What determines European real exchanges rates?

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Abstract

We study a newly constructed panel data set of relative prices of a large number of consumer goods among European countries. We find that there is a substantial and non-diminishing deviation from PPP at all levels of aggregation. However, real exchange rates are very closely tied to relative GDP per capita within Europe. Quantitatively, we find that both across countries and over time, deviations in real exchange rates from PPP are smaller than deviations in relative GDP from the European average. We find that this prediction is consistent with a basic theoretical model of real exchange rate determination.

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1 Introduction

One of the principal objectives of international macroeconomics is the understanding of international relative prices. Empirical observations over many countries and time periods show very large variations in cross-country relative prices of goods, both when measured for similar goods at the micro level, and for good bundles at a more aggregated level. Early open economy models used to assume that free international trade would equalize relative prices, so that PPP held in the small and the large. But it is now universally recognized that there are persistent deviations from equality of prices across countries both for individual goods and at the aggregate level. Equivalently, real exchange rates measured at the level of goods, or in terms of aggregate price indices, display large and persistent departures from PPP.

Despite the consensus on the fact of departures from PPP, there is little agreement on the explanation of these departures. Many competing theories have been put forward, highlighting nominal price rigidities, trade costs, non-traded goods, compositional effects, aggregation bias, and other features, as well as combinations of these elements. One of the difficulties in providing a good account of the source of relative price movements across countries is the absence of a large panel of detailed comparable data on goods prices at the disaggregated level. Another, related problem is that most disaggregated time series price data used in international studies are in the form of indices, rather than price levels. This rules out the possibility of comparing prices across countries at a moment in time, instead allowing only studies of the movement in cross-country relative prices over time. What is necessary therefore, is to obtain a representative panel involving observations of price levels on a large number of similar goods across a large number of countries over time.

This paper employs a newly constructed data set of European price levels to conduct such a study. The data includes relative prices of a large number of categories of consumer goods across 31 European countries over a 13 year period. From these data we can construct measures of real exchange rates at both disaggregated and aggregate levels. We find that there are large and persistent deviations from absolute PPP among European countries. These deviations hold for all categories of goods, but are much more pronounced among non-tradable goods than for tradable goods. In addition, the deviations have not been eliminated by membership of the single currency area. Even among Eurozone members, there are persistent devia-

tions from PPP that show no obvious signs of erosion within the sample. For emerging Eastern Europe countries, the conclusions are somewhat nuanced. For these countries, the deviations from PPP are much larger, but there is much greater evidence of convergence in price levels towards the European average, while still, at least in the sample, remaining quite far away from PPP.

While the data show very persistent departures from PPP, this does not mean that such divergences in real exchange rates cannot be rationalized. In fact, we find that real exchange rates are very closely tied to relative GDP per capita, both in comparisons across countries, and in movement over time. The data show that some countries displayed declining relative GDP per capita over time, combined with persistent depreciation in their real exchange rate - in particular this applied to the 'Old-Europe' countries; France, Germany, the Netherlands, Belgium, and Austria, while other countries displayed substantial appreciation combined with increasing relative GDP per capita - notably Ireland, UK, some Scandinavian countries, as well as many countries of emerging Eastern Europe.

Relative GDP per capita is an important determinant of the real exchange rate not just in the aggregate, but also at the level of individual goods. Almost 50 percent of the variation in good level real exchange rates, across goods, time and countries, is explained by relative GDP per capita differences across countries and movements over time. Quantitively we find that, roughly speaking, a one percent increase in the relative GDP per capita for a given country towards the European average leads to a 0.35 percent appreciation of the real exchange rate to the European average. When broken down into non-tradable and tradable goods separately, the real appreciation coefficient becomes 0.5 percent and 0.2 percent, respectively.

For all categories of goods, movements in relative GDP per capita are associated with less than proportionate movements in real exchange rates. This leads to a particularly robust finding in the data - the deviation of real exchange rates from the EU average tend to be substantially less than the deviations of relative GDP from the EU average. We find a striking pattern in the relationship between relative GDP per capita and real exchange rates. For countries such as Ireland, where relative GDP per capita moved from being below the EU average to being above the EU average over the sample, the deviation of relative GDP from the EU average switched from being below the real exchange rate deviation at the beginning of the sample to being above the real exchange rate deviation at the end of the sample.

An interesting question concerns the relationship between nominal and real exchange rate flexibility. While, as to be anticipated, we find that floating exchange rate countries exhibit greater time variation in real exchange rates, it is striking how much real exchange rate movement has taken place among Eurozone members or between the Euro area and euro-pegging Eastern European countries. Generally, we find little evidence that the Euro area has stymied adjustments in real exchange rates. Moreover, when we look at disaggregated real exchange rates, we find that there is much less difference in volatility between Eurozone members and floating exchange rate countries.

Having explored the characteristics of real exchange rates in the data, we go on to develop a highly stylized model of real exchange rate determination, and show that the model can account reasonably well for the main features of the relationship between relative GDP and the real exchange rate. In particular, for standard choice of parameter values, we find that the model implies a smaller deviation of real exchange rates than relative GDP amoung countries. Moreover, when the model is simulated by choosing a path for GDP that matches the historical sample, we find that we can match the real exchange rate transition experienced by some of the European countries in the sample. In particular, the model does a very good job at matching the 'real exchange rate transition' discussed above.

The following section presents a short literature survey. Section 3 discusses the data in detail. Section 4 describes the properties of real exchange rates, both at the aggregate level and the disaggregated level. Section 5 discusses the relationship between real exchange rates and relative GDP, and between real exchange rates and nominal exchange rate volatility. Section 6 shows that a simple structural model based on relative GDP, distance, and euro membership can account for a large part of the variation in real exchange rates both at the aggregate and disaggregated level. Finally, section 6 discusses the extent to which the empirical findings are consistent with a simple general equilibrium model of exchange rate determination.

2 Literature Review

There has been a large literature discussing the properties of real exchange rates and relative price comparisons across countries, using both aggregate and disaggregated data. Engel and Rogers (1996) study movements in price indices across Canadian and US cities, and find that both distance and border

matter for relative price variability. Engel and Rogers (2001) use European data, and separate the border into two factors; a) "real barriers" effect caused by barriers to market integration and b) a "sticky consumer price-volatile exchange rate" factor. They find the second factor to be empirically more important. Similar to our findings below, Engel and Rogers (2004) find no evidence of prices in Europe to converge after euro's introduction in 1999.

Crucini, Zachiaradis, and Telmer 2005 present a study quite similar to that of our paper, using a more disaggregated data set on European prices, for four separate sample years for up to 13 EU countries. They argue that PPP holds quite well in these data, especially when adjusting for GDP per capita. Our paper differs from theirs in that we have a panel covering up to thirteen years, we focus on a more aggregated sample of consumer products (see the discussion below for the differences in aggregation levels), and we examine a much larger set of countries, including both EU countries and non-EU countries, emerging economies in Eastern Europe, floating and fixed exchange rate countries, and pre-and post Eurozone countries. We find less compelling evidence for PPP in our study. In addition, our study extrapolates from the results to the implications for general equilibrium modelling of real exchange rates.

Crucini and Telmer (2007) using EIU data on city prices find that cross-sectional variance in long-run absolute deviations from LOP is large relative to time-series variance and time series variance in changes in LOP deviations is dominated by idiosyncratic variation, rather than country-specific variation (such as would be driven by nominal exchange rate movements). Our findings are consistent with their paper in the sense that, when we focus on the volatility of real exchange rates at the disaggregated level, we find much less difference in the average volatility between Eurozone countries (or euro-pegging countries) and floating exchange rate countries that the equivalent volatility at the level of the aggregate real exchange rate.

Finally, our paper is related the literature documenting a relationship between price levels and GDP per capita (sometimes called the 'Penn' effect, after Kravis, Heston and Summers). This has led to large number of papers exploring the 'Balassa-Samuelson' effect, which can rationalize this relationship. An alternative explanation is explored by Bergstrand (1991). He argues that a 'demand-side' explanation, due to the property that the income elasticity of demand for services exceeds unity, plays an important role in explaining the relationship. Our paper provides a further documentation of the nature of this relationship for European countries. We argue

that the relationship holds almost in the same way both across countries and over time. Furthermore, we find that, in European data, the relationship between real exchange rates and GDP has the distinct property that deviations from PPP are narrower than differences in relative GDP per capita. Finally, we explore the extent to which these findings are consistent with a simple general equilibrium model based loosely on a Balassa-Samuelson type mechanism.

3 Data-Description

3.1 Annual Price Level Indices

We use a dataset on European price levels for a large number of European countries over the 1995-2007 period. The data are annual Price Level Indices, or PLIs, constructed by Eurostat as part of the Eurostat-OECD PPP Programme. They give the price of the good heading at a given time and for a given country, relative to the price in the reference country. The level of aggregation of the PLI is at the 'Basic Heading'. Basic Headings are constructed as unweighted averages of product level observations in each country. Basic Headings are then aggregated using expenditure weights to form HICP categories used at a higher level of aggregation. For our purposes, for the full sample 1995-2007, PLIs are available for 146 consumer expenditure headings on goods and services, 36 government expenditure headings, and 32 headings for expenditures on gross fixed capital formation. In this paper, we focus on consumer PLI's. The 1995-2007 sample extends across 18 western European countries. The country coverage is as follows: Belgium, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, Netherlands, Austria, Portugal, Finland, Denmark, Sweden, UK, Iceland, Norway, and Switzerland. In addition, for 1999-2007, we have an identical sample for 13 additional countries, mostly Eastern European[1]. PLI's themselves are derived from good-level PPP's, and are measured relative to the 15 members of the EU area[2]. The PPP for any country and good is just the ratio of the good price for that country to the average price of that good for the EU15. For the euro area

[1]The countries are Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia, Bulgaria, Romania, and Turkey.

[2]That is, Austria, Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Spain, Sweden, Portugal, Finland, and the United Kingdom.

countries (after the euro, 1999), the PLI is just equal to the PPP (multiplied by 100). For non-euro are members, the PLI for the country-good is obtained by dividing the PPP by the exchange rate, relative to the euro, so as to obtain the price in the same units. In each year, the EU15 price for each good is scaled to 100, so prices above 100 for a country-good in any year represents a price above the EU15 average price. Thus, for each country-good-year, the PLI gives us a measure of the good level real exchange rate against the EU15. Denote the individual PLI for good i, country j, time t as $p_{i,j,t}$. Thus, from our definition, we have that:

$$p_{i,j,t} = PPP_{i,j,t}/S_{j,t} = \frac{P_{i,j,t}}{S_{j,t}P^*_{i,t}},$$

where $S_{j,t}$ is the exchange rate of country j against the EU15, $P_{i,j,t}$ is price of good i for country j, and $P^*_{i,t}$ is the price of good i for the EU15.

Table 1 gives a list of good categories included in the consumer PLI's, while Figure 1 gives some examples of the level and time path of categories for some countries.

3.2 Monthly HICP price levels

While the PLI's have the advantage of being expressed in terms of price levels, they have the drawback of being published only at annual frequencies. By contrast, the European Harmonized Index of Consumer Prices (HICP) for all countries in Europe is reported at a monthly frequency. The HICP has the converse disadvantage of being an index, rather than a price level, however. But it is possible to use the PLI's and the HICP's in combination, so as to produce a monthly series of price level equivalents. We do this by using Eurostat expenditure weights to aggregate from the BH-PPP level of prices up to the HICP level[3]. Since the BH-PPP PLI's are in terms of levels, relative to the EU average, we can then compute a proxy relative price level for categories in the HICP, and then, using the rates of change of the HICP indices for each category, derive a montly frequency series in relative price levels for all countries in the sample. The difficulty of aggregating up from the annual PLI frequency to the monthy HICP frequency is handled by using a Eurostat provided set of 'temporal adjustment factors' which are used to go from the annual frequency of the PLI's to the implied PLI for any

[3]This uses the EKS method of aggregation (see Eurostat Manual).

month. A matrix of these temporal adjustment factors is available for years 2003-2006.

In the discussion below, we report some preliminary results for comparative prices using the monthly data. One drawback of this analysis is that missing data in the HICP series reduces significantly the number of goods that can be used in a balanced panel of monthly HICP level prices.

Results to be added...

4 Characteristics of PLI's

4.1 Mean Comparisons across Countries

We first focus on the properties of annual PLI's. PLI's can be thought of as good-level real exchange rates. Average PLI's then represent a measure of aggregate real exchange rates. Define the aggregate real exchange rate for country j as:

$$p_{j,t} = \frac{1}{N} \sum_{i}^{N} p_{i,j,t}. \tag{1}$$

In this definition, aggregate real exchange rates are unweighted. Eurostat does provide expenditure weights for good categories, but since we wish to focus on deviations from PPP (or the law of one price) at the micro level, we find it more compelling to report unweighted averages of PLI's. In the Appendix, it is shown that the properties of the weighted averages, using expenditure weights, are very similar to those of the unweighted averages.

We begin by reporting the characteristics of $p_{i,j,t}$ for the sample of 18 Western European countries. The top left panel of Figure 2 describes the path of $p_{j,t}$ for all 12 countries in the eurozone, while the bottom left panel shows the prices for the group of 6 countries with independent currencies and floating exchange rates.

It is clear that, even within the eurozone, and particularly outside the eurozone, there is a substantial and continuing departure from PPP in the aggregated data. Although there is some tendency for price differentials across countries to narrow over time (as discussed below), this fall in dispersion across countries is very small relative to the departures from overall PPP.

If we focus on the eurozone countries in particular, there is admittedly some evidence of a narrowing of price differentials in the average over time.

This is shown on the right hand panel of Figure 1, which shows two measures of the movement in the dispersion of $p_{j,t}$ across countries over time. The first measure is simply the standard deviation:

$$SD_t = \sqrt{\frac{1}{M}\sum_j \left(\frac{1}{N}\sum_i p_{i,j,t} - \frac{1}{MN}\sum_j\sum_i p_{i,j,t}\right)^2}.$$

Since the PLI's are measured relative to the EU15 scaled average of 100 however, it is possible that the standard deviation for a given group of countries is small, but there is still a significant departure of parity with the EU15. Therefore, we define an alternative measure of dispersion across countries as

$$MAD_t = \text{mean}_j(\text{ABS}(p_{jt} - 100)).$$

If the sample of countries are evenly dispersed above and below the EU15 average, then the two measures will be very close. But MAD_t may be considerably higher than SD_t for a group of countries whose price is far above or below the EU15 average.

Over the whole sample period, there was a significant reduction in the dispersion of real exchange rates across countries that later made up the eurozone, using either measure of cross country dispersion. But all of this fall in relative price dispersion took place before the euro came into effect in 1999. There has been no change in dispersion between 2000 and 2007. Interestingly however, this conclusion depends solely on the presence of one country; Ireland. Without Ireland, Figure 3 shows that the average dispersion across the eurozone countries continued to fall slowly even after 1999, although.

An inspection of Figure 2 reveals interesting patterns among the eurozone countries and the nature of the convergence in average price levels. Six of the high real exchange rate countries at the beginning of the sample - Germany, France, Belgium, Austria, Luxembourg, and the Netherlands, have persistently depreciating real exchange rates over the sample. Two countries with initially low real exchange rates, Ireland and Italy, have substantial real appreciations over the sample. Ireland went from being below the EU average in 1995 to being considerably above the average by 2007. On the other hand, Greece, Spain, and Portugal show little convergence, with real exchange rates 10-15 percent below the European average for the full sample. Finally, Finland remains an outlier, remaining 15-20% above the EU average over the whole sample.

For the non-eurozone countries of Western Europe, there is no evidence at all of convergence over time in real exchange rates. For almost all of the sample, these countries have higher prices than the EU average. This leads to the MAD_t measure of dispersion being significantly larger than the SD_t measure. Moreover, as to be anticipated, for the freely floating countries, real exchange rate year to year variation over the sample is much higher than that for the eurozone countries.

Figure 4 illustrates the PLI's for the additional, Eastern and Southern European countries for the shorter sample of 1999-2007. The key feature of these countries is that their real exchange rates are far lower than the EU average. Since most of these countries had a much lower GDP per capita than Western Europe, it may not be too surprising to find considerably lower prices. Nevertheless, there was substantial upwards convergence over the sample. Figure 4 shows the average deviation from PPP relative to the EU average fell progressively over the sample. This still remains considerably higher than the equivalent measure for the Western European countries however - on average the Western European countries were about 15 percent away from PPP over the whole sample. For the Eastern and Southern European countries, the average was over 34 percent.

How representative are the mean PLI's of the individual prices at the disaggregated level? Figure 5 illustrates the deviation from PPP of each of the 146 consumer goods for three separate years in the sample for both groups of countries, respectively. It is apparent that the mean PLI's are quite representative. For for the central European group of countries (Belgium, Germany, Netherlands, France and Austria), there is an even distribution above and below PPP across the goods. For the Scandinavian countries, most goods are above PPP, while for the southern European countries, most goods are below PPP. In addition, the time variation seen in the means can be seen across the range of goods, for Ireland, UK, Iceland, and Switzerland, for instance.

Figure 5 also shows that for the Eastern European countries, almost all goods are substantially below PPP relative to the EU15. For some countries, the comparison is quite dramatic. For instance, in 2007, Bulgaria had only 6 of the total 146 good categories with prices at or above the EU average.

Thus, the evidence from Figures 1-5 makes clear that, at both the mean level and at the level of individual goods, there is substantial and continuing deviation from equality within European consumer goods prices. Moreover, average real exchange rate departures from PPP are strongly representative

of PPP departures at the individual good level, for most countries. Equivalently, if a country's average real exchange rate is far above (below) PPP relative to the EU average, almost all individual real exchange rates are above (below) PPP.

4.2 Dispersion within countries

We now focus in more detail the nature of price dispersion *within* countries. Recall that each individual price is measured relative to the EU average set equal to 100 in each year. Thus, in each year, the degree of price dispersion measures the variation across goods in real exchange rates for a country. The measure of dispersion we focus on is the country-dated coefficient of variation:

$$cv_{j,t} = \frac{\sqrt{\frac{1}{N}\sum_i^N (p_{i,j,t} - p_{j,t})^2}}{p_{j,t}}.$$

Since Figures 2 and 3 indicate that there are large persistent differences in country means, $p_{j,t}$, the coefficient of variation $cv_{j,t}$ is a more accurate measure of within-country price dispersion than the simple standard deviation of prices across goods.

Figures 6 illustrates the path of $cv_{j,t}$ for the three groups of countries. Price dispersion is lowest for the eurozone countries, and highest for the Eastern and Southern European group of countries. Price dispersion tends to fall over time in each of the three groups, particularly so in the Eastern and Southern European group. The picture also seems to suggest that price dispersion is higher for the countries with real exchange rates further away from the EU average. Figure 7 confirms this. It shows the relationship between the mean average departure from PPP (over the whole sample) and the mean of price dispersion. There is a clear positive relationship between the departure from PPP and the dispersion of within country prices. Countries with PLI's further away from the EU average have a higher degree of price dispersion.

Figure 8 gives an alternative representation of price dispersion. It displays the kernel densities of the PLI's for each country, for three separate years. The densities have narrowed for the central European countries, although, consistent with the evidence above, most of this reduction took place before 2000. The densities show substantial instability for the floating rate countries - particulary Iceland and the UK, which had large movement in the

euro-based nominal exchange rates over the sample. As we see below, nominal and real exchange rates move closely together for these countries, over the sample. In addition however, even some euro are members (e.g. Ireland and Italy) showed substantial shifts up over time in their kernel densities. For the Eastern European countries, the densities are much wider, and also tend to shift up over time. Note again, that while there is substantial movement in the densities, there is a large and continued distance between densities for the highest real exchange rate countries (e.g. Finland, Denmark, and the lowest real exchange rate countries of southern and eastern europe).

A final perspective on price dispersion can be seen in Figure 9. Here we show the kernal density over all goods, for the three separate groupings of countries, for all years. The distribution for the Euro are countries is narrow and stable over time, compared to that for the floating countries, which is wider, further to the right on average, and substantially more volatile across years. For the Eastern European countries, the distribution is far to the left of those of the other two groupings, and wider, but tends to shift up progressively over time, consistent with the evidence in the previous Figures. Again, we note that the persistent differences in the means of the densities still persist when measured in this way.

4.3 Decomposition into Traded and Non-Traded

We now look deeper into real exchange rates and price dispersion by decomposing both measures separately into tradable and non-tradable goods. The Appendix describes how tradability is defined at the good level. A minimal theoretical presumption is that the departures from PPP in real exchange rates is lower in traded goods than in non-traded goods. Figure 10 shows the separate breakdown of the country level PLI's for traded and non-traded goods for the eurozone countries. The properties of average traded and non-traded goods PLI's, in terms of deviations from the EU average, are similar to the overall PLI's. Even for traded goods, there is significant and continued departure from PPP in both directions. Spain and Portugal have real exchange rates for traded goods equal to 90 percent of the EU average, and show no indications of convergence. Finland's real exchange rate in traded goods is persistently more than 15 percent above the EU average. Again Ireland and Italy go from being below to being above the average. France, Germany, Belgium, Austria and the Netherlands display gradual downward convergence as before.

For the non-traded goods categories we see basically the same features, except that the magitudes of departures from PPP are substantially greater for the countries both above and below the EU average. Given that retail prices of all goods should contain some non-tradable component, this pattern of persistent departures from PPP in both tradable and non-tradable categories is quite consistent with standard theory. This statement is made more precise in Section 6 below.

For both categories of goods, there is a significant convergence of prices just prior to the euro, and little convergence thereafter (interesting, there is more continued convergence for non-traded goods than traded goods). But the key difference is that the average departure from PPP for the eurozone countries is twice as great for the non-traded goods category as that for traded goods.

Figures 11 show the same results for the floating exchange rate countries of Western Europe. The average departure from PPP is much higher for the non-traded category, although again, there are significant departures from PPP for the traded category, and the time series properties of real exchange rates are essentially identical for both traded and non-traded categories. In terms of convergence in average real exchange rates across countries for these group of countries, Figures 11 show that in non-traded goods, there is significant divergence over time, while in traded goods, there is no convergence at all over the whole sample path.

Finally, Figure 12 describes the pattern of movement in tradable and non-tradable categories for the countries of Eastern and Southern Europe. As for the other groups of countries, there are large and persistent departures from PPP in both categories of goods, but those for traded goods are roughly 50 percent less than for non-traded goods.

5 Real Exchange Rate Determinants

5.1 Real Exchange Rates and Relative GDP per capita

If PPP was satisfied in the data, we would not need to investigate the determinants of real exchange rates. But the evidence clearly establishes the presence of wide departures from PPP, even among the Euro are countries, and even more-so for the non-euro Western European countries and the Eastern European countries. What explains the patterns in real exchange rates,

both over time and among countries? It is well known that in levels, real exchange rates tend to be positively correlated with per capita income. This is implied for instance, by the celebrated Balassa-Samuelson framework, (Obstfeld and Rogoff, 1995), although other theories make similar predictions (e.g. Neary 1988).

With this channel in mind Figure 13 illustrates the relationship between relative GDP per capita and country level average real exchange rates for each of the countries in the sample. Relative GDP is defined as US dollar GDP per capita, relative to the EU15 average US dollar GDP per capita[4]. Then, if real exchange rate differentials were driven primarily by differences in income per capita, we should anticipate that countries with GDP per capita equal to the EU average should have real exchange rates at the EU average (i.e. PPP should hold when compared to the EU12) . Figure 13 shows that this rule of thumb holds fairly accurately for the Western European sample. Belgium, Germany, France, Austria and the Netherlands all have GDP per capita close to the EU average, and the same holds for their real exchange rates. For Greece, Spain and Portugal, real exchange rates and relative GDP's are considerably below the EU average, while the Scandinavian countries, both real GDP per capita and real exchange rates are substantially above the EU average. In the case of Ireland, the beginning of the sample has both GDP per capita and the real exchange rate below the EU average, with both increasing substantially over time. Note that for most countries, the deviation of GDP per capita from the EU average exceeds that of the real exchange rate, in absolute terms. That is, for the relative poorer countries of Greece, Spain and Portugal, the deviation from PPP is far less than the deviation of GDP per capita. A similar characteristic is seen in the opposite direction for Luxembourg, Switzerland, Norway and the Netherlands; real GDP per capita is proportionally more above the EU average that are their real exchange rates.

For the Eastern and Southern European countries, real GDP per capita is far below the EU average, as is the real exchange rate for these countries. But again, we see that the deviation of the relative price from the EU average is substantially less than that of GDP per capita.

Figures 13 suggests that the relationship between GDP per capita and real

[4]Since the purpose is to explore the relationship between GDP per capita and real exchange rates, we use actual GDP per capita rather than PPP adjusted GDP per capita.

exchanges holds both in the cross section and over time. Across countries, high real exchange rates are associated with higher GDP per capita. But also within countries, movements movements in relative GDP per capita tend to be associated with movements in real exchange rates in the same direction. This is particularly true for the floating exchange rate countries; i.e. Sweden, UK, Iceland, Norway and Switzerland[5] . Moreover, both across countries and over time, there is a less than proportional response of the real exchange rate to movements in relative GDP. This leads to a particularly striking feature about the relationship between real exchange rates and relative GDP. For a country that begins with a GDP per capita below the average, relative GDP is below the real exchange rate. But as the country catches up and overtakes the average, the relative GDP line cuts the real exchange rate from below, and converges to a position where relative GDP is above the real exchange rate. In Figure 13, Ireland is a key example of this. But the dynamic also holds in reverse, as seen for Belgium, Germany, Austria, and Denmark, who experience falling relative GDP and real depreciation over the sample. In these cases, the relative GDP locus cuts the real exchange rate locus from above. In Section 5 below, we see that this convergence related feature of the link between relative GDP and real exchange rates is predicted by a simple structural model of the real exchange rate.

Figure 14 gives a broader illustration of the relationship between relative GDP and real exchange rates. The figure presents a scatter plot of real exchange rates and GDP per capita over all countries and time periods in the sample. We see a close association, aside from outliers due to Luxembourg, which, from Figure 13, has a relative GDP per capita substantially out of proportion to its real exchange rate. The Figure also supports the observation made above that, unconditionally, the real exchange rate increases by less than in proportion to relative GDP. Countries with lower (higher) than average relative GDP have lower (higher) real exchange rates, but closer to the EU average than for relative GDP.

[5]Note, because we are using relative GDP per capita, rather than PPP adjusted GDP, there is a tendency for movements in GDP to follow relative nominal exchange rates, given slow movements in GDP deflators. Hence it is not surprising to see a high correlation between relative GDP per capita and real exchange rates for the floating exchange rate countries. But, as is seen in Figure 13 below, the relationship between the nominal and real exchange rates for the floating countries is not perfect.

5.2 Real and Nominal Exchange Rates

Figure 14 illustrates the relationship between real and nominal exchange rates. The Euro area countries have zero nominal exchange rate variability after 1999. It is well known that for most countries and exchange rates, real exchange rate volatility against a reference currency or basket of currencies is much higher when the nominal exchange rate floats against those currencies. If nominal prices are slow to adjust, then fixed exchange rates may inhibit real exchange rate adjustment. Figure 13 shows that for the floaters, annual real and nominal exchange rate variability is much higher than for the euro area countries, and there is a high correlation between nominal and real exchange rate variability. But at the same time, many euro area countries achieved considerable real exchange rate adjustment over the sample without movements in nominal exchange rates. In particular, Germany France, Austria and to a lesser extent Belgium and the Netherlands experienced substantial real depreciation even after entry into the euro area, while Ireland, Italy, Spain and Portugal went through real appreciation without changes in the nominal exchange rate. The mean annual standard deviation of the real exchange rate for the floating countries is 4.24 percent over the sample, while it is 1.9 percent for the euro area countries. It is not apparent that euro membership inhibited real exchange rate adjustment.

An even more striking pattern is seen for the Eastern European countries. The annual real exchange rate volatility for many countries is substantially greater than nominal volatility, even for the floating exchange rate countries. Effectively, much of the real exchange rate movements between Eastern European countries and the euro area took place via differential inflation rates. This 'convergence based' real exchange rate volatility is conceptually very different from traditional interpretations of the real exchange rate based on the combination of sticky prices and nominal exchange rate volatility.

Table 2 further investigates the impact of alternative exchange rate regimes on real exchange rate adjustment, but at the level of disaggregated prices rather than the aggregate real exchange rate. We measure the average standard deviation of real exchange rate changes across all 146 consumer goods over the full sample, for all countries. The difference in volatility of these micro level real exchange rates when comparing the floaters to the euro area countries is much less pronounced than in the aggregate real exchange rates. The average standard deviation across euro area members is 6.7 percent, while among the floating rate countries of Western Europe the average volatil-

ity is 8.9 percent. Thus, the proportional difference in real exchange rate adjustment among euro area members and floaters at the disaggregated level is much less than at the aggregate level. In describing disaggregated real exchange rates, there seems little indication of that the euro inhibited exchange rate adjustment. For the Eastern European countries, the average volatility is also 6.7 percent, the same as that for the Euro area.

6 Structural Determinants of Real Exchange Rates

We now provide a more careful statistical investigation of the determinants of real exchange rates. From the figures above, relative GDP is clearly a key driver of country-level real exchange rates. But from the theoretical literature, it is likely that other variables are important for real exchange rates, both across countries and over time. One obvious factor is the existence of trade barriers or trade costs. While PPP should hold for pure traded goods in the absence of any restrictions to international trade, the empirical trade literature has identified significant trade costs (Anderson Van Wincoop). Measures of bilateral trade costs among all European countries are not readily available however. As an alternative proxy measure, we use distance of the national capital from Frankfurt [need to improve this see CTZ on trade flows?]. To the extent that trade costs are proportional to the shipping distance involved, this should be a roughly accurate representation of the costs of arbitrage over traded goods[6]. A second important variable is whether the country is a member of the euro area. The transparency of price comparisons implied by membership of the European single currency area may impart forces towards price convergence that do not operate for other countries, even if they maintain stable exchange rates vis a vis the euro. 11 countries entered the euro area at its inception in 1999, followed by 4 more at various dates up to the end of our sample. The Euro variable introduces a dummy for the year and country for which euro membership applies.

[6]Of course it must be noted that the PLI's we are examining are not pure traded goods, but represent measures of retail level prices paid by consumers, which incorporate local service content for distribution, marketing, etc. We do not have information on differences in marketing and distribution across countries however.

Table 3 reports results from an OLS regression of country level real exchange rates on RGDP, Distance, and Euro for the full sample. The elasticity of the real exchange rate to relative GDP is highly significant and equal to 0.35. Euro membership is significantly negative, while distance has a significantly positive coefficient. Relative GDP has an influence on real exchange rates that is important in both the cross section and over time. When country fixed effects are included, the coefficient on relative GDP is essentially unchanged. On average, within countries, a 1 percent increase in relative GDP per capita is associated with a 0.35 percent increase in the real exchange rate. Interestingly, the significance of the euro dummy (Euro) is eliminated when including country fixed effects. This is consistent with the pattern in the figures above, showing that most of the price convergence among euro members took place before entry into the euro system. The coefficient on Distance increases after the inclusion of country fixed effects[7]. Intuitively, without country fixed effects, Distance is partially proxying for time-invariant real exchange rate differences across countries. Thus, the pure effect of Distance is corrupted by other cross country fixed differences in prices.

Table 3 also provides a breakdown of these regressions separately into tradable and non-tradable goods . For tradables, the coefficient on relative GDP falls to approximately 0.28, but remains highly significant. Euro and Distance are still significant in the basic specification, but again, Euro loses significance when fixed effects are allowed. In the non-tradables case, the GDP coefficient is much higher - around 0.55, and again highly significant under all specifications. In this case, Euro is insignificant even without the inclusion of fixed effects.

Table 4 decomposes the regressions separately for Western Europe and Eastern Europe. The main message from here is that the relationship between GDP and the real exchange rate is stronger for Western European countries, although still, in all cases, the coefficient is highly significant, both for all goods and for tradable and non-tradable goods separately.

In the aggregate then, the relationship between real exchange rates and real GDP per capita is very close. But real exchange rates in the aggregate mask considerable heterogeneity among different consumer categories of goods. How much variability at the disaggregated level can be explained by relative GDP per capita? Table 5 reports the results of a regression using all

[7]Since Distance is linearly dependent on the full set of country dummy vectors, when Distance is included, we drop one country from the fixed effects matrix.

the individual PLI's across all countries and dates. The coefficient on RGDP is very significant, and even higher than before. With our without fixed effects, the elasticity is about 0.4. The striking feature of this regression however is that even at this disaggregated level, the R2 is 0.5. Thus, even at level of disaggregated individual prices, relative GDP, Euro, and Distance can explain 50 percent of the price variability across countries and over time.

7 A Simple General Equilibrium Model

The key feature of the European data we have seen is the very strong cross-country and time-series relationship between real exchange rates and relative GDP, and in particular the less than proportionate elasticity of the real exchange rate to relative GDP in both dimensions of the data. Countries with relative GDP above (below) the EU average have higher (lower) real exchange rates than the EU average, and moreover, the deviation of the aggregate real exchange rate from the EU average is less than the depature of relative GDP from the EU average. Moreover, countries that have had an increase in relative GDP from below to above the EU average have had a real exchange rate appreciation from below to above the EU average, with a 'crossing' point for the relative GDP and real exchange rate locus. The opposite mechanism holds for most countries that have had relative GDP falling from above to below the EU average.

Is this relationship consistent with a theoretical model of real exchange rate determination? We now construct a very simple structural model of the real exchange rate to ask this question. To be consistent with the data it should be that a structural model delivers; a) positive but less than proportional relationship between relative GDP and the real exchange rate, and b) a similar relationship, though different in magnitude, for all goods, both nontradable and tradable.

Here we construct theoretical representation of the real exchange rate and relative GDP from a simple two country endowment model. Denote the countries as 'Home' and 'Rest of World', with the Home country consumption aggregate defined as

$$C = \left(\gamma^{\frac{1}{\theta}} C_T^{1-\frac{1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} C_N^{1-\frac{1}{\theta}} \right)^{\frac{\theta}{1-\theta}},$$

where C_T and C_N represent respectively, the composite consumption of tradable and non-tradable goods. The elasticity of substitution between tradable

and non-tradable is θ. Tradable consumption in turn is decomposed into consumption of home goods (exportable), and foreign goods (importables), as follows:

$$C_T = \left(\mu^{\frac{1}{\lambda}}\omega^{\frac{1}{\lambda}}C_X^{1-\frac{1}{\lambda}} + (1-\omega)^{\frac{1}{\lambda}}C_M^{1-\frac{1}{\lambda}}\right)^{\frac{\lambda}{1-\lambda}},$$

where ω represents the relative size of the home country, in both population terms, and in the measure of total tradable goods produced in the world economy, and λ is the elasticity of substitution between home and foreign tradables. In addition, $\mu \geq 1$ is a home bias parameter, indicating a preference for home goods in tradable consumption, above and beyond the share of such goods in world tradables.

These consumption aggregates imply the following price index definitions:

$$P = \left(\gamma P_T^{1-\theta} + (1-\gamma)P_N^{1-\theta}\right)^{\frac{1}{1-\theta}},$$

$$P_T = \left(\mu\omega P_X^{1-\lambda} + (1-\omega)P_M^{1-\lambda}\right)^{\frac{1}{1-\lambda}},$$

where P_T and P_N represent tradable and non-tradable price levels, and P_X and P_M are prices of home exportables and foreign importables. The analogue of the real exchange rate variable $p_{j,t}$ above is defined as the price of the home good, relative to the rest of the world. Thus we define the real exchange rate as:

$$RER = \frac{P}{P^*}$$

where an asterisk indicates the 'Rest of World' price level. Since we are focusing purely on a flexible price model, we may ignore the presence of nominal exchange rates. The real exchange rate measured separately for traded and non-traded goods is defined as $RER_T = P_T/P_T^*$, and $RER_N = P_N/P_N^*$.

Since we are primarily interested in accounting for relative prices, and not quantities, we assume an endowment economy, where the output of non-tradable and tradable goods are assumed to evolve exogenously.

The evidence presented above indicated that relative prices move in proportion to relative GDP for *all* categories of goods, both tradable and non-tradable. In order to account for this, we allow for a difference between wholesale and retail prices. Retail goods in the tradable sector are produced using a combination of raw wholesale goods and non-tradable good as inputs.

This captures the presence of a marketing or distribution sector. There is strong evidence for the role of distribution costs in retail pricing of tradable goods (refs). Here, we assume that the production of retail goods in sectors X and M must employ non-tradable goods in addition to raw wholesale goods, in order to transform these goods into consumable tradable goods. Thus, we assume that:

$$\begin{aligned} C_X &= \left(\kappa_1 I_X^{(1-\phi_1)} + (1-\kappa_1) I_{XN}^{1-\phi_1}\right)^{\frac{1}{1-\phi_1}} \\ C_M &= \left(\kappa_2 I_M^{(1-\phi_2)} + (1-\kappa_2) I_{MN}^{1-\phi_2}\right)^{\frac{1}{1-\phi_2}} \end{aligned}$$

where I_X (I_M), represents the direct use of wholesale tradable goods in producing retail consumables for X and M, respectively, and I_{XN} (I_{MN}) represents the use of non-tradable distribution services.

The model is closed with the addition of a home country budget constraint, and goods market clearing conditions. The home budget constraint is given by:

$$PC = P_X Y_X + P_N Y_N,$$

where Y_X (Y_N) indicates output off good X (N), and it is assumed that there is no intertemporal borrowing or lending across countries. This is a simplifying assumption, but it unlikely to have first order implications for the evolution of the real exchange rate, at least over the sample period in question for European exchange rates.

Goods market clearing conditions are given as:

$$\begin{aligned} \omega Y_X &= \omega I_X + (1-\omega) I_X^*, \\ (1-\omega) Y_M &= \omega I_M + (1-\omega) I_M^*, \\ Y_N &= C_N + I_{XN} + I_{MN}, \\ Y_N^* &= C_N^* + I_{XN}^* + I_{MN}^*. \end{aligned}$$

We use the model to look at the relationship between different real exchange rate measures, as defined above, and relative GDP. In the model without investment or government spending, relative GDP is just defined as relative real consumption, or

$$\frac{C}{C^*} = \frac{P_X Y_X + P_N Y_N}{P_M^* Y_M^* + P_N^* Y_N^*} \frac{P^*}{P}.$$

The relationship between the real exchange rate and relative GDP is obviously going to depend on the calibration of the model, as well as the assumptions about the drivers of GDP growth. For our calibration, we take a very standard set of parameter values. As regards sectoral shares, we set $\gamma = 0.7$ so that the non-tradable goods sector would represent thirty percent of consumption in a steady state with $P_N = P_T = 1$. Assume that the home country is relatively small as a part of the European economy, so that $\omega = 0.1$. For now, we abstract away from home bias in preferences, so that $\mu = 1$ is assumed. We assume that distribution services make up approximately 30 percent of the value added in the consumption of retail tradable goods, so that $\kappa_1 = \kappa_2 = 0.7$. This, in combination with $\gamma = 0.7$, implies that in total, non-traded goods would make up 50 percent of total production in a steady state with $P_N = P_T = 1$.

As regards elasticities, we use the standard assumpton of a low elasticity between tradable and non-tradable goods, in both final consumption and in distribution services. We follow Mendoza (1995), and use an elasticity of 0.65. Thus, we set $\lambda = \phi_1 = \phi_2 = 0.65$. Finally, the elasticity of substitution between home and foreign goods is an important parameter. If this elasticity is too low, then economic growth will lead to a large terms of trade deterioration and a real exchange rate depreciation, even if growth is quite concentrated in the traded goods sector. The recent literature has emphasized a distinction between short run and long run elasticities of substitution (e.g. Ruhl 2008). For annual data, the international business cycle literature has typically used elasticities lower than the long run estimates. We follow this lead, and set $\theta = 2$. This is lower than estimates of 5 or 6 found in long run trade estimates, but in the range of the estimates used in the macro literature. In fact, the results are not particularly sensitive to different values of θ in the range of 2 to 5.

We wish to examine the implications of differential *levels* and *growth rates* of relative GDP on real exchange rates. Given all other parameters in the model, the real exchange rate will depend on *cross-country differences* in the relative supply of exportables to non-tradables within a country. Even if the home countries GDP per capita was lower than that of the rest of the world, this would not necessarily imply a lower real exchange rate unless it also implied that the ratio of tradable goods to non-tradable was also less than that in the rest of the world. Likewise, growth over time in relative GDP per capita will be associated with real appreciation only if the growth rate of tradable goods exceeds that of non-tradable goods.

Our results above indicate an *empirical* elasticity of the real exchange rate to relative GDP per capita equal to about .35, *both* across countries and over time. We use the model to reproduce this elasticity in both dimensions. This involves calibrating a) the cross country differences in the ratios of tradable to non-tradable endowment as a function of relative GDP, and b) the cross country differences in the growth rate of tradable relative to non-tradable endowments.

In Figure 16, given the other parameters of the model, we calibrate as follows. First, assume that the home economy is growing relative to the rest of the world, so that home relative GDP per capita is increasing. In the Figure, the growth rate is set at 1.04 for illustration purposes, but it could be set at any rate. Without loss of generality, we set the ratio of Y_M to Y_N^* in the rest of the world economy to unity, and assume a zero growth rate in Y_M and Y_N^*. Then, we assume that the growth rate of Y_N in the home economy is .75 times the growth rate of Y_X. This implies, for the calibration in the Figure, that N will grow at less than 4 percent, and Y_X will grow at greater than four percent. Finally, we calibrate the initial ratio of Y_N to Y_X so that, when relative GDP per capita is equal to unity, then the real exchange rate is also equal to unity. The Figure then illustrates the path of the home country's relative GDP, and its overall real exchange rate, as well as the real exchange rate in tradable goods. The bottom panel of the Figure illustrates the analogue of the empirical elasticity of the real exchange rate to relative GDP. It is the ratio of the rate of change of the real exchange rate to the rate of change of relative GDP per capita, as a function of relative GDP per capita (on the x-axis). As we see, at a relative GDP equal to unity, the elasticity is approximately 0.32, which roughly matches the empirical elasticity. The simulation illustrates the key properties of the real exchange rate seen in the data - the deviations in relative GDP per capita are larger than the deviations in the real exchange rate from PPP, and as relative GDP per capita transits from below average to above average, the real exchange rate moves from being below PPP to being above PPP, with the relative GDP per capita locus intersecting the real exchange rate locus from below. We see also that very similar features apply to the tradable good real exchange rate, except the time-varying deviation in the tradable good real exchange rate from PPP is less than that for the overall real exchange rate.

This calibration therefore matches the gross features of the real exchange rate-relative GDP relationship found in the data. We now take this exact calibration and apply it to to observed GDP data. In particular, we take

Irelands relative GDP per capita as an example. As seen above, Ireland's real exchange rate-GDP displayed the exact features we see in Figure 16. But since our calibration was based on the empirical elasticity estimated for all countries, not just Irish data, then it is not automatic that the calibration in Figure 16 will apply to Ireland.

To apply this to the Irish case, we simulate the model in the following way. First, we choose the levels and growth rates of Y_X and Y_N so as to exactly reproduce the historical path of relative GDP per capita for Ireland over the sample. Secondly, we follow Figure 16 in choosing the growth rate of Y_N equal to 0.75 times the growth rate in Y_X, and choose the initial ratio of Y_N to Y_X so that if the growth rate were constant over time, the real exchange rate would be at purchasing power parity when relative GDP per capita equals unity. This equality will not occur exactly in the model, because the historical path of the growth rate in relative GDP per capita was not in fact constant.

Figure 17 illustrates the simulated path of the real exchange rate based on the two-part calibration just described, given than we have chosen the path of real GDP per capita to match the historical sample. The match between the simulated real exchange rate and the historical data is quite remarkable, given that the calibration is based on the properties of the real exchange rate-relative GDP per capita relationship for all countries and time periods.

8 Conclusions

To be added..

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Table 1. PLI basic headings, Household expenditures

Rice	Major tools and equipment
Other cereals, flour and other cereal products	Small tools and miscellaneous accessories
Bread	Non-durable household goods
Other bakery products	Domestic services
Pasta products	Household services
Beef and Veal	Pharmaceutical products
Pork	Other medical products
Lamb, mutton and goat	Therapeutical appliances and equipment
Poultry	Medical Services
Other meats and edible offal	Services of dentists
Delicatessen and other meat preparations	Paramedical services
Fresh, chilled or frozen fish and seafood	Hospital services
Preserved or processed fish and seafood	Motor cars with diesel engine
Fresh milk	Motor cars with petrol engine of cubic capacity of less than 1200cc
Preserved milk and other milk products	Motor cars with petrol engine of cubic capacity of 1200cc to 1699cc
Cheese	Motor cars with petrol engine of cubic capacity of 1700cc to 2999cc
Eggs and egg-based products	Motor cars with petrol engine of cubic capacity of 3000cc and over
Butter	Motor cycles
Margarine	Bicycles
Other edible oils and fats	Animal drawn vehicles
Fresh or chilled fruit	Spare parts and accessories for personal transport equipment
Frozen, preserved or processed fruit	Fuels and lubricants for personal transport equipment
Fresh or chilled vegetables other than potatoes	Maintenance and repair of personal transport equipment
Fresh or chilled potatoes	Other services in respect of personal transport equipment
Frozen, preserved or processed vegetables	Passenger transport by railway
Sugar	Passenger transport by road
Jams, marmalades and honey	Passenger transport by air
Confectionery, chocolate and other cocoa preps	Passenger transport by sea and inland waterway
Edible ice, ice cream and sorbet	Combined passenger transport
Coffee, tea and cocoa	Other purchased transport services
Mineral waters	Postal services
Soft drinks and concentrates	Telephone and telefax equipment
Fruit and vegetable juices	Telephone and telefax services
Spirits	Equipment for reception, recording and reproduction of sound and pictures
Wine	Photographic and cinematographic equipment and optical instruments
Beer	Information processing equipment
Tobacco	Pre-recorded recording media
Narcotics	Unrecorded recording media
Other clothing and clothing accessories	Repair of audio-visual, photographic and information processing equipment
Clothing materials	Major durables for outdoor recreation
Men's clothing	Musical instruments and major durables for indoor recreation
Women's clothing	Maintenance and repair of other major durables for recreation and culture
Childrens and infants clothing	Games, toys and hobbies
Other clothing and clothing accessories	Equipment for sport, camping and open-air recreation
Cleaning, repair and hire of clothing	Gardens, plants and flowers
Men's footwear	Pets and related products
Women's footwear	Veterinary and other services for pets
Children's and infant's footwear	Recreational and sporting services
Repair and hire of footwear	Photographic services
Actual rentals for housing	Other cultural services
Imputed rentals for housing	Games of chance
Materials for maintenance and repair of dwelling	Books
Services for maintenance and repair of dwelling	Newspapers and periodicals
Water supply oils and fats	Miscellaneous printed matter, stationery and drawing materials
Miscellaneous services relating to the dwelling	Package holidays
Electricity	Pre-primary and primary education
Gas	Secondary education
Liquid fuels	Post-secondary education
Solid fuels	Tertiary education
Heat energy	Education not definable by level
Kitchen furniture	Restaurant services whatever the type of establishment
Bedroom furniture	Pubs, bars, cafs, tea rooms and the like
Living-room and dining-room furniture	Canteens
Other furniture and furnishings	Accommodation services
Carpets and other floor coverings	Hairdressing salons and personal grooming establishments
Repair of furniture, furnishings and floors	Electric appliances for personal care
Household textiles	Other appliances, articles and products for personal care
Major household appliances electric or not	Prostitution
Repair of furniture, furnishings and floors	Jewellery, clocks and watches
Household textiles	Other personal effects
Major household appliances electric or not	Social protection
Small electric household appliances	Insurance
Repair of household appliances	Net purchases abroad
Glassware, tableware and household utensils	Other financial services n.e.c.
	Other services n.e.c.

Table 2: Mean standard deviation of disaggregated real exchange rates

Belgium	6.2	Netherlands	7.1	Cyprus	6.5	Slovenia	7.5
Denmark	7	Austria	5.7	Czech Rep.	6.9	Bulgaria	5.8
Germany	5.5	Portugal	7.8	Estonia	5.5	Romania	7.8
Greece	7.7	Finland	6.1	Hungary	7.8	Turkey	6.1
Spain	6.1	Sweden	8.2	Latvia	5.9		
France	6.3	United Kingdom	9.7	Lithuania	6.7		
Ireland	7.7	Iceland	13.2	Malta	7.2		
Italy	7.6	Norway	8.8	Poland	7.1		
Luxembourg	6.5	Switzerland	6.4	Slovakia	6.9		

Table 3. Price level regressions, average country price

	All goods and services			Traded goods			Non-traded goods		
	Pooled	Country FE	Period FE	Pooled	Country FE	Period FE	Pooled	Country FE	Period FE
	1	2	3	4	5	6	7	8	9
log(RGDP)	**0.35*****	**0.34*****	**0.34*****	**0.28*****	**0.29*****	**0.29*****	**0.55*****	**0.48*****	**0.48*****
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Euro dummy	**-0.06*****	-0.01	-0.01	**-0.07*****	-0.01	-0.01	-0.03	-0.02	-0.02
	(0.00)	(0.23)	(0.23)	(0.00)	(0.34)	(0.34)	(0.23)	(0.21)	(0.21)
log(Distance)	**0.1*****	–	**0.2*****	**0.11*****	–	**0.18*****	**0.1*****	–	**0.29*****
	(0.00)		(0.00)	(0.00)		(0.00)	(0.00)		(0.00)
R^2	0.94	0.94	0.98	0.91	0.98	0.98	0.94	0.99	0.99
N	351	351	351	351	351	351	351	351	351

Dependant variable: Logarithm of price level relative to EU15. All standard errors computed using Arellano (1987) adjustment of White's HCCM. p-values in parentheses. A * denotes 10%, ** 5% and *** 1% significance.

Table 4. Price level regressions (average price) by country group

	Western Europe						Southern and Eastern Europe					
	All		Traded goods		Non-traded goods		All		Traded goods		Non-traded goods	
	Pool	FE	Pool	FE	Pool	FE	Pool	FE	Pool	FE	Pool	FE
	1	2	3	4	5	6	7	8	9	10	11	12
log(RGDP)	**0.41*****	**0.42*****	**0.36*****	**0.34*****	**0.51*****	**0.57*****	**0.27*****	**0.31*****	**0.23*****	**0.27*****	**0.43*****	**0.44*****
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Euro dummy	**-0.06*****	-0.01	**-0.05*****	-0.01	-0.07**	-0.02	**0.06*****	0.003	**0.04*****	0.004	**0.11****	-0.03
	(0.00)	(0.26)	(0.00)	(0.35)	(0.03)	(0.25)	(0.00)	(0.66)	(0.00)	(0.53)	(0.02)	(0.77)
log(Distance)	**0.11*****	–	**0.13*****	–	**0.07****	–	**0.15*****	–	**0.12*****	–	**0.2*****	–
	(0.00)		(0.00)		(0.03)		(0.00)		(0.00)		(0.00)	
R^2	0.81	0.96	0.80	0.96	0.78	0.96	0.89	0.96	0.87	0.92	0.90	0.96
N	234	234	234	234	234	234	117	117	117	117	117	117

Dependant variable: Logarithm of price level relative to EU15. "FE" denotes a country fixed effect regression. All standard errors computed using Arellano (1987) adjustment of White's HCCM. p-values in parentheses.

Table 5. Price level regressions, all prices

	All goods			Traded		Non-Traded	
	Pooled	Country dummies		Pooled	CD	Pooled	CD
	1	2	3	4	5	6	7
log(RGDP)	**0.40*****	**0.39*****	**0.39*****	**0.29*****	**0.35*****	**0.61*****	**0.53*****
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Euro dummy	**-0.04*****	**-0.01*****	**-0.01*****	**-0.06*****	**-0.01****	**-0.02****	**-0.02****
	(0.00)	(0.00)	(0.00)	(0.00)	(0.03)	(0.02)	(0.04)
log(Distance)	**0.11*****	–	0.23	**0.11*****	–	**0.11*****	**0.38***
	(0.00)		(0.14)	(0.00)		(0.00)	(0.09)
R^2	0.48	0.50	0.50	0.43	0.45	0.67	0.71
N	51,246	51,246	51,246	34,047	34,047	17,199	17,199

Dependant variable: Logarithm of price level relative to EU15. p-values in parentheses, computed using Newey-West standard errors. A * denotes 10%, ** 5% and *** 1% significance.

Table 5b. Productivity in price regressions, all prices

	All goods			Traded			Non-Traded	
	Pooled	Country dummies		Pooled	CD	CD	Pooled	CD
	1	2	3	4	5	6	7	8
log(RGDP)	**0.40*****	**0.45*****	–	**0.30*****	**0.38*****	–	**0.60*****	**0.60*****
	(0.00)	(0.00)		(0.00)	(0.00)		(0.00)	(0.00)
log(RPROD)	**0.04*****	**0.01**	**0.03*****	**0.02****	0.01	**0.03*****	**0.10*****	**0.08*****
	(0.00)	(0.35)	(0.01)	(0.04)	(0.46)	(0.01)	(0.00)	(0.00)
Euro dummy	**-0.04*****	**-0.01*****	**-0.01*****	**-0.04*****	**-0.01****	**-0.01****	**-0.04*****	**-0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.03)	(0.04)	(0.00)	(0.07)
log(Distance)	**0.08*****	**0.30*****	**0.30*****	**0.08*****	**0.12***	**0.13***	**0.07*****	**0.57***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.1)	(0.07)	(0.00)	(0.09)
R^2	0.46	0.51	0.50	0.40	0.45	0.44	0.66	0.73
N	33,783	33,783	33,783	22,944	22,944	22,944	10,839	10,839

Dependant variable: Logarithm of price level relative to EU15. p-values in parentheses, computed using Newey-West standard errors. A * denotes 10%, ** 5% and *** 1% significance.

Figure 1: Examples of prices

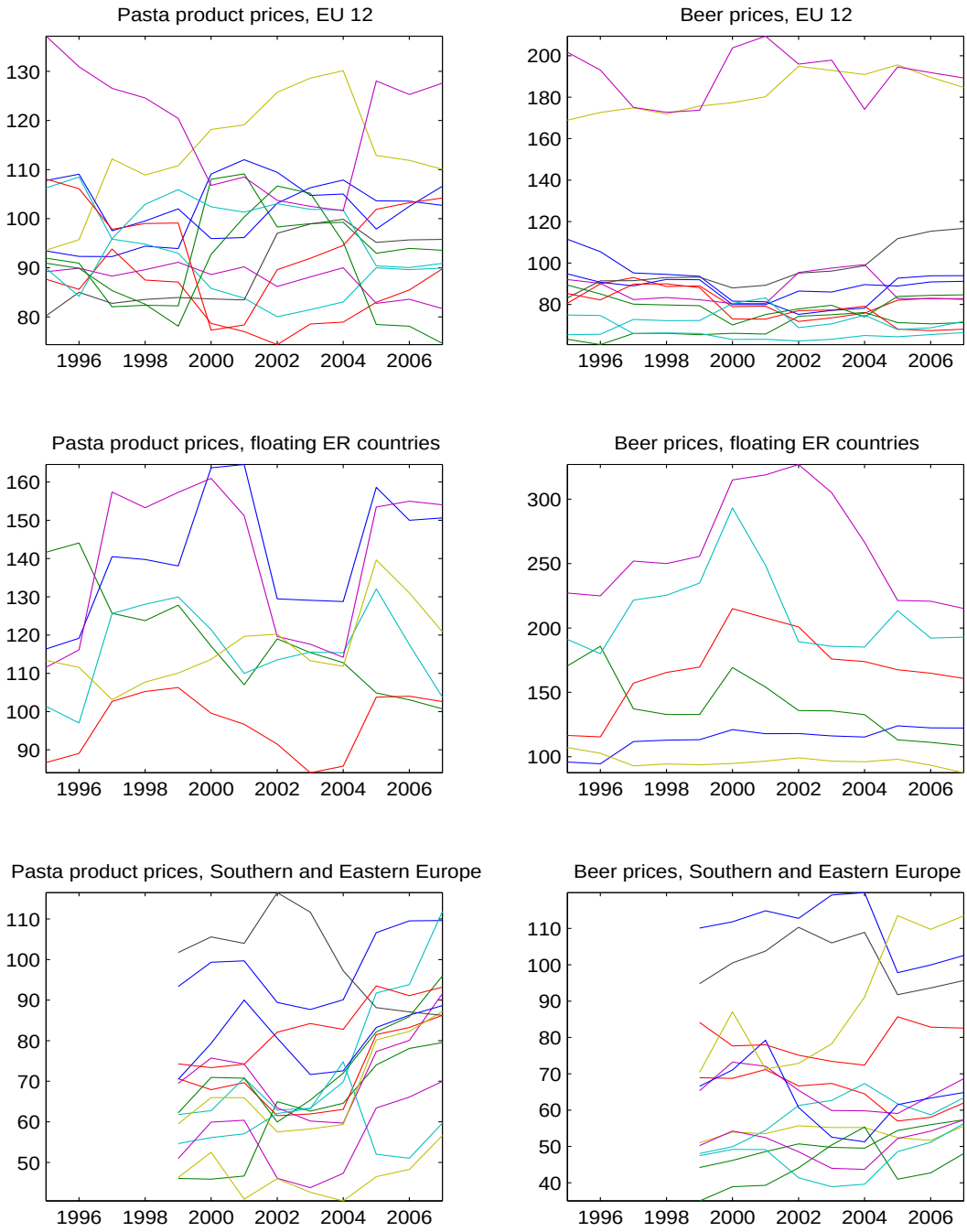


Figure 2: Average PLI's

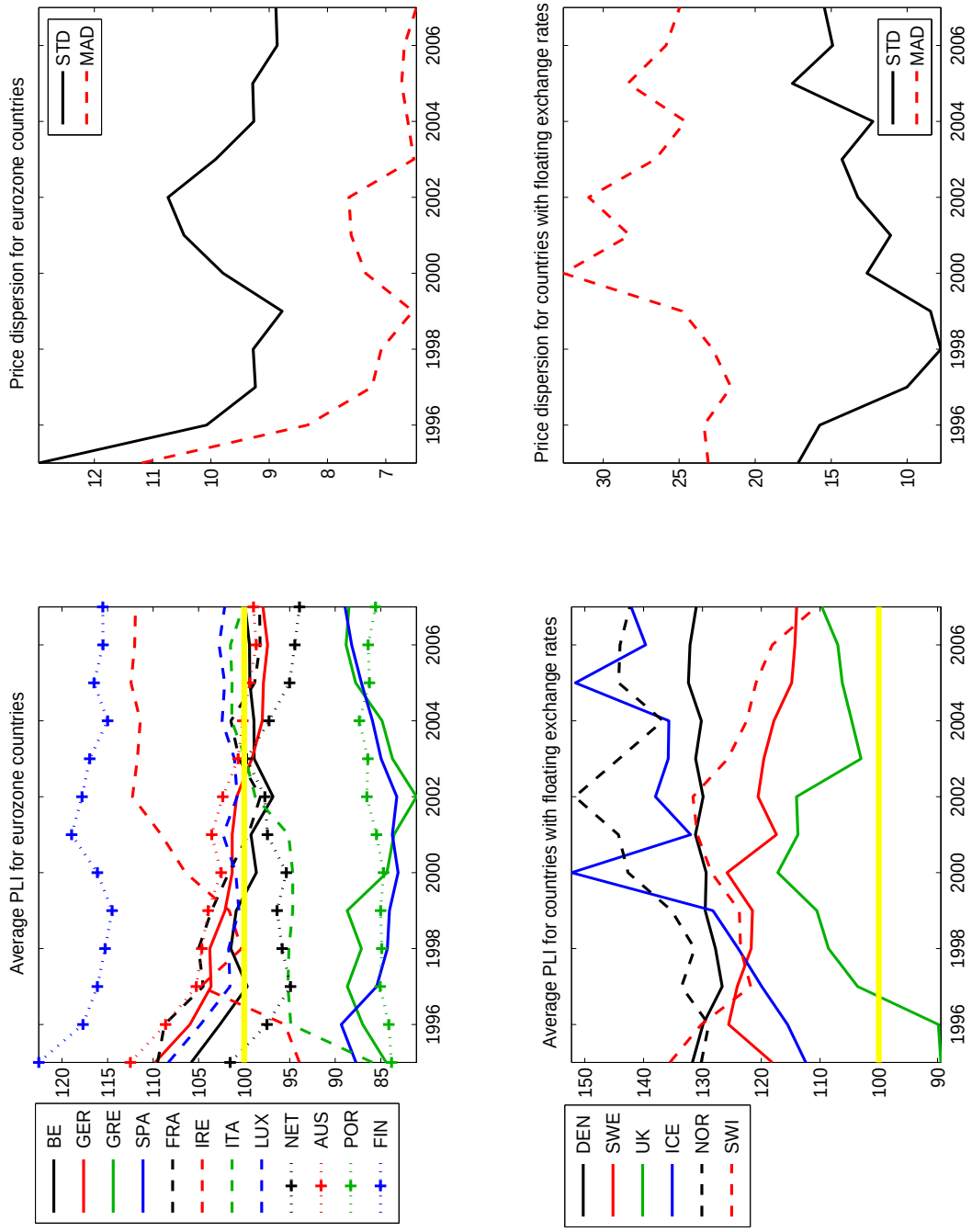


Figure 3: Price dispersion between eurozone countries without Ireland

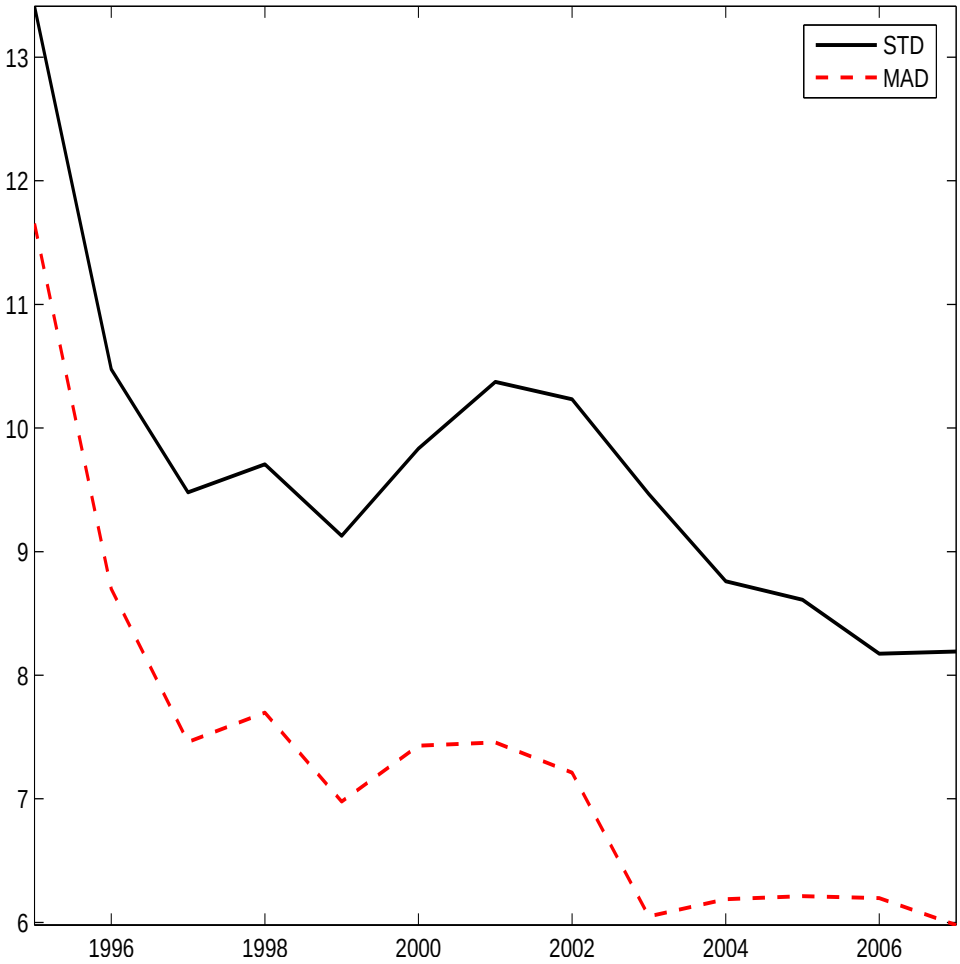


Figure 4: Average PLI's in Southern and Eastern Europe

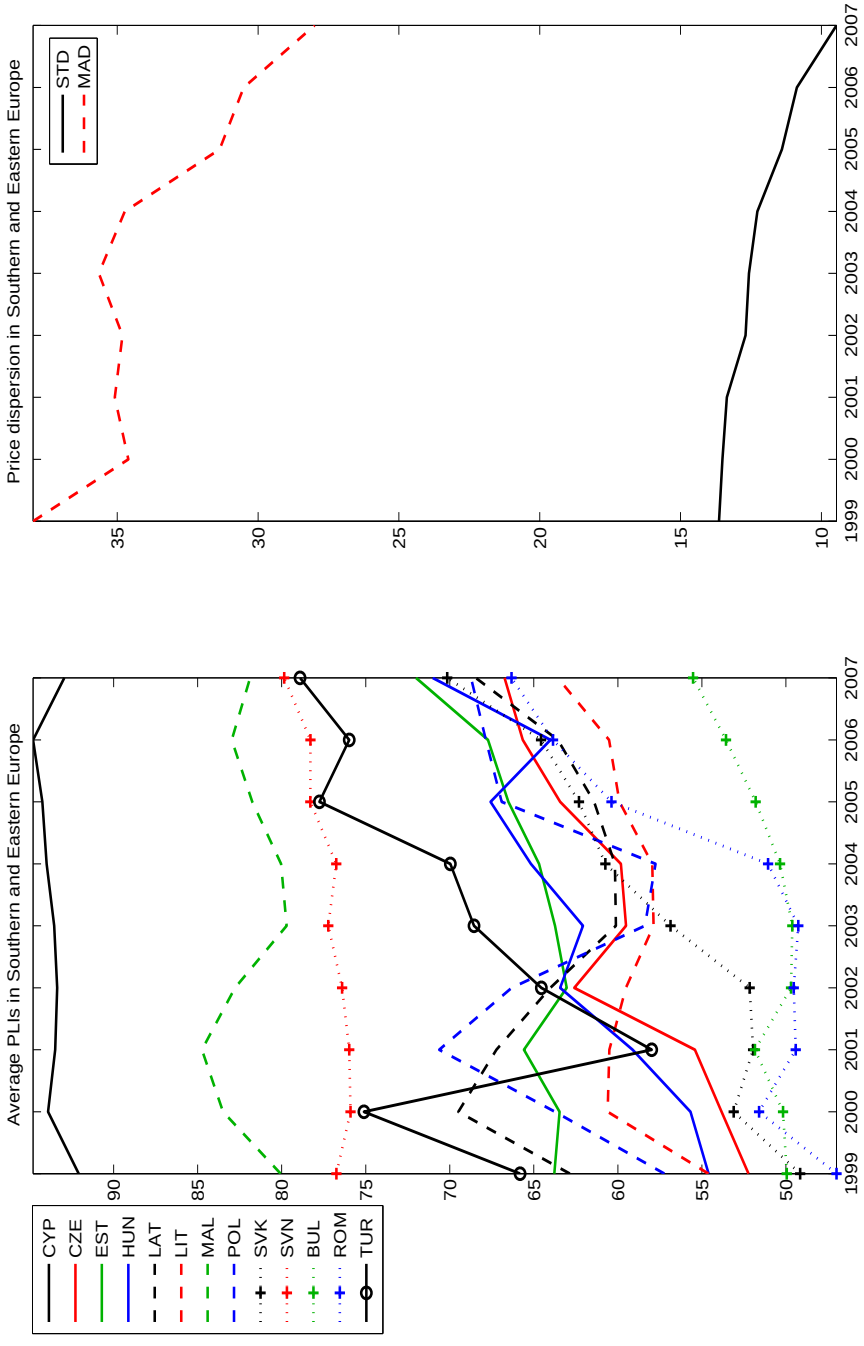


Figure 5: Prices of 146 goods and services vis-a-vis EU15 mean, Western Europe

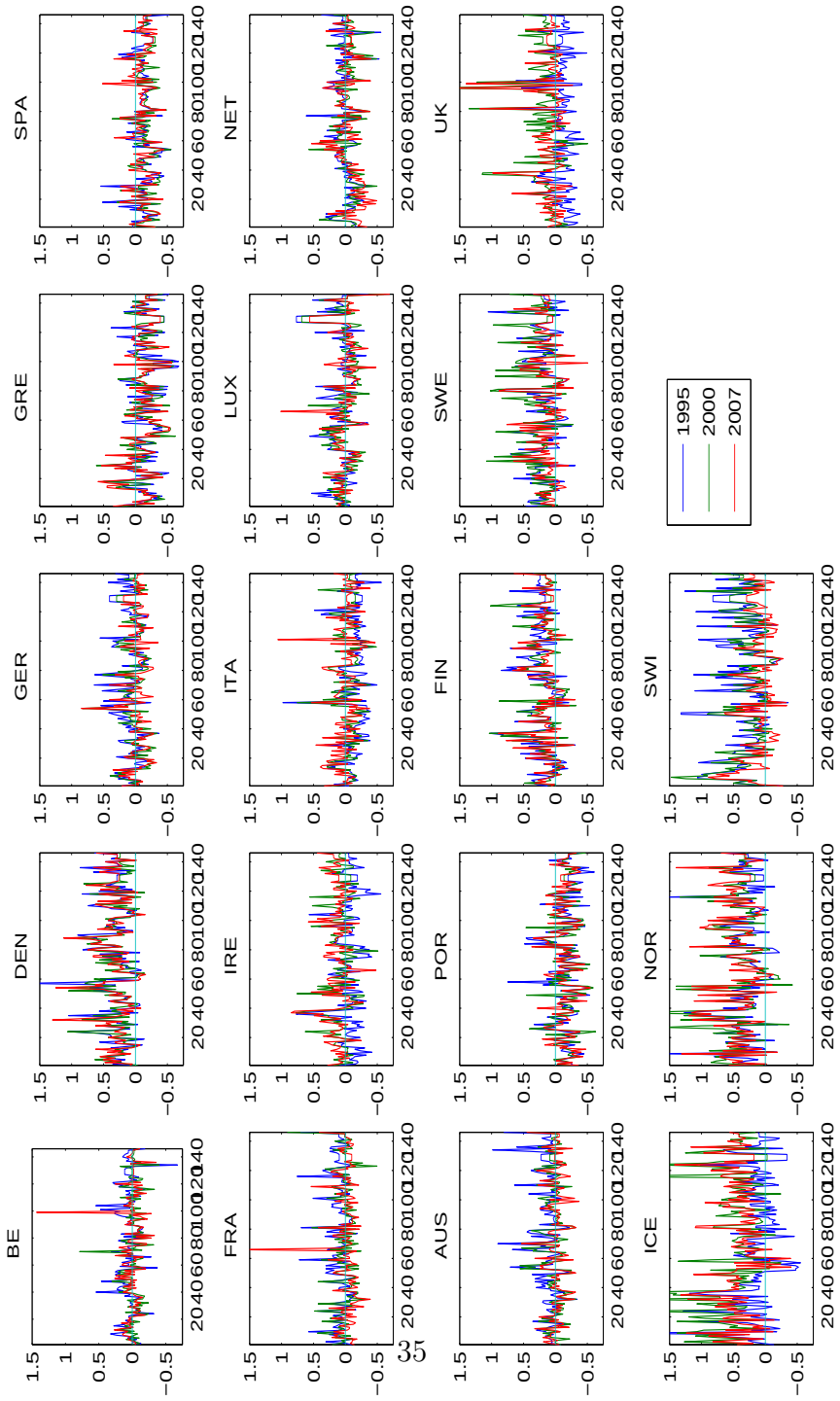


Figure 5 continued: Prices of 146 goods and services vis-a-vis EU15 mean, Southern and Eastern Europe

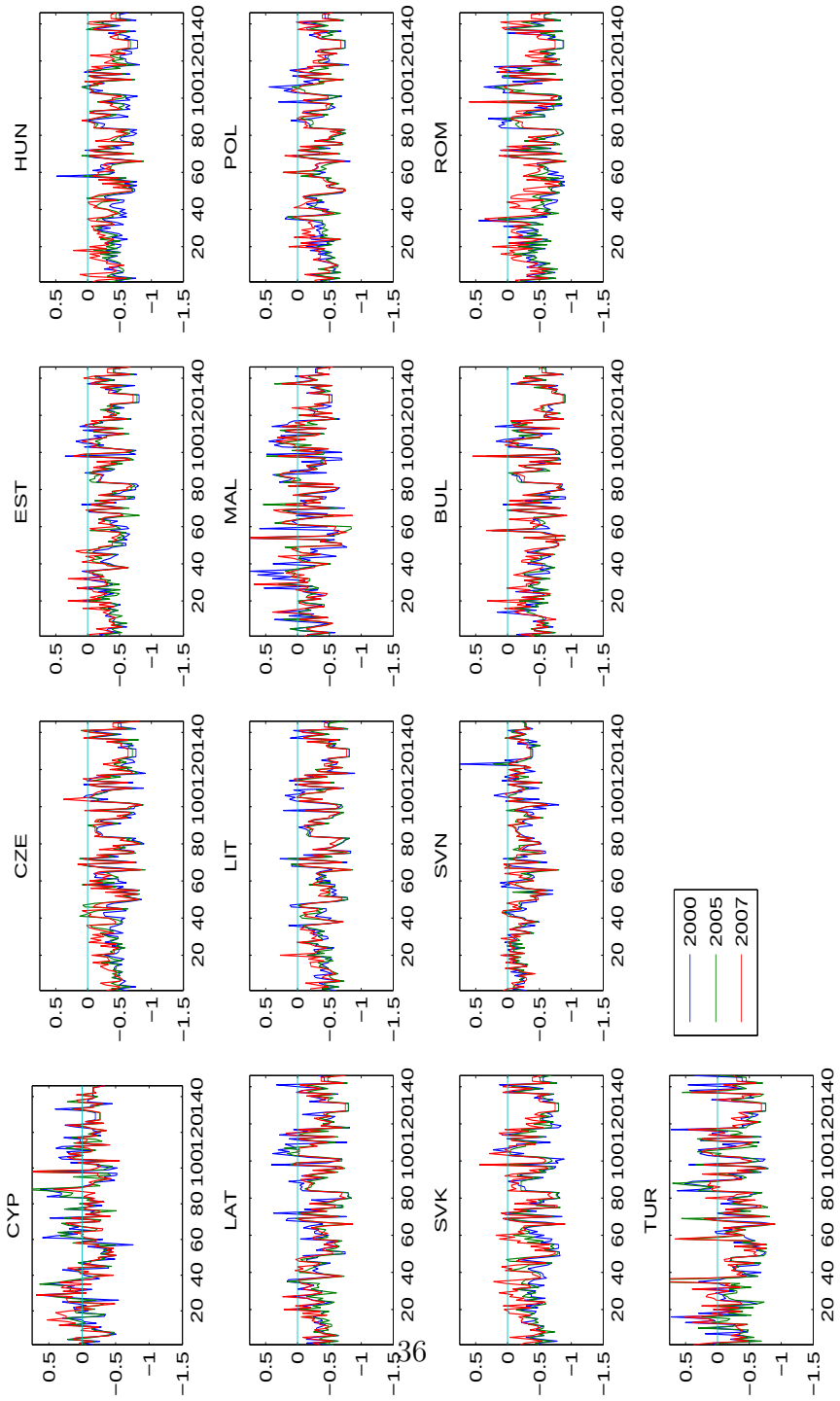


Figure 6: Dispersion within countries

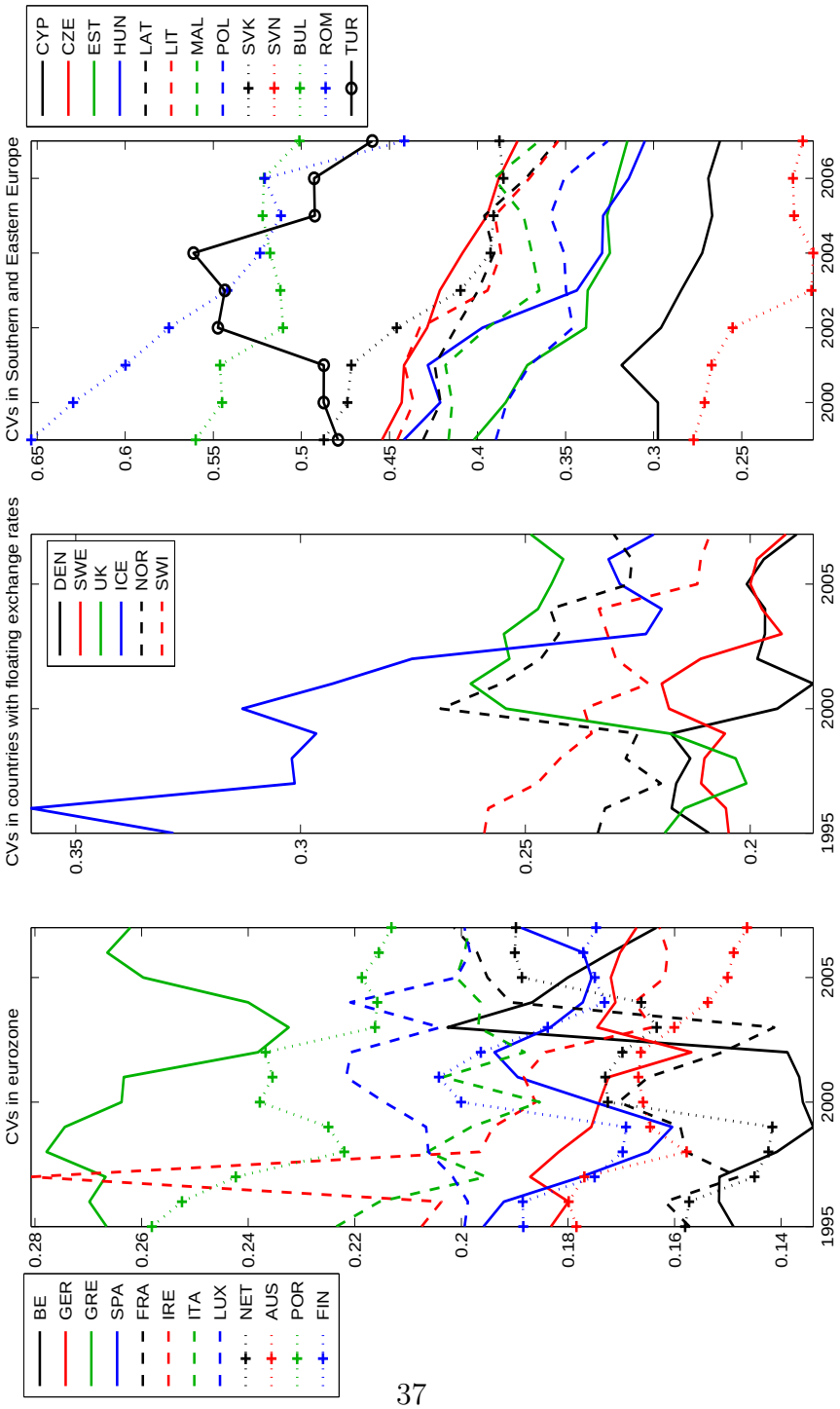


Figure 7: Relationship between mean PLI and price dispersion within country

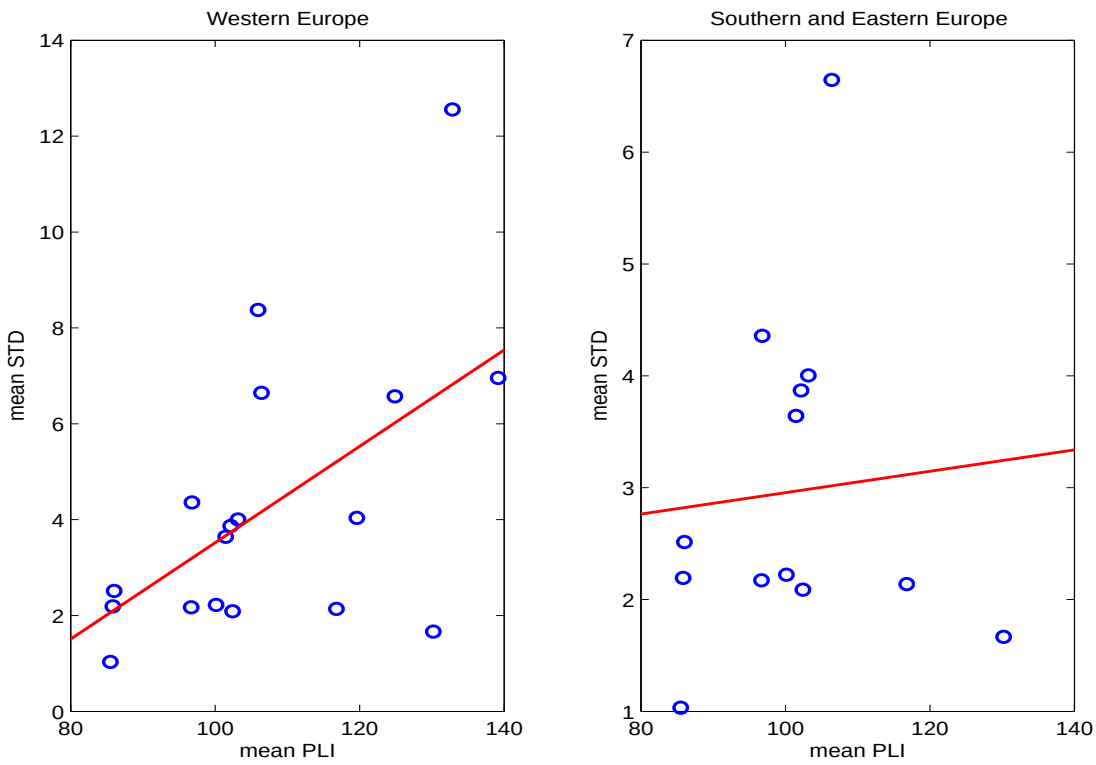


Figure 8: Kernel density estimates of all price levels, Western Europe

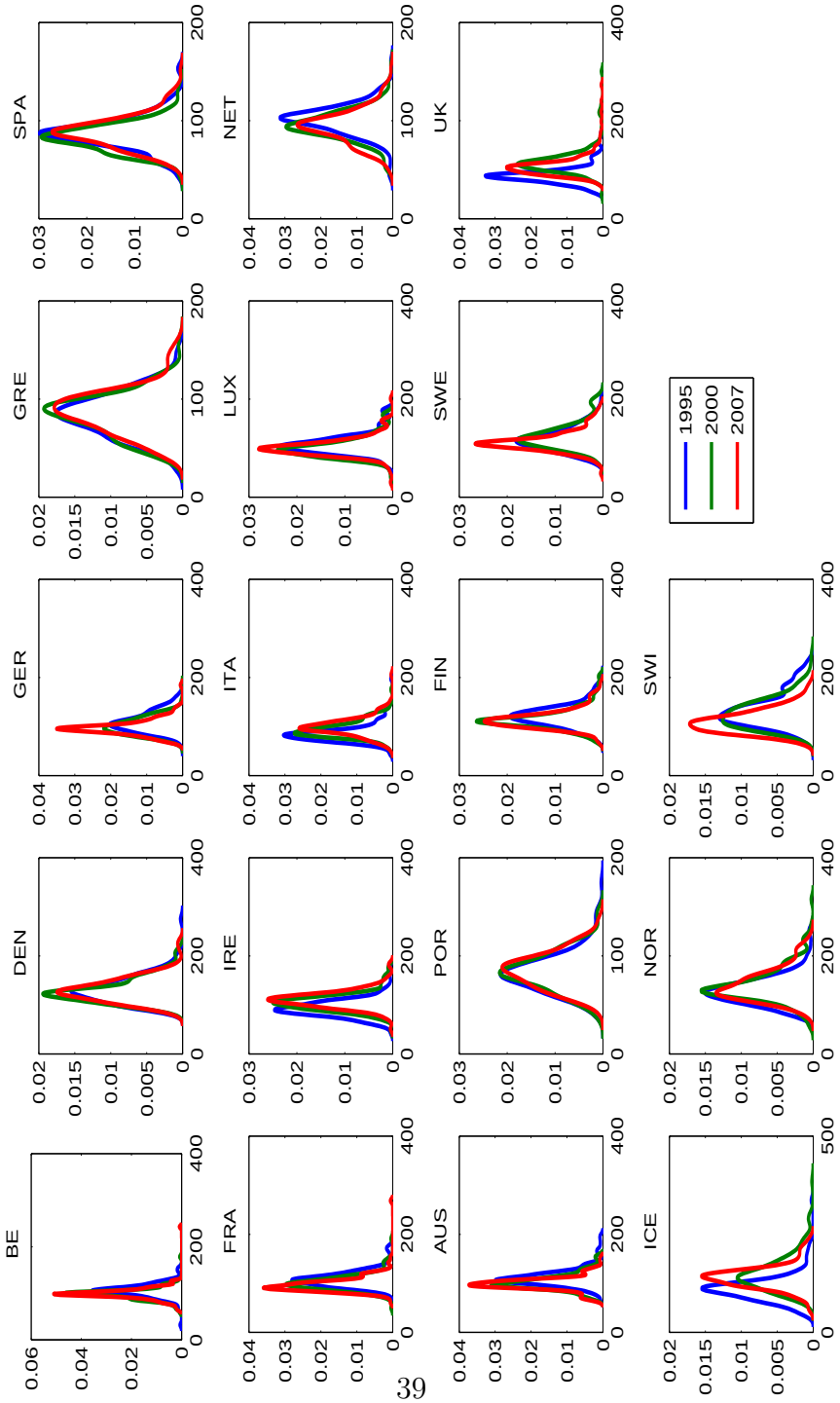


Figure 8 continued: Kernel density estimates of all price levels, Southern and Eastern Europe

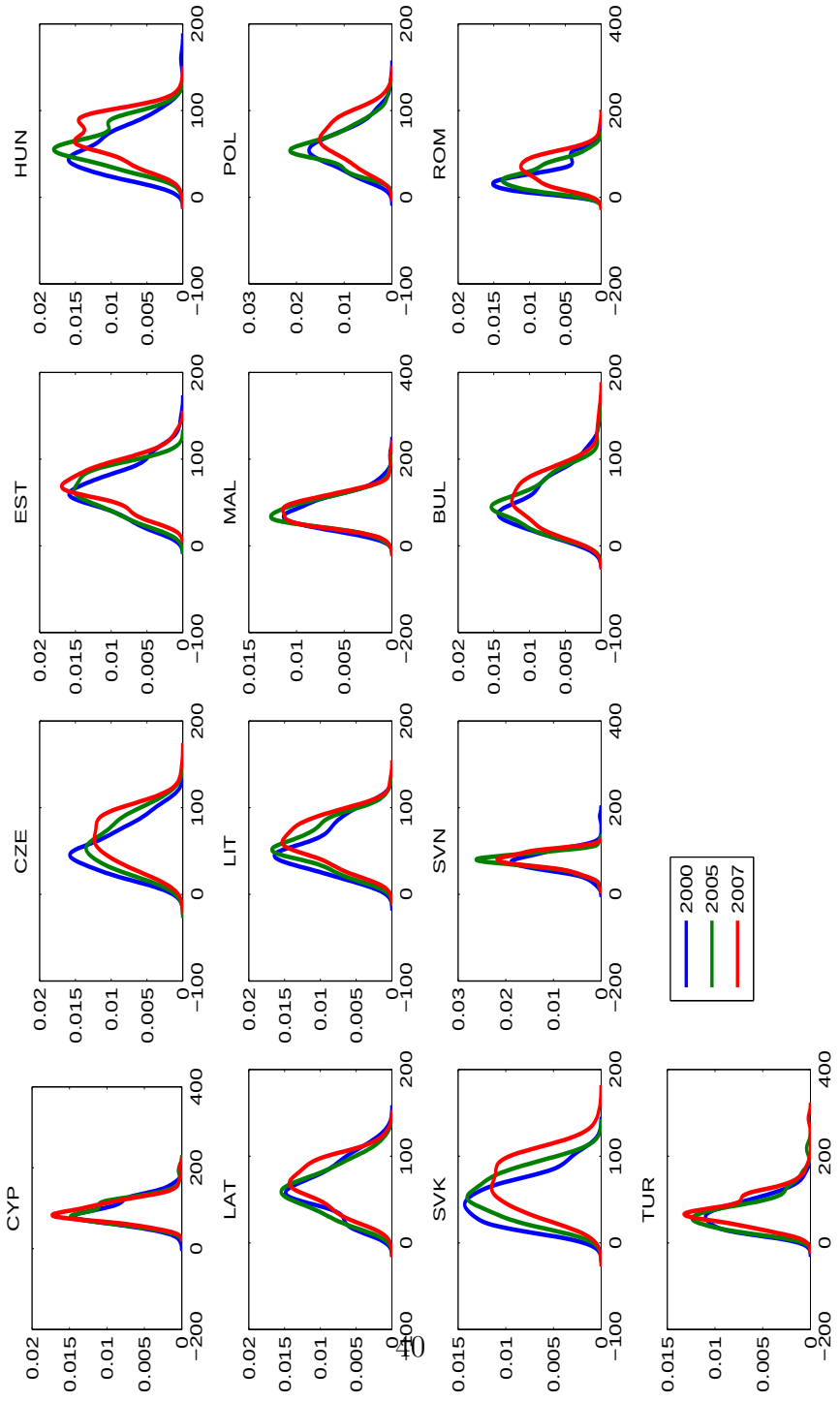


Figure 9: Evolution of price distribution for euro-member countries

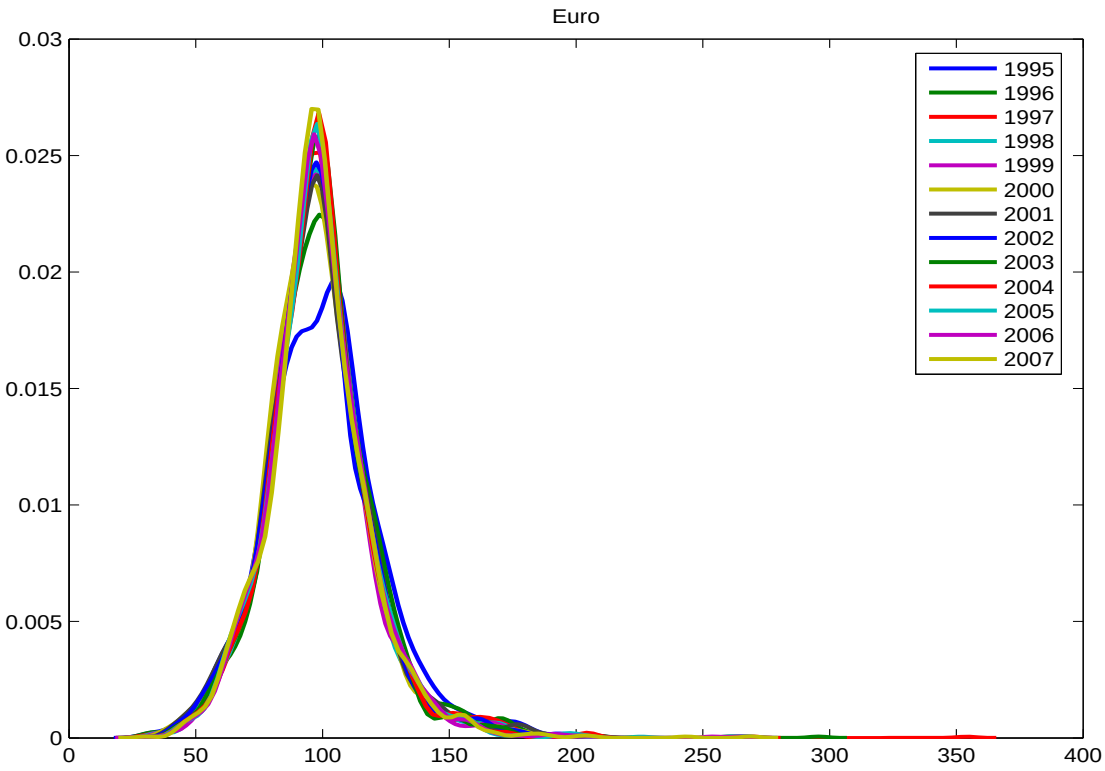


Figure 9 continued: Evolution of price distribution for countries with floating exchange rates

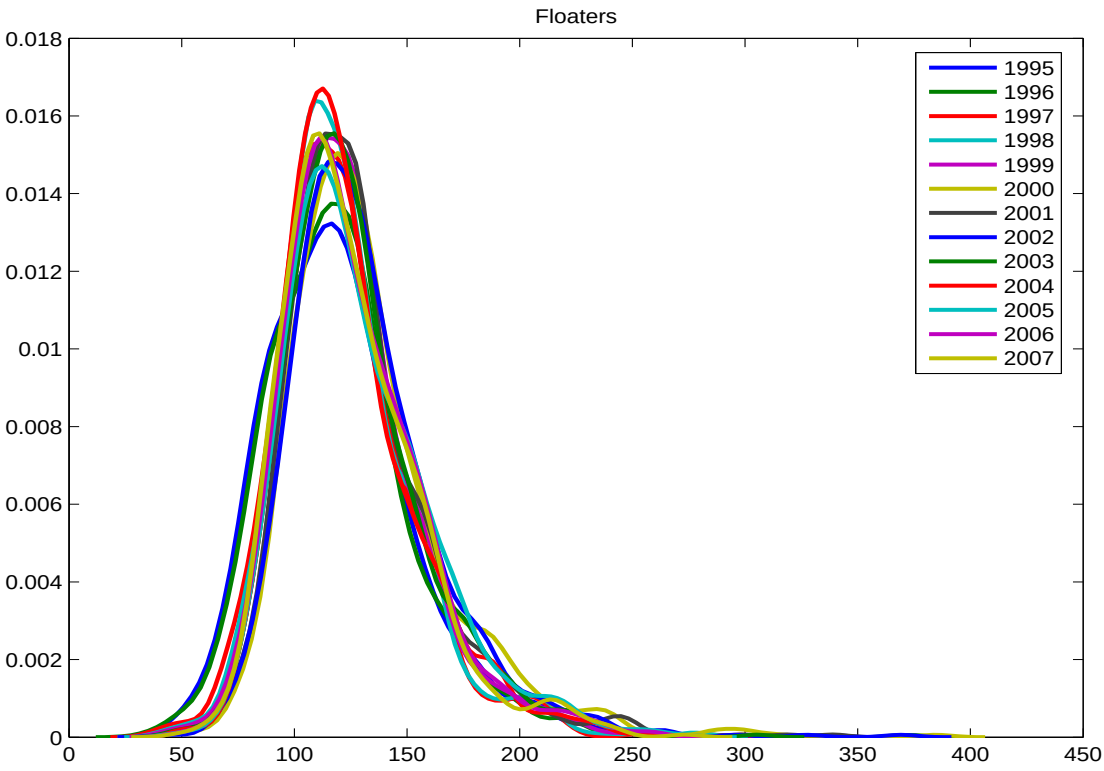


Figure 9 continued: Evolution of price distribution for countries in Southern and Eastern Europe

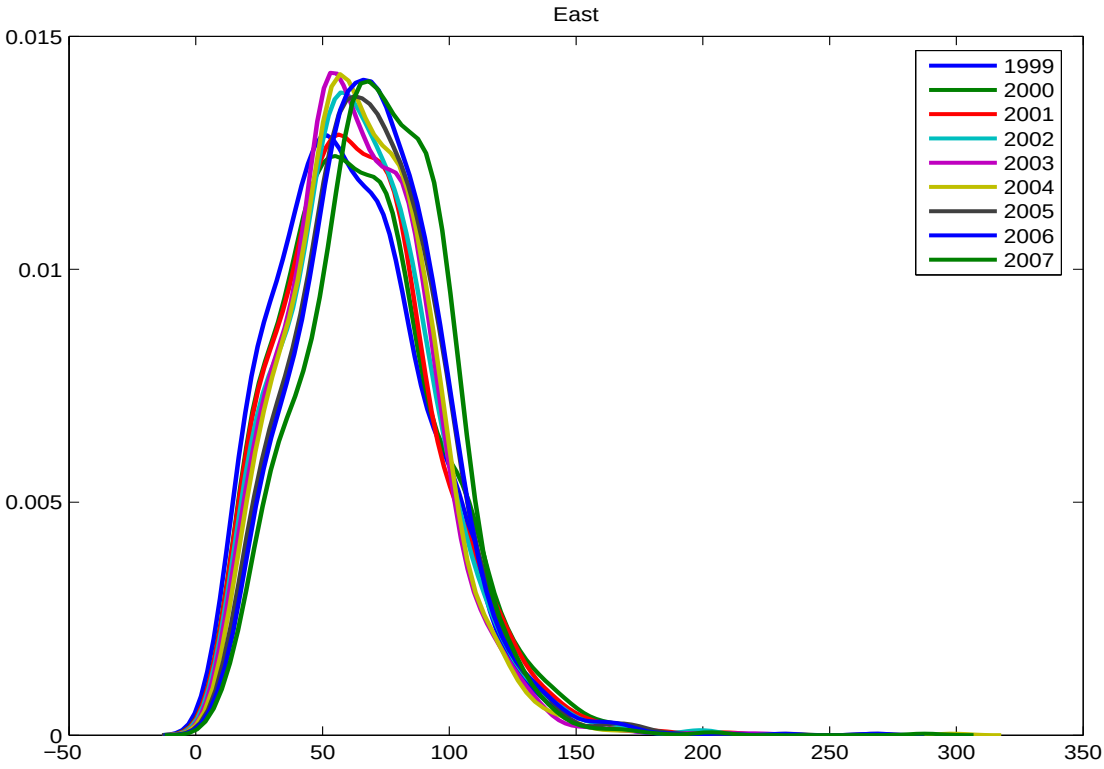


Figure 10: Decomposition into Traded and Non-Traded, Western Europe

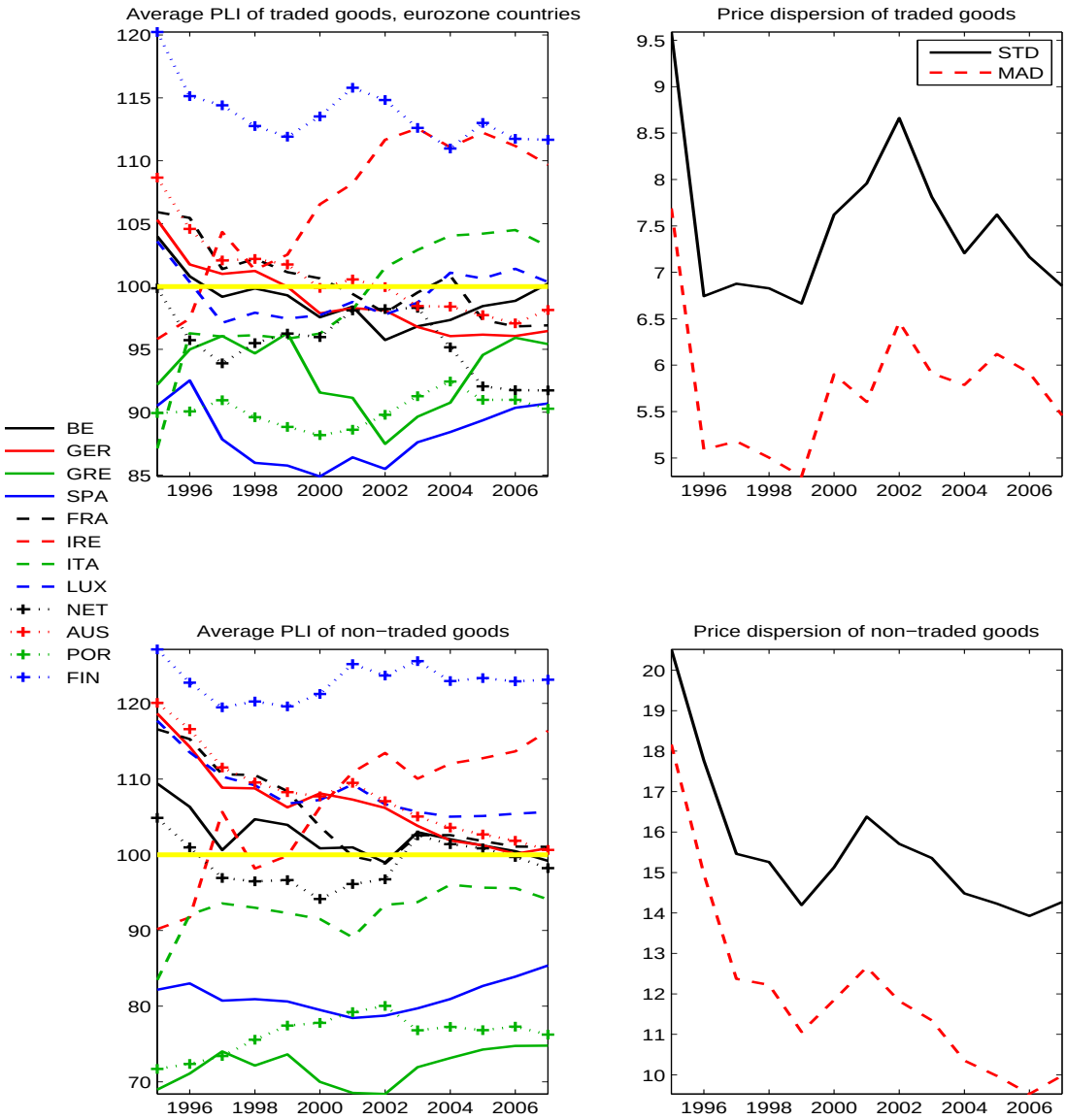


Figure 11: Decomposition into Traded and Non-Traded, countries in Western Europe with floating exchange rates

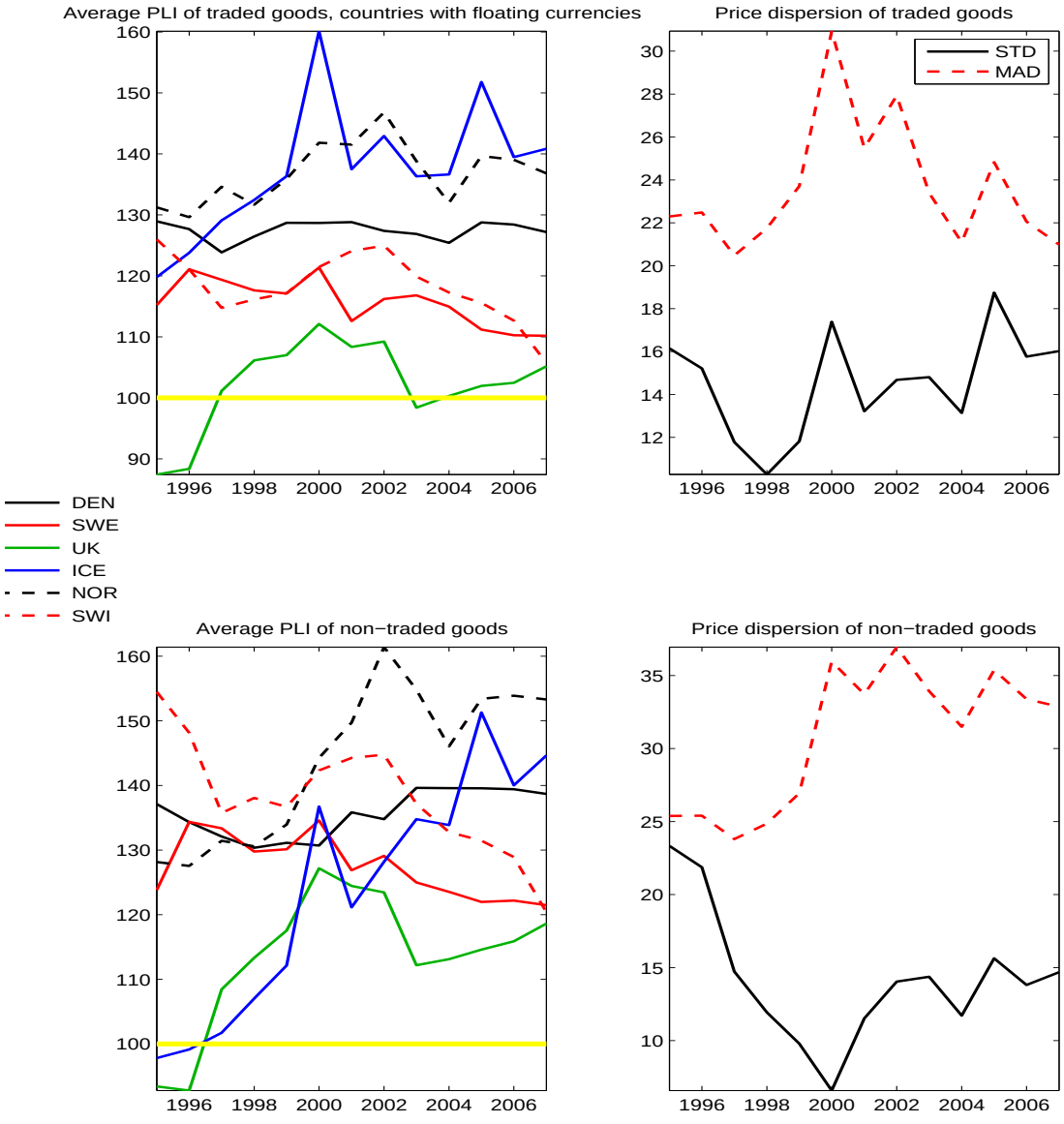


Figure 12: Decomposition into Traded and Non-Traded, Southern and Eastern Europe

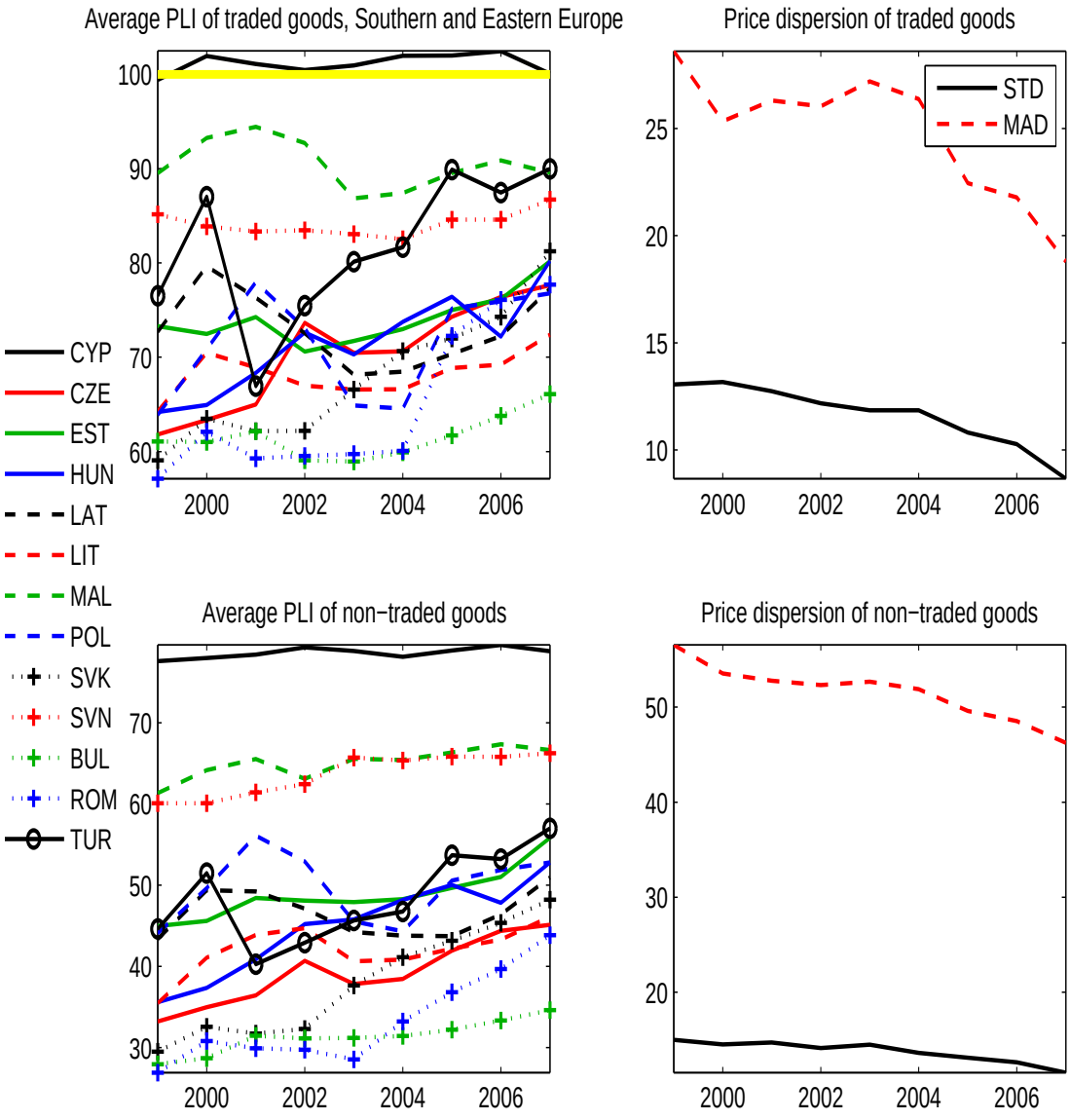


Figure 13: Relative GDP per capita and average PLI's in Western Europe

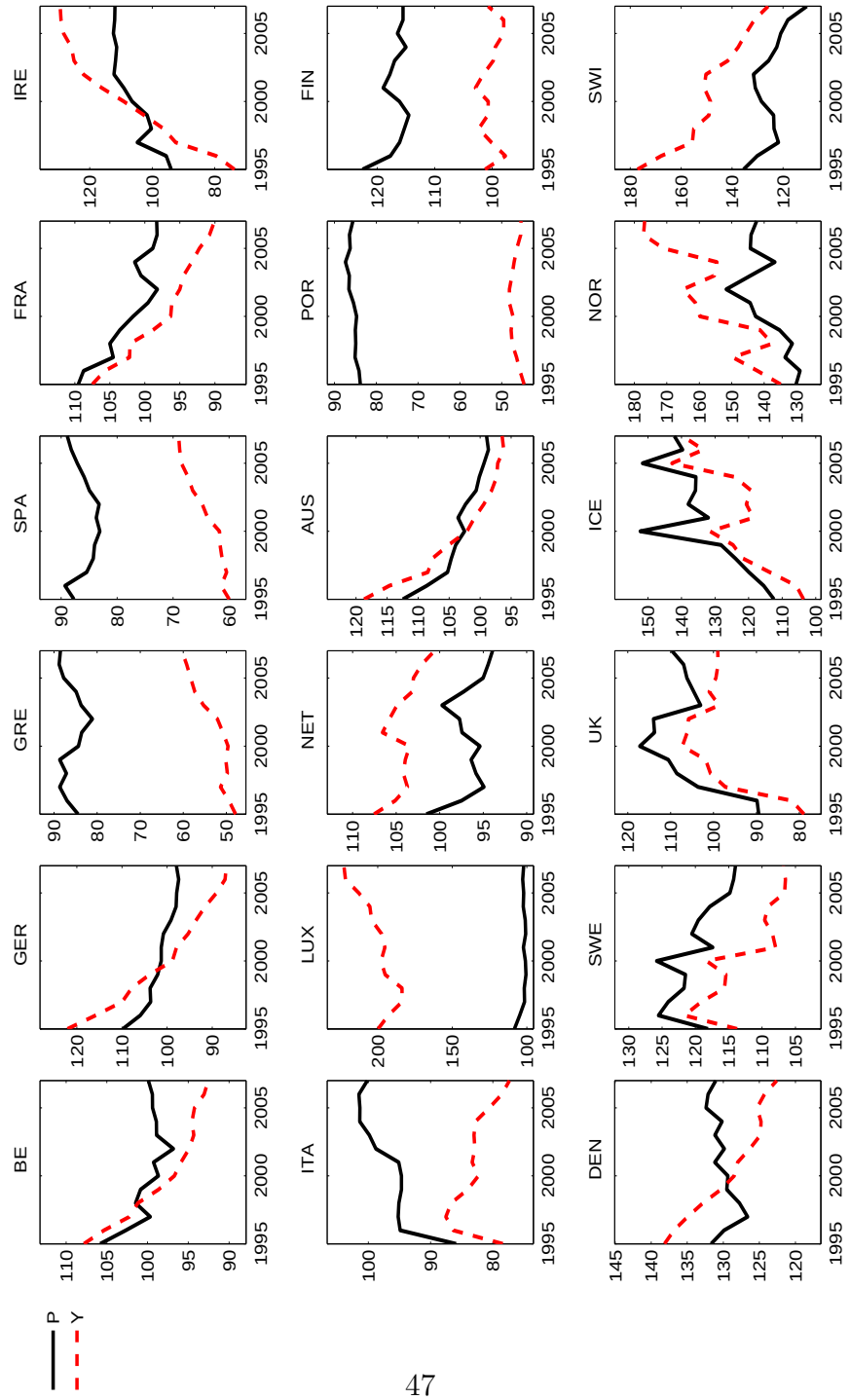


Figure 13 continued: Relative GDP per capita and average PLI's in Southern and Eastern Europe

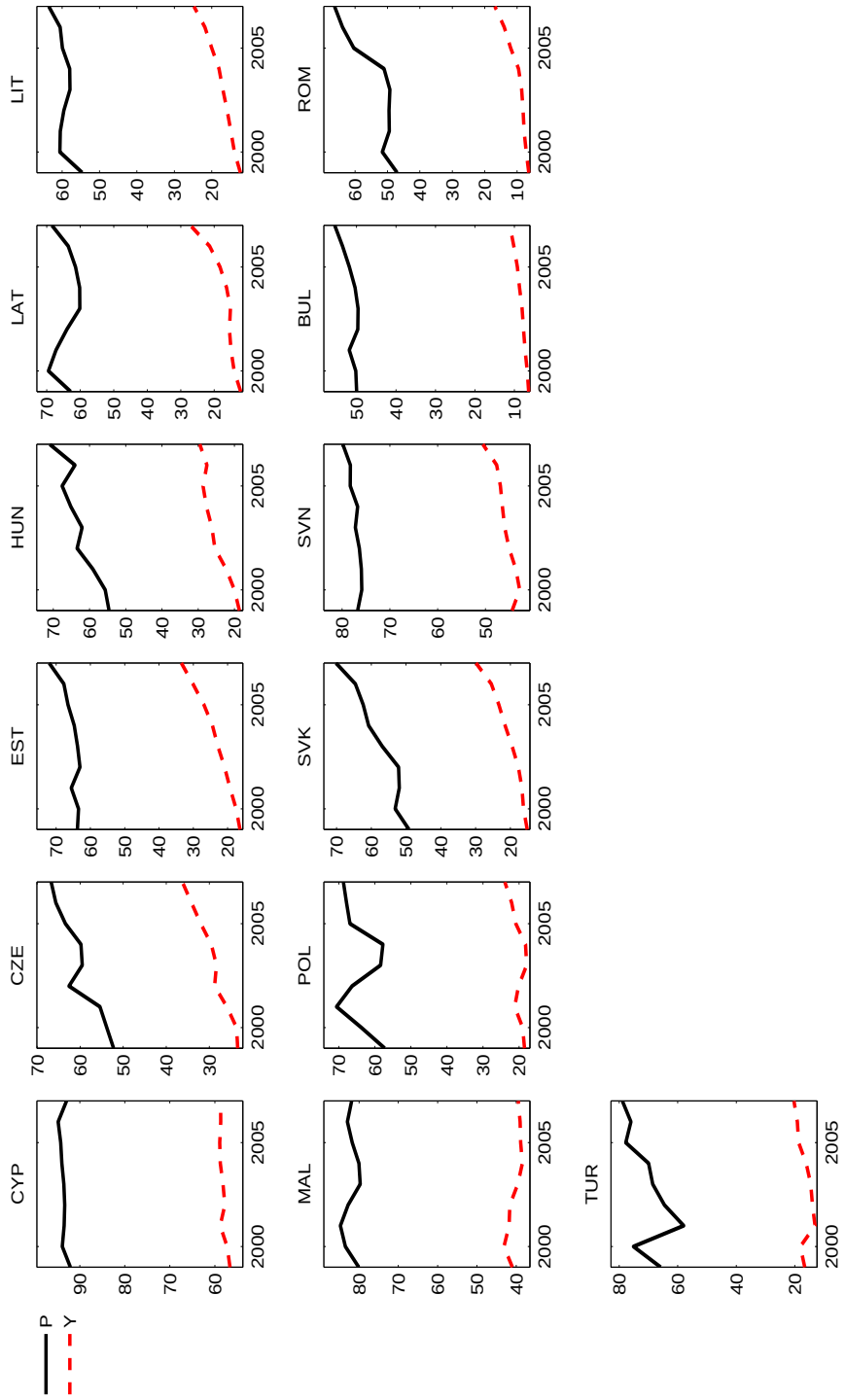


Figure 14: Real exchange rate and GDP: pooled

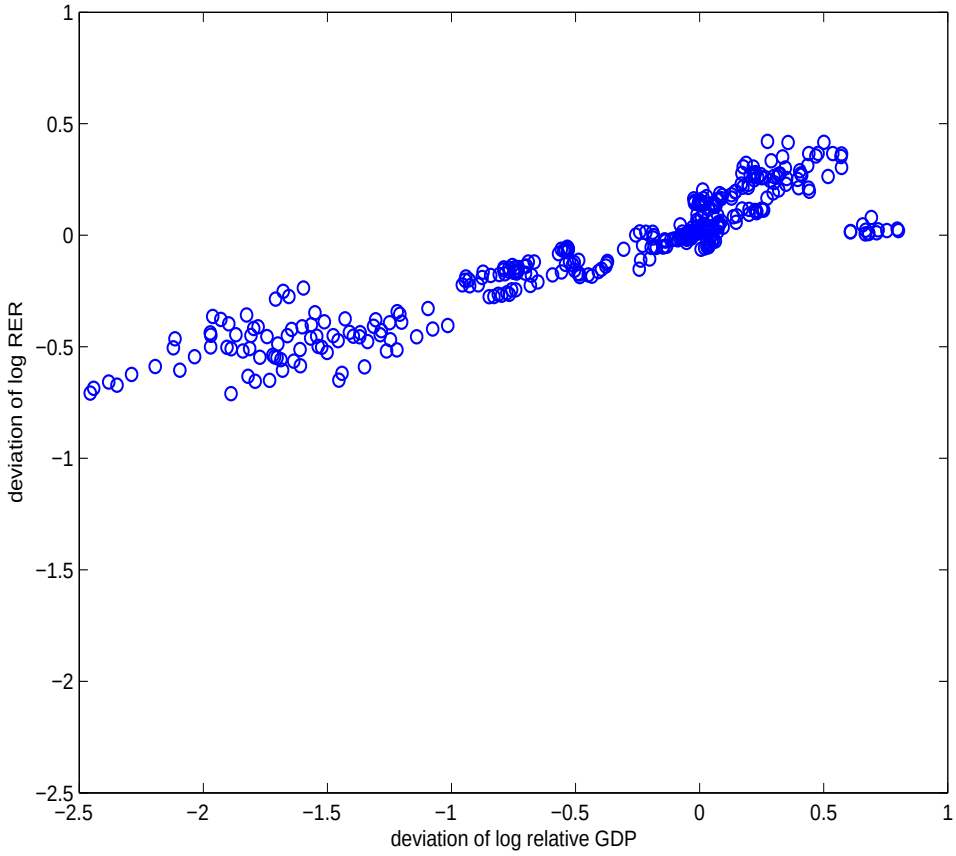


Figure 15: Real Exchange Rate and Nominal Exchange Rate: Western Europe

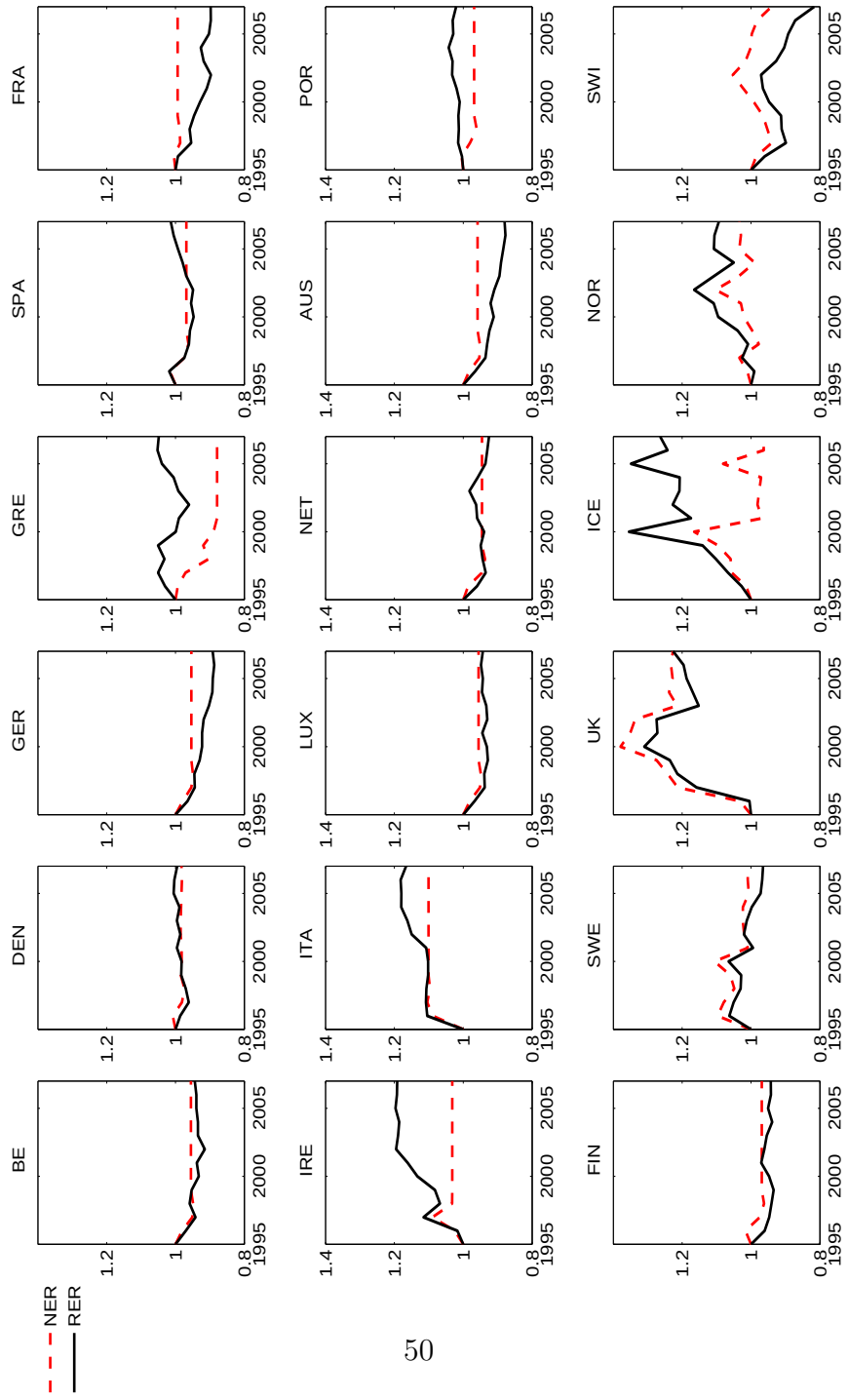
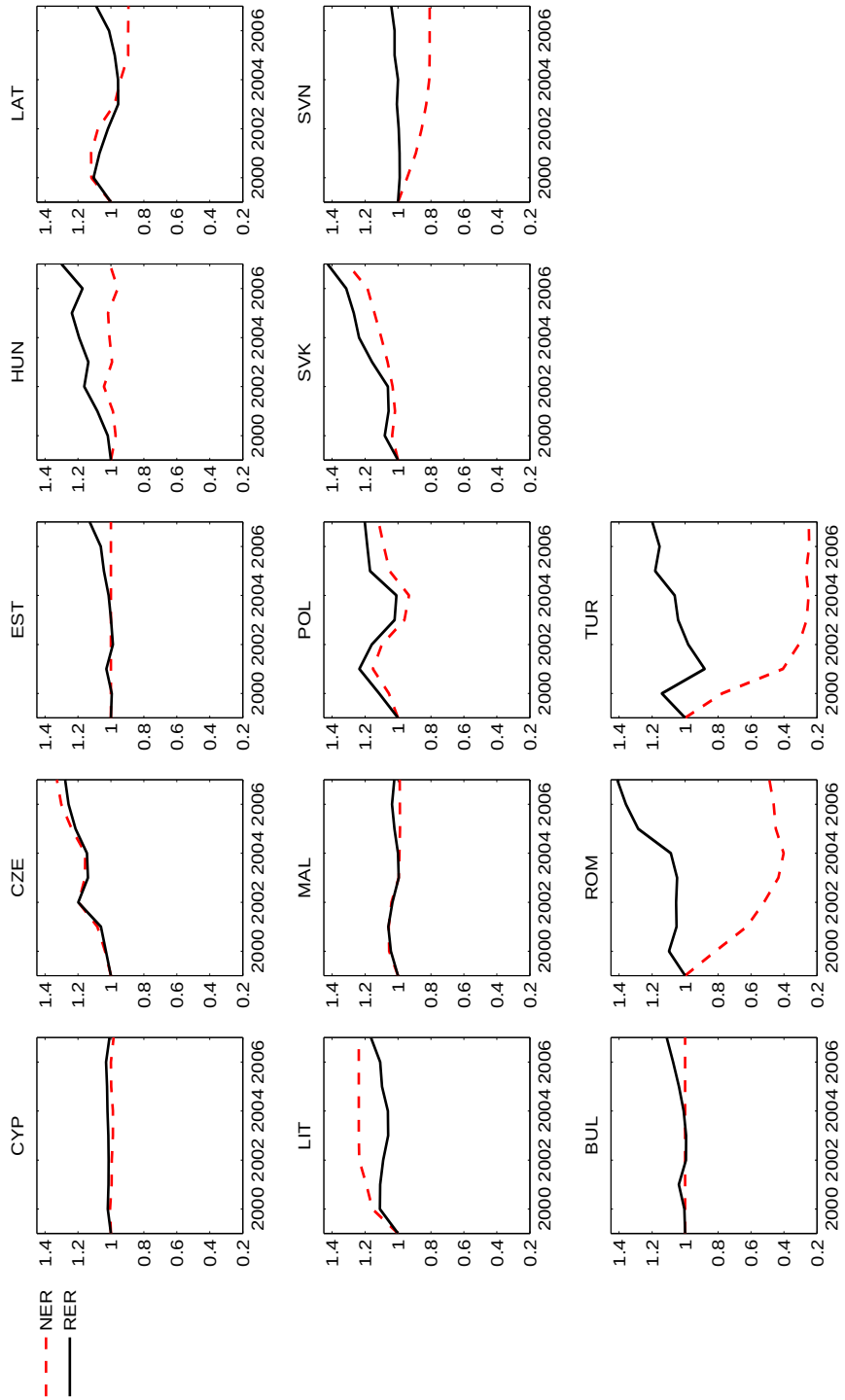


Figure 15 continued: Real Exchange Rate and Nominal Exchange Rate: Southern and Eastern Europe



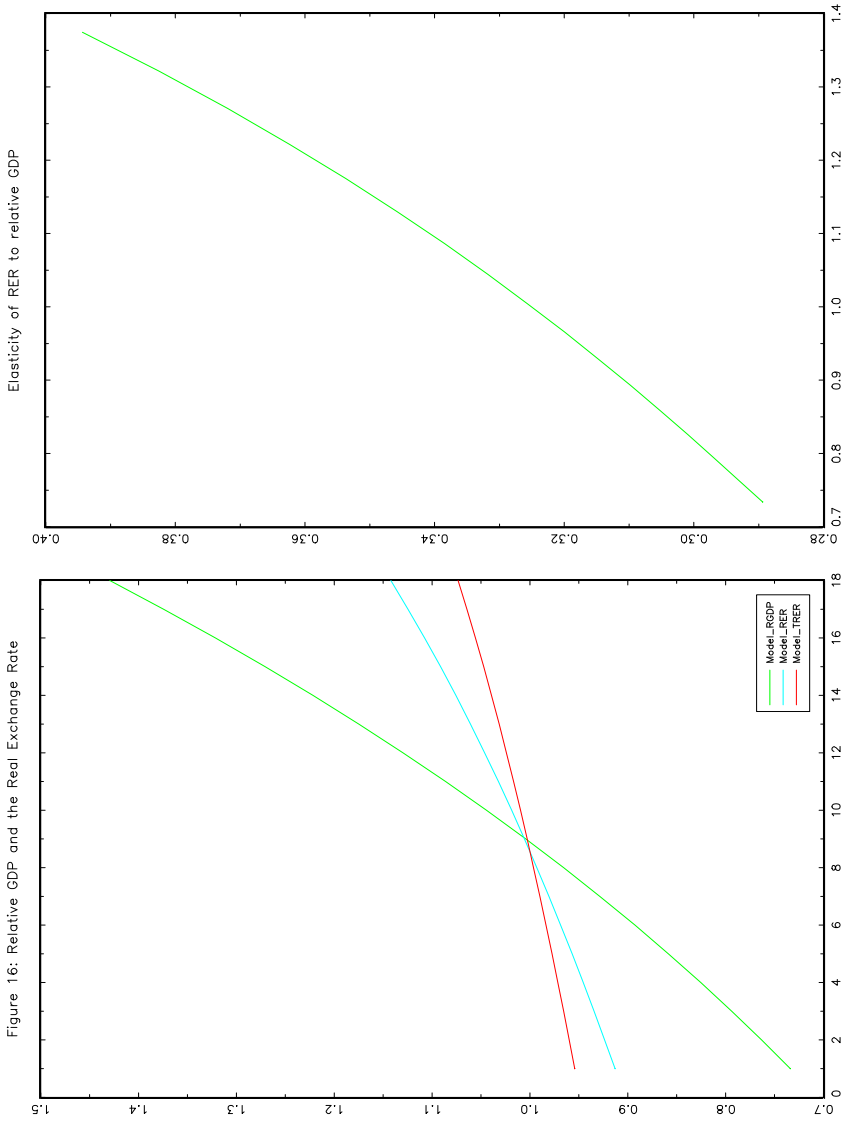


Figure 16: Relative GDP and the Real Exchange Rate

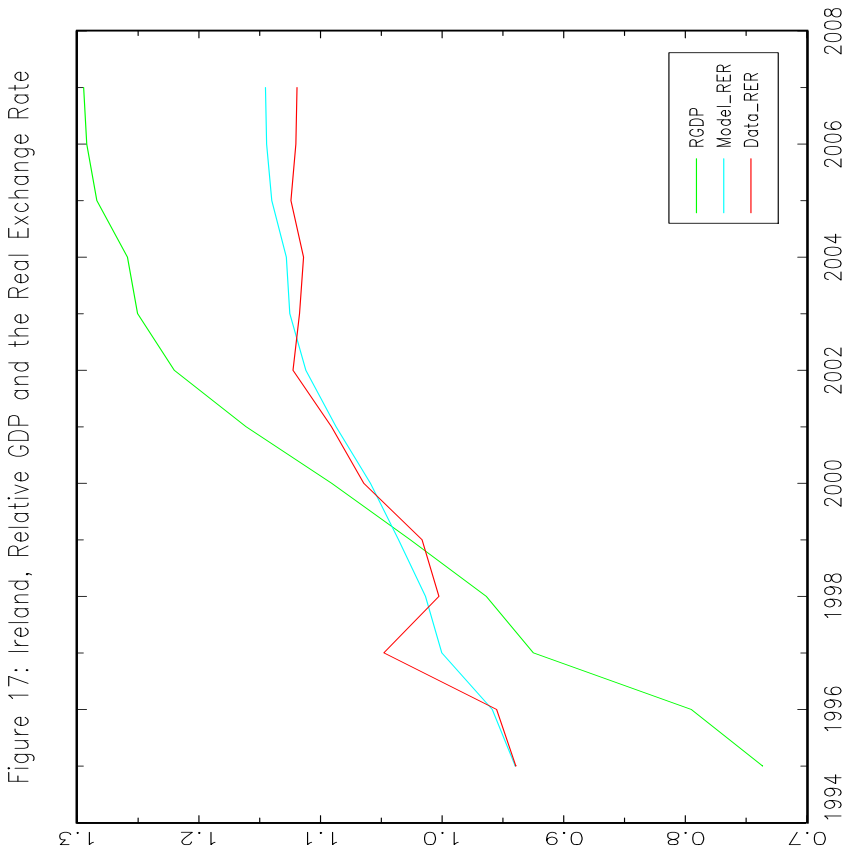


Figure 17: Ireland, Relative GDP and the Real Exchange Rate

Figure 16: Examples of monthly prices

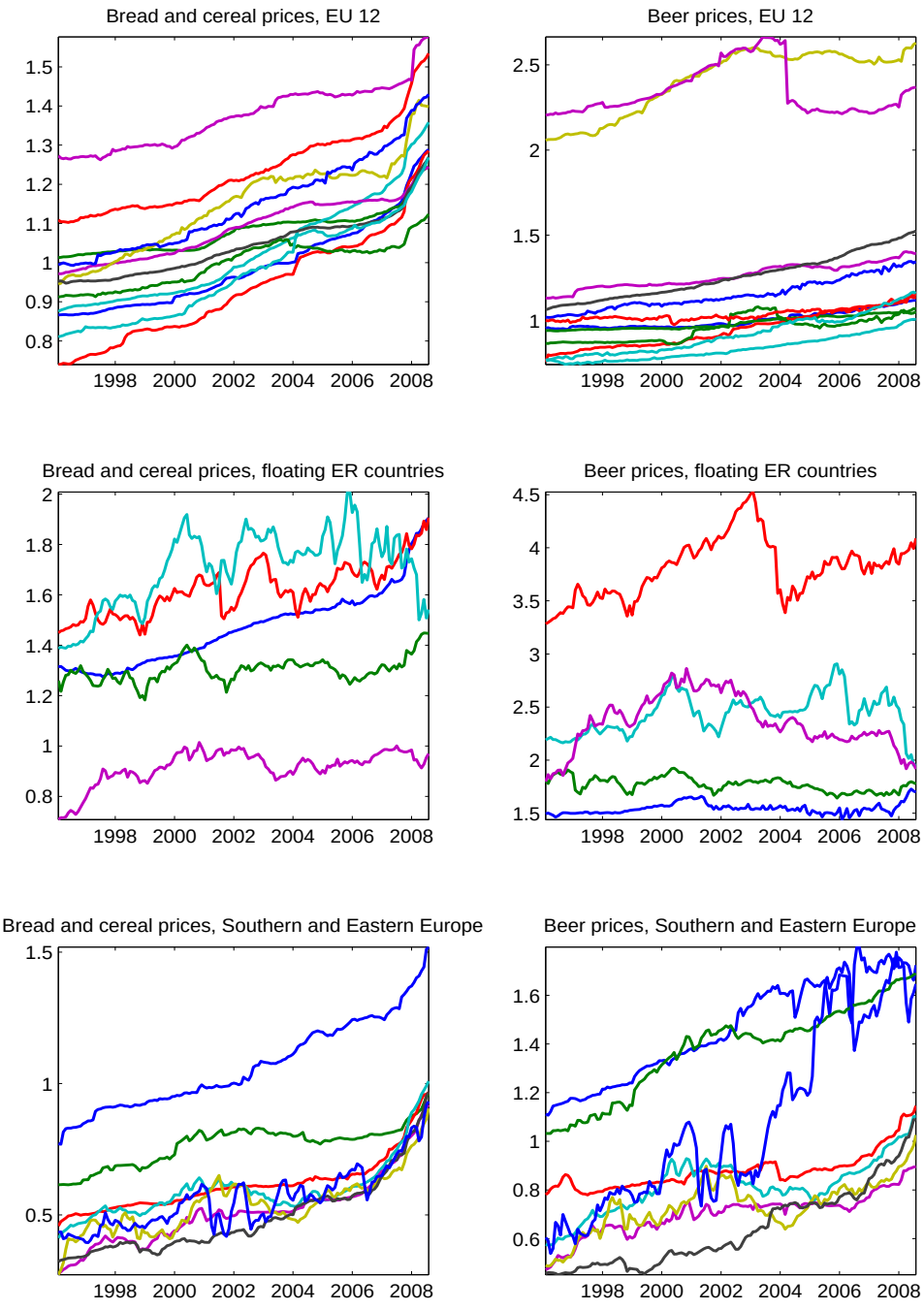


Figure 17: Deviations of average monthly prices from EU15 mean, 38 goods and services