1. INTRODUCTION

The existence of wage and price rigidities is widely recognised as a crucial issue for macroeconomics and notably for monetary policy design. On the theoretical front, recent literature – of which Erceg et al. (2000), Christiano et al. (2005), Levin et al. (2005) and Blanchard and Gali (2007) are notable examples – has re-affirmed the importance of price and wage rigidities for the reaction of the economy to shocks. On the empirical front, there is now a large bulk of evidence on the existence of price rigidities at the firm level. Studies documenting this kind of nominal rigidities include, among many others, Bils and Klenow (2004), Klenow and Kryvtsov (2008) and Nakamura and Steinson (2008) who study consumer prices in the United States and Dhyne et al. (2006), Fabiani et al. (2006) and Vermeulen et al. (2007) who give a synthesis of studies carried out for the euro area countries. The evidence for nominal wages is not as extensive as for prices, but recently Druant et al. (2009) documented the existence of significant wage rigidities for the euro area countries.

In the real world, the existence of price and nominal wage rigidities is expected to translate into persistent responses of wages and prices to shocks hitting the economy. Thus, the aim of this article is to investigate the dynamics of aggregate wages and prices in the United States (US) and the euro area (EA) with a special focus on the persistence of real wages, wage and price inflation. Following a theoretical model where wages are determined through a bargaining process and prices are set by imperfectly competitive firms, we estimate a structural vector error-correction model (SVECM) involving nominal wages, consumer prices, the unemployment rate, labour productivity and import prices, which allows for a distinction between permanent and transitory shocks (see, King et al. (1991), and Jacobson et al. (1997)). The three permanent shocks, labelled as import price, unemployment and technology/productivity shocks are identified using the properties of the theoretical model, as well as the cointegrating properties of the system. By looking at the models’ impulse response functions, we investigate the main features of wages and prices responses to these shocks and evaluate the short and long-run persistence of real wages and wage and price inflation.

The rest of the article is organized as follows. Section 2 presents a simple theoretical model of wages and prices, which will be used to identify the long-run wage and price equations, as well as the perma-
nent structural shocks. Section 3 presents the estimation and identification of the long-run wage and price equations. Section 4 focuses on the identification of the structural shocks and on the dynamic response of wages and prices to these shocks, including some measures of short and long-run persistence. Section 5 tries to account for the main differences in the impulse responses of the shocks in the US and the EA. Section 6 concludes.

2. A MACROECONOMIC MODEL FOR WAGES AND PRICES IN AN OPEN ECONOMY

The model consists of a production function, a wage setting equation, an equation describing price formation, an equation for the unemployment rate and an equation for import prices in domestic currency. The equations contain a minimum of dynamics in order to simplify the discussion about the long-run properties of the model.

We assume that the production in the economy may be described by a constant returns to scale Cobb-Douglas function (with lower case letters denoting logs):

$$\begin{align*}
y - e &= \eta + (1 - \gamma)(k - e) \\
\end{align*}$$

where \( y \) is output, \( e \) is employment, \( k \) is the stock of capital, \( \gamma \) is the output elasticity of labour and \( \eta \) a stochastic technology variable. We may further simplify the production function and write:

$$h = y - e = \xi_n$$

where \( h \) stands for labour productivity and \( \xi_n \) for a stochastic technology trend (technical progress and capital accumulation) that shifts labour productivity in the long run. It is assumed that technology is exogenous and follows a stochastic random-walk process, i.e., \( \xi_n = \xi_{n-1} + \phi_n \) where \( \phi_n \) is a pure technology innovation.

As regards the wage formation, we assume that wages are determined through a bargaining process between firms and employees. This type of models predicts that the bargaining solution will depend on the real producer wage and productivity on the firms’ side, and on the real consumer wage on the workers’ side. A simple log-linear form of the wage equation corresponding to the bargaining solution can be written as:

$$w - q = c_1 + \mu(p - q) + \delta h - \theta u,$$

where \( w \) is the nominal wage rate, \( q \) is the producer price level, \( p \) is the consumer price level and \( u \) is the unemployment rate.

According to (3), the real wage faced by firms (real producer wage) is affected by \( \mu(p - q), h \) and \( u \). The price wedge \( (p - q) \), which measures the difference between the producer real wage and the con-

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For text book expositions of the model for wages and prices see, for instance, Layard et al. (1991), Lindbeck (1993) or Bardsen et al. (2005).
sumer real wage, plays an important role in theoretical wage bargaining models. Its coefficient, $\mu$, can be interpreted as a measure of real wage resistance, which measures workers’ ability to obtain higher wages to compensate for exogenous changes in their living standards (increases in consumer prices brought about, for example, by changes in indirect taxes). The bargaining solution (3) also implies that an increase in labour productivity, $h$, will increase wages, since higher productivity increases the profitability of firms, making them more likely to accept higher wage claims from the employees or their representatives. The unemployment rate, $u$, represents the degree of tightness in the labour market, which influences the outcome of the bargaining process through the relative bargaining power of employees and employers organizations.

For the process of price formation we assume an economy with imperfect competition where producers target their prices, $q$, as a mark-up, $m$, over marginal costs. If there are constant returns to scale, marginal costs are constant and therefore prices are set as a mark-up over unit labour costs:

$$ q = m + (w - h). \quad (4) $$

The mark-up is not necessarily constant and, in an open-economy, it may be a function of the level of international competitiveness (see Layard et al. (1991)). Here, we assume that the mark-up may be written as:

$$ m = c_2 + \lambda (z - q), \quad c_2, \lambda \geq 0, \quad (5) $$

where $z$ is the price of imports in domestic currency and $\lambda$ reflects the exposure of domestic firms to international competition. Thus, the smaller is $\lambda$ the smaller is the pass-through from foreign price or exchange rate shocks to domestic producer prices.

If we further assume that consumer prices are a weighted average of producer and import prices:

$$ p = (1 - \rho)q + \rho z, \quad 0 < \rho < 1 \quad (6) $$

we may solve the model for wages and consumers prices and obtain the following long-run wage and price equations (ignoring the constants for simplicity):

$$ w = (1 + \alpha)p - \alpha z + \delta h - \theta u + \tau_w, \quad (7) $$

$$ p = \beta(w - h) + (1 - \beta)z + \tau_p, \quad (8) $$

where $\alpha = \rho(1 - \mu)/(1 - \rho)$ and $\beta = (1 - \rho)/(1 + \lambda)$.

From the price equation, we see that there are two channels through which foreign price and exchange rate shocks impact on domestic consumer prices. First, there is a direct channel through imported goods prices given by $\rho$. Second, a rise in import prices reduces competitiveness of foreign firms, allowing domestic producers to increase their mark-up and thus the price of their products.

We see the wage and price equations (7) and (8) as long-run or equilibrium targets that are not necessarily
achieved by workers and firms in a specific time period. Thus, under the assumption that the two relations are stationary, the stochastic variables $\tau_w$ and $\tau_p$ can be interpreted as exogenous wage and price shocks that follow stationary stochastic processes, i.e., $\tau_i = \sigma_i \tau_{i-1} + \varepsilon_i$, $0 \leq \sigma_i < 1$ ($i = w, \ldots, p$).

The unemployment rate is assumed to be the result of the difference between the labour supply and labour demand, so that in the long run unemployment may be affected both by real wages, ($w - p$), and productivity, $h$:

$$u = \pi_i (w - p) + \pi_z h + \epsilon_u,$$  (9)

where $\epsilon_u$ is an exogenous stochastic variable. Equation (9), being a reduced form equation, has the implication that $\epsilon_u$ is a combination of labour supply and demand shocks.

Finally, we assume that import prices in domestic currency may depend on unemployment, as well as on productivity:

$$z = \gamma_i u + \gamma_z h + \epsilon_z$$  (10)

This way we allow for the possibility of unemployment and technology shocks to have long-run impacts on import prices through changes in the prices of imported goods in foreign currency, as well as through changes in the exchange rate of the domestic currency.

The stochastic variables $\epsilon_u$ and $\epsilon_z$ would be stationary processes if equations (9) and (10) turn out to be cointegrating relationships and in such a case would be interpreted as stationary shocks. In the absence of cointegration, they will be assumed to follow random-walk processes, i.e., $\epsilon_u = \epsilon_{u-1} + \phi_u$ and $\epsilon_z = \epsilon_{z-1} + \phi_z$, where $\phi_u$ and $\phi_z$ are pure exogenous unemployment and import price shocks, respectively.

Summing up, our theoretical model expressed in terms of the variables we consider in the empirical analysis is composed of equations (2), (7), (8), (9) and (10).

### 3. ECONOMETRIC ANALYSIS

To estimate the model above we use quarterly seasonally adjusted data for the period 1993Q1-2007Q4 in the case of the US and for the period 1989Q1-2007Q4 in the case of the EA. Wages ($w$) refer to nominal compensation per employee for the whole economy, whereas labour productivity ($h$) is measured as real GDP per employed person. Consumer prices ($p$) are measured by the Consumer Price Index for the US and the Harmonized Consumer Price Index for the EA. Import prices ($z$) are measured by price indexes for imports of goods (extra-euro area imports in the case of the EA).

Chart 1 plots the levels of the logs of all five variables, as well as the real wage, the labour share and unit labour costs for the US and the EA in the common period 1993Q1-2007Q4. From this chart we can

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(3) Data for the US is from the Department of Labour (series on unemployment and prices) and the Department of Commerce (national accounts data). Data for the EA from 1995 onwards was collected from the Eurostat database, except for compensation per employee which came from the ECB database. Prior to mid-90s, the data was backdated with the Area Wide Model database (see Fagan et al. (2001)) and Eurostat extra-euro area historical trade data.
see that real wages in the US decreased until 1997, but soared afterwards with a significantly larger growth rate than in the EA, where real wages seem to have levelled off after 2003. The labour share also exhibits a different pattern in the two economies with a very pronounced downward trend in the EA and some levelling off from 1997 onwards in the US. An important point to keep in mind is that the labour share does not seem to behave as a stationary variable neither in the EA nor in the US. For the analysis that follows we assume that $w_p, u$ and $h$ are all integrated of order one.4

We set up a VAR model in $w, p, u, h$ and $z$ with three lags and an unrestricted constant.5 According to the theoretical model outlined in Section 2, we expect two stationary long-run relationships or, in other words, two cointegrating vectors, one corresponding to the wage equation and the other to the price equation. Based on the results of the cointegration tests, the hypothesis of two cointegrating vectors

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(4) For further details on the econometric analysis, namely on the discussion of unit root and cointegration tests results, see Duarte and Marques (2009).

(5) In the case of the US, the model also includes the quarterly change in the price of oil, lagged one period, as an exogenous stationary variable. In addition, we include some impulse dummy variables in the model for each of the economies to account for outliers in the residuals of some equations.
emerges as the natural choice that reconciles the empirical evidence with the theoretical features of the model for both the US and the EA. Next, we use structural information derived from the theoretical model to identify the long-run wage and price equations (7) and (8). In general terms, this amounts to imposing restrictions on the estimated coefficients based on the restrictions on the parameters of the theoretical model. However, in the present case, this is not sufficient since the wage equation is not in fact identified. In order to overcome this problem, we impose $\alpha = 0$ in equation (7), such that import prices drop from the wage equation. It is possible to show that in such a case the system becomes over-identified with three over-identifying testable restrictions.

After imposing these over-identifying restrictions together with the additional restrictions of a null coefficient of productivity in the wage equation ($h = 0$) and of the weak-exogeneity property of the unemployment, productivity and import prices (which are not rejected by the data), the two long-run estimated wage and price equations for the EA read as follows (with asymptotic standard errors in parenthesis):

\[
w = p - 0.157u_{(0.023)}
\]

\[
p = 0.626(w - h) + 0.374z_{(0.045)}
\]

For the US, the three over-identifying restrictions on the two cointegrating vectors are not accepted as a whole given that the restriction of a symmetric coefficient of wages and productivity in the price equation is strongly rejected by the data. When we estimate the model by imposing the two remaining over-identifying restrictions, as well as the additional restriction of $h = 1$ (which is not rejected by the data), we get the following two long-run estimated wage and price equations:

\[
w = p + h - 0.327u_{(0.065)}
\]

\[
p = 0.872w - 0.480h + 0.128z_{(0.042)}
\]

Some comments on the long-run wage and price equations are in order. The fact that the coefficient of productivity is equal to zero in the wage equation for the EA probably reflects the fact that the labour share is decreasing during the sample period, which means that wages have not been able to capture a significant fraction of productivity gains. This phenomenon, however, seems not to be present in the wage equation for the US, where the coefficient on productivity turns out not to be statistically different from one, which means that in the long run wages will completely absorb productivity gains. This, as we shall see below, explains why technology shocks have quite different consequences for real wages in the two economies. The coefficient of the unemployment rate in the wage equation is significantly larger in the US, suggesting higher flexibility of wages to unemployment shocks, in line with the belief of a smaller degree of employment protection in the US vis-à-vis the EA.

As regards the price equations, we note that both include the restriction that the sum of the wages’ coefficient and that of import prices is equal to one, but, in contrast to the EA, the price equation for the
US does not involve the unit labour costs as a relevant variable, as productivity enters in the equation with a lower (in absolute terms) coefficient than wages. This implies that not all the productivity gains are reflected in lower prices in the long run, which may suggest that the hypothesis of constant returns to scale is not fully consistent with US data. Another distinguishing feature between the two economies is the estimated parameter of import prices, which is significantly higher in the EA.

4. WAGE AND PRICE DYNAMICS

We now proceed to analyse the reaction of model variables to specific shocks that hit the two economies. We start by discussing the identification of the structural shocks based on the theoretical model and the empirical cointegration results from the previous section. Next, we have a look at the impulse response functions of the structural shocks, with a special focus on their persistence.

4.1. Identification of the structural shocks

The existence of two cointegrating vectors in our five-variable system implies that there must be three structural shocks with permanent effects and two structural shocks with transitory effects. According to our theoretical model, the permanent shocks can be labelled as import price, unemployment and technology/productivity shocks, whereas the transitory shocks can be labelled as wage and price shocks. The interpretation of these last two shocks is not as intuitive as that of the permanent ones, as they may stem from a variety of alternative sources with different implications for the dynamics of the model. Therefore, the discussion will focus mainly in the three permanent shocks.

The permanent import price shock is defined as the shock that has no long-run impact on unemployment or productivity. Such a shock may stem from an unexpected change in the foreign prices of imported goods or from an unexpected change in the nominal exchange rate. The permanent unemployment shock is identified by the condition that it has a zero long-run effect on productivity and is interpreted as a shock that may stem from an unexpected increase in labour supply or labour demand. Finally, the permanent technology shock is the shock that may have permanent effects on all the variables of the system and may be seen as the result of technical progress and capital accumulation that shift labour productivity in the long run.6

4.2. Impulse response functions to permanent shocks

The impulse response functions of model variables, as well as the responses of real wages, to positive permanent import prices, unemployment and technology shocks are depicted in Charts 2 to 4.7 In order to evaluate how fast the wages and prices approach the new long-run equilibrium level, we com-

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6 Note that this identification conforms to the restriction satisfied by a broad range of models, where only technology shocks have a permanent effect on labour productivity (see, for instance, Gali (1999)).

7 The impulse response functions for the five original variables of the system are depicted together with 80 percent confidence bands. Note that the impulse responses reflect the impact of a unit shock to the corresponding trend innovation.
puted two measures of persistence defined as the proportion of the total disequilibrium that dissipates in the two years after the shock, and the number of periods required for 99 percent of the total disequilibrium to dissipate (see Table 1). We see the first measure as a simple way of quantifying the speed of reaction in the short-term, so that we will loosely denote it as ‘short-term persistence’ and the second as a way to measure ‘long-run persistence’. When the speed of the responses varies throughout the convergence period, we will need to look at both measures to better characterize the adjustment process. Although the impulse responses and the measures of persistence involve in some cases a relatively high degree of uncertainty, it is possible nonetheless to draw some conclusions on how the EA and US economies react to different shocks.

Table 1

<table>
<thead>
<tr>
<th>PERSISTENCE OF WAGES AND PRICES</th>
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<tbody>
<tr>
<td>( \Delta w ) ( \Delta p ) ( w - p )</td>
</tr>
<tr>
<td>US</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>Share of total disequilibrium dissipated after 8 quarters</td>
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<tr>
<td>Permanent import price shock</td>
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<tr>
<td>Permanent unemployment shock</td>
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<tr>
<td>Permanent technology shock</td>
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<th>Number of quarters required for 99 percent of the total disequilibrium to dissipate</th>
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<tbody>
<tr>
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<tr>
<td>Permanent import price shock</td>
</tr>
<tr>
<td>Permanent unemployment shock</td>
</tr>
<tr>
<td>Permanent technology shock</td>
</tr>
</tbody>
</table>

Source: Authors’ calculations.

Permanent import price shock

Chart 2 depicts the impulse responses to an unexpected permanent positive import price shock in the US and the EA. As expected, given the property of long-run nominal homogeneity of the model, this shock brings about a permanent increase in nominal wages and prices of the same magnitude. As a result, real wages remain unchanged in the long run. A noteworthy result is that the import price shock has a larger impact on prices (and wages) in the EA than in the US, in line with the estimated parameters of wage and price equations, which reflect the relative openness of the two economies.

As could also be expected, prices increase faster than nominal wages in the short run, so that real wages decrease during the first two years in the US and the first three years in the EA. In addition, the adjustment of real wages displays a very persistent hump-shaped response to this type of shock in both economies, particularly in the US. From Table 1, we can see that real wages emerge as clearly more persistent in the US than in the EA especially in the short-run. In fact, in the first two years after the shock, only about 30 percent of the disequilibrium has dissipated in the US, compared to 60 per-
Chart 2

RESPONSES TO A PERMANENT IMPORT PRICE SHOCK

US

EA

Nominal wages (w)

Prices (p)

Unemployment (u)

Labour productivity (h)

Import prices (z)

Real wages (w-p)

Source: Authors’ calculations.
In the long run, the difference in the number of periods required for 99 percent of the adjustment to take place is however not so significant. It takes about 11 years for the full adjustment of real wages in the US, compared to 10 years in the EA.

In the case of price inflation (measured by the first difference of the log of prices), the largest impact occurs almost contemporaneously in both economies. Wage inflation also exhibits a strong short-term response in the US, while in the EA the largest impact occurs only after 10 quarters. As regards short-term persistence, both wage and price inflation display a more sluggish response in the EA. From Table 1 we can see that after 2 years only 42 percent and 55 percent of the total disequilibrium of wage and price inflation has dissipated in the EA, compared to 80 percent in the US. At longer horizons, the difference between the two economies partly fades away, but the number of periods required for 99 percent of the total disequilibrium to dissipate for wage and price inflation in the EA still remains slightly above that of the US (around 11 and 10 years, respectively).

**Permanent unemployment shock**

Chart 3 depicts the impulse responses to an unexpected permanent positive unemployment shock. This shock leads to a larger permanent decrease of real wages in the EA than in the US, which stems mainly from the fact that nominal wages decrease in the EA, but remain virtually unchanged in the US. The explanation for this result might be found in the response of import prices and of the unemployment rate itself. The unemployment rate levels off at a higher level in the EA, eventually reflecting greater institutional rigidity of its labour market. In turn, although import prices increase permanently in the long run in both economies (eventually following a currency depreciation induced by higher unemployment), the reaction is stronger in the US, possibly due to higher sensitivity of the dollar to domestic conditions. As a consequence, prices rise more markedly in the US economy relatively to the EA, and partially offset the direct effect of higher unemployment on wages in the long run.

In the short run, labour productivity temporarily increases and unemployment temporary falls in the US leading to a rise in nominal wages. Given the sluggish response of prices, real wages increase in the first year after the shock, resuming a downward trend afterwards. This contrasts with the short-term behaviour of real wages in the EA, which start declining immediately after the shock, reflecting the increase in prices. As a result, in the short-run real wages adjust somewhat faster in the EA relatively to the US (the proportion of the disequilibrium in real wages dissipated after 2 years is 64 percent in the EA and 50 percent in the US). However, the long-run adjustment of real wages occurs somewhat faster in the US than in the EA (it takes around 9 years in the US compared to around 10 years in the EA).

As regards wage and price inflation, both variables emerge as more persistent in the EA than in the US, especially at longer horizons. The full adjustment takes about 9 to 10 years in the US compared to about 12 years in the EA.
**Chart 3**

**RESPONSES TO A PERMANENT UNEMPLOYMENT SHOCK**

**US**

- **Nominal wages (w):**
  - Year 1: -0.012
  - Year 2: -0.010
  - Year 3: -0.008
  - Year 4: -0.006
  - Year 5: -0.004
  - Year 6: -0.002
  - Year 7: 0.000
  - Year 8: 0.002
  - Year 9: 0.004
  - Year 10: 0.006

- **Prices (p):**
  - Year 1: -0.004
  - Year 2: -0.002
  - Year 3: 0.000
  - Year 4: 0.002
  - Year 5: 0.004
  - Year 6: 0.006

- **Unemployment (u):**
  - Year 1: -0.040
  - Year 2: -0.020
  - Year 3: 0.000
  - Year 4: 0.020
  - Year 5: 0.040
  - Year 6: 0.060

- **Labour productivity (h):**
  - Year 1: -0.002
  - Year 2: -0.001
  - Year 3: 0.000
  - Year 4: 0.001
  - Year 5: 0.002
  - Year 6: 0.003
  - Year 7: 0.004

- **Import prices (z):**
  - Year 1: -0.010
  - Year 2: 0.000
  - Year 3: 0.010

- **Real wages (w-p):**
  - Year 1: -0.008
  - Year 2: -0.006
  - Year 3: -0.004
  - Year 4: -0.002
  - Year 5: 0.000
  - Year 6: 0.002
  - Year 7: 0.004

**EA**

- **Nominal wages (w):**
  - Year 1: -0.012
  - Year 2: -0.010
  - Year 3: -0.008
  - Year 4: -0.006
  - Year 5: -0.004
  - Year 6: -0.002
  - Year 7: 0.000
  - Year 8: 0.002
  - Year 9: 0.004
  - Year 10: 0.006

- **Prices (p):**
  - Year 1: -0.004
  - Year 2: -0.002
  - Year 3: 0.000
  - Year 4: 0.002
  - Year 5: 0.004
  - Year 6: 0.006

- **Unemployment (u):**
  - Year 1: -0.040
  - Year 2: -0.020
  - Year 3: 0.000
  - Year 4: 0.020
  - Year 5: 0.040
  - Year 6: 0.060

- **Labour productivity (h):**
  - Year 1: -0.002
  - Year 2: -0.001
  - Year 3: 0.000
  - Year 4: 0.001
  - Year 5: 0.002
  - Year 6: 0.003
  - Year 7: 0.004

- **Import prices (z):**
  - Year 1: -0.010
  - Year 2: 0.000
  - Year 3: 0.010

- **Real wages (w-p):**
  - Year 1: -0.008
  - Year 2: -0.006
  - Year 3: -0.004
  - Year 4: -0.002
  - Year 5: 0.000
  - Year 6: 0.002
  - Year 7: 0.004

Source: Authors’ calculations.
Permanent technology shock

In the context of our estimated models, productivity gains are completely absorbed by nominal wages in the long run in the US, which strongly contrasts with the EA where changes in productivity have no long-run direct impact on wages \((i.e., \delta = 1\) for the US, but \(\delta = 0\) for the EA in equation (7)). Thus, the effects of a technology shock may be expected to differ markedly between the two economies. From Chart 4 we find that this is indeed the case, especially where prices and real wages are concerned. The long-run response of nominal wages is similar in both economies, although slightly more pronounced in the case of the US given the estimated long-run wage equation. In what concerns prices, a permanent technology shock causes a permanent decline of import prices in the US, which translates into a decrease of the consumer price level in the long run. In the EA, there is a permanent increase in the equilibrium price level brought about by a positive reaction of import prices. As a consequence, real wages rise more significantly in the long run in the US than in the EA.

In line with the behaviour of nominal wages and consumer prices, the technology shock has a temporary positive impact on wage inflation in both economies, but brings about a symmetric reaction of price inflation (it declines in the US and rises in the EA). The short-run persistence of wage and price inflation is slightly lower in the EA, but the long-run adjustment is somewhat slower than in the US (it takes between 10 and 11 years in the EA and between 8 and 10 years in the US). Real wages emerge as more persistent in the EA than in the US both in the short and the long run (it takes almost 12 years for the full adjustment to take place in the EA, compared to about 10 years in the US).

5. ACCOUNTING FOR THE MAIN DIFFERENCES BETWEEN THE US AND THE EA

According to the results presented in the previous section, wage and price inflation emerge as less persistent in the US compared to the EA in the face of the three permanent shocks. In this section we investigate whether this finding is likely to stem from the use of different sample periods and/or different model specifications rather than from structural dissimilarities between the two economies.

For this purpose, we estimate a new model for the EA that is strictly comparable to the one of the US as far as the specification and sample period are concerned. Importantly, the main qualitative features of the responses to the permanent shocks do not change and the conclusions of

(8) The final effect on import prices (in domestic currency) may be thought of as depending on the relative importance of two channels with opposite effects. The exchange rate channel, which could be expected to bring about a decrease in import prices through a currency appreciation and the foreign price channel, which could be expected to increase import prices through higher import demand brought about by a rise in economic activity. The results suggest that the first channel seems to be stronger in the US, while in the EA the second one seems to predominate.

(9) The new cointegrating VAR model was estimated using the same period as for the US (1993Q1-2007Q4) and includes the quarterly change in the price of oil lagged one period as an exogenous regressor.
Chart 4

RESPONSES TO A PERMANENT TECHNOLOGY SHOCK

US

Nominal wages ($w$)

Prices ($p$)

Unemployment ($u$)

Labour productivity ($h$)

Import prices ($z$)

Real wages ($w-p$)

EA

Nominal wages ($w$)

Prices ($p$)

Unemployment ($u$)

Labour productivity ($h$)

Import prices ($z$)

Real wages ($w-p$)

Source: Authors’ calculations.
section 4 about the relative persistence of the two economies still hold. If anything, the long-run persistence of wage and price inflation in the EA emerges as somewhat higher (especially so for the import price and technology shocks), thus increasing the difference vis-à-vis the US economy.\(^\text{10}\) Against this background, we believe that the main differences concerning the persistence and features of the responses to the shocks may be traced to some macro and micro structural differences between the two economies, among which international openness, institutional rigidity of the labour market, as well as price and wage setting practices may be expected to play a prominent role.

The different degree of openness implies that import price shocks have significantly different implications for the two economies. On the one hand, import price shocks are expected to have stronger direct long-run impact on the EA, given the larger share of imports in total GDP in this economy, which is reflected in the significantly larger coefficient associated with import prices in the estimated long-run price equation. On the other hand, the higher openness of EA is also expected to imply larger effects stemming from some shocks usually associated with globalisation (imports of final goods, outsourcing of the production of intermediate goods), with implications on the labour market. For instance, a lower workers' bargaining power of immigrant employees has been used to help explain the strong decreasing trend exhibited by the labour share in some EA countries, or in other words why, in the EA, wages have not been able to absorb a significant proportion of productivity gains (see, for instance, Bentolila et al. (2008) for Spain and European Commission (2007) for the OECD countries). This, as we have seen, emerges in our model as an estimated coefficient of productivity in the long-run wage equation for the EA which is not statistically different from zero. In strong contrast, the empirical results for the US suggest that wages have been able to completely absorb productivity gains in the long run, which is consistent with the evidence in Feldstein (2008), who shows that in this economy the rise in compensation per employee has been very similar to the rise in productivity. Similar evidence can be seen in European Commission (2007), where the US emerges as the country where the labour share exhibits a closer to stationarity long-run behaviour, in contrast to the EA and Japan, where the labour share displays a decreasing trend during the last twenty years or so.

As regards the institutional rigidity of the labour market (involving, for instance, employment protection, firing and hiring costs), the evidence in the existing literature suggests that the US labour market is more flexible compared to the EA, thus allowing a faster adjustment to shocks hitting the economy (see, for instance, Abbritti and Weber (2008) and Peersman and Robays (2009)).

Finally, the empirical literature mentioned in the introduction of this article clearly suggests that the US and the EA also differ as far as price and wage setting practices are concerned. Using comparable data sets of quantitative micro data on consumer prices, Dhyne et al. (2006) find that the estimated monthly frequency of price changes is around 15 percent in the EA and 25 percent in the US, and that the average duration of a price spell ranges from 4 to 5 quarters in the EA compared to 2 to 3 quarters.

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\(^\text{10}\) In order to see whether the use of the price of oil in the two models could be distorting the main conclusions documented in the paper on the relative persistence of the shocks, we also estimated a model for the US without the price of oil, and compared the results to the ones obtained for the EA in the model used in Section 4. Again we find that the conclusion about the relative persistence of the shocks between the two economies does not change.
in the US. These results on quantitative data are consistent with evidence from survey data. In fact, according to Fabiani et al. (2006), the median frequency of price changes is one year in the EA, lower than the estimated 1.4 price changes a year in the US obtained in Blinder et al. (1998).\footnote{Altissimo et al. (2006) notice that the lower frequency of price changes in the EA cannot be explained by differences in the consumption structure, as EA consumption is characterised by a larger share of food products (which change prices frequently) and a smaller share of services (with less frequent price changes). Thus, the difference in the frequency of price changes would be even larger if both economies shared the same consumption structure.} Empirical evidence for nominal wages is not as extensive as it is for prices. Nevertheless, recent evidence based on survey data suggests that nominal wages in the EA are changed less often than prices. In fact, according to Druant et al. (2009) around 60 percent of the firms change base wages once a year and 26 percent less frequently, implying an estimated average duration of wage spells of about 15 months. Even though there is no comparable evidence for the US, it is usually accepted in the literature that wages in the US are less rigid than in the EA (see, for instance, Altissimo et al. (2006), Peersman and Robays (2009)).

Thus, overall, our finding of a larger persistence of wage and price inflation in the EA compared to the US appears consistent with the above micro evidence for both economies on wage and price setting practices, as well as on the institutional rigidity of the labour market, which suggest greater wage and price stickiness in the former. Moreover, the relative inflation persistence documented in this article is also consistent with the evidence found in the literature based on time series models with aggregate price data, which suggests that persistence of price inflation in the EA might be larger than in the US (see, for instance, Levin and Piger (2004), Gadzinski and Orlandi (2004), or Altissimo et al. (2006)).

6. CONCLUSIONS

This article investigates wage and price dynamics in the United States (US) and the euro area (EA) assuming an economy where wages are determined through a bargaining process and prices are set by imperfectly competitive firms. The analysis is conducted within a structural vector error-correction model (SVECM) where two separate cointegrating relationships for wages and prices are identified by imposing the long-run restrictions implied by the theoretical model. Against this background, we identify three permanent shocks (labelled as import price, unemployment and technology/productivity shocks) and two transitory shocks (labelled as wage and price shocks). By definition, the permanent shocks are allowed to have significant long-run effects on some (or all) the variables of the system as opposed to transitory shocks that do not affect the model variables in the long run.

Our main findings can be summarized as follows. Following an import price shock, wages and prices rise more significantly in the long run in the EA than in the US, in line with the relative degree of international openness of the two economies. However, real wages remain unchanged in the long run. A permanent unemployment shock brings about a larger decrease of real wages in the EA than in the US. This stems mainly from the fact that nominal wages decrease in the EA, but remain virtually unchanged in the US, as a reaction to higher consumer prices brought about by higher import prices. Following a permanent technology shock real wages rise more significantly in the US than in the EA.
stemming from a slightly higher response of nominal wages (which absorb a larger proportion of productivity gains) combined with lower consumer prices.

Overall, in terms of long-run persistence, wage and price inflation emerge as more persistent in the EA than in the US in the face of the three permanent shocks, especially so for the unemployment and technology shocks. The evidence for real wages is not so clear-cut, as their relative persistence depends on the type of shock hitting the economy. EA real wages emerge as more persistent following permanent unemployment and technology shocks, but somewhat less persistent in the face of an import price shock. This finding on the relative persistence is robust to the changes in the estimation period and in the models’ specifications entertained in this study.

The larger persistence of wage and price inflation in the EA compared to the US, as documented in this article, appears consistent with the micro evidence for both economies on wage and price setting practices and on the institutional rigidity of the labour market, which suggest greater wage and price stickiness in the former. In turn, the relative inflation persistence is also consistent with the evidence found in the literature based on time series models with aggregate price data, which suggests that persistence of price inflation in the EA might be larger than in the US.

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