II. Revisiting the relative price mechanism

In the absence of national exchange rates, euro area Member States need to respond to asymmetric shocks via internal adjustment processes. This section analyses the functioning of a key built-in internal adjustment process in EMU, namely the "relative price mechanism" (frequently called the "competitiveness channel"), which links price developments to both the cyclical phases of the business cycle as well as to structural developments.

The findings of panel data estimations suggest that the relative price mechanism has indeed worked since the launch of the euro: differentials in cyclical conditions and structural reforms have contributed to closing price differentials across the euro area. The observed relative price mechanism is stronger when measured using unit labour costs (ULCs) compared with the GDP deflator, which could be explained by the fact that many Member States are (small) open economies acting as price takers. ULCs are determined largely by domestic factors, while the GDP deflator is also influenced by world prices, especially when exporters act as price takers.

In the post-2009 period, however, the relative price mechanism has acted with a delay, kicking in only after the start of the European debt crisis in 2011. The response to output gap differentials was more rapid in the private than in the public sector when ULCs are calculated separately for the two sectors. Furthermore, the functioning of the mechanisms has remained hampered by structural rigidities, in particular in the national labour, product and financial markets. The wider related literature suggests that, due to downward nominal rigidities, price adjustment could be stronger once the euro area moves out of the current low inflation environment. Overall, the findings stress the relevance of structural reforms in both vulnerable and core countries not only for raising growth potential, but also for accelerating the adjustment to asymmetric shocks in euro-area countries.

II.1. Introduction ([44])

In the absence of flexible nominal exchange rates, euro area Member States need to respond to asymmetric shocks via internal adjustment processes. There is an automatic built-in adjustment process in a currency union, namely the "relative price mechanism" (frequently called the "competitiveness channel"). ([45]) Countries that have lost price competitiveness will eventually experience recessionary forces in the form of negative output gaps that, in turn, help re-establishing relative prices via lower inflation.

Some price differentials across countries are inevitable in a monetary union, reflecting, *inter alia*, different catching-up mechanisms, economic structures, institutions and adjustment processes. However, large and persistent price differentials across euro area Member States can hamper the smooth functioning of the Economic and Monetary Union (EMU) for mainly three reasons:

First, they can be a symptom of deeper structural economic imbalances and policy mistakes. For instance, they can be caused by booms in house prices, sectoral misallocation or large indebtedness in euro area Member States. These kinds of inefficiencies cannot be addressed by the single monetary policy.

Second, internal adjustment can be slow and painful. ([46]) A period of excessive overheating would likely require a protracted period of low growth to rebalance relative prices. This is particularly painful in economies characterised by a significant degree of price and wage rigidity.

Finally, the global economic and financial crisis revealed that excessive imbalances are not only a national problem, but can spill over to other countries, notably through financial contagion. These negative spillover effects can endanger the stability of the euro area.

It is therefore essential for the smooth functioning of EMU that relative prices can adjust quickly to cyclical and structural differences. This channel

([44]) The section was prepared by Philipp Mohl and Thomas Walsh.

([45]) See e.g. European Commission (2008), 'EMU@10. Successes and challenges after ten years of Economic and Monetary Union', *European Economy*, 2.

([46]) Jaumotte, F. and P. Sodsriwiboon (2010), 'Current account imbalances in the southern euro area', *IMF Working Paper*, No. 10/139, June.

becomes even more important in the absence of other potentially stabilising adjustment channels in the euro area, such as a high degree of labour mobility from depressed to booming regions or large fiscal transfers across Member States.

While the relative price mechanism is a quasi-automatic process, its effectiveness is an open empirical question, which is addressed here, focusing on the original 11 euro area countries and Greece ([47]). It extends previous empirical work to the period after the global economic and financial crisis using panel data. ([48]) The findings suggest that the relative price mechanism in the post-2009 period occurred with a delay and it was hampered by structural rigidities, in particular in the national labour, product and financial markets.

The section is structured as follows. Section II.2 presents some stylised facts on relative price differentials in EMU before and after the crisis. Section II.3 outlines the main transmission channels on the drivers of relative price differentials. Section II.4 presents the empirical results of the panel analyses. Finally, Section II.5 concludes.

II.2. Stylised facts

The pre-crisis period was characterised by large capital inflows and subsequent credit booms in several euro area countries such as Spain and Ireland. Cheap domestic credit, in particular, contributed to an overheating housing market and to misallocations of resources into non-tradeable sectors such as construction and real estate.

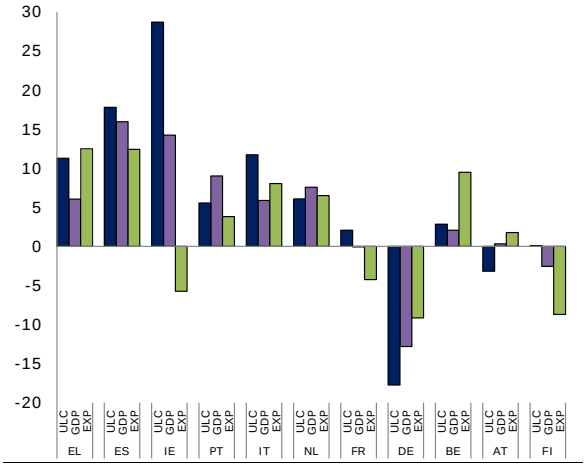
Peripheral euro area countries more broadly lost relative price competitiveness over the period 1999-2009 (see Graph II.1). In Greece, Spain, Ireland and Italy the unit labour cost (ULC)-based real exchange rate vis-à-vis the group of twelve euro area Member States appreciated by more than 10 percent relative to the position at the start of EMU in 1999.

([47]) Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain.

([48]) Previous work among others by: Honohan, P. and P. Lane (2003), 'Inflation divergence', *Economic Policy*, October, pp. 357-394; Biroli, P, G. Mourre and A. Turrini (2010), 'Adjustment in the euro area and regulation of product and labour markets: an empirical assessment', *CEPR Discussion Paper Series*, 8010: European Commission (2014) 'Help firms grow', European Competitiveness Report 2014.

Given the primacy of the relative price mechanism in the euro area, recouping lost competitiveness is seen as an essential component of post-crisis recovery. Using carefully constructed counterfactual scenarios, it has been shown, at least in countries such as Ireland and Spain, that if lost price competiveness had been fully regained during the crisis period, the subsequent cyclical positions could have been substantially improved. ([49])

Graph II.1: **Pre-crisis developments in REERs, selected euro area countries**
(1999-2008, %)



Source: DG ECFIN calculations based on AMECO. REER vis-à-vis the EA-12 measured using the unit labour cost, GDP and export deflator.

Another group of countries, in particular Germany, experienced a significant fall in unit labour costs in the pre-crisis period.

Post-crisis rebalancing

Since the outbreak of the global economic and financial crisis, several euro area countries have regained part of their lost competitiveness (see Graph II.2). This seems to be the case especially for countries which went through a macroeconomic adjustment programme.

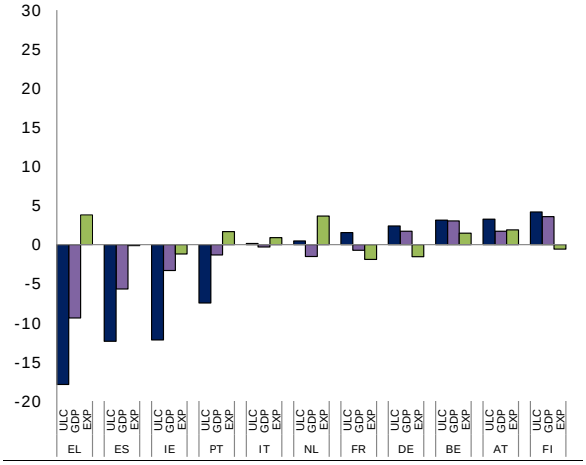
Greece and Portugal have now regained the lost ground, and even moved to a net position lower than at the start of EMU. Spain is also very close to a balanced position with respect to ULC.

Meanwhile, those countries which experienced reductions in relative unit labour costs before the

([49]) Martin,P. and T. Philippon (2014), 'Inspecting the mechanism - Leverage and the great recession in the eurozone', *CEPR Discussion Paper Series*, 10189.

crisis have shown increases of relative prices in the post-crisis period. All northern euro area countries (Finland, Austria, Belgium and Germany) have shown at least some rebalancing, with small to moderate increases in their ULC and GDP-based REERs.

Graph II.2: **Post-crisis developments in REERs, selected euro area countries (2009-2014, %)**



Source: DG ECFIN calculations based on AMECO. REER vis-à-vis the EA-12 measured using the unit labour cost, GDP and export deflator.

The degree of rebalancing depends on the deflator used. For instance, while Greece, Spain and Portugal show substantial progress in relative price adjustment based on the GDP and ULC deflators, the rebalancing is less strong using an export deflator. ([50])

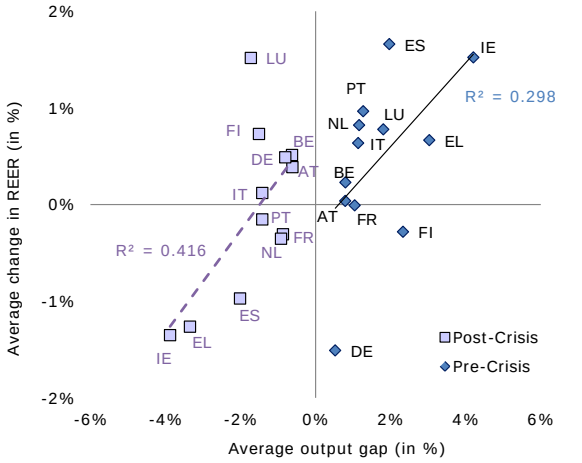
II.3. Factors affecting relative prices in EMU

Several factors have been identified as drivers of relative price developments. ([51])

Cyclical conditions

According to modern macroeconomic theory, cyclical conditions (as measured for instance by the output gap) can be a key determinant of inflation. ([52]) Negative output gaps and spare resources in an economy put downward pressure on prices and wages, resulting in a depreciation of relative prices. ([53]) This relationship appears to be slightly stronger in the post-crisis period (see Graph II.3).

Graph II.3: **Output gaps and REER (EA-12) (1)**



(1) Output gap calculated using Hodrick-Prescott filter techniques. REER vis-à-vis the EA-12 based on the GDP deflator. Pre-crisis period: 1999-2008; post-crisis period: 2009-2014.
Source: DG ECFIN calculations based on AMECO.

A key factor behind this development is the labour market, as the unemployed bid down the wages of those in work. In competitive markets, these labour cost savings then pass through to lower prices.

The strength of the response of relative prices to relative cyclical conditions is, however, likely to vary with characteristics of the institutional labour,

([50]) The differences in strength between the deflators may indicate that many Member States are (small) open economies acting as price takers. ULCs are determined largely by domestic factors, while prices based on the GDP/export deflator are partly/largely influenced by world prices, especially when exporters act as price takers.

([51]) For a survey see also de Haan, J. (2010), 'Inflation differentials in the euro area: a survey', in: de Haan, J. and H. Berger (editors), *The European Central bank at Ten*, Springer-Verlag Berlin Heidelberg, pp. 11-32.

([52]) Phillips, A.W. (1958), 'The relation between unemployment and the rate of change of money wage rates in the United Kingdom, 1861–1957', *Economica*, 25(100), pp. 283-299.

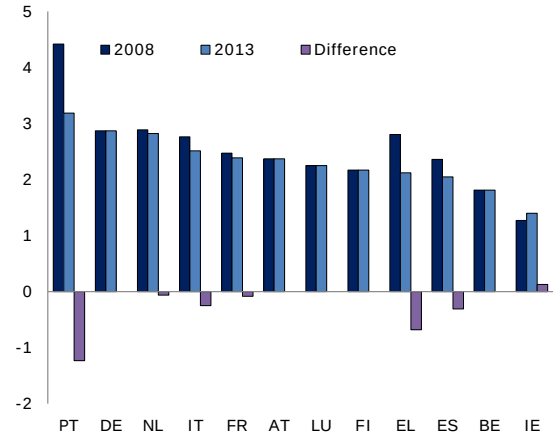
([53]) In recent years inflation in advanced economies has remained higher than would be expected from previous historical relations between inflation and the size of recent output gaps (IMF (2013), 'The dog that didn't bark: Has inflation been muzzled or was it just sleeping?', *IMF World Economic Outlook*, pp. 1-17). There are several explanations for this so-called "missing disinflation", in particular the impact of changes in the short-term (not total) unemployment rate in the determination of wage inflation (see Coibion, O. and Y. Gorodnichenko (2013), 'Is the Phillips curve alive and well after all? Inflation expectations and the missing disinflation', *National Bureau of Economic Research,* 19598; Gordon, R.J. (2013); 'The Phillips curve is alive and well: inflation and the NAIRU during the slow recovery', *National Bureau of Economic Research*, 19390; Llaudes, R. (2005), 'The Phillips curve and long-term unemployment', *ECB Working Paper*, 440; February; Rudebusch, G.D. and J.C. Williams (2015), 'A wedge in the dual mandate: monetary policy and long-term unemployment', *Journal of Macroeconomics,* in press).

product, and financial market set-ups at the national level.

Labour market institutions

Institutions which do not allow for a sufficient degree of flexibility of prices and quantities of labour can hamper the strength of relative price adjustment (see Graph II.4). While labour market flexibility is generally crucial for the smooth functioning of the euro area, it is more challenging to define it with a single indicator, since there are several possibilities to achieve a sufficient degree of flexibility.

Graph II.4: **Employment protection legislation (EA-12) (1)**



(1) Employment protection legislation is measured with the synthetic OECD indicator for individual and collective dismissals (regular employment) on a scale from 0 (least restrictions) to 6 (most restrictions).
Source: DG ECFIN calculations based on OECD data.

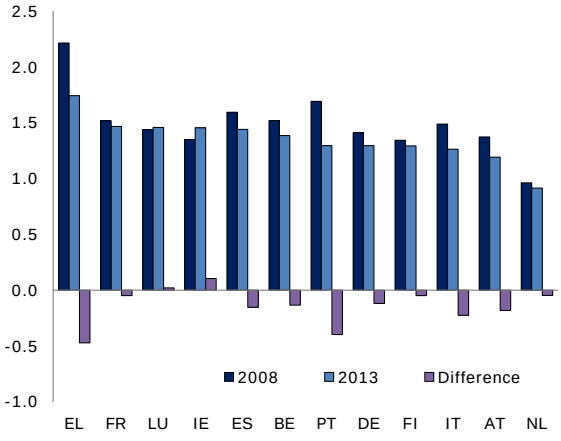
On the price side, labour market institutions can be too rigid to allow firms to pay the wages they can afford. For instance, a minimum wage that is set too high could prevent the employment of the lowest skilled workers in particular. Since minimum wages frequently set a wage floor for an economy as a whole, they can further artificially push up other wage levels. Moreover, in case of an asymmetric shock, minimum wage levels typically do not fall. Similarly, the nature of the wage bargaining process, the power of workers' unions ([54]) can be important factors in shaping the labour market adjustment process. ([55])

On the quantity side, the ease with which businesses can hire and dismiss staff, set out in employment protection law, can affect the flexibility in working hours. In addition a too generous unemployment replacement scheme could aggravate the reduction of long-term unemployment.

Product market institutions

Rigid product market regulation can result in less competitive markets, where firms acquire more monopoly power and higher mark-ups (see Graph II.5). These firms will be able to absorb part of an economic shock in their mark-ups, while in competitive markets one would expect that a larger part of the shock passes through to prices. As such we might expect to see a weaker transmission from labour cost shocks to changes in prices in markets that are less competitive.

Graph II.5: **Product market regulation index (EA-12) (1)**



(1) Product market regulation is measured with an OECD indicator on a scale from 0 (least restrictions) to 6 (most restrictions).
Source: DG ECFIN calculations based on OECD data.

Some evidence from the euro area and the UK shows that firms which face stronger competition in their industry also review and reset their prices more often. ([56])

([54]) The relationship between wages and union size may in fact take an inverse-U shape, with very large unions aware of the aggregate consequences that their wage demands have on employment. Internalising such processes, large unions might then moderate wage developments to maintain employment.

([55]) Biroli et al. (2010), op. cit.
Jaumotte, F. and H. Morsy (2012), 'Determinants of inflation in the euro area: the role of labor and product market institutions', *IMF Working Paper*, pp. 12-37, January.

([56]) Fabiani, S., M. Druant, I. Hernando, C. Kwapil, B. Landau, C. Loupias and A.C. Stokman (2005), 'The pricing behaviour of

Financial frictions

While credit market disruption can affect the size of output gaps directly, (57) recent research concludes that financial frictions can also affect the process by which relative prices adjust to output gaps and therefore alter the speed with which output gaps close. (58)

For instance, it has been shown theoretically and empirically that firms in the US and euro area facing financial constraints are more likely to increase their mark-ups in order to build a buffer-stock of internal finance, and this mechanism significantly attenuates the response of prices to output gaps.

Possible explanations for such a channel are falling capital productivity, restrictions on credit supply, high deleveraging needs, and weaker competition. The channel is also a potential explanation for the increase in margins observed through the crisis in vulnerable euro area countries.

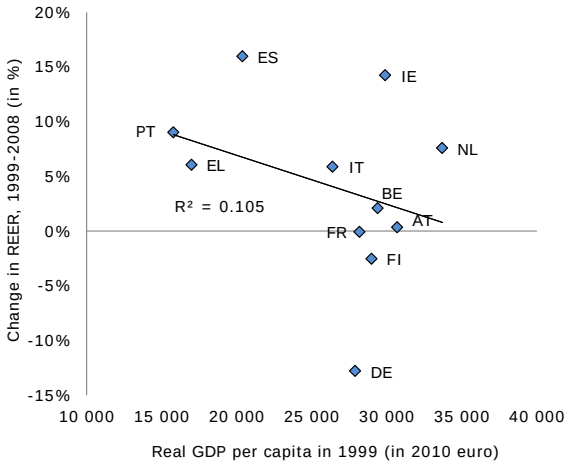
Catch-up mechanism

Apart from cyclical position, price level convergence can generate temporary inflation differentials. Empirical evidence suggests that in the early years of EMU a significant part of the price differentials can be explained by price level convergence. (59)

Aggregate productivity can further drive relative price developments via the "Balassa-Samuelson" effect. Competition from global markets ensures that price pressures in the tradeable sector remain contained. However, higher wage levels in the comparatively productive tradeable sector will compete for resources with other sectors and put upward pressure on wages in the rest of the economy. This raises prices levels in other sectors which have experienced no similar rise in productivity. This effect can explain higher price levels in richer, more productive countries.

Countries with lower levels of GDP per capita can be expected to grow faster as they converge to the same levels as the richest, and so we would expect to see a relationship between the starting level GDP per capita and the appreciation in the REER over the medium term (see Graph II.6).

Graph II.6: **Real GDP per capita and REER (EA-12) (1)**



(1) REER vis-à-vis the EA-12 based on the GDP deflator.
Source: DG ECFIN calculations based on AMECO.

Inflation expectations

Inflation expectations are found to be an important driver of prices. (60) Ceteris paribus, an increase in today's expectations about future prices will reduce the real interest rate and will cause firms and households to bring forward their spending. Through this mechanism, increased expectations of inflation in the future can cause today's inflationary pressures to rise.

firms in the euro area: new survey evidence', *Banque de France Working Paper*, No. NER-E 135, November.
Hall, S., M. Walsh and A. Yates (2000), 'Are UK companies' prices sticky?', *Oxford Economic Papers*, 52(3), pp. 425-446.

(57) Chodorow-Reich, G. (2014), 'The employment effects of credit market disruptions: firm-level evidence from the 2008–2009 financial crisis', *The Quarterly Journal of Economics*, 129(1), pp. 1-59. Amiti, M. and D.E. Weinstein (2013), How much do bank shocks affect investment? Evidence from matched bank-firm loan data' *National Bureau of Economic Research*, No. 18890.

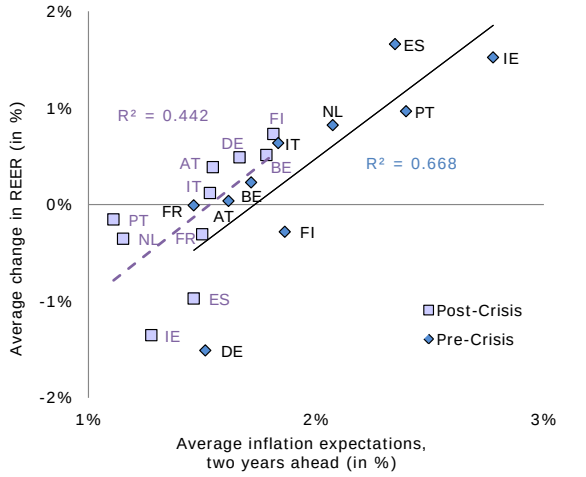
(58) Breitenfellner A., A. D. Dragu and P. Pontuch (2013), 'Labour costs pass-through, profits and rebalancing in vulnerable Member States', *Quarterly Report on the Euro Area,* 12(3), pp. 19-25. Montero, J.M. and A. Urtasun (2014), 'Price-cost mark-ups in the Spanish economy: a microeconomic perspective', *Bank of Spain Working Paper,* No. 1407.
Gilchrist, S., R. Schoenle, J. Sim and E. Zakrajsek (2015), 'Inflation dynamics during the financial crisis', *Federal Reserve Board*, *Finance and Economics Discussion Series*, 2015 (012); Gilchrist, S. and E. Zakrajsek (2015), 'Customer markets and financial frictions: implications for inflation dynamics', *prepared for the 2015 Economic Policy Symposium organised by the Federal Reserve Bank of Kansas City and held at Jackson Hole*, WY, August, pp. 27–29; de Almeida, L.A. *(2015*), 'Firms' balance sheets and sectoral inflation in the euro area during the financial crisis', *Economics Letters*, 135, pp. 31-33.

(59) Honohan and Lane (2003), op. cit.

(60) Coibion and Gorodnichenko (2013), op. cit.

Since the onset of the crisis, the relationship between inflation expectations and REER evolution has remained stable, as captured by a similar gradient in trend lines. However, the explanatory power of inflation expectations has fallen (see Graph II.7).

Graph II.7: **Inflation expectations and REER (EA-12) (1)**



(1) REER vis-à-vis the EA-12 based on the GDP deflator. Pre-crisis period: 1999-2008; post crisis period: 2009-2014. ***Source:*** DG ECFIN calculations based on AMECO. Inflation expectations taken from the Consensus forecast.

House prices

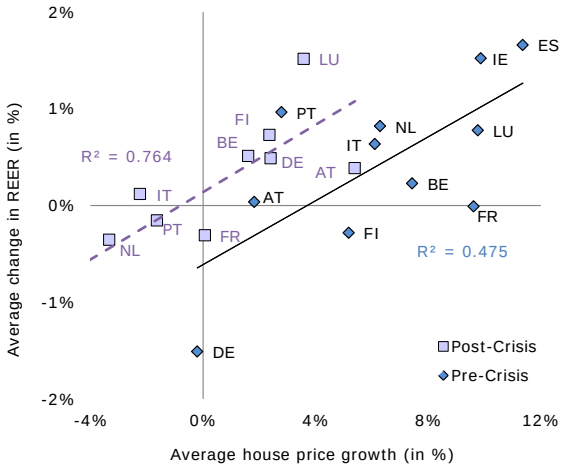
Changes in house prices may also influence relative prices, through changes in consumption patterns and consumer wealth effects. ([61])

If there is an asymmetry between the fluctuations in the output gap and the housing market due to divergent financial and real cycles, the effect of rising house prices and increased consumption will to some extent become embedded as structural with respect to the business cycle and measures of the output gap. Therefore including house prices also measures the extent to which the wealth effect generated by house price changes influences demand, beyond the frequency of the business cycle.

House prices appear to have a moderate to strong relationship with price developments in both periods (see Graph II.8).

([61]) Case, K.E., J.M. Quigley and R.J. Shiller (2005), 'Comparing wealth effects: the stock market versus the housing market', *The B.E. Journal of Macroeconomics*, 5(1), pp. 1534-6013.

Graph II.8: **House prices and REER (EA-12) (1)**



(1) REER vis-à-vis the EA-12 based on the GDP deflator. Pre-crisis period: 1999-2008; post crisis period: 2009-2014. ***Source:*** DG ECFIN calculations based on AMECO.

External dimensions

The external dimension can play an important role in affecting prices.

The oil price is a key determinant of the external component of inflation, given its use as a fuel for transportation and heating, as well as an input in production processes more generally.

Oil price shocks will directly affect the price adjustment mechanism to the extent that oil price shocks feed into headline consumer or producer prices. A second order effect will be the impact of higher consumer price inflation on inflation expectations formed by firms and households, which will in turn affect wage-bargaining and price-setting behaviour and future prices.

While all countries are exposed to the same oil price, the knock-on effects of oil shocks will not be equal across all euro area Member States, since they will be hit by shocks to the extent that they are reliant on oil.

Finally, the nominal exchange rate is a key factor in determining net exports. While all euro area members will experience the same appreciations and depreciations in nominal terms, they are not all equally open, and may have very different demand and supply elasticities, different trading partners etc.

II.4. Empirical evidence of the functioning of the relative price mechanism

Previous studies of the price adjustment mechanism in euro area countries from the pre-crisis decade found that the relative price adjustment mechanism was indeed present. Empirical evidence suggests that after the start of EMU, relative prices appear to have become less reactive to country-specific shocks but also less persistent. ([62]) Empirical analyses further show that price level convergence played a major role in driving price differentials in the early years of EMU. ([63]) In addition, inflation differentials seem to be particularly driven by cyclical conditions ([64]) and inflation persistence. ([65])

Some findings from the recent literature on internal devaluation and adjustment in euro area deficit countries suggest that although relative prices have indeed adjusted to negative output gaps, such price changes might not have triggered the redistribution of productive resources within the countries yet (i.e. from non-tradeable to tradeable). ([66])

Own empirical analysis for the post-crisis era

To get a better understanding on the functioning of the relative price mechanism in the euro area for the post-crisis period, a panel data model was estimated for 12 euro area countries over the period 1999 to 2014 (see Box II.1).

In contrast to the existing literature, this work focuses on the possible effect of the global economic and financial crisis on the functioning of the relative price mechanism. Furthermore, the empirical approach controls not only for the role of product and labour market institutions in shaping the relative price adjustment., but also takes into account the latest findings of the literature by investigating the role of financial frictions in the price adjustment process.

As highlighted in the previous section a weak responsiveness of relative prices to comparative excess supply or demand conditions will tend to prolong the adjustment process.

The empirical work delivers the following stylised findings:

- The relative price adjustment mechanism seems to play an important role in the euro area. Relative prices tend to react positively and significantly to output gap differentials.

- The relative price mechanism is stronger when based on unit labour cost compared with GDP deflators. This could be explained by the fact that many euro area Member States are (small) open economies acting as price takers. ULCs are driven to a large extent by domestic factors, whereas prices based on the GDP deflator are also determined by world prices, in particular when exporters act as price takers.

- The global economic and financial crisis had a significant impact on the functioning of the relative price mechanism.

- The relative price mechanism has responded with a significant delay to the economic and financial crisis, proving to be weak during the first phase of the crisis and then strengthening significantly after the European debt crisis in 2011. The strengthening could be linked to some catching-up effect (after the weak response of the first phase of the crisis) and the effect of the implementation of structural reforms.

- While public sector prices show a pro-cyclical pattern in the first phase of the crisis, private sector wages, in particular, contributed to the relative price adjustment during 2012 to 2014.

- In addition, price persistence appears to have been reduced in the post-crisis period. These results are, however, only statistically significant in the case of the GDP deflator and the initial crisis years.

- The analysis further shows that the dynamics in relative price developments reveal a significant element of inertia. In addition, relative prices tend to be mean-reverting, i.e. that the price level tends to be stable over time. Both features

([62]) Biroli et al. (2010), op. cit.
([63]) Honohan and Lane (2003), op. cit.
([64]) Andersson, M., K. Masuch and M. Schiffbauer (2009), 'Determinants of inflation and price level differentials across the euro area countries', *ECB Working Paper*, 1129, December.
([65]) Angeloni, I. and M. Ehrmann (2004), 'Euro area inflation differentials', *ECB Working Paper*, 388, September.
([66]) For a summary of the recent work done by the IMF on this topic, see Tressel, T., S. Wang,, J. S. Kang., and J. Shambuagh (2014), 'Adjustment in euro area deficit countries: progress, challenges, policies', *IMF Staff Discussion Note,* 14/7.

can be seen irrespective of the sample period and estimation approach chosen.

- The empirical model also reveals that stricter employment protection legislation, more generous unemployment benefit schemes, higher long-term unemployment and stricter price controls reduce the responsiveness of the relative price mechanism. In addition, high costs of borrowing and sovereign bond spreads seem to have had a harmful effect on the adjustment speed of relative prices to cyclical divergences during the crisis period.

- Finally, stricter employment protection legislation, higher minimum wages, stricter price controls and sovereign bond yields seem to increase the price persistence in the euro area.

II.5. Conclusions

The smooth functioning of the relative price mechanism (frequently also called the "competitiveness channel") is key to responding to asymmetric shocks in the euro area given the absence of national exchange rates to act as a 'shock absorber' – cushioning recessions and restraining overheating during boom phases.

This section sheds new light on the functioning of the relative price mechanism in EMU since 1999, examining how relative prices adjust to the relative slack in national economies.

In brief, the findings of panel data estimations suggest that the relative price mechanism has indeed been active: cyclical conditions and structural reforms contributed to closing price differentials across the euro area.

However, the strength of the mechanism varies along several different dimensions.

- The relative price mechanism is stronger when based on unit labour cost compared with GDP deflators. This could be explained by the fact that many euro area Member States are (small) open economies acting as price takers. ULCs are influenced mainly by domestic factors, while the GDP deflator is also determined by world prices, in particular when exporters act as price takers.

The mechanism in the post-2009 period acted with a lag, and only took effect after the European debt crisis in 2011.

Furthermore, it has been hampered by structural rigidities: More flexible labour and product markets, as well as less stressed financial markets, would have enabled a stronger response of relative prices to the business cycle position. The reservation must be made that it is challenging to define the sufficient degree of labour market flexibility with a single indicator, since there are complex interactions within the field of labour market institutions.

The wider related literature suggests that, due to downward nominal rigidities, relative price adjustment could be stronger once the euro area moves out of the current low inflation environment which could be hampering the downwards adjustment of prices in certain vulnerable euro area Member States.

Overall, the findings stress the relevance of structural reforms not only for raising the growth potential, but also for accelerating the adjustment to asymmetric shocks to euro-area countries.

Box II.1: Relative price adjustment in EMU – an empirical assessment

This box provides empirical evidence on the main drivers of relative price adjustment in the euro area, with a particular focus on the period following the global economic and financial crisis.

Empirical specification

The drivers of relative prices (P) are analysed using a dynamic panel data approach. The analysis focuses on 12 euro area countries (i) throughout the whole of the EMU period (t) 1999 to 2014. The basic specification follows Biroli et al. (2010): [1]

(*a*) *Baseline specification:* $\Delta P_{i,t} = \beta_0 + \beta_1 \Delta P_{i,t-1} + \beta_2 \ln(P_{i,t-1}) + \beta_3 GAP_{i,t-1} + \varepsilon_{i,t}$

(*b*) *Interaction specification to test for a regime switch following the global economic and financial crisis:*

$$\Delta P_{i,t} = \beta_0 + \beta_1 \Delta P_{i,t-1} + \beta_2 \ln(P_{i,t-1}) + \beta_3 GAP_{i,t-1} + \beta_4 C_{t-1} + \beta_5 (C_{t-1} * GAP_{i,t-1}) + \beta_5 (C_{t-1} * P_{i,t-1}) + \beta_6 X_{i,t-1} + \varepsilon_{i,t}$$

(c) Interaction specifications to test for the impact of institutional variables:

(*c1*)
$$\Delta P_{i,t} = \beta_0 + \beta_1 \Delta P_{i,t-1} + \beta_2 \ln(P_{i,t-1}) + \beta_3 GAP_{i,t-1} + \beta_4 X_{i,t-1} + \beta_5 Z_{i,t-1} + \beta_6 (Z_{i,t-1} * GAP_{i,t-1}) + \beta_7 C_t + \ldots$$
$$\ldots + \beta_8 (C_t * GAP_{i,t-1}) + \beta_9 (C_t * Z_{i,t-1}) + \beta_{10} (C_t * Z_{i,t-1} * GAP_{i,t-1}) + \varepsilon_{i,t}$$

(*c2*)
$$\Delta P_{i,t} = \beta_0 + \beta_1 \Delta P_{i,t-1} + \beta_2 \ln(P_{i,t-1}) + \beta_3 GAP_{i,t-1} + \beta_4 X_{i,t-1} + \beta_5 Z_{i,t-1} + \beta_6 (Z_{i,t-1} * \Delta P_{i,t-1}) + \beta_7 C_t + \ldots$$
$$\ldots + \beta_8 (C_t * \Delta P_{i,t-1}) + \beta_9 (C_t * Z_{i,t-1}) + \beta_{10} (C_t * Z_{i,t-1} * \Delta P_{i,t-1}) + \varepsilon_{i,t}$$

All variables are expressed in differences to the simple arithmetic mean of the sample excluding the given country, and are z-standardised for each year to have mean zero and unit variance. Since the impact of the variables tends to occur only gradually, they are included with a lag of one year. We use different measures for prices, ranging from the real effective exchange rate relative to the 12 euro area countries based on the GDP deflator to measures of deflators expressed in differences to the sample average excluding the country concerned using the GDP deflator as well as the unit labour cost (ULC) deflator for the total economy, the public and private sector. [2]

As a first step, relative prices are regressed in a baseline specification on three independent variables (see equation *a*). The inclusion of the lagged price growth variable (ΔP) captures a potential inertia factor in the dynamics of relative price adjustment. The lagged level of prices ($ln\ P$) controls for a mean reversion effect. The output gap (GAP) indicates the strength of the price adjustment channel, measuring the reaction of relative prices to country-specific cyclical differences relative to the euro area average. The output gap is measured using HP filter techniques, but the results are broadly unchanged when based on a production function methodology. [3]

(1) Biroli, P., G. Mourre and A. Turrini (2010), 'Adjustment in the euro area and regulation of product and labour markets: an empirical assessment', *European Economy, Economic Papers*, No. 428, October.

(2) Biroli et al. (2010) use as a dependent variable the growth of real effective exchange rates (REERs) based on the GDP deflator, which implies using double export weights that take into account export competition both on own and third markets. In order to ensure consistency with the independent variables used, we do not use REERs, but construct a price measure in differences to simple arithmetic averages of the sample excluding the country concerned.

(3) See D'Auria, F., C. Denis, K. Havik, K. Mc Morrow, C. Planas, R. Raciborski, W. Roeger und A. Rossi (2010), 'The production function methodology for calculating potential growth rates and output gaps', *European Economy Economic Papers*, No. 420, July.

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As a second step, the baseline specification is augmented with a dummy variable (*C*) to test for the impact of the global economic and financial crisis (see equation *b*). To be more precise, the panel models are estimated using dummies for two sub-periods since the outbreak of the crisis, namely 2009 to 2011 and 2012 to 2014. In addition, the specification is estimated by adding further control variables (X) with a potential impact on prices. The selection of these variables was guided by a review of the literature (see section I.3. in the main text).

Finally, some *interaction specifications* are estimated to find out whether the impact of the output gap and the price persistence on relative prices occurs conditional on the labour, product and financial market institutions at the national level (*Z*) (see equations *c*). For this purpose, the output gap (see equation *c1*) and the lagged price growth (see equation *c2*) are interacted with the institutional variable. An additional interaction term with a post-2009 crisis dummy (*C*) is added to analyse whether the conditional impact has changed since the crisis. To avoid biased estimates due to multicollinearity, the institutional variables are added consecutively but separately into the specification and the interaction relative to the output gap and inflation persistence is estimated separately.

Data

Our matrix of controls *X* in the augmented baseline specification uses data on the growth rate of total factor productivity (TFP), the level of the real GDP per capita, the government primary balance, the change in VAT rates, the growth rate of the nominal effective exchange rate relative to 37 industrial countries, the change in the nominal house price index according to the European Commission indicator, today's expectations of future inflation rates (as measured by Consensus economics).

The interaction terms using variables *Z* are constructed to account for the institutional settings of labour, product and financial markets. The following proxies are used:

- Employment protection indicator and real unemployment benefit replacement ratio (as a measure of *labour market institutions*),
- Product market regulation index and price controls (as measures of *product market institutions*),
- Sovereign 10 year yields and a composite indicator of the cost of financing (measures of *financial frictions).*

To allow for a better interpretation of the results, again for each year all variables are centred on a zero mean, and have variance of one. They are measured in difference to the simple arithmetic average of the sample excluding the country concerned. Labour and product market variables are taken from the OECD. Financial variables are available via the ECB. Sovereign yields are taken from Bloomberg.

Results

Baseline specification

The results of the baseline specifications reveal that the relative price adjustment channel seems to play an important role in the euro area (see Table 1). Relative prices tend to react positively and significantly to output gap differentials. In addition, relative prices exhibit a significant degree of price persistence and appear to be strongly mean-reverting. The results are robust to the estimation approach used and the price measure (REER based on GDP vs. GDP deflator) chosen.

(Continued on the next page)

Box (continued)

Table 1: **Baseline specifications for GDP price measures (1)**

	REER based on GDP			***GDP deflator***		
	FE	LSDVc	SYS-GMM	FE	LSDVc	SYS-GMM
	(1)	(2)	(3)	(4)	(5)	(6)
Prices growth (t-1)	0.534***	0.714***	0.639***	0.707***	0.829***	0.695***
	(4.258)	(10.33)	(2.882)	(8.587)	(13.18)	(6.482)
Log prices (t-1)	-0.940***	-0.976***	-0.120	-0.930***	-0.686**	-0.162**
	(-3.715)	(-3.021)	(-1.437)	(-4.488)	(-2.548)	(-2.105)
Output gap (t-1)	0.129*	0.117**	0.247***	0.0447	0.0521	0.131**
	(2.014)	(2.066)	(2.865)	(1.057)	(0.992)	(2.209)
Lt. elasticity (size)	0.277	0.408	0.684	0.153	0.305	0.429
Lt. elasticity (p-value)	0.058	0.035	0.014	0.393	0.302	0.043
AR(1) (p-value)			0.075			0.022
AR(2) (p-value)			0.805			0.984
Hansen (p-value)			0.330			0.308
#instruments			12			12
R-squared	0.357			0.467		
Observations	192	180	192	192	180	192
# countries	12	12	12	12	12	12

(1) The specifications control for time fixed effects (via z-standardisation on an annual basis) and country fixed effects (via the estimation approach chosen). FE shows the results of the fixed effect estimator using heteroskedasticity-robust Huber-White standard errors. Due to the dynamic nature of the panel estimation approach, the simple FE estimations suffer from the well-known Nickell bias (Nickell, 1981). Two estimation approaches are used to control for it. First, the bias-corrected least square dummy variable estimator (LSDVc) proposed by Kiviet (1995) and extended by Bruno (2005) to unbalanced panel data, which turns out to have better properties in the case of small N. Second, the two-step system GMM (SYS-GMM) estimator following Blundell and Bond (1998), which not only allows controlling for endogeneity of the lagged dependent variable, but also for other potential endogenous variables. In the specification shown above internal instruments were used for the lagged prices and output gap variable. Due to the small sample size the set of internal instrumental variables is restricted by "collapsing" the matrix of instruments and restricting its lags up t-3. The standard errors are corrected following Windmeijer (2005). AR(1,2) and Hansen tests confirm the validity of the system GMM specifications. ***, ** and * denote respectively statistical significance at 1, 5 and 10%. (4)
Source: DG ECFIN calculations.

The relative price mechanism becomes stronger when measured with the unit labour cost rather than the GDP deflator (see Table 2). Since this pattern prevails for the pre- and post-crisis period, it could be explained with a general phenomenon of open economies acting as price takers. Within the group of ULC, the response to the output gap is more rapid in the private than in the public sector. At the same time, prices appear to be more persistent and more-rapidly mean-reverting in the private than in the public sector.

Table 2: **Baseline specification for different ULC deflators (1)**

	ULC total economy			***ULC private sector***			***ULC public sector***		
	FE	LSDVc	SYS-GMM	FE	LSDVc	SYS-GMM	FE	LSDVc	SYS-GMM
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Prices growth (t-1)	0.428***	0.525***	0.540***	0.408***	0.514***	0.505***	0.253*	0.344***	0.202**
	(5.759)	(8.084)	(7.534)	(5.914)	(7.98)	(6.549)	(2.095)	(5.652)	(1.962)
Log prices (t-1)	-0.867***	-0.802***	-0.193**	-0.905***	-0.956***	-0.187**	-0.611***	-0.638***	-0.342***
	(5.025)	(3.633)	(2.540)	(4.120)	(3.589)	(2.398)	(3.979)	(5.887)	(2.695)
Output gap (t-1)	0.283***	0.280***	0.328***	0.280***	0.272***	0.342***	0.137**	0.130**	0.244***
	(3.155)	(4.806)	(6.181)	(3.416)	(4.637)	(5.748)	(2.605)	(2.059)	(3.573)
Lt. elasticity (size)	0.495	0.588	0.713	0.472	0.560	0.690	0.184	0.198	0.306
Lt. elasticity (p-value)	0.012	0.000	0.000	0.006	0.000	0.000	0.003	0.036	0.000
AR(1) (p-value)			0.008			0.023			0.006
AR(2) (p-value)			0.111			0.160			0.153
Hansen (p-value)			0.566			0.422			0.514
#instruments			12			12			12
R-squared	0.397			0.361			0.242		
Observations	192	180	192	192	180	192	192	180	192
# countries	12	12	12	12	12	12	12	12	12

(1) For a description of the estimation procedure see footnote of Table 1.
Source: DG ECFIN calculations.

(4) See: Blundell, R. and S. Bond (1998), 'Initial conditions and moment restrictions in dynamic panel data models', *Journal of Econometrics*, 87, pp. 115-143; Bruno, G. (2005), 'Approximating the bias of the LSDV estimator for dynamic unbalanced panel data models', *Economic Letters*, 87, pp. 361-366; Kiviet, J.V. (1995), 'On bias, inconsistency and efficiency of various estimators in dynamic panel data models', *Journal of Econometrics*, 68, pp. 53-78; Nickell, S. (1981), 'Biases in dynamic models with fixed effects', *Econometrica*, 49, pp. 1417-1426; Windmeijer, F. (2005), 'A finite sample correction for the variance of linear efficient two-step GMM estimators', *Journal of Econometrics*, 126(1), pp. 25-51.

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The global economic and financial crisis had a significant impact on the functioning of the relative price mechanism (see Table 3). The relative price adjustment channel was only effective in the last three years of the investigation (2012-14), but not in the first three years following the crisis (2009-11). From 2009 to 2010, the unit labour costs of the public sector increased significantly despite the strong decline of the output gap, which points to a pro-cyclical pattern. Between 2011 and 2013, the relative price adjustment was substantially stronger in the private than in the public sector. Overall, the results seem to suggest that the relative price mechanism only acted with a delay, but was then comparatively stronger than in the pre-crisi period which could be linked to some catching-up effect and the effect of the implementation of structural reforms.

In addition, price persistence appears to have been reduced in the post-crisis period. The results are, however, only statistically significant in the case of the GDP deflator and the initial crisis years.

Table 3: **Impact from the global economic and financial crisis (1)**

Prices:	*GDP deflator*		*ULC private sector*		*ULC public sector*	
Period dummy (years of coverage):	2009-11	2012-14	2009-11	2012-14	2009-11	2012-14
	(1)	(2)	(3)	(4)	(5)	(6)
Prices growth (t-1)	0.768***	0.661***	0.459***	0.572***	0.306***	0.285**
	(4.807)	(4.222)	(2.612)	(4.806)	(2.711)	(2.139)
Log prices (t-1)	-0.182**	-0.0907	-0.133*	-0.226***	-0.390**	-0.338**
	(-1.971)	(-0.814)	(-1.648)	(-3.225)	(-1.996)	(-2.199)
Output gap (t-1)	0.127**	0.0505	0.548***	0.238***	0.406***	0.290**
	(2.077)	(0.427)	(9.105)	(3.692)	(5.563)	(2.497)
Period dummy (t-1)	-0.0779	-0.0646	0.00113	-0.0564	0.142	-0.127
	(-0.296)	(-0.317)	(0.00744)	(-0.442)	(0.672)	(-0.555)
Output gap x period dummy (t-1)	-0.163	0.451*	-0.458*	0.532***	-0.852***	0.0640
	(-1.120)	(1.812)	(-1.841)	(3.472)	(-4.314)	(0.187)
Prices growth x period dummy (t-1)	-0.321	-0.522*	-0.193	-0.518***	0.0276	-0.418***
	(-1.034)	(-1.852)	(-0.795)	(-3.333)	(0.115)	(-3.393)
Short-term elast. output gap:						
Period dummy = 1 (size)	-0.036	0.502	0.090	0.771	-0.447	0.354
Period dummy = 1 (p-value)	0.834	0.085	0.724	0.000	0.020	0.374
Short-term elast. prices growth:						
Period dummy = 1 (size)	0.447	0.139	0.266	0.054	0.333	-0.133
Period dummy = 1 (p-value)	0.009	0.475	0.478	0.645	0.105	0.311
AR(1) (p-value)	0.023	0.027	0.062	0.019	0.019	0.072
AR(2) (p-value)	0.904	0.742	0.200	0.151	0.568	0.103
Hansen (p-value)	0.168	0.102	0.238	0.614	0.432	0.498
#instruments	13	11	13	10	10	11
Observations	192	192	180	180	180	180

(1) The ULC for the public (private) sector is measured as the compensation in NACE sectors O-Q (total compensation excluding compensation in NACE sectors O-Q) divided by real gross value added (GVA) in sectors O-Q (total real GVA excluding GVA in sectors O-Q). Sectors O-Q represent a rather broad interpretation of the government sector, covering public administration, defence, education, human health and social work activities. We also run the same analysis using a narrower definition of the public sector (NACE sector O, representing public administration and defence; compulsory social security) and the results remain broadly unchanged. Data are taken from Eurostat national accounts data. The regressions displayed above are based on two-step system GMM estimations following Blundell and Bond (1998) using internal instruments for the lagged prices and output gap variable. Due to the small sample size the set of internal instrumental variables is restricted by "collapsing" the matrix of instruments and restricting its lags up t-3. The standard errors are corrected following Windmeijer (2005). AR(1,2) and Hansen tests confirm the validity of the System GMM specifications. t-statistics are displayed in parentheses. ***, ** and * denote respectively statistical significance at 1, 5 and 10%.
Source: DG ECFIN calculations.

Furthermore, the empirical analysis points to a significant impact of additional explanatory variables in line with the literature review (see Table 4). In particular, a marginal increase in the TFP growth rate, real GDP per capita, the government primary balance and the house price index tend to lead to an increase, i.e. an appreciation, of relative prices. An increase in the top marginal income tax rate, the growth rate of the nominal effective exchange rate appears to reduce prices, therefore leading to depreciations.

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Box (continued)

Table 4: **Impact of additional independent variables (1)**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Prices growth (t-1)	0.541***	0.557***	0.554***	0.545***	0.574***	0.601***	0.362***	0.609***
	(2.937)	(3.514)	(5.091)	(2.680)	(4.777)	(4.375)	(5.037)	(5.516)
Log prices (t-1)	0.476*	-0.241***	-0.230***	-0.122	-0.252***	-0.234***	-0.348***	-0.284*
	(1.748)	(-3.839)	(-3.178)	(-1.238)	(-4.104)	(-3.624)	(-3.071)	(-1.878)
Output gap (t-1)	0.265**	0.250***	0.204**	0.492***	0.246***	0.229***	0.318***	0.278***
	(2.007)	(2.945)	(2.076)	(4.172)	(4.247)	(3.293)	(4.942)	(3.142)
Period dummy (t-1)	0.0987	-0.0997	-0.0228	-0.0642	-0.0295	-0.00576	0.154	0.0504
	(0.670)	(-0.648)	(-0.188)	(-0.324)	(-0.229)	(-0.0460)	(0.690)	(0.156)
Output gap x period dummy (t-1)	0.252**	0.552***	0.573***	0.458*	0.544***	0.631***	0.269*	0.276*
	(2.059)	(3.140)	(3.469)	(1.719)	(3.707)	(3.378)	(1.694)	(1.743)
Prices growth x period dummy (t-1)	-0.746***	-0.524***	-0.586***	-0.616**	-0.547***	-0.612***	-0.540***	-0.636***
	(-3.395)	(-2.611)	(-5.333)	(-2.452)	(-3.794)	(-2.908)	(-4.753)	(-3.073)
TFP growth (t-1)	0.324***							
	(3.628)							
Real GDP per capita (t-1)		0.120**						
		(2.259)						
Govt. primary balance (t-1)			0.113*					
			(1.759)					
Δ VAT				-0.166				
				(-1.372)				
Top marginal income tax rate (t-1)					-0.0850*			
					(-1.946)			
NEER rel. IC37 growth (t-1)						-0.150**		
						(-2.152)		
Δ House prices							0.222***	
							(5.028)	
Δ Inflation expectations								0.0259
								(0.136)
Short-term elast. output gap:								
Period dummy = 1 (size)	0.577	0.564	0.457	1.082	0.577	0.573	0.498	0.712
Period dummy = 1 (p-value)	0.010	0.006	0.002	0.023	0.005	0.014	0.000	0.017
Short-term elast. prices growth:								
Period dummy = 1 (size)	1.127	1.809	1.743	2.089	1.854	2.152	0.919	1.417
Period dummy = 1 (p-value)	0.012	0.007	0.002	0.040	0.001	0.026	0.131	0.484
AR(1) (p-value)	0.016	0.023	0.011	0.093	0.018	0.026	0.008	0.017
AR(2) (p-value)	0.426	0.167	0.946	0.483	0.178	0.336	0.340	0.482
Hansen (p-value)	0.907	0.463	0.751	0.159	0.657	0.724	0.713	0.597
#instruments	14	11	11	12	11	11	11	10
Observations	180	179	173	168	180	180	164	150
#countries	12	12	12	12	12	12	11	10

(1) Prices are measures using the ULC deflator for the private sector. The period dummy covers the years from 2011 to 2014. Regressions were run using internal instruments for the lagged prices and output gap variable using the two-step system GMM estimator by Blundell and Bond (1998). Due to the small sample size the set of internal instrumental variables is restricted by "collapsing" the matrix of instruments and restricting its lags up t-3. The standard errors are corrected following Windmeijer (2005). AR(1,2) and Hansen tests confirm the validity of the System GMM specifications. t-statistics are displayed in parentheses. ***, ** and * denote respectively statistical significance at 1, 5 and 10%.
Source: DG ECFIN calculations.

Despite adding additional control variables, the findings of the baseline specification still hold. In particular, relative prices show a positive and significant reaction to changes in output gap differentials. This points to a rather robust relationship in spite of the relatively small sample size.

Interaction specification

The interpretation of the empirical model with interaction terms is less straightforward. ([5]) The impact of a change in the output gap or the price persistence on relative prices needs to be assessed based on partial derivatives, which depend on the institutional setup (Z) and the crisis state (C) as shown below:

$$(d)\left(\frac{\partial RP_{i,t}}{\partial GAP_{i,t-1}}\middle| C_t, Z_{i,t-1}\right) = \begin{cases} (\beta_3 + \beta_8) + (\beta_6 + \beta_{10}) Z_{i,t-1} & if\ C = 1 \\ \beta_3 + \beta_6 Z_{i,t-1} & if\ C = 0 \end{cases}$$

To derive meaningful results we assess the size and statistical significance of the partial derivatives of the output gap or price persistence for low (L), mean (M) and high (H) observed values of the institutional variables (see Chart 1 for an illustration). Due to the z-standardisation of the institutional variables, values below (above) the mean indicate more (less) rigid regulations. For example, in the illustrative chart below, the relative price mechanism becomes weaker with increasing values for the institutional variable, i.e. for stricter regulation, and it is no longer statistically significant for high values of the institutional variable.

([5]) For the interpretation of interaction terms see e.g. Braumoeller, B.F. (2004), 'Hypothesis testing and multiplicative interaction terms', *International Organization*, 58(4), October, pp. 807-820 or Brambor, T., W.R. Clark, M. Golder (2006), 'Understanding interaction models: improving empirical analyses', *Political Analysis*, 14, p.p. 63-82.

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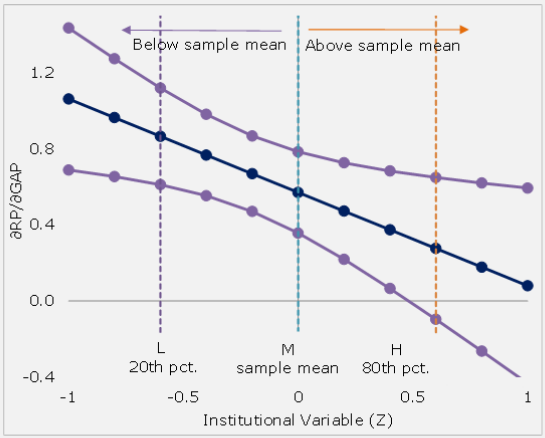
Box (continued)

Chart 1: **Illustration interaction specification**



Source: DG ECFIN calculations.

The interaction specifications show that stricter employment protection legislation, more generous unemployment benefit schemes and stricter price controls have reduced the responsiveness of relative prices to cyclical divergences as indicated by the negative slope parameter (see Chart 2). During the crisis period, high costs of borrowing and sovereign bond spreads seem to have had a harmful effect on the adjustment speed of relative prices to cyclical divergences.

The interaction models further show that stricter employment protection legislation, higher minimum wages, stricter price controls and sovereign bond yields seem to have prolonged the price persistence in the euro area.

Chart 2: **Interaction specifications**

	No crisis period				Crisis period				No crisis period				Crisis period			
	Slope	L	M	H	Slope	L	M	H	Slope	L	M	H	Slope	L	M	H
Labour markets																
Employment protection	-	■	■	□	-	■	■	□	-	□	□	□	+	□	■	■
Minimum wage	+	□	□	□	+	□	□	□	+	□	■	■	+	□	■	■
Unemp. benefits repl. rate	-	■	■	■	-	■	■	■	+	□	□	□	-	□	□	□
Product markets																
PMR	-	□	□	□	+	□	□	□	-	□	□	□	+	□	□	□
Price controls	-	■	▨	□	-	■	▨	□	+	□	□	▨	+	□	□	▨
Financial markets																
Cost of financing	-	▨	□	□	-	■	■	■	-	□	□	□	+	□	□	□
Sovereign bond yields	-	■	□	□	-	■	■	□	-	□	□	□	+	□	▨	▨

(1): The table shows the derivative of relative prices with respect to the output gap (two blocks on the left) or price persistence (two blocks on the right) for low (L), median (M) and high (H) values of the observed values of the labour, product and financial market variable, corresponding to the 20th/50th/80th percentile of the observed distribution. "Slope" indicates the direction of the slope parameter (- negative, + positive). The calculations are done for the crisis (i.e. the period from 2009 to 2014) and non-crisis period. Black and striped fields denote statistical significance at the 1 and 10% level, whereas white fields point to a no statistically significant coefficient.

Reading example: More stringent employment protection legislation (EPL) appears to reduce the responsiveness of relative prices to cyclical conditions both during crisis and non-crisis times. In case of low or medium values of the EPL relative to the EA-12 average, the relative price channel is statistically significant, i.e. it works successfully, whereas it is no longer significant for high values of EPL, i.e. very strict employment protection legislation. In addition, more rigid EPL tends to raise inflation persistence in crisis times.

Source: DG ECFIN calculations.