The relationships between inflation, wages and unemployment have not disappeared

A comparative study of the French and American economies

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The negative relationship between the unemployment rate and inflation, first demonstrated by Phillips in the late 1950s, appears to be less and less empirically significant since the 1990s in both Europe and the United States. In France this relationship became much weaker, and was temporarily reversed, for a period in the 2000s when the pace of per capita productivity (in value) picked up.

This report tests the persistence of that relationship, based on a joint study of the French and American contexts, separating the effect of unemployment on wages on the one hand, and the transmission of wages to prices on the other. It also measures the direct effects of productivity on both wages and prices.

The rise in unemployment during the financial crisis of 2008-2009 clearly held back wage growth. While it rapidly slipped back in the USA, sustaining wages, it remained high in France and continued to weigh heavily on earned income. Nevertheless, productivity remains the principal determinant of wages. In both France and the USA, it is the profile of productivity gains which has been the primary force behind wage variations since the crisis.

While the transmission of wages on prices has been increasingly disrupted, the analysis shows that wages remain the principal determinant of price dynamics: the slowdown in wages, particularly since the crisis, has taken its toll on inflation. In France, recent wage dynamics do not suggest that a sharp acceleration in prices is likely, at least in the short term.

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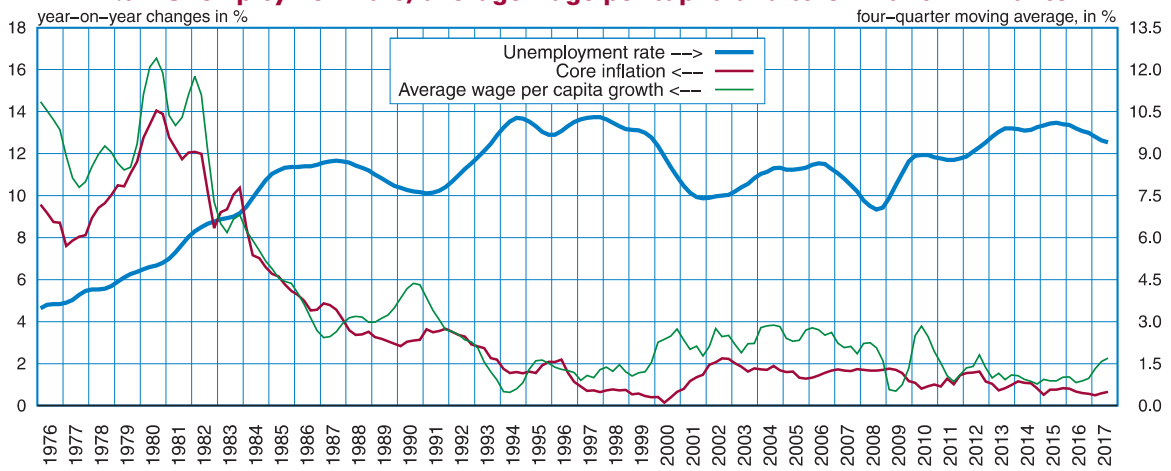
The negative relationship between inflation and unemployment reflects labour market tensions

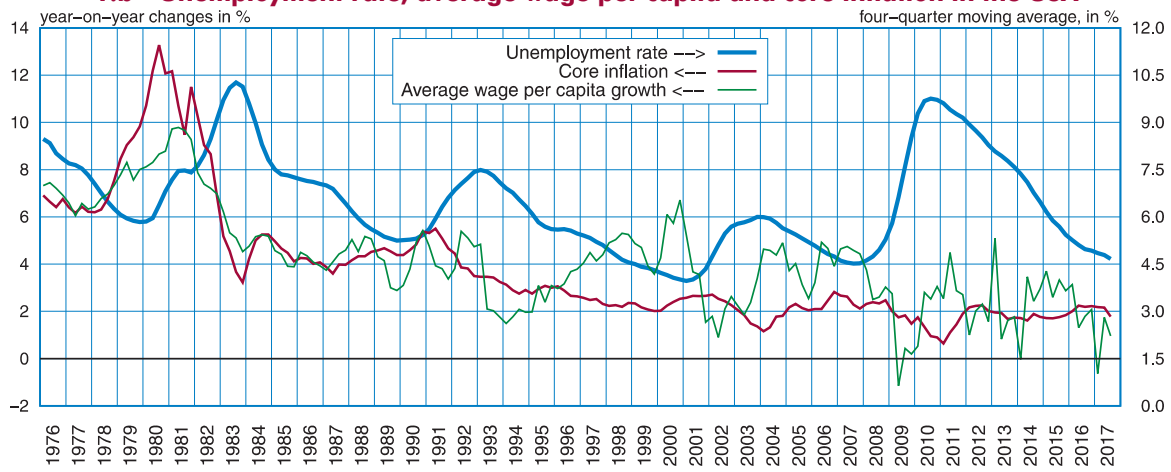
The negative correlation between the unemployment rate on one hand and inflation or wage variations on the other can be observed empirically from the long-term French and American data. It reflects the propagation of tensions in the labour market or the productive system to wages and prices (*Box*). *Graphs 1.a* and *1.b* show the average quart-on-quarter unemployment rate over four quarters, along with the growth of average wages per capita and the annual variation in the price index excluding food and energy in France and the United States since 1975. These data suggest that wage variation rates shift in the opposite direction to the unemployment rate, as an average over the whole period (except during oil shocks), but that this relationship has become less and less clear over time. Moreover, the negative correlation between unemployment and inflation is transmitted via wages, whose fluctuations tend to be passed on to consumer prices: a slowdown in wages generally precedes a slowdown in prices during economic turning-points. Nonetheless, this relationship also seems less and less clear-cut, disrupted during one-off episodes of decorrelation between wages, unemployment and inflation.

1.a - Unemployment rate, average wage per capita and core inflation in France



Note: the average wage per capita is considered in the non-agricultural market sectors.
Source: INSEE

1.b - Unemployment rate, average wage per capita and core inflation in the USA



Sources: BEA, BLS

Box - The Phillips curve is the negative relationship between inflation and unemployment: from empirical correlation to theoretical debates

The existence of a negative relationship between the unemployment rate and the growth of prices was first demonstrated by A. Phillips using American data, represented as a descending curve tracing the relationship between unemployment and nominal wages growth rate. E. Phelps then reformulated this postulate in the classical inflation-unemployment format, with prices replacing wages, as these two variables were strongly and positively correlated. It is common practice in modelling to view short-term prices as the result of companies applying margins to their payroll costs, which account for the majority of their production costs.

The Phillips curve can be interpreted as a reflection of the degree of tension on the labour market and the bargaining power of employees or their representative bodies: this bargaining power is boosted if available labour is limited, i.e. if unemployment is low and tensions in productive capacities are high (Gordon, 2011).

The theoretical consistency of this relationship was questioned as early as the 1960s. Friedman (1968) considered that it could not hold in the long term because 1) only structural factors inherent to the economy and the labour market can determine the equilibrium or "natural" unemployment rate, and 2) short-term expansionary monetary policies could drive the unemployment rate below this natural level, creating an inflationary spiral sustained by the concerted expectations of economic agents regarding price increases, with no effect on the long-term unemployment rate. Friedman's critique can be read as an attempt to replace the familiar negative correlation between inflation and unemployment with a negative correlation between the unemployment rate and the trajectory of inflation, known as the "accelerationist" position.

Friedman's challenge was itself challenged in the 1980s. The existing theoretical models were enhanced with mechanisms reflecting the imperfect nature of information and competition on the markets, which limits companies' ability to adjust their prices and, by extension, restricts the knock-on effects of monetary policy shifts on prices. Faced with this rigidity, and even allowing for the hypothesis of perfectly rational expectations, supply-side shocks affecting prices are partly passed on to activity and employment, which lends further theoretical ballast to the Phillips curve in its traditional inflation/unemployment format. Nevertheless, in the new-generation models it appears in an enhanced form which aims to take into account the impact of rigidities and price adjustments derived from different forms of competition, which makes it less practical as a tool for forecasting or empirical analysis. Furthermore, during the 1980s inflation was less volatile in the world's developed economies, particularly the USA, in the wake of the oil crisis and the consequent tightening of monetary policy. As such, prices were less clearly dependent upon fluctuations in activity levels and the labour market.

There are several potential explanations for the periods of turbulence observed in the empirical correlation between unemployment and inflation. Matheson *et al.* (2013) analysed the American post-recession recovery of 2011, demonstrating that prices increased at a rate below that predicted by the Phillips curve model. Indeed the post-recession recovery saw a sharp increase in productivity, attributed to the disappearance of the most economically inefficient businesses and the destruction of the least productive jobs.

Another potential explanation may be found in the transformation of the link between expected and observed inflation. Blanchard *et al.* (2015; 2017) have shown that expected inflation depends less and less on past inflation and more and more on long-term forecasts, with past instances of inflation deviating substantially from long-term expectations having a steadily decreasing influence on present and future inflation. This phenomenon may be linked to a change in the nature of the policies implemented by central banks, placing greater emphasis on ensuring the credibility of their pronouncements and managing expectations. The same authors also reveal that this gradual formalisation of inflation expectations has been accompanied by a decline in the impact of the unemployment rate on inflation, according to their econometric model.

Finally, the level of competition on the markets may also play a role here: an increase in the market power of the most productive companies, as observed in the USA since the mid-1990s, is reflected in an increase in their margin rates, which could lead to less frequent price adjustments, thus making inflation less sensitive to production costs in the short term. ■

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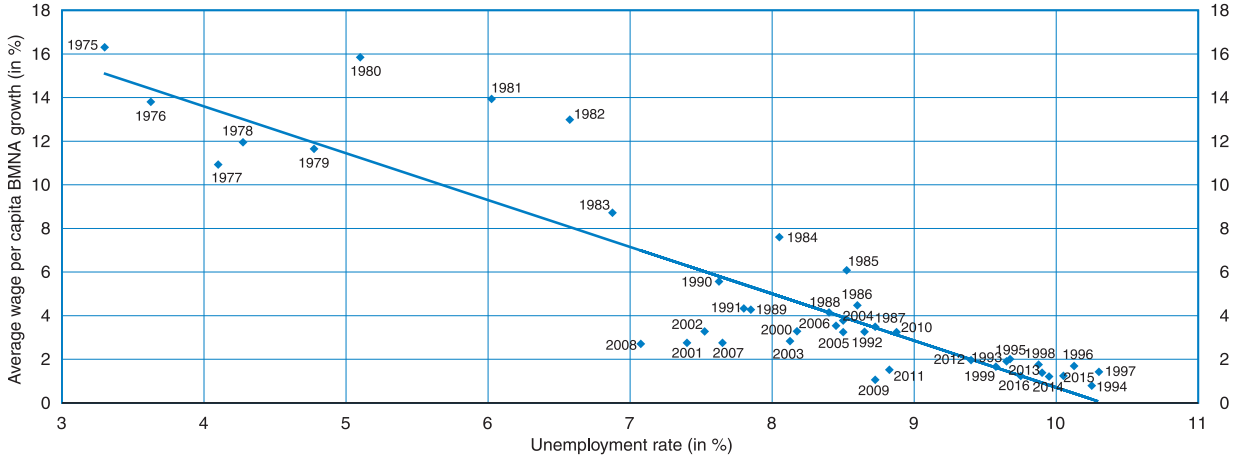
The relationship between unemployment and wages, and that between wages and inflation, are also illustrated by *Graphs 2.a* and *2.b* respectively for France since 1975, and by *Graphs 2.c* and *2.d* for 1990 onwards. With specific regard to the relationship between wages and unemployment, the scatter graph has been much flatter since 1990, as inflation appears to depend less directly on the unemployment rate.

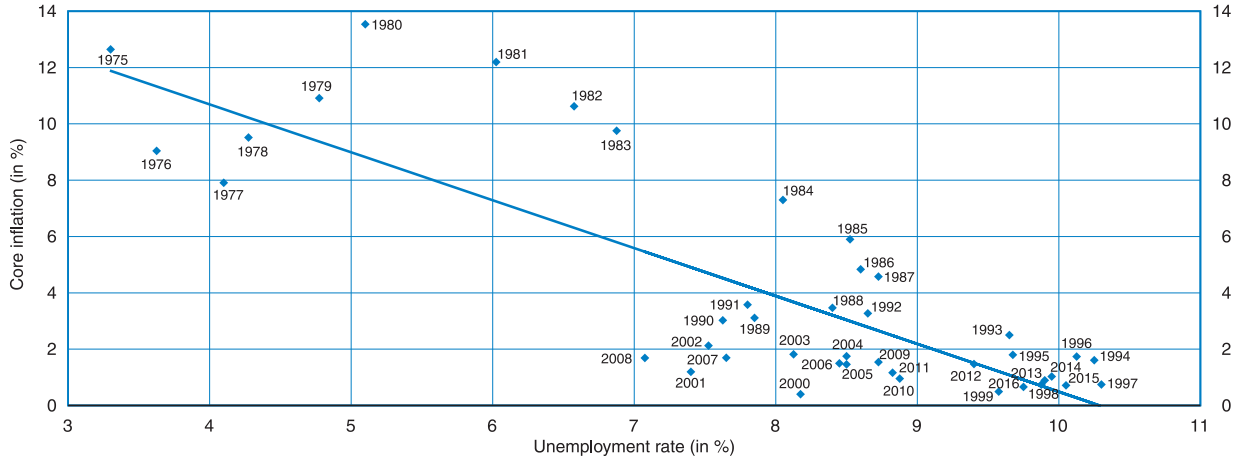
The approach adopted in the rest of this report aims to examine the persistence of the relationship between inflation and unemployment, by means of a joint and comparative analysis of the respective circumstances in France and America. The British and German economies could also provide relevant models for comparison with France, but studying the relationship between inflation and unemployment in these countries is a more complex affair with the data currently

2.a - Wages/unemployment relationship in France since 1975



Source: INSEE

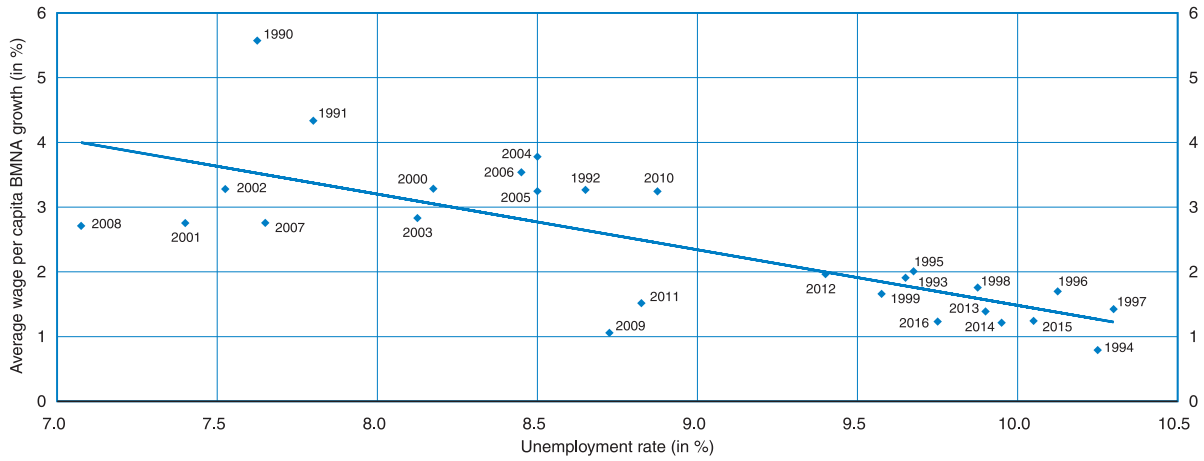
2.b - Inflation/unemployment relationship in France since 1975



Source: INSEE

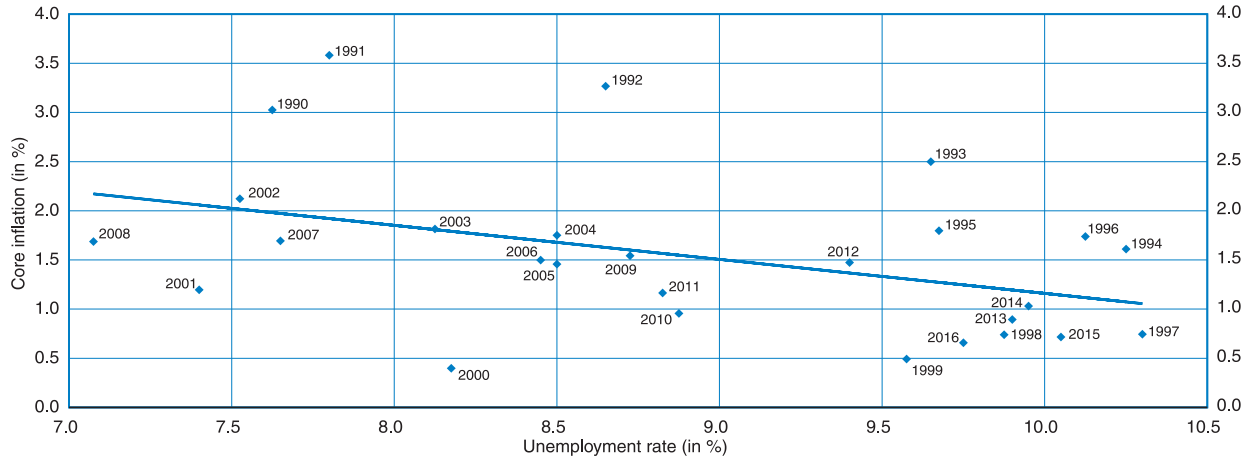
available, particularly because the process by which wage fluctuations are passed on to prices is difficult to understand and model (*Graphs 3*, see De Waziers [2016] for a study of the link between wages and unemployment in Germany, Argouarc'h *et al.* [2007] for a study of the British labour market and IMF [2013] for an international comparison). Furthermore, certain data on the labour markets in other European countries are only available for a relatively recent timeframe. This prevents the enrichment of econometric models with indicators complementary to the unemployment figures and pertinent for understanding the specific dynamics of the labour markets and of competition (the development of non-standard employment contracts, for example). Conversely, data regarding the American economy are more substantial and available over a longer period.

2.c - Wages/unemployment relationship in France since 1990



Source: INSEE

2.d - Inflation/unemployment relationship in France since 1990



Source: INSEE

The relationships between inflation, wages and unemployment have not disappeared

The negative relationship between inflation and unemployment appears to have decreased over time in France and the United States

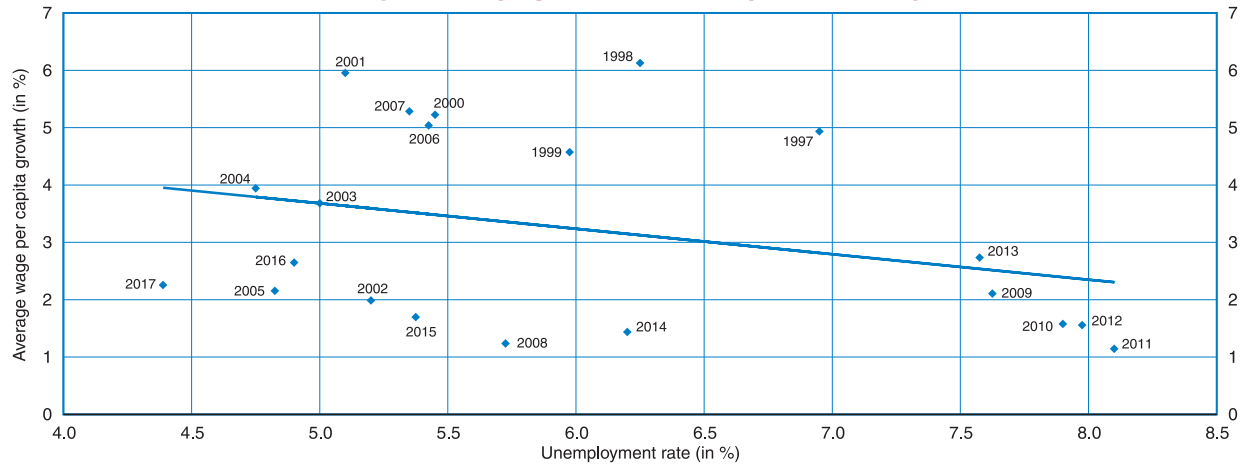
An increasingly weaker relationship in both France and the USA

In empirical terms, the data seem to indicate an attenuation of the negative correlation between unemployment and inflation over time, in both France and the USA. This relationship can be broken down into two stages: 1) a negative relationship between unemployment and wage growth, and 2) a positive relationship between wage growth and price increases. *Graphs 4.a* and *4.b* present the year-on-year correlation coefficients over a period of twelve quarters between the unemployment rate and annual average wage per capita on the one hand, and annual average wage per capita and prices excluding food and energy on the other hand. In the mid-1980s the correlation between unemployment and wages was negative overall, while that between wages and inflation was positive, in line with the prevalent theory, but the strength of the link between these variables appears to have declined over time. The relationship even becomes unstable at times, switching between positive and negative increasingly frequently and for increasingly long periods of time since the 1990s. Nonetheless, these correlation coefficients must be treated with prudence, especially since certain shocks (on oil prices, for example) have seen unemployment and prices move in the same direction.

In France, the relationship is turbulent over the long term

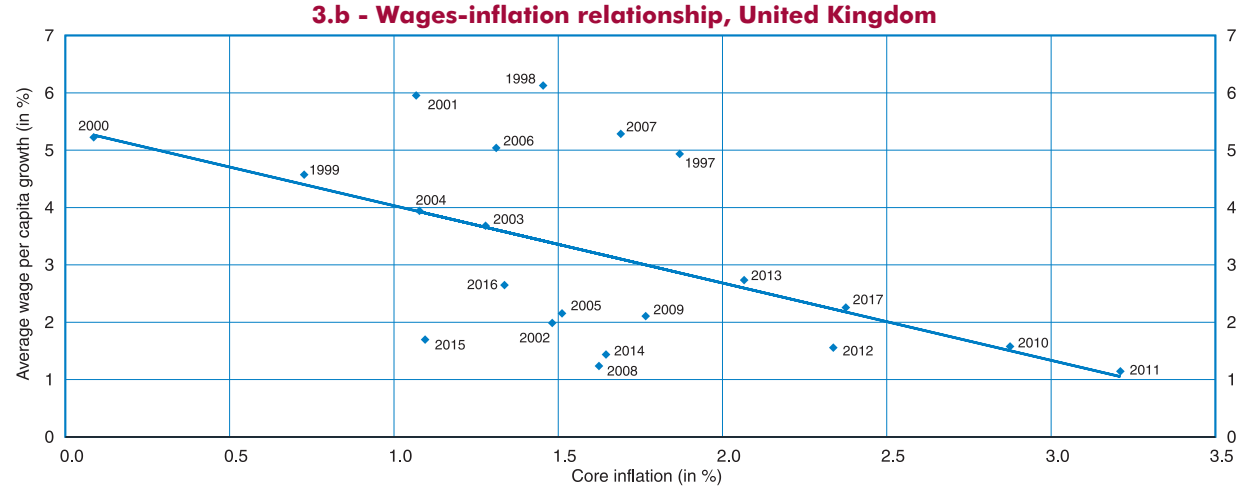
In France, the correlation between unemployment and wages became generally positive in the 2000s, while that between wages and prices went negative. This period corresponds to a phase of accelerating per capita productivity which simultaneously drove up wages and kept prices in check.

3.a - Wages-unemployment relationship, United Kingdom



Source: ONS

3.b - Wages-inflation relationship, United Kingdom



Source: ONS

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In the USA the relationship has remained stable, outside of certain one-off episodes

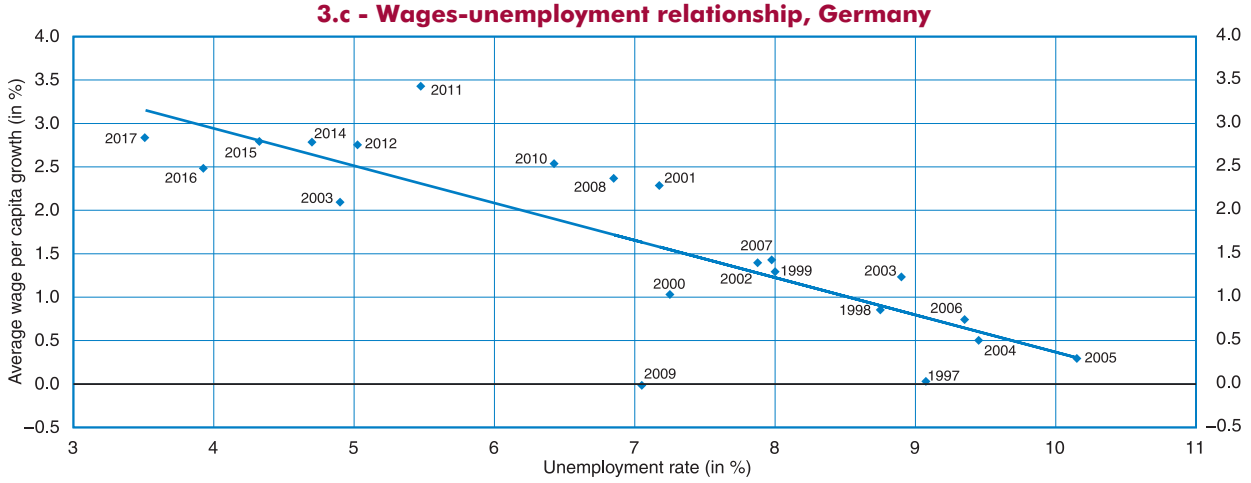
In the United States, the relationship between unemployment and wages also occasionally strays into positive territory, particularly during phases of economic recovery, reflected in the coexistence of accelerating productivity and unemployment which may remain stubbornly high during restructuring of productive capacities, with lasting effects (Matheson *et al.* 2013). The correlation between wage growth and inflation has also switched between negative and positive in the United States during episodes of disconnection between the two variables, as seen in the late 1990s, when prices increased as a result of increased concentration of enterprises and an increase in margin rates, with no corresponding upturn in wages.

With regard to the labour market, since 2015 the unemployment rate has dropped significantly in the USA. It is now at its lowest level since the 2000s, at just over 4%. The fact that this rebound in the American labour market has thus far not been matched by a clear acceleration in wages could be a sign that levels of unemployment historically considered as low are no longer indicative of tensions on the labour market.

The inclusion of productivity gains improves estimates of the Phillips curve

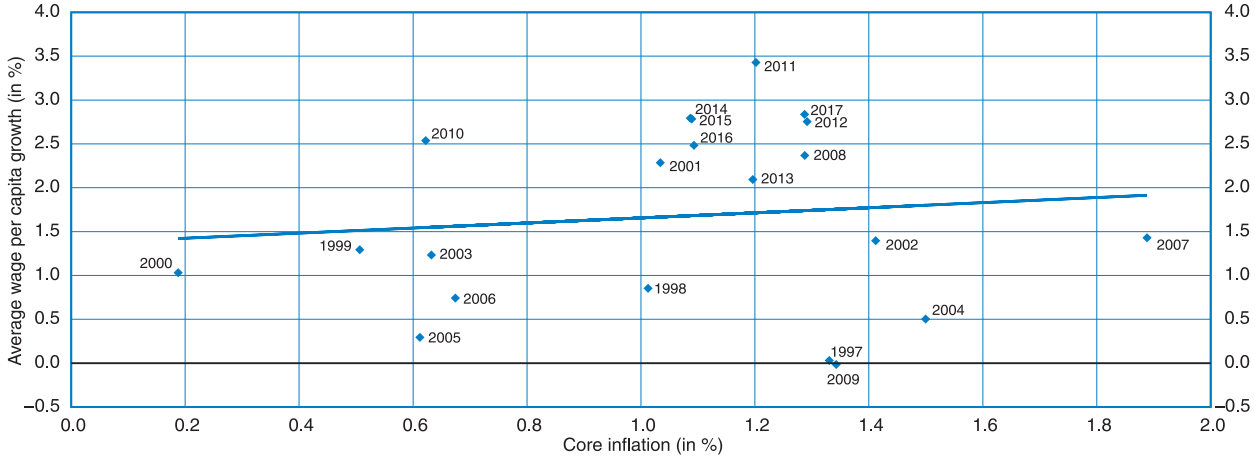
The approach taken in this report consists of studying the way that shocks in the labour market and productive capacities, measured using the unemployment rate, are transmitted to variations in prices via variations in wages. The model makes no specific assumption as to the level of the unemployment rate below which inflation accelerates, but it does incorporate productivity, with which it is strongly correlated, as a determinant of wages and prices. Indeed, Staiger *et al.* (2001) demonstrated that the apparent instability of the link between inflation and unemployment in the 1980s and 1990s disappears when the corresponding

3.c - Wages-unemployment relationship, Germany



Source: Destatis

3.d - Wages-inflation relationship, Germany



Source: Destatis

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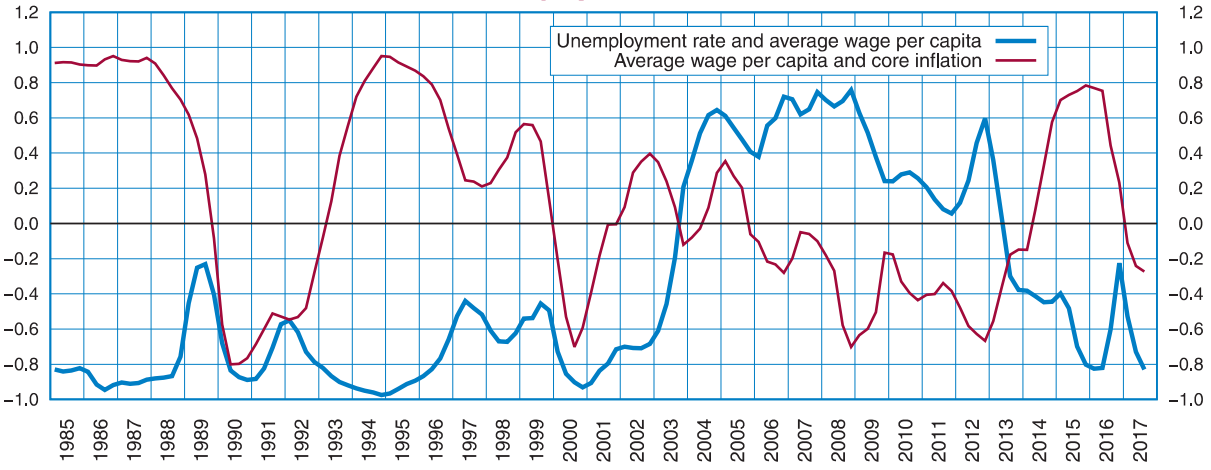
macro-econometric modelling of these two variables is updated to incorporate wages and productivity.

In the model used here (*Methodology*), wages are indexed to long-term per capita productivity and a linear trend is added in order to take into account the long-term variation in wages in value added. Furthermore, for the equation modelling wages in France, the model considers the crisis of 2008-2009 and its negative impact on margin rates as a lasting shift in level, affecting the trend for the proportion of wages in value added in the ensuing years. In the short term, wage growth was negatively affected by the unemployment rate, following a traditional Phillips curve.

In the same manner, a more detailed econometric model is constructed in order to take into account the effects of productivity gains on the relationship between wages and prices (*Methodology*). In this model, price levels are connected in level terms to the ratio between the average per capita wage and real per capita labour productivity. A linear trend is added to the long-term equilibrium in order to take into account the long-term variation in corporate margin rates, and hence the pricing behaviours of companies.

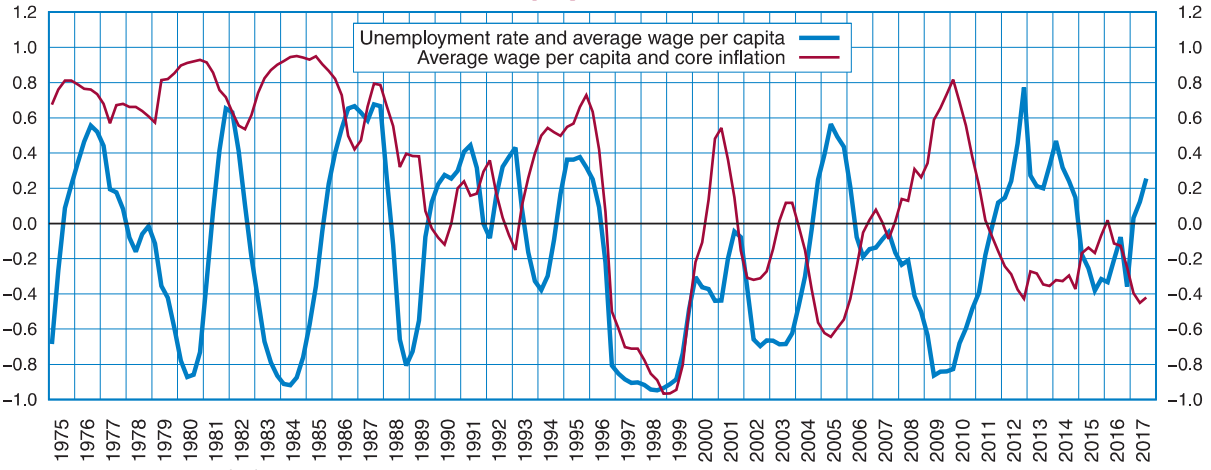
4.a - Correlation coefficient between fluctuations in wages and the rates of unemployment and inflation in France



Note: correlation coefficients are calculated year-on-year for twelve quarters based on the unemployment rate, the year-on-year variations in the average wage per capita and the core consumer price index (CPI).

Source: INSEE

4.b - Correlation coefficient between fluctuations in wages and the rates of unemployment and inflation in the USA



Sources : BEA, BLS, INSEE calculations

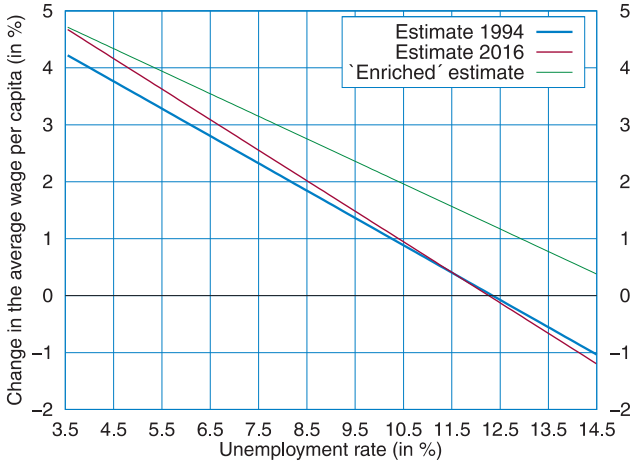
The relationships between inflation, wages and unemployment have not disappeared

The transmission of wages to prices has been increasingly disrupted

The data appear to suggest that there has been a weakening — apparently more so in France than in the USA — in the relationship between inflation and unemployment since the mid-1990s, which can be attributed largely to the disruption in the transmission of wages to prices. This connection can be estimated in two ways. This first approach is a simple estimate which allows the coefficient for the relationship between unemployment and wages or wages and inflation to vary linearly over time: this model is purely descriptive, and demonstrates that – without the inclusion of additional explanatory variables – the ratio changes between the start and end of the estimation period (in 1994 and 2016 respectively). Going into greater detail, the econometric models presented above result in a more precise relationship controlling for the long-term effects of productivity.

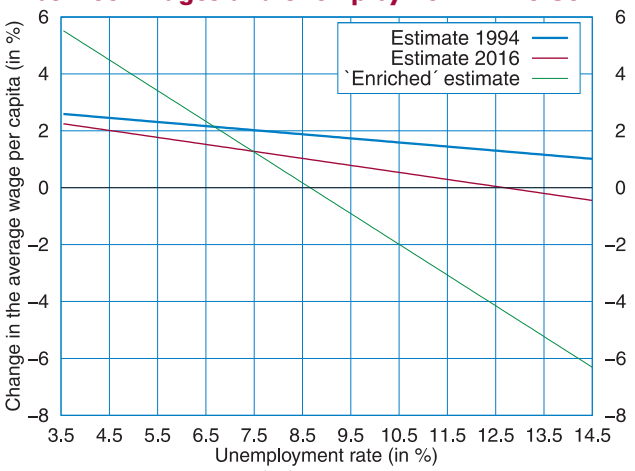
Graphs 5.a to *6.b* present both types of estimate for the relationships between wages and unemployment and between prices and wages in France and the USA (*Methodology*).

5.a - Estimating the relationship between wages and unemployment in France



Source: INSEE

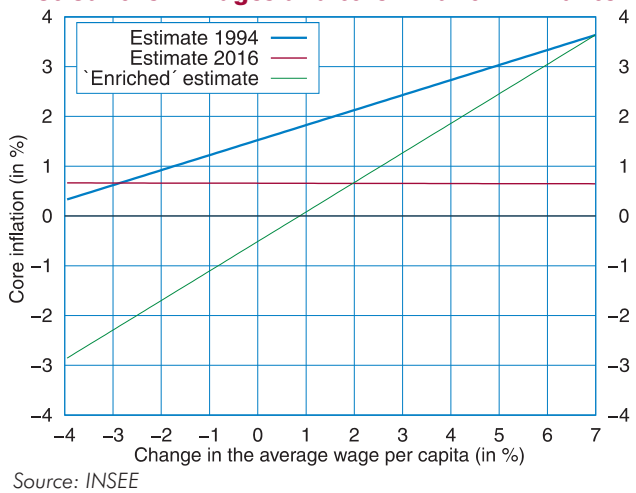
5.b - Estimating the relationship between wages and unemployment in the USA



Sources: BEA, BLS, INSEE calculations

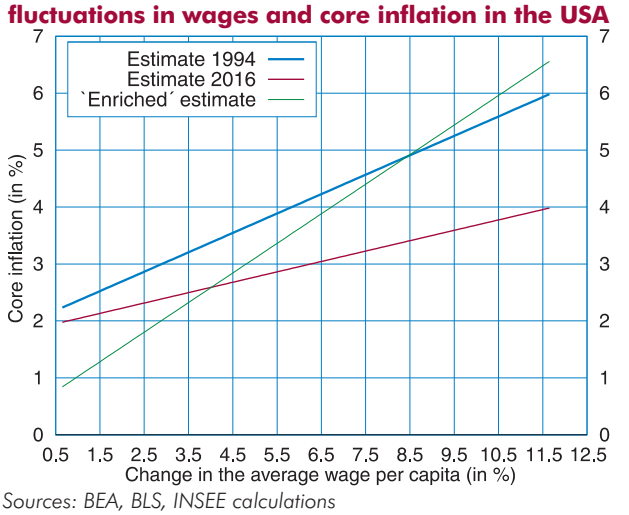
Note: the econometric relationships are calculated using the equations presented in the *Methodology* section. "Gross" estimates for 1994 and 2016 are obtained using equations 1.a for France and 1.b for the USA, allowing the effects of unemployment on changes in wages to vary linearly over time. An "enriched" estimate is obtained using equations 3.a for France and 3.b for the USA, controlling for the long-term effects of productivity.

6.a - Estimation of the correlation between fluctuations in wages and core inflation in France



Source: INSEE

6.b - Estimation of the correlation between fluctuations in wages and core inflation in the USA



Sources: BEA, BLS, INSEE calculations

Note: the econometric relationships are calculated using the equations presented in the *Methodology* section. "Gross" estimates for 1994 and 2016 are obtained using equations 2.a for France and 2.b for the USA, allowing the effects of unemployment on changes in prices to vary linearly over time. An "enriched" estimate is obtained using equations 4.a for France and 4.b for the USA, controlling for the long-term effects of the relationship between average per capita wages and productivity.

The relationships between inflation, wages and unemployment have not disappeared

First and foremost, they reveal the disruption which has affected the transmission of wages to prices. In France in particular, this correlation appears to be disappearing (*Graph 6.a*), while the knock-on effects of unemployment and labour market tensions on wages does not seem to have been affected (*Graph 5.a*). In the USA, the transmission of wages to prices appears to have diminished while remaining positive, while the knock-on effects of unemployment on wages are still present. Finally, the correlation between wages and prices is steeper in the models incorporating productivity effects, in both France and the USA, which suggests that productivity variations disturb the transmission of the Phillips curve *via* this channel (*Graphs 6.a* and *6.b*).

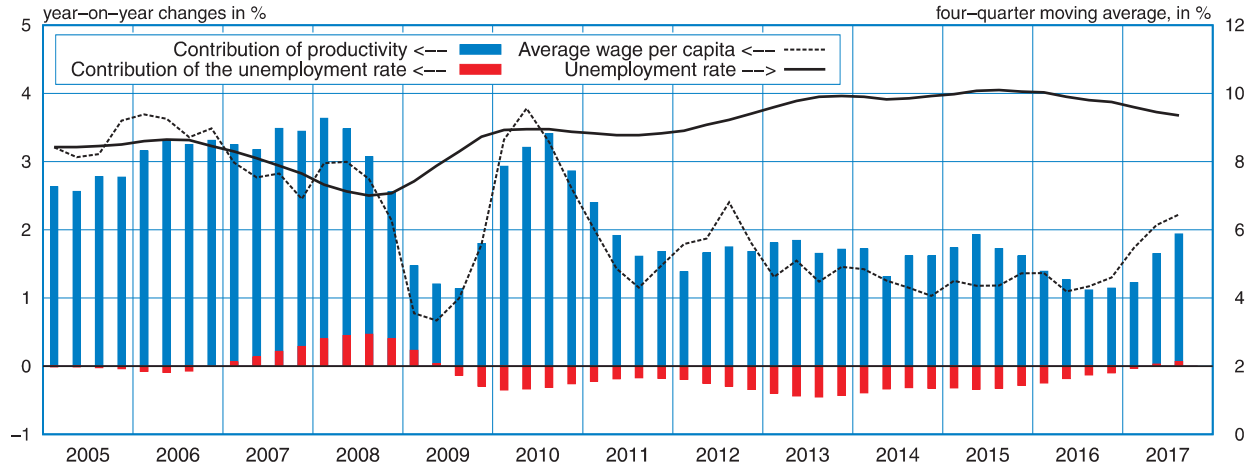
Unemployment has an impact on wage fluctuations, but productivity remains a major long-term determinant

The estimated effects of the different explanatory factors for wage growth are presented in *Graph 7.a* for France, and *Graph 7.b* for the United States.

In France as in the USA, wages slow when productivity slows

The econometric model deployed here shows that the nominal productivity of labour is the fundamental determinant of the rate of wage growth. In France, the dynamism of productivity in the period to 2008 clearly bolstered wage growth, which averaged three points per annum between 2005 and 2008 (*Graph 7.a*). During the recession of 2009 productivity shrank by 1.7%, causing wages to slow sharply. Productivity bounced back in 2010-2011, but has since remained less dynamic than it was before the crisis (between +0.8% and +1.9% per year between 2012 and 2016, compared with an average of +3.0% between 2005 and 2008). As such, wages have remained relatively sluggish, growing just 1.5% on average between 2011 and 2016 (compared with +3.1% between 2005 and 2008). But wages did bounce back somewhat in 2017, boosted by an upturn in productivity, with estimated growth of 2.0%.

7.a - Contribution to variations in median per capita wages in France



Note: the estimated contributions for the period 1994-2017 as a whole are only presented here for 2005 onwards, for reasons of clarity and in order to concentrate on recent developments.

Source: INSEE

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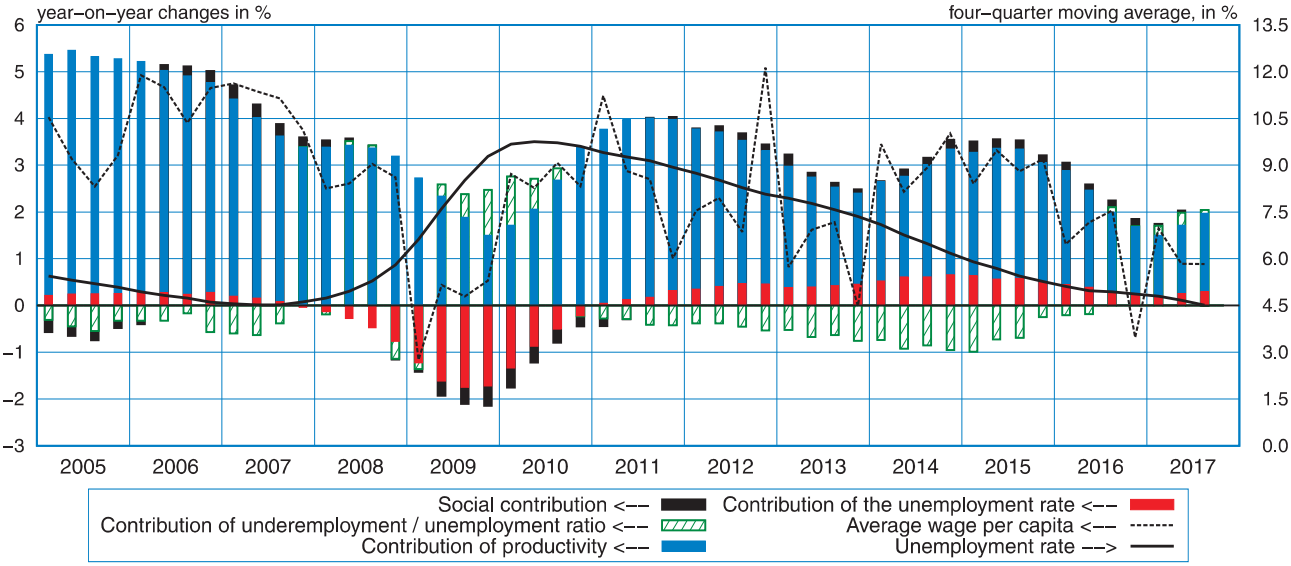
The trajectory followed by wages in the USA is also fundamentally linked to the per capita productivity of labour. The general slowdown in productivity since 2005 accounts for most of the slowdown in wage growth (*Graph 7.b*). The difficulties encountered in recovering from the financial crisis continue to take their toll on wages.

The unemployment rate has stopped hampering wage growth since the end of the crisis, but has not made a significant contribution to its recovery

In France the rise in unemployment during the crisis of 2008-2010, along with the decline in productivity, contributed to the slowdown in wages (*Graph 7.a*). Between 2008 and 2010, the unemployment rate in Metropolitan France increased by 1.6.points (8.7 on average in 2010, up from 7.1 in 2008), which contributed 0.6 points to the slowdown in wages between 2008 and 2010. Unemployment remained high throughout the following years, and actually continued to rise until peaking at 10.2% in Q2 2015, further hampering wages. Unemployment began to subside in late 2015 and has fallen more noticeably since the start of 2017, reaching 8.6% in Metropolitan France by the end of 2017, the lowest level recorded since 2009. The unemployment rate has therefore stopped hindering wage growth, after seven years of negative contribution. Nevertheless, and in spite of the turnaround seen in 2017, unemployment remains high and is yet to make a significant positive contribution to wage growth.

In the USA, the increase in the unemployment rate during the crisis slowed wages more sharply than in France, by 1.6 points in 2009 and 0.7 points in 2010. However, the unemployment rate fell more rapidly than in France from 2010 onwards, and in 2017 hit the lowest level seen since 2000 (4.4%). The negative impact of unemployment on wage growth disappeared in 2011, and since 2012 the unemployment rate has made a positive contribution to the dynamism of wages. Nevertheless, the general outlook on the american labour market has not yet led to a clear increase in tension on wages. The proportion of those in employment who consider themselves to be under-employed (i.e. who would like to work more hours) remains high, which could have an adverse effect on wage growth.

7.b - Contribution to variations in median per capita wages in the USA



Note: the estimated contributions for the period 1994-2017 as a whole are only presented here for 2005 onwards, for reasons of clarity and in order to concentrate on recent developments.

Sources: BEA, BLS, INSEE calculations

The relationships between inflation, wages and unemployment have not disappeared

The knock-on effects of wages on prices are attenuated by productivity gains in both France and the USA

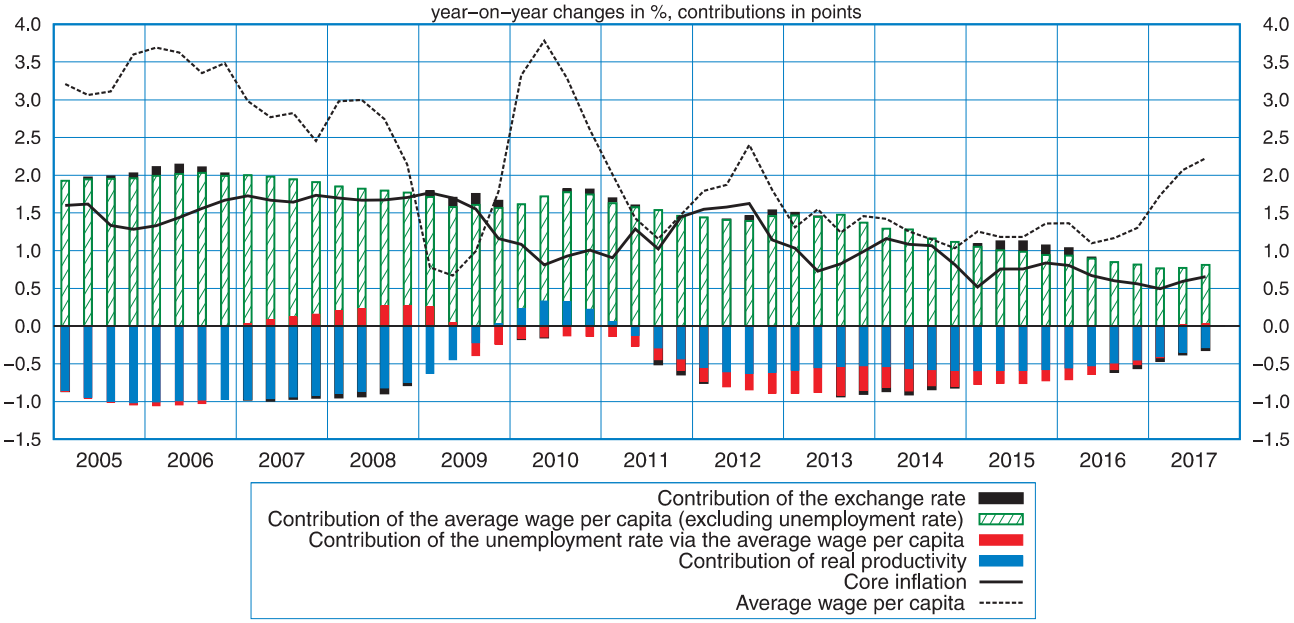
The results of the econometric model for prices, and the influence of the different explanatory variables used, are shown in *Graph 8.a* for France and *Graph 8.b* for the USA.

The contribution of wages and unemployment to inflation is steadily decreasing

According to the econometric estimates, variations in the average wage per capita remain a major explanatory factor in price fluctuations, via the two channels identified in *Graphs 8.a* and *8.b*: on the one hand via the contribution made by wage growth which can be explained with reference to the unemployment rate, as per the model presented above, and on the other hand via the contribution of wage increases not determined by unemployment.

In France, the contribution of average per capita wages to the year-on-year changes in prices appears to have decreased steadily in recent years, losing around one point since 2005 (*Graph 8.a*). The recent wage dynamics do not suggest that prices will increase considerably in the short term, despite the turnaround in the unemployment rate since 2016. The latter, which influences prices via its effect on wages, did contribute to containing inflation after 2009. This contribution therefore has declined considerably since then. The sluggish growth of wages thus appears to be the principal explanatory factor behind the slowdown in inflation observed in recent years.

8.a - Contribution to variations in core prices in France



Note: the estimated contributions for the period 1994-2017 as a whole are only presented here for 2005 onwards, for reasons of clarity and in order to concentrate on recent developments.

Source: INSEE

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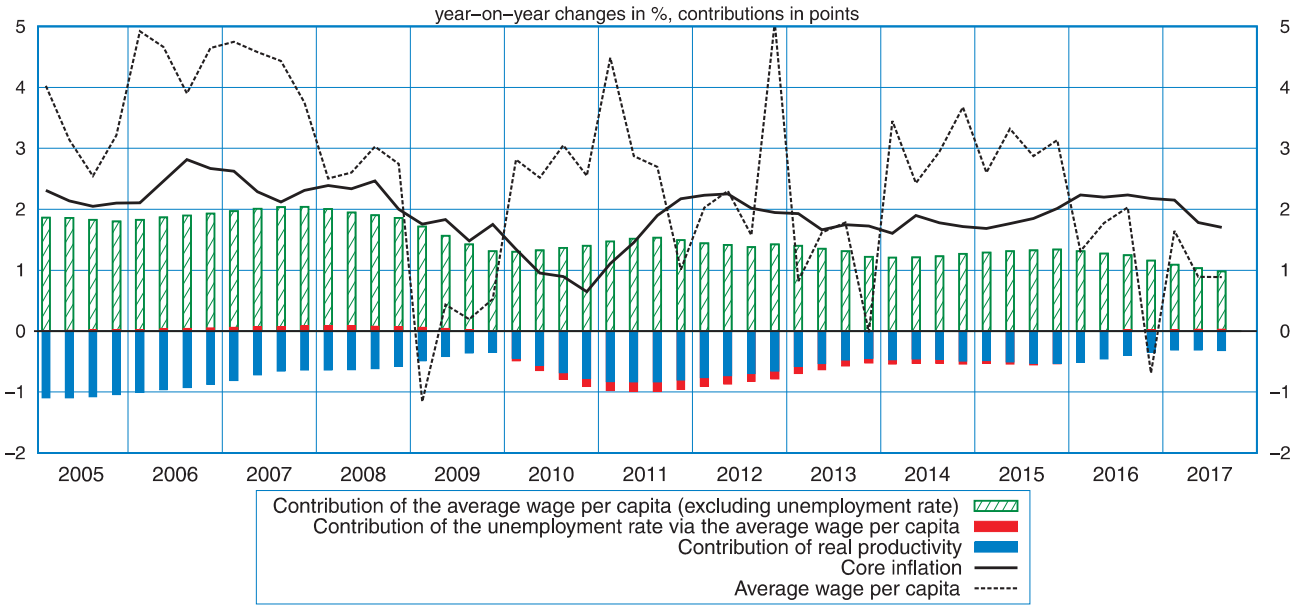
The situation is broadly similar in the USA, where the contribution of average per capita wages to year-on-year changes in prices appears to have decreased steadily since 2005 (*Graph 8.b*). The recent wage dynamics in the USA do not suggest that inflation will increase significantly in the short term.

The per capita productivity of labour, expressed in volume terms, slowed price increases in France in the period leading up to the crisis of 2009. Its contribution to inflation became positive during the recovery of 2010, then negative again from 2011, but it now has a less substantial effect on prices than it did in the pre-crisis period.

All in all, the correlations between inflation, wages and unemployment have not disappeared, but productivity variations make it difficult to analyse the links between the labour market and the goods and services market

In France as in the United States, the analysis shows that wages are still guided by productivity and that prices are still driven by wages, even if the incidence of these two factors has waned since the 2000s as productivity has slowed. The impact of unemployment on wages and prices, which was noticeable until the great recession of 2008-2009 during which it severely restricted their growth, has also been on the wane since the end of the crisis, without totally disappearing. ■

8.b - Contribution to variations in core prices in the USA



Note: the estimated contributions for the period 1994-2017 as a whole are only presented here for 2005 onwards, for reasons of clarity and in order to concentrate on recent developments.

Sources: BEA, BLS, INSEE calculations

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Methodology

Empirical results are derived from econometric models using American (sources: Bureau of Economic analysis for national accounts and the Bureau of Labor Statistics for payroll employment) and French (source: INSEE) data series. The estimates were calculated using quarterly data for the period 1994-2016. This period was selected because it provided sufficient data for the estimation of all the necessary equations, particularly with regard to the rate of under-employment in the United States.

In order to estimate the un-adjusted Phillips curves for the years 1994 and 2016 presented in *Graphs 5.a* and *6.b*, a simple regression was performed, linking the growth of the average wage per capita to a constant value, to the unemployment rate and to the product of the latter with a linear trend. This descriptive projection served to study the deformation of the correlation coefficient between the unemployment rate and the growth of the average wage per capita, based on the hypothesis that the latter follows a linear trend over the period as a whole. This gives:

France

$$(1.a) \quad \Delta\log(SMPT_t) = 0.018 - (1.2.10^{-3} + 1.6.10^{-6}.t)u_t$$

USA

$$(1.b) \quad \Delta\log(SMPT_t) = 0.013 - (3.6.10^{-4} + 2.9.10^{-6}.t)u_t$$

where:
- u is the unemployment rate;
- $SMPT$ is the average wage per capita (in the non-farm market sectors of the economy for France);
- t is the number of quarters elapsed since Q1 1994.

A similar approach is used to estimate the correlation between core inflation and the growth of average wages per capita. This gives:

France

$$(2.a) \quad \Delta\log(P_t^{sj}) = 2.7.10^{-3} + 0.30.\Delta\log(SMPT_t) - 1.6.10^{-3}.t.\Delta\log(SMPT_t)$$

USA

$$(2.b) \quad \Delta\log(P_t^{sj}) = 5.1.10^{-3} + 0.34.\Delta\log(SMPT_t) - 1.8.10^{-3}.t.\Delta\log(SMPT_t)$$

where:
- P^{sj} is the core price index (consumer price index excluding energy and food);
- *SMPT* is the average wage per capita (in the non-farm market sectors of the economy for France).

More detailed equations are also estimated using error correction models, in order to incorporate more explanatory variables into the model and isolate their respective effects. The results of these models are used to plot *Graphs 7* and *8*. Estimates are produced in a single phase, using the dynamic least square method. The Student statistics are given in brackets underneath the coefficients, for the short-term parameters. However, they are not given for the long-term equations, replaced here by (*) because they do not conform to the Student law.

To begin with, an equation is performed for average wages per capita. A constraint is introduced to this model, indexing the average wage per capita to productivity (in value terms) over the long term. This constraint, which is common for this type of macroeconomic model, is reinforced by the addition of a linear trend taking into account the long-term fluctuations of wages as a proportion of value added. This gives:

France

$$(3.a) \quad \Delta\log(SMPT_t) = \underset{(-2.0)}{-0.05} + \underset{(7.8)}{1.2}.\Delta\log(prod_t) - \underset{(-6.6)}{1.0}.\Delta\log(prod_{t-1}) - \underset{(-3.2)}{0.001}.u_t$$

$$- \underset{(-2.8)}{0.07}\left[\log(SMPT_{t-1}) - \log(prod_{t-1}) - \underset{(*)}{2.9.10^{-4}}.t\right]$$

$$R_o^2 = 0.52$$

where:
- *SMPT* is the average wage per capita (natural persons) in the non-farm market sectors of the economy;
- *prod* is productivity in terms of value of labour, smoothed with a moving average of order 4;
- *u* is the unemployment rate.

USA

$$(3.b) \quad \Delta\log(SMPT_t) = \underset{(5.0)}{9.94} - \underset{(-2.0)}{0.19}.\Delta\log(SMPT_{t-1}) - \underset{(-3.7)}{0.003}.u_t$$

$$- \underset{(-5.0)}{0.47}\left[\log(SMPT_{t-1}) - \log(prod_{t-1}) + \underset{(*)}{0.13}\log(u6_{t-1}) - \underset{(*)}{4.0.10^{-4}}.t + \underset{(*)}{0.56}\log(cs_{t-1})\right]$$

$$R_o^2 = 0.32$$

where:
- *SMPT* is the average wage per capita (natural persons);
- *prod* is productivity in terms of value of labour, i.e. the ratio between nominal GDP and total employment, smoothed with a moving average of order 4;
- *u* is the unemployment rate;
- *u6* is the ratio between the under-employment rate (proportion of employed persons who would like to work more) and the unemployment rate;
- *cs* is the social wedge, defined here as the ratio between the total cost of labour (including employers' social security contributions) and gross wages.

Under-employment is included in the equation for the USA but not for France, because it is not statistically significant.

The relationships between inflation, wages and unemployment have not disappeared

Finally, an equation is estimated to model the core price index. This gives:

France

$$(4.a)\quad \Delta\log(P_t^{sj}) = \underset{(5.3)}{0.48} + \underset{(1.8)}{0.15}\,\Delta\log(P_{t-1}^{sj}) + \underset{(2.8)}{0.25}\,\Delta\log(P_{t-2}^{sj}) - \underset{(-2.0)}{0.01}\,\Delta\log(change_{t-1})$$
$$+\underset{(4.9)}{0.30}\,VAT_t^h + \underset{(4.9)}{0.52}\,VAT_{t-3}^b$$
$$-\underset{(-5.0)}{0.09}\left[\log(P_{t-1}^{sj}) - \underset{(*)}{0.59}\log(SMPT_{t-1}) + \underset{(*)}{0.59}\log(prod_{t-1}^{r}) - \underset{(*)}{0.001}.t + \underset{(*)}{0.02}.sup_{09T1}\right]$$

$$R_a^2 = 0.62$$

where:
- $Prod^r$ is productivity in volume terms per capita, i.e. the ratio between GDP in volume and total employment, smoothed with a moving average of order 4;
- *change* is the exchange rate euro/dollar;
- VAT^h and VAT^b are the theoretical effects on core inflation of increases or decreases (respectively) of the rate of VAT;
- sup_{09T1} is an indicator equal to 1 from Q1 2009.

USA

$$(4.b)\quad \Delta\log(P_t^{sj}) = -\underset{(-2.7)}{0.63} + \underset{(2.7)}{0.33}\,\Delta\log(P_{t-1}^{sj}) + \underset{(1.5)}{0.03}\,\Delta\log(SMPT_t)$$
$$-\underset{(-3.5)}{0.06}\left[\log(P_{t-1}^{sj}) - \underset{(*)}{0.52}\log(SMPT_{t-1}) + \underset{(*)}{0.52}\log(prod_{t-1}^{r}) - \underset{(*)}{0.003}.t\right]$$

$$R_a^2 = 0.41$$

where:
- $Prod^r$ is productivity in volume terms, smoothed with a moving average of order 4. ■