Job Polarization, Labor Market Fluidity and the Flattening of the Phillips Curve*

Daniele Siena†
Politecnico di Milano
Banque de France

Riccardo Zago‡
Banque de France

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Abstract

This paper shows that job polarization –i.e. the disappearance of routine jobs– is changing the characteristics of the labor market. This has structural implications for the relationship between inflation and unemployment, the price Phillips Curve (PC). Using data from the European Monetary Union (EMU) and exploiting the fact that job polarization accelerates during recessions, we obtain two empirical results. First, countries experiencing a bigger shift in the occupational structure during a downturn exhibit a flatter PC afterward. Second, the occupational shifts experienced during the Great Recession and the Sovereign Debt Crisis explain up to a fourth of the flattening of the curve in the 2002-2018 period. Then, we reconcile this evidence through a New Keynesian model with unemployment and search and matching frictions. We show that increasing labor market *fluidity* –i.e. higher separation and hiring rate– decreases the slope of the PC. Using micro-data, we find that in the EMU non-routine jobs are more *fluid*. We conclude that job polarization flattened the PC.

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KEYWORDS: Phillips curve, job polarization, occupational composition, monetary policy, labor market fluidity.

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†mail: daniele.siena@polimi.it

‡mail: riccardo.zago@banque-france.fr

1. Introduction

In the European Monetary Union (EMU), the negative relationship between price inflation and unemployment –the price Phillips Curve (PC)– has recently weakened (see Figure 1(a)). Contemporaneously, the share of routine employment has declined (see Figure 1(b)).[1] This phenomenon, called job polarization, is mostly explained by technological change which led to employment relocation from routine to non-routine tasks.[2] The contribution of this paper is to combine these two apparently unrelated events to show how job polarization has been a crucial driver of the flattening of the PC in the EMU. In other words, this paper demonstrates that changes in the occupational composition –due to polarization– affect the overall characteristics of the labor market, with direct implications for the structural relationship between prices and unemployment. This goes beyond the simple idea that polarization –if interpreted as a result of technological change– can affect the level of prices through a reduction in marginal costs.

Fig. 1. The Phillips Curve and the Routine Employment Share in the EMU

(a) The Phillips Curve

(b) The Routine Share

Note: Figure 1(a) plots the coefficient of the Phillips Curve estimated over 8-year rolling windows for those countries that joined the EMU before 2002 (Luxembourg excluded). The estimating equation for each window is $\Delta log(p)_{i,t} = \alpha_i + \beta u_{i,t-1} + X'_{i,t-1}\gamma + \epsilon_{i,t}$, where $\Delta log(p)_{i,t}$ is the year-on-year log-change of the harmonized consumer price index (energy and food excluded) in country i; α_i is the country fixed-effect; $u_{i,t-1}$ is the unemployment gap measured as deviation of the unemployment series from a linear trend; $X'_{i,t-1}$ is a vector of controls including lagged inflation, past expectations on current inflation, the change in the import price index, and a dummy for each country-specific business cycle phase; $\epsilon_{i,t}$ is the error term. On the x-axis, dates indicate the starting point of each 8-year estimating window. Figure 12(b) plots the evolution of the average abstract employment share from 2002q1 to 2018q4 across the same 11 EMU countries. The routine employment share is defined as the sum of employment in clerical, craft and plant occupations over total employment. The two grey-shaded areas indicate respectively the periods of the Great Recession and of the Sovereign Debt Crisis as defined by the CEPR Business Cycle Committee. For both figures, the light-blue-shaded area represents the 95% confidence interval. Data is at quarterly frequency.

[1] The same two facts are observed in the US. See Del Negro, Lenza, Primiceri and Tambalotti (2020) for the evolution of the price Phillips Curve and Jaimovich and Siu (2020) for the dynamics of routine shares.

[2] See, among others, Autor, Levy and Murnane (2003), Goos, Manning and Salomons (2009) and Firpo, Fortin and Lemieux (2011).

Both in Europe and in the U.S., economists broadly agree that the price PC has weakened in the aftermath of the Great Recession of 2008. This fact has become of great concern among central bankers since a flatter PC prevents monetary policy to be effective when trying to stabilize prices (as in the EMU), unemployment or both (as in the US). For this reason, a good deal of research was conducted to properly assess to what extent the slope of the PC has decreased, and why this has happened. The literature has so far proposed explanations that can be grouped in two not mutually exclusive categories. The first focusing on inflation expectations and the stronger ability/commitment of central banks to keep inflation low (e.g. Blanchard (2016)). The second studying the impact of structural changes in the economy, like demographic transition, globalization and labor market transformations (see, among others Guerrieri, Gust and López-Salido (2010) and Faccini and Melosi (2020)). We contribute to the latter by providing (theory-backed) empirical evidence that changes in the occupational structure of the labor market has critical relevance for the slope of the PC.

To do this, we leverage on recent developments in the job-polarization literature, which documents that the disappearance of routine jobs (clerical, craft and plant occupations) is not only a long-run phenomenon, but it has also cyclical features. In fact, as demonstrated in Jaimovich and Siu (2020) for the U.S., job polarization accelerates during downturns. In other words, the cycle leads to (out of trend) shifts in the occupational composition of the labor market in favour of non-routine jobs (professional, managerial, services and sales occupations). Given this, first we provide evidence that the long-run and cyclical properties of job polarization hold also in the EMU. In particular, we show that, in normal times, the decline of the routine employment share is very homogeneous across EMU members. Conversely, the Great Recession (GR) and the following Sovereign Debt Crisis (SDC) operate on the common long-run trend of job polarization through occupational shifts, which are very heterogeneous across countries and recessions. More importantly for identification purposes, these occupational shifts depend on the depth and length of the downturn rather than on pre-recession (i.e. labor or product market) country characteristics. Hence, we exploit these exogenous and heterogeneous compositional changes to assess if and by how much the disappearance of routine jobs affected the relationship between prices and the real economy.

Our main finding is that countries experiencing a bigger change in the composition of the job ladder during a recession exhibit a flatter PC afterwards. In particular, the occupational shifts witnessed during the last two recessions in the EMU explain up to a fourth of the flattening of the price PC observed in the last ten years. These results are robust to (i) controlling for other structural breaks, (ii) controlling for changes in the sectorial composition of the economy (i.e. for the transition towards a service economy), (iii) several definitions of price inflation and unemployment gap, and (iv) different country/data sample selection. An additional important aspect to consider, which has been most often overlooked in the existing literature, is that our results are robust when we reasonably assume the unemployment gap to be endogenous (e.g. in presence of supply shocks). By instrumenting the unemployment gap with monetary policy shocks from Jarociński and Karadi (2020)[3], we show that all our findings are confirmed. Therefore, we conclude that the composition of the labor market matters for the slope of the price PC.

If occupational composition matters for the price PC, we should find similar results also for the wage PC. By applying the same identification strategy, we confirm that changes in the occupational structural –coming from job polarization– flattened also the relationship between wages and unemployment.

But, why is this the case? The answer lies in the differences between the surviving and disappearing jobs, i.e. between non-routine and routine occupations. As suggested by the polarization literature, these jobs are very different in several dimensions. For example, routine workers can be easily substituted by automation and ICT technology (Acemoglu (2002)), and routine jobs are more affected by trade shocks (Autor, Dorn and Hanson (2013)). Here, we highlight another important difference: *labor market fluidity*, the rate at which workers separate from the current employer and find another job.

Does this dimension matter for the slope of the PC? To show that it does, we take the standard New Keynesian model with unemployment and search-and-matching frictions of Blanchard and Galí (2010) and we derive the analytical relationship between the slope of the PC and labor market characteristics. We prove that increasing the *fluidity* of the labor market indeed flattens the price Phillips Curve. Hence, relocation of workers from less to more fluid markets –due to job polarization– can indeed weak the relationship between prices and unemployment. The intuition behind this result is simple: higher fluidity reduces the elasticity of marginal costs to economic conditions (e.g. market tightness) such that employers adjust more the stock of employment rather than wages. This happens because the labor demand becomes more elastic as employers can substitute workers more easily. In other words, the labor demand becomes flatter.

Finally, we provide micro-evidence showing that the non-routine labor market is indeed more *fluid*: non-routine jobs exhibit higher separation and hiring rate; non-routine employees are more likely to be offered temporary contracts and to have multiple jobs contemporaneously; non-routine employment adjusts more at the intensive margin (hours). As a result, an increase in *fluidity* –due to polarization– reduces the elasticity of inflation to unemployment.

[3]The shocks from Jarociński and Karadi (2020) allow us to identify exogenous aggregate demand fluctuations in the Euro Area, by distinguishing between pure monetary policy surprises from Central Bank information shocks.

Literature review – This paper relates to two strands of the literature. The first one is on job polarization, which documents the long-run falling of employment in jobs with high content of routine tasks (among the many, see Acemoglu (2002), Autor, Katz and Kearney (2006), Acemoglu and Autor (2011)). In this literature, this phenomenon is typically explained by technological change: throughout time, new and cheaper technologies allow the substitution of man-work with machines in performing routine tasks, whereas it complements workers in performing non-routine tasks (see for example Autor *et al.* (2003), Autor (2007) and Acemoglu and Restrepo (2017)). Other sources of polarization, usually cited in the literature, are international trade and globalization. In fact, trade and offshoring allow respectively to substitute home routine productions with imports and to move routine activities in countries with lower labor costs (see Autor *et al.* (2013) and Autor, Dorn and Hanson (2015)) so to trigger the decline of home routine employment.

Instead of looking at polarization as a result of technological change, we focus on its implications on labor market characteristics. To do so, we lean on the cyclical properties of polarization. As explained in Jaimovich and Siu (2020) and Gaggl and Kaufmann (2019) for the U.S., the long-run trend of job polarization accelerates during downturns, with routine jobs being permanently destroyed. As mentioned above, we show that this property holds also for EMU countries and we leverage on it to study its implications for the PC.

The second strand of the literature is on the flattening of the Phillips Curve, and it is both empirical and theoretical. On the empirical side, the work is abundant on both shores of the Atlantic. For the U.S., Blanchard (2016), Murphy (2018) and Powell (2018) state that the PC is still alive, but its slope became flatter already from the 80's on, while inflation expectations have become more anchored. In the same direction go Hooper, Mishkin and Sufi (2020), Fitzgerald and Nicolini (2014), Mavroeidis, Plagborg-Møller and Stock (2014). McLeay and Tenreyro (2020) show that this evolution over time of the PC is true also at state and city level, although the correlation between unemployment and inflation is stronger than in the aggregate time series. Fitzgerald, Jones, Kulish and Nicolini (2020) show, using state level data, that the price Phillips Curve flattened only marginally due to structural changes. Hazell, Herreo, Nakamura and Steinsson (2020), using a multi-region model, show that the slope of the Phillips Curve is small and was small even during the early 1980s. On the other hand, Del Negro *et al.* (2020) offer evidence that the flattening has started in the 90's along with a progressive flattening of the aggregate supply curve. All these papers point out that the flattening is therefore less recent than we thought, and not entirely explained by the Great Recession.

For the EMU, Ball and Mazumder (2019), Moretti, Onorante and Zakipour-Saber (2019), Deroose, Stevens *et al.* (2017) and Berson, de Charsonville, Diev, Faubert *et al.* (2018) show that the price PC has flattened from the financial crisis of 2008, but the structural relation between price dynamics and unemployment and other variables of economic slack still exists. In disagreement with this view is Giannone, Lenza, Momferatou and Onorante (2014), which shows that the PC actually was steeper during the GR, whereas Ciccarelli and Osbat (2017) show that the disconnection between prices and unemployment started after 2012 due to both structural and cyclical factors that have affected aggregate demand.

In both continent, one of the main explanations for the flattening of the PC is that inflation expectations have become more important (e.g. Coibion and Gorodnichenko (2015)). Moreover, expectations have become more firmly anchored as the Fed and the ECB have more clearly committed to their inflation objectives. This view has been analyzed and expressed in a wide range of research, Fed and ECB communications, including among others, Roberts (2004), Bernanke (2007), Mishkin (2011), Kiley *et al.* (2015), Yellen *et al.* (2015), Pfajfar and Roberts (2018), Ng, Wessel and Sheiner (2018) for the US, and Draghi (2015), Natoli and Sigalotti (2017), Speck (2016), Dovern and Kenny (2017), Ciccarelli, Garcia and Montes-Galdón (2017) and Bobeica and Jarocinski (2017) for Europe.

Other explanations of the flattening have focused more on structural changes in economic fundamentals, for example due to demographic dynamics. Daly, Hobijn and Pyle (2016) show that the shifting composition of the labor force – due to the retirement of baby-boomers– has imparted a downward bias to aggregate wage inflation thus affecting the PC. The importance of demographic dynamics for inflation and inflation expectations is documented also in Yoon, Kim and Lee (2018), Pfajfar and Santoro (2008), Bruine de Bruin, Vanderklaauw, Downs, Fischhoff *et al.* (2010) which show –in summary– that aging population is deflationary. Other papers focus on the role of technology for the level of inflation. Mincer and Danninger (2000), Ciccarelli and Osbat (2017), Jorgenson (2001), Akerlof, Dickens, Perry, Gordon *et al.* (1996) and many others show that technological innovation, digitalization, automation and ICT contribute to the long-run downward trend of inflation. For what concerns the level of inflation, our paper is in line with this literature: polarization, as a product of technological change, can have a deflationary effect.

Additionally, our paper is related to a growing literature emphasizing the role of labor market dynamics and characteristics. Ravenna and Walsh (2008) estimate a New Keynesian PC with a frictional labor market and show that search-and-matching frictions are important for a better fit of the price PC with the data. In a similar theoretical framework, Trigari (2009) shows that search frictions in the labor market generate a lower elasticity of marginal costs with respect to output. Ravenna and Walsh (2012) show that labor market composition is important for the unemployment-inflation trade-off faced by the monetary authority. Moscarini and Postel-Vinay (2017) introduce on-the-job search in a New Keynesian model and show that cyclical labor misallocation leads to deflation. Through a similar theoretical set-up, Faccini and Melosi (2020) stress the importance of mobility of workers on the job ladder to rationalize the missing inflation and a flatter PC in the post-GR era.[4] Cantore, Ferroni and Len-Ledesma (2020) highlight how it is important to look at labor market dynamics, as the labor market share, to correctly model the relationship between the real economy and prices. Finally, Lombardi, Riggi and Viviano (2020) show that the decline in bargaining power of workers has weakened the inflation-output gap relationship. We contribute to this literature by showing that labor market *fluidity* is another important channel to explain the recent evolution of the price PC. Moreover, our paper relates to that niche in the literature showing how polarization can also explain the de-unionization of the workforce (see for example Foster, Grim and Haltiwanger (2016), Açıkgöz and Kaymak (2008), Dinlersoz and Greenwood (2016) and Acemoglu, Aghion and Violante (2001)).

Along with the literature on the price PC, there is another strand focusing on the wage PC. For example, Leduc, Wilson *et al.* (2017) and Galí and Gambetti (2019) show that, in the U.S., also the relationship between wages and unemployment flattened. As explained in Daly and Hobijn (2014), Benigno and Ricci (2011), Schmitt-Grohé and Uribe (2013), downward wage rigidities are important to rationalize this fact. Conversely, Petrosky-Nadeau, Wasmer and Weil (2021) show that efficient rent-sharing between consumers and producers in the goods market drives down wage bargaining and cause the flattening of the wage PC. While these papers provide evidence for a flattening of the wage PC in the U.S., evidence for the Euro Area is less clear. For example Bulligan and Viviano (2017) show that the wage PC has been steepening, while Nickel, Bobeica, Koester, Lis *et al.* (2019) show that the GR flattened the PC. Similarly, we also find a flattening in post-GR periods.

Our paper is organized as follows. Section 2 presents the data and facts on job polarization in the EMU. Section 3 estimates an augmented price PC for the EMU which takes into account changes in the occupational structure of the labor market. Section 4 repeat the exercise for the wage PC. Section 5 uses an analytical theoretical model to highlight one channel through which job polarization can affect the slope of the price PC and gives micro-evidence that differences among surviving and non-surviving jobs is key for our result. Section 6 concludes.

[4]Despite its importance, our theoretical framework does not include on-the-job search since no data is available on job-to-job transitions by occupation for the sample of countries under consideration.

2. Data and Labor Market Dynamics in the EMU

2.1. Data, Definitions and Sample Selection

Our focus is on the European Monetary Union. In particular on countries that joined the EMU from the beginning: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain. We do it for two reasons. First, countries that joined the EMU more recently have very peculiar convergence trajectories in terms of inflation and employment. Additionally, their entrance in the EMU in some cases coincides with the beginning of a downturn (e.g. see Estonia). Therefore, it would be inappropriate to use our identification strategy for these set of countries.[5] Second, late entrants have very unreliable employment and unemployment series. Unfortunately, Luxembourg suffers the same problem with employment data. Therefore, we exclude it from the analysis. As a result, we end-up with 11 countries (EMU11) and consider data from 2002q1 until 2018q4.

Data comes from three main sources: the Eurostat, the ECB Data Warehouse and the ECB Surveys of Professional Forecasters. Eurostat gives information on employment by occupation, according to the International 2008 Standard Classification of Occupations (ISCO-08). We consider employment series for workers in the 15-74 age bracket. Once these series are corrected from statistical breaks and changes in occupation classification,[6] we follow Jaimovich and Siu (2020) and group these jobs in three major categories based on their task-content: (i) managers, professionals, technical and associate professionals, armed force employees as *abstract* workers; (ii) clerical, craft and plant employees as *routine* workers; (iii) elementary, skilled agricultural, forestry and fishery employees, sales and service workers as *manual* workers. Finally, under this grouping, we build employment shares series for each category. Eurostat is also used to build the quarterly series of the unemployment rate for population in the 15-74 age bracket and the year-on-year change in the import price index.

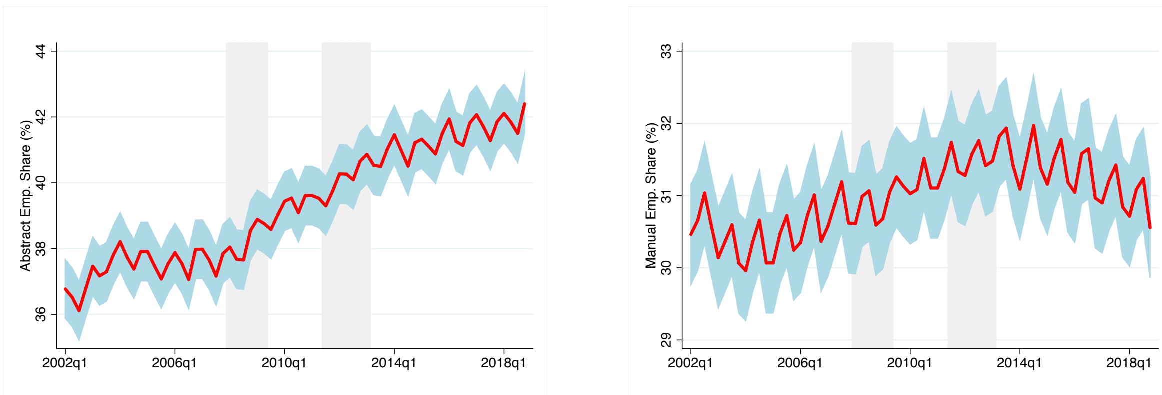
The ECB Data Warehouse and the ECB Survey of Professional Forecasters (SPF) provide information on prices and expected inflation by country. In particular, we use the Harmonized Consumer Price Index (excluded energy and food) to build year-on-year inflation rate at quarterly frequency, and the SPF for expected inflation at quarterly frequency.[7] We use also the ECB Data Warehouse to extrapolate country-specific business cycle dates from the time series of real GDP. For each country, we define a recession a period in which GDP falls for at least two consecutive quarters. The peak of the recession is identified as the

[5]For details on the identification strategy, refer to Section 3.1.
[6]See Appendix A.1 for details.
[7]See Appendix A.4 for details.

last quarter before which real GDP starts falling and the trough of the recession as the last quarter after which real GDP starts increasing again for at least two consecutive quarters.[8] This allows us to punctually identify in which phase of the business cycle every country is in every quarter.

2.2. *Job Polarization in the EMU11*

Fig. 2. Abstract and Manual Share across the EMU11



(a) Abstract Share (b) Manual Share

Note: Figure 2(a) plots the evolution of the mean abstract employment share from 2002q1 to 2018q4 for those countries that joined the EMU before 2002 (Luxembourg excluded). The abstract employment share is defined as the sum of employment in managerial, professional, technical and associate professional, and armed force occupations over total employment. Figure 2(b) plots the evolution of the mean manual employment share from 2002q1 to 2018q4 for the same 11 EMU countries. The manual employment share is defined as the sum of employment in elementary, skilled agricultural, forestry and fishery, sales and services occupations over total employment. The light-blue-shaded area represents the 95% confidence interval. The two grey-shaded areas indicate respectively the periods of the Great Recession and of the Sovereign Debt Crisis as defined by the CEPR Business Cycle Committee. Data is at quarterly frequency.

The large literature on job polarization documents the long-run falling of employment in jobs with a high content of routine tasks (among the many see Acemoglu (2002), Autor *et al.* (2006), Goos and Manning (2007) and Acemoglu and Autor (2011)). Yet, this long-run trend has a short-run counterpart. As shown in Jaimovich and Siu (2020) for the U.S., job polarization accelerates during recessions with job-losses concentrated the most in routine occupations. We leverage on these results for the U.S. and show that both the long and short-run properties of job polarization hold for countries in the EMU11 as well. As Figure 1(b) displays, the share of routine employment across EMU11 countries has been following a downward trend. From the beginning of the Great Recession (GR) until the end of the Sovereign Debt Crisis (SDC), the process of polarization accelerated and the downward

[8]See Appendix A.3 for full list of country-specific business cycle dates along with plots of real GDP series and recession brackets in accordance with our business-cycle dates definition.

trend became steeper. Afterward, the routine share have returned to the pre-GR trend. However, this first-sight analysis is confounding since it looks that the trend accelerated without interruption until the end of the SDC, and without any effect of the economic expansion between the two crisis. But, if "job polarization follows the cycle" –as explained in Jaimovich and Siu (2020)– we should observe a change in the trend in every single phase of the business cycle, i.e. in every single contractionary and expansionary phase. In order to check this point, we estimate the following expression:

$$Share^R_{i,t} = \alpha_i + \beta_1 time + \beta_2 phase_{i,t} + \beta_3 phase_{i,t} \times time + \epsilon_{i,t} \tag{1}$$

where $Share^R_{i,t}$ is the routine employment share at time t in country i, α_i is the country fixed effect, $time$ is the number of quarters, $phase_i$ = [Before GR, GR, Between GR and SDC, SDC, After SDC] is a vector of mutually exclusive dummies taking value one if, at time t, country i is currently in that cyclical phase. The $phase_i$ time-dummy is country specific, i.e. we use country specific business cycle dates to define the beginning and the end of each recession, as explained in Section 2.1. $\epsilon_{i,t}$ is the error term.

Table 1 shows results from this panel regression. From column (1), we see that –between 2002q1 and 2018q4– the routine employment share follows a downward trend across countries, with an average decline of 0.10pp every quarter. In column (2), we investigate how much of this decline is imputable to each different phase of the business cycle. Before the GR, the routine share is decreasing by 0.06pp every quarter. When entering the GR, the trend accelerates by five times across all countries. Between the two recessions, the slope of the trend is not significantly different from the slope estimated in pre-GR periods. When EMU11 economies enter the SDC, the trend of job-polarization returns to accelerate at a pace two times bigger than before the GR. Once EMU11 countries are out of the SDC, again there is no statistical difference between pre-GR and post-SDC trends. This empirical evidence generalizes the results of Jaimovich and Siu (2020) and proves that, also in the EMU, job polarization has not only a long-run driver but also a cyclical component: there is a negative trend in routine employment, which temporarily accelerates every time the economy enters a recession.

What about the dynamics of other jobs? Figure 2(a) and 2(b) show respectively the evolution of the employment share of abstract and manual jobs. While both present strong seasonal fluctuations, the abstract share follows a clear upward trend whereas the manual share looks more stationary. This is confirmed also in column (3) and (5) of Table 1 where we perform the same analysis of equation (1), but now with the abstract ($Share^A$) and manual share ($Share^M$) as dependent variables. We see that, across all countries, the long-

Table 1: Trend Decomposition of Occupational Shares across the EMU11

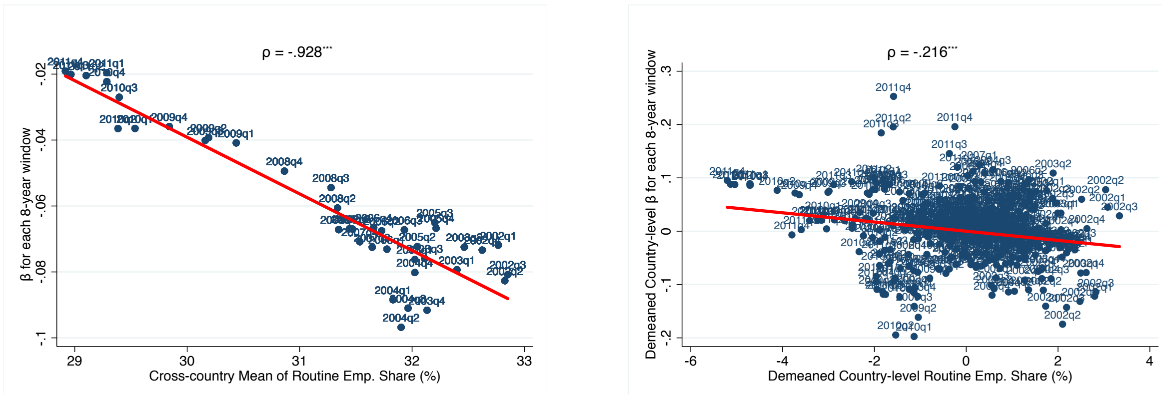
	(1) $Share^R$	(2) $Share^R$	(3) $Share^A$	(4) $Share^A$	(5) $Share^M$	(6) $Share^M$
time	-0.103***	-0.062**	0.087***	0.047**	0.016	0.016
	(0.012)	(0.020)	(0.018)	(0.020)	(0.015)	(0.015)
GR × *time*		-0.332***		0.272**		0.060
		(0.058)		(0.092)		(0.063)
Between GR and SDC × *time*		-0.061		0.045		0.016
		(0.035)		(0.056)		(0.029)
SDC × *time*		-0.128**		0.091		0.037
		(0.049)		(0.054)		(0.034)
After SDC × *time*		0.048		0.003		-0.051**
		(0.030)		(0.028)		(0.017)
Observations	748	748	748	748	748	748
R^2	0.764	0.813	0.565	0.588	0.070	0.118
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	No	No	No	No	No

Note: Standard errors in parentheses, clustered at country-level. The unit of observation in column (1) and (2) is the share of routine employment, i.e. clerical, craft, plant employment. The unit of observation in column (3) and (4) is the share of abstract employment, i.e. managers, professionals, technical and associate professionals, armed force employment. The unit of observation in column (5) and (6) is the share of manual employment, i.e. elementary, skilled agricultural, forestry, fishery, sales and service employment. The variable *time* is the number of quarters. GR is a country-specific dummy variable taking value one for periods in which a country is experiencing the Great Recession. Between GR and SDC is a country-specific dummy variable taking vale one for periods in which a country is in between the GR and the Sovereign Debt Crisis. SDC is a country-specific dummy variable taking vale one for periods in which a country is experiencing the Sovereign Debt Crisis. After SDC is a country-specific dummy taking value one for periods after the Sovereign Debt Crisis. *, **, *** indicate significance at 90%, 95% and 99% level.

run fall in the routine share is almost entirely compensated by an expansion of the abstract share. When looking at the decomposition of this trend across different business cycle phases, we find that the abstract share increases by 0.047pp every quarter in pre-recession periods (column (4)). When the EMU11 enters the GR, this positive trend accelerates by 5 times before going back to the pre-GR trend from there afterward. On the other hand, in pre-GR periods, the share of manual employment is stationary (column (6)), and neither the GR nor the SDC significantly affect this behavior. Only in periods after the SDC, the share of manual jobs starts to significantly decline by 0.05pp each quarter.

3. The Slope of the Phillips Curve and the Occupational Composition of the Labor Market

Fig. 3. The Slope of the Phillips Curve and Employment Composition



(a) Aggregate Evidence (b) Cross-country Evidence

Note: Figure 3(a) plots the coefficients of the Phillips Curve –estimated across countries and over 8-year rolling windows– on the cross-country mean routine employment share as observed at the beginning of each 8-year window. The sample is composed of those countries that joined the EMU before 2002 (Luxembourg excluded). The equation used to estimate the slope of the Phillips Curve for each window $\Delta log(p)_{i,t} = \alpha_i + \beta u_{i,t-1} + X'_{i,t-1}\gamma + \epsilon_{i,t}$, where $\Delta log(p)_{i,t}$ is the year-on-year log-change of the harmonized consumer price index (energy and food excluded) in country i; α_i is the country fixed-effect; $u_{i,t-1}$ is the unemployment gap measured as deviation of the unemployment series from a linear trend; $X'_{i,t-1}$ is a vector of controls including lagged inflation, past expectations on current inflation, the change in the import price index, and a dummy for each country-specific business cycle phase; $\epsilon_{i,t}$ is the error term. Figure 3(b) plots the coefficients of the Phillips Curve –estimated for each country and over 8-year rolling windows– on the country-level routine employment share as observed at the beginning of each 8-year window. The slope for each country is estimated using the same specification and variables as above. For comparability across countries, variables are taken in deviation from each country's mean. On top of both graphs, the correlation (ρ) between variables is reported along with its significance level. *, **, *** indicate significance at 90%, 95% and 99% level

Does employment composition matter for the relationship between price dynamics and unemployment? Figure 3(a) combines the slopes of the Phillips Curve –estimated across countries for each 8-year window– with the cross-country mean share of routine employment observed at the beginning of each 8-year window. There is a strong negative relationship –significant at 99% level– between the two variables. Yet, this relationship comes from aggregate data. Does it hold also when considering the evolution of the PC and of the routine share within country? In Figure 3(b) we plot the slope of PC –estimated for each country and each 8-year window– on the country-level routine share as observed at the beginning of each 8-year window. For cross-country comparability, both variables are considered in deviation from the mean. Also in this case, there is a negative correlation ($\rho = -.22$) –significant at 99% level– between the slope of the Phillips Curve and the routine employment share. In words, when a country is relatively richer of routine jobs, the slope of the PC is relatively steeper (more negative). Conversely, when a country is relatively scarcer of routine jobs, the slope of the PC will be relatively flatter (more positive).

Clearly, this evidence –although interesting– cannot tell us anything on the causal relationship between employment composition and the slope of the PC, as it is exposed to several sources of endogeneity. First of all, as discussed in Section 2.2, job polarization follows a long-run trend such that there might be a spurious correlation between the gradual decline in routine employment and the gradual flattening of the PC over time. Second, there are other long-run factors which might have influenced the slope of the PC, such as changes in the sectorial composition of the economy, demography, etc.

In light of this, we need a strategy to assess correctly whether employment composition is important for the relationship between prices and unemployment. In particular, we need to find a variation of the occupational composition which is ex-ante orthogonal (i) to past country specific characteristics and (ii) to past price dynamics.

3.1. Cyclical Occupational Shifts

In this section we provide evidence that cyclical movements in job polarization are not driven by ex-ante country characteristics, but only by the recession and its severity.

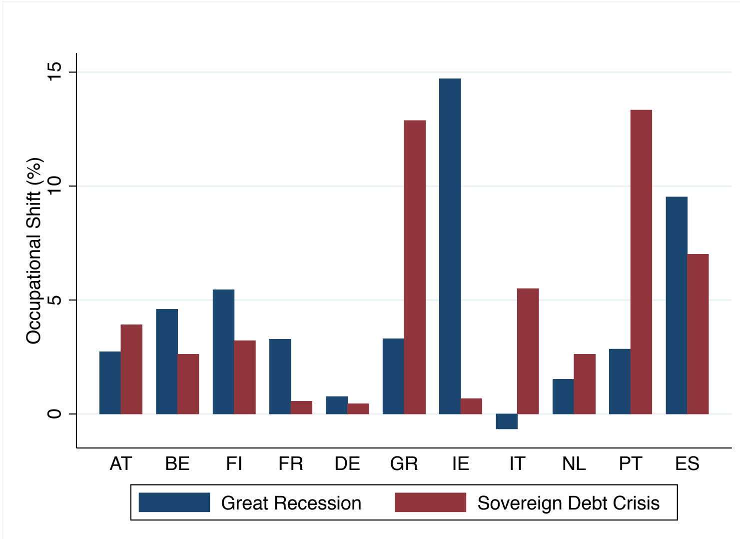
As we know from section 2.2, recessions operate on the long-run trend of job-polarization through (level) shifts in the occupational composition of the labor market. This translates into a bigger destruction of routine jobs in favor of non-routine ones (most of all abstract jobs) during recessions. To quantify these structural shifts occurred within each country, we consider the change in the level of the routine employment share matured during each recession. In other words, the extent to which the composition of the labor market of country i changed due to the cycle $c = \{GR, SDC\}$ can be measured as the percentage change of the routine employment share between the peak and trough of the recession c, according to the business cycle dates specific to country i. Formally:

$$Shift^R_{i,c} = \frac{Share^R_{peak_{i,c}} - Share^R_{trough_{i,c}}}{Share^R_{peak_{i,c}}}. \tag{2}$$

Figure 4 plots the levels of our measure of occupational shift ($Shift^R_{i,t}$) for each country of the EMU11 and each recession. Despite that all countries were following the same job polarization trend (as shown in Section 2.2), the cyclical rate of routine job destruction varies substantially across EMU11 members and across recessions. The mean occupational shift is 4.6% (4.4% for the GR and 4.8% for the SDC). The correlation between the shifts matured during the two recessions is 0.15 and it is not significantly different from zero.

Yet, it is important to test whether the heterogeneity in $Shift_{i,c}$ observed across countries

Fig. 4. Occupational Shifts across EMU11 countries, by recession

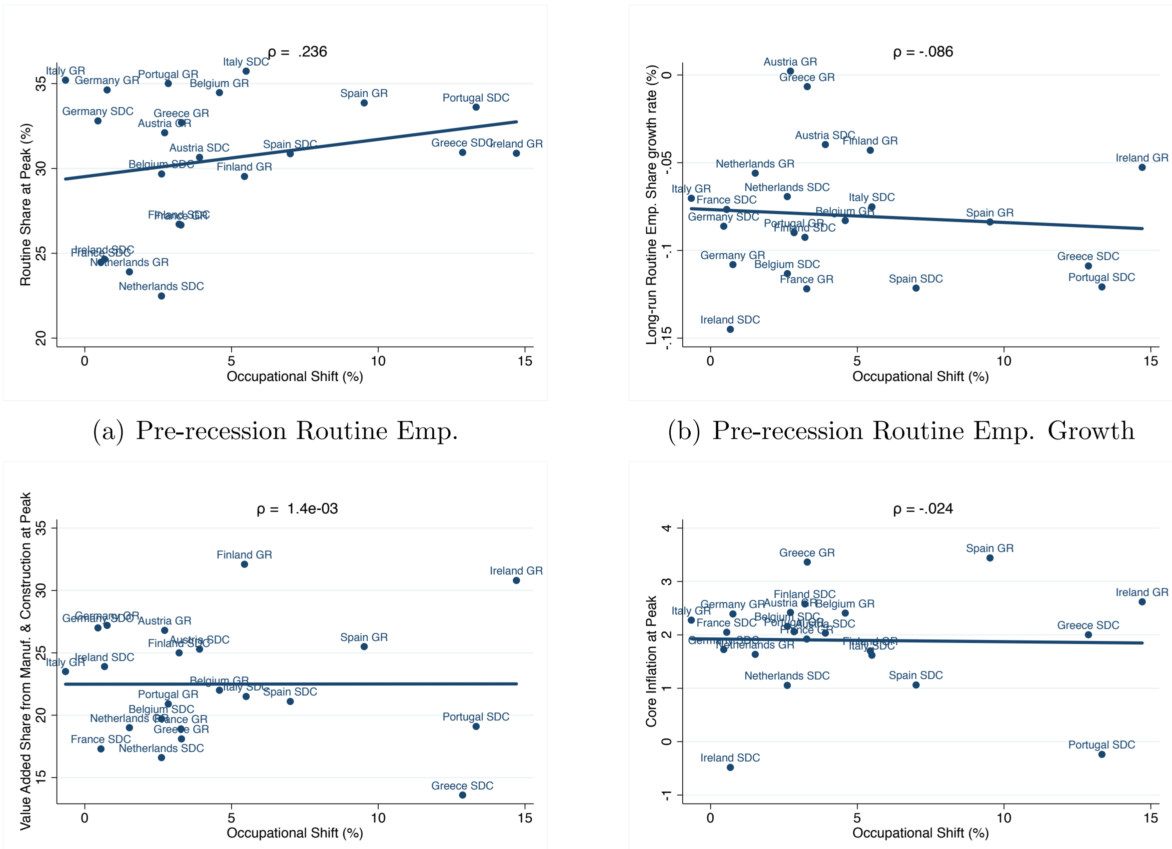


Note: This figure plots the occupational shifts experienced by each country that joined the EMU before 2002 (Luxembourg excluded) during the Great Recession and the Sovereign Debt Crisis. Each occupational shift is defined as the percentage change in routine employment share between the peak and trough of each recession, according to country-specific business cycle dates.

and recessions is due to pre-recession country-specific characteristics. In fact, as shown in Autor *et al.* (2013), the exposure of the labor market to a "polarization shock" can be explained by the employment composition of that market before the downturn. In light of this, we look at the correlation between the routine employment share –measured one quarter before the beginning of the recession– and our measure of occupational shift. As from Figure 5(a), we find only a mild correlation not significantly different from zero. Once checked that the pre-recession employment composition does not matter, in Figure 5(b) we check if the pace at which each economy has polarized until the start of each recession matters for the size of the cyclical occupational shift. This is mostly to control if the polarization trend is not explaining the size of the shift. Again we find a correlation not significantly different from zero. This confirms that the cyclical occupational shifts are heterogeneous across countries and recession and they are not path-dependent.

Since the occupational composition varies also across sectors in the economy (e.g. manufacturing and construction have a larger share of routine workers), we study whether the sectorial composition could be related to the cyclical shift. To do so, in Figure 5(c) we plot the share of value added from manufacturing and construction, measured one quarter before the beginning of the recession, on the shift. Once again we do not find any significant correlation. Finally, we check if pre-recession inflation dynamics correlates with the shift. Figure 5(d) show no significant relationship between pre-recession inflation and our measure of occupational shift.

Fig. 5. Pre-recession Characteristics vs. Occupational Shift



(a) Pre-recession Routine Emp.

(b) Pre-recession Routine Emp. Growth

(c) Pre-recession Sectorial Composition

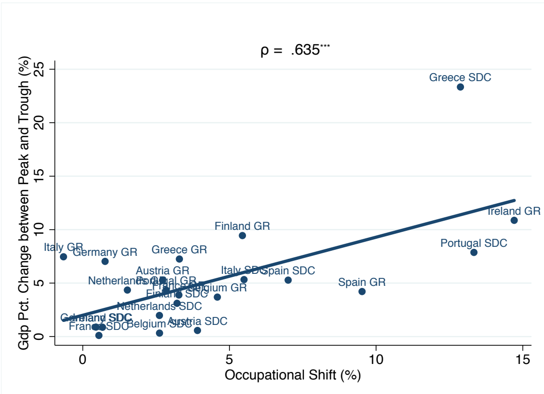
(d) Pre-recession Inflation

Note: For all subplots, the x-axis shows the occupational shift (in percentage) experienced during both downturns by each country that joined the EMU before 2002 (Luxembourg excluded). Each occupational shift is defined as the percentage change in routine employment share between the peak and trough of each recession, according to country-specific business cycle dates. In Figure 5(a) the y-axis is the routine employment share, measured at the peak of the Great Recession (GR) and Sovereign Debt Crisis (SDC). In Figure 5(b), the y-axis is the long-run growth rate of the routine employment share, measured as the slope of the linear trend fitting the routine share series until the GR and SDC respectively. For figure 5(c), the y-axis is the value added from manufacturing and construction (as percentage of GDP), measured at the peak of the GR and SDC. For figure 5(d), the y-axis is the level of core inflation, measured at the peak of the GR and SDC. On top of each graph, the correlation (ρ) between variables is reported along with its significance level. *, **, *** indicate significance at 90%, 95% and 99% level.

In light of this, we conclude that the extent to which a country destroyed routine jobs during the two crisis is not predetermined. In other words, the rate of routine job destruction does not depend on ex-ante country-specific labor and product market characteristics and inflation dynamics.

It is now important to show that the variation in the occupational shift is really imputable to the economic downturn only. As shown in Figure 6(a), our measure of occupational shift is significantly correlated at the 99% level with the percentage change in GDP matured between the peak and trough of each recession. Similarly, Figure 6(b) displays a strong correlation –significant at 99% level– between the duration of each downturn (expressed in

Fig. 6. Duration and Size of the Recession vs. Occupational Shift



(a) GDP Contraction

(b) Recession Duration

Note: For both subplots, the x-axis shows the occupational shift (in percentage) experienced during both downturns by each country that joined the EMU before 2002 (Luxembourg excluded). Each occupational shift is defined as the percentage change in routine employment share between the peak and trough of each recession, according to country-specific business cycle dates. In Figure 6(a), the y-axis is the GDP percentage change measured between the peak and trough of the Great Recession (GR) and Sovereign Debt Crisis (SDC). In Figure 6(b), the y-axis is duration (in quarters) of each recession, measured as the number of quarters between peak and trough. On top of each graph, the correlation (ρ) between variables is reported along with its significance level. *, **, *** indicate significance at 90%, 95% and 99% level.

quarters) and our measure of occupational change.

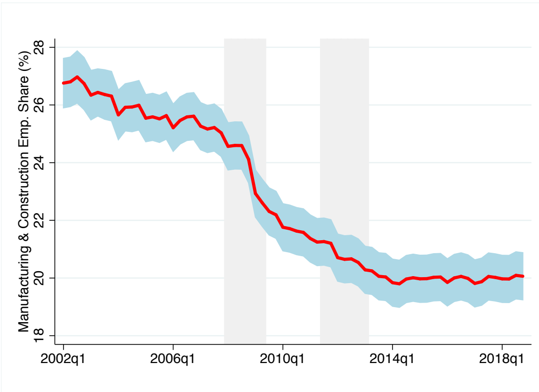
This evidence suggests that the labor market transformation experienced by each country during each recession is orthogonal to country-specific characteristics, but its magnitude depends on the size and persistency of the downturn. This is true independently on the very different nature of each recession (i.e. GR –a financial crisis– and the SDC –a confidence crisis) and it is not affected by the fact that the two downturns are close in time.

3.2. *Sectorial Dynamics behind Job Polarization*

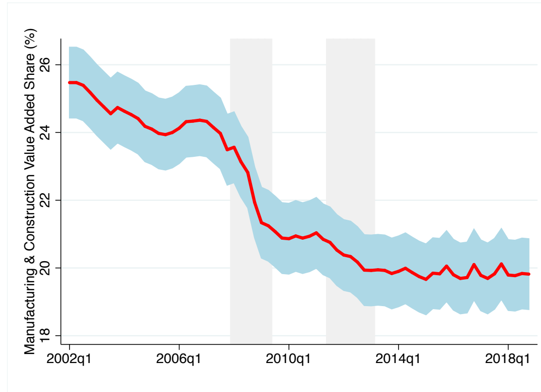
Although Figure 5(c) tells us the that the sectorial composition does not matter ex-ante for the cyclical shift in the occupational structure of the labor market, we know that some specific sectors are much more concentrated of routine workers and more cyclical. This is particularly true for the manufacturing and construction sector. Figure 7(a) plots the cross-country employment share in manufacturing and construction. Clearly, the sectorial employment dynamic mimics the routine employment share dynamic of Figure 1(b). This implies that –although job polarization remains a fact across all sectors– its long-run and cyclical behavior is intertwined with manufacturing and construction.

This rises a red flag, in particular for the implication that specific sectorial dynamics can have on both price dynamics and employment composition. In other words, sectorial dynamics could be confounding factors when trying to address the role of occupational

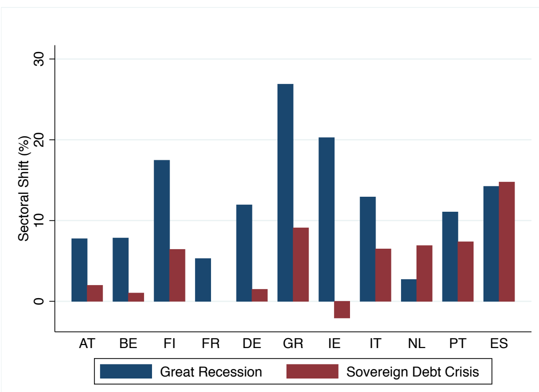
Fig. 7. Manufacturing and Construction Employment and Relative Weight in the Economy



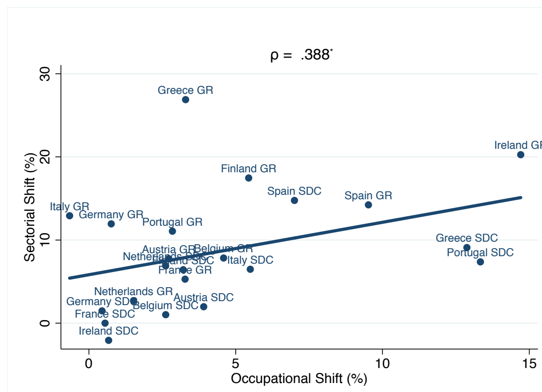
(a) Manuf. & Construction Emp. Share



(b) Manuf. & Construction Share of Value Added



(c) Sectorial Shifts



(d) Sectorial vs. Occupational Shifts

Note: Figure 7(a) plots the evolution of the mean employment share in manufacturing and construction across those countries that joined the EMU before 2002 (Luxembourg excluded). Figure 7(b) plots the evolution of the mean share of value added from manufacturing and construction across the same 11 EMU countries. The light-blue-shaded area represents the 95% confidence interval. The two grey-shaded areas indicate respectively the periods of the Great Recession and of the Sovereign Debt Crisis as defined by the CEPR Business Cycle Committee. Data is quarterly and spans from 2002q1 to 2018q4. Figure 7(c) plots the sectorial shifts experienced by each country that joined the EMU before 2002 (Luxembourg excluded) during the Great Recession and the Sovereign Debt Crisis. Each sectorial shift is defined as the percentage change in the share of value added from manufacturing and construction measured between the peak and trough of each recession, according to country-specific business cycle dates. For Figure 7(d), the y-axis is the sectorial shift and the x-axis is the occupational shift, defined as the percentage change in routine employment share measured between the peak and trough of each recession, according to country-specific business cycle dates. On top of the graph, the correlation (ρ) between variables is reported along with its significance level. *, **, *** indicate significance at 90%, 95% and 99% level.

composition on the slope of the PC. Therefore, it is convenient to analyze how the sectorial structure of EMU11 countries has evolved over time and over the cycle. As shown in Figure 7(b), the contribution of manufacturing and construction (in terms of value added) has moved across countries roughly from 25% to 20% in the last two decades. This trend has accelerated in both recessions. Given this, we build a measure of sectorial shift isomorphic to equation (2):

$$Shift_{i,c}^{Manuf} = \frac{VA.Share_{peak_{i,c}}^{Manuf} - VA.Share_{trough_{i,c}}^{Manuf}}{VA.Share_{peak_{i,c}}^{Manuf}} \tag{3}$$

which captures the percentage change of the share of value added from manufacturing and construction in country i, as measured between the peak and trough of each recession $c = \{GR, SDC\}$, according to the business cycle dates of country i. Figure 7(c) plots the levels of our measure of sectorial shift ($Shift_{i,t}^{Manuf}$) for each country of the EMU11 and each recession. The mean sectorial shift is 8.7% (12.6% for the GR and 4.8% for the SDC). Finally, Figure 7(d) plots the sectorial shift on the occupational shift. As expected, there is a positive correlation equal to 0.38, although it is only significant at the 90% level.[9] We will take this carefully into account in the following analysis.

3.3. Occupational Structural Changes and the Flattening of the Price PC

If the composition of the labor market matters for the slope of the PC, changes in composition –orthogonal to price dynamics and country characteristics– should affect the structural relationship between prices and unemployment. In light of this argument, in this section we exploit the cross-country variation in occupational shifts occurred during the GR and SDC crisis to study the flattening of the PC in periods following each downturn. In order to do so, we estimate the following panel equation:

$$\begin{aligned}
\Delta log(p)_{i,t} = {} & \alpha_i + \beta u_{i,t-1} + X_{i,t-1}'\gamma \\
& + \sum_{c=\{GR,SDC\}} \Big\{ \delta_{1,c} After_{i,c} + \beta_c After_{i,c} \times u_{i,t-1} \Big\} \\
& + \sum_{c=\{GR,SDC\}} \Big\{ \delta_{2,c} After_{i,c} \times Shift_{i,c}^{R} + \tilde{\beta}_c After_{i,c} \times Shift_{i,c}^{R} \times u_{i,t-1} \Big\} \\
& + \sum_{c=\{GR,SDC\}} \Big\{ \delta_{3,c} After_{i,c} \times Shift_{i,c}^{Manuf} + \tilde{\tilde{\beta}}_c After_{i,c} \times Shift_{i,c}^{Manuf} \times u_{i,t-1} \Big\} + \varepsilon_{i,t}
\end{aligned} \tag{4}$$

where $\Delta log(p)_{i,t}$ is core inflation in country i at time t, measured as the year-on-year log-change of the harmonized consumer price index excluding food and energy goods.[10] α_i is the country fixed-effect. $u_{i,t-1}$ is the unemployment gap measured as deviation of the

[9] In Appendix B, we repeat the analysis of Section 2.2 and 3.1 and test if the employment share of manufacturing and construction and the value added share from these two sectors follows the cycle as the routine employment share does. We find a significant acceleration during the GR only. Moreover, we check whether our measure of sectorial shift from equation (3) correlates with ex-ante country characteristics. Differently from the occupational shift, the sectorial shift mildly depends on pre-recession country characteristics.

[10] See Figure A.6 for the evolution of core inflation across EMU11 countries in Appendix A.4.

unemployment series from a linear trend.[11] $X'_{i,t-1}$ is the basic vector of controls used in the literature and it includes: lagged inflation, past expectations on current inflation, the change in the import price index. We add to this set of controls a time dummy to take into account that post-GR periods include also other business cycle phases that might affect the level of inflation. $After_{i,GR}$ ($After_{i,SDC}$) is a dummy taking value one for periods after the GR (SDC) according to country i specific business-cycle dates; $Shift^{R}_{i,GR}$ ($Shift^{R}_{i,SDC}$) is the shift in the occupational structure occurred during the GR (the SDC) as defined in equation (2) of Section 3.1. $Shift^{Manuf}_{i,GR}$ ($Shift^{Manuf}_{i,SDC}$) is the shift in the sectorial structure occurred during the GR (the SDC) as defined in equation (3) of Section 3.2. $\varepsilon_{i,t}$ is the error term.

In words, equation (4) augments the baseline estimating equation of the price PC (i.e. the first line of the equation) by taking into account all potential structural changes occurred during each recession that might have affected both the relationship between unemployment and inflation and the level of inflation in post recession periods (i.e. the second line of the equation). On top of this, the third line of equation (4) takes into account by how much the flattening in post recession periods can be explained by structural changes in the occupational composition of the labor market occurred during each recession, once controlling contemporaneously for changes in the the sectorial composition of the economy (i.e. line four of the equation). Therefore, we will use the augmented PC of equation (4) to test whether changes in the occupational composition matter for the slope of the PC. Formally, we want to test

$$H_0 : \tilde{\beta}_c = 0, \quad \forall c = \{GR, SDC\}$$

once netting out the effect of all other possible structural changes that might have flattened the curve after the GR and the SDC. Table 2 shows results. In column (1), we start by considering the baseline PC and we include all controls. For a 1% increase in the unemployment gap, core inflation falls by 0.03%. In column (2), we add the time dummy $After_{GR}$ among the controls and we study the flattening of the PC in post-GR years by adding the interaction $After_{GR} \times u_{t-1}$. Here we find that the slope of the PC is -0.09 in pre-GR periods, but it significantly flattens and becomes equal to $-0.09 + 0.07 = -0.02$ in post-GR periods. This indicates that some structural change has affected the relationship between unemployment and inflation after the GR. Now, we want to understand by how much such a flattening can be attributed to the occupational shift occurred during the GR. For this reason, we add the interaction $After_{GR} \times Shift_{GR} \times u_{t-1}$, along with $After_{GR} \times Shift_{GR}$

[11] Unemployment is a stationary process for all countries but Germany for which it follows a negative trend (see Appendix A.2). For this reason, we decided to build the unemployment gap in the simplest possible way: as deviation from a linear trend. This solves the problem for Germany, and transforms the unemployment series for all other countries roughly as deviation from their mean. See Figure A.4 in Appendix A.2 for the evolution of the unemployment gap across EMU11 countries.

Table 2: The Flattening of the Price Phillips Curve across the EMU11

	(1) $\Delta log(p)$	(2) $\Delta log(p)$	(3) $\Delta log(p)$	(4) $\Delta log(p)$	(5) $\Delta log(p)$	(6) $\Delta log(p)$
u_{t-1}	-0.033***	-0.087***	-0.086***	-0.085***	-0.079***	-0.231**
	(0.007)	(0.013)	(0.012)	(0.013)	(0.014)	(0.097)
$After_{GR} \times u_{t-1}$		0.069***	0.052**	0.029*	0.057*	-0.520**
		(0.019)	(0.018)	(0.013)	(0.027)	(0.239)
$After_{GR} \times Shift^{R}_{GR} \times u_{t-1}$			0.002**	0.005**	0.004***	0.046**
			(0.001)	(0.002)	(0.001)	(0.023)
$After_{SDC} \times u_{t-1}$				-0.011	0.010	-0.265
				(0.026)	(0.015)	(0.286)
$After_{GR} \times Shift^{R}_{SDC} \times u_{t-1}$				0.010**	0.010***	0.087*
				(0.005)	(0.003)	(0.049)
$After_{GR} \times Shift^{Manuf}_{GR} \times u_{t-1}$					-0.002**	0.017*
					(0.001)	(0.010)
$After_{SDC} \times Shift^{Manuf}_{SDC} \times u_{t-1}$					-0.030***	0.320**
					(0.009)	(0.144)
Observations	748	748	748	748	748	638
R^2	0.893	0.896	0.897	0.898	0.900	0.793
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Estimator	Ols	Ols	Ols	Ols	Ols	2sls

Note: Standard errors in parentheses, clustered at country-level. The unit of observation is inflation, measured as the year-on-year log-change of the harmonized consumer price index (energy and food excluded). $After_{GR}$ ($After_{SDC}$) is dummy taking value one for periods after the GR (SDC) according to country-specific business-cycle dates; $Shift^{R}_{GR}$ ($Shift^{R}_{SDC}$) is the shift in the occupational structure occurred during recession GR (SDC), i.e. the percentage change in the routine employment share between the peak and trough of the recession according to country-specific business cycle dates; $Shift^{Manuf}_{GR}$ ($Shift^{Manuf}_{SDC}$) is the shift in the share of value added from manufacturing and construction occurred during recession GR (SDC), i.e. the percentage change in the share of value added from these two sectors between the peak and trough of the recession according to country-specific business cycle dates; u_{t-1} is the unemployment gap measured as deviation of the unemployment series from a linear trend; the vector of controls includes lagged inflation, past expectations on current inflation, the change in the import price index, and a dummy for each country-specific business cycle phase. In column (6), we instrument the unemployment gap and its interaction terms with three lags of the high-frequency monetary policy shocks from Jarociński and Karadi (2020), aggregated at quarterly frequency. The sample is composed of all countries that joined the EMU before 2002 (Luxembourg excluded). Data is quarterly. *, **, *** indicate significance at 90%, 95% and 99% level.

as control. As from column (3), adding these controls does not change the slope of the PC in pre-GR periods. On the other hand, the coefficient on the slope of the PC in post-GR years has now become smaller and moved from 0.07 to 0.05. This difference is explained by cross-country variation in the occupational shift occurred during the GR. In fact, $\tilde{\beta}_{GR}$ is significantly positive meaning that countries experiencing a larger occupational shift during the GR had a flatter PC afterward. Therefore, we could conclude that –despite other potential structural changes that might have occurred during the GR and that might have influenced the relationship between unemployment and inflation– the permanent shift in the occupational structure significantly explains part of the flattening of the PC.

Since all countries in the sample experienced also the SDC, the flattening could not be entirely due to the occupational shift occurred during the GR, but also due to the shift occurred during the SDC or other potential structural breaks happened during that downturn. We address this issue in column (4), where we add the interaction $After_{SDC} \times Shift_{SDC} \times u_{t-1}$. For the same reasoning as before, we control for any other structural break that might explain the flattening in post-SDC periods ($After_{SDC} \times u_{t-1}$) and check whether any potential structural break in the post-SDC years ($After_{SDC}$) and the occupational shift occurred in that recession ($After_{SDC} \times Shift_{SDC}$) have a direct effect on inflation afterward. Under this specification, we find that the occupational shift occurred during each recession plays a role in explaining the post-recession flattening of the PC. In detail, for the same level of unemployment gap, a 1% shift in the occupational structure occurred during the GR flattens the PC by 0.005 just after the GR. However, the PC flattens out even further in countries where there was a bigger shift in the occupational structure during the SDC. In particular, 1% occupational shift occurred during the SDC leads to a further flattening by 0.01.

Yet, this result is exposed to omitted variable bias. In fact, as explained in Section 3.2, for our sample of countries the process of polarization goes hand in hand with the change in sectorial compositions. In fact, the role of manufacturing and construction in all EMU11 economies is decreasing, and both the GR and the SDC seems to have contributed to this. Therefore, our results could be biased due to the fact that the change in sectorial composition might not only influence inflation dynamics, but also the disappearance of routine jobs. In light of this argument, in column (5) we augment the PC with the variable $After_{i,c} \times Shift^{Manuf}_{i,c}$ and $After_{i,c} \times Shift^{Manuf}_{i,c} \times u_{i,t-1}$ to control respectively for the effect of the sectorial shifts matured in each recession $c = \{GR, SDC\}$ on the level of inflation and on the relationship between unemployment and inflation in periods after each recession c. Notably, both $\tilde{\beta}_{GR}$ and $\tilde{\beta}_{SDC}$ are robust to this control. The only major change is for the estimates of β_{GR}, now closer to what found in column (2) and (3). As shown in Appendix D, these results are robust to several definitions of price inflation, unemployment gap, and are not driven by sub-set of EMU11 countries.

Finally, we perform another important robustness check. Most of the empirical literature overlooks the fact that the unemployment gap could be correlated with the error term. This could occur, for example, in the presence of supply shocks which might jointly determine both unemployment and inflation. For this reason, we use high frequency monetary policy shocks for the Euro Area (mps_t) from Jarociński and Karadi (2020), aggregated at quarterly frequency, to instrument $u_{i,t}$[12]. In particular, we use three lags of mps_{t-1}, $mps_{t-1} \times After_{i,c}$, $mps_{t-1} \times Shift^{R}_{i,c}$, $mps_{t-1} \times Shift^{Manuf}_{i,c}$ to instrument $u_{i,t-1}$, $u_{i,t-1} \times After_{i,c}$, $u_{i,t-1} \times Shift^{R}_{i,c}$, $u_{i,t-1} \times Shift^{Manuf}_{i,c}$ for $c \in \{GR, SDC\}$. Moreover, we assume past inflation and past expectations on current inflation to be exogenous to the current level of inflation. As reported in column (6), the coefficients of interest are significant also under this identification strategy.

In light of this, we can reject H_0 for all $c = \{GR, SDC\}$, and state that the structural change occurred in the labor market during the last two recessions had a role in the recent flattening of the PC. By how much? Now, we can back up the aggregate contribution of both occupational shifts on the flattening through a back-of-the-envelope calculation. By simply using our (significant) estimates from column (5) –our most preferred model– we can say that the occupational shifts can jointly explain $(\tilde{\beta}_{GR} + \tilde{\beta}_{SDC})/0.057 = 25\%$ of the overall flattening of the Phillips Curve from the end of the GR onward.

4. Any implication for the Wage PC?

If the occupational structure matters for prices, it should matter also for wages. In this section, we check if the result for the price PC hold true when looking at the wage PC.

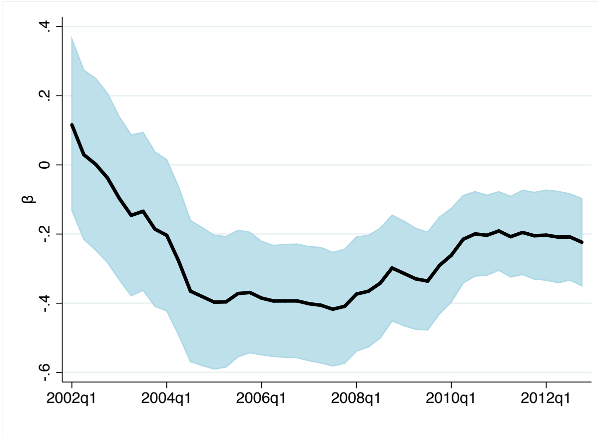
First, we inspect the evolution of the slope of the wage PC across EMU11 countries. As shown in Figure 8, the dynamic of slope is u-shaped. Initially, the cross-country estimate of the slope was not significantly different from zero.[13] Then, after a rapid steepening between 2002 and 2004, the slope is stable and negative until 2008. From 2008, the slope gradually flattens, but remains significantly below zero.

In light of this, now we want to investigate if changes in the slope of the wage PC –in particular those occurred after 2008– can be related to shifts in the occupational composition of the labor market matured during the GR and SDC. To do so we consider again equation (4), but with wage inflation ($\Delta log(w)_{i,t}$) as dependent variable. The wage inflation is build as the year-on-year log-change of the labor cost index (wages and salaries) available on Eurostat for the business economy. Here, the controls are slightly different from before. Since we do not have any measure of expectations on future wage inflation, we control for the 4-quarters

[12] We use Jarociński and Karadi (2020) "pure" monetary policy shocks as for our purpose is important to distinguish between an aggregate demand and a Central Bank information shock. Shocks cover the 1999-to-2016 period.

[13] In Appendix D.2, we show that the pre-GR behavior of the wage PC –i.e. zero-slope– is due to peripheral countries (Greece, Ireland, Portugal). Once cutting them out of the sample, the dynamic of the wage PC is similar to the dynamic of the price PC: the slope is initially negative and then it starts flattening after the GR.

Fig. 8. The Behavior of the Wage Phillips Curve



Note: Figure 8 plots the coefficient of the wage Phillips Curve estimated over 8-year rolling windows for those countries that joined the EMU before 2002 (Luxembourg excluded). The estimating equation for each window is $\Delta log(w)_{i,t} = \alpha_i + \beta u_{i,t-1} + X'_{i,t-1}\gamma + \epsilon_{i,t}$, where $\Delta log(w)_{i,t}$ is the year-on-year log-change of the business economy labor-cost index (salary and wages) in country i; α_i is the country fixed-effect; $u_{i,t-1}$ is the unemployment gap measured as deviation of the unemployment series from a linear trend; $X'_{i,t-1}$ is a vector of controls including a 4-quarters moving average of past wage inflation, past expectations over current price inflation and a dummy for each country-specific business cycle phase; $\epsilon_{i,t}$ is the error term. On the x-axis, dates indicate the starting point of each 8-year estimating window. The light-blue-shaded area represents the 95% confidence interval. Data is at quarterly frequency.

moving average of wage inflation along with observed expectations on current price inflation. All other variables are the same as in the price PC.

Table 3 shows results. As from column (1), we find that the slope of the wage PC in pre-GR periods is not different from zero, consistently with Figure 8. On the other hand, in all post-GR periods, the slope of the wage PC is significant and equal to -0.81, with no further impact of the SDC in post-SDC periods. However, when looking at the role of the occupational shifts on the slope, we find a significant effect: countries that destroyed more routine jobs during the GR and SDC experienced a flattening of the wage PC in post-recession periods. In column (2), we control for sectorial changes occurred during both recessions, and we find that the flattening can be partially explained also by those occurred during the SDC. As shown in Appendix D.2, these results are robust to several definitions of wage inflation, unemployment gap, and are almost always not driven by subset of EMU11 countries. As for the price PC, we use the same IV procedure to instrument the unemployment gap. Also under this identification strategy, the result is confirmed: the exogenous shifts in the occupational structure matter also for the slope of the wage PC.

Table 3: The Behavior of the Wage Phillips Curve across the EMU11

	(1) $\Delta log(w)$	(2) $\Delta log(w)$	(3) $\Delta log(w)$
u_{t-1}	0.069	0.131	0.069
	(0.175)	(0.214)	(0.280)
$After_{GR} \times u_{t-1}$	-0.812***	-1.192**	-3.744**
	(0.224)	(0.387)	(1.459)
$After_{GR} \times Shift^{R}_{GR} \times u_{t-1}$	0.053***	0.066***	0.200*
	(0.015)	(0.018)	(0.106)
$After_{SDC} \times u_{t-1}$	0.000	-0.103	0.055
	(0.083)	(0.114)	(0.907)
$After_{SDC} \times Shift^{R}_{SDC} \times u_{t-1}$	0.062*	0.083**	0.400***
	(0.028)	(0.028)	(0.153)
$After_{GR} \times Shift^{Manuf}_{GR} \times u_{t-1}$		0.008	0.062
		(0.008)	(0.043)
$After_{SDC} \times Shift^{Manuf}_{SDC} \times u_{t-1}$		0.268**	0.769
		(0.101)	(0.491)
Observations	748	748	638
R^2	0.264	0.274	0.104
Country FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Estimator	Ols	Ols	2sls

Note: Standard errors in parentheses, clustered at country-level. The unit of observation is wage inflation, measured as the year-on-year log-change of the labor-cost index (salary and wages) for the business economy. $After_{GR}$ ($After_{SDC}$) is dummy taking value one for periods after the GR (SDC) according to country-specific business-cycle dates; $Shift^{R}_{GR}$ ($Shift^{R}_{SDC}$) is the shift in the occupational structure occurred during recession GR (SDC), i.e. the percentage change in the routine employment share between the peak and trough of the recession according to country-specific business cycle dates; $Shift^{Manuf}_{GR}$ ($Shift^{Manuf}_{SDC}$) is the shift in the share of value added from manufacturing and construction occurred during recession GR (SDC), i.e. the percentage change in the share of value added from these two sectors between the peak and trough of the recession according to country-specific business cycle dates; u_{t-1} is the unemployment gap measured as deviation of the unemployment series from a linear trend; the vector of controls includes past expectations on current wage inflation (measured as a 4-quarters moving average), past expectations on current price inflation, and a dummy for each country-specific business cycle phase. In column (6), we instrument the unemployment gap and its interaction terms with three lags of the high-frequency monetary policy shocks from Jarociński and Karadi (2020), aggregated at quarterly frequency. The sample is composed of all countries that joined the EMU before 2002 (Luxembourg excluded). Data is quarterly. *, **, *** indicate significance at 90%, 95% and 99% level.

5. Theoretical Framework and Micro-foundation

Why does job-polarization flatten the price Phillips Curve? We now move to the theoretical analysis with three objectives. First, to show that labor market characteristics matter for the slope of the price PC. Second, to illustrate how changing the composition of the labor market (for a given level of equilibrium unemployment) can flatten the price PC through an increase in labor market *fluidity*. Third, to provide micro-evidence on how job polarization increased the *fluidity*. Moreover, we cross-validate the role of job polarization on the level of inflation. In fact, using the theoretical model, we show also how technology (the main driver of polarization) and *fluidity* affect the intercept of the PC.

5.1. The model

We start by introducing an analytical New Keynesian model with unemployment and search and matching frictions, following Blanchard and Galí (2010).[14] There is a continuum of members in a representative household that consumes a differentiated basket of imperfectly substitutable goods, supplies labor $0 \leq N_t \leq 1$, and discounts the future at rate β. The household maximises the following expected utility:

$$E_0 \sum \beta^t \left(logC_t - \chi \frac{N_t^{1+\phi}}{1+\phi} \right)$$

where $C_t = \left(\int_0^1 C_t(z)^{\frac{\varepsilon-1}{\varepsilon}} dz \right)^{\frac{\varepsilon}{\varepsilon-1}}$ and ϕ is the inverse Frisch labor supply elasticity. There is a continuum of firms $i \in [0,1]$ producing a differentiated final good $Y_t(i)$:

$$Y_t(i) = X_t(i) \tag{5}$$

where $X_t(i)$ is the quantity of the intermediate good bought by firm i from the large number of identically and perfectly competitive intermediate firm producers $j \in [0,1]$. Intermediate firms produce the homogeneous good X with a linear production function $X_t(j) = A_t N_t$, where A_t is an exogenous process depicting technology. Employment decisions are taken by the intermediate firm j and are described by the following labor demand accumulation equation:

$$N_t(j) = (1-\delta)N_{t-1}(j) + H_t(j). \tag{6}$$

$\delta \in (0,1)$, a crucial parameter for our analysis, determines the exogenous separation rate and $H_t(j)$ measures the workers hired in period t. δ can be interpreted as the fraction of workers that had a job at $t-1$ but are not working anylonger at the beginning of period t and need to find a job. δN_{t-1} will therefore be the increase in the stock of people unemployed between period $t-1$ and t. This drives the necessity to define two "types" of unemployment: U_t, *ex-ante* unemployment (i.e. unemployment at the beginning of the period) and u_t, *ex-post* unemployment (i.e. unemployment, after hiring, at the end of period t). Therefore $U_t = u_{t-1} + \delta N_{t-1}$.

As long as our parametrization guarantees that the benefit from an extra hour of work is higher than its marginal rate of substitution at full employment (i.e. $W_t > \chi C_t$), then the labor market is characterized by full participation. This condition implies that $u_t = 1 - N_t$ and $U_t = 1 - (1-\delta)N_{t-1}$. As a consequence, the flow of newly hired workers in period t can

[14] We refer to the original paper for more details.

be rewritten as $H_t = \int_0^1 H_t(j)dj = N_t - (1-\delta)N_{t-1}$.

We now define labor market tightness x_t (or job finding rate). This measures the ratio of aggregate hires to unemployment $x_t = \frac{H_t}{U_t} \in [0,1]$, capturing the probability of being hired in period t. Hiring is costly and the cost is a positive function of market tightness and vacancies are filled any time the hiring cost is paid:

$$G_t = A_t B x_t^{\alpha} \tag{7}$$

with $\alpha \geq 0$ and $B > 0$, where B is the parameter governing matching efficiency. We also follow Blanchard and Galí (2010) to introduce real wage rigidities in a simple manner, assuming a wage schedule of the form:

$$W_t = \left[\frac{1}{\mu} - (1-\beta(1-\delta)) B x^{\alpha} A^{\gamma}\right] A_t^{1-\gamma} = \Theta A_t^{1-\gamma}$$

This implies that when $\gamma = 0$ our wage will correspond to Nash bargaining, while when $\gamma = 1$ we will have rigid wages, as in Hall (2005). μ is the gross desired markup of the final good producer.

To complete the model, we need to introduce final firm's price setting behavior. Price are rigid and follow Calvo (1983) pricing formulation: each period the final good producer has probability $(1-\theta)$ to reset prices, while the remaining producers θ keep their prices unchanged. The optimal price setting rule turns to be the standard

$$E_t\left\{\sum_{k=0}^{\infty} \theta^k Q_{t,t+k} Y_{t+k,t}\left(P_t^* - \mu P_{t+k} MC_{t+k}\right)\right\} = 0 \tag{8}$$

where $P_t = [(1-\theta)(P_t^*)^{1-\varepsilon} + \theta(P_{t-1})^{1-\varepsilon}]^{\frac{1}{1-\varepsilon}}$. P_t^* denotes the price picked by the firm able to reset prices, $Y_{t+k,t}$ is the level of output in period $t+k$ for a firm last able to reset prices in period t, $Q_{t.t+k}$ is the stochastic discount factor common across all households $\equiv \beta^k \frac{C_t}{C_{t+k}} \frac{P_t}{P_{t+k}}$, and finally MC_{t+k} is the real marginal cost. The latter is given by the relative prices of intermediate good producers $P_t^I = MC_t^n$, given the assumption of perfect competition, and the aggregate consumption price level P_t:

$$\begin{aligned} MC_t = \frac{P_t^I}{P_t} =& \frac{1}{A_t}\left[W_t + G_t - \beta(1-\delta)E_t\left\{\frac{C_t}{C_{t+1}} G_{t+1}\right\}\right] \\ &= \Theta A_t^{-\gamma} + B x_t^{\alpha} - \beta(1-\delta)E_t\left\{\frac{C_t}{C_{t+1}}\frac{A_{t+1}}{A_t} B x_{t+1}^{\alpha}\right\}. \end{aligned}$$

In this formulation of the marginal cost function lies the crucial difference with respect to the standard NK model. It is immediate to see how labor market frictions and the real wage rigidity appear and affect the marginal cost function.

5.2. *The Price Phillips Curve*

Now, we focus on the relationship between inflation and unemployment, the NK Phillips Curve, in log-deviations from a zero inflation steady state (denoted with lower case letters with a hat):[15]

$$\pi_t = \beta E_t\{\pi_{t+1}\} - \kappa_0 \hat{u}_t + \kappa_L \hat{u}_{t-1} + \kappa_F E_t\{\hat{u}_{t+1}\} - \lambda\Phi\gamma\hat{a}_t \tag{9}$$

where

$$\begin{aligned}
&\lambda = \frac{(1-\beta\theta)(1-\theta)}{\theta} \\
&\Phi \equiv \frac{\mu W}{A} = 1-(1-\beta(1-\delta))g\mu \\
&\kappa_0 \equiv \frac{\lambda h_0}{(1-u)}, \quad \kappa_L \equiv \frac{-\lambda h_L}{(1-u)}, \quad \kappa_F \equiv -\frac{\lambda h_F}{(1-u)} \\
&h_0 \equiv \left(\frac{\alpha g\mu}{\delta}\right)\left(1+\beta(1-\delta)^2(1-x)\right) + \beta(1-\delta)g\mu\left(\xi_1-\xi_0\right) \\
&h_L \equiv -\left(\frac{\alpha g\mu}{\delta}\right)(1-\delta)(1-x) - \beta(1-\delta)g\mu\xi_1 \\
&h_F \equiv -\beta(1-\delta)g\mu\left(\frac{\alpha}{\delta}-\xi_0\right) \\
&\xi_0 \equiv \frac{1-g(1+\alpha)}{(1-\delta g)}, \quad \xi_1 \equiv \frac{g(1-\delta)(1+\alpha(1-x))}{(1-\delta g)}.
\end{aligned}$$

What comes out clearly from this formulation, is that the slope of the price Phillips Curve, κ_0, depends on labor market characteristics. In particular on the separation rate, δ, market tightness x and on the curvature of the cost function α.

Before analyzing the characteristics of this formulation in details, we derive a simplified version of it. As in Blanchard and Galí (2010), we assume that both hiring cost with respect to output g and the separation rate δ are small. These assumptions allow to rewrite an approximated Phillips Curve simply as:

$$\widehat{\pi}_t = \kappa\widehat{u}_t + \kappa(1-\delta)(1-x)\widehat{u}_{t-1} - \Psi\gamma\widehat{a}_t \tag{10}$$

[15]See Appendix C for a full derivation.

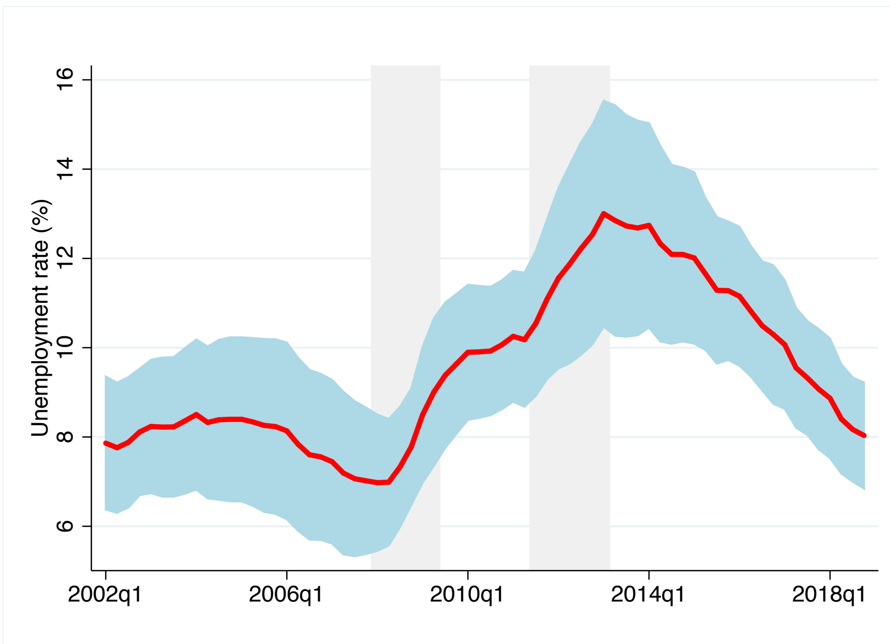
where

$$\kappa \equiv -\frac{\alpha g \mu \lambda}{\delta(1-u)} \quad \text{and} \quad \Psi \equiv \frac{\lambda \Phi}{(1-\beta\rho_a)}$$

which is easy to study analytically. We start by noticing that the slope of the Phillips Curve can be written as a function of standard Calvo parameters λ, the markup μ and labor market characteristics (i.e. the level of equilibrium unemployment (u), the separation rate (δ), the market tightness condition (x) and the parameters of the hiring cost function (B, α)):

$$\frac{\alpha g \mu \lambda}{\delta(1-u)} = \frac{\alpha B x^{\alpha} \mu \lambda}{\delta(1-u)} = \frac{\alpha B \left(\frac{H}{U}\right)^{\alpha} \mu \lambda}{\delta(1-u)} = B\mu\lambda \frac{\alpha \left(\frac{\delta N}{1-(1-\delta)N}\right)^{\alpha}}{\delta N}.$$

Fig. 9. EMU Unemployment Rate



Note: This figure plots the evolution of the unemployment rate (for the labor force in the 15-74 age bracket) across those countries that joined the EMU before 2002 (Luxembourg excluded). The light-blue-shaded area represents the 95% confidence interval. The two grey-shaded areas indicate respectively the periods of the Great Recession and of the Sovereign Debt Crisis as defined by the CEPR Business Cycle Committee. Data is quarterly and spans from 2002q1 to 2018q4.

In order to investigate the effects of the labor market composition on the slope of the Phillips Curve, first we need to take a stand on the effect of polarization on the equilibrium level of unemployment. Supported by the overall dynamic of unemployment in the European Monetary Union (Figure 9 shows that the unemployment level converged back to its pre-recession level), we maintain steady state unemployment $u = 1 - N$ constant.[16]

[16]This implies that every movement in the separation rate will result in an adjustment of the job finding

Let us define, as in Blanchard and Galí (2010), a *fluid* labor market one characterized by high separation and high job finding rate. How does the Phillips Curve slope change in response to an increase in the fluidity of the labor market? How does an increase in the separation rate affects the slope of the Phillips Curve? We can easily show that:

$$\frac{\partial \kappa}{\partial \delta} = \mu \lambda B \frac{\alpha (\delta N)^{(\alpha-2)} N}{(1-(1-\delta)N)^{1+\alpha}} \left[(\alpha-1)(1-(1-\delta)N) - \alpha \delta N\right] \tag{11}$$

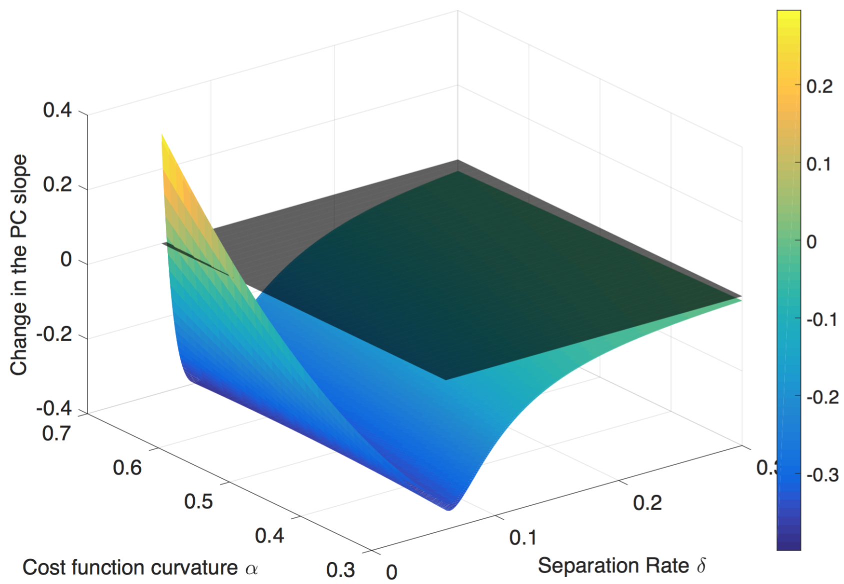
is negative when $\alpha < \frac{1-N+\delta N}{1-N} = \frac{U}{u}$. Notice that this condition is always satisfied when $\alpha < 1$, an empirical (see Pissarides and Petrongolo (2001) and Barnichon and Figura (2015)) and theoretical regularity (Shimer (2005)). Therefore, an increase in the fluidity of the labor market results in a flattening of the Phillips Curve.

We now need to investigate if this result generalizes to the full extended model. We proceed with calibrating the model, considering each period a quarter. For preferences, price setting and wage rigidity we take the standard parameters used in Blanchard and Galí (2010): $\beta = 0.99$, $\phi = 1$, $\epsilon = 6$, and $\theta = 0.7457$. For the other parameters we look at evidence from the EMU. We estimate the hiring cost as a fraction of GDP to be 1.512%, implying a matching efficiency B equal to 0.3297. The equilibrium level of unemployment is set to 8%, the average value for the EMU11 in the pre-recession period. Regarding labor market parameters, we take a large range of possible values, considering an aggregate $\delta \in [0.05, 0.3]$, implying $x \in [0.36, 0.78]$, and a curvature parameter $\alpha \in [0.3, 0.7]$. Figure 10 shows the sign of the derivative of the slope of the Phillips Curve for different values of δ and α. The relationship is highly non linear but negative for most of the considered subset. The exception is when the separation rate is extremely low and α quite high, which are unrealistic values for these parameters. Therefore, even in the extended model, higher separation rate leads to a flatten price PC.

What is the economic intuition behind this result? Higher fluidity reduces the elasticity of marginal costs to economic conditions (e.g. market tightness) such that employers adjust more the stock of employment rather than wages. This happens because the labor demand becomes more elastic as employers can substitute workers more easily. In other words, the labor demand becomes flatter. Therefore, for a higher δ, the elasticity of wages to an aggregate shock will be smaller: the marginal cost will be more stable and therefore also prices. As a result, the relationship between prices and unemployment will be weaker.

rate to maintain constant the equilibrium level of unemployment. In particular an increase in the separation rate implies an increase in tightness $\frac{\partial x}{\partial \delta} = \frac{N(1-N)}{[1-(1-\delta)N]^2} > 0$. Notice that this assumption, made to match equilibrium unemployment data in the EMU11, reduces the effect of δ on the slope of the PC.

Fig. 10. Derivative of the Slope of the Price Phillips Curve - Full Model



Note: This figure plots the partial derivative of the Price Phillips Curve with respect to the separation rate $\frac{\partial \kappa_0}{\partial \delta}$, computed from equation (9), for different starting values of δ, the separation rate, and α the curvature of the cost function.

5.3. *Job Polarization and Labor Market Fluidity*

5.3.1. *Labor Market Fluidity vs. Price Stickiness*

As shown in the previous section, higher separation rate δ leads to a more *fluid* labor market and a flattening of the PC. If job polarization affects the slope of the PC through this channel, we should observe in the data some heterogeneity in the separation rate across jobs and time. This would corroborate the idea that the transition to a more fluid labor market –through the disappearance of routine jobs– has implication for the observed flattening of the PC. In order to analyze if this is the case, first we build a measure for δ by job. In particular, in line with the methodology of Shimer (2012) and Hobijn and Şahin (2009), we collect country-level (Eurostat) data on unemployment composition by duration and last occupation. This allows to approximate the timing and size of flows from each occupation to unemployment. Then, we normalize each job-specific flow from employment to unemployment by the level of aggregate employment in the previous period and make minor corrections for the potential measurement errors rising from the fact that employment and unemployment composition are trendy. Hence, we obtain three job-specific separation rates such that their sum equates the aggregate separation rate in the economy (see Appendix E.1 for the details).

Figure 11(a) shows the cross-country mean separation rate by occupation (along with

95% confidence interval).[17] The average separation rate of non-routine jobs is significantly higher than the rate of routine ones. In particular, the average separation rate for abstract and manual workers are respectively 1.4% and 1.8%, whereas the routine market exhibits a separation rate equal to 0.8%.

In light of this fact, if the trend of job-polarization implies employment relocation into more fluid occupations, also the the aggregate separation rate should increase over time. In Figure 11(b) we show that this is indeed the case. On average, the aggregate separation rate across EMU11 members moved from 3.5% in 2002 to 4%.[18] Using the calibrated model of Section 5.2, this change in δ would imply a flattening of the PC of 13.2%.

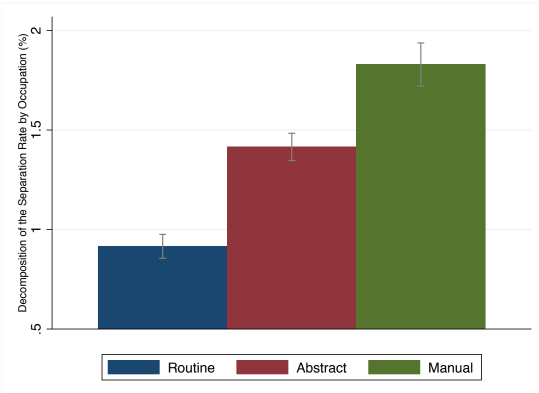
If a higher separation rate (as driven by the process of polarization) is important for the slope of the PC, we should observe that countries with higher separation in a specific period exhibit a flatter PC at the same time. We check this fact in Figure 11(c) both at aggregate level for the EMU11, and across country. In Figure 11(c).1 we plot the coefficient of the price PC –estimated across countries for each 8-year window– on the cross-country mean of the separation rate as observed at the first quarter of the same 8-year window. The correlation is strong and significant at 99%. In Figure 11(c).2 we plot the country-level slope of the PC –estimated for each country and 8-year window– on the country level separation rate. For cross-country comparability, both variables are considered in deviation from the mean. Again, we find a 23% correlation, which is significant at the 99%. This gives further evidence in support of our theory: when a labor market becomes relatively more fluid, the relationship between price inflation and unemployment becomes weaker.

If these arguments points directly at labour market *fluidity* as plausible explanation of the flattening of the PC, it is important to check if the traditional variable controlling price-update behavior –the Calvo parameter λ– is somehow influenced by the composition of the labor market. In fact, we know that the process of job polarization goes hand in hand with technological adoption, automation and offshoring, which ultimately can influence pricing behavior in the product market (see for example Aghion, Antonin, Bunel and Jaravel (2020), Fujiwara and Zhu (2020), and Fueki, Maehashi *et al.* (2019)). For this reason, we exploit the

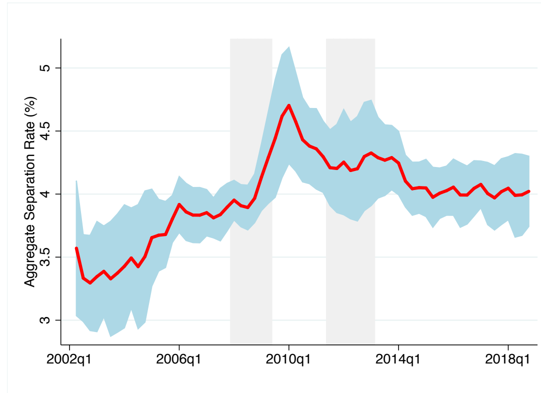
[17] The mean is computed by considering only periods before the GR and after the SDC (according country-specific business cycle dates). See Appendix E.1 for details and Appendix E.3 for the cross-country dynamic of each job-specific separation rate.

[18] As a theoretical consequence of higher separation rate for abstract and manual jobs, the hiring rate x should also be higher for these occupations. In Appendix E.2 and E.3, we show that this is the case, even if the aggregate hiring rate has slightly declined, in particular after the SDC. For an unemployment rate close to pre-GR levels in post-SDC periods, this would suggests an aggregate decline of the matching efficiency parameter B, that instead we have assumed to be constant. An indirect way to test such deterioration in matching efficiency would be to check whether the Beveridge Curve has shifted out in recent years. We know this is the case. Latest data on the Beveridge Curve can be seen here: ec.europa.eu/eurostat/statistics-explained/index.php?title=Job vacancy_and_unemployment_rates_-_Beveridge_curve.

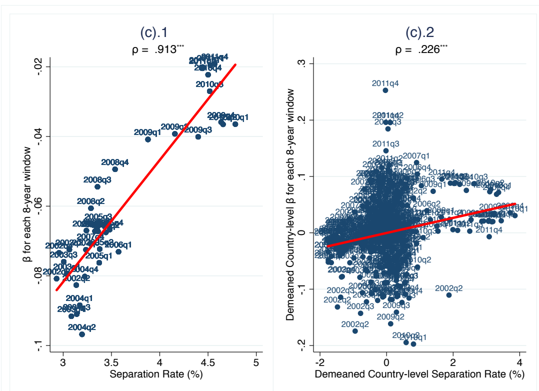
Fig. 11. Separation Rates and Calvo Parameter by Occupation across EMU11



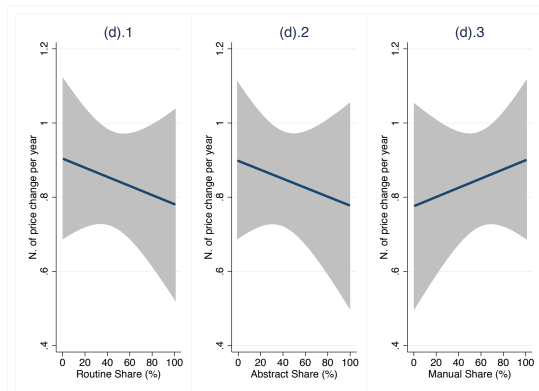
(a) Separation Rate by Job



(b) Aggregate Separation Rate



(c) Slope of the PC vs. Separation Rate



(d) Calvo Parameter

Note: Figure 11(a) plots the mean separation rate (with 95% confidence interval) by occupation (routine, abstract or manual) across countries that joined the EMU before 2002 (Luxembourg excluded). Each job-specific separation rate is build by studying the (last) job composition and duration of the unemployment pool in each year and country in order to identify correctly the timing and size of flows from each job to unemployment (see Appendix E.1 for details). Each cross-country mean is computed considering only periods before the Great Recession and after the Sovereign Debt Crisis, according to country-specific business cycle dates. Figure 11(b) plots the aggregate separation rate. The light-blue-shaded area represents the 95% confidence interval. Figure 11(c).1 plots the coefficients of the Phillips Curve –estimated across countries and over 8-year rolling windows– on the cross-country mean separation rate as observed at the beginning of each 8-year window. The equation used to estimate the slope of the Phillips Curve for each window $\Delta log(p)_{i,t} = \alpha_i + \beta u_{i,t-1} + X'_{i,t-1}\gamma + \epsilon_{i,t}$, where $\Delta log(p)_{i,t}$ is the year-on-year log-change of the harmonized consumer price index (energy and food excluded) in country i; α_i is the country fixed-effect; $u_{i,t-1}$ is the unemployment gap measured as deviation of the unemployment series from a linear trend; $X'_{i,t-1}$ is a vector of controls including lagged inflation, past expectations on current inflation, the change in the import price index, and a dummy for each country-specific business cycle phase; $\epsilon_{i,t}$ is the error term. Figure 11(c).2 plots the coefficients of the Phillips Curve –estimated for each country and over 8-year rolling windows– on the country-level separation rate as observed at the beginning of each 8-year window. The slope for each country is estimated using the same specification and variables as above. For comparability across countries, variables are taken in deviation from each country's mean. On top of both graphs, the correlation (ρ) between variables is reported along with its significance level. *, **, *** indicate significance at 90%, 95% and 99% level. Figure 11(d).1 to 11(d).3 plots the linear relationship between the number of product price updates and the occupational workforce composition at the firm level. Data comes from the three waves of the Wage Dynamics Survey of the ECB, which includes response from firms in all countries that joined the EMU before 2002, but Finland. The three waves were conducted in 2008, 2009, 2014.

Wage Dynamic Survey[19] from the ECB to relate the frequency of final good price update to

[19]This survey was conducted in 3 ways (2008, 2009, 2014) and asks the representative manager of a company some price-related questions. For example, if the management has recently changed prices

the workforce composition of a sample of firms across the EMU11. Figure 11(d) plots the linear relationship (and 95% confidence interval) between the number of price changes (per year) –as reported by the management of the firm– and the workforce job composition of the firm. In Figure 11(d).1 the share of routine workers is on the x-axis. Although the relationship is negative there is no statistical difference in the frequency of price update between firms fully composed by routine workers and firms fully composed by non-routine workers. If –on the contrary– such heterogeneity would be true, then the decline of non-routine workers in the economy should lead to lower price stickiness, higher λ and –all else equal– a steeper slope of the PC, which is not the case in the data. We obtain similar (non significant) evidence when considering the share of abstract workers on the x-axis, as in Figure 11(d).2. The relationships turns positive when considering the share of manual workers on the x-axis, as in Figure 11(d).3, but –also in this case– there is no significant difference between firms rich or poor of manual workers.

All in all, this evidence proves that employment relocation from less to more fluid occupations –as triggered by the process of job polarization– is indeed an important channel to rationalize the observed flattening of the PC in recent years.

5.3.2. Further Anecdotal Evidence on Labor Market Fluidity

The heterogeneity in the separation rate can be explained also by different labor market regulations and working arrangements across jobs. In this section, we introduce some other statistics which corroborate the idea that non-routine occupations are more fluid.

First, we use Eurostat data on EMU11 countries to measure the (conditional) probability for a worker to have a temporary contract when employed in each specific type of job.[20] In fact, the fluidity of non-routine occupations could come also from a more common use of short-term contracts. Figure 12(a) shows that this is indeed the case for abstract workers. As evident, abstract employees have –on average– a significantly higher probability (8.5%) to have a temporary contract with respect to routine (7%) and manual ones (6.5%).

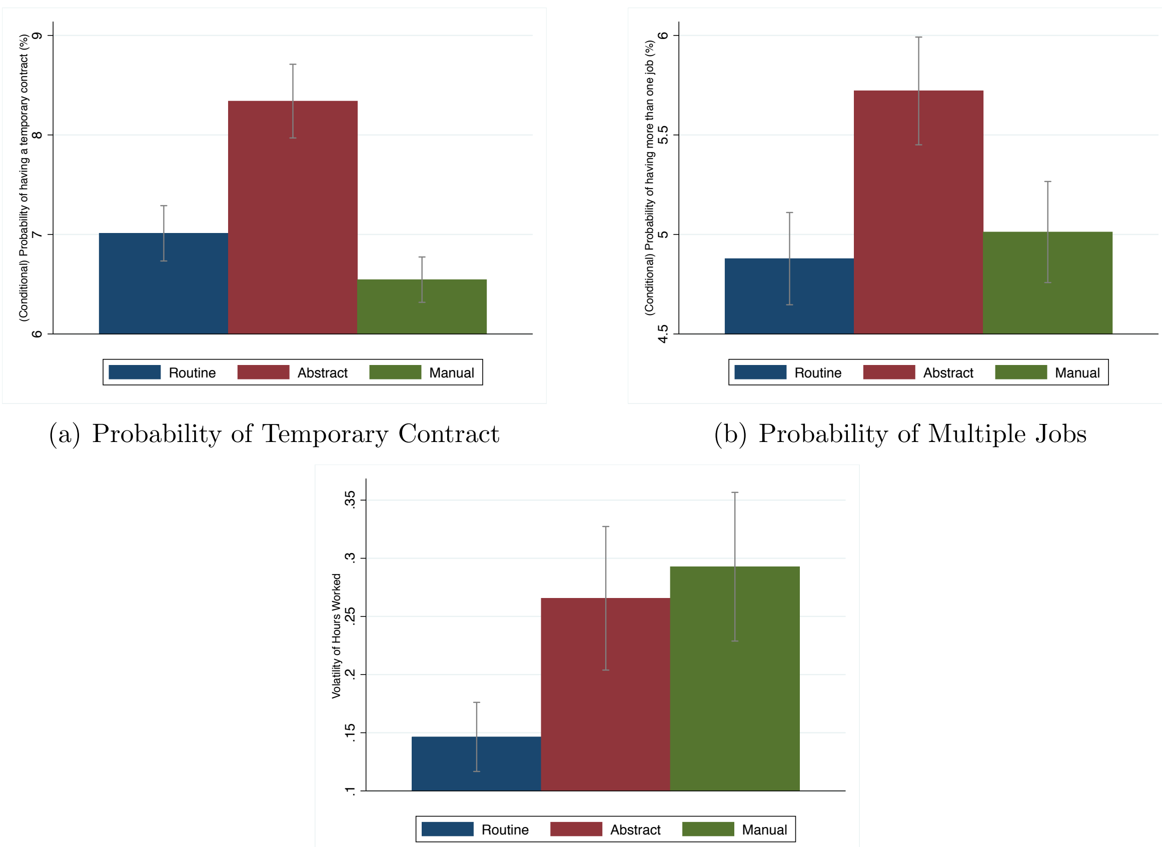
The second measure under consideration is the probability for a worker to have more than one job (i.e. more than one employer) when employed in a specific occupation. As shown in Figure 12(b), abstract workers exhibit a higher (average) probability to have multiple jobs

of the final product and how many times prices where changed in a year. Moreover, the survey also asks the share of workers employed in a routine, abstract or manual occupation. Once considering only respondents to questions on both price updates and workforce composition, we end up with a sample of 3325 firms spread over 10 of the EMU11 countries considered (no data is available for Finland). See https://www.ecb.europa.eu/pub/economic-research/research-networks/html/researcher_wdn.en.html for more information on the survey and variables construction.

[20]See Appendix E.4 for details.

(around 5.7%), whereas the probability for all other jobs is statistically smaller (around 5%). Along with Figure 12(a), this evidence suggests that abstract employment is more uncertain since it depends on short-term contract and multiple employers. This is particularly true for those abstract workers –e.g. designers, architects, lawyers, etc.– whose work arrangement depends more on the delivery of a specific service (service-based employment) or project (project-based employment) rather than on a continuous and binding relationship with a single employer. As explained in Blanchard and Landier (2002), all of this increases the turnover rate and dynamism of the labor market, but at the expenses of more frequent unemployment spells. The last measure considers the volatility of hours worked by occupation,

Fig. 12. Temporary Contracts, Multiple Jobs and Hours Worked



(a) Probability of Temporary Contract

(b) Probability of Multiple Jobs

(c) Volatility of Hours Worked

Note: Figure 12(a) plots the mean (conditional) probability of having a temporary contract (with 95% confidence interval) by occupation (routine, abstract or manual) across countries that joined the EMU before 2002 (Luxembourg excluded). Each cross-country mean is computed considering only periods before the Great Recession (GR) and after the Sovereign Debt Crisis (SDC), according to country-specific business cycle dates. Figure 12(b) plots the mean (conditional) probability of having multiple jobs (with 95% confidence interval) for workers currently employed in a specific occupation (routine, abstract or manual). Figure 12(c) plots the mean volatility of hours worked (with 95% confidence interval) for employees with a full-time job in a specific occupation (routine, abstract or manual). See Appendix E.4 for details.

i.e. the labor intensive margin. In this case, both abstract and manual employment exhibit higher volatility in hours worked with respect to routine employment. This suggests that employers in non-routine markets can more easily adjust employment (in the intensive margins).

To conclude, this evidence suggests that the non-routine labor market –and more particularly the market of abstract jobs– is more *fluid*: workers are more likely to have temporary contracts, multiple-job arrangements and to adjust on the intensive margin. Therefore, employment relocation from the routine to the non-routine market –as explained by job polarization– can explain the overall increase in fluidity in the last two decades.

5.4. Cross-Validation: the Intercept of the PC

The previous section focused on the slope effect of job polarization through the process of relocation of worker to occupations with higher δ. In this section, we investigate the role of polarization on the intercept of the PC.

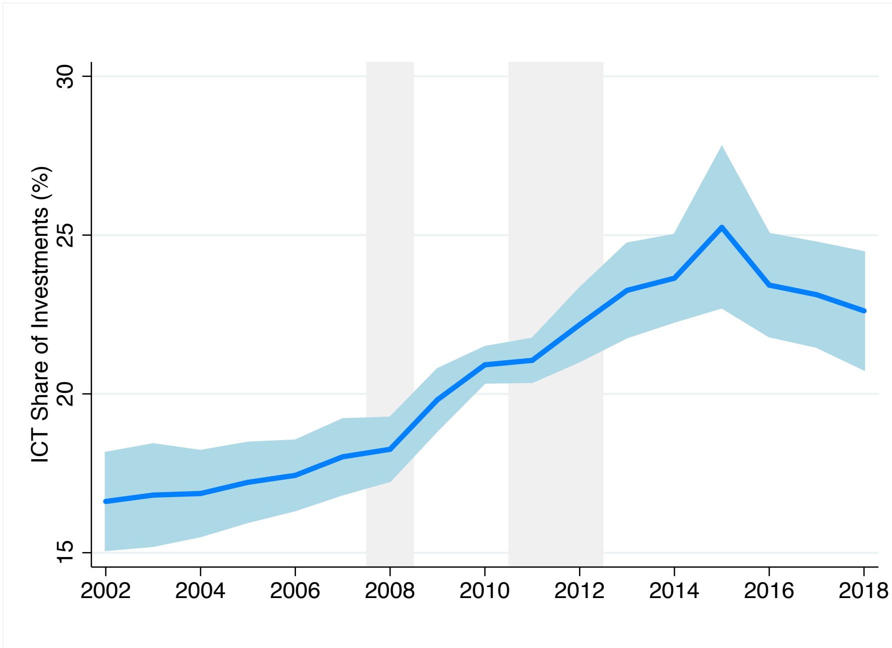
5.4.1. Polarization and Disinflation

The literature on polarization is mostly grounded on the role of technological change for the relocation of workers from less productive (routine) to more productive (non-routine) jobs. In particular, as discussed in Acemoglu and Restrepo (2017), technological change and adoption typically comove with the process of polarization since new technologies (e.g. ICT) better complement non-routine workers. This is what we observe also for the EMU11. In Figure 13, we plot the dynamic of the ICT investment share, a proxy for adoption of non-routine biased technologies. As evident, just after the GR, the rate of ICT adoption deviated from its pre-recession trend.

How does this phenomenon affect inflation? In the context of the model of Blanchard and Galí (2010), an increase in technology should have direct disinflationary effects. This is captured by $-\Psi\gamma\hat{a}_t$, the intercept of the analytical Phillips Curve of equation (10). Therefore, an increase in technology (i.e. $\hat{a}_t > 0$) decreases the level of inflation.

Given this, if we consider polarization as a labor market outcome of technological change, we should observe that countries experiencing larger occupational shifts in favour of more productive (non-routine) jobs also witnessed larger disinflation. This is something we can easily check in the data by looking at the estimates for $After_{i,c} \times Shift^R_{i,c}$ (with $c = \{GR, SDC\}$) from regression (4) in Section 3.3. Avoiding the reporting of all estimates of column (5) of

Fig. 13. ICT Penetration



Note: This figure plots the evolution of the ICT share of total investment (construction investment excluded) across those countries that joined the EMU before 2002 (Luxembourg excluded). ICT investment is measured as the sum of the investment in ICT equipment, computer and software database. The light-blue-shaded area represents the 95% confidence interval. The two grey-shaded areas indicate respectively the periods of the Great Recession and of the Sovereign Debt Crisis as defined by the CEPR Business Cycle Committee. Data is from Eurostat, it is at annual frequency and spans from 2002q1 to 2018q4.

Table 2, here we highlight only the coefficients of interest:

$$\Delta log(p)_{i,t} = [...] - \underset{(0.006)}{0.001} After_{GR} \times Shift_{GR} - \underset{(0.006)}{0.017^{**}} After_{SDC} \times Shift_{SDC}$$
$$R^2 = 0.900 \quad , \quad n = 748.$$

Countries that experienced a larger shift in the occupational structure during the GR exhibited (non-significant) disinflation between the two crisis. On the other hand, the more a country destroyed routine jobs during the SDC the more it (significantly) experienced disinflation afterwards.

5.4.2. Fluidity vs. Technological Change

Through the lens of the model, if the cyclical acceleration of job polarization implies contemporaneously higher productivity (i.e. $\hat{a}_t > 0$) and higher fluidity ($\Delta\delta > 0$), the disinflationary effect is dampened. In fact, the intercept of the PC is also a function of δ through the parameter Ψ, such that an increase in δ decreases Ψ. Formally, the intercept can be written as $-\Psi(\delta)\gamma\hat{a}_t$, where $\Psi'(\delta) < 0$. Hence, in a cross-country comparison, those with similar increases in ICT adoption but bigger increases in δ should have higher inflation.

We can check this in the data. This will corroborate the idea that the main forces explaining the level of inflation (fluidity vs. technology) are actually in place and operates as the theory predicts. To do so, we compare the cross-country level of inflation before the GR and after the SDC, and study how the change in the level of inflation can be explained by an heterogeneous increase in ICT adoption and separation rate. Formally, we estimate this fixed-effect regression:

$$\Delta log(p)_{i,t} = \underset{(0.050)}{2.076^{***}} - \underset{(0.11)}{0.402^{***}} After_{i,SDC} + \underset{(0.002)}{0.005^{*}} After_{i,SDC} \times \Delta\delta_i - \underset{(0.001)}{0.013^{***}} After_{i,SDC} \times \Delta ICT_i$$

$$R^2 = 0.426 \quad , \quad n = 517$$

In periods before the GR, the average inflation across EMU11 countries was 2.07%. On the other hand, the level of inflation decreased on average by 0.40pp in periods after the SDC, i.e. there was disinflation. Such phenomenon is mitigated in countries experiencing a larger percentage increase in the aggregate separation rate between 2002 and 2018 ($\Delta\delta_i > 0$), whereas it exacerbates in countries experiencing a larger percentage increase in ICT adoption in the same years ($\Delta ICT_i > 0$).

In light of this, we conclude that the role of technological change and fluidity in the data operates on the level of inflation as the theory predicts. This cross-validates the role of both channels (fluidity and technology) to explain how job polarization can differently affect the slope of the price PC (through fluidity only) and the intercept (through both fluidity and technology).

6. Conclusions

In the last twenty years, labor markets across the European Monetary Union (EMU) have dramatically changed composition: the share of routine employment (clerical, craft and plant occupations) has shrunk in favour of abstract employment (professional, managerial occupations). At the same time, the same economies experienced a flattening of the price Phillips Curve (PC). This paper combines these two apparently unrelated events and proves that occupational composition and differences across jobs have important implications for the structural relationship between unemployment and inflation.

In the empirical part of the paper, we demonstrate that countries experiencing bigger changes in the occupational structure exhibit a flatter price (and wage) PC. By exploiting the exogenous acceleration of polarization induced by recessions, we show that changes in job composition occurred during the Great Recession and Sovereign Debt Crisis are responsible for a fourth of the flattening of the PC observed between 2002 and 2018.

In the theoretical part of the paper, we show that this is driven by the transformation of labor market characteristics induced by job polarization. Using the analytical properties of Blanchard and Galí (2010), we prove that a key factor affecting the slope of the PC is the *fluidity* of the labor market, i.e. the rate at which workers separate from employers and find other jobs. Hence, we show that higher *fluidity* leads to a flatter PC as the labor demand becomes more elastic to wages.

We conclude by providing micro-evidence supporting the implications of our theoretical results. The market of abstract jobs is on average more fluid than the market of routine jobs: it has higher separation and hiring rate, it makes more frequent use of temporary contracts and multiple-job arrangements, and it adjusts more frequently at the intensive margin. Therefore, the overall transition from routine to non-routine occupations have increased the overall fluidity of the labor market in EMU. This has decreased the elasticity of prices to unemployment.

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APPENDIX (not for publication)

Appendix A. Data

A.1. Employment Data

Eurostat gives both information on employment shares and employment levels for several countries and age-groups. We consider only time-series for Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal and Spain, but not for Luxembourg since this has several points in the series defined as unreliable by the Eurostat itself. Thus, we refer to this group of eleven countries as the EMU11. Occupations are coded according to International 2008 Standard Classification of Occupations 2008 (ISCO-08) in 14 groups. We consider employment series for workers in the 15-74 age bracket. Unfortunately, there is a statistical break in the employment-occupation series in 2011q1 due to changes in occupation classification and definition. We correct for this such that employment shares still sum to one and the aggregate unemployment rate does not change in the period of the reclassification. Hence, we follow Jaimovich and Siu (2020) and group these 14 jobs in three major categories based on their task-content. Hence, we define (i) managers, professionals, technical and associate professionals, armed force employees as abstract workers; (ii) clerical, craft and plant employees as routine workers; (iii) elementary, skilled agricultural, forestry and fishery employees, sales and service workers as manual workers. Under this grouping, we finally build employment shares series for each major category. Figure A.1, A.2 and A.3 plot employment shares for each occupation and country, for periods between 2002q1 and 2018q4.

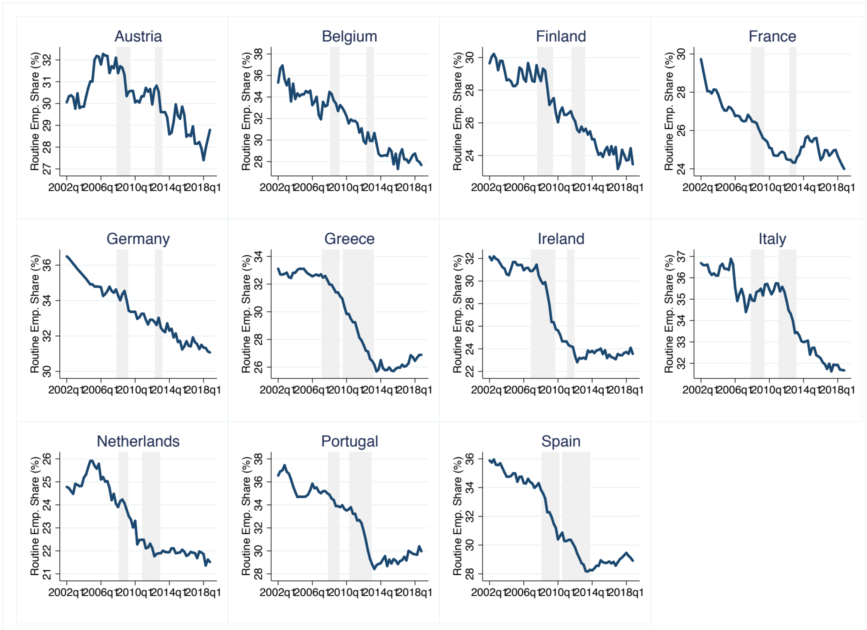
A.2. Unemployment Data

Eurostat provides quarterly series of the unemployment rate for population in the 15-74 age bracket by country. Hence, we consider data for Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal and Spain. Figure A.4 plots the unemployment rate for each country between 2002q1 and 2018q4.

A.3. Country-specific Business Cycle Dates

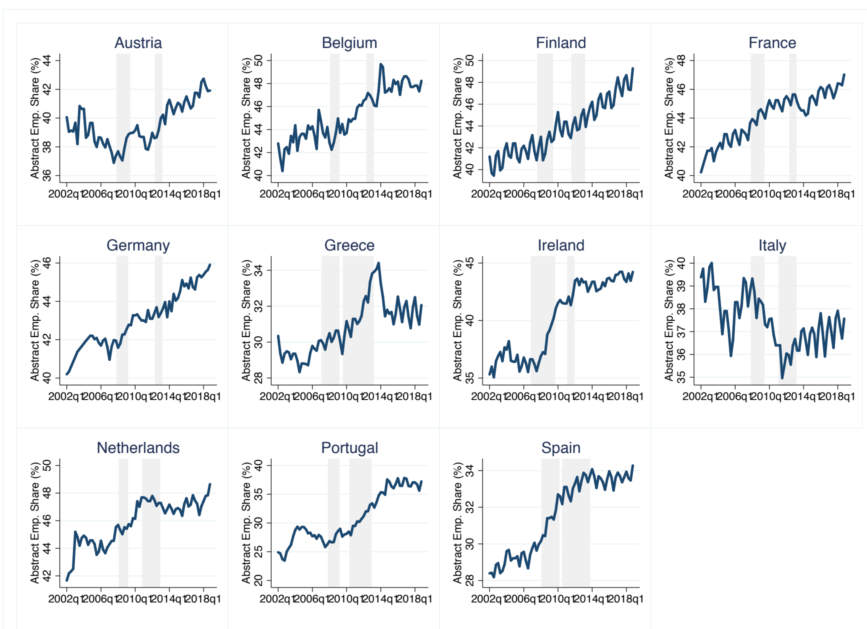
Typically, a recession is defined as a time-window for which GDP falls for at least two consecutive quarters. According to this, the peak of a recession is the date before the GDP contraction begins and the trough is the last date for which GDP growth rate is still

Fig. A.1. Routine Employment Share by EMU11 country



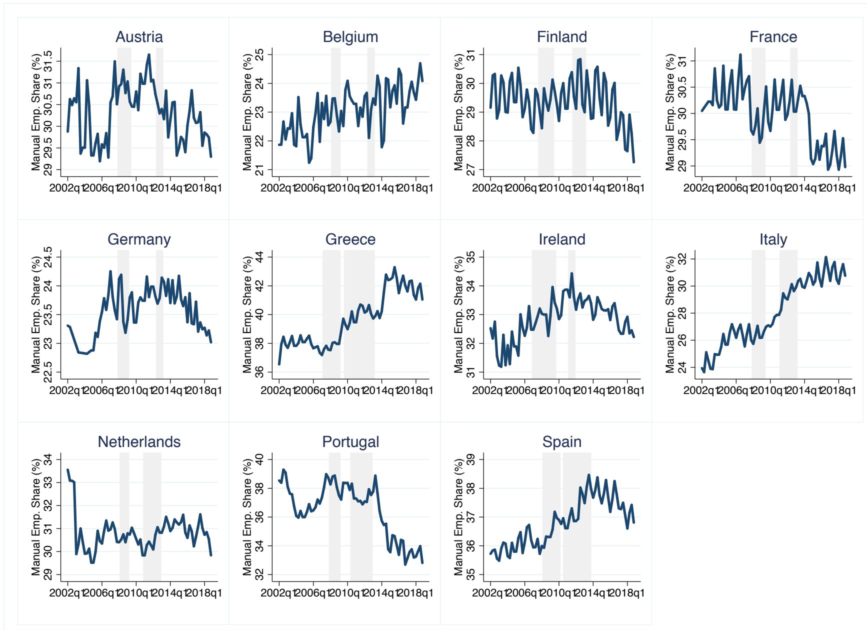
Note: The figure plots the routine employment share for each country that joined the EMU before 2002 (Luxembourg excluded). The routine employment share is defined as the sum of employment in clerical, craft a plant occupations over total employment. Data is at quarterly frequency and comes from EUROSTAT. The two grey-shaded areas indicate respectively the periods of the Great Recession (GR) and of the Sovereign Debt Crisis (SDC) specific to each country.

Fig. A.2. Abstract Employment Share by EMU11 country



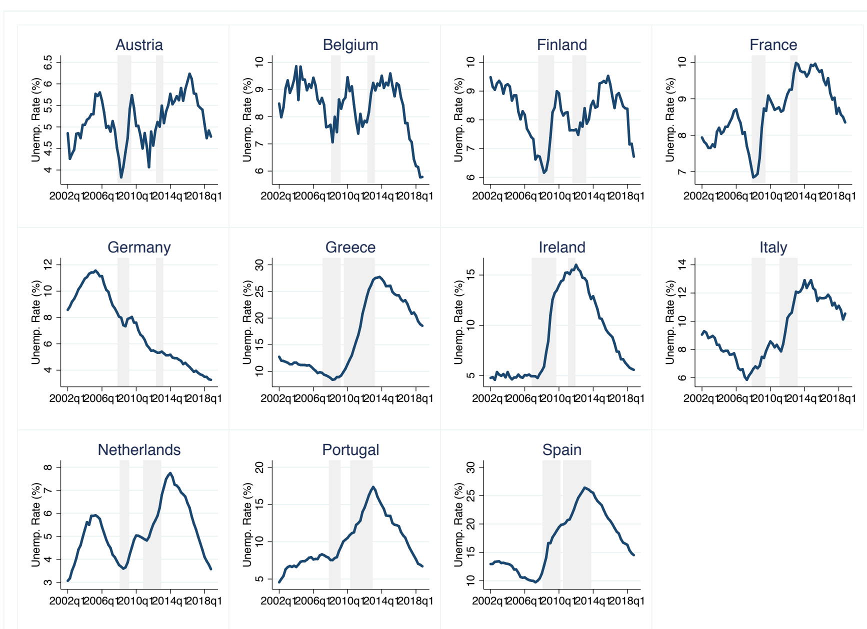
Note: The figure plots the abstract employment share for each country that joined the EMU before 2002 (Luxembourg excluded). The abstract employment share is defined as the sum of employment in managerial, professional, technical and associate professional, and armed force occupations over total employment. Data is at quarterly frequency and comes from EUROSTAT. The two grey-shaded areas indicate respectively the periods of the Great Recession (GR) and of the Sovereign Debt Crisis (SDC) specific to each country.

Fig. A.3. Manual Employment Share by EMU11 country



Note: The figure plots the manual employment share for each country that joined the EMU before 2002 (Luxembourg excluded). The routine employment share is defined as the sum of employment in skilled agricultural, forestry and fishery occupations, and sales and service occupations over total employment. Data is at quarterly frequency and comes from EUROSTAT. The two grey-shaded areas indicate respectively the periods of the Great Recession (GR) and of the Sovereign Debt Crisis (SDC) specific to each country.

Fig. A.4. Unemployment Rate by EMU11 country



Note: The figure plots the unemployment rate for each country that joined the EMU before 2002 (Luxembourg excluded). Data is at quarterly frequency and comes from EUROSTAT. The two grey-shaded areas indicate respectively the periods of the Great Recession (GR) and of the Sovereign Debt Crisis (SDC) specific to each country.

negative. In this paper, we slightly depart from this standard definition. As usual, we define as a recession a period in which GDP falls for at least two consecutive quarters such that the peak of the recession is identified as the last quarter before which real GDP starts falling. However, we define the trough of the recession as the last quarter after which real GDP starts increasing again for at least two consecutive quarters. In case of two consecutive recessions, this definition is more convenient than the standard one because (i) it allows us to consider as a unique recession two consecutive GDP contractions when distanced only by one quarter of GDP expansion, (ii) and therefore to exclude minor changes in the business cycle phase. Table A.1 reports business cycle dates backed-up according to our definition.

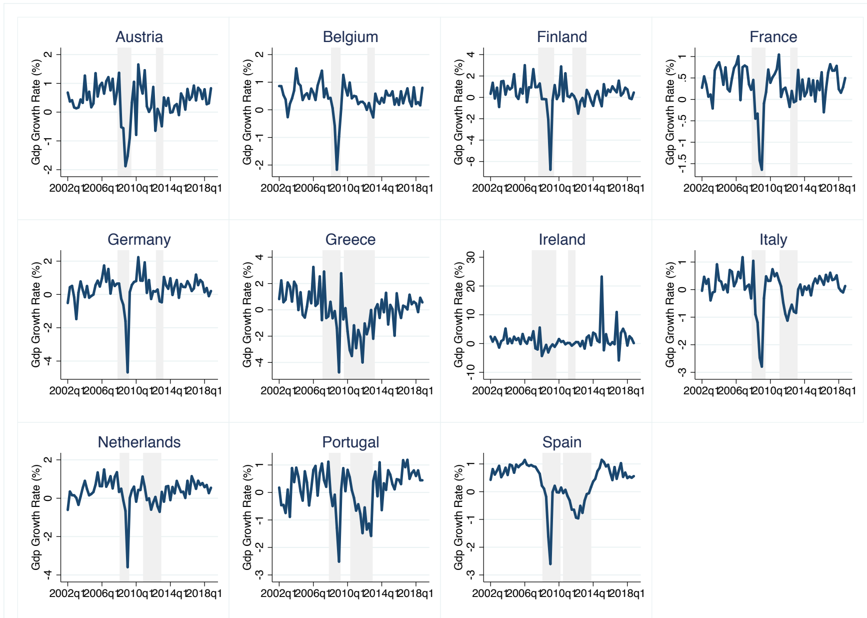
Table A.1: Business Cycle Dates for EMU11 countries

COUNTRY		Great Recession	Sovereign Debt Crisis
Austria	peak	2008q1	2012q3
	trough	2009q2	2013q1
Belgium	peak	2008q2	2012q3
	trough	2009q1	2013q1
Finland	peak	2007q4	2011q4
	trough	2009q2	2013q1
France	peak	2008q1	2012q3
	trough	2009q2	2013q1
Germany	peak	2008q1	2012q3
	trough	2009q1	2013q1
Greece	peak	2007q2	2009q4
	trough	2009q1	2013q1
Ireland	peak	2007q1	2011q2
	trough	2009q3	2011q4
Italy	peak	2008q1	2011q2
	trough	2009q2	2013q1
Netherlands	peak	2008q2	2011q1
	trough	2009q1	2012q4
Portugal	peak	2008q1	2010q3
	trough	2009q1	2012q4
Spain	peak	2008q2	2010q4
	trough	2010q1	2013q3

A.4. Core Inflation Data

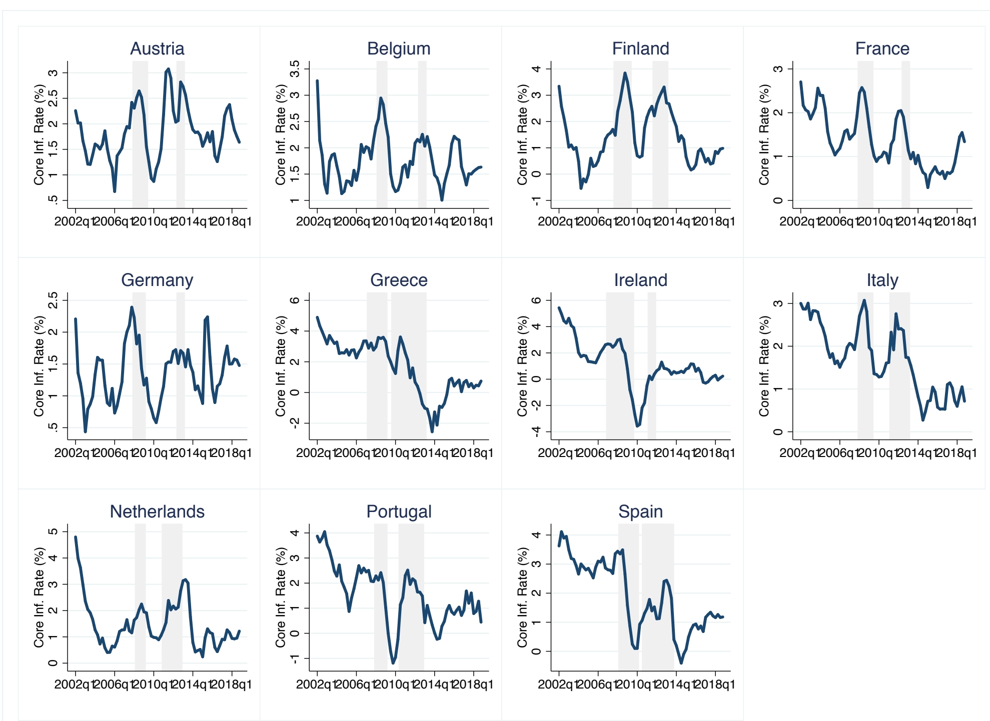
From the ECB Data Warehouse we collect information on prices and expected inflation. In particular, we use the Harmonized Consumer Price Index (excluded energy and food) to

Fig. A.5. GDP Growth Rate by EMU11 country



Note: The figure Gdp growth rate for each country. Data is at quarterly frequency and comes from EUROSTAT. The two grey-shaded areas indicate respectively the periods of the Great Recession (GR) and of the Sovereign Debt Crisis (SDC) specific to each country.

Fig. A.6. Core Inflation by EMU11 country



Note: The figure plots the year-on-year core inflation rate (food and energy excluded) for each country that joined the EMU before 2002 (Luxembourg excluded). Data is at quarterly frequency and comes from the ECB Data Warehouse. The two grey-shaded areas indicate respectively the periods of the Great Recession (GR) and of the Sovereign Debt Crisis (SDC) specific to each country.

build year-on-year inflation rate at quarterly frequency. Figure A.6 plots core inflation for Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal and Spain.

Appendix B. The Role of Manufacturing and Construction

B.1. Trend Decomposition

Consider the time series of the share of manufacturing and construction employment and the time series of the share of value added from these two sectors. How do these series behave in the long-run and over the cycle? To answer this question, we repropose the analysis of Section 2.2:

$$Y_{i,t} = \alpha_i + \beta_1 time + \beta_2 phase_{i,t} + \beta_3 phase_{i,t} \times time + \epsilon_{i,t} \tag{12}$$

where α_i is the country fixed effect, $time$ is the number of quarters and $phase_i$ = [Before GR, GR, Between GR and SDC, SDC, After SDC] is a vector of mutually exclusive dummies taking value one if, at time t, country i is currently in that cyclical phase. The $phase_i$ time-dummy is country specific, i.e. we use country specific business cycle dates to define the beginning and the end of each recession, as explained in Section 2.1. $\epsilon_{i,t}$ is the error term. $Y_{i,t}$ is either the manufacturing and construction employment share or the share of value added from the same two sectors. Table B.1 shows results. As from column (1), the employment share in manufacturing and construction has been following a negative trend in the period 2002q1-2018q4. In column (2), we decompose this trend and find that the GR has actually accelerated it. In between the GR and SDC, the decline of this employment share was not significantly different from the pre-GR trend. Although the coefficient of the interaction term is negative, the SDC did not significantly affect the trend of manufacturing and construction employment. On the other way around, in post-SDC periods the slope of the trend changes with respect to pre-GR periods. In particular, in post-SDC periods the share of manufacturing and construction employment is basically stable.

We find a similar pattern when considering the share of value added from manufacturing and construction as dependent variable. As shown in column (3), the share of value added in these two sectors is declining over time. When we decompose this trend for each phase of the business cycle, we find that the GR has dramatically accelerated the trend. In between the GR and SDC, the decline of the value added share in not significantly different from pre-GR periods. Although the coefficient on the interaction term is negative, the SDC does not significantly affect the trend. Conversely, after the SDC, the decline in the share of value added from manufacturing and construction stops.

All in all, this evidence suggests that also the share of employment and value added in manufacturing and construction follows a negative trend (at least until the end of the SDC) and the cycle. However, differently from the behavior of the routine employment share described in Section 2.2, only the GR significantly accelerates the process of destruction of manufacturing and construction jobs and the reorganization of the economy away from these two sectors.

Table B.1: Trend Decomposition of Manufacturing and Construction Employment Share and Value Added across the EMU11

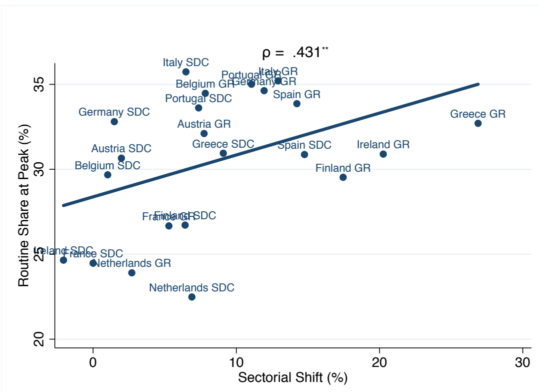
	(1) Share^{Manuf}	(2) Share^{Manuf}	(3) VA.Share^{Manuf}	(4) VA.Share^{Manuf}
time	-0.127***	-0.085***	-0.100***	-0.070*
	(0.017)	(0.018)	(0.024)	(0.033)
GR × *time*		-0.438***		-0.388***
		(0.065)		(0.096)
Between GR and SDC × *time*		0.021		0.119
		(0.051)		(0.066)
SDC × *time*		-0.105		-0.063
		(0.095)		(0.069)
After SDC × *time*		0.092**		0.066***
		(0.034)		(0.019)
Observations	736	736	748	748
R^2	0.724	0.801	0.538	0.609
Country FE	Yes	Yes	Yes	Yes
Controls	No	No	No	No

Note: Standard errors in parentheses, clustered at country-level. The unit of observation in column (1) and (2) is the share of manufacturing and construction employment. The unit of observation in column (3) and (4) is the share of value added from manufacturing and construction. The variable *time* is the number of quarters. GR is a country-specific dummy variable taking value one for periods in which a country is experiencing the Great Recession. Between GR and SDC is a country-specific dummy variable taking value one for periods in which a country is in between the GR and the Sovereign Debt Crisis. SDC is a country-specific dummy variable taking vale one for periods in which a country is experiencing the Sovereign Debt Crisis. After SDC is a country-specific dummy taking value one for periods after the Sovereign Debt Crisis. *, **, *** indicate significance at 90%, 95% and 99% level.

B.2. Sectorial Shift and ex-ante Country Characteristics

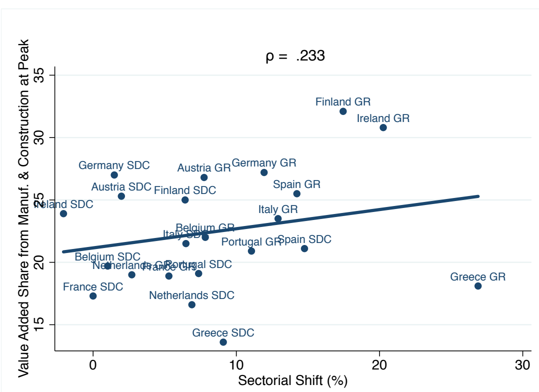
Symmetrically to what shown in Section 3.1, here we study whether our measure of change in sectorial composition $Shift_{i,c}^{Manuf}$ correlates with country-specific characteristics as observed before each recession $c = \{GR, SDC\}$ (see Figure B.1(a) to B.1(d)). Differently from what found in Section 3.1, here we find that countries with higher level of routine employment at the peak, with faster decline in routine employment, and with higher level of core inflation at the peak of each recession tend to experience significantly a larger shift of the value added share from manufacturing and construction in the upcoming recession. Figure B.2(a) and B.2(b) show that our measure of sectorial shift correlates well with the size and length of each recession.

Fig. B.1. Pre-recession Characteristics vs. Sectorial Shift

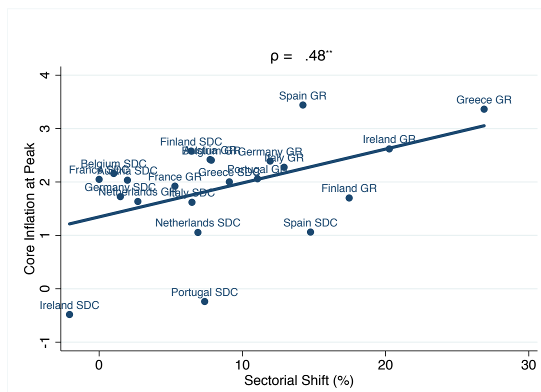


(a) Pre-recession Routine Emp.

(b) Pre-recession Routine Emp. Growth



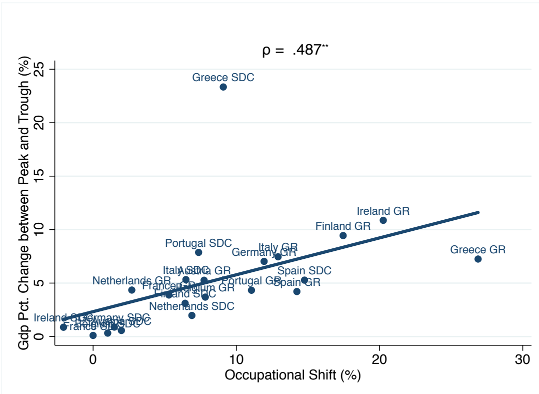
(c) Pre-recession Sectorial Composition



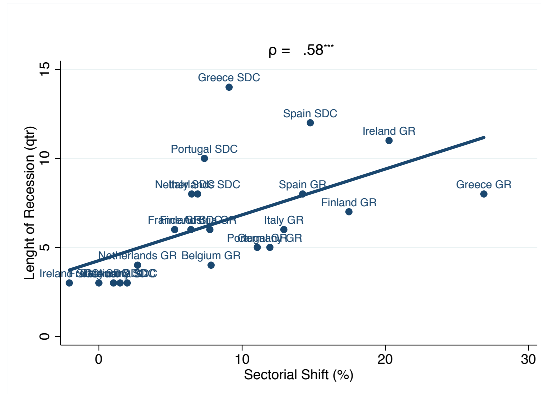
(d) Pre-recession Inflation

Note: For all subplots, the x-axis shows the sectorial shift (in percentage) experienced during both downturns by each country that joined the EMU before 2002 (Luxembourg excluded). Each sectorial shift is defined as the percentage change in routine employment share between the peak and trough of each recession, according to country-specific business cycle dates. In Figure B.1(a), the y-axis is the level of the routine employment share, measured at the peak of the Great Recession (GR) and Sovereign Debt Crisis (SDC). In Figure B.1(b), the y-axis is the long-run growth rate of the routine employment share, measured as the slope of the linear trend fitting the routine share series until the GR and SDC respectively. In Figure B.1(c), the y-axis is the value added from manufacturing and construction (as percentage of Gdp), measured at the peak of the GR and SDC. In Figure B.1(d), the y-axis is the level of core inflation, measured at the peak of the GR and SDC. On top of each graph, the correlation (ρ) between variables is reported along with its significance level. *, **, *** indicate significance at 90%, 95% and 99% level.

Fig. B.2. Duration and Size of the Recession vs. Sectorial Shift



(a) GDP Contraction



(b) Recession Duration

Note: For both subplots, the x-axis shows the sectorial shift (in percentage) experienced during both downturns by each country that joined the EMU before 2002 (Luxembourg excluded). Each sectorial shift is defined as the percentage change in routine employment share between the peak and trough of each recession, according to country-specific business cycle dates. In Figure B.2(a), the y-axis is the GDP percentage change, measured between the peak and trough of the Great Recession (GR) and Sovereign Debt Crisis (SDC). In Figure B.2(b), the y-axis is duration (in quarters) of each recession, measured as the number of quarters between peak and trough. On top of each graph, the correlation (ρ) between variables is reported along with its significance level. *, **, *** indicate significance at 90%, 95% and 99% level.

Appendix C. Model Derivation

Here we derive the price Phillips Curve from Blanchard and Galí (2010) in log-deviations from steady state (lower case letters with hats) in the reduced and extended formulation. Equation (8) becomes

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \lambda \widehat{mc}_t \quad \text{where} \quad \lambda \equiv \frac{(1-\beta\theta)(1-\theta)}{\theta} \tag{C.13}$$

and therefore we need to focus on the expression for the marginal cost.

C.1. Log-linearized Phillips Curve: Reduced Formulation

The marginal cost function can be written as:

$$MC_t = \Theta A_t^{-\gamma} + Bx_t^{\alpha} - \beta(1-\delta)E_t\left\{\frac{C_t}{C_{t+1}}\frac{A_{t+1}}{A_t}Bx_{t+1}^{\alpha}\right\}$$

$$MC\exp(\widehat{mc}_t) =$$
$$= \Theta A^{-\gamma}\exp(-\gamma\widehat{a}_t) + Bx^{\alpha}\exp(\alpha\widehat{x}_t) - \beta(1-\delta)Bx^{\alpha}\exp((\widehat{c}_t - \widehat{a}_t) - (\widehat{c}_{t+1} - \widehat{a}_{t+1}) + \alpha\widehat{x}_{t+1})$$

which in log-deviation gives:

$$\begin{aligned}&MC + MC\widehat{mc}_t = \Theta A^{-\gamma} - \Theta A^{-\gamma}\gamma\widehat{a}_t + \\ &\quad + Bx^{\alpha} + Bx_t^{\alpha}\alpha\widehat{x}_t - \beta(1-\delta)Bx^{\alpha} - \beta(1-\delta)Bx^{\alpha}((\widehat{c}_t - \widehat{a}_t) - (\widehat{c}_{t+1} - \widehat{a}_{t+1}) + \alpha\widehat{x}_{t+1}).\end{aligned}$$

In steady state, the latter can be written as

$$\begin{aligned}MC &= \Theta A^{-\gamma} + Bx^{\alpha} - \beta(1-\delta)Bx^{\alpha} \\ MC &= \Theta A^{-\gamma} + Bx^{\alpha}(1-\beta(1-\delta)) \quad \text{but} \quad \Theta = \left(\frac{1}{\mu} - (1-\beta(1-\delta)\right)Bx^{\alpha})A^{\gamma} \\ MC &= \frac{1}{\mu} - (1-\beta(1-\delta)\,Bx^{\alpha}) + (1-\beta(1-\delta))Bx^{\alpha} \\ MC &= \frac{1}{\mu}.\end{aligned}$$

This becomes

$$\begin{aligned}\frac{1}{\mu}\widehat{mc}_t = &-\left(\frac{1}{\mu} - (1-\beta(1-\delta)\right)Bx^{\alpha})\gamma\widehat{a}_t + \\ &\qquad + Bx^{\alpha}\alpha\widehat{x}_t - \beta(1-\delta)Bx^{\alpha}((\widehat{c}_t - \widehat{a}_t) - (\widehat{c}_{t+1} - \widehat{a}_{t+1}) + \alpha\widehat{x}_{t+1}).\end{aligned}$$

Remembering that $g = Bx^{\alpha}$, the latter becomes

$$\widehat{mc}_t = -\left(1 - \mu\left(1-\beta(1-\delta)\right)g\right)\gamma\widehat{a}_t + \mu g\alpha\widehat{x}_t - \beta(1-\delta)g\mu((\widehat{c}_t - \widehat{a}_t) - (\widehat{c}_{t+1} - \widehat{a}_{t+1}) + \alpha\widehat{x}_{t+1})$$

which implies

$$\widehat{mc}_t = \alpha g\mu\widehat{x}_t - \beta(1-\delta)g\mu E_t\left\{(\widehat{c}_t - \widehat{a}_t) - (\widehat{c}_{t+1} - \widehat{a}_{t+1}) + \alpha\widehat{x}_{t+1}\right\} - \Phi\gamma\widehat{a}_t. \tag{C.14}$$

where $\Phi = \frac{\mu W}{A} = 1 - (1-\beta(1-\delta))g\mu < 1$

C.2. Log-linearized Phillips Curve: Extended Formulation

We start by changing the formulation of $\Theta = \left(\frac{1}{\mu} - (1-\beta(1-\delta)\right)Bx^{\alpha})A^{\gamma}W^{-\gamma}$.

Therefore, the marginal cost can be written as:

$$MC_t = \Theta A_t^{-\gamma} W_{t-1}^{\gamma} + Bx_t^{\alpha} - \beta(1-\delta)E_t\left\{\frac{C_t}{C_{t+1}}\frac{A_{t+1}}{A_t}Bx_{t+1}^{\alpha}\right\}$$

$$MC\exp(\widehat{mc}_t) =$$

$$= \Theta A^{-\gamma}W^{\gamma}\exp(-\gamma\widehat{a}_t + \gamma\widehat{w}_{t-1}) + Bx^{\alpha}\exp(\alpha\widehat{x}_t) - \beta(1-\delta)Bx^{\alpha}\exp((\widehat{c}_t - \widehat{a}_t) - (\widehat{c}_{t+1} - \widehat{a}_{t+1}) + \alpha\widehat{x}_{t+1})$$

$$MC + MC\widehat{mc}_t = \Theta A^{-\gamma}W^{\gamma} - \Theta A^{-\gamma}W^{\gamma}\gamma\widehat{a}_t + \Theta A^{-\gamma}W^{\gamma}\gamma\widehat{w}_{t-1} + Bx^{\alpha} +$$

$$Bx_t^{\alpha}\alpha\widehat{x}_t - \beta(1-\delta)Bx^{\alpha} - \beta(1-\delta)Bx^{\alpha}((\widehat{c}_t - \widehat{a}_t) - (\widehat{c}_{t+1} - \widehat{a}_{t+1}) + \alpha\widehat{x}_{t+1})$$

which in steady state becomes

$$MC = \Theta A^{-\gamma}W^{\gamma} + Bx^{\alpha} - \beta(1-\delta)Bx^{\alpha} \quad \text{but} \quad W = \Theta^{\frac{1}{1-\gamma}}A$$

$$MC = \Theta A^{-\gamma}W^{\gamma} + Bx^{\alpha}(1-\beta(1-\delta)) \quad \text{but} \quad \Theta = \left(\frac{1}{\mu} - (1-\beta(1-\delta)\right)Bx^{\alpha})A^{\gamma}W^{-\gamma}$$

$$MC = \frac{1}{\mu} - (1-\beta(1-\delta)\,Bx^{\alpha}) + (1-\beta(1-\delta))Bx^{\alpha}$$

$$MC = \frac{1}{\mu}.$$

We therefore can rewrite it as:

$$MC\widehat{mc}_t =$$

$$= -\Theta A^{-\gamma}W^{\gamma}\gamma\widehat{a}_t + \Theta A^{-\gamma}W^{\gamma}\gamma\widehat{w}_{t-1} + Bx_t^{\alpha}\alpha\widehat{x}_t - \beta(1-\delta)Bx^{\alpha}((\widehat{c}_t - \widehat{a}_t) - (\widehat{c}_{t+1} - \widehat{a}_{t+1}) + \alpha\widehat{x}_{t+1})$$

$$\frac{1}{\mu}\widehat{mc}_t = -\left(\frac{1}{\mu} - (1-\beta(1-\delta)\right)Bx^{\alpha})\gamma\widehat{a}_t +$$

$$+\left(\frac{1}{\mu} - (1-\beta(1-\delta)\right)Bx^{\alpha})\gamma\widehat{w}_{t-1} + Bx^{\alpha}\alpha\widehat{x}_t - \beta(1-\delta)Bx^{\alpha}((\widehat{c}_t - \widehat{a}_t) - (\widehat{c}_{t+1} - \widehat{a}_{t+1}) + \alpha\widehat{x}_{t+1}).$$

Then remembering that $g = Bx^{\alpha}$

$$\widehat{mc}_t = -\left(1 - \mu\left(1-\beta(1-\delta)\right)g\right)\gamma\widehat{a}_t + \left(1 - \mu\left(1-\beta(1-\delta)\right)g\right)\gamma\widehat{w}_{t-1} +$$

$$+ \mu g\alpha\widehat{x}_t - \beta(1-\delta)g\mu((\widehat{c}_t - \widehat{a}_t) - (\widehat{c}_{t+1} - \widehat{a}_{t+1}) + \alpha\widehat{x}_{t+1})$$

we arrive to

$$\widehat{mc}_t = \alpha g\mu\widehat{x}_t - \beta(1-\delta)g\mu E_t\left\{(\widehat{c}_t - \widehat{a}_t) - (\widehat{c}_{t+1} - \widehat{a}_{t+1}) + \alpha\widehat{x}_{t+1}\right\} - \Phi\gamma\widehat{a}_t + \Phi\gamma\widehat{w}_{t-1}. \quad \text{(C.15)}$$

Now consider:

$$\delta \widehat{x}_t = \widehat{n}_t - (1-\delta)(1-x)\,\widehat{n}_{t-1} \tag{C.16}$$

$$\widehat{c}_t = \widehat{a}_t + \frac{1-g}{1-\delta g}\widehat{n}_t + \frac{g(1-\delta)}{1-\delta g}\widehat{n}_{t-1} - \frac{\alpha g}{1-\delta g}\delta\widehat{x}_t \tag{C.17}$$

$$\widehat{c}_t = E_t\{\widehat{c}_{t+1}\} - (i_t - E_t\{\pi_{t+1}\} - \rho) \quad \text{where} \quad \rho = -\log\beta \tag{C.18}$$

$$\widehat{u}_t = -(1-u)\widehat{n}_t \quad \text{implying} \quad \widehat{n}_t = -\frac{1}{(1-u)}\widehat{u}_t \tag{C.19}$$

which combined with equation (C.16) becomes

$$\begin{aligned}
\delta\widehat{x}_t &= -\frac{1}{(1-u)}\widehat{u}_t + \frac{(1-\delta)(1-x)}{(1-u)}\widehat{u}_{t-1} \\
\delta(1-u)\widehat{x}_t &= -\widehat{u}_t + (1-\delta)(1-x)\,\widehat{u}_{t-1}.
\end{aligned} \tag{C.20}$$

Combining equation (C.16) with equation (C.17) gives:

$$\begin{aligned}
\widehat{c}_t &= \widehat{a}_t + \frac{1-g}{1-\delta g}\widehat{n}_t + \frac{g(1-\delta)}{1-\delta g}\widehat{n}_{t-1} - \frac{\alpha g}{1-\delta g}\widehat{n}_t + \frac{\alpha g}{1-\delta g}(1-\delta)(1-x)\,\widehat{n}_{t-1} \\
\widehat{c}_t &= \widehat{a}_t + \frac{1-g-\alpha g}{1-\delta g}\widehat{n}_t + \frac{g(1-\delta)(1+\alpha(1-x))}{1-\delta g}\widehat{n}_{t-1}
\end{aligned} \tag{C.21}$$

which can be rewritten as:

$$\widehat{c}_t = \widehat{a}_t + \xi_0\widehat{n}_t + \xi_1\widehat{n}_{t-1} \tag{C.22}$$

where

$$\begin{aligned}
\xi_0 &= \frac{1-g(1+\alpha)}{1-\delta g} \\
\xi_1 &= \frac{g(1-\delta)(1+\alpha(1-x))}{1-\delta g}.
\end{aligned}$$

Now combine equation (C.21) with equation (C.16) into equation (C.15):

$$\widehat{mc}_t = \alpha g\mu\widehat{x}_t - \beta(1-\delta)g\mu E_t\{(\widehat{c}_t - \widehat{a}_t) - (\widehat{c}_{t+1} - \widehat{a}_{t+1}) + \alpha\widehat{x}_{t+1}\} - \Phi\gamma\widehat{a}_t$$

$$\widehat{mc}_t = \alpha g\mu\left(\frac{\widehat{n}_t - (1-\delta)(1-x)\widehat{n}_{t-1}}{\delta}\right) +$$

$$- \beta(1-\delta)g\mu E_t\left\{(\xi_0\widehat{n}_t + \xi_1\widehat{n}_{t-1}) - (\xi_0\widehat{n}_{t+1} + \xi_1\widehat{n}_t) + \alpha\left(\frac{\widehat{n}_{t+1} - (1-\delta)(1-x)\widehat{n}_t}{\delta}\right)\right\} - \Phi\gamma\widehat{a}_t$$

$$\widehat{mc}_t = \frac{\alpha g\mu}{\delta}\widehat{n}_t - \frac{\alpha g\mu}{\delta}(1-\delta)(1-x)\widehat{n}_{t-1} +$$

$$- \beta(1-\delta)g\mu E_t\left\{(\xi_0 - \xi_1)\widehat{n}_t + \xi_1\widehat{n}_{t-1} - \xi_0\widehat{n}_{t+1} + \frac{\alpha}{\delta}\widehat{n}_{t+1} - \frac{\alpha}{\delta}(1-\delta)(1-x)\widehat{n}_t\right\} - \Phi\gamma\widehat{a}_t$$

$$\widehat{mc}_t = \frac{\alpha g\mu}{\delta}\widehat{n}_t - \frac{\alpha g\mu}{\delta}(1-\delta)(1-x)\widehat{n}_{t-1} +$$

$$- \beta(1-\delta)g\mu E_t\left\{\left(-\frac{\alpha}{\delta}(1-\delta)(1-x) + \xi_0 - \xi_1\right)\widehat{n}_t + \xi_1\widehat{n}_{t-1} - \left(\xi_0 - \frac{\alpha}{\delta}\right)\widehat{n}_{t+1}\right\} - \Phi\gamma\widehat{a}_t$$

$$\widehat{mc}_t = \left(\frac{\alpha g\mu}{\delta} + \beta(1-\delta)g\mu\left[\frac{\alpha}{\delta}(1-\delta)(1-x) - \xi_0 + \xi_1\right]\right)\widehat{n}_t +$$

$$- \left[\frac{\alpha g\mu}{\delta}(1-\delta)(1-x) + \beta(1-\delta)g\mu\xi_1\right]\widehat{n}_{t-1} + \beta(1-\delta)g\mu\left(\xi_0 - \frac{\alpha}{\delta}\right)E_t\{\widehat{n}_{t+1}\} - \Phi\gamma\widehat{a}_t$$

$$\widehat{mc}_t = h_0\widehat{n}_t - h_1\widehat{n}_{t-1} - h_F E_t\{\widehat{n}_{t+1}\} - \Phi\gamma\widehat{a}_t$$

where:

$$h_0 \equiv \frac{\alpha g\mu}{\delta}\left[1 + \beta(1-\delta)^2(1-x)\right] + \beta(1-\delta)g\mu(\xi_1 - \xi_0)$$

$$h_1 \equiv \frac{\alpha g\mu}{\delta}(1-\delta)(1-x) - \beta(1-\delta)g\mu\xi_1$$

$$h_F \equiv \beta(1-\delta)g\mu\left(\frac{\alpha}{\delta} - \xi_0\right).$$

Now, using the fact that $\widehat{n}_t = -\frac{1}{(1-u)}\widehat{u}_t$, we can with the marginal cost as:

$$\widehat{mc}_t = h_0\left(-\frac{1}{(1-u)}\widehat{u}_t\right) - h_1\left(-\frac{1}{(1-u)}\widehat{u}_{t-1}\right) - h_F E_t\left\{-\frac{1}{(1-u)}\widehat{u}_{t+1}\right\} - \Phi\gamma\widehat{a}_t$$

$$\widehat{mc}_t = -\frac{h_0}{(1-u)}\widehat{u}_t + \frac{h_1}{(1-u)}\widehat{u}_{t-1} + \frac{h_F}{(1-u)}E_t\{\widehat{u}_{t+1}\} - \Phi\gamma\widehat{a}_t$$

$$\widehat{mc}_t = -\frac{h_0}{(1-u)}\widehat{u}_t + \frac{h_1}{(1-u)}\widehat{u}_{t-1} + \frac{h_F}{(1-u)}E_t\{\widehat{u}_{t+1}\} - \Phi\gamma\widehat{a}_t. \tag{C.23}$$

Finally, substitute in the pricing equation:

$$\pi_t = \beta E_t\{\pi_{t+1}\} - \frac{\lambda h_0}{(1-u)}\widehat{u}_t + \frac{\lambda h_1}{(1-u)}\widehat{u}_{t-1} + \frac{\lambda h_F}{(1-u)}E_t\{\widehat{u}_{t+1}\} - \lambda\Phi\gamma\widehat{a}_t$$

$$\pi_t = \beta E_t\{\pi_{t+1}\} - \kappa_0\widehat{u}_t + \kappa_1\widehat{u}_{t-1} + \kappa_F E_t\{\widehat{u}_{t+1}\} - \lambda\Phi\gamma\widehat{a}_t \tag{C.24}$$

where

$$\kappa_0 = \frac{\lambda h_0}{(1-u)} \quad ; \quad \kappa_1 = \frac{\lambda h_1}{(1-u)} \quad ; \quad \kappa_F = \frac{\lambda h_F}{(1-u)}.$$

Appendix D. Robustness Checks for Sample Selection and Variable Definition

D.1. Checks for the Price Phillips Curve

Are the results of Section 3.3 driven by our measures of inflation, unemployment gap, or by sample selection? Here, we show that this is not the case. In Table E.1 we repeat recursively the estimation of equation (4) (i) by excluding (including) peripheral countries (Greece, Ireland, Portugal) from the sample, (ii) by excluding (including) at least one between energy and food prices in the calculation of inflation, (iii) by defining the unemployment gap either as deviation of the unemployment rate from a linear trend or either as deviation from a trend extracted via Hodrick-Prescott filtering. Our results are robust: in almost all cases, changes in the occupational structure significantly affect the slope of the price PC after the GR, independently on the definition of price inflation, unemployment gap and sample selection.

D.2. Checks for the Wage Phillips Curve

Are the results of Section 4 driven by our measures of wage inflation, unemployment gap, or by sample selection? In Table E.2 we repeat recursively the estimation of the wage PC (i) by excluding (including) peripheral countries (Greece, Ireland, Portugal) from the sample, (ii) by excluding (including) at the component of wage inflation explained by services of the business economy, (iii) by defining the unemployment gap either as deviation of the unemployment rate from a linear trend or either as deviation from a trend extracted via Hodrick-Prescott filtering. All in all, these robustness checks confirm that –almost always– occupational shifts play a role in explaining the slope of the wage PC, independently on the definition of wage inflation, unemployment gap and sample selection.

Table E.1: The Flattening of the Price Phillips Curve across the EMU11 - Robustness Checks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	$\Delta log(p)$	$\Delta log(p)$	$\Delta log(p)$	$\Delta log(p)$	$\Delta log(p)$	$\Delta log(p)$	$\Delta log(p)$	$\Delta log(p)$	$\Delta log(p)$	$\Delta log(p)$	$\Delta log(p)$
u_{t-1}	-0.086***	-0.133***	-0.151***	-0.079**	-0.089**	-0.143***	-0.191***	-0.069***	-0.065***	-0.115***	-0.111***
	(0.021)	(0.008)	(0.022)	(0.026)	(0.029)	(0.039)	(0.038)	(0.015)	(0.014)	(0.019)	(0.017)
$After_{GR} \times u_{t-1}$	0.083*	0.099**	0.113	0.043	0.042	0.138	0.300***	0.019	0.044	0.001	-0.035
	(0.040)	(0.034)	(0.090)	(0.046)	(0.073)	(0.092)	(0.076)	(0.020)	(0.035)	(0.039)	(0.104)
$After_{GR} \times Shift^{R}_{GR} \times u_{t-1}$	0.009**	0.008*	0.017*	0.007***	0.008*	0.017***	0.013	0.004***	0.008**	0.010**	0.009*
	(0.003)	(0.004)	(0.008)	(0.001)	(0.003)	(0.003)	(0.008)	(0.001)	(0.002)	(0.004)	(0.004)
$After_{SDC} \times u_{t-1}$	-0.024	-0.012	-0.019	-0.018	-0.081	-0.075	-0.200*	0.013	0.002	-0.038	-0.007
	(0.027)	(0.062)	(0.122)	(0.015)	(0.044)	(0.050)	(0.088)	(0.012)	(0.023)	(0.048)	(0.114)
$After_{SDC} \times Shift^{R}_{SDC} \times u_{t-1}$	0.021***	0.030**	0.044**	0.015***	0.013*	0.040***	0.046**	0.009***	0.013***	0.027**	0.023*
	(0.003)	(0.012)	(0.014)	(0.003)	(0.006)	(0.008)	(0.015)	(0.002)	(0.002)	(0.010)	(0.011)
$After_{GR} \times Shift^{Manuf}_{GR} \times u_{t-1}$	-0.006	-0.004**	-0.010	-0.003***	-0.004	-0.010***	-0.015***	-0.001	-0.005	-0.001	0.003
	(0.003)	(0.002)	(0.008)	(0.001)	(0.006)	(0.002)	(0.004)	(0.001)	(0.003)	(0.002)	(0.008)
$After_{SDC} \times Shift^{Manuf}_{SDC} \times u_{t-1}$	-0.023	-0.107***	-0.127**	-0.036***	0.013	-0.142***	-0.081	-0.022***	-0.031	-0.064**	-0.103
	(0.014)	(0.015)	(0.044)	(0.010)	(0.040)	(0.028)	(0.064)	(0.007)	(0.017)	(0.023)	(0.072)
Observations	544	748	544	748	544	748	544	748	544	748	544
R^2	0.865	0.898	0.866	0.852	0.810	0.850	0.809	0.895	0.841	0.894	0.842
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Periphery	Out	In	Out	In	Out	In	Out	In	Out	In	Out
HCPI excluding:											
Energy	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes
Food	Yes	Yes	Yes	No	No	No	No	No	No	No	No
Unemp. Gap	Linear	HP	HP	Linear	Linear	HP	HP	Linear	Linear	HP	HP

Note: Standard errors in parentheses, clustered at country-level. The unit of observation is inflation, measured as the year-on-year log-change of the harmonized consumer price index (HCPI) with energy and food goods excluded in column (1) to (3), with energy and food goods included in column (4) to (7), with energy (food) goods excluded (included) in column (9) to (11). $After_{GR}$ ($After_{SDC}$) is dummy taking value one for periods after the GR (SDC) according to country-specific business-cycle dates; $Shift^{R}_{GR}$ ($Shift^{R}_{SDC}$) is the shift in the occupational structure occurred during recession GR (SDC), i.e. the percentage change in the routine employment share between the peak and trough of the recession according to country-specific business cycle dates; $Shift^{Manuf}_{GR}$ ($Shift^{Manuf}_{SDC}$) is the shift in the share of value added from manufacturing and construction occurred during recession GR (SDC), i.e. the percentage change in the share of value added from these two sectors between the peak and trough of the recession according to country-specific business cycle dates; u_{t-1} is the unemployment gap measured as deviation of the unemployment series from a linear (Linear) trend (column (1), (4), (5), (8) and (9)) or as deviation of the unemployment series from its trend component extracted via Hodrick-Prescott (HP) filtering (column (2), (3), (6), (7), (10) and (11)); column (1), (3), (5), (7), (9) and (11) exclude peripheral countries (Greece, Ireland, Portugal), whereas all other columns consider all EMU11 countries. The vector of controls includes lagged inflation, past expectations on current inflation, the change in the import price index, and a dummy for each country-specific business cycle phase. The sample is composed of all countries that joined the EMU before 2002 (Luxembourg excluded). Data is quarterly. *, **, *** indicate significance at 90%, 95% and 99% level.

Table E.2: The Behavior of the Wage Phillips Curve - Robustness Checks

	(1) $\Delta log(w)$	(2) $\Delta log(w)$	(3) $\Delta log(w)$	(4) $\Delta log(w)$	(5) $\Delta log(w)$	(6) $\Delta log(w)$	(7) $\Delta log(w)$
u_{t-1}	-0.179*	-0.247**	-0.170	0.133	-0.172*	-0.212**	-0.200**
	(0.098)	(0.103)	(0.189)	(0.218)	(0.076)	(0.091)	(0.063)
$After_{GR} \times u_{t-1}$	-0.387	-1.757**	-0.576	-1.012**	-0.321	-1.494**	-0.294
	(0.389)	(0.681)	(0.791)	(0.361)	(0.285)	(0.572)	(0.420)
$After_{GR} \times Shift^R_{GR} \times u_{t-1}$	0.112***	0.154***	0.101	0.053**	0.112*	0.110**	0.128
	(0.038)	(0.039)	(0.085)	(0.018)	(0.059)	(0.040)	(0.096)
$After_{SDC} \times u_{t-1}$	-0.193	-0.065	0.328	-0.013	-0.211*	0.252	0.320
	(0.249)	(0.283)	(0.689)	(0.128)	(0.110)	(0.306)	(0.536)
$After_{SDC} \times Shift^R_{SDC} \times u_{t-1}$	0.138*	0.138	0.152	0.072*	0.128*	0.099	0.176
	(0.081)	(0.085)	(0.144)	(0.035)	(0.061)	(0.079)	(0.104)
$After_{GR} \times Shift^{Manuf}_{GR} \times u_{t-1}$	-0.034	0.001	-0.034	0.003	-0.038	-0.004	-0.073
	(0.036)	(0.020)	(0.067)	(0.006)	(0.039)	(0.016)	(0.057)
$After_{SDC} \times Shift^{Manuf}_{SDC} \times u_{t-1}$	0.023	0.267	-0.579	0.163*	-0.011	0.035	-0.689
	(0.194)	(0.309)	(0.480)	(0.081)	(0.125)	(0.309)	(0.387)
Observations	544	748	544	748	544	748	544
R^2	0.268	0.273	0.260	0.354	0.303	0.354	0.299
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Periphery	Out	In	Out	In	Out	In	Out
Labor Cost Index excluding:							
Services of the Bus. Economy	No	No	No	Yes	Yes	Yes	Yes
Unemp. Gap	Linear	HP	HP	Linear	Linear	HP	HP

Note: Standard errors in parentheses, clustered at country-level. In column (1) to (3), the unit of observation is wage inflation, measured as the year-on-year log-change of the labor-cost index (salary and wages) for the business economy. In column (4)-(7), we exclude the component of wage inflation explained by services in the business economy. $After_{GR}$ ($After_{SDC}$) is dummy taking value one for periods after the GR (SDC) according to country-specific business-cycle dates; $Shift^R_{GR}$ ($Shift^R_{SDC}$) is the shift in the occupational structure occurred during recession GR (SDC), i.e. the percentage change in the routine employment share between the peak and trough of the recession according to country-specific business cycle dates; $Shift^{Manuf}_{GR}$ ($Shift^{Manuf}_{SDC}$) is the shift in the share of value added from manufacturing and construction occurred during recession GR (SDC), i.e. the percentage change in the share of value added from these two sectors between the peak and trough of the recession according to country-specific business cycle dates; u_{t-1} is the unemployment gap measured as deviation of the unemployment series from a linear (Linear) trend (column (1), (4) and (5)) or as deviation of the unemployment series from its trend component extracted via Hodrick-Prescott (HP) filtering (column (2), (3), (6) and (7)); column (1), (3), (5) and (7) exclude peripheral countries (Greece, Ireland, Portugal), whereas all other columns consider all EMU11 countries. The vector of controls includes past expectations on current wage inflation (measured as a four quarters moving average), past expectations on current price inflation and a dummy for each country-specific business cycle phase. The sample is composed of all countries that joined the EMU before 2002 (Luxembourg excluded). Data is quarterly. *, **, *** indicate significance at 90%, 95% and 99% level.

Appendix E. Definition of Separation and Hiring Rate

E.1. Decomposition of the Aggregate Separation Rate by Occupation

Eurostat provides data on unemployment duration by country. Following the methodology of Hobijn and Şahin (2009), this data allows to reconstruct the flow of workers that recently (i.e. in the last quarter) joined the unemployment pool from employment. Then, by following Shimer (2012), the evolution of aggregate unemployment can be written as:

$$u_{t+1} = (1 - h_t)u_t + u^s_{t+1} \tag{F.1}$$

where u_{t+1} is unemployment, h_t is the hiring rate, u^s_{t+1} is "short-term" unemployment, i.e. the number of people that recently joined the unemployment pool from employment. At the same time, the dynamic of unemployment can be written as:

$$u_{t+1} = \delta_t n_t + (1 - h_t)u_t \tag{F.2}$$

where n_t is employment and δ is the separation rate. By substituting F.1 into F.2 we obtain the definition of the separation rate:

$$\delta_t = \frac{u^s_{t+1}}{n_t} \tag{F.3}$$

which can be precisely mapped to Eurostat data.

However, we want to decompose the aggregate separation rate δ_t by occupation $j = \{a, r, m\}$:

$$\delta_t = \sum_{j=\{a,r,m\}} \delta^j_t = \frac{\sum_{j=\{a,r,m\}} u^{s,j}_{t+1}}{n_t}$$

where a stands for abstract, r for routine and m for manual jobs; $u^{s,j}_{t+1}$ is the flow of workers from occupation $j = \{a, r, m\}$ to unemployment. Unfortunately, Eurostat does not provide information to reconstruct $u^{s,j}_{t+1}$. We only have information on employment and unemployment composition by job, i.e. respectively $Share^{e,j}_t$, and $Share^{u,j}_t$. In light of this, we would have two possible probabilistic approaches to compute the single occupational δ^j_t and to study their contribution to the aggregate separation rate:

$$\delta_t = \frac{\sum_{j=\{a,r,m\}} u^{s,j}_{t+1} \times Share^{e,j}_{t+1}}{n_t} \quad \text{or} \quad \delta_t = \frac{\sum_{j=\{a,r,m\}} u^{s,j}_{t+1} \times Share^{u,j}_{t+1}}{n_t}.$$

Yet, both approaches would lead to biased measures of each single δ^j_t because the dynamic of both $Share^{e,j}_t$ and $Share^{u,j}_t$ follows a trend. In fact, due to job polarization, the weight of routine jobs (both in the employment and unemployment pool) will decline over time such that –mechanically– the separation rate of non-routine occupations will be always higher. In other words, the job polarization trend will explain entirely the heterogeneity in separation rate across jobs, with abstract occupations exhibiting the higher separation rate in the long-run.

Therefore, we need to take into account the job polarization trend when considering one between employment and unemployment composition in the calculation of δ_t^j. In order to do, so we write the job-specific evolution of employment as follows:

$$n_{t+1}^j = (1+g^j)n_t^j - \tilde{\delta}^j n_t^j + h_t^j u_t^j \tag{F.4}$$

where g^j is the growth rate of the trend of employment of type j. In words, there is a component in the change of employment that is explained by a trend governed by the rate g^j. Rearranging the latter, we obtain:

$$\tilde{\delta}_t^j = \frac{h_t u_t^j - \Delta n_{t+1}^j}{n_t^j} + g^j. \tag{F.5}$$

Job-specific unemployment can be written as:

$$u_{t+1}^j = (1-h_t)u_t^j + u_{t+1}^{s,j}. \tag{F.6}$$

By substituting (F.6) into (F.5), we obtain:

$$\tilde{\delta}_t^j = \frac{u_{t+1}^{s,j} - \Delta n_{t+1}^j - \Delta u_{t+1}^j}{n_t^j} + g^j. \tag{F.7}$$

which is the conditional probability of separation when being employed in occupation j.

Now, at aggregate level it must be that

$$\delta_t n_t = \sum_{j=\{a,r,m\}} \tilde{\delta}_t^j n_t^j = \sum_{j=\{a,r,m\}} [u_{t+1}^{s,j} - \Delta n_{t+1}^j - \Delta u_{t+1}^j + g^j n_t^j]. \tag{F.8}$$

Since the job-polarization trend implies a zero-sum relocation across jobs (see Section 2.2), we have:

$$\sum_{j=\{a,r,m\}} g^j n_t^j = 0. \tag{F.9}$$

At the same time, at aggregate level, it must be that

$$\Delta n_{t+1} = \sum_{j=\{a,r,m\}} \Delta n^j_{t+1} = \sum_{j=\{a,r,m\}} \Delta u^j_{t+1} = \Delta u_{t+1} \tag{F.10}$$

at the end of the period. Therefore, given (F.9) and (F.10), equation (F.8) simplifies to:

$$\delta_t n_t = u^s_{t+1} \quad i.e. \quad \delta_t = \frac{u^s_{t+1}}{n_t} \tag{F.11}$$

Hence, our methodology to measure each job-specific separation rate and to correct for the bias due to job polarization is consistent with the definition of aggregate separation rate. Therefore, we can finally write the job-specific separation rate as:

$$\delta^j_t = \sum_{j=\{a,r,m\}} \frac{[u^{s,j}_{t+1} - \Delta n^j_{t+1} - \Delta u^j_{t+1} + g^j n^j_t]}{n_t} = \sum_{j=\{a,r,m\}} \tilde{\delta}_t^{\,j} \frac{n^j_t}{n_j}. \tag{F.12}$$

Given the correction of the bias due to occupational trends, we can finally bring δ^j_t to country-level data as follows:

$$\delta^j_{i,t} = \sum_{j=\{a,r,m\}} \frac{[u^s_{i,t+1} \times Share^{u,j}_{i,t+1} - \Delta n^j_{i,t+1} - \Delta u^j_{i,t+1} + g^j_i n^j_t]}{n_{i,t}} \tag{F.13}$$

where g^j_i is calculated as the slope of the linear trend fitting the time series of the employment share of job j in country i in periods before the GR (according to country i business cycle dates). Despite this methodology, our time-series have several missing values. For this reason, when considering job-specific separation rate, we consider simple cross-country means. Moreover, to avoid further bias due to business cycle fluctuations, we consider observations only for periods before the GR and after the SDC. Figure 11(a) of Section 5.3.1 shows cross-country average of each job-specific separation rate (along with 95% confidence interval) for periods before the GR and after the SDC.

E.2. Decomposition of the Aggregate Hiring Rate by Occupation

Once we have knowledge of the aggregate separation rate δ_t –as defined in equation (F.2)– and the (trend-corrected) job-specific separation rate $\tilde{\delta}^j_t$ –as defined in equation (F.7)– we can back-up immediately the aggregate hiring h_t and its decomposition into job-specific hiring rates h^j_t.

Hence, the aggregate hiring rate for country i is:

$$h_{i,t} = \frac{n_{i,t+1} - (1 - \delta_{i,t})n_{i,t}}{u_{i,t}} \tag{F.14}$$

whereas the (trend-corrected) job-specific hiring rate is

$$h^j_{i,t} = \frac{n_{i,t+1} - (1 - \tilde{\delta}^j_{i,t})n_{i,t}}{u^j_{i,t}} \times \frac{u^j_{i,t}}{u_{i,t}}. \tag{F.15}$$

Therefore, by construction we have that:

$$h_{i,t} = \sum_{j=\{a,r,m\}} h^j_{i,t}. \tag{F.16}$$

Mimicking what shown in Figure 11(a) of Section 5.3.1 for the separation rate, Figure F.1(a) shows the cross-country average level of the hiring rate by occupation before the GR and after the SDC (according to country-specific business cycle dates).[21] The average routine hiring rate is roughly 10%, whereas the abstract and manual hiring rates are respectively 17% and 19%.

E.3. Separation and Hiring Rate Analysis

Consider the aggregate separation rate for each country i:

$$\delta_{i,t} = \frac{u^s_{i,t+1}}{n_{i,t}}$$

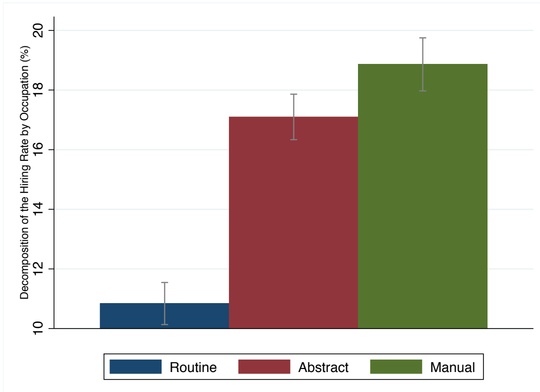
as observed in the data. This time-series can be decomposed its structural component and cyclical component. Formally:

$$\delta_{i,t} = \delta^{struc.}_{i,t} + \delta^{cyc.}_{i,t}.$$

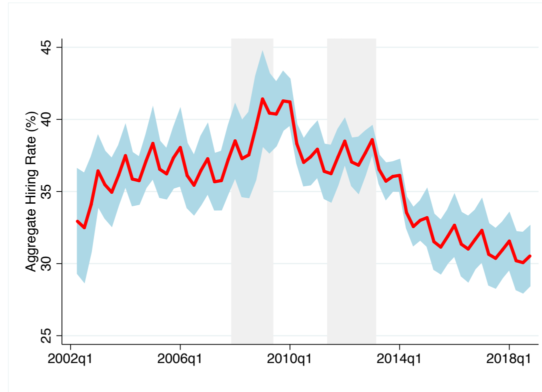
The first component captures the long-run evolution of the separation rate whereas the second captures the part of $\delta_{i,t}$ explained by the business cycle, i.e. by the cyclical change in unemployment. In light of our model, we are interested in the evolution of the structural separation rate over time, i.e the probability to leave employment (independent on business cycle condition). In order to so, we extrapolate $\delta^{struc.}_{i,t}$ in the simplest possible way. First

[21]For hiring rates, we exclude Ireland from the sample of EMU11 countries since the imputed rates are mostly outliers with respect to other countries' rates.

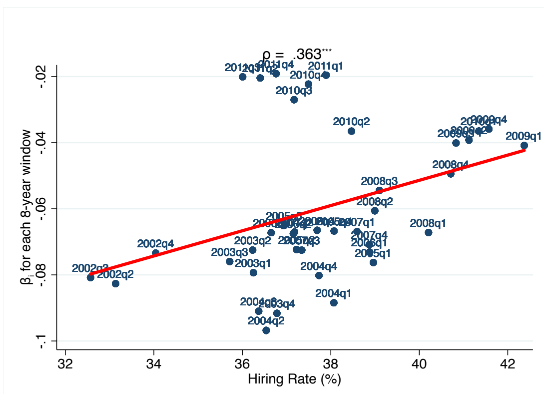
Fig. F.1. Hiring Rates at Aggregate and Occupational Level



(a) Hiring Rate by Job



(b) Aggregate Hiring Rate



(c) Slope vs. Hiring Rate (Aggregate)

(d) Slope vs. Hiring Rate (Cross-country)

Note: Figure F.1(a) plots the mean hiring rate (with 95% confidence interval) by occupation (routine, abstract or manual) across countries that joined the EMU before 2002 (Luxembourg excluded). Ireland is excluded as well since it represents an outlier. Each cross-country mean is computed considering only periods before the Great Recession and after the Sovereign Debt Crisis, according to country-specific business cycle date. Figure F.1(b) plots the aggregate hiring rate. The light-blue-shaded area represents the 95% confidence interval (see Appendix E for details). Figure F.1(c) plots the coefficients of the Phillips Curve –estimated across countries over 8-year rolling windows– on the cross-country mean hiring rate as observed at the beginning of each 8-year window. The equation used to estimate the slope of the Phillips Curve for each window $\Delta log(p)_{i,t} = \alpha_i + \beta u_{i,t-1} + X'_{i,t-1}\gamma + \epsilon_{i,t}$, where $\Delta log(p)_{i,t}$ is the year-on-year log-change of the harmonized consumer price index (energy and food excluded) in country i; α_i is the country fixed-effect; $u_{i,t-1}$ is the unemployment gap measured as deviation of the unemployment series from a linear trend; $X'_{i,t-1}$ is a vector of controls including lagged inflation, past expectations on current inflation, the change in the import price index, and a dummy for each country-specific business cycle phase; $\epsilon_{i,t}$ is the error term. Figure F.1(d) plots the coefficients of the Phillips Curve –estimated for each country and over 8-year rolling windows– on the country-level hiring rate as observed at the beginning of each 8-year window. The slope for each country is estimated using the same specification and variables as above. For comparability across countries, variables are taken in deviation from each country's mean. On top of both graphs, the correlation (ρ) between variables is reported along with its significance level. *, **, *** indicate significance at 90%, 95% and 99% level.

–due to the high seasonality of the series– we take the 4-quarters moving average of the data. By doing so, we create the variable $\bar{\delta}_{i,t}$. Second, instead of filtering the variables, we consider this simple linear model:

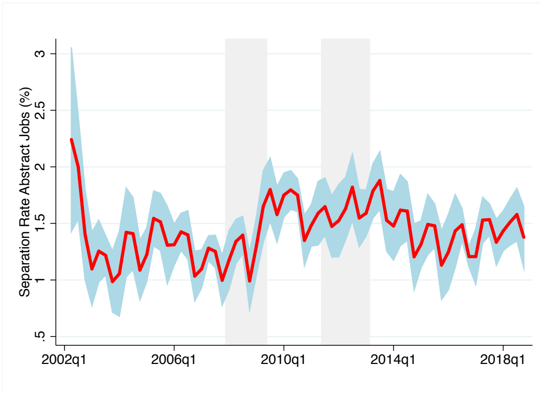
$$\bar{\delta}_{i,t} = \alpha_i + \sum_{t=2002q1}^{T=2018q4} \beta_t \times t + \gamma u_{i,t} + \varepsilon_{i,t} \tag{F.17}$$

where α_i is the country fixed effect, t is the time-period, $u_{i,t}$ is the country-specific unemployment rate, $\varepsilon_{i,t}$ is the error term. Once netting out the cyclical component of the separation rate explained by unemployment, the series of coefficients β_t will capture the cross-country (average) evolution of the structural separation rate. Figure 11(b) of Section 5.3.1 plots the βs for the aggregate separation rate. We proceed identically to study the evolution of the aggregate hiring rate across country. In other words, we consider again the model of equation (F.17) with the 4-quarters moving average of the aggregate hiring rate as dependent variable. Figure F.1(b) shows the evolution of the aggregate hiring rate. Notably, the hiring rate is slightly declining, i.e. it moves from an average of 36% before the GR to an average of 32% after the SDC. In Figure F.1(c) we plot the coefficient of the price PC estimated for each country (Luxembourg and Ireland excluded) and each 8-year window on the cross-country average level of the hiring rate as observed at the first quarter of the same 8-year window. The correlation between the slope of the PC and the hiring rate is 0.36 and it is significant at 99% level. In Figure F.1(d), we consider country-level data. In particular, we plot the country-specific slope of the price PC (estimated over 8-year rolling windows) on country-specific level of the hiring rate. For cross-country comparability, country-level variables are taken in deviation from their mean. Differently from the aggregate result, here the sign of the correlation has turned negative and it has become significant only at the 95% level.

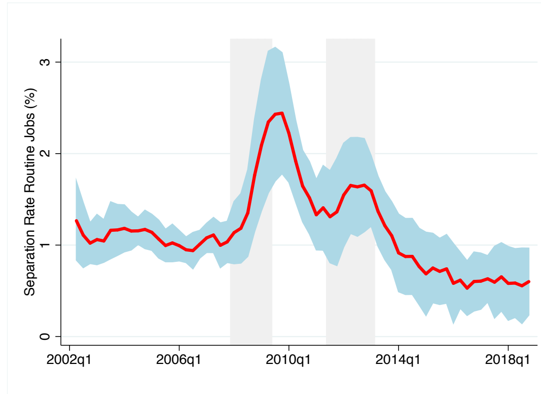
All in all, this evidence suggests non-routine jobs exhibit a higher hiring-rate, which contributes to the fluidity of these segments. However, the role of the hiring rate on the slope of the PC is smaller (with respect to the role of the separation rate).

Figure F.2 plots the evolution of the separation and hiring rate for each single occupation. To do so, we use once more equation (F.17) with each job-specific separation and hiring rate as dependent variable.

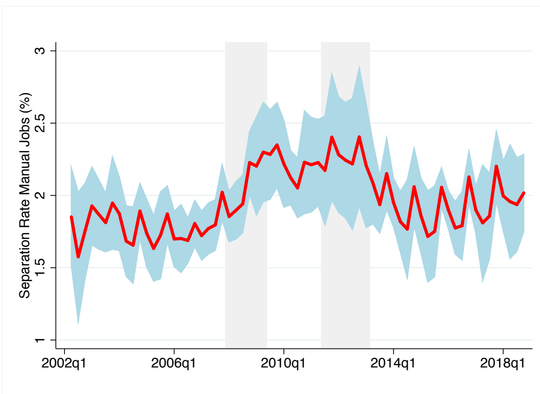
Fig. F.2. Separation and Hiring Rates by Occupation



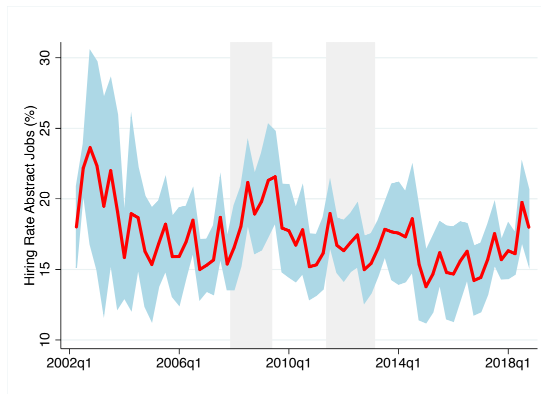
(a) Separation Rate - Abstract Jobs



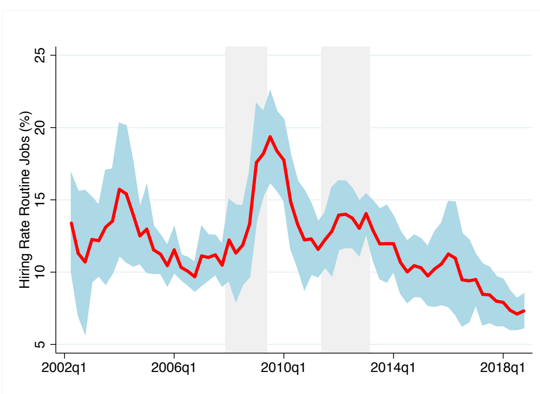
(b) Separation Rate - Routine Jobs



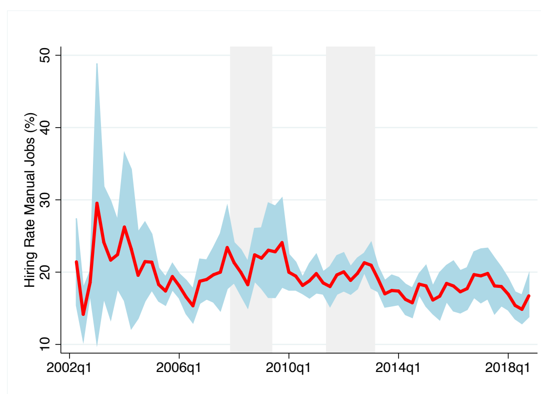
(c) Separation Rate - Manual Jobs



(d) Hiring Rate - Abstract Jobs



(e) Hiring Rate - Routine jobs



(f) Hiring Rate - Manual Jobs

Note: Figure F.2(a)-(c) plots the evolution of the separation rate respectively for abstract, routine and manual job, across countries that joined the EMU before 2002 (Luxembourg and Ireland excluded). Figure F.2(d)-(f) plots the evolution of the hiring rate respectively for abstract, routine and manual job, across countries that joined the EMU before 2002 (Luxembourg and Ireland excluded). The light-blue-shaded area represents the 95% confidence interval. The two grey-shaded areas indicate respectively the periods of the Great Recession and of the Sovereign Debt Crisis as defined by the CEPR Business Cycle Committee. Data is at quarterly frequency. See Appendix E for details.

E.4. Other Measures of Fluidity

In this section, we describe the data used in Figure 12(a)-(c). For Figure 12(a) we use Eurostat data on temporary contracts by occupation and total employment by occupation at quarterly frequency for all countries EMU11. The sample is composed of workers in the 15-to-74 age bracket. Then, for each country i, time t and job $j \in \{a, r, m\}$, we compute the following:

$$Pr(\text{Temporary Contract in j}|\text{Employed in j})_{i,t} = \frac{[\textit{n. of employees with temp. contract in j}]_{i,t}}{[\textit{n. of employees in j}]_{i,t}}.$$

Given the high heterogeneity of this measure across countries, we normalize it by its standard deviation for a better comparability.

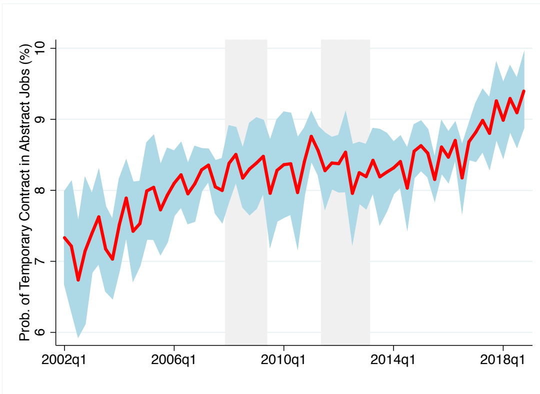
For Figure 12(b), we use Eurostat data on workers reporting to have multiple jobs (i.e. multiple employers) in a specific occupations. The sample is composed of workers in the 15-to-74 age bracket. Then, we build the following:

$$Pr(\text{Multiple jobs in j}|\text{Employed in j})_{i,t} = \frac{[\textit{n. of employees working in j with multiple jobs}]_{i,t}}{[\textit{n. of employees in j}]_{i,t}}.$$

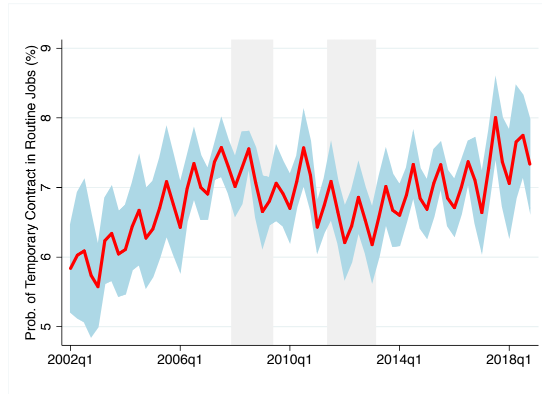
Here below (Figure F.3) we plot the evolution of this two probabilities across countries.

Finally, for Figure 12(c), we consider data on hours worked by occupation. The sample is composed of workers in the 15-to-74 age bracket with a full-time contract. We evaluate the volatility for each country and cyclical phase (defined according to country specific business cycle dates). When plotting these measure as in Figure 12(a)-(c), for each country we consider only observations in periods before the Great Recession and after the Sovereign Debt Crisis.

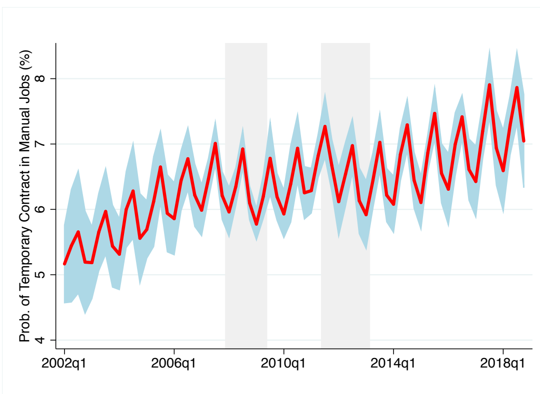
Fig. F.3. Temporary Contracts and Multiple Jobs by Occupation



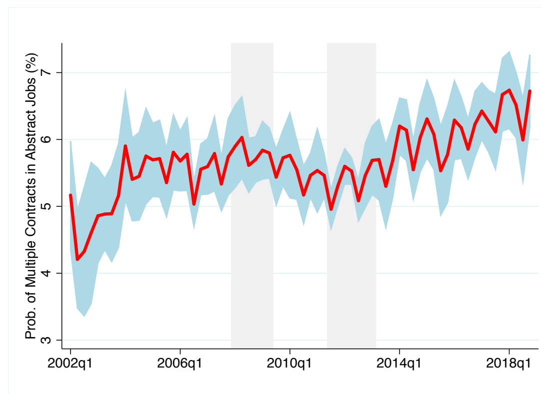
(a) Temp. Contract - Abstract Jobs



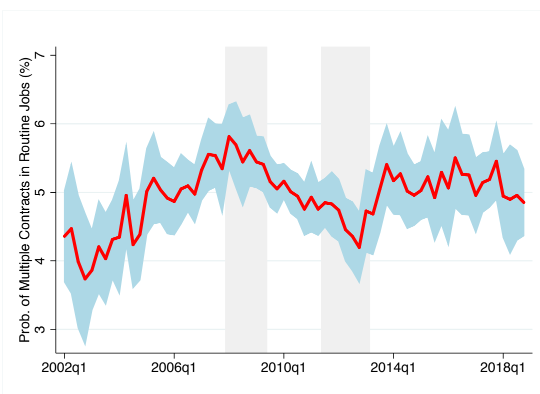
(b) Temp. Contract - Routine Jobs



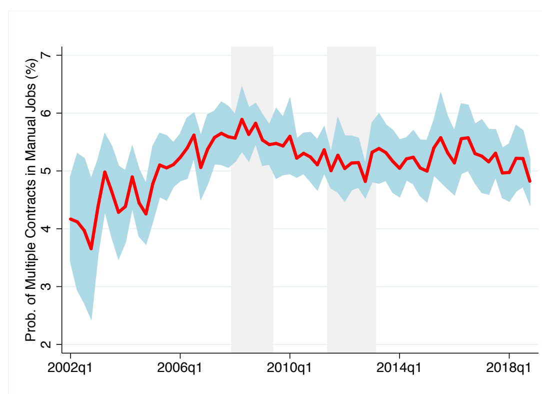
(c) Temp. Contract - Manual Jobs



(d) Multiple Contracts - Abstract Jobs



(e) Multiple Contracts - Routine jobs



(f) Multiple Contracts - Manual Jobs

Note: Figure F.3(a)-(c) plots the evolution of the (average) probability to have temporary contract across countries that joined the EMU before 2002 (Luxembourg excluded). Figure F.2(d)-(f) plots the evolution of the (average) probability to have multiple contracts (i.e. employers) across countries that joined the EMU before 2002 (Luxembourg excluded). The light-blue-shaded area represents the 95% confidence interval. The two grey-shaded areas indicate respectively the periods of the Great Recession and of the Sovereign Debt Crisis as defined by the CEPR Business Cycle Committee. Data is at quarterly frequency. See Appendix E.4 for details.