Wages During Recoveries in Euro-Area Economies. A Structural View

Nikolaos Charalampidis *

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Abstract

This paper examines the drivers of wage growth during economic recoveries since the 1990s in the big four European economies. It adopts a structural approach involving Bayesian estimation that features several measures of wage inflation. The findings suggest a *cyclical real wage recovery* in Germany after the sovereign debt crisis that is statistically different from the past and is driven by a weakening in firms' pricing power despite a productivity slowdown. In contrast, a *cyclical (real) wage-less output recovery* is observed in France and Italy. In France, the productivity slowdown dominates the weakening in firms' market power. In Italy, the latter effect along with a demand pick up boosting wages do not suffice to exceed the weakening in workers' market power. In Spain, *cyclical wage growth* is positive – the sizable weakening in firms' pricing power and rising demand exceed the weakening in workers' market power over wages – only in real terms and not in nominal terms, highlighting the importance of jointly examining price and wage inflation.

Keywords: Wage Growth, Euro Area, DSGE, Bayesian Estimation
JEL classification: E32, E24, J30

* PhD in Economics Candidate, University of California, Irvine. Email: charalan@uci.edu, Website: http://sites.uci.edu/nikolaoscharalampidis/.
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1 Introduction

Although unemployment is declining, even to pre-recession levels in some cases, and employment steeply increases, wages exhibit a sluggish evolution in several economies. The puzzling phenomenon of subdued wage growth is documented in the U.S. [Hee Hong et al., 2018, Abdih and Danninger, 2018], the UK [Bell and Blanchflower, 2018], and to some extent in the Euro Area [ECB, 2018; European Commission, 2017; Ciccarelli and Osbat, 2017] and in the southern economies [Charalampidis, 2018].

Fig.(1) gives a flavor of the puzzling wage development by comparing developments in a variety of wage indicators[1], the change in the unemployment rate, and the change in employment after the sovereign debt crisis to their analogues during the recoveries in the pre-2013 period in Germany, France, Italy, and Spain. The figure demonstrates that a large decline in unemployment and a sizable pick up in employment in all the economies in the post-2013 period are not accompanied by strong wage growth. For instance, in France and Italy, the post-2013 wage growth remains lower than it was in the previous recoveries.

Several explanations for the puzzling phenomenon of subdued wage growth have been proposed. The declining labor productivity and labor's share of income, and to some extent advances in automation, the decline in unionization, and trade globalization, have been found in empirical studies for the U.S. economy [Abdih and Danninger, 2018]. Du Caju, Rycx, and Tojerow (2011), too, find international trade influential for wage dispersion in Belgium. A flattening of the Phillips curve [Leduc and Wilson, 2017] and a problematic measurement of the economic slackness [Hee Hong et al., 2018; Bell and Blanchflower, 2018; Smith, 2014] have been proposed in other empirical analyses. Other authors resort to arguments about a non-linear Phillips curve [Donayre and Panovska, 2016; Kumar and Orrenius, 2016] implying

[1]compensation per employee, wages & salaries per employee, hourly compensation, private hourly earnings

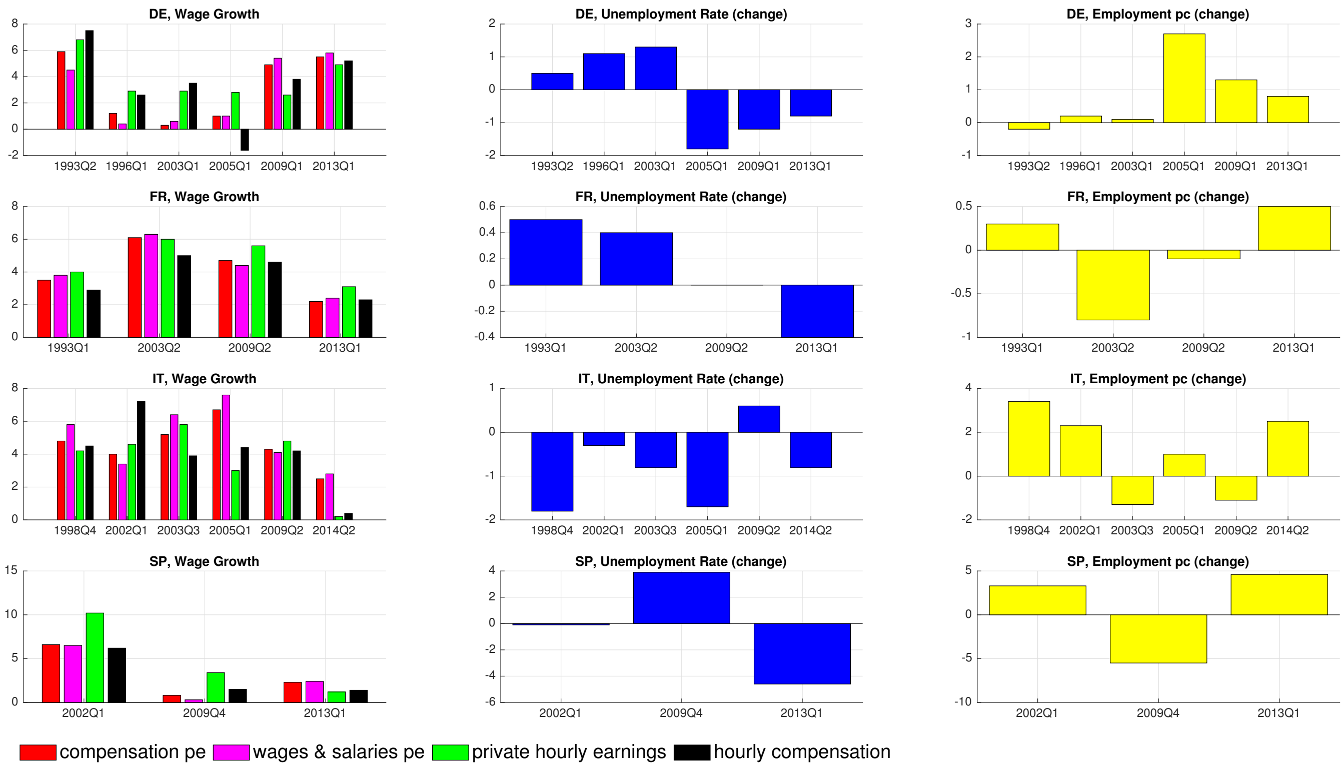
that wage growth is going to pick up once unemployment hits a low level. Structural evidence for the southern euro-area periphery points to a weakening in workers' market power [Charalampidis, 2018] which is compatible with the idea of monopsonies in labor markets [Krugman, 2018]. Bulligan, Guglielminetti, and Viviano (2017) highlight the importance of the intensive margin of labor utilization in the determination of wage growth. Finally, Faberman and Justiniano (2015) find a strong relationship between job switching and nominal wage inflation.

Despite the various explanations above, there still are unresolved issues in the existing literature. We split them in two categories; the first involves the identification of the phenomenon of subdued wage growth itself, and the second involves the identification of the determinants of the phenomenon. As for the first category, not all papers use the same wage measure, the same period of analysis, or the same set of economies. In addition, sometimes even the notion of subdued wage growth is not clear: is wage growth subdued compared to its past experience, compared to what is currently observed in other economies, or compared to what is expected given the slack in the labor market? As for the second category, almost the entire existing literature – with the exception of Charalampidis (2018) – employs reduced form studies blurring causality issues and impeding a general equilibrium approach that would quantify the relative importance of all the driving factors of wage growth.

The present paper contributes in the literature by addressing the above issues. To that end, it focuses on the behavior of wages during output recoveries, and compares the post-2013 wage evolution with the wage evolution during the recoveries from previous troughs. In doing so, it delves into the drivers of wages during those episodes through the lens of a structural workhorse model, namely Galí, Smets, and Wouters (2012a)[2] model. This approach is applied, in turn, on the big four European economies. It is worth mentioning that with the exception of Charalampidis (2018), no other paper employs a structural approach to the determinants of wage growth.

[2]These authors introduce unemployment following the approach of Gali (2011) in the framework developed in Smets and Wouters (2007) and Christiano, Eichenbaum, and Evans (2005).

Figure 1: Wages in Recoveries



Notes: Authors' computations. Cumulative change (eight-quarter-ahead after trough) for the pre-2013 troughs. Cumulative change (average eight-quarter-ahead quarterly rolling) for the recovery after the trough of the sovereign debt crisis. Troughs are shown in the horizontal axis – in Spain's panels, the 2002Q1 sizable drop in output is added. *Mnemonics:* Nominal Wage Growth Rate: Compensation per Employee; Wages and Salaries per Employee; Hourly Private Earnings (after 1995; hourly earnings in manufacturing for earlier periods); Hourly Compensation. Unemployment: Unemployment Rate. Employment: (log of) Employment per capita. *Data Sources:* OECD, SDW.

The model is estimated with state-of-the-art Bayesian techniques on a set of observables that includes multiple wage measures to overcome restrictions stemming from the use of a single wage series. The present paper, thus, builds on the strand of the literature that considers a factor approach to DSGE models, as in Boivin and Giannoni (2006), as well as multiple wage indicators in order to strengthen the identification of wage markup shocks. More specifically, in addition to the two wage indicators used in Galí et al. (2012a), Justiniano et al. (2013), and Lindé et al. (2016), the present paper uses up to three more series, as in Charalampidis (2018), in order to deepen our understanding of wage fluctuations.

1.1 Results. The paper finds a *cyclical real wage recovery* in Germany and Spain (the average cumulative eight-quarter-ahead rates are 0.4% and 0.3%, respectively[3]) after the trough of the sovereign debt crisis, but a *cyclical (real) wage-less output recovery* in France and Italy (-1% and -0.6%, respectively).

The main determinant of real wage growth in Germany and Spain is sizable shifts in the pricing power of firms and, in particular, a contraction in price markup shocks that leads to an economic stimulus, rising real wages, and rather small gyrations in price inflation. This effect dominates a productivity slowdown exerting downward pressure to the real wage. In France, the effect of the weakened market power of firms does not exceed that from the productivity slowdown resulting in negative cyclical real wage growth. In Italy, as it is the case in Spain, more factors are at play. In fact, in Italy, the effect of price markup shocks, reinforced by a pick up in demand side shocks, does not suffice to overcome the real wage repression stemming from a weakening in workers' market power over wages, mirrored in negative wage markup shocks, and an increase in labor force participation. In contrast, in Spain, the real wage increases coming from price markup and demand side shocks dominate the downward pressures coming from the weakening in workers' marker power.

Differences in wage developments are observed across recoveries over time. In

[3]A pro-cyclical real wage in Spain is also found in Font, Izquierdo, and Puente (2015).

fact, real wage growth in Germany, France, and Italy during the period after the sovereign debt crisis trough is statistically different from the wage growth during the recoveries over the 1990s-2013 period. The post-2013 weakening in the pricing power of German firms is statistically different from the pricing power observed during past recoveries. A similar result holds for Italy. In both Germany[4] and France, the productivity slowdown is statistically different from the strong productivity growth observed during the pre-2013 recoveries. In Spain, the post-2013 sizable weakening in workers' market power, possibly capturing some of the structural reforms that took place during that period, is statically different from the past power of workers' in raising wages above its equilibrium level during output recoveries.

The above picture is compatible with the evidence for the drivers of unemployment and nominal wage inflation in the post-2013 period. In Germany and France, economies where price markup and productivity shocks are the main influence of the real wage, wage markup shocks mainly account for unemployment. In contrast, in Italy and Spain, economies where all shocks influence the real wage, demand side shocks are highly influential for unemployment. As for nominal wage inflation, the case of Spain demonstrates the need of jointly examining price and wage inflation. More specifically, cyclical nominal wage inflation is the highest in Germany whereas in the other economies it is not only below that of Germany, but it is also below its past level and negative. Only when price inflation is taken into account in the case of Spain, the Spanish cyclical real wage growth appears positive and above that of France and Italy. A difference in the decomposition between nominal and real wages is that the entire set of innovations determine nominal wage inflation in all the economies of the sample.

Despite the statistically different behavior of wages during recoveries over time, we find no evidence of a change in the wage evolution during recessions leading to

[4]Interestingly, in Germany, although wage markup shocks have never exerted sizable influence on the real wage, their influence changes sign after 2003, from boosting wages to negatively affecting them while pushing unemployment downwards. This sign change likely reflects the implementation of the various waves of labor market reforms (Hartz reforms) after 2003.

troughs. Furthermore, the volatility of the real wage and of its determinants during recoveries suggests no differences over time. Overall, price markup shocks are more volatile than demand side shocks during recoveries, while wage markup shocks have always been volatile in Spain.

Although the above analysis puts emphasis on structural innovations, we also investigate the role of the structural characteristics of the sample economies in influencing the transmission of innovations. More specifically, we assess the structural differences between the German labor market and the labor markets of the other economies. We find that the structural differences among the German, French, and Italian labor markets are not enough to generate a counterfactual real wage growth that would be higher than the realized one. Nonetheless, if the Spanish labor market were more similar to the German one – if, in particular, it had a higher inverse Frisch elasticity than the observed one – then the Spanish real wage growth would be higher during the recovery from the sovereign debt crisis.

Section 2 outlines the structural model. Section 3 briefly presents the estimation and identification strategy. Section 4 displays the results. Section 5 concludes. A detailed Appendix includes the full model, the complete estimation approach, and additional results.

2 Model

Wage fluctuations are examined through the lens of a medium-scale DSGE model and, in particular, the Galí, Smets, and Wouters (2012b) model that has also been used in Galí, Smets, and Wouters (2012a), Lindé, Smets, and Wouters (2016), Lindé, Maih, and Wouters (2017), and has been extended in an open economy framework in Charalampidis (2018).

This paragraph sketches the model, while the log-linearized solution[5] is rele-

[5] Given the linear solution, the case of downward nominal wage rigidities (DNWR) cannot be examined and remains outside the scope of the paper. Recent studies using high-quality administrative data find no DNWR before and during the Great Recession in some euro-area economies [Verdugo, 2016] and Ireland [Doris et al., 2015] (Kurmann and McEntarfer (2017) and Elsby et al.

gated to the Appendix – the next paragraph reports the stochastic sources of fluctuations included in the model. Capital, produced by units of the final good, is channeled to a continuum of monopolistically competitive firms. The firms combine capital and labor to produce intermediate goods, and choose prices in a staggered fashion. Households invest in one-period risk-less nominal bonds[6], consume the final good, and supply labor. Perfect risk sharing holds. Each household is a large family and consists of a continuum of members situated in the unit square – the members have heterogeneous labor types and labor disutility. The differentiated labor is uniformly distributed, indivisible and supplied along the extensive margin, and priced in a staggered fashion by monopolistically competitive unions.

The model features eight disturbances categorized in three groups: demand side, supply side, and labor market shocks. Demand side shocks include the risk premium shock altering the inter-temporal price of consumption, the investment shock altering the conversion of investment to capital, the government spending shock affecting the allocation of economy wide resources, and a shock affecting the interest rate paid on bonds. Supply side shocks include a technology shock affecting labor productivity, and a price markup shock stemming from the degree of substitutability between goods and mirroring shifts in the degree of competition in goods markets. Labor market shocks involve a labor disutility shock causing variations in labor supply and capturing factors such as immigration and the women's entrance in the labor force, and a wage markup shock reflecting shifts in the degree of workers' market power over wages and, thus, the degree of competition in labor markets [Justiniano et al., 2011, Galí et al., 2012b].

(2016) find similar evidence for the U.S.A.), and challenge previous survey-based studies [Fabiani et al., 2010; Babecký et al., 2010].

[6]The determination of the country-specific interest rate is stylized and in response to domestic developments in inflation, as well as in the level and the growth rate of the output gap. This is a sufficient approach for our purpose which is the study of wage fluctuations. An alternative option would entail a multi-country framework and a common monetary policy; doing so, though, would make us lose focus by increasing the model complication without adding any substantial gain from additional observables; in fact, Charalampidis (2018) shows that open economy shocks have negligible influence on labor market variables.

3 Estimation

The DSGE model is estimated with Bayesian methods, starting in 1991Q2 for Germany and France, and in 1995Q2 for Italy and Spain, and stoping in 2017Q4. Briefly discussed below are the data, the measurement equations, and the state space approach – a detailed discussion is relegated to the Appendix.

3.1 Data And A Factor Approach To Wages. Twelve quarterly series are obtained from ECB, Eurostat, and OECD; a detailed description appears in the Appendix. The series for nominal GDP, private final consumption, and investment are divided by aggregate population and the GDP price deflator. The quarterly log-difference of the latter corresponds to the model's inflation rate. In addition, the three-month interbank interest rate, the unemployment rate, and (the log of) employment per capita enter the observation vector.

Five wage measures are used. First, compensation per employee is the most widely used wage measure. Second, to exclude the influence of social benefits from compensation, wages and salaries per employee are included. Third, to incorporate information on remuneration in the non-public sector (and, thus, attenuating the impact of public sector wage freezes[7]), hourly earnings in the private sector[8] are used. Fourth, to further incorporate wages in the private sector, an index for negotiated wages is included[9]. Fifth, to take into account the fluctuations in hours (since, as pointed out by Galí et al. (2012a), the production function is written in terms of labor hours), we include compensation per hour in the observation vector. All wage measures are plotted in the Appendix. They are loaded through a factor specification (the factor for compensation per employee is normalized to one) as in Galí et al. (2012a), Justiniano et al. (2013), Lindé et al. (2016), and Charalampidis (2018), and

[7]The findings of Holm-Hadulla et al. (2010) suggest a pro-cyclical bias in public wages. Radowski and Bonin (2008) find wage freezes in the private sector too and, in particular, in services and manufacturing in Germany.

[8]The index is available from the mid-90s; it is bridged to hourly earnings in the manufacture for the countries where the estimation starts earlier than the mid-90s.

[9]No such index is available for Spain

all wage series include a disperse measurement error.

3.2 Priors. The priors are conventional and reported in Table (E.1). The loading factors are sampled from a disperse Normal distribution around 1 (0.5 std). The prior for the standard deviation of the measurement errors associated with the wage measures is as disperse as that for the standard deviation of the structural shocks. To ease the exploration of the posterior surface, we set a high prior mean for the autoregressive coefficient of the labor disutility shock (0.8) – Galí et al. (2012a), in fact, fix it at 0.999. Including in the sample the volatile behavior of the series during the Great Recession is going to influence the volatility of shocks. This inclusion along with a relative moderate sample length renders useful to reduce the standard deviation of a couple of parameters so that they are kept within ranges aligned with economic theory. For example, the standard deviation of the capital share and of wage stickiness are a tad lower than what is usually postulated in the literature.

3.3 State Space. As for the Bayesian estimation, the treatment of the state space proceeds as in Charalampidis (2018) who operationalizes the state approach of Chan and Jeliazkov (2009) in a DSGE context. That approach achieves computational gains and does not require filtering recursions. The Random Walk Metropolis-Hastings algorithm is used to simulate draws from the non-tractable posterior.

4 Findings

The presentation of findings begins with real wage growth before moving to nominal wage inflation and unemployment. After that, I examine, in turn, the drivers of wages during the downturns before the troughs, the volatility of shocks during recoveries, and the the role of structural differences in the labor markets of the sample economies in influencing wage growth.

4.1 The Determinants of Cyclical Wage Growth during Recoveries.

4.1.1 Real Wage Growth. Table (1) collects the decomposition of real wage growth to trend and cycle, as well as the structural decomposition of the cyclical component.

According to these figures, sizable and statistically significant differences in the speed of real wage recoveries across countries and time are observed. In particular, real wage growth in Germany and Spain is about the same, and faster in the period following the sovereign debt crisis than it was on average during the recoveries since the 1990s and up to 2013. In contrast, real wage growth in France and Italy is slower in the former period than it is in the latter. In fact, real wage growth in Italy is negligible. Furthermore, those differences in wage evolution across time are statistically significant in Germany, France, and Italy, but not in Spain.

The above differences are shaped by the cyclical component of real wage growth. More specifically, the evidence of the present paper suggests *a cyclical real wage recovery* in Germany and Spain (the average cumulative eight-quarter-ahead rates are 0.4% and 0.3%, respectively[10]) after the trough of the sovereign debt crisis, and *a cyclical (real) wage-less output recovery* in France and Italy (-1% and -0.6%, respectively).

Delving into the determinants of the cyclical component reveals both similarities and differences across the economies of the sample. A productivity slowdown putting downward pressures to wages in the post-2013 period is observed in all the economies – more so in Germany and France than in Italy and Spain. Moreover, in the post-2013 period, Germany and Spain – the two economies with sizable real wage growth – are characterized by sizable negative price markup shocks elevating the real wage. These shocks imply shifts in the pricing power of firms and a weakening in the pass-through of production costs tp inflation during that period.

In Germany, both cyclical components are ultimately determined by the two supply shocks, namely the competing influence of productivity and price markup shocks, while demand side and labor market shocks have a negligible influence. In the post-2013 period, the upward wage pressures stemming from the price markup shocks exceed the negative effect of the productivity slowdown resulting in a positive

[10]A pro-cyclical real wage in Spain is also found in Font, Izquierdo, and Puente (2015).

real wage growth. In contrast, in the pre-2013 the opposite picture is observed: positive price markup shocks, exerting downward pressure in the real wage, cannot match the positive wage effect stemming from an acceleration in productivity.

The underlying forces of real wage growth in France are similar to those in Germany. The absence of strong negative price markup shocks in the post-2013 period is the only difference compared to the German case. That absence, in fact, explains why the post-2013 real wage growth is not stronger than it was in the pre-2013 period. The absence of an influential role for those shocks in France in the post-2013 period, is validated by the absence of a statistically significant difference between the effect of price markup shocks between the two time windows. In Germany and France, therefore, the size and direction of price markup shocks are highly influential for real wage growth.

What do positive and markup shocks imply in terms of real wage growth though? Exogenous changes in price markup shocks mirror shifts in the competitiveness of goods markets, and result in a misalignment of prices and production costs: positive/negative price markups raise/decrease price inflation independently of the evolution of costs. Fig.(2) reports the impulse response functions to price markup and productivity shocks[11]. In response to a negative price markup shock, inflation decreases and the real wage rises. Decreasing prices lower the interest rate paid on bonds, and trigger an economic stimulus: output, the output gap, investment, and nominal wage inflation are boosted while unemployment falls.

Before moving to the analysis of Italy and Spain, it is worth delving into the role of wage markup shocks in the case of Germany where the implementation of the various waves of the Hartz labor market reforms started in 2003. According to the evidence of Table (1) no statistically significant or sizable difference is observed between the pre- and post-2013 effect of wage markup shocks in Germany. Nevertheless, delving into the effect of wage markup shocks after each trough of the past

[11] The parameters are set at the posterior mean of Germany.

Table 1: Real Wage Inflation in Recoveries: A Structural Decomposition

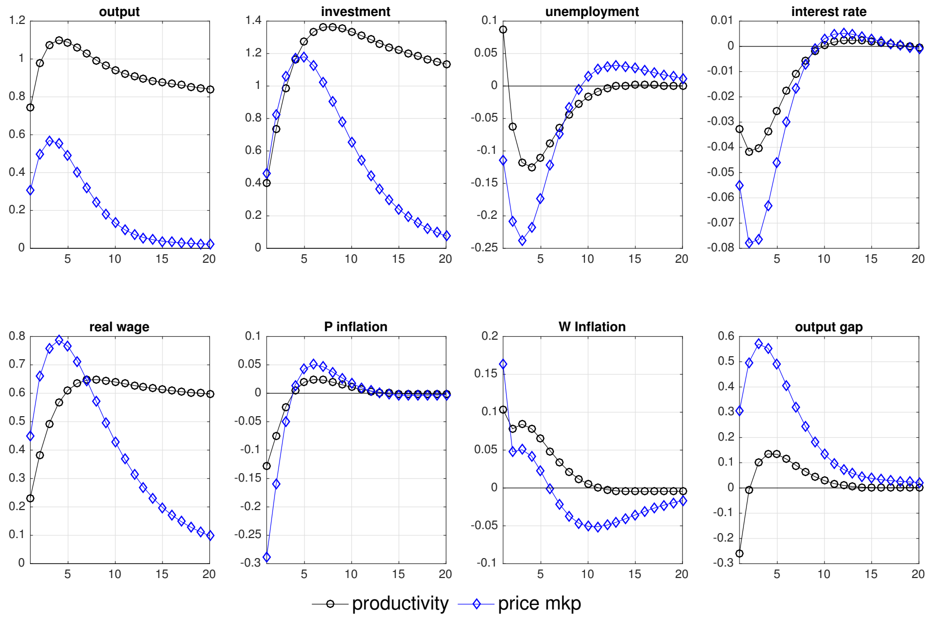
	Germany			France			Italy			Spain		
	pre	post	diff	pre	post	diff	pre	post	diff	pre	post	diff
extracted	1.2	2.6	1.4*	2.2	1.0	-1.2**	1.7	-0.1	-1.7**	1.1	2.9	1.8
trend growth	2.2	2.2	0.0	2.1	2.1	0.0	0.5	0.5	0.0	2.5	2.5	0.0
cycle	-1.0	0.4	1.5*	-0.0	-1.0	-1.0	0.8	-0.6	-1.4	-1.8	0.3	2.0
initial obs.	0.0	0.0	-0.0	0.2	-0.0	-0.2	0.4	-0.0	-0.4	0.4	0.1	-0.3
supply	-0.7	0.5	1.2	0.1	-1.1	-1.2**	-0.0	0.3	0.3	-0.6	1.3	1.9
productivity	0.7	-0.8	-1.5*	1.0	-0.7	-1.7**	-1.3	0.0	1.3	-0.3	-0.4	-0.0
price mkp	-1.4	1.3	2.7**	-0.9	-0.3	0.5	1.3	0.3	-1.0*	-0.3	1.6	1.9
demand	-0.2	-0.1	0.1	-0.1	0.1	0.2	1.1	0.5	-0.5	-1.0	1.6	2.6
risk premium	-0.1	0.1	0.2	-0.1	0.0	0.1	0.3	1.3	1.0***	-0.9	1.3	2.3
investment	0.1	-0.1	-0.2**	-0.0	0.1	0.1	0.1	-0.4	-0.5**	0.3	-0.2	-0.5
spending	0.0	-0.1	-0.1***	-0.0	-0.0	0.0	-0.2	-0.2	0.0	-0.2	-0.0	0.1
int. rate	-0.2	0.0	0.3	0.1	-0.0	-0.1	0.8	-0.2	-1.0	-0.3	0.5	0.8
labor	-0.1	-0.0	0.1	-0.1	-0.1	0.0	-0.3	-1.4	-1.2	-0.1	-2.5	-2.5*
wage mkp	-0.1	-0.1	0.1	-0.1	-0.1	-0.0	-0.5	-0.9	-0.4	0.3	-2.7	-3.0**
labor disutility	-0.0	0.1	0.1	-0.0	0.0	0.1	0.2	-0.5	-0.7	-0.4	0.1	0.5

Notes: "Pre": average eight-quarter-ahead cumulative change after a trough during the pre-2013 recoveries. "Post": average eight-quarter-ahead quarterly-rolling cumulative change after the sovereign debt crisis trough and up to the end of the sample. "diff": difference between the pre and post figures. Asterisks (***,** ,*) indicate rejection of the null hypothesis that the cumulative changes during the pre-2013 recoveries come from a normal distribution with mean equal to the post-2013 average change and unknown variance at the (1%, 5%, 10%) significance level (one-sample t-test). *Data Sources:* See text; Authors' computations.

reveals a richer picture. According to the findings of Table (2), the influence of wage markup shocks on real wages, unemployment, and nominal wages changes before and after 2003. For real wages and unemployment, in particular, that influence changes sign. During the pre-2003 recoveries, the real wage increases above what was justified by the labor market slack. In contrast, during the post-2003 recoveries, a weakening in workers' market power over wages leads to a real wage contraction and a steep decline in unemployment. As for nominal wages, they are boosted by wage markup innovations during the pre-2003 recoveries more than they are during the post-2003 recoveries. Labor supply innovations do not reveal a clear pattern of time variation.

Turning to the determinants of the cyclical part of real wage inflation in Italy

Figure 2: Price Markups, Productivity, and the Real Wage



Notes: Authors' computations. Impulse Response Functions to a negative price markup shock and a positive productivity shock, evaluated at the posterior parameter mean of Germany.

Table 2: Workers' Market Power and Adjustment in the German Labor Market

		93:2	96:1	03:1	05:1	09:1	13:1
Δw_t^r	cycle	-0.6	-1.0	-2.6	-2.2	1.2	0.4
	labor	-0.2	-0.1	0.2	-0.7	0.0	-0.0
	wage mkp	-0.1	0.0	0.3	-0.7	-0.1	-0.1
	labor disutility	-0.1	-0.1	-0.1	0.0	0.1	0.1
ΔU_t	cycle	0.7	1.1	1.3	-1.8	-1.2	-0.8
	labor	0.2	0.3	1.2	-1.0	-0.8	-0.5
	wage mkp	0.1	0.3	1.1	-1.0	-0.4	-0.5
	labor disutility	0.1	0.1	0.0	-0.0	-0.4	0.0
π_t^w	cycle	-1.3	-5.1	-4.6	-4.3	-0.6	0.1
	labor	1.2	1.7	2.9	0.9	1.0	-0.2
	wage mkp	1.3	1.9	3.1	0.9	1.0	-0.1
	labor disutility	-0.2	-0.2	-0.2	-0.0	0.0	-0.1

Notes: Eight-quarter-ahead cumulative change after a trough. *Data Sources:* See text; Authors' computations. Δw_t^r: real wage growth; ΔU_t: change in the unemployment rate; π_t^w: nominal wage inflation.

and Spain, we observe that all types of innovations are influential. During the post-2013 period, both countries exhibit similarities in the sense that, in both economies, price markup shocks shape the overall effect of supply side shocks, and that both supply and demand side shocks boost real wage growth whereas labor market shocks, driven by a weakening in workers' market power exert downward pressures to real wages. In both economies, the pick-up of demand side shocks is determined by the risk premium shock – a result that is compatible with the rising role of that shock in the U.S. economy found by Galí, Smets, and Wouters (2012a). Nevertheless, the -0.6% post-2013 cyclical real wage change in Italy falls below the 0.3% wage change observed in Spain due to fact that in the latter country the combination of demand and supply side shocks exceeds the effect of labor market shocks whereas in the former country it does not. That difference is heavily influence by the sizable price markup shocks in Spain.

Italy and Spain demonstrate additional differences between their respective pre- and post-2013 recoveries. More specifically, in Italy risk premium and investment shocks exhibit a statistically significant difference across time, implying an increase in the sensitivity of the real wage to demand conditions. In contrast, in Spain, sizable wage markup shocks suggest a weakening of workers' market power and bridge the declining unemployment with the observed weak wage growth. It is worthwhile to mention that labor supply shocks in Italy during the post-2013 period exert downward wage pressures. This effect likely implies an increase in the Italian labor force participation. The origins of the latter could be a combination of immigration, a decrease in the number of undocumented employees, and an increase in the participation of workers in the market.

4.1.2 Nominal Wage Growth. Considering nominal wage growth in Table (3) reveals a picture compatible with that observed for real wage growth. In nominal terms, wage growth during the recovery from the Great Recession is weaker in France and Italy than it is in Germany and Spain. Nevertheless, the cyclical component of nominal wage inflation is negative in the post-2013 period in all the economies but in Germany. This observation for the case of Spain in the post-2013 period highlights the importance of jointly studying wages and inflation: despite the negative cyclical nominal wage growth(-4.1%), cyclical real wage growth is positive (0.3%).

The decomposition of the cyclical part of nominal wage inflation reveal that the entire set of innovations influences nominal wages contrary to real wages where only subset of disturbances matters in some economies. In Germany, no influence of supply side shocks on nominal wage inflation is found. Instead, the positive cyclical nominal wage growth in Germany is driven by a demand stimulus that overcomes a small negative effect coming from labor market shocks. In fact, both effects are statistically different from the negative effect of demand side shocks and the positive effect coming from the market power of workers during the pre-2013 recoveries.

France and Germany are not as similar in terms of nominal wages as they are in term of the real wage. In France, sizable supply side shocks, accompanied by demand side shocks and in particular risk premium innovations, exert downward pressures on nominal wages. In Italy, sizable downward pressures on nominal wages coming from the supply side and the labor market dominate the positive, albeit small, effect of rising demand. The cyclical nominal wage contraction in Spain is driven by demand and labor market shocks.

4.1.3 Unemployment. It is important to investigate how the above findings about the shocks' influence are reflected on the unemployment fluctuations. Table (4) reports the decomposition for unemployment. The table reveals that in all economies but in Italy, a weakening in workers' market power is the main determinant of the post-2013 unemployment decline. In Italy, and in Spain to a some extent, a sizable influence of the post-2013 demand pick up on the unemployment decline is found.

4.2 The Determinants of Cyclical Wage Growth during Recessions.

The present paper has uncovered a statistically different wage behavior between the output recoveries in the pre-2013 period and the post-2013 experience. That

Table 3: Nominal Wage Inflation in Recoveries: A Structural Decomposition

	Germany			France			Italy			Spain		
	pre	post	diff	pre	post	diff	pre	post	diff	pre	post	diff
extracted	3.2	5.9	2.7**	4.7	2.3	-2.4*	5.0	1.5	-3.5***	5.1	3.7	-1.3
trend growth	5.5	5.5	0.0	4.9	4.9	0.0	4.8	4.8	0.0	6.9	6.9	0.0
cycle	-3.2	0.1	3.3**	-0.9	-2.7	-1.8	-0.7	-3.6	-2.9**	-3.9	-4.1	-0.2
initial obs.	0.8	0.2	-0.6*	0.7	0.1	-0.6	0.9	0.3	-0.6	2.1	0.9	-1.1
supply	-0.2	-0.2	0.0	-0.0	-1.0	-1.0**	-0.0	-2.3	-2.3**	0.4	0.1	-0.3
productivity	-0.0	-0.7	-0.7	0.3	-0.7	-1.0	-2.1	0.1	2.2**	-2.3	-1.0	1.3
price mkp	-0.2	0.6	0.8	-0.3	-0.3	-0.0	2.1	-2.4	-4.5***	2.7	1.0	-1.6
demand	-4.5	0.5	5.0***	-1.2	-1.7	-0.5	1.1	0.7	-0.4	-1.5	-0.4	1.2
risk premium	-4.0	-2.2	1.9**	-1.1	-3.0	-1.9**	0.4	1.3	0.9***	-2.9	0.1	3.0
investment	-0.1	-1.0	-0.9*	-0.4	0.3	0.8*	0.1	-0.2	-0.2	-0.3	-0.5	-0.2
spending	0.1	0.5	0.5***	0.0	0.1	0.1	-0.2	-0.2	0.0	-0.1	0.2	0.3*
int. rate	-0.5	3.2	3.6*	0.3	0.8	0.5	0.9	-0.2	-1.1	1.7	-0.2	-1.9
labor	1.5	-0.2	-1.7***	0.3	0.0	-0.3*	-1.8	-2.0	-0.2	-2.8	-3.8	-1.0
wage mkp	1.6	-0.1	-1.7**	0.4	0.2	-0.2	-2.0	-1.5	0.5	-2.8	-4.0	-1.2
labor disutility	-0.1	-0.1	-0.0	-0.1	-0.1	-0.0	0.2	-0.5	-0.7*	0.0	0.2	0.2

Notes: "Pre": average eight-quarter-ahead cumulative change after a trough during the pre-2013 recoveries. "Post": average eight-quarter-ahead quarterly-rolling cumulative change after the sovereign debt crisis trough and up to the end of the sample. "diff": difference between the pre and post figures. Asterisks (***,**,*) indicate rejection of the null hypothesis that the cumulative changes during the pre-2013 recoveries come from a normal distribution with mean equal to the post-2013 average change and unknown variance at the (1%, 5%, 10%) significance level (one-sample t-test). *Data Sources:* See text; Authors' computations.

difference has been traced out to its origins. Nevertheless, the above analysis does not shed light on whether the wage developments in the pre- and post-2013 periods differ during recessionary episodes that end up in an economic trough.

This section tackles this issue by pinning down the determinants of the wage evolution during recessions that led to a trough in the pre- and post-2013 period. Table (5) computes wage growth during the recessionary episodes and decomposes it in its driving forces – in the interest of space, only the decomposition to the three categories of shocks is shown; detailed results are available upon request.

According to the evidence of Table (5), three results stand out. First, the evidence does not suggest statistically significant differences across time in the wage

Table 4: The Unemployment Rate in Recoveries: A Structural Decomposition

	Germany			France			Italy			Spain		
	pre	post	diff	pre	post	diff	pre	post	diff	pre	post	diff
cycle	0.0	-0.8	-0.8	0.4	-0.4	-0.7*	-0.8	-0.8	0.0	1.9	-4.6	-6.5
initial obs.	-0.0	0.0	0.0	-0.1	0.0	0.1	-0.0	0.0	0.0	0.0	0.0	-0.0
supply	0.3	-0.2	-0.6***	0.2	-0.0	-0.2	1.6	0.2	-1.4*	-0.1	-0.2	-0.1
technology	-0.1	-0.1	-0.0	-0.3	-0.0	0.2	1.5	0.1	-1.4**	-0.3	0.0	0.3
price mkp	0.4	-0.1	-0.5***	0.4	0.0	-0.4*	0.1	0.1	-0.0	0.1	-0.2	-0.4
demand	-0.3	-0.1	0.2	-0.3	-0.1	0.2	-1.4	-1.1	0.3	0.2	-1.1	-1.3
risk prem.	-0.3	-0.1	0.2**	0.1	-0.1	-0.2	-1.5	-1.2	0.3	-0.4	-0.7	-0.3
investment	-0.5	-0.0	0.5	-0.3	-0.0	0.3	-0.5	0.3	0.9*	-0.2	0.2	0.4
spending	-0.2	0.1	0.3	0.1	0.0	-0.1	0.4	0.0	-0.4	-0.2	-0.0	0.2
int. rate	0.8	0.0	-0.7***	-0.2	0.0	0.2	0.3	-0.3	-0.5	1.0	-0.5	-1.6
labor	-0.0	-0.5	-0.5	0.5	-0.3	-0.8***	-1.0	0.2	1.2	1.8	-3.2	-5.1
wage mkp	0.0	-0.5	-0.5	0.4	-0.2	-0.6**	-0.4	-0.4	-0.0	1.3	-3.4	-4.8
supply	-0.0	0.0	0.1	0.1	-0.0	-0.2*	-0.7	0.5	1.2	0.5	0.2	-0.3

Notes: "Pre": average eight-quarter-ahead cumulative change after a trough during the pre-2013 recoveries. "Post": average eight-quarter-ahead quarterly-rolling cumulative change after the sovereign debt crisis trough and up to the end of the sample. "diff": difference between the pre and post figures. Asterisks (***,**,*) indicate rejection of the null hypothesis that the cumulative changes during the pre-2013 recoveries come from a normal distribution with mean equal to the post-2013 average change and unknown variance at the (1%, 5%, 10%) significance level (one-sample t-test). *Data Sources:* See text; Authors' computations.

behavior during economic downturns that lead to a recession. This observation contradicts the statistically different wage behavior uncovered during the recoveries. Second, rather surprisingly, in Germany, wage growth is positive during the eight quarters preceding the sovereign debt crisis trough, whereas the opposite holds in all other economies. This result entirely stems from the effect of supply side shocks. Given the positive effect of those shocks on the real wage during the recovery, this result implies that the positive effect of supply side shocks, and in particular of the negative price markup shocks, on the German real wage has started well before the trough and continued after that, and it was not affected by the economic downturn. Third, demand side shocks are prevalent in the southern economies during the recession of the sovereign debt crisis, and imply a steep decline in the real wage.

Table 5: Real Wage Growth, Recoveries vs Recessions

	Germany			France			Italy			Spain		
	pre	post	diff	pre	post	diff	pre	post	diff	pre	post	diff
recession												
cycle	-0.3	1.0	1.4	0.4	-0.5	-0.9	-0.8	0.0	0.7	2.5	-5.2	-7.7
supply	-0.4	1.0	1.4	0.3	-0.7	-1.1	-0.3	0.2	0.5	0.1	-0.7	-0.8
demand	-0.1	0.0	0.1	-0.3	0.1	0.3**	0.2	-2.1	-2.3**	-0.8	-3.8	-2.9
labor	0.1	0.0	-0.1	0.3	0.2	-0.1	-0.7	1.9	2.6**	3.3	-0.7	-4.0
recovery												
cycle	-1.0	0.4	1.5*	0.0	-1.0	-1.0	0.8	-0.6	-1.4	-1.8	0.3	2.0
supply	-0.7	0.5	1.2	0.1	-1.1	-1.2**	0.0	0.3	0.3	-0.6	1.3	1.9
demand	-0.2	-0.1	0.1	-0.1	0.1	0.2	1.1	0.5	-0.5	-1.0	1.6	2.6
labor	-0.1	0.0	0.1	-0.1	-0.1	0.0	-0.3	-1.4	-1.2	-0.1	-2.5	-2.5*

Notes: "Pre": average eight-quarter cumulative change before a trough during the pre-2013 recoveries. "Post": average eight-quarter cumulative change before the sovereign debt crisis trough. "diff": difference between the pre and post figures. Asterisks (***,** ,*) indicate rejection of the null hypothesis that the cumulative changes during the pre-2013 recoveries come from a normal distribution with mean equal to the post-2013 average change and unknown variance at the (1%, 5%, 10%) significance level (one-sample t-test). *Data Sources:* See text; Authors' computations.

4.3 The Determinants of Wage Volatility during Recoveries. The above analysis has examined the first moments of the stochastic properties of wages and of their determinants. Thus, it has not been informative about the volatility of the influence of its shock on wage growth. Hence, we now turn to the volatility of wages and of their determinants during recoveries – we consider the pre-2009 recoveries, and the recoveries from the Great Recession and the sovereign debt crisis separately to examine whether those two periods exhibit similar or different characteristics.

Table (6) reveals sizable time differences neither in wage volatility nor in the volatility of the drivers of real wage growth. Price markup shocks are one of the most volatile shocks contradicting the low volatility of demand side shocks. Wage markup shocks too exhibit low volatility, with Spain being an exception where these shocks have been volatile across time.

4.4 Wages and the Role of Structures during Recoveries. The present study has so far investigated the stochastic properties of the disturbances across time,

Table 6: Wage Volatility In Recoveries

	Germany			**France**			**Italy**			**Spain**		
	pre	GR	SD	pre	GR	SD	pre	GR	SD	pre	GR	SD
cycle	0.3	0.5	0.2	0.2	0.3	0.2	0.6	0.3	0.2	0.4	0.5	0.5
productivity	0.1	0.7	0.1	0.1	0.2	0.1	0.1	0.2	0.0	0.0	0.0	0.0
price mkp	0.3	0.4	0.2	0.1	0.3	0.2	0.6	0.3	0.2	0.2	0.2	0.4
risk premium	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.1
investment	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
spending	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.1
int. rate	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.1	0.2	0.1
wage mkp	0.2	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.3	0.4	0.4
labor disutility	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.1

Notes: "Pre": average eight-quarter volatility after a trough during the pre-2009 recoveries. "GR": average eight-quarter volatility after the trough of the Great Recession. "SD": average eight-quarter volatility after the trough of the sovereign debt crisis. *Data Sources:* See text; Authors' computations.

but has remained silent about structural differences across the economies that may influence the transmission of shocks and, in turn, wage growth. To that end, we now look at the role of structural differences in the labor markets of the sample economies. Table (7) presents a subset of the posterior parameter estimates that includes only those that are directly associated with the labor market. The table reveals some differences across the four economies – the differences are rather sizable in terms of the inverse Frisch elasticity and the volatility of wage and labor disutility shocks. Both Germany and France suggest high inverse Frisch elasticity estimates compared to the estimates for Italy and Spain. The volatility of wage markup shocks is the highest in Germany, whereas the volatility of exogenous shifts in the labor force is the largest in Spain.

To understand the influence of the above structural differences on wage growth, we conduct the following experiment. We ask, how would the post-2013 real wage growth have looked like, if the labor markets of all the economies had been similar to the German labor market ? To answer this question, the posterior mean estimates of the parameters associated with the German labor market are substituted in the

Table 7: Parameter Estimates associated with the Labor Market

		Posterior Mean [5-95%]			
		Germany	**France**	**Italy**	**Spain**
wage mkp	υ_w	0.33 [0.26, 0.40]	0.43 [0.32, 0.54]	0.27 [0.18, 0.38]	0.33 [0.23, 0.47]
inv. Frisch	χ	5.73 [4.69, 6.95]	3.99 [3.11, 4.90]	2.18 [1.46, 3.00]	1.37 [1.00, 1.89]
wage Calvo	ζ_w	0.42 [0.31, 0.56]	0.48 [0.40, 0.55]	0.54 [0.45, 0.63]	0.40 [0.31, 0.51]
wage index.	ι_w	0.33 [0.15, 0.53]	0.23 [0.11, 0.37]	0.14 [0.07, 0.22]	0.40 [0.18, 0.65]
wealth effect	ν	0.04 [0.00, 0.14]	0.04 [0.00, 0.10]	0.01 [0.00, 0.02]	0.00 [0.00, 0.01]
AR wage mkp	ρ_w	0.86 [0.68, 0.95]	0.91 [0.85, 0.96]	0.93 [0.86, 0.97]	0.85 [0.76, 0.91]
std wage mkp	σ_w	8.83 [4.62, 18.46]	2.28 [1.57, 3.27]	1.58 [0.74, 3.10]	4.60 [2.73, 7.53]
AR labor dis.	ρ_χ	1.00 [0.99, 1.00]	0.99 [0.97, 1.00]	0.94 [0.89, 0.97]	0.92 [0.90, 0.95]
std labor dis.	σ_χ	1.62 [1.31, 1.99]	0.79 [0.61, 1.00]	1.74 [1.22, 2.38]	2.49 [1.78, 3.44]

Notes: The table reports a subset of the posterior distribution of all the parameters estimates of the model. The complete set is relegated to the Appendix. *Data Sources:* See text; Authors' computations.

model for each of the economies of the sample – the latter model is then simulated on the set of extracted innovations for the period after the sovereign debt crisis trough. The eight-quarter-ahead quarterly rolling cumulative change in the real wage is then computed and displayed in Table (8).

The evidence of the table suggests no sizable differences when all the parameters associated with the labor market are similar to those in Germany. Thus, in the sample economies, the structural differences in the labor market are not sufficient to generate sizable differences in terms of the wage evolution. An exception is the case of Spain, where the simulated cyclical real wage growth is higher than its observed counterpart. The entire effect in that case comes from replacing the low Spanish inverse Frisch elasticity (1.4) with the much higher German one (5.7): the higher that elasticity, the higher the response of wages to labor market aggregates. Hence, the steep unemployment decline in Spain would translate to strong wage growth for a high inverse Frisch elasticity.

5 Concluding Remarks

The present paper contributes in the literature that studies the driving factors of wage growth after the Great Recession in two ways. First, it provides a structural

Table 8: Post-2013 Real Wage Growth, The Role of Structural Differences

	actual	**simulated**	**diff.**
Germany	0.4	0.4	-0.1
France	-1.0	-1.1	-0.1
Italy	-0.6	-0.8	-0.2
Spain	0.4	2.7	2.3

Notes: The table reports the simulated real wage growth in each economy when the posterior mean of the parameters associated with the labor market in Germany replaces the same parameters of each economy, and simulation takes place in the time period after the sovereign debt crisis trough.

interpretation of the driving factors of wage growth and, thereby, quantifies the relative importance of a variety of factors. Second, it emphasizes the wage evolution during output recoveries since the 1990s to today. In doing so, it sheds light on an unexplored aspect of business cycle fluctuations.

The present paper documents the phenomenon of a cyclical real wage recovery in Germany and Spain, and of a cyclical wage-less output recovery in France and Italy during the period after the sovereign debt crisis. In terms of the underlying forces of those phenomena, this paper finds a weakening in the pass-through of production costs to inflation, as well as a productivity slowdown, in all the economies of the sample to some extent. Those phenomena are prevalent in Germany and France and influential in Italy and Spain. In the last two economies, however, both a pick up in demand and a weakening in workers' market power are highly influential on wage growth as well.

This study provided a versatile platform to further build upon it. Further explorations to be undertaken involve digging deeper on the role of structural differences in the labor markets of the sample economies, understanding better the post-2013 wage experience compared to previous recoveries in terms of changes in the structural features of the sample economies, and connecting the results of the post-2013 period to the structural reforms that took place in those economies.

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Appendices

A Model Equilibrium

The equilibrium conditions, log-linearized around the balanced growth steady state path, are collected here. The log-deviation of a generic non-stationary variable (X_t) from its steady state (x), after rendering the former stationary, is denoted by $\widehat{x}_t \equiv ln(X_t/e^{\gamma t}/x)$.

A.1 Sticky Price and Wage Equilibrium. .

Aggregate Production Function

$$\widehat{y}_t = (1+\Phi_y/y)[\alpha\widehat{k}_t + (1-\alpha)\widehat{L}_t + \widehat{z}_t] \tag{A.1}$$

Capital-To-Labor Ratio

$$\widehat{k}_t = \widehat{w}_t^r - \widehat{r}_t^{k,r} + \widehat{L}_t \tag{A.2}$$

Marginal Cost

$$\widehat{mc}_t^r = (1-\alpha)\widehat{w}_t^r + \alpha\widehat{r}_t^{k,r} - \widehat{z}_t \tag{A.3}$$

Rental Rate of Capital

$$\widehat{r}_t^{k,r} = [\psi/(1-\psi)]\widehat{u}_t \tag{A.4}$$

Effective Capital

$$\widehat{k}_t = \widehat{u}_t + \widehat{\bar{k}}_{t-1} \tag{A.5}$$

Capital Accumulation

$$\widehat{\bar{k}}_t = k_1(\widehat{\bar{k}}_{t-1}) + (1-k_1)(\widehat{v}_t^i + \widehat{\bar{i}}_t) \tag{A.6}$$

where $k_1 = (1-\delta)/e^\gamma$.

Price of Capital

$$\widehat{q}_t^k = E_t\left(\widehat{\xi}_{t+1} - \widehat{\xi}_t\right) + q_1 E_t\widehat{r}_{t+1}^{r,k} + (1-q_1)\, E_t\widehat{q}_{t+1}^k \tag{A.7}$$

where $q_1 = \left(r^{k,r}/[r^{k,r}+1-\delta]\right)$.

Investment

$$\widehat{i}_t = i_1(\widehat{i}_{t-1}) + (1-i_1)\left(E_t\widehat{i}_{t+1}\right) + i_2(\widehat{q}_t^k + \widehat{\upsilon}_t^i) \tag{A.8}$$

where $i_1 = 1/[1+\beta]$ and $i_2 = i_1/\left[e^{2\gamma}S''\right]$.

Price Inflation

$$\widehat{\pi}_t = (\pi_1\beta)E_t\widehat{\pi}_{t+1} + (\pi_1\iota_p)\widehat{\pi}_{t-1} + \kappa_p\left(\widehat{mc}_t^r + (1/\lambda_p)\,\widehat{\upsilon}_t^p\right) \tag{A.9}$$

where $\kappa_p = (1-\zeta_p)(1-\zeta_p\beta)/\left[\zeta_p(1+\iota_p\beta)\right]$, $\pi_1 = 1/[1+\iota_p\beta]$, $\widehat{\upsilon}_t^p \equiv log(\upsilon_t^p/\upsilon^p)$, and $1+\upsilon_t^p \equiv \lambda_t^p/(\lambda_t^p-1)$.

Wage Inflation

$$\widehat{\pi}_t^w - \iota_w\widehat{\pi}_{t-1} = \beta\left[E_t\widehat{\pi}_{t+1}^w - \iota_w\widehat{\pi}_t\right] - \kappa_w\left(\widehat{\mu}_t^w - \widehat{\mu}_t^{w,n}\right) \tag{A.10}$$

where $\kappa_w = (1-\zeta_w)(1-\zeta_w\beta)/\left[\zeta_w(1+\chi\lambda_w)\right]$.

Real Wage

$$\widehat{w}_t^r - \widehat{w}_{t-1}^r = \widehat{\pi}_t^w - \widehat{\pi}_t \tag{A.11}$$

Endogenous Wage Markup,

$$\widehat{\mu}_t^w = \chi\widehat{U}_t \tag{A.12}$$

Exogenous Wage Markup,

$$\widehat{\mu}_t^{w,n} = (1/\lambda_w)\,\widehat{\upsilon}_t^w \tag{A.13}$$

where $\widehat{\upsilon}_t^w \equiv log(\upsilon_t^w/\upsilon^w)$, and $1+\upsilon_t^w \equiv \lambda_t^w/(\lambda_t^w-1)$.

Natural Unemployment,

$$\widehat{\mu}_t^{w,n} = \chi\widehat{U}_t^n \tag{A.14}$$

Unemployment,

$$\widehat{U}_t = \widehat{LF}_t - \widehat{L}_t \tag{A.15}$$

Labor Supply,

$$\widehat{w}_t^r = \widehat{\chi}_t + \widehat{\theta}_t + \chi \widehat{LF}_t \tag{A.16}$$

Interest Rate Determination,

$$\widehat{r}_t = \rho_r \widehat{r}_{t-1} + (1-\rho_r)\left[\psi_\pi \widehat{\pi}_t + \psi_y(\widehat{y}_t - \widehat{y}_t^f) + \psi_{\Delta y}\Delta(\widehat{y}_t - \widehat{y}_t^f)\right] + \epsilon_t^{mp} \tag{A.17}$$

Resource Constraint

$$(c/y)\widehat{c}_t + (i/y)\widehat{i}_t + (g/y)\widehat{g}_t + (r^{k,r}k/y)\widehat{u}_t = \widehat{y}_t \tag{A.18}$$

Lagrange Multiplier

$$-(1-\eta/e^\gamma)\widehat{\xi}_t = \widehat{c}_t - (\eta/e^\gamma)\widehat{c}_{t-1} \tag{A.19}$$

Inter-Temporal Consumption Dynamics

$$\widehat{\xi}_t = E_t\left(\widehat{\xi}_{t+1} + \widehat{\upsilon}_t^b + \widehat{r}_t - \widehat{\pi}_{t+1}\right) \tag{A.20}$$

Shifter

$$\widehat{\theta}_t = (1-\nu)\widehat{\theta}_{t-1} - \nu\widehat{\xi}_t \tag{A.21}$$

A.2 Flexible Price and Wage Equilibrium. The solution of the model in the flexible price and wage equilibrium (variables associated with that equilibrium are denoted with a superscript "f") is obtained from the above set of equations (A.1–A.21) for zero price and wage stickiness.

A.3 Stochastic Structure. The disturbances follow AR(1) processes. A few shocks are scaled: the risk premium shock is scaled in (A.20) after substituting in (A.19), and is adjusted accordingly in (A.7) after substituting in (A.20); the price and wage markup shocks are scaled in equations (A.9) and (A.13), respectively; the government spending shock is scaled in (A.18); the investment shock is scaled in (A.8) and adjusted accordingly in (A.6). These adjustments improve the convergence of the sampler and introduce correlated priors.

B Observation Equations

The observation equations are shown below.

$$dln(GDP_t/ImplicitPriceDeflator_t/Pop_t) = \gamma + \Delta\widehat{y}_t + \mu_t^y \tag{B.1}$$

$$dln(PrivateCons_t/ImplicitPriceDeflator_t/Pop_t) = \gamma + \Delta\widehat{c}_t + \mu_t^c \tag{B.2}$$

$$dln(GrossFixedInvestment_t/ImplicitPriceDeflator_t/Pop_t) = \gamma + \Delta\widehat{i}_t + \mu_t^i \tag{B.3}$$

$$dln(ImplicitPriceDeflator_t) = \pi + \widehat{\pi}_t + \mu_t^\pi \tag{B.4}$$

$$InterestRate_t = r + \widehat{r}_t + \mu_t^r \tag{B.5}$$

$$UnemploymentRate_t = u + \widehat{u}_t + \mu_t^u \tag{B.6}$$

$$ln(Employment_t/Pop_t) = l + \widehat{l}_t + \mu_t^l \tag{B.7}$$

The mean of the latter's left hand side is normalized to zero.

$$dln\begin{bmatrix} Compensation_t/ImplicitPriceDeflator_t/Employment_t \\ WagesAndSalaries_t/ImplicitPriceDeflator_t/Employment_t \\ NegotiatedWagesIndex_t/ImplicitPriceDeflator_t \\ PrivateEarningsIndex_t/ImplicitPriceDeflator_t/Employment_t \\ HourlyCompensationIndex_t/ImplicitPriceDeflator_t \end{bmatrix} =$$

$$= \begin{bmatrix} \gamma_{cpe} \\ \gamma_{wnspe} \\ \gamma_{neg} \\ \gamma_{priv} \\ \gamma_{cph} \end{bmatrix} + \begin{bmatrix} 1 \\ \Psi_{wnspe} \\ \Psi_{neg} \\ \Psi_{priv} \\ \Psi_{cph} \end{bmatrix} \Delta\widehat{w}_t + \begin{bmatrix} \mu_t^{cpe} \\ \mu_t^{wnspe} \\ \mu_t^{neg} \\ \mu_t^{priv} \\ \mu_t^{cph} \end{bmatrix} \tag{B.8}$$

C State Space

Following Charalampidis (2018) who operationalizes the state approach of Chan and Jeliazkov (2009) in a DSGE context, the measurement equations are stacked vertically to yield the following matrix equation:

$$\Upsilon_t = \Gamma_q + H_0\zeta_t + H_1\zeta_{t-1} + M_t \quad , \quad M_t \sim N(0, \Sigma_q) \tag{C.1}$$

where Υ_t and Γ_q are $(o_q \times 1)$ vectors of observables and intercepts, respectively.

$\{H_0, H_1\}$ denote the $(o_q \times n_\zeta)$ selection matrices and include the slope coefficients of the measurement equations. ζ_t is the period-t $(n_\zeta \times 1)$ state vector. M_t collects the measurement errors. Σ_q is the diagonal covariance matrix of measurement errors.

The log-linearized equilibrium conditions of the model are casted in the form

$$\Gamma_2(\Theta)E_t\zeta_{t+1} + \Gamma_0(\Theta)\zeta_t = \Gamma_1(\Theta)\zeta_{t-1} + \Psi(\Theta)\epsilon_t \tag{C.2}$$

The system matrices $\{\Gamma_0, \Gamma_1, \Gamma_2, \Psi\}$ are functions of the parameter vector Θ. The structural shocks are grouped in the $(n_\epsilon \times 1)$ vector $\epsilon_t \sim N(0_{n_\epsilon}, I_{n_\epsilon})$, and are fewer than the number of observables $(n_\epsilon < o_q)$. The rational expectations solution of Sims (2002) reads as

$$\zeta_t = \Phi_1(\Theta)\zeta_{t-1} + \Phi_2(\Theta)\epsilon_t \tag{C.3}$$

Stacking both measurement and state equations across time yields the following matrix representations,

$$\Upsilon = \Gamma + H\zeta + M \quad , \quad M \sim N\left(0_{o_q n_q}, \Sigma_M \equiv I_{n_q} \otimes \Sigma_q\right) \tag{C.4}$$

$$Z\zeta = \tilde{\epsilon} \quad , \quad \tilde{\epsilon} \sim N(0_{n_\zeta n_q}, K_{\tilde{\epsilon}}^{-1}) \tag{C.5}$$

where $\Upsilon \equiv [\Upsilon'_{t=1}, \Upsilon'_{t=2}, \ldots]'$ is the observation vector. $\Gamma \equiv [\Gamma'_q, \Gamma'_q, \ldots]'$ is a vector of intercepts. $\zeta \equiv [\zeta'_1, \zeta'_2, \ldots]'$ is the $(n_\zeta n_q) \times 1$ state vector. $M \equiv [M'_{t=1}, M'_{t=2}, \ldots]'$ collects the measurement errors. H and Z are sparse and block-banded matrices. According to (C.4), the likelihood of the data given the parameter vector Θ and the states ζ is $P(\Upsilon - \Gamma|\Theta, \zeta)$. $\tilde{\epsilon} \equiv [\tilde{\epsilon}'_1, \tilde{\epsilon}'_2 \ldots]'$ is the $(n_\zeta n_q) \times 1$ vector of reduced-form errors, and $K_{\tilde{\epsilon}}$ is the sparse and block-banded precision of the latter. A change of variable transformation in (C.5) yields the prior state distribution, $P(\zeta|\Theta)$, with $\zeta|\Theta \sim N(\zeta_0, K^{-1})$ and $\zeta_0 = 0_{n_\zeta n_q}$. The precision $K = Z'K_{\tilde{\epsilon}}Z$ is also sparse and block-banded [Chan and Jeliazkov, 2009].

Bayes rule, $P(\zeta|\Upsilon, \Theta) \propto P(\Upsilon|\Theta, \zeta)P(\zeta|\Theta)$, yields the block-banded posterior precision: $P = K + H'\Sigma_M^{-1}H$. The posterior mean state $(\widehat{\zeta})$ is computed based on forward and backward substitution in (C.6):

$$P\widehat{\zeta} = K\zeta_0 + H'\Sigma_M^{-1}(\Upsilon - \Gamma) \tag{C.6}$$

The integrated log-likelihood is evaluated at a high density point along the lines of Chib (1995) and, in particular, at the posterior mean of the states: $lnP(\Upsilon|\Theta) = lnP(\Upsilon|\Theta, \widehat{\zeta}) + lnP(\widehat{\zeta}|\Theta) - lnP(\widehat{\zeta}|\Upsilon, \Theta)$.

D Data Sources

The data sources are explained below.

- Germany (1991Q1-2017Q4):
    1. Gross Domestic Product, current prices, s.a., Euro, millions, OECD Quarterly National Accounts
    2. GDP Price Deflator, index (2010=100), s.a., OECD Quarterly National Accounts
    3. Gross Capital Formation, current prices, s.a., Euro, millions, OECD Quarterly National Accounts
    4. Private Final Consumption Expenditure, current prices, s.a., Euro, millions, OECD Quarterly National Accounts
    5. 3-Month or 90-day Rates and Yields: Interbank Rates for Germany, Percent, Quarterly, Not Seasonally Adjusted, FRED, Federal Reserve Economic Data
    6. Total Population, persons, thousands, s.a., OECD Quarterly National Accounts
    7. Total Employment, persons, thousands, s.a., OECD Quarterly National Accounts
    8. Harmonized Unemployment Rate: Total: All Persons for Germany, Percent, Quarterly, Seasonally Adjusted, Labour Force Survey, OECD, Key Short-Term Economic Indicators

9. Compensation of employees, total, current prices, s.a., Euro, millions, OECD Quarterly National Accounts
10. Wages and Salaries, total, current prices, s.a., Euro, millions, OECD Quarterly National Accounts
11. Hourly Earnings, index, s.a., Manufacturing (1991Q1-1996Q1), Private Sector (1996Q2-2017Q4), OECD
12. Hourly Compensation, Domestic (home or reference area), Total economy, Total - All activities, Index, Current prices, Non transformed data, s.a., not calendar adjusted, SDW
13. Negotiated wages, Total - Index. Neither seasonally nor working day adjusted, retrieved from SDW. Seasonality is removed with the Census X13 filter.

- France (1991Q1-2017Q4): as above; the unempl. rate is obtained from FRED.
- Italy (1995Q1-2017Q4): as above; 6 from Eurostat and is not seasonally adjusted.
- Spain (1995Q1-2017Q4): as above; no negotiated wages index is available.
- Euro Area 19 (1995Q1-2017Q4): as above; no negotiated wages index is available.

The series matched in the estimation are shown below for each economy.

E Posterior

Table (E.1) collects the posterior distribution of the parameters. The parameters are in general aligned with that is usually obtained in the literature.

Table (E.2) reports the standard deviation of measurement errors for variables with a single observable series. Those are tightly estimated with a low prior mean.

A few parameters are calibrated since they are not identified in the data. δ and g are set at the values chosen in Galí et al. (2012a). β is fixed at 0.998.

Figure D.1: Observables, Germany

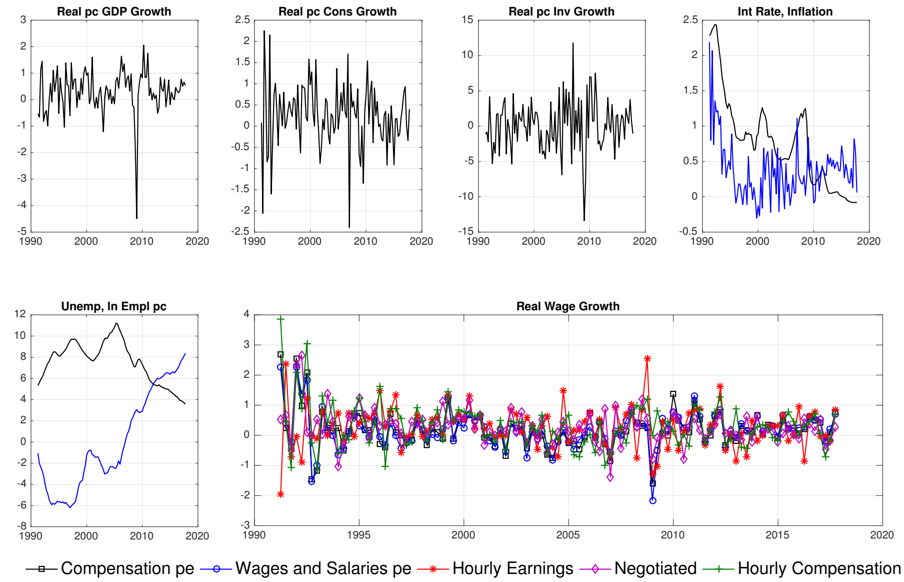

Figure D.2: Observables, France

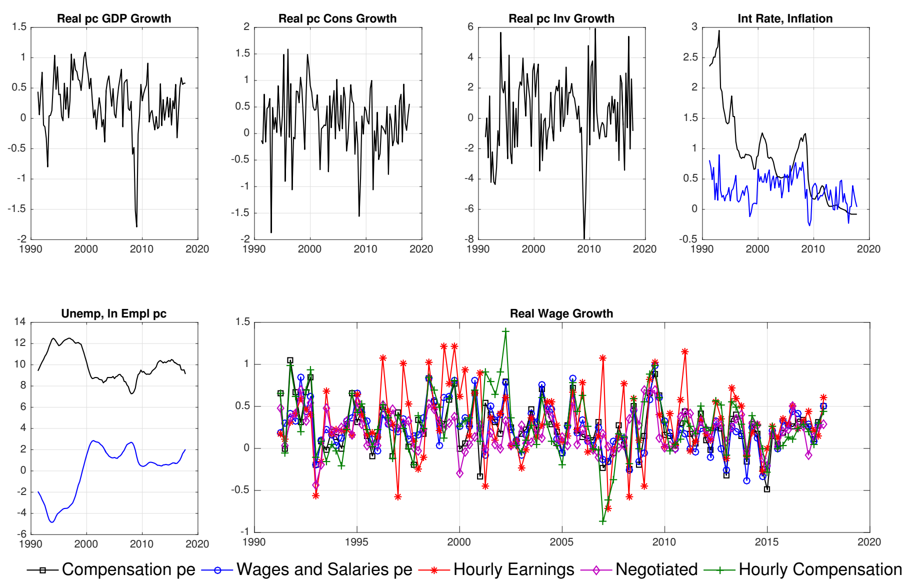

Figure D.3: Observables, Italy

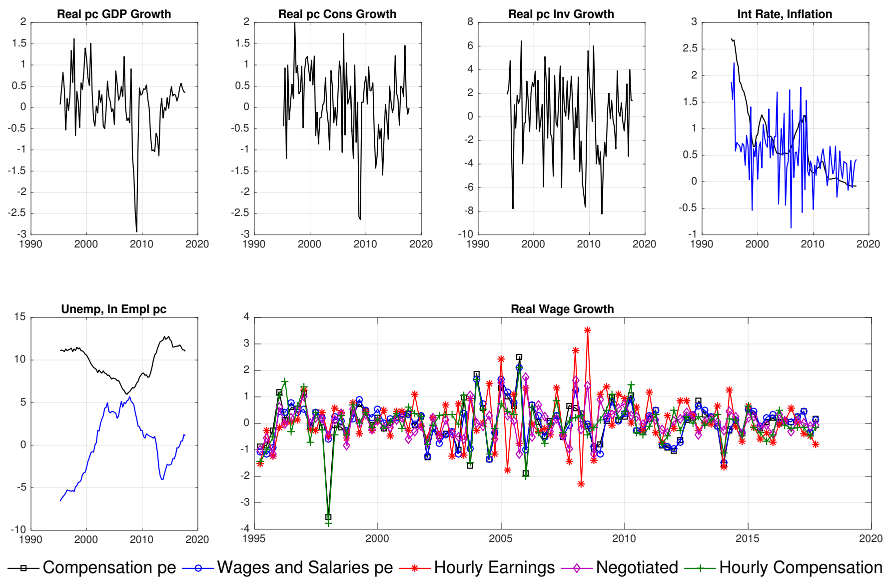

Figure D.4: Observables, Spain

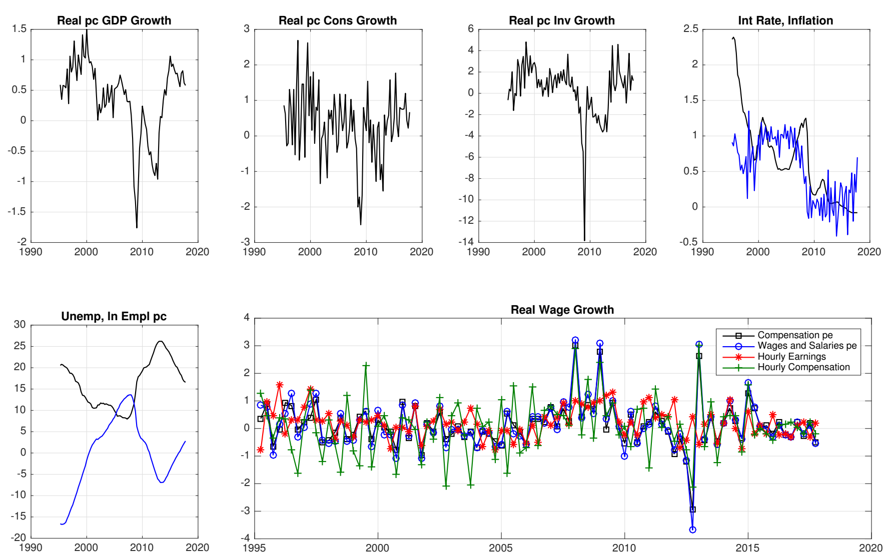

Table E.1: Posterior Distribution

		Prior	Posterior Mean [5-95%]			
			Germany	**France**	**Italy**	**Spain**
capital share	α	N (0.30, 0.02)	0.15 [0.13, 0.17]	0.15 [0.14, 0.17]	0.19 [0.16, 0.21]	0.22 [0.20, 0.25]
habit	η	B (0.70, 0.10)	0.36 [0.28, 0.44]	0.45 [0.39, 0.52]	0.79 [0.67, 0.87]	0.46 [0.37, 0.54]
util. cost elast.	ψ	B (0.50, 0.10)	0.30 [0.14, 0.52]	0.44 [0.29, 0.60]	0.67 [0.54, 0.78]	0.51 [0.39, 0.64]
adj. cost elast.	S	N (4.00, 1.00)	3.67 [1.57, 5.60]	4.19 [2.70, 5.69]	5.50 [4.26, 6.85]	4.89 [3.59, 6.27]
price indexation	ι_p	B (0.50, 0.15)	0.13 [0.05, 0.24]	0.23 [0.11, 0.39]	0.17 [0.07, 0.30]	0.17 [0.07, 0.32]
resp. to int.rate	ρ_r	B (0.75, 0.10)	0.90 [0.87, 0.92]	0.83 [0.80, 0.86]	0.92 [0.90, 0.94]	0.92 [0.90, 0.94]
resp. to inflation	ψ_π	N (1.70, 0.25)	2.13 [1.82, 2.43]	2.54 [2.24, 2.84]	1.51 [1.18, 1.87]	1.93 [1.61, 2.26]
resp. to growth	$\psi_{\Delta y}$	N (0.12, 0.05)	0.05 [0.01, 0.10]	0.03 [-0.03, 0.08]	0.19 [0.13, 0.25]	0.07 [0.04, 0.11]
resp. to gap	ψ_y	N (0.12, 0.05)	0.16 [0.08, 0.24]	0.16 [0.08, 0.25]	0.13 [0.05, 0.21]	0.08 [0.01, 0.15]
growth	γ	N (*, 0.03)	0.27 [0.23, 0.30]	0.26 [0.23, 0.28]	0.06 [0.03, 0.09]	0.31 [0.28, 0.35]
inflation	π	N (*, 0.03)	0.42 [0.37, 0.47]	0.35 [0.30, 0.40]	0.54 [0.49, 0.58]	0.55 [0.50, 0.60]
price stickiness	ζ_p	B (0.50, 0.10)	0.65 [0.56, 0.77]	0.61 [0.53, 0.70]	0.95 [0.92, 0.97]	0.84 [0.80, 0.90]
st.st. net P mkp	υ_p	N (0.30, 0.03)	0.34 [0.29, 0.39]	0.35 [0.30, 0.39]	0.33 [0.28, 0.38]	0.27 [0.22, 0.32]
st.st. net W mkp	υ_w	N (0.50, 0.10)	0.33 [0.26, 0.40]	0.43 [0.32, 0.54]	0.27 [0.18, 0.38]	0.33 [0.23, 0.47]
inv. Frisch elast.	χ	N (2.00, 1.00)	5.73 [4.69, 6.95]	3.99 [3.11, 4.90]	2.18 [1.46, 3.00]	1.37 [1.00, 1.89]
wage stickiness	ζ_w	B (0.50, 0.05)	0.42 [0.31, 0.56]	0.48 [0.40, 0.55]	0.54 [0.45, 0.63]	0.40 [0.31, 0.51]
wage indexation	ι_w	B (0.50, 0.15)	0.33 [0.15, 0.53]	0.23 [0.11, 0.37]	0.14 [0.07, 0.22]	0.40 [0.18, 0.65]
wealth effect	ν	B (0.20, 0.20)	0.04 [0.00, 0.14]	0.04 [0.00, 0.10]	0.01 [0.00, 0.02]	0.00 [0.00, 0.01]
st.st. labor	$\bar{l}$	N (0.00, 0.10)	-0.06 [-0.21, 0.09]	-0.33 [-0.49, -0.18]	-0.15 [-0.33, 0.01]	-0.10 [-0.26, 0.07]
AR risk premium	ρ_b	B (0.60, 0.20)	0.96 [0.92, 0.98]	0.95 [0.91, 0.98]	0.35 [0.14, 0.65]	0.93 [0.86, 0.97]
std risk premium	σ_b	IG (0.15, 1.00)	0.06 [0.04, 0.07]	0.06 [0.05, 0.07]	0.29 [0.20, 0.38]	0.07 [0.04, 0.10]
AR technology	ρ_z	B (0.60, 0.20)	0.99 [0.99, 1.00]	0.99 [0.99, 1.00]	0.97 [0.96, 0.99]	0.94 [0.92, 0.96]
std technology	σ_z	IG (0.15, 0.20)	0.58 [0.52, 0.65]	0.29 [0.25, 0.33]	0.84 [0.74, 0.96]	1.58 [1.40, 1.80]
AR investment	ρ_i	B (0.60, 0.20)	0.73 [0.36, 0.94]	0.79 [0.68, 0.88]	0.32 [0.17, 0.46]	0.70 [0.49, 0.85]
std investment	σ_i	IG (0.15, 1.00)	1.14 [0.83, 1.65]	0.66 [0.55, 0.79]	1.35 [1.10, 1.63]	0.53 [0.40, 0.72]
AR price markup	ρ_p	B (0.50, 0.20)	0.86 [0.69, 0.96]	0.88 [0.78, 0.95]	0.11 [0.03, 0.24]	0.90 [0.77, 0.97]
std price markup	σ_p	IG (0.15, 1.00)	0.21 [0.16, 0.29]	0.13 [0.10, 0.17]	0.49 [0.42, 0.56]	0.08 [0.06, 0.11]
AR wage markup	ρ_w	B (0.60, 0.20)	0.86 [0.68, 0.95]	0.91 [0.85, 0.96]	0.93 [0.86, 0.97]	0.85 [0.76, 0.91]
std wage markup	σ_w	IG (0.15, 1.00)	8.83 [4.62, 18.46]	2.28 [1.57, 3.27]	1.58 [0.74, 3.10]	4.60 [2.73, 7.53]
std int rate	σ_r	IG (0.15, 1.00)	0.14 [0.11, 0.16]	0.16 [0.14, 0.19]	0.12 [0.10, 0.13]	0.11 [0.09, 0.13]
AR spending	ρ_g	B (0.60, 0.20)	0.98 [0.96, 1.00]	0.98 [0.97, 0.99]	0.86 [0.76, 0.96]	1.00 [0.99, 1.00]
std spending	σ_g	IG (0.15, 1.00)	0.51 [0.45, 0.57]	0.32 [0.28, 0.36]	0.51 [0.45, 0.59]	0.59 [0.53, 0.67]
tech. resp. to govt	ρ_{gz}	B (0.50, 0.20)	0.27 [0.18, 0.36]	0.07 [0.03, 0.11]	0.09 [0.03, 0.17]	0.20 [0.10, 0.31]
AR labor disutility	ρ_χ	B (0.80, 0.15)	1.00 [0.99, 1.00]	0.99 [0.97, 1.00]	0.94 [0.89, 0.97]	0.92 [0.90, 0.95]
std labor disutility	σ_χ	IG (0.15, 1.00)	1.62 [1.31, 1.99]	0.79 [0.61, 1.00]	1.74 [1.22, 2.38]	2.49 [1.78, 3.44]
LF wages & sal.	Ψ_{wnspe}	N (1.00, 0.50)	1.17 [1.05, 1.29]	0.96 [0.83, 1.09]	0.34 [0.14, 0.53]	1.18 [1.13, 1.23]
LF priv. earnings	Ψ_{priv}	N (1.00, 0.50)	0.39 [0.21, 0.61]	0.91 [0.67, 1.16]	1.18 [0.96, 1.41]	0.23 [0.11, 0.34]
LF negot. wages	Ψ_{neg}	N (1.00, 0.50)	0.66 [0.50, 0.82]	0.52 [0.39, 0.64]	0.93 [0.83, 1.03]	[,]
LF hourly comp.	Ψ_{cph}	N (1.00, 0.50)	1.00 [0.82, 1.19]	1.11 [0.94, 1.29]	0.20 [-0.05, 0.45]	0.87 [0.67, 1.07]
std me comp.	μ^{cpe}	IG (0.15, 1.00)	0.23 [0.20, 0.28]	0.14 [0.12, 0.17]	0.94 [0.83, 1.06]	0.14 [0.07, 0.17]
std me wages & sal.	μ^{wnspe}	IG (0.15, 1.00)	0.17 [0.10, 0.23]	0.13 [0.10, 0.15]	0.66 [0.58, 0.75]	0.09 [0.03, 0.17]
std me priv. earnings	μ^{priv}	IG (0.15, 1.00)	0.65 [0.58, 0.73]	0.32 [0.28, 0.36]	0.64 [0.56, 0.74]	0.52 [0.46, 0.59]
std me negot. wages	μ^{neg}	IG (0.15, 1.00)	0.46 [0.41, 0.52]	0.17 [0.15, 0.19]	0.18 [0.11, 0.23]	[,]
std me hourly comp.	μ^{cph}	IG (0.15, 1.00)	0.56 [0.50, 0.63]	0.22 [0.19, 0.25]	0.79 [0.70, 0.89]	0.82 [0.73, 0.93]
trend comp.	γ_{cpe}	N (*, 0.03)	0.20 [0.17, 0.24]	0.26 [0.23, 0.28]	0.01 [-0.04, 0.05]	0.13 [0.10, 0.17]
trend wages & sal.	γ_{wnspe}	N (*, 0.03)	0.20 [0.17, 0.24]	0.26 [0.23, 0.29]	0.05 [0.01, 0.09]	0.14 [0.10, 0.17]
trend priv. earnings	γ_{priv}	N (*, 0.03)	0.28 [0.23, 0.33]	0.31 [0.27, 0.35]	0.08 [0.03, 0.12]	0.21 [0.17, 0.26]
trend negot. wages	γ_{neg}	N (*, 0.03)	0.28 [0.24, 0.32]	0.21 [0.19, 0.24]	0.04 [0.00, 0.07]	[,]
trend hourly comp.	γ_{cph}	N (*, 0.03)	0.33 [0.28, 0.37]	0.29 [0.26, 0.32]	0.01 [-0.04, 0.06]	0.07 [0.03, 0.12]
logL			-1156	-427	-1301	-1216

Notes: *The prior means for $\{\gamma, \pi, \gamma_{cpe}, \gamma_{wnspe}, \gamma_{neg}, \gamma_{priv}, \gamma_{cph}\}$ are their sample averages: $\{.31, .37, .19, .18, .28, .28, .32\}$ in DE, $\{.27, .25, .25, .31, .21, .28, .32\}$ in FR, $\{.08, .01, .05, .08, .04, .01, .51\}$ in IT, and $\{.36, .13, .13, .21, \emptyset, .07, .53\}$ in ES.

Table E.2: Posterior Distribution

	Prior	**Posterior** Mean [5-95%]			
		Germany	**France**	**Italy**	**Spain**
std me output	μ_y (IG, 0.01)	0.001 [0.0100, 0.0086]	0.0116 [0.0100, 0.0084]	0.0117 [0.0100, 0.0085]	0.0119 [0.0100, 0.0085]
std me cons.	μ_c (IG, 0.01)	0.001 [0.0101, 0.0085]	0.0118 [0.0101, 0.0085]	0.0121 [0.0100, 0.0084]	0.0118 [0.0100, 0.0085]
std me inv.	μ_i (IG, 0.01)	0.001 [0.0099, 0.0083]	0.0118 [0.0100, 0.0085]	0.0119 [0.0100, 0.0084]	0.0119 [0.0100, 0.0085]
std me int.	μ_r (IG, 0.01)	0.001 [0.0102, 0.0085]	0.0120 [0.0101, 0.0085]	0.0119 [0.0100, 0.0083]	0.0118 [0.0099, 0.0084]
std me unemp.	μ_u (IG, 0.01)	0.001 [0.0100, 0.0085]	0.0119 [0.0100, 0.0085]	0.0118 [0.0100, 0.0085]	0.0117 [0.0101, 0.0084]
std me labor	μ_l (IG, 0.01)	0.001 [0.0099, 0.0085]	0.0115 [0.0100, 0.0084]	0.0117 [0.0101, 0.0085]	0.0118 [0.0100, 0.0085]
std me infl.	μ_π (IG, 0.01)	0.001 [0.0100, 0.0083]	0.0117 [0.0099, 0.0084]	0.0116 [0.0101, 0.0085]	0.0120 [0.0100, 0.0083]
logL		-1156	-427	-1301	-1216