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Beveridge Curve Shifts across Countries since the Great Recession

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We discuss the magnitude of and reasons for the shift in the Beveridge curve in the U.S. since the Great Recession and argue that skill mismatch and the extension of unemployment insurance benefits likely have played a nontrivial role in this shift. We then introduce a method to estimate fitted Beveridge curves for other OECD countries for which data on vacancies and employment by job tenure are available. We show that Portugal, Spain, Sweden, and the U.K. also experienced rightward shifts in their Beveridge curves. We argue that the shift in the first three countries is due to similar mismatch factors as in the U.S. while the shift in Sweden is due to labor market reforms passed right before the Great Recession.

Keywords: Cross-country analysis, Great Recession, labor market dynamics.

JEL-codes: J2, O5, E32.

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1. Introduction

Since the onset of the Great Recession, there has been a change in the relationship between the unemployment rate and vacancy rate in the U.S. This relationship, summarized by the Beveridge curve, was remarkably stable from 2000 through 2007, even during the 2001 recession. However, since the summer of 2009 the vacancy rate has trended upwards while the unemployment rate has only come down slightly. In fact, in June 2012 the job openings rate in the U.S. was back to its June 2008 level, before the depth of the financial crisis. The unemployment rate, however, was 2.7 percentage points higher than in June 2008. This change in the relationship between the unemployment and vacancy rates caused a rightward shift in the Beveridge curve.

The availability of data on hires, quits, and layoffs, from the Job Openings and Labor Turnover Survey (JOLTS), has allowed us to examine this rightward shift in detail. The rightward shift of the U.S. Beveridge curve is a consequence of firms hiring fewer workers per job opening than one would expect given the historical regularities (Barnichon et al. (2012)). This is often interpreted as an increase in labor market frictions or, equivalently, a decline in the efficiency with which workers and employers get matched in the U.S. labor market.²

The three most prominent explanations for the decline in match efficiency are: (i) occupational, industrial, and skill mismatch between labor supply and demand, (ii) house lock (geographical mismatch), and (iii) disincentive and labor supply effects of the extensions of UI benefits. Recent studies which examined the potential causes of the shift in the Beveridge curve indicate that, while geographical mismatch was quantitatively unimportant, skill mismatch and extension of UI benefits have contributed to the shift in the Beveridge curve in the U.S. and that these factors are largely transitory.

In this paper, we study the Beveridge curves and recent labor market outcomes of a large set of countries to compare and contrast their experiences with those of the U.S. Specifically, we quantify deviations from the Beveridge curve for 14 OECD countries, including the U.S., since the Great Recession.

In order to quantify the recent deviations from the Beveridge curve for different countries, we introduce a new method, based on the one used in Barnichon et al. (2012), to construct fitted

² Several recent studies have estimated the magnitude of this decline in match efficiency. Among them Borowczyk-Martins et al. (2011), Barnichon et al. (2012), Davis, Faberman, and Haltiwanger (2012), and Sedláček (2012).

Beveridge curves for OECD countries for which data on vacancies and employment by job tenure are available. These fitted Beveridge curves are calculated as the vacancy rate at which the unemployment rate is equal to its turnover-steady-state value. The turnover steady state is the one in which hires minus separations as a fraction of employment equals the growth rate of the labor force. Our method consists of three steps.

First, we derive estimates of total hires and separations in each country in a year from annual data on the distribution of employees by job tenure. These estimates can be interpreted in the same way as the hires and separations measures for the U.S. from the JOLTS. Second, given the estimates of labor turnover in a year, we then estimate how the number of hires per vacancy, known as the vacancy yield, fluctuated with the number of unemployed persons per vacancy before the onset of the Great Recession. This method provides us with the estimates of the matching functions for the countries in our sample. In addition, we also estimate how separations commoved with labor market tightness. Finally, having obtained how hires and separations commove with the unemployment and vacancy rates, we solve for those combinations of these rates that satisfy the turnover steady-state condition. These combinations are the fitted pre-2008 Beveridge curves. We then compare these estimated curves with the actual realized unemployment and vacancy rates both before the Great Recession as well as during and afterwards.

We find that the fitted Beveridge curves provide a strikingly good description of the actual unemployment and vacancy rate relationship in the countries in our sample for the 15 years preceding the Great Recession. This proves the usefulness of interpreting the Beveridge curve in terms of a labor-turnover steady-state relationship.

For the observations during and after the Great Recession, we find that, besides the U.S., there are four other countries in our sample of 14 that seem to have experienced a rightward shift in their Beveridge curves: Portugal, Spain, Sweden, and the U.K. The other countries in our sample, i.e. Australia, Austria, Belgium, France, Germany, Japan, the Netherlands, Norway, and Switzerland, seem to continue to be close to or on the Beveridge curve that they were on before 2008.

After we estimate these deviations we consider what these countries have in common and are the likely factors that drive these shifts. We find that skill mismatch, resulting from a housing bust and a disproportionate decline in construction employment, is likely to be the main cause of the shifts in Portugal, Spain, and the U.K. In Sweden, the apparent increase in labor market frictions

since 2007 is the result of changes in labor market policies which included an increase of the duration of unemployment insurance benefits. Finally, to put the recent Beveridge curve shifts in historical context, we compute the magnitude of Beveridge curve shifts that took place between 75-85 and 91-07 in many of the countries in our sample. Though these shifts were much larger than those observed since the Great Recession, they were, to a large extent, caused by similar factors as the current shifts. In particular, (changes in) labor market institutions and policies played an important role in the proliferation of these shifts in Continental Europe as compared to Anglo-Saxon and Scandinavian countries (Blanchard and Wolfers, 2000, Nickell et al., 2001).

The structure of the rest of this paper is as follows. In Section 2 we review the evidence on the U.S. Beveridge curve and its rightward shift since the summer of 2009. In Section 3, we introduce our method to construct annual time series of labor market turnover for OECD countries and use these estimates of hires and separations to construct fitted pre-Great-Recession Beveridge curves for the 14 countries in our sample. We then compare these curves to the outcomes, in terms of the unemployment and vacancy rates, since 2008. This allows us to estimate the Beveridge curve shifts across countries since the Great Recession. In Section 4, we line the shifts in the Beveridge curves since the start of the Great Recession up against evidence on the potential causes of the shifts and compare them to the shifts that occurred between the mid-1980's and 2000's. Finally, we conclude with Section 5. We discuss the data and most important equations we use in the main text. More detailed derivations of the equations can be found in Appendix A.

2. U.S. Beveridge curve shift since the Great Recession

Figure 1 shows the U.S. Beveridge curve from December 2000 through June 2012. It plots the unemployment rate against the job openings rate. The black dots are monthly observations before the Great Recession, while the squares are observations from January 2008 onwards.

The black dots show a clear pre-Great-Recession relationship between the unemployment and vacancy rates: a stable Beveridge curve. During the Great Recession, there was a steep decline in labor demand, reflected by a drop in the vacancy rate that led to a run up in the unemployment rate. However, in June 2012 the vacancy rate had recovered to its June 2008 level, while the unemployment rate was still more than 2.5 percentage points higher than in the summer of 2008. Thus, the stable pre-recession Beveridge curve had fallen apart; for a given vacancy rate, the unemployment rate is now several percentage points higher than it was before the recession.

As Tasci and Lindner (2010) point out, temporary deviations from the Beveridge curve in which unemployment is high relative to the level of vacancies have been commonplace in the U.S. In fact, Mortensen (1994) points out that counter-clockwise loops in the unemployment vacancy relationship are a feature of the transitional dynamics of labor market models with search frictions. However, the recent deviation from the pre-recession Beveridge curve has been continuing for more than three years. That is much longer than the duration of counter-clockwise loops implied by the search model that is analyzed in Mortensen (1994). This observation suggests that the rightward shift of the U.S. Beveridge curve since mid-2009 is likely to be a persistent shift. In order to assess how persistent the shift is, it is important to understand what drives it.

The Beveridge curve as a turnover-steady-state relationship

The drivers of the Beveridge curve shift are best understood by interpreting the curve as the steady-state relationship between the unemployment and vacancy rates at which the net hiring offsets the flows into and out of the labor force such that the unemployment rate is constant (see Barnichon et al., 2012).³

³ Labor turnover, as in hires and separations, includes job-to-job transitions. This is in contrast to Budd et al. (1987) and Barnichon and Figura (2010) which define the Beveridge curve in terms of the flow-steady-state of unemployment in which inflows into and outflows from unemployment are equal.

Since the total number of unemployed persons, U_t , is equal to the size of the labor force, LF_t , minus those employed, E_t , we can write the change in unemployment as the change in the labor force minus the change in employment:

$$\Delta U_{t+1} = \Delta LF_{t+1} - \Delta E_{t+1} = \Delta LF_{t+1} - H_t + S_t. \quad (1)$$

Note that the second equality is obtained by using the observation that the change in employment equals the difference between hires (H_t) and separations (S_t).

Rearranging the above equation yields that the change in the unemployment rate, $u_t = U_t/LF_t$, is proportional to the difference between the growth rate, $g_{t+1} = (LF_{t+1} - LF_t)/LF_t$, of the labor force and that of employment, given by $(H_t - S_t)/E_t$. In particular,

$$\Delta u_{t+1} = \frac{1-u_t}{1+g_{t+1}} \left(g_{t+1} - \frac{H_t}{E_t} + \frac{S_t}{E_t} \right) \quad (2)$$

Hence, the unemployment rate does not change whenever the growth rate of employment equals the growth rate of the labor force. That is, the labor market is in its turnover steady state when

$$g_{t+1} = \frac{H_t}{E_t} - \frac{S_t}{E_t}. \quad (3)$$

The above turnover steady-state condition is not written as a function of the unemployment and vacancy rates. We introduce them by assuming that the number of hires per vacancy, known as the vacancy yield, is a function of the ratio of the number of unemployed per vacancy. That is, if there are a lot of unemployed persons per vacancy, i.e. there is a lot of slack in the labor market, then it is relatively easy for employers to fill job openings. Since measured vacancies are a stock and hires a flow, this would show up in the data as a high number of hires per vacancy. The opposite is true in case the labor market is tight and there are very few unemployed persons per job opening.

In particular, we assume the common functional form (Petrngolo and Pissarides, 2001) of a Cobb-Douglas matching function and write hires per vacancy (H_t/V_t) as

$$\ln(H_t/V_t) = \mu_h + \alpha_h \ln(U_t/V_t) + \varepsilon_{h,t}, \quad (4)$$

where V_t is the number of vacancies, μ_h is the average match efficiency and $\varepsilon_{h,t}$ reflects the deviation from the Cobb-Douglas relationship at time t .

Moreover, we also allow total separations as a fraction of employment, S_t/E_t , to commove with the unemployment to vacancy ratio. Separations consist of layoffs and quits, which move in

opposite directions over the business cycle. When the labor market is tight, and there are few unemployed persons and a lot of vacancies, layoffs are rare but many people quit and switch from one job to another (Akerlof, Rose, and Yellen, 1988). During recessions and recoveries, when there is a lot of slack in the labor market, layoffs tend to be elevated (especially in early stages of the recession), switching jobs becomes harder, and quits decline.

Given these two opposite cyclical patterns for layoffs and quits, the cyclicity of separations as a whole depends on which of them dominates. Hall (2005) argues that these two effects approximately offset each other in the U.S. and that, as a result, the separation rate commoves little with the business cycle. However, the JOLTS data that have become available since Hall's (2005) conjecture suggest that the quits effect dominates and that the U.S. separation rate is procyclical.

To allow for cyclicity in the separation rate, we postulate the following functional form for the cyclicity of separations:

$$\ln(S_t/E_t) = \mu_s + \alpha_s \ln(U_t/V_t) + \varepsilon_{s,t}. \quad (5)$$

If $\alpha_s > 0$, then separations are countercyclical and the layoffs effect dominates. When $\alpha_s < 0$, separations tend to decline during labor market downturns, making them procyclical, which is when the quits effect dominates.

Throughout the rest of this paper, we define the vacancy rate as the ratio of the number of vacancies to the number of employed persons, i.e. $v_t = V_t/E_t$.⁴ Given this definition of the vacancy rate, we show in the Appendix that combining the turnover steady state condition, (3), with the matching function, (4), and the equation that captures the cyclicity of the separation rate, (5), yields that

$$g_{t+1} = e^{\mu_h + \varepsilon_{h,t}} \left(\frac{u_t}{1-u_t} \right)^{\alpha_h} v_t^{(1-\alpha_h)} - e^{\mu_s + \varepsilon_{s,t}} \left(\frac{u_t}{1-u_t} \right)^{\alpha_s} v_t^{-\alpha_s}. \quad (6)$$

We interpret the Beveridge curve as all combinations of (u_t, v_t) that satisfy the above equation. Thus, the Beveridge curve is the implicit functional relationship between the unemployment and vacancy rates that satisfies the turnover steady-state condition.

⁴ This is slightly different from the definition used in most published statistics where $v_t = V_t/(V_t + E_t)$, which would make the vacancy rate conceptually equivalent to the unemployment rate. The problem with this definition is that it assumes that the units of measurement of the vacancy statistic is defined in terms of number of jobs comparable to the employment number used. It turns out that in some of our source data this is not the case. Using the vacancy to employment rate as a measure of the vacancy rate means that cyclical fluctuations in the rate are not dependent on the unit of measurement of vacancies.

Of course, this implicit relationship between the unemployment and vacancy rates only holds in the data if the labor market tends to be close to its steady state. Moreover, this relationship is only stable as long as (a) the growth rate of the labor force, g_{t+1} , is relatively constant, (b) there are no major changes in match efficiency, $\mu_h + \varepsilon_{h,t}$ and in the level of separations $\mu_s + \varepsilon_{s,t}$, and (c) the elasticities, α_h and α_s , do not change over time.

The fitted U.S. Beveridge curve and its post-recession shift

We follow Barnichon et al. (2012) and use equations (3), (4), and (5) to construct a fitted Beveridge curve for the U.S.⁵ First, we estimate the matching function, (4), and the cyclicity of separations, (5), to obtain estimated values for μ_h , α_h , μ_s , and α_s . We then construct a fitted Beveridge curve by solving for the combinations of u_t and v_t that satisfy (6) evaluated at the estimated parameters μ_h , α_h , μ_s , and α_s , at the average growth rate of the labor force, and $\varepsilon_{h,t} = \varepsilon_{s,t} = 0$. Note that this way of constructing a fitted Beveridge curve does *not* involve any direct estimation of a relationship between the unemployment rate and the vacancy rate. This relationship is derived through the assumption of the labor market being close to its turnover steady state.

An updated version of the fitted pre-recession Beveridge curve from Barnichon et al. (2012) is plotted in Figure 1.⁶ As can be seen from the figure, the U.S. labor market only slightly deviated from its Beveridge curve from December 2000 through December 2007. Even during the depth of the Great Recession, when U.S. labor demand declined sharply, the U.S. labor market remained relatively close to the pre-recession turnover steady-state relationship.

However, in the middle of 2009, the U.S. Beveridge curve relationship started to change; the vacancy rate increased substantially while the unemployment rate barely declined. This is the same time at which the observed vacancy yield started falling short of that predicted by the estimated matching function. This can be seen from Figure 2. Since the end of the recession hires per vacancy have been about 30 percent lower than the fitted pre-recession matching function would suggest. In terms of equation (4), this implies that $\varepsilon_{h,t} \approx -0.3$ over the three years preceding June 2012.

⁵ The exact specification of the equations used in Barnichon et al. (2012) is slightly different because they are tailored to the monthly JOLTS and CPS data available in the United States. See Barnichon et al. (2012) for details. The functional forms here are the ones we subsequently implement in our cross-country analysis using OECD data.

⁶ This fitted curve is based on estimates of equation (4) and (5) using pre-2008 data.

The decline in match efficiency in the U.S. is only one side of the coin, however. The other side is that separations also declined more than one would have expected based on their pre-recession comovements with the unemployment-to-vacancy ratio. This excessive decline in separations is due to people staying put in their jobs and not quitting to pursue other opportunities. Figure 3 shows that since mid-2009 quits have been about 15 percent lower than predicted by their pre-recession cyclicity. In terms of equation (5), this indicates that $\varepsilon_{s,t} \approx -0.15$ over the last several years

In Figure 1, we recalculate the fitted Beveridge curve with the same parameters as the pre-recession one except we set $\varepsilon_{h,t} \approx -0.3$ and $\varepsilon_{s,t} \approx -0.15$ and obtain the shifted Beveridge curve. It turns out that the actual realizations of the unemployment and job-openings rates over the past two years have been very close to this shifted curve. This suggests that the rightward shift in the U.S. Beveridge curve since the Great Recession is a result of the decline in the rate of labor turnover rather than of a change in the growth rate of the labor force, g_t , or of the cyclicity of the vacancy yield and separation rate, captured by α_h , μ_s , and α_s .

Rightward shifts in Beveridge curve like the one in Figure 1 have, in the past, coincided with increases in the natural rate of unemployment. To see how big an increase in the natural rate of unemployment the current shift implies, it is important to put this Great Recession episode in a historical perspective. As Tasci and Lindner (2010) and Daly, Hobijn, Şahin, and Valletta (2012) point out, the current shift is not as big as the one in the 1970's and 1980's when the natural rate is estimated to have risen to 6.3 percent.⁷ Hence, based on that observation, it is not very likely that the current shift in the U.S. Beveridge curve results in a natural rate well above 6 percent. Using more formal time-series techniques, Dickens (2009), Fleischman and Roberts (2011), and Dickens and Triest (2012) reach a similar conclusion.

The effect of the shift in the Beveridge curve on the natural rate of unemployment largely depends on whether it is permanent or not. Various recent studies which examined the potential causes of the shift in Beveridge curve concluded that these factors are mostly transitory. We briefly discuss this literature here in the context of the declines in labor turnover as reflected by the reduction in match efficiency and the separation rate.

⁷ This is the peak of the Congressional Budget Office's natural rate of unemployment estimates in 1978.

Decline in match efficiency

The persistent decline in measured U.S. match efficiency since the end of the recession has been widely documented, (See for example Barnichon et al., 2012, Borowczyk-Martins et al., 2011, Davis, Faberman, and Haltiwanger, 2012, Elsby, Hobijn, and Şahin, 2010, Sedláček, 2012). The three most prominent explanations for it are: (i) occupational, industrial, and skill mismatch between labor supply and demand, (ii) house lock (geographical mismatch), and (iii) disincentive and labor supply effects of the extensions of UI benefits.

Mismatch has been analyzed in several papers that used disaggregated job openings and hires data for different industries or occupations or both. Some industry-level studies, like Barnichon et al. (2010), and Davis, Faberman, Haltiwanger (2012), find that a large part of the decline in match efficiency is driven by the low level of job openings and hires per vacancy in the construction sector. Studies that also look at occupations, like Şahin et al. (2011) and Hobijn (2012), find that the shift in the occupational mix of job openings is more important than the cross-industry composition for the observed decline in match efficiency. Studies that construct a formal index of mismatch (Şahin et al., 2011, Dickens and Triest, 2012, and Lazear and Spletzer, 2012b) all find that mismatch increased during the recession but has since has almost returned to its pre-recession level.

Several authors have investigated whether homeowners who have negative equity in their homes are less likely to relocate to take a job, in case they are unemployed, or switch jobs, in case they are employed. Most studies that aim to quantify the importance of this effect tend to find it is very small. This is true both for empirical studies (Molloy, Smith, and Wozniak, 2011, Schulhofer-Wohl, 2012, and Valletta, 2010) as well as those based on more formal labor market models with search frictions (Sterk, 2010, and Karahan and Rhee, 2012).

Finally, the effects of the extension of unemployment insurance benefits from 26 weeks up to 99 weeks that occurred during 2008 have been analyzed extensively. Since the extension of benefits may reduce the job search effort of job seekers and/or prolong labor force attachment of UI recipients, it can potentially explain the rightward shift in the Beveridge curve. While the estimates of the effects of UI extensions range from 0.3-1.7 percentage points, most studies find an effect of around 1 percentage point or less. (See Aaronson, Mazumder, and Schecter, 2010; Farber and Valletta, 2011; Fujita, 2010; Nakajima, 2012; Rothstein, 2011; Valletta and Kuang, 2010). For example, Daly, Hobijn, and Valletta (2011) focus on the comparison of the duration of

unemployment for individuals who are eligible or not eligible for UI receipt and find that the increase in duration was larger for UI eligibles. They argue that even if one fully attributes this difference to UI eligibility, only about 0.8 percentage points of the increase in the unemployment rate is due to extended UI benefits.

In addition, there is a growing theoretical literature that provides models in which match efficiency endogenously fluctuates over the business cycle. Sedláček (2012) and Ravenna and Walsh (2012) both provide models in which firms are more picky in selecting workers during times of high unemployment than during times of tightness in the labor market.

Decline in quits

We have shown that the decline in quits partially offset the effect of the decline in match efficiency in terms of the rightward shift in the Beveridge curve. However this decline is not necessarily an improvement since it is indicative of a substantial decline in the rate of reallocation of workers in the U.S. labor market. As Lazear and Spletzer (2012a) point out, such churning is an important part of the process of creative destruction that moves resources from less productive to more productive economic activities.

In a related paper, Saint-Paul (1995), following an argument in Blanchard and Summers (1998), introduces a model in which a decline in quits makes firms more reluctant to hire in the first place when there are costs to firing workers. He shows that such a feedback effect between quits and hires has the potential to generate multiple labor market equilibria. In a slightly generalized version of his model, movement from a low unemployment/high labor turnover to a high unemployment/low labor turnover equilibrium would result in both a decline in the quits rate as well as measured match efficiency.

In short, recent studies of the U.S. labor market indicate that the shift in the U.S. Beveridge curve is mostly due to transitory factors. Of course, the U.S. is not the only country *(i)* that saw a run up in unemployment in the wake of the Great Recession, *(ii)* that experienced a drop in house prices, an associated reduction in residential investment, and a decrease in the demand for construction workers, *(iii)* whose government responded to the financial crisis by increasing the generosity of UI benefits, *(iv)* where the rate at which workers quit and move to other jobs slowed down since 2007.

In the rest of this paper we consider whether these factors have also resulted in movements in the Beveridge curves in other countries.

This requires the construction of fitted Beveridge curves for countries other than the U.S, for which we introduce a new methodology in the next section.

3. Beveridge curve shifts since 2007 for 14 OECD countries

In order to examine shifts in the Beveridge curves across countries we need to construct fitted Beveridge curves for countries other than the U.S. The main problem is that direct measures of labor turnover, like hires and separations from the JOLTS for the U.S., are not available for other countries.⁸

However, estimates of hires and separations can be constructed using data on the number of employees by job tenure. The most direct way of doing so is to measure the number of hires in a year as the number of workers who, at the end of the year, are on a job with tenure shorter than 12 months. This is the methodology applied in OECD (2009). This way of measuring hires ignores the workers who get hired in a year and separate from their jobs before the end of the year. Thus, such a measure would underestimate the amount of turnover in the labor market.

To overcome this undercounting, we introduce a way to use the published numbers on job tenure distributions to impute total hires and separations, taking into account that the turnover in jobs that takes place within a year. In the first part of this section we introduce our method to construct time series for hires and separations across countries. In the second part we combine these time series with those on unemployment and vacancies and estimate matching functions as well as the cyclicalities of separations for the 14 countries in our sample. In the next part, we then use these estimates to obtain fitted pre-Great-Recession Beveridge curves in the same way as discussed in Section 2. Finally, we consider the deviations from these fitted curves that occurred since the start of the Great Recession.

⁸ The only other country for which we found data on hires and separations is Japan, where annual time series for hires and separations have been published as part of the Survey of Employment Trends done by the Japanese Ministry of Health, Labour, and Welfare since 1952.

Estimating hires and separations using annual data on employment by job tenure

Time, t , is continuous and measured in years. Total employment at time t is given by E_t . We also keep track of the number of workers who were employed at the beginning of the year and are still in the same job at the end of the year. These workers, by definition, have a job tenure, τ , longer than a year at the end of the year, and we denote them by $E_t^{\tau > 1}$.

Our imputation method assumes that firms hire at a constant rate over the year. That is, the number of hires at any time is equal to hE_t , where E_t is the level of employment and h is the hires rate. Those who were employed separate from their jobs at the rate s . Both h and s are annualized continuous-time flow rates. For these two turnover rates, we assume that they are constant over year t , i.e. over $(t, t + 1]$.

In Appendix A, we show that, given E_t , E_{t+1} , and $E_{t+1}^{\tau > 1}$, one can solve for the implied hires rate h , and the separation rate, s . The solution is given by

$$h = \ln(E_{t+1}) - \ln(E_{t+1}^{\tau > 1}) \quad (7)$$

and

$$s = \ln(E_t) - \ln(E_{t+1}^{\tau > 1}). \quad (8)$$

These are estimates of continuous-time flow rates. Given that we have data at an annual frequency, we are interested in the actual flows implied by these rates. As we show in Appendix A, these flows can be calculated by time aggregating the continuous-time flows. This yields that the total number of hires and separations over the year, H_t and S_t , equal to

$$H_t = \left(\frac{h}{h-s}\right) [e^{(h-s)} - 1]E_t \quad \text{and} \quad S_t = \left(\frac{s}{h-s}\right) [e^{(h-s)} - 1]E_t. \quad (9)$$

Thus, for countries and years for which we have observations on the fraction of workers with a job tenure longer than a year as a fraction of total employment in the next year, total employment in that year, and total employment in the next year, we can calculate an estimate of total hires and separations during the year using equations (7), (8), and (9).

These estimates of hires and separations are similar to the estimates of total flows into and out of unemployment for OECD countries introduced in Elsby, Hobijn, and Şahin (2008), who tailor the

method used in Shimer (2005, 2012) to impute monthly unemployment inflow and outflow rates for the U.S. to the available data for a broad set of OECD countries.⁹

Annual data on employment levels are available for all OECD countries as part of the OECD's Annual Labour Force Statistics. In addition, the OECD publishes annual data on employment by job tenure intervals for many countries. For most European countries for which these data are available, they go back to the early 1990's when Eurostat started collecting these data as part of the European Labour Force Survey. Data for Australia cover years as far back as 1986.¹⁰ Biannual data for the U.S. are available for 1996 onwards.¹¹ For Japan, a direct measure of total number of hires is available starting in 1952.

Matching functions and cyclicalities of separations

The time series of hires and separations allow us to estimate pre-Great-Recession matching functions, (4), and the cyclicalities of separations, (5). This can be done for countries for which data on vacancies are available.

We draw upon two sources for our job vacancy data. Our main source is the OECD's Job Vacancies Statistics. We supplement it with data from Eurostat for some countries since 2008 for which no data from the OECD are available.¹² The sample of advanced economies for which we have the data required for the estimation of (4) and (5) and have data through 2011 consists of 14 countries. The U.S. is one of these 14. We include the U.S. in our analysis to allow for a comparison of the results in Section 2, based on JOLTS data, with those obtained using the employment by job tenure data.

⁹ Similar to the unemployment inflow and outflow measures in Elsby, Hobijn, and Şahin (2008) which are affected by the duration dependence of unemployment outflow hazards, our estimates here are affected by the tenure dependence of job separation rates. We discuss in the appendix how this mainly affects the level of the turnover measures and not the cyclical fluctuations that are of interest for the rest of our analysis.

¹⁰ For Australia, we supplement the OECD data with data from the Australian Bureau of Statistics' Labour Mobility release.

¹¹ The U.S. data are taken from the Displaced Workers and Job Tenure supplement that is part of the Current Population Survey (CPS). We use the data available every two years since 1996. Before 1996 the job tenure question was phrased in an ambiguous way that makes it hard to interpret it as a continuous job tenure.

¹² This is the case for Spain and Portugal. For Portugal the fluctuations in the vacancy data published by the OECD and Eurostat are very different. We use the Eurostat data here because those give the smallest deviation from the Beveridge curve, which we already argue to be large.

Table 1 contains the estimated parameters α_h , α_s , as well as their standard errors and the R^2 's associated with the regressions for the 14 countries in our sample.¹³ The last column (VII) shows the number of annual observations on which the results are based.

For most countries our estimates of hires and separations based on employment by job tenure data go back to 1991. Because we end the sample in 2007, we have 17 annual observations for these countries before the Great Recession. For the U.S., the data are biannual, while for Austria and Sweden, they start later than 1991.

For France and Japan, we deliberately use a sample that starts later than the start date of the data. Both these countries saw a noticeable shift in their Beveridge curves during the period for which we have data. Because we aim to estimate fixed labor turnover equations that underlie a stable fitted Beveridge curve, we start the estimation for France and Japan after the Beveridge curve shifts; in 1996 and 2001 respectively.

For the U.K., we use all available observations but we allow for a change in the units of measurement of vacancies that coincides with a break in the U.K. vacancy series in 1998. The details of how we take this into account can be found in the Appendix.

In spite of the relatively small sample sizes and the annual frequency of the data, we obtain positive estimated match elasticities with relatively small standard errors for all countries in the sample (Table 1, Columns I-III). For 10 out of the 14 countries more than half of the variation in the vacancy yield is explained by the log variation in labor market tightness ($R^2 > .5$ in column III of Table 1).¹⁴

The estimates of the matching function elasticity of unemployment based on the annual employment by job tenure data from the OECD are quite similar across countries. Estimates of the elasticity α_h across countries vary from 0.12 for Japan to 0.83 for Austria while half of the estimated elasticities, α_h , are in the range of 0.40-0.55, with a median of 0.47.¹⁵

¹³ We do not report the intercepts, μ_h and μ_s , because they depend on the units of measurement of vacancies which differ across countries. This makes comparison of these parameters hard to do.

¹⁴ It has to be noted that the type of OLS regressions that are at the basis of Table 1 have been criticized (Borowczyk-Martins, 2011) because of the potential for endogeneity of the number of vacancies posted with respect to the level of match efficiency, $\varepsilon_{h,t}$.

¹⁵ It is worth noting that the results for the two countries with the lowest estimated α_h 's are not based on annual data on employment by job tenure. Instead, the results for the U.S. and Japan are based on biannual data and a direct measure of hires respectively. The range 0.12-0.83 is similar to the range of estimates surveyed by Petrongolo and Pissarides (2001, Table 3). The estimate of 0.27 for the U.S., is much smaller than the one of 0.58 obtained using the monthly JOLTS data, that are the source of Figure 2, and is also smaller than the estimated matching function elasticity for the U.S. of 0.72 in Shimer (2005), which uses an estimate of the outflow rate out of unemployment rather than hires.

There is much less similarity across countries in the estimated cyclicalities of separations (Columns IV and V of Table 1). Moreover, as can be seen by comparing the R^2 's in columns III and VI of Table 1, fluctuations in labor market tightness explain a much smaller fraction of movements in separations than in hires. This is not surprising because the degree and sign of the cyclicalities of separations depends on the relative importance of quits and layoffs.

For most countries, though, we find that separations are procyclical, i.e. $\alpha_s < 0$. They increase when the labor market is tight and u/v is low and they decrease when there is a lot of slack and u/v is high. The only two countries where separations are not procyclical are Austria, where they seem acyclical (as Hall, 2005, conjectured to be the case for the U.S.), and Spain, where we find significant countercyclicalities of separations.

The latter suggests that in Spain, more than in other countries, it is the fluctuations in layoffs over the business cycle and not quits that drive separations from employment. This is the result of the disproportionate reliance on temporary labor contracts in Spain's dual labor markets. Such contracts are likely not to be renewed in a downturn and drive up the cyclicalities of layoffs (Costain et al., 2010, OECD, 2012).

On the whole, our results imply that only considering hires does not suffice for the analysis of the dynamics of labor turnover in OECD countries. The cyclical fluctuations in separations imply that quits are an important driving force of variations in labor turnover.¹⁶

Fitted Beveridge curves

We use the estimates of μ_h , α_h , μ_s , and α_s from Table 1 to fit pre-recession Beveridge curves for the countries in our sample by solving for the unemployment rate/vacancy rate locus that solves the turnover-steady-state equation (3). We evaluate (3) at the average growth rate of the labor force between 1990 and 2012 and set $\varepsilon_{h,t} = \varepsilon_{s,t} = 0$. The fitted curves are shown in Figure 4, for the U.S., Figure 6, for the U.K., and Figure 5 for all 12 other countries.

We start by considering the fitted Beveridge curve based on the data on employment by job tenure for the U.S. in Figure 4. Doing so allows us to compare it to the fitted curve from Figure 1, which is based on monthly JOLTS data.

¹⁶ This finding is in line with the results in Hagedorn and Manovskii (2010) and Daly et al. (2012) which both suggest that job-to-job transitions are crucial for understanding cyclical fluctuations in real wages.

Compared to Figure 1, which shows the JOLTS sample from 2001-2011, Figure 4 contains a longer time series on vacancies that covers 1960-2011, based on Barnichon (2010). The grey dots are annual pre-2008 observations that are not used for the estimation of the parameters in Table 1. The black dots are the observations for the years for which labor turnover estimates are available which are used in the estimation results listed in Table 1. The black squares are observations since 2008. The numbers next to them indicate the year.

The black dashed line is the fitted Beveridge curve based on the seven biannual observations for which we have data on employment by job tenure for the U.S. Even though the fitted curve is only based on 7 observations, it is remarkably similar to the fitted curve in Figure 1. Just like in Figure 1, the fitted curve shows that before the Great Recession, the U.S. had a relatively stable Beveridge curve and that during the recession, the labor market seemed to move along this curve. It was during the recovery that started in the summer of 2009 that the U.S. unemployment-vacancy relationship started to deviate from the stable relationship it exhibited in the decade before.

In addition to the fitted Beveridge curve, Figure 4 also contains another curve. The grey dashed line, labeled “Fitted – constant separations,” is the imputed turnover-steady-state u/v -locus when one does not take into account the cyclicity of separations and sets S/E equal to its sample average in equations (3) and (6).

The reason we included this line is to show how important it is to take into account the cyclicity of separations to understand the shape of the Beveridge curve. Brügemann (2008) notes that there is a puzzling discrepancy between estimates of α_h obtained from matching functions and from fitting Beveridge curves. Our result here suggests that, in addition to the issues pointed out by Brügemann (2008), such a discrepancy should not be surprising since the shape of the Beveridge curve is not only determined by α_h but also by α_s .¹⁷

The panels in Figure 5 show the equivalent of Figure 4 for the other countries in our sample.¹⁸ For most countries the fitted Beveridge curve traces out the (u,v) sample observations really well. Of course, this is a judgment about the distance of the sample observations from the fitted curves.

¹⁷ Ignoring the cyclicity of separations for the construction of the fitted JOLTS-based Beveridge curve of Figure 1 yields a very similar curve to the grey dashed line in Figure 4.

¹⁸ The U.K. is included separately, in Figure 6, which takes into account a break in the definition of vacancies in 1998, to make the figure more readable.

Because we will discuss distances from the fitted Beveridge curves throughout the rest of our analysis, it is worthwhile to formally introduce them here.

We define the fitted Beveridge curves as the implicit function $u_{bc}(v)$ which gives the unemployment rate on the Beveridge curve as a function of the vacancy index. The horizontal distance of a point (u_t, v_t) from the fitted Beveridge curve is then defined as

$$D_t = (u_t - u_{bc}(v_t)). \quad (10)$$

Throughout, we compare these distances with the square root of the sum of squared distances for the points for which the curve is fitted, which is given by

$$\sqrt{\frac{1}{n} \sum_{t \in \text{sample}} D_t^2}, \quad (11)$$

where n is the number of observations listed in Column VII of Table 1. If the fitted Beveridge curve was a (non-linear) regression line, then this could be interpreted as the standard error of the residuals and thus as a measure of goodness of fit.¹⁹

Column VII of Table 2 lists the value of (11) for all 14 countries in our sample. Except for Belgium, Portugal, and Spain, the value of (11) is smaller than 1.5 percentage points for all countries in the sample.

Belgium, Portugal, and Spain are countries with very slow unemployment adjustment dynamics.²⁰ This means that the labor markets in these countries are subject to larger and more persistent deviations from their labor-turnover steady states. As a result, because the fitted Beveridge curve is an estimate of the steady-state (u, v) -locus, one would expect bigger deviations from the curve in these countries than in other ones.

Besides the sample observations, the fitted steady-state relationships also capture out-of-sample observations in the latter part of the sample ('95 onwards) as well. For example, the high points on Austria's Beveridge curve and the low points on the Dutch curve all are points that were not part of the sample for which the matching function and cyclicity of separations were estimated.

¹⁹ Since the fitted curve is a locus constructed based on estimates of (4) and (5) and the average distance for the sample observations does not have to be zero this is not literally a standard error of the residuals. However, in the rest of our analysis we will informally treat it as such.

²⁰ See Elsby, Hobijn, and Şahin (2008) for a discussion of these adjustment rates and for estimates for Spain and Portugal.

Though a detailed discussion of the fitted curves for each of the countries goes beyond the scope of our analysis, we provide a detailed discussion of the case of Germany since it implemented substantial labor market reforms in the last decade. Our hires and separations time series for Germany cover 1991 through 2007. In the middle of this sample period, from January 2003 through January 2005, the Hartz reforms of German labor market policies were implemented.

The reforms implemented include two broad policy measures. The first was to reduce the generosity of unemployment insurance by reducing the unemployment insurance benefit level for the long-term unemployed to that of unemployment assistance (“Sozialhilfe”). This, in effect, reduced the duration of German unemployment benefits. The second was to increase the number of German job centers and reorganize them to focus them more on helping the unemployed find jobs rather than on administering the unemployment insurance program. In addition, two types of jobs, with lower taxes and insurance payments, as well as grants for entrepreneurs were introduced.²¹

These reforms seem to have resulted in an inward shift of the German Beveridge curve. This can be seen from the sample points on the left-hand side of the fitted Beveridge curve in the panel for Germany in Figure 5. These are the post 2004 observations.

So far, we focused on the black circles in Figures 4, 5, and 6 and discussed the fitted curves. We now turn our attention to the black squares, which represent the observations since the onset of the Great Recession.

Shifts in Beveridge curves since 2007

Table 2 lists the main results related to the outcomes since the start of the Great Recession for the 14 countries in our sample. Columns I and II contain the level of the unemployment rate in 2011 and its percentage point change between 2007 and 2011. As can be seen from Column II, not all countries saw a large run-up in unemployment during the recession. Portugal, Spain, the U.K., and the U.S. are the countries with the largest increase in their unemployment rates from 2007-2011.

Columns VIII and IX of Table 2 list the distance of the post-recession observations for 2010 and 2011 from the fitted Beveridge curves. As can be seen from these columns as well as from Figures

²¹ Jacobi and Kluve (2007) and Fahr and Sunde (2009) provide evidence that the change in active labor market policies that was part of the Hartz reforms increased match efficiency in the German labor market. As far as the effect of the UI reforms, Schmieder et al. (2012), using a pre-Hartz-reform data, find that that elasticity of the response to UI extensions in Germany is similar to those estimated for other countries (and fluctuates over the business cycle).

4, 5, and 6, in almost all countries, except for Belgium, Germany, and Japan, the post-recession observations are to the right of the fitted Beveridge curves. Observations to the right of the curve are not unprecedented.

To get a sense of how big these distances are compared to the in-sample deviations, we list the ratio of the 2010 and 2011 deviations and the approximate standard deviation of the in sample horizontal distances, (11), in Columns X and XI. We report this ratio since they are in the spirit of a conventional Chow (1960) forecast test in which this ratio would have an actual t -distribution.²² Consistent with this t -test interpretation, we first focus on countries for which these ratios equal or exceeded 2 in both 2010 and 2011. The countries for which this is the case are Norway, Portugal, Sweden, the U.K. and the U.S.

From our analysis in Section 2, we know that the post-recession deviations from the Beveridge curve in the U.S. are driven by the joint decline in match efficiency, i.e. $\varepsilon_h < 0$ in (4), and decline in the cyclical separations, i.e. $\varepsilon_s < 0$ in (5). Columns III-VI of Table 2 contain the cross-country equivalent of ε_h and ε_s for 2010 both in levels as well as normalized by the standard error of the regressions.

Norway, Portugal, and the U.K. are among the countries with the highest decline in estimated match efficiency. In addition, Norway and the U.K. also saw their separation rate decline more than expected. In this sense, the deviations from the pre-recession curves in Norway and the U.K. mimic those in the U.S. in that they are driven by a decline in match efficiency partly offset by a reduction in quits. Instead of partly offsetting the decline in match efficiency, separations in Portugal, presumably layoffs, actually contributed to the rightward deviation from the fitted Beveridge curve. This probably reflects the passing of austerity measures by the Portuguese government in the fall of 2010.

Among Norway, Portugal, Sweden, the U.K., and the U.S., Norway and Sweden are the outliers. Though the deviations from the fitted Beveridge curve in Norway are large compared to their historical magnitudes, at 0.6 percentage points in 2011, they are small in absolute terms. Moreover, contrary to the other four countries, Norway only had a less than one percentage point run up in its

²² The limited number of observations in our sample and the fact that the distances, D_t , are not really regression residuals prevent us from doing a more formal statistical analysis.

unemployment rate and did not see a large decline in the number of vacancies posted. Because of this, we do not classify Norway as having seen a large rightward shift in its Beveridge curve.

Contrary to Norway, Sweden has seen large deviations, of about 3 percentage points, from its Beveridge curve since the onset of the recession. What is different in Sweden as compared to the other countries is that this shift seems to be fully driven by unprecedentedly high separations and not by a decline in match efficiency.

Spain is the opposite of Norway. It had the highest increase in its unemployment rate coinciding with the largest deviations from the pre-recession Beveridge curves of all countries. Because such large deviations have occurred before, the recent observations might not seem like a significant deviation when one only considers the unemployment and vacancy rate observations.

However, when one considers the labor turnover measures, a different picture emerges. Spain has seen by far the highest decline in labor turnover, both in hires and quits, relative to its historical patterns of all countries in our sample. In fact, our results for 2010 indicate a 51 percent decline in match efficiency in Spain compared to before the recession. This is indicative of a very substantial deterioration of the workings of the Spanish labor market.

These results for Spain illustrate an important advantage of constructing fitted Beveridge curves based on labor turnover series rather than from a non-linear regression of the unemployment rate on its own lags and the vacancy rate.²³ Constructing the fitted Beveridge curves from labor turnover measures allows one to more explicitly identify what, in terms of the dynamics of the labor market, is driving deviations from the curve.

As we have discussed before, Germany is another interesting case because our results suggest that the leftward movement of its Beveridge curve that started after the Hartz reforms continued during and after the Great Recession.

The results in Table 2 suggest that, in addition to the U.S., we have seen evidence of increased labor market frictions in Portugal, Spain, Sweden, and the U.K. that have resulted in the unemployment rate being higher than implied by its pre-recession relationship with the vacancy rate. In Portugal, Spain, and the U.K., this movement of the Beveridge curve coincides with a

²³ Such non-linear regressions are the most common empirical method of studying Beveridge curves. See Nickell et al. (2001), Valletta (2005), Bouvet (2012), and Bonthuis et al. (2012) for example.

decline in measured match efficiency, while in Sweden, it has been driven by an increase in separations. In the next section, we provide evidence to help explain these findings.

4. Historical context and cross-country evidence on causes of shifts

We take two approaches to explaining the recent Beveridge curve movements. In the first part of this section we consider direct cross-country evidence related to the three factors we identified as having shaped the U.S. curve since 2008; house lock, mismatch, UI extensions. In the second part we put the current movements in the Beveridge curves across countries in a historical context and compare them with those that occurred from the mid-1980's onwards.

Cross-country evidence on house lock, mismatch, and unemployment insurance extensions

The results in the last part of Section 4 bring to mind four main questions with regards to possible explanations of the recent Beveridge curve shifts: (1) What do Portugal, Spain, the U.K., and the U.S. have in common compared to the other countries in our sample?; (2) Why, among these four countries, is the response in the Spanish labor market so outsized compared to the other three?; (3) What causes the outward shift in the Swedish Beveridge curve since 2007, which was fully driven by above normal separations rather than a decline in match efficiency?; and (4) What makes Germany's labor market performance since 2007 stand out compared to that of other countries?

With respect to the first question, Table 3 reports several cross-country statistics on unemployment insurance (Columns I and II) and on housing and mismatch (Columns III-V). Where Portugal, Spain, the U.K., and the U.S. stand out is in the last two columns. These are the countries that were most severely hit by the housing crisis, causing both the steepest house price declines of the countries in our sample as well as large drops in the share of construction employment.

Because house price declines and job losses in the construction sector are highly correlated across countries, this evidence does not directly allow us to distinguish between house lock or mismatch due to displacement of a large number of construction workers. As we discussed in Section 2, we know from the analyses that were specifically done for the U.S. that there is ample evidence that the decline in construction employment has reduced measured match efficiency and that house lock has not significantly reduced labor market turnover in the U.S.. Bonthuis et al.

(2012) find that declines in the share of construction employment are an important factor explaining Beveridge curve shifts in the euro area.

Together with the results for the U.S., we take this as evidence that the common factor that contributes to the rightward shift in the Beveridge curves of Portugal, Spain, the U.K., and the U.S. is skill mismatch. In particular, the Great Recession has resulted in disproportionate job losses among workers in the construction sector. Since the vacancy yield in the construction sector is very high compared to other sectors, this results in a decline in observed match efficiency.

Although skill mismatch seems to be the common factor behind the Beveridge curve shifts in Portugal, Spain, the U.K., and the U.S., the labor markets in these countries responded very differently to this shock. In particular, the Spanish labor market's response is much larger than in the other countries. This is true not only in terms of the increase in the unemployment rate, but also in the size of Beveridge curve shift, the decline in match efficiency, and shortfall in separations.

As discussed in OECD (2012) this is the result of Spain's dual labor market system. One part of this dual labor market, 66 percent of total employment before the crisis and 75 percent in 2010, consists of permanent jobs shielded by many provisions of Employment Protection Legislation. The other part is temporary jobs with contracts a year or shorter. During the downturn, 90 percent of the reduction in employment occurred among workers under temporary contract. Since, just like construction jobs, jobs under temporary contracts are likely to have high vacancy yields the decline in temporary contract jobs in Spain put additional downward pressure on match efficiency.

Besides the mismatch factors listed in Columns IV and V of Table 3, the U.S. Beveridge curve was also affected by the UI extensions in 2008. As Column II of Table 3 shows, the U.S. was not the only country that increased the duration of its unemployment insurance benefits in our sample. Sweden also did so in 2007. This extension was part of a broad set of labor market reforms that were implemented in Sweden in 2007 with the aim to increase the labor supply and employment-to-population ratio. These reforms also included a reduction in the UI benefit replacement rate as well as reduction in the level of other benefit programs, the introduction of an Earned Income Tax Credit, and a reduction in payroll taxes.

Finally, the other country that saw a big deviation from its fitted pre-recession Beveridge curve, but to the left rather than the right, was Germany. The German "Labor Market Miracle" has been analyzed in detail in Burda and Hunt (2011). Our results for Germany on labor turnover here

(Columns V and VI in Table 2) suggest much lower than expected separations in Germany but no decline in match efficiency. This is consistent with the use of working time accounts reducing the incentives for employers to lay off workers in the downturn.

Historical Perspective: Shifts between 75-85 and 91-07

The Beveridge curve shifts in the wake of the Great Recession are not the first. What stands out most from Figure 4 is that the fitted pre-Great-Recession curve for the U.S., based on data from 1996 through 2006, is on the left-hand side of the (u,v) -points in the diagram. This is because from the mid 1970's through the late 1980's, the U.S. Beveridge curve shifted outward. This outward shift coincided with the deep recessions of the early 1980's. This outward shift in the Beveridge curve during this period was not limited to the U.S. Most other countries also saw their Beveridge curve shift outwards during this period. Where the U.S. experience stands out is that its Beveridge curve subsequently moved left. In most other countries movements in the 1980's were more persistent.

The panels in Figure 5 show the equivalent of Figure 4 for the other countries in our sample. As can be seen by comparing the fitted curve to the grey non-sample dots in all the panels, just like the U.S., all other countries saw a large rightward shift in their Beveridge curves.

To put the deviations from the pre-recession curves since the start of the Great Recession in a better perspective, it is worthwhile to first quantify the historical shifts in the Beveridge curves that occurred in the 1980's.

Table 4 lists the level of the unemployment rate in 1985, the increase in the rate in the preceding decade, as well as the average distance of the 1975-1985 observations from the fitted Beveridge curves. As can be seen by comparing Column II of Tables 2 and 4, increases in unemployment rates during the deep recessions of the late 1970's and early 1980's were much more widespread and generally larger than those during the Great Recession.²⁴

Rightward shifts in Beveridge curves following these deep recessions were also bigger and more widespread than those that we documented for the Great Recession. As can be seen from Column IV of the Table 4, the U.S. is the only country for which the fitted curve lies to the left of the 1975-1985 observations, by, on average, 3.7 percentage points on the unemployment rate to be precise.

²⁴ This comes with the caveat that in many countries the unemployment rate continued to increase after 2011, the end of our sample.

For all other countries, the fitted Beveridge curve is to the right of the 1975-1985 observations. Countries with the biggest movements are Spain, Belgium, Japan, France, and Germany. Comparison of Tables 2 and 4 shows that the magnitudes of these shifts are much bigger than the ones we observed during the Great Recession.

Though we are the first to formally quantify these shifts relative to the pre-Great-Recession curves, they have been analyzed and discussed in a large number of previous studies. The one most closely related to ours is Nickell et al. (2001).²⁵ Two main reasons for these shifts have been pointed out.

The first is the change in the composition of the pool of unemployed, partly because of the change in the labor force due to the entry of the baby-boomers and partly because of the displacement of a large number of workers due to the depth of the recessions of the late 1970's and early 1980's. This is reminiscent of the skill mismatch argument related to construction employment for the recent shifts.

Entry of the baby-boomers in the labor market and an increase in female labor force participation drove a secular increase in frictional unemployment in the 1980's. As Shimer (1998) points out for the U.S., this composition effect largely reversed with the aging of the baby boomers. He attributes a large part of the inward shift in the U.S. Beveridge curve to this reversal.²⁶

Pissarides (2006) discusses how the grey points on the right-hand side of Figure 6 can be interpreted as a prolonged counter-clockwise loop of the U.K. Beveridge curve, which reflect a slow adjustment of the British labor market after steep declines in manufacturing and mining employment in the 1980's resulted in the equivalent of the current construction-related mismatch.

The demographic trends and displacement of workers of the 1980's were widespread across many countries. The puzzle is then why the U.S. Beveridge curve shifted back while those of most other countries did not.

Blanchard and Wolfers (2000) argue that this is because differences in labor market institutions/policies across countries made some countries more susceptible to a persistent unemployment problem after the deep recessions of the late 1970's and early 1980's than others.

²⁵ Other cross-country analyses of these movements in the (u,v) -curve are Budd et al. (1987) and Bouvet (2012) for example.

²⁶ The replication files to Elsby, Hobijn, and Şahin (2010, figure 5) include results for a fully demographically adjusted unemployment rate. These results suggest that the adjusted for the 2010 composition of the U.S. labor force the U.S. unemployment rate would have been a bit more than 2 percentage points lower than the published number.

Nickell et al. (2001, Table 10) present results that suggest that it is not only the labor market institutions and policies in place but also the change in them that contributed to the outwards shifts in the Beveridge curves in many countries. In particular, they find that countries that increased the durations of their unemployment benefits, not unlike the U.S. in 2008, saw a rightward shift in their (u,v) -relationships.²⁷

Sweden is an interesting case. Forslund and Krueger (2010) argue that the rightward shift in the Swedish Beveridge curve after the financial crisis of the early 1990's was largely the result not of a change in labor market policies but a change in their implementation. In particular, they argue that allowing individuals to reset their unemployment duration benefits after participation in active labor market programs (ALMP) induced them to rotate between UI and ALMP. This effectively amounted to an extension of the duration of UI benefits.

Changes in labor market policies have also been pointed to as having contributed to a partial reversal of the Beveridge curve shifts of the 1980's in the Netherlands and the U.K. (Nickell and van Ours, 2000). The Netherlands and the U.K. are the two countries with the relatively smallest outward movement of their (u,v) -curves between 1975-1985 and the fitted sample (Table 4, columns III and VI). Nickell and van Ours emphasize that the reduction in unemployment in the Netherlands and the U.K. in the 1990's was a result of a combination of a reduction in the generosity of unemployment benefits and a transition to cooperative wage bargaining (in the U.K.: the Netherlands already had such a system).²⁸

5. Conclusion

What emerges from a comparison of the evidence across countries and over time is a surprisingly consistent story. The displacement of a large part of the labor force during deep recessions results in mismatch in the labor market which leads to a decline in measured match efficiency. This tends to be accompanied by a decline in the quits rate which partially offsets the effect of the reduction in match efficiency on the position of the Beveridge curve. The common policy response to reduce the

²⁷ In addition, they find that in countries where home ownership rates increased the Beveridge curve drifted outward. They interpret this as significant cross-country evidence of an effect of labor mobility on the Beveridge curve.

²⁸ In addition to the change in wage bargaining, Pissarides (2006) also discusses the change in monetary policy in the U.K. in 1993. He argues, on page 218, that the outward movement in the British Beveridge curve in the 1980's can be better interpreted as a prolonged counter-clockwise loop than an actual shift.

burden of displacement for the unemployed by increasing the generosity and duration of unemployment insurance further contributes to the rightward shift of the Beveridge curve.

As it turns out, the U.S. experience in the wake of the Great Recession perfectly fits this profile. Going forward, the issue for the U.S. is then how long the increase in skill imbalances between labor demand and labor supply in the market will last and whether and when, as the economy recovers and mismatch unwinds, the extensions of UI will be allowed to expire.

Because (i) a large part of the sectoral shifts during recessions that drive the skill mismatch tends to be cyclical rather than structural in nature (Abraham and Katz, 1986; Şahin et al., 2011), (ii) the rate of adjustment of the U.S. labor market is very high (Elsby, Hobijn, and Şahin, 2008), (iii) U.S. workers are very mobile across industries and occupations (Hobijn, 2012), and (iv) UI extensions are not expected to be permanent, the current rightward shift in the U.S. Beveridge curve is likely to largely reverse over the coming years. This is not unlike, and probably faster than, the prolonged loop in the U.K. Beveridge curve in the late 1980's discussed by Pissarides (2006).

The labor market dynamics in the U.S. are the exception compared to other countries. In countries like Portugal and Spain, which have much slower rates of labor market adjustment and have permanently more generous UI benefits, the current rightward shift of the Beveridge curve is bound to be much longer-lasting than the one in the U.S.

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Appendix A: Mathematical derivations

The Beveridge curve as an implicit function

The estimated matching function that fits the vacancy yield, H/V , as a function of the unemployment to vacancy ratio, U/V is given by

$$\ln(H_t/V_t) = \mu_h + \alpha_h \ln(U_t/V_t) + \varepsilon_{h,t}. \quad (12)$$

This implies that hires per employee equals

$$\ln(H_t/E_t) = \mu_h + \alpha_h \ln(U_t/E_t) + (1 - \alpha_h) \ln(V_t/E_t) + \varepsilon_{h,t}. \quad (13)$$

Since the unemployment to employment ratio can be written in terms of the unemployment rate as

$$\frac{U_t}{E_t} = \frac{u_t}{1-u_t} \quad (14)$$

and because we define the vacancy rate as $v_t = V_t/E_t$, the estimated matching function implies that we can write the ratio of hires per employee as

$$\frac{H_t}{E_t} = e^{\mu_h + \varepsilon_{h,t}} \left(\frac{U_t}{E_t}\right)^{\alpha_h} v_t^{(1-\alpha_h)}. \quad (15)$$

Similarly, since we estimate the cyclicity of separations using the iso-elastic functional form

$$\ln(S_t/E_t) = \mu_s + \alpha_s \ln(U_t/V_t) + \varepsilon_{s,t}, \quad (16)$$

we can write this in terms of the unemployment and vacancy rates as

$$\frac{S_t}{E_t} = e^{\mu_s + \varepsilon_{s,t}} \left(\frac{U_t}{E_t}\right)^{\alpha_s} v_t^{-\alpha_s}. \quad (17)$$

Combining (15) and (17), and the turnover steady-state condition (3) yields that the combinations of the unemployment rate and vacancy rate that are on the Beveridge curve need to satisfy

$$g_{t+1} = e^{\mu_h + \varepsilon_{h,t}} \left(\frac{U_t}{E_t}\right)^{\alpha_h} v_t^{(1-\alpha_h)} - e^{\mu_s + \varepsilon_{s,t}} \left(\frac{U_t}{E_t}\right)^{\alpha_s} v_t^{-\alpha_s}, \quad (18)$$

which is the equation in the main text. This defines the unemployment rate on the Beveridge curve as an implicit function of the vacancy rate.

Construction of labor turnover estimates using annual employment by job tenure data

Our aim is to estimate the hires and separation rates for different countries over time. In this appendix we show how the hires and separation rates can be estimated using data on employment growth and on the fraction of workers that report to have a job tenure smaller than a year. Throughout, time t is continuous and measured in years. We consider a year that runs from $t \in [0,1]$.

The parameters that we are interested in estimating are the monthly separation rate, s , and the monthly hires rate, h . We assume that these rates are constant over the year. Our method uses data on employment at the beginning of the year in month 0, E_0 , and at the end of the year at $t = 1$, E_1 . Moreover, we also have data on the fraction of workers that have been employed at a job with tenure of less than a year at the end of the year. This fraction allows us to calculate the number of workers at the year with a job tenure shorter than a year, which we denote by $E_1^{\tau < 1}$, where τ denotes job tenure in years.

With the assumed constant hires and separation rates, h and s , the number of employed persons evolves according to

$$\dot{E}_t = hE_t - sE_t. \quad (19)$$

Solving this differential equation results in the solution that

$$E_t = e^{(h-s)t} E_0 \text{ for } t \in [0,1]. \quad (20)$$

Hence, the growth rate of employment is the difference between the hiring rate, h , and the separation rate, s .

As for the number of workers hired over the period $[0, t)$ who are still employed at time t , i.e. $E_t^{\tau \leq t}$, this stock evolves according to

$$\dot{E}_t^{\tau \leq t} = hE_t - sE_t^{\tau \leq t} \text{ for } t \in [0,1] \text{ and where } E_0^{\tau < 0} = 0. \quad (21)$$

This is where the assumption that the separation rate is independent of job tenure comes in, since this equation assumes that the overall separation rate, s , applies to those with job tenures in the interval $[0, t)$.

Since we know the solution for E_t , we can solve the non-homogenous linear differential equation for $E_t^{\tau < t}$ to obtain that

$$E_t^{\tau \leq t} = [1 - e^{-ht}]E_t. \quad (22)$$

This equation does not depend on the separation rate because of the assumption that the same rate applies to those workers with short tenures as well as long tenure.

This equation thus implies that the share of workers with a job tenure of a year or less as a fraction of total employment at time $t = 1$ satisfies

$$\frac{E_1^{\tau \leq 1}}{E_1} = [1 - e^{-h}]. \quad (23)$$

This is a very useful result, because it implies that, even if there are no direct data on the hires rate as in JOLTS for the United States, the hires rate can be inferred from the share of workers with short tenures. In particular, the monthly hires rate can be calculated using

$$h = -\ln\left(1 - \frac{E_1^{\tau \leq 1}}{E_1}\right). \quad (24)$$

Given this estimate of the hires rate, the separation rate can be inferred from the survivor rate of those employed at the end of last period. That is,

$$s = -\ln\left(\frac{E_1^{\tau > 1}}{E_0}\right). \quad (25)$$

These are the estimates of the annualized hires and separation rates, equivalent to the ones reported in JOLTS.

These flow rates can be transformed into estimates of actually flows of hires and separations. Let H_t be the total number of hires over the period $[0, t)$. These total flows are given by

$$H_t = \int_0^t h E_v dv = \left(\frac{h}{h-s}\right) [1 - e^{-(h-s)t}] E_t = \left(\frac{h}{h-s}\right) [e^{(h-s)t} - 1] E_0 \text{ for } t \in [0, 1]. \quad (26)$$

Similarly, the total number of separations over $[0, t)$, S_t , can be calculated as

$$S_t = \int_0^t s E_v dv = \left(\frac{s}{h-s}\right) [1 - e^{-(h-s)t}] E_t = \left(\frac{s}{h-s}\right) [e^{(h-s)t} - 1] E_0 \text{ for } t \in [0, 1]. \quad (27)$$

These two flow measures satisfy the identity that the change in employment is the difference between total hires and total separations. That is,

$$E_t - E_0 = H_t - S_t. \quad (28)$$

The above derivations describe how data on the distribution of job tenures can be used to construct hires and separation measures that are conceptually the same as those measured on a monthly basis for the United States as part of JOLTS.

For the empirical implementation of these equations, we assume that E_1 is the employment level observed in the year after which h and s are the turnover rates. This is because the job tenure surveys are done in the first half of the year and thus, those with a job tenure smaller than 12 months generally were hired in the previous year.

Similar cyclicity of turnover measures from JOLTS and employment by job tenure

For our calculation, we assume that workers of all job tenures separate at the same rate s . We know this is, at best, an approximation since there is ample evidence that the separation rate from a job is declining in the tenure length. However, this tenure-dependence of the separation rate turns out to be of second-order importance for our calculation and ignoring it results in much simpler expressions.

In an extension of the methodology, we allowed for the separation rate of recently hired workers to be different from s . This requires using additional data on employment by job tenure shorter than 6 months which turns out to be noisy across countries and also depends on when in the year the job tenure distribution is measured.²⁹ When we applied this generalized method we got more noisy estimates of hires and separations.

What is, in particular, important for our calculation is not the level of hires and separations imputed from the data but the percent fluctuations over the business cycle. These fluctuations were highly correlated across both methodologies. Because of this, we present the result for the simpler methodology that is less subject to noise measures of employment with tenure less than half a year.

A final way to consider whether our method captures cyclical fluctuations in separations and hires reasonably well is to compare the biannual estimates for 1996 through 2010 for the U.S. with the direct measures from JOLTS. Figure A1 shows that the logs of the JOLTS and job-tenure-data based estimates of hires and separations commove a lot. The correlations between the hires measures is .99 and between the separations series 0.91. Hence, the cyclical movements in job-

²⁹ Seasonality is actually also an issue for the share of workers employed longer than a year.

tenure-based estimates of labor turnover are highly correlated with direct measures of labor turnover from JOLTS.

Taking into account break in U.K. vacancy series in 1998

The U.K. vacancy statistics contain a structural break between 1998 and 2001. There are no data for 1999 and 2000 (the OECD data for this year have been interpolated). The units of measurement of vacancies in the U.K. seems to have changes between the pre- and post-break data. To take this break into account we include a dummy, d_t , in the estimated matching and separations functions which equals one for the pre-break data and zero for the post-break period.

We then estimate the matching and separation functions as

$$\ln(H_t/E_t) = \mu_h + \alpha_h \ln(U_t/E_t) + (1 - \alpha_h) \ln(V_t/E_t) + \gamma_h d_t + \varepsilon_{h,t} \quad (29)$$

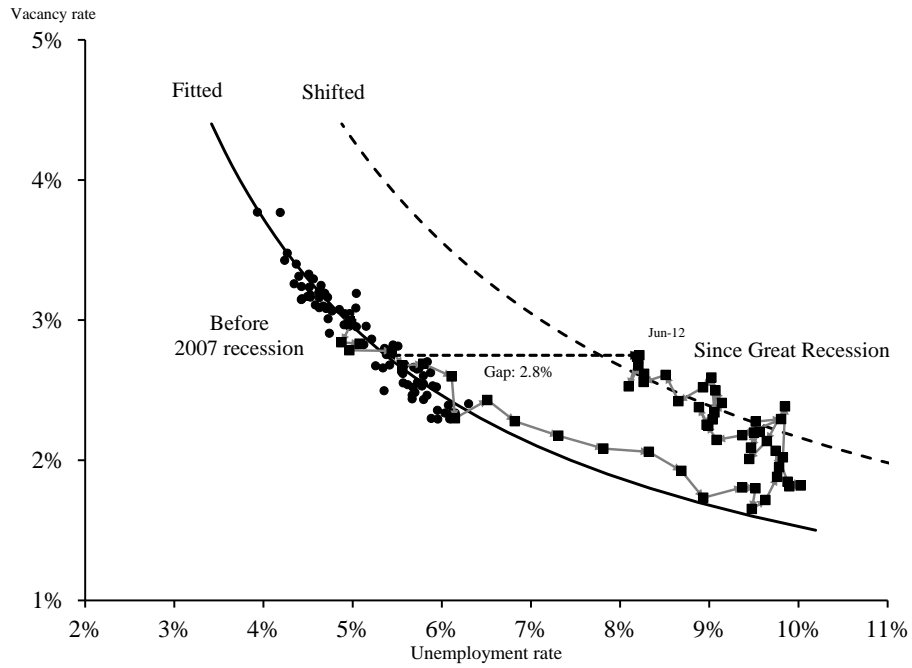
and

$$\ln(S_t/E_t) = \mu_s + \alpha_s \ln(U_t/V_t) + \gamma_s d_t + \varepsilon_{s,t}. \quad (30)$$

Combining these two conditions yields two turnover-steady-state loci. One that holds for the pre-break definition of vacancies, i.e. $d_t = 1$, and one that holds post-break, i.e. $d_t = 0$.

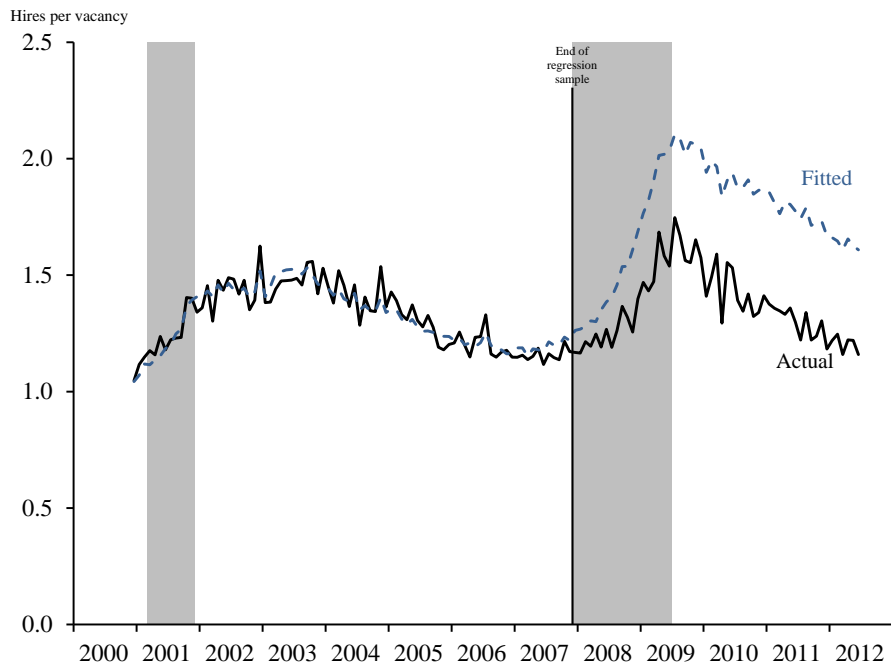
Of course, this way of taking into account the break assumes that the only thing that changed in terms of the vacancy measure is its unit of measurement and not its cyclical properties.

Figure 1. The U.S. Beveridge curve: Dec 2000 – Jun 2012.



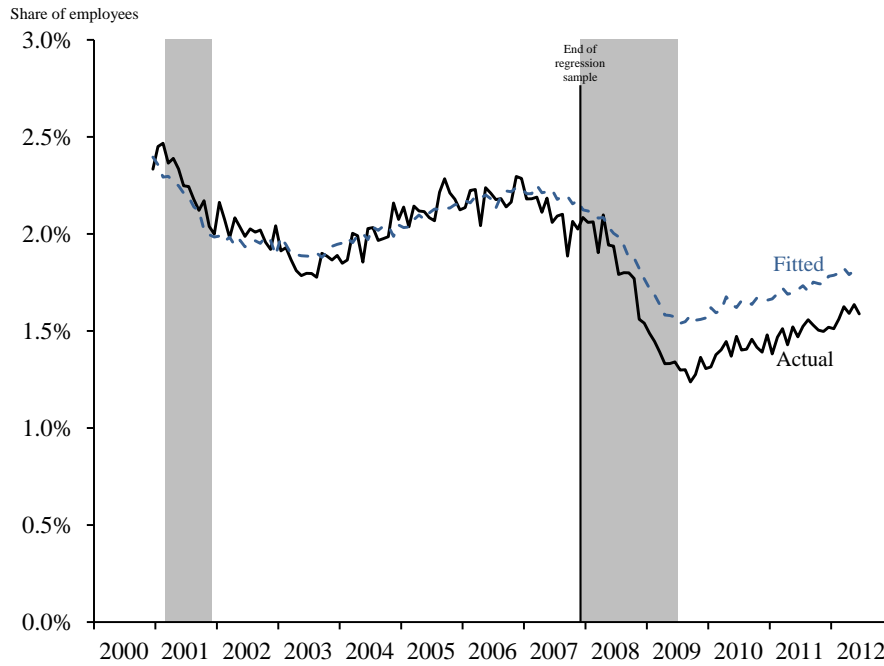
Source: JOLTS and authors' calculations, based on Barnichon et al. (2012).

Figure 2. Actual and fitted U.S. vacancy yield: Dec 2000 – Jun 2012.



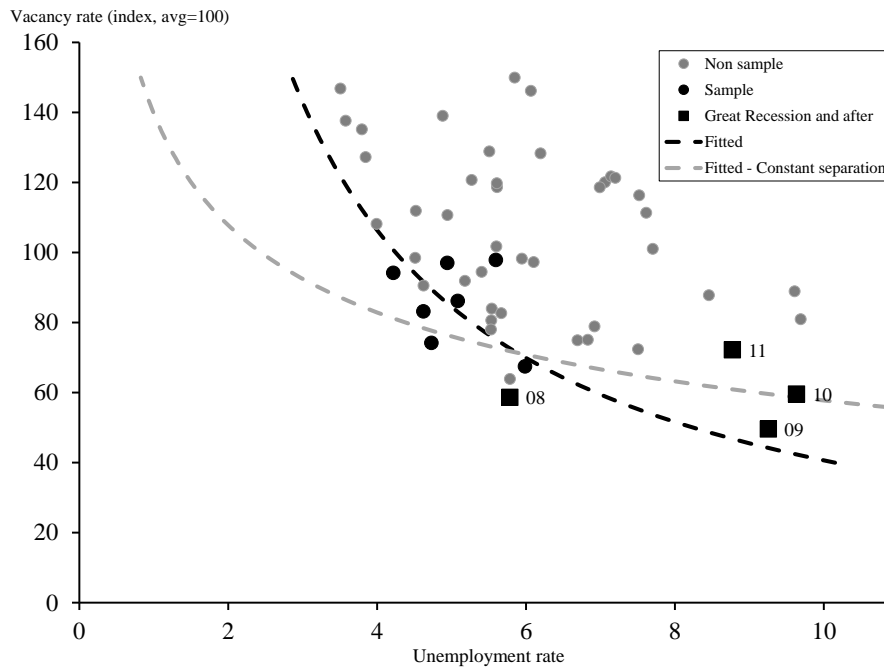
Source: JOLTS and authors' calculations, based on Barnichon et al. (2012).

Figure 3. Actual and fitted U.S. quits rate: Dec 2000 – Jun 2012.



Source: JOLTS and authors' calculations, based on Barnichon et al. (2012).

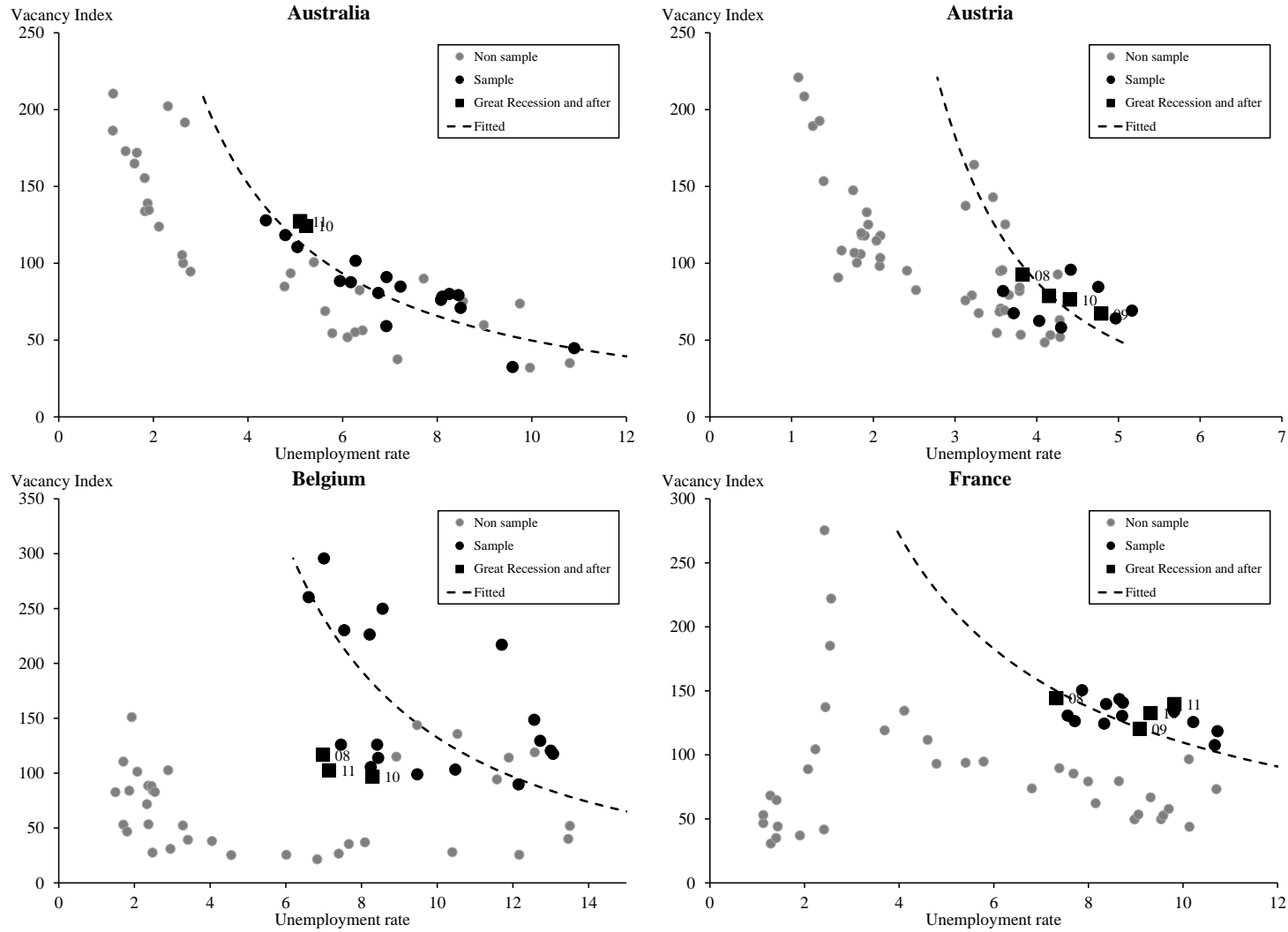
Figure 4. Actual and fitted U.S. Beveridge curve, job tenure data methodology, 1960-2011.



Source: BLS, Barnichon (2010), and authors' calculations

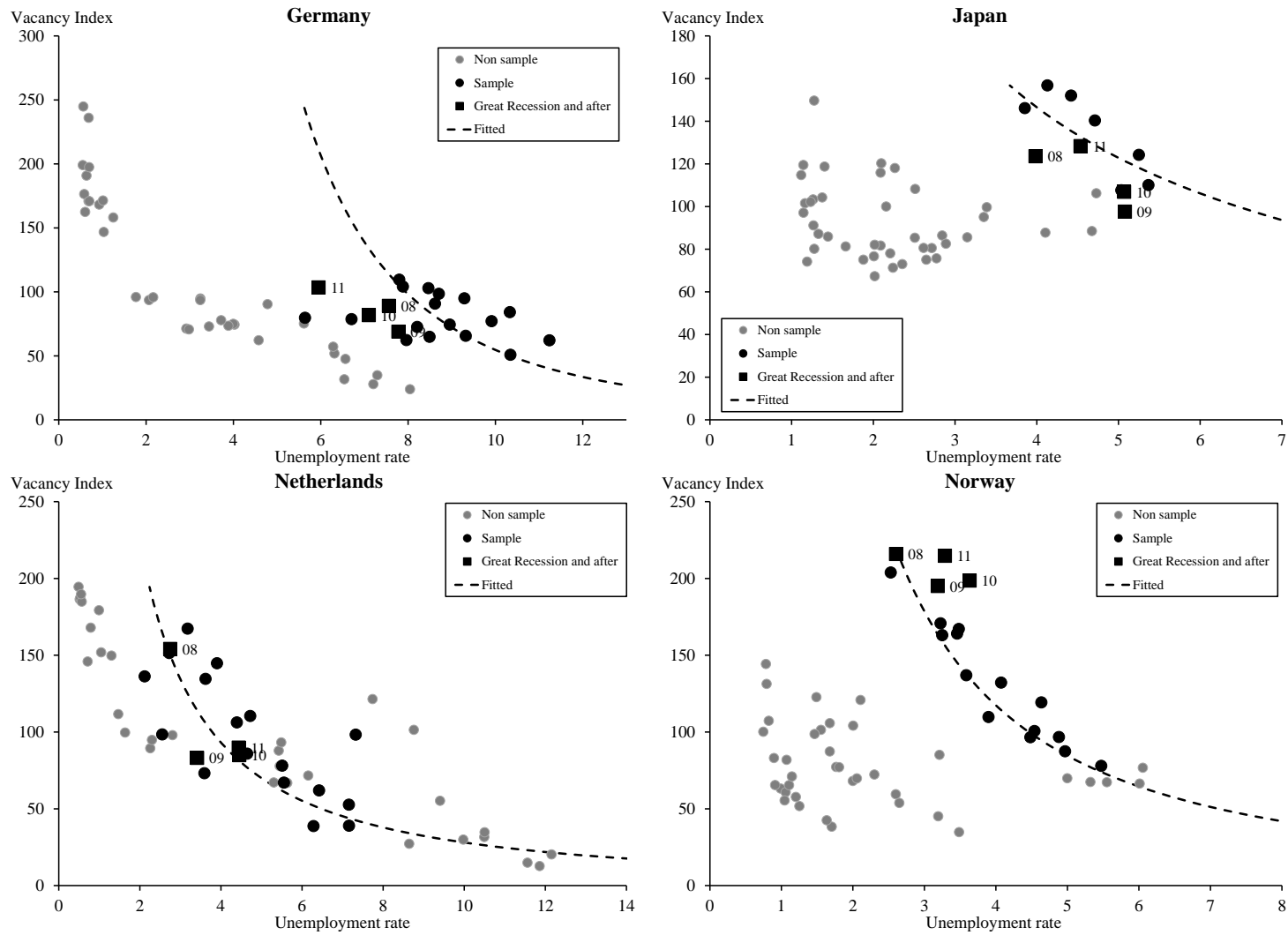
Note: The grey dashed line is the fitted Beveridge curve in which cyclicity of separations is ignored in the sense that $\alpha_s = 0$ and μ_s is the mean of the log of the ratio of separations to employment.

Figure 5. Actual and fitted Beveridge curves across countries.



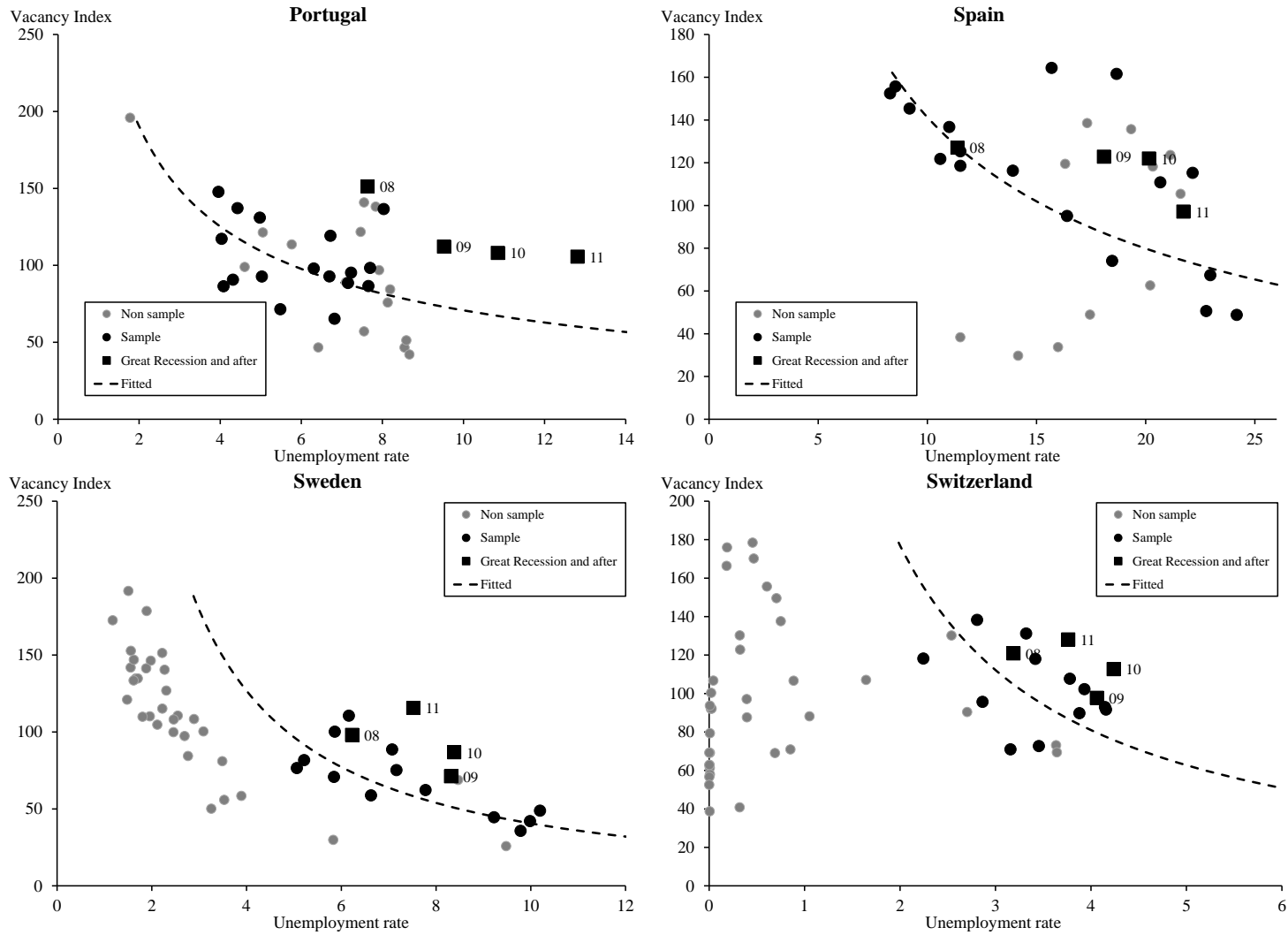
Note: Vacancy index is constructed to have an average of 100 over all observations plotted.

Figure 5 (continued). Actual and fitted Beveridge curves across countries.



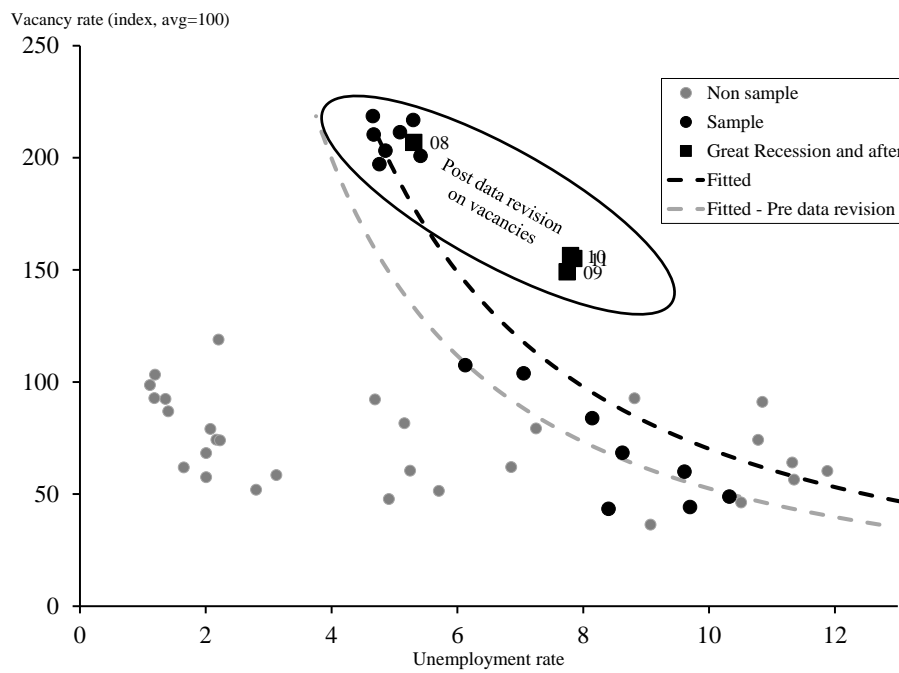
Note: Vacancy index is constructed to have an average of 100 over all observations plotted.

Figure 5 (continued). Actual and fitted Beveridge curves across countries.



Note: Vacancy index is constructed to have an average of 100 over all observations plotted.

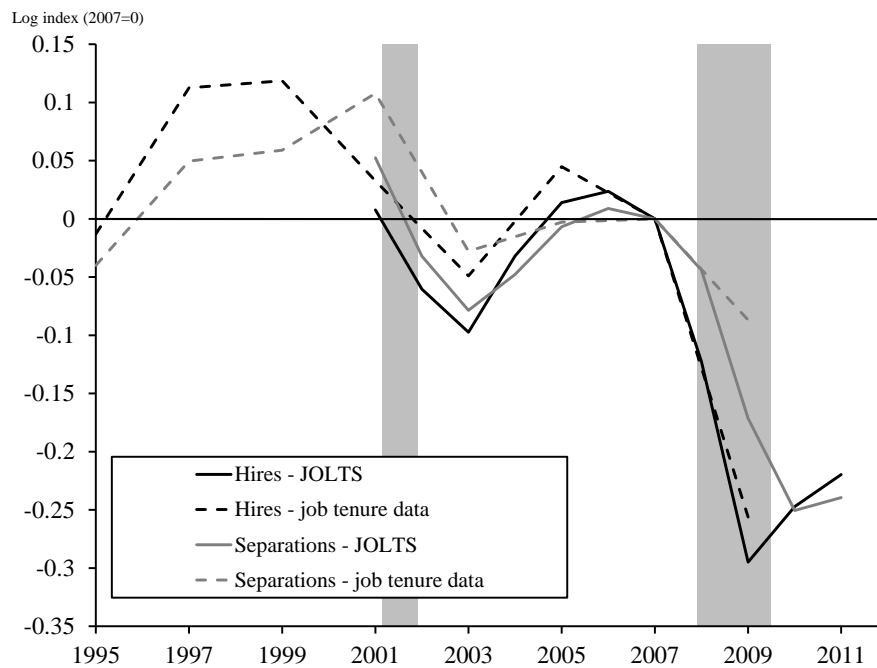
Figure 6. U.K. Beveridge curve, 1960-2011, taking into account break in vacancy series in 1998.



Source: OECD and authors' calculations.

Note: Fitted Beveridge curves taking into account the structural break in U.K. vacancy statistics in 1998. The grey dashed line is the pre-break fitted Beveridge curve and the black dashed line the post-break one. See the appendix for details on how we dealt with the break.

Figure A1. Comparison of labor-turnover measures for the U.S.



Source: JOLTS, OECD, and authors' calculations.

Note: JOLTS measures are annual data and job-tenure-data based measures are biannual. Series are log indices of hires and separations, normalized to equal 0 in 2007.

Table 1. Estimated matching functions and cyclicalities of separations.

No.	Country	I	II	III	IV	V	VI	VII
		Vacancy yield			Separation rate			Sample size
		α_h	std.err.	R^2	α_s	std.err.	R^2	
1	Australia	0.53	0.04	0.91	-0.01	0.04	0.00	17
2	Austria	0.83	0.14	0.85	0.13	0.23	0.05	8
3	Belgium	0.48	0.09	0.66	-0.13	0.05	0.37	17
4	France	0.24	0.09	0.39	-0.25	0.05	0.69	12
5	Germany	0.49	0.08	0.71	-0.22	0.03	0.77	17
6	Japan	0.12	0.08	0.32	-0.31	0.11	0.62	7
7	Netherlands	0.49	0.11	0.57	-0.07	0.11	0.03	17
8	Norway	0.46	0.09	0.70	-0.13	0.09	0.16	14
9	Portugal	0.23	0.11	0.24	-0.14	0.09	0.14	17
10	Spain	0.60	0.05	0.90	0.21	0.04	0.62	17
11	Sweden	0.41	0.09	0.64	-0.13	0.09	0.17	13
12	Switzerland	0.41	0.12	0.54	-0.12	0.06	0.27	12
13	United Kingdom*	0.48	0.04	0.99	-0.10	0.03	0.43	17
14	United States	0.27	0.14	0.44	-0.23	0.11	0.48	7

Note: Estimated equations are $\ln(H/V) = \mu_h + \alpha_h \ln(U/V)$ and $\ln(S/E) = \mu_s + \alpha_s \ln(U/V)$, where H is hires, S is separations, U the total number of unemployed, E total employment, and V is the stock of vacancies. All results based on OECD job tenure data available before 2008. Except France where sample starts in 1996 and Japan where sample starts in 2001. We truncated these samples to avoid including shifts in Beveridge curve that occurred before these starting dates. Estimates of μ_h and μ_s are not reported because they vary across countries due to differing units of measurement of vacancies. The results for the U.K. allow for a structural break in the vacancy series in 1998. For details see the Appendix.*

Table 2. Change in unemployment rate, labor turnover residuals, and Beveridge curve shifts since 2007 across countries.

No.	Country	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
		Unemployment rate		Labor turnover residuals				Distance from fitted Beveridge curve				
		u_t	Δu_t	$\varepsilon_{h,t}$	$t_{h,t}$	$\varepsilon_{s,t}$	$t_{s,t}$	$\frac{1}{n} \sqrt{\sum D_t^2}$	D_t	D_t	$\frac{VIII}{VII}$	$\frac{IX}{VII}$
		'11	'07-'11	'10	'10	'10	'10	sample	'10	'11	'10	'11
1	Australia	5.1	0.7					1.4	0.5	0.5	0.4	0.3
2	Austria	4.2	-0.3	14	1.6	16	1.2	0.6	0.2	0.0	0.3	0.0
3	Belgium	7.1	-0.3	41	2.1	21	2.0	2.2	-3.7	-4.5	-1.6	-2.0
4	France	9.8	2.0	-10	-1.6	-1	-0.3	1.0	1.0	2.0	1.0	2.0
5	Germany	5.9	-2.8	16	1.5	-14	-3.5	1.3	-1.5	-1.9	-1.2	-1.5
6	Japan	4.5	0.7					0.5	-0.9	-0.2	-1.7	-0.4
7	Netherlands	4.4	1.3	28	0.8	41	1.1	1.2	0.2	0.3	0.1	0.3
8	Norway	3.3	0.8	-30	-1.9	-17	-1.1	0.3	0.8	0.6	3.0	2.3
9	Portugal	12.8	4.8	-19	-1.1	38	2.5	2.3	5.8	7.5	2.5	3.2
10	Spain	21.7	13.4	-73	-4.6	-29	-2.3	5.4	8.1	5.8	1.5	1.1
11	Sweden	7.5	1.4	7	0.4	25	1.4	1.1	2.9	3.2	2.8	3.0
12	Switzerland	3.8	0.3	-10	-0.8	-1	-0.1	0.7	1.2	1.1	1.8	1.6
13	United Kingdom	7.9	2.6	-34	-6.2	-19	-3.9	0.9	2.0	2.0	2.1	2.1
14	United States	8.8	4.1					0.7	2.6	3.0	3.9	4.4

Note: Sample statistics based on years for which job tenure data are available and are used to construct fitted Beveridge curves.

Δu_t is the percentage point change in the unemployment rate, $\varepsilon_{h,t}$ and $\varepsilon_{s,t}$ are 100 times the forecast errors for 2010 for the equations (4) and (5). $t_{h,t}$ and $t_{s,t}$ are these forecast errors divided by the standard error of the regression. n in column VII is the sample size reported in column VII of Table 1.

Table 3. Changes in UI benefits, separations, house prices, construction employment, and average hours.

No.	Country	I	II	III	IV	V
		Unemployment Insurance		Housing and mismatch		
		Maximum duration '07-'10 (months)	Change in maximum duration '07-'10	Home ownership rate '00s	Change in house prices '07-'10	Change in construction employment '07-'10
1	Australia			70	11.4	0.0
2	Austria	9	0	56		0.6
3	Belgium	∞	0	78	5.7	0.6
4	France	24	1	57	-4.7	0.4
5	Germany	12	0	46	0.0	0.0
6	Japan	9	0	61	-5.2	-1.0
7	Netherlands	38	0	57	-4.3	-0.7
8	Norway	24	0	77	0.8	0.1
9	Portugal	24	0	76		-2.3
10	Spain	24	0	85	-14.7	-5.8
11	Sweden*	35	21	68	6.0	0.3
12	Switzerland	18	0	35	9.8	-0.5
13	United Kingdom	6	0	67	-10.3	-0.7
14	United States	23	17	67	-16.9	-1.7

*Note: Unemployment insurance data are from OECD Benefits and Wages: Policies. * The extension of the duration of UI benefits in Sweden was part of a bigger labor market reform that also included a reduction in the level UI benefits, the introduction of an EITC, a reduction in the level of non-UI benefits. House price changes taken from OECD Economic Outlook Annex tables Change in construction employment is percentage point change in construction employment as share of the sum of employment in construction, industry, and services (OECD Short-Term Labour Market Statistics, 2012). Home ownership rates from Pollock (2010) and Department for Communities and Local Government for U.K. Homeownership statistics are reported for most recent year since 2001 for which data are available. See sources for additional detail.*

Table 4. Horizontal and vertical Beveridge curve shifts between '75-'85 and the fitted curves ('91-'07).

No.	Country	I	II	III	IV	V
		Unemployment rate		Distance from fitted Beveridge curve		
		u_t	Δu_t	$\frac{1}{n} \sqrt{\sum D_t^2}$	\bar{D}	$\frac{III}{IV}$
		'85	'75-'85	sample	'75-'85	'75-'85
1	Australia	8.3	3.4	1.4	-2.3	-1.7
2	Austria	3.6	1.8	0.6	-1.5	-2.6
3	Belgium	12.6	8.0	2.2	-12.2	-5.4
4	France	9.5	5.8	1.0	-6.8	-7.0
5	Germany	7.3	3.3	1.3	-5.1	-4.0
6	Japan	2.6	0.7	0.5	-6.7	-13.2
7	Netherlands	10.5	5.2	1.2	-0.5	-0.4
8	Norway	2.6	0.3	0.3	-3.8	-13.5
9	Portugal	8.7	4.1	2.3	-3.7	-1.6
10	Spain	21.6	16.9	5.4	-24.3	-4.5
11	Sweden	3.1	1.5	1.1	-2.4	-2.3
12	Switzerland	0.9	0.6	0.7	-3.1	-4.4
13	United Kingdom	11.3	8.0	0.9	-1.5	-1.6
14	United States	7.2	-1.3	0.7	3.7	5.6

Note: Sample statistics based on years for which job tenure data are available and are used to construct fitted Beveridge curves. n in column III is the sample size reported in column VII of Table 1. Statistics for 1975-1985 are for all years for which unemployment rate and vacancy rate data are available.