economy* 115(2):171-99.
- [27] Hellwig, Christian and Laura Veldkamp (2009) "Knowing What Others Know: Coordination Motives in Information Acquisition" *Review of Economic Studies* 76:223-251.
- [28] Imbs, J., Mumtaz, A., Ravn, M.O. and Rey, H. (2005) "PPP Strikes Back: Aggregation and the Real Exchange Rate." *Quarterly Journal of Economics* 120:1-43.
- [29] Lucas, Robert E. Jr (1972) "Expectations and the Neutrality of Money" *Journal of Economic Theory* 4 (2):103-124.
- [30] Maćkowiak, Bartosz, Emanuel Moench, and Mirko Wiederholt (2009) "Sectoral Price Data and Models of Price Setting," *Journal of Monetary Economics*, 56(S):78-99.
- [31] Maćkowiak, Bartosz and Mirko Wiederholt (2009) "Optimal Sticky Prices under Rational Inattention" *The American Economic Review*, 99(3):769-803.
- [32] Monacelli, Tommaso and Luca Sala (2009) "The International Dimension of Inflation: Evidence from Disaggregated Consumer Price Data" *Journal of Money Credit and Banking* 41(1):101-120.
- [33] Obstfeld, Maurice and Kenneth Rogoff (2000) "The Six Major Puzzles in International Macroeconomics: Is there a common cause?" NBER Working Paper No. 7777.
- [34] Pesaran, M. Hashem (2006) "Estimation and Inference in Large Heterogeneous Panels with a Multifactor Error Structure," *Econometrica* 74:967-1012.
- [35] Pesaran, M. Hashem (2007) "A Simple Panel Unit Root Test in the Presence of Cross-Section Dependence," *Journal of Applied Econometrics* 22:265-312.
- [36] Reis, Ricardo (2006) "Inattentive Producers," *Review of Economic Studies* 73(3):793-821.

- [37] Reis, Ricardo and Mark W. Watson, (2010) “Relative Goods’ Prices, Pure Inflation, and the Phillips Correlation,” *American Economic Journal: Macroeconomics*, 2(3):128-57.
- [38] Rogoff, Kenneth (1996) “The Purchasing Power Parity Puzzle” *Journal of Economic Literature*, 34:647-668.
- [39] Sheshinsky Eytam, and Yoram Weiss (1977) “Inflation and Cost of Price Adjustment,” *Review of Economic Studies* 44(2):287-303.
- [40] Woodford, Michael (2009) “Information-Constrained State-Dependent Pricing” *Journal of Monetary Economics*, 56(S):100-124.

Table 1: Description of sample: list and classification of goods and locations

List of Countries		
Less Developed Countries	More Developed Countries	
Bangladesh	Argentina	Singapore
Brazil	Australia	Spain
China	Austria	Sweden
Colombia	Bahrain	Switzerland
Ecuador	Belgium	Taiwan
Egypt	Canada	UK
Guatemala	Czech Republic	US
India	Chile	
Indonesia	Denmark	
Iran	Finland	
Kenya	France	
Mexico	Germany	
Nigeria	Greece	
Pakistan	Hong Kong	
Panama	Hungary	
Paraguay	Israel	
Peru	Italy	
Philippines	Japan	
Poland	Korea	
Russia	Luxembourg	
Serbia	Malaysia	
South Africa	Netherlands	
Thailand	New Zealand	
Turkey	Norway	
Uruguay	Portugal	
Venezuela	Saudi Arabia	

Notes: Less developed countries have PPP-adjusted income per capita below the world mean (\$12000) for 1990–2007.

Table 2: Description of sample: list and classification of goods and locations

List of Cities

In Less Developed Countries	In More Developed Countries		
ASUNCION	ADELAIDE	LOS ANGELES	TOKYO
BANGKOK	AL KHOBAR	LUXEMBOURG	TORONTO
BELJING	AMSTERDAM	LYON	VANCOUVER
BELGRADE	ATHENS	MADRID	VIENNA
BOGOTA	ATLANTA	MELBOURNE	WASHINGTON DC
CAIRO	AUCKLAND	MIAMI	WELLINGTON
CARACAS	BAHRAIN	MILAN	ZURICH
DHAKA	BARCELONA	MONTREAL	
GUATEMALA CITY	BERLIN	MUNICH	
ISTANBUL	BOSTON	NEW YORK	
JAKARTA	BRISBANE	OSAKA / KOBE	
JOHANNESBURG	BRUSSELS	OSLO	
KARACHI	BUDAPEST	PARIS	
LAGOS	BUENOS AIRES	PERTH	
LIMA	CHICAGO	PITTSBURGH	
MANILA	CLEVELAND	PRAGUE	
MEXICO CITY	COPENHAGEN	RIYADH	
MONTEVIDEO	FRANKFURT	ROME	
MOSCOW	GENEVA	SAN FRANCISCO	
NAIROBI	HAMBURG	SANTIAGO	
NEW DELHI	HELSINKI	SEATTLE	
PANAMA CITY	HONG KONG	SEOUL	
QUITO	HOUSTON	SINGAPORE	
RIO DE JANEIRO	JEDDAH	STOCKHOLM	
SAO PAULO	KUALA LUMPUR	SYDNEY	
TEHRAN	LISBON	TAIPEI	
WARSAW	LONDON	TEL AVIV	

Notes: Less developed countries have PPP-adjusted income per capita below the world mean (\$12000) for 1990–2007.

Table 3: Description of sample: list and classification of goods and locations

List of goods: Non traded	
Annual premium for car insurance (high)	Moderate hotel, single room, one night including breakfast (average)
Annual premium for car insurance (low)	One drink at bar of first class hotel (average)
Babysitter's rate per hour (average)	One good seat at cinema (average)
Cost of a tune up (but no major repairs) (high)	Simple meal for one person (average)
Cost of a tune up (but no major repairs) (low)	Taxi rate per additional kilometre (average)
Cost of developing 36 colour pictures (average)	Taxi: airport to city centre (average)
Dry cleaning, man's suit (mid-priced outlet)	Taxi: initial meter charge (average)
Dry cleaning, man's suit (standard high-street outlet)	Three-course dinner at top restaurant for four people (average)
Dry cleaning, trousers (mid-priced outlet)	Two-course meal for two people (average)
Dry cleaning, trousers (standard high-street outlet)	Unfurnished residential apartment: 2 bedrooms (high)
Dry cleaning, woman's dress (mid-priced outlet)	Unfurnished residential apartment: 2 bedrooms (moderate)
Dry cleaning, woman's dress (standard high-street outlet)	Unfurnished residential apartment: 3 bedrooms (high)
Fast food snack: hamburger, fries and drink (average)	Unfurnished residential apartment: 3 bedrooms (moderate)
Four best seats at cinema (average)	Unfurnished residential apartment: 4 bedrooms (high)
Four best seats at theatre or concert (average)	Unfurnished residential apartment: 4 bedrooms (moderate)
Furnished residential apartment: 1 bedroom (high)	Unfurnished residential house: 3 bedrooms (high)
Furnished residential apartment: 1 bedroom (moderate)	Unfurnished residential house: 3 bedrooms (moderate)
Furnished residential apartment: 2 bedrooms (high)	Unfurnished residential house: 4 bedrooms (high)
Furnished residential apartment: 2 bedrooms (moderate)	Unfurnished residential house: 4 bedrooms (moderate)
Furnished residential house: 3 bedrooms (high)	Woman's cut & blow dry (tips included) (average)
Furnished residential house: 3 bedrooms (moderate)	Yearly road tax or registration fee (high)
Hilton-type hotel, single room, one night including breakfast (average)	Yearly road tax or registration fee (low)
Hire car, weekly rate for lowest price classification (average)	
Hire car, weekly rate for moderate price classification (average)	
Hourly rate for domestic cleaning help (average)	
Laundry (one shirt) (mid-priced outlet)	
Laundry (one shirt) (standard high-street outlet)	
Maid's monthly wages (full time) (average)	
Man's haircut (tips included) (average)	

Table 4: Description of sample: list and classification of goods and locations

List of goods: Traded

Available at both a supermarket and a mid-priced store		
Apples (1 kg)	Flour, white (1 kg)	Peas, canned (250 g)
Aspirins (100 tablets)	Fresh fish (1 kg)	Pork: chops (1 kg)
Bacon (1 kg)	Frozen fish fingers (1 kg)	Pork: loin (1 kg)
Bananas (1 kg)	Frying pan (Teflon or good equivalent)	Potatoes (2 kg)
Batteries (two, size D/LR20)	Gin, Gilbey's or equivalent (700 ml)	Razor blades (five pieces)
Beef: filet mignon (1 kg)	Ground coffee (500 g)	Scotch whisky, six years old (700 ml)
Beef: ground or minced (1 kg)	Ham: whole (1 kg)	Shampoo & conditioner in one (400 ml)
Beef: roast (1 kg)	Hand lotion (125 ml)	Sliced pineapples, canned (500 g)
Beef: steak, entrecote (1 kg)	Insect-killer spray (330 g)	Soap (100 g)
Beef: stewing, shoulder (1 kg)	Instant coffee (125 g)	Spaghetti (1 kg)
Beer, local brand (1 l)	Lamb: chops (1 kg)	Sugar, white (1 kg)
Beer, top quality (330 ml)	Lamb: leg (1 kg)	Tea bags (25 bags)
Butter (500 g)	Lamb: Stewing (1 kg)	Toilet tissue (two rolls)
Carrots (1 kg)	Laundry detergent (3 l)	Tomatoes (1 kg)
Cheese, imported (500 g)	Lemons (1 kg)	Tomatoes, canned (250 g)
Chicken: fresh (1 kg)	Lettuce (one)	Tonic water (200 ml)
Chicken: frozen (1 kg)	Light bulbs (two, 60 watts)	Toothpaste with fluoride (120 g)
Cigarettes, local brand (pack of 20)	Liqueur, Cointreau (700 ml)	Veal: chops (1 kg)
Cigarettes, Marlboro (pack of 20)	Margarine (500g)	Veal: fillet (1 kg)
Coca-Cola (1 l)	Milk, pasteurised (1 l)	Veal: roast (1 kg)
Cocoa (250 g)	Mineral water (1 l)	Vermouth, Martini & Rossi (1 l)
Cognac, French VSOP (700 ml)	Mushrooms (1 kg)	White bread (1 kg)
Cornflakes (375 g)	Olive oil (1 l)	White rice (1 kg)
Dishwashing liquid (750 ml)	Onions (1 kg)	Wine, common table (750 ml)
Drinking chocolate (500 g)	Orange juice (1 l)	Wine, fine quality (750 ml)
Eggs (12)	Oranges (1 kg)	Wine, superior quality (750 ml)
Electric toaster (for two slices)	Peaches, canned (500 g)	Yoghurt, natural (150 g)
Facial tissues (box of 100)	Peanut or corn oil (1 l)	

Table 5: Description of sample: list and classification of goods and locations

List of goods: Traded (continued)

Available at both a chain and mid-priced/branded stores	Available only once
Boy's dress trousers	Business trip, typical daily cost
Boy's jacket, smart	Compact car (1300-1799 cc) (high)
Child's shoes, sportswear	Compact car (1300-1799 cc) (low)
Child's shoes, dresswear	Compact disc album (average)
Child's jeans	Daily local newspaper (average)
Girl's dress	Deluxe car (2500 cc upwards) (high)
Lipstick (deluxe type)	Deluxe car (2500 cc upwards) (low)
Men's business shirt, white	Electricity, monthly bill for family of four (average)
Men's business suit, two piece, medium weight	Family car (1800-2499 cc) (high)
Men's raincoat, Burberry type	Family car (1800-2499 cc) (low)
Men's shoes, business wear	Gas, monthly bill for family of four (average)
Socks, wool mixture	Heating oil (100 l) (average)
Women's cardigan sweater	International foreign daily newspaper (average)
Women's dress, ready to wear, daytime	International weekly news magazine (Time) (average)
Women's raincoat, Burberry type	Kodak colour film (36 exposures) (average)
Women's shoes, town	Low priced car (900-1299 cc) (high)
Women's tights, panty hose	Low priced car (900-1299 cc) (low)
	Paperback novel (at bookstore) (average)
	Paperback novel (at bookstore) (average)
	Pipe tobacco (50 g) (average)
	Regular unleaded petrol (1 l) (average)
	Telephone line, monthly rental (average)
	Telephone, charge per local call from home (3 mins) (average)
	Television, colour (66 cm) (average)
	Water, monthly bill for family of four (average)

Table 6: Cross-section distribution of price level, volatility and persistence

CITY LEVEL ANALYSIS					
CURRENCY UNIT: USD					
SAMPLE PERIOD: 1990–2010					
	WHS	LDC	DEV	NT	TR
LOG-PRICE, p_{ilt}					
Mean	2.49	2.18	2.60	4.49	2.04
Median	1.89	1.52	2.01	4.81	1.54
95 th	7.58	7.40	7.63	8.01	6.26
5 th	-.56	-.85	-.40	.55	-.65
Std-Dev.	2.57	2.60	2.55	2.55	2.35
TIME VOLATILITY, $\sigma(p_{ilt}|il)$					
Mean	.33	.41	.30	.34	.32
Median	.27	.36	.25	.28	.27
95 th	.62	.77	.52	.65	.62
5 th	.14	.17	.13	.13	.14
Std-Dev.	.26	.29	.24	.33	.24
AUTO-CORRELATION, $\rho(p_{ilt}, p_{ilt-1}|il)$					
Mean	.81	.77	.82	.85	.80
Median	.85	.81	.86	.89	.84
95 th	.99	.97	1.00	1.00	.99
5 th	.50	.46	.59	.59	.49
Std-Dev.	.16	.17	.16	.14	.16
# of obs	831193	214061	617132	152643	678550

Notes: WHS = Whole set of goods and locations; LDC = locations in less developed countries (PPP-adjusted income per capita < \$12000); DEV = locations in more developed countries; NT = non-traded goods; TR = traded goods

Table 7: Unit-root tests

CITY LEVEL ANALYSIS			
CURRENCY UNIT: USD			
SAMPLE PERIOD: 1990–2010			
	WHS	DEV	NT
PRICE LEVELS, \bar{p}_t (global mean)			
t-stat, t	-.07		
Significance level, $s(t)$	.95		
DEVIATIONS FROM THE LOP, \bar{q}_{lt} (city mean)			
Average t-stat, $\bar{t} = \frac{1}{n_l} \sum_l t_l$	-1.56	-1.57	
Significance level, $s(\bar{t})$	.059	.059	
# of cities with $s(t_l) < .10$	62 out of 88	43 out of 61	
GOODS RELATIVE PRICES, \bar{r}_{it} (goods mean)			
Average t-stat, $\bar{t} = \frac{1}{n_i} \sum_i t_i$	-1.73		-1.63
Significance level, $s(\bar{t})$	.043		.052
# of goods with $s(t_i) < .10$	183 out of 276		35 out of 51
DEVIATIONS FROM THE LOP, q_{ilt}			
Average t-stat, $\bar{t} = \frac{1}{n_l} \sum_l t_l$	-1.84	-1.85	
Significance level, $s(\bar{t})$	.033	.032	
# of cities with $s(t_l) < .10$	74 out of 88	58 out of 61	
GOODS RELATIVE PRICES, r_{ilt}			
Average t-stat, $\bar{t} = \frac{1}{n_i} \sum_i t_i$	-2.25		-2.04
Significance level, $s(\bar{t})$	.012		.021
# of goods with $s(t_i) < .10$	275 out of 276		50 out of 51
# of locations	88	61	88
# of goods	276	276	51

Notes: ADF (for \bar{p}_t) and Pesaran (2007) CADF (otherwise) unit-root tests with 3 lags. WHS = Whole set of goods and locations; DEV = locations in more developed countries (PPP-adjusted income per capita > \$12000); NT = non-traded goods.

Table 8: Persistence estimates

COUNTRY LEVEL ANALYSIS					
CURRENCY UNIT: USD					
SAMPLE PERIOD: 1990–2010					
	WHS	LDC	DEV	NT	TR
RESPONSE TO					
<i>Local Macro shocks</i>					
ρ (mean)	.65	.61	.68	.65	.65
half-life	9.65	8.41	10.78	9.65	9.65
<i>Global Micro shocks</i>					
ρ (mean)	.80	.84	.77	.88	.79
half-life	18.64	23.85	15.91	32.53	17.64
<i>Local Micro shocks</i>					
ρ (mean)	.55	.50	.59	.69	.54
half-life	6.96	6.00	7.88	11.21	6.75
<i>Macro shocks</i>					
ρ (mean)	.83	.83	.84	.82	.83
half-life	22.32	22.32	23.85	20.96	22.32
<i>Micro shocks</i>					
ρ (mean)	.72	.71	.73	.80	.71
half-life	12.66	12.14	13.21	18.64	12.14
# of locations	49	26	23	49	49
# of goods	276	276	276	51	225

Notes: Persistence parameter estimates applying Pesaran (2006) mean-group procedure (CCEMG) to equations (3) and (4) with 3 lags. Sample of countries excluding euro-area members other than Germany. WHS = Whole set of goods and locations; LDC = locations in less developed countries (PPP-adjusted income per capita < \$12000); DEV = locations in more developed countries; NT = non-traded goods; TR = traded goods.

Table 9: Persistence estimates – Robustness checks

SAMPLE PERIOD: 1990–2010					
	(1)	(2)	(3)	(4)	(5)
Currency unit	USD	STG	JPY	USD	USD
RESPONSE TO					
<i>Local Macro shocks</i>					
ρ (mean)	.66	.63	.66	.65	.69
half-life	10.0	9.00	10.00	9.65	11.21
<i>Global Micro shocks</i>					
ρ (mean)	.81	.84	.85	.81	.78
half-life	19.74	23.85	25.59	19.74	16.74
<i>Local Micro shocks</i>					
ρ (mean)	.56	.60	.62	.61	.54
half-life	6.96	8.14	8.69	8.41	6.75
# of locations	59	59	59	59	88
# of goods	276	276	276	176	276

Notes: Persistence estimates applying Pesaran (2006) mean-group procedure (CCEMG) to equations (3) and (4) with 3 lags. Complete sample of goods and countries, including euro-area members. **(1)** Prices converted in US Dollars; **(2)** Prices converted in Sterling pounds; **(3)** Prices converted in Japanese yen; **(4)** Average of mid-priced and supermarket (or chain) stores where available, for prices converted in US Dollars; **(5)** City level analysis, for prices converted in US Dollars.

Table 10: Time-variance of components (average)

COUNTRY LEVEL ANALYSIS
 CURRENCY UNIT: USD
 SAMPLE PERIOD: 1990–2010

	WHS	LDC	DEV	NT	TR
TOTAL					
$E_{il} \{V(p_{ilt}|il)\}$	.18	.24	.15	.22	.17
GLOBAL MACRO					
$\widehat{V}(m_t)$	.02	.02	.02	.02	.02
Share in $E_{il} \{V(p_{ilt}|il)\}$	11	8	13	9	12
LOCAL MACRO					
$E_l \{\widehat{V}(m_{tt}|l)\}$	.03	.05	.01	.03	.03
Share in $E_{il} \{V(p_{ilt}|il)\}$	17	21	7	14	18
GLOBAL MICRO					
$E_i \{\widehat{V}(m_{it}|i)\}$	.07	.07	.07	.10	.06
Share in $E_{il} \{V(p_{ilt}|il)\}$	39	29	47	45	35
LOCAL MICRO					
$E_{il} \{\widehat{V}(m_{ilt}|il)\}$	.06	.10	.05	.07	.06
Share in $E_{il} \{V(p_{ilt}|il)\}$	33	42	33	32	35

Notes: Average of time variances across goods and locations for a sample of countries excluding euro-area members other than Germany. WHS = Whole set of goods and locations; LDC = locations in less developed countries (PPP-adjusted income per capita < \$12000); DEV = locations in more developed countries; NT = non-traded goods; TR = traded goods.

Table 11: Cross-section determinants of persistence

	(1)	(2)	(3)
LOCAL MACRO, $\log \rho_{il}(m_l)$			
$\log \sigma(m_{it}|i)$		.04*** (.015)	.04*** (.015)
$\log \sigma(m_{it}|l)$	-.06*** (.021)	-.09*** (.023)	-.13*** (.027)
$\log \sigma(m_{it}|il)$		.07** (.025)	.06** (.025)
(log) gdp per capita			-.01 (.016)
share of World pop			-1.60*** (.606)
good (log) price average			-.02*** (.004)
GLOBAL MICRO, $\log \rho_{il}(m_i)$			
$\log \sigma(m_{it}|i)$	-.00 (.016)	-.01 (.016)	-.01 (.016)
$\log \sigma(m_{it}|l)$		.19*** (.026)	.09*** (.032)
$\log \sigma(m_{it}|il)$		.12*** (.026)	.11*** (.026)
(log) gdp per capita			-.10*** (.017)
share of World pop			-1.85*** (.509)
good (log) price average			.01* (.005)
LOCAL MICRO, $\log \rho_{il}(m_{il})$			
$\log \sigma(m_{it}|i)$		-.00 (.013)	.00 (.013)
$\log \sigma(m_{it}|l)$		-.16*** (.017)	-.14*** (.021)
$\log \sigma(m_{it}|il)$	-.07*** (.017)	.02 (.017)	-.00 (.018)
(log) gdp per capita			.01 (.012)
share of World pop			.21 (.440)
good (log) price average			.03*** (.003)

Notes: OLS estimates of equation (5) for prices converted in USD observed over 1990-2010. Whole set of goods and locations excluding euro-area members other than Germany. Numbers in brackets are White-robust standard errors of estimates. ***, **, *, denote, respectively, significance at the 1%, 5% and 10% levels.