The Cyclical Behavior of Equilibrium Unemployment and Vacancies Across OECD Countries

Pedro S. Amaral
Federal Reserve Bank of Cleveland

Murat Tasci
Federal Reserve Bank of Cleveland

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Abstract

We show that the inability of a standardly-calibrated stochastic labor search-and-matching model to account for the observed volatility of unemployment and vacancies extends beyond US data to a set of OECD countries. We also argue that using cross-sectional data is a promising method for: (i) establishing other dimensions in which the standard model may fail to perform well; and (ii) helping evaluate the merits of the alternatives that have been proposed in the literature. To illustrate this last point we show how the solution proposed in Hagedorn and Manovskii (2008) has problems with this cross-country scrutiny.

JEL Classification: E24, E32, J63, J64.

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1 Introduction

Labor market search models as pioneered by Diamond (1982), Mortensen and Pissarides (1994), and Pissarides (2000), henceforth DMP, proved to be very useful in understanding equilibrium unemployment and vacancies as well as the long-run relationship between the two. However, when the model is extended to accommodate aggregate fluctuations, as in Shimer (2005), it fails to generate the observed volatility at business-cycle frequencies by an order of magnitude. In particular, the model requires implausibly large shocks to generate substantial variation in key variables; unemployment, vacancies and market tightness (vacancy to unemployment ratio). This result, sometimes referred to as the "Shimer Puzzle", spurred a large literature on the subject and a scramble for a "solution" to the puzzle.

The availability of vacancy data from the OECD, as well as the work of Elsby, Hobijn, and Sahin (2011) in estimating job-finding and separation rates in a set of OECD countries has created opportunities to analyze labor market fluctuations in the context of a search model across a fairly large set of countries beyond the U.S. This is important because potential solutions to the volatility puzzle identified by Shimer (2005) have been associated with features of the economic environment that might vary, at least to a degree, across countries.

In this paper, we accomplish three goals. First,we document a set of labor market facts for a cross-section of OECD countries over a period of time, focusing on unemployment, vacancies, market tightness, and labor productivity. Second, we evaluate the DMP model's ability to replicate business-cycle frequency fluctuations in these variables. We find that all countries in our sample exhibit significant volatility in their labor market variables relative to labor productivity. Moreover, simulations of the DMP model calibrated to country-specific parameter values in a standard Shimer (2005) way fail to generate the observed empirical volatility in the labor market variables relative to labor productivity.[1] Third, and most important, we show how the cross-country scrutiny this data allows can be of help in evaluating the different solutions to the puzzle that have been proposed in the literature. To illustrate this point we take the work of Hagedorn and Manovskii (2008) that shows how calibrating a modified version of Shimer (2005) to target average market tightness and the elasticity of wages with respect to productivity, enables the model to replicate the observed labor market fluctuation in the U.S. This strategy fails to work for some of the countries in our sample.

Our paper is related to a large body of literature that emerged in response to Shimer (2005). In the standard stochastic version of the DMP model, firms respond to a positive productivity shock by

[1] Zhang (2008) compares the U.S. to Canada, while Miyamoto (2011) and Esteban-Pretel, Ryo, and Ryuichi (2011) focus at the Japanese labor market. Their findings are similar to ours for the respective countries.

creating more vacancies and unemployment duration goes down. This in turn puts upward pressure on wages, absorbing most of the gains in productivity, and thus resulting in insignificant changes in unemployment and vacancies. Several studies proposed wage rigidity as a potential resolution to the puzzle. Shimer (2004), Hall (2005) and Kennan (2010) build on this diagnosis and introduce wage rigidity either exogenously or through an endogenous mechanism, such as asymmetric information. Nonetheless, Mortensen and Nagypál (2007), argue that introducing wage rigidity is not, by itself, sufficient to generate amplification.[2] Moreover, Pissarides (2009) argues that there is no empirical evidence in favor of wage rigidity over the cycle for newly created matches, which is the important margin for job creation in the canonical DMP model.

Several recent studies also provide mechanisms that can amplify the effects of business cycles on unemployment and vacancies by extending the prototype model in several dimensions and/or approaching the calibration differently. This includes not only the aforementioned Hagedorn and Manovskii (2008), but also Silva and Toledo (2009) that introduces post-match labor turnover costs. While both Costain and Reiter (2008) and Hornstein, Krusell, and Violante (2005) argue that the former study gives rise to counterfactual implications regarding the impact of unemployment subsidies on the equilibrium unemployment rate, the latter study's result depends on a particular constellation of parameter values for separation, hiring and training costs that is hard to justify empirically. There is also a line of research that argues that incorporating on-the-job-search improves the quantitative fit of the model: Krause and Lubik (2006), Nagypál (2006), and Tasci (2007). Finally, Petrosky-Nadeau and Wasmer (2010) argue that financial frictions, in addition to the labor market frictions, can significantly increase the response of vacancies and unemployment to productivity shocks.

While our paper does not provide a direct test of the validity of each channel in a cross-country context, it is certainly a step in that direction. The ability of most (if not all) of the mechanisms described above to quantitatively match the volatility of labor market variables is predicated on particular calibrations designed to hit U.S. targets for the most part. We bring in an extra dimension of scrutiny that we hope will prove helpful in distinguishing between all the existent potential explanations. Recent work by Justiniano and Michelacci (2011) has proceeded in exactly this direction. They look at a real business cycle model with search and matching frictions driven by several shocks capturing some transmission mechanisms suggested in the literature and estimate it on data from 5 European countries, in addition to the U.S. They find that while technology shocks are able replicate the volatility in labor market variables in the U.S., matching shocks and job destruction shocks play a substantially more important role in European countries.

[2] The level of the wage rate must also be such that the future flows of surpluses from new matches are sufficiently small.

Our work is also related to a strand of literature that focuses mainly on the role of labor market institutions and policies, in accounting for the differences in unemployment rates across countries in the long-run; in particular between Europe and North America. Nickell, Nunziata, and Ochel (2005) and Blanchard (2006) provide nice surveys of this literature and illustrate how the debate evolved over time and mostly settled on the conclusion that a particular interaction between shocks and labor market institutions can explain both the relatively low average rates of unemployment in Europe early in the post-war period as well as the higher rates observed between 1985 and the early 2000s.[3] Our focus, instead, is on the business-cycle frequency variation in the unemployment rate and also involves a discussion of additional labor market variables such as vacancies and market tightness for a similar cross-section of countries.

2 Data

We have collected unbalanced data panels at a quarterly frequency on vacancies, unemployment, employment, labor force, and real GDP for a set OECD countries. The proximate sources are the OECD's Economic Outlook Database, the IMF's International Finance Statistics, as well as some direct national sources.

While the data collection process for unemployment, employment, labor force and real GDP is fairly standard across the set of OECD countries we look at, the same cannot be said for the vacancy data. The OECD compiles its vacancy data from a variety of national sources with no harmonized reporting procedures. As a result, this study will not emphasize cross-country comparisons. Instead, we opt for using all the available data we have for each country as opposed to choosing common dates to compare across.

Tables 1 to 3 summarize the data.[4] Here, the statistics pertain to all the data available for each variable-country pair, as indicated by the columns labeled "Start date" and "End date".

Tables 5 to 21 show the business cycle statistics for each country when we control for the dates by choosing those for the shortest-lived series in that country.[5] Some interesting patterns emerge, even though we do not investigate them further in the paper. Within each country, a volatility ranking emerges, with productivity being the less volatile series, followed by unemployment, then vacancies, leaving labor market tightness as the most volatile. Moreover, vacancies and unemployment exhibit more persistency than productivity. In terms of correlations, labor markets that we usually think of as more flexible, like the U.S., Canada, the U.K. and the Scandinavian countries, seem to exhibit

[3] See Blanchard and Wolfers (2000) and Nickell (1997).

[4] Here, and throughout the paper, productivity is defined as output per worker. Unemployment, vacancies and employment data are in levels and are H-P filtered.

[5] We excluded Belgium and Turkey. For both countries we had only one decade's worth of productivity data.

a stronger negative correlation between unemployment and vacancies.

There are some peculiarities in the data that we plan to investigate further. For example, Australia, Poland and Spain all exhibit a positive correlation between unemployment and productivity, while Spain exhibits a negative correlation between vacancies and productivity.

3 Model

We use an aggregate, stochastic, discrete time version of the DMP model akin to the one used in Shimer (2005). Each country is a closed economy and even though the calibration below is country-specific, in detailing the model, we abstract from country-indexing to make the notation easier to follow.

There is an underlying exogenous productivity process $\{p_t\}_{t=0}^{\infty}$ that evolves according to an AR(1) process $\log p_t = \rho \log p_{t-1} + \varepsilon_t$, where $\varepsilon \sim N\left(0, \sigma_\varepsilon^2\right)$.

The economy is populated by two types of risk-neutral, infinitely-lived agents, both in a measure one continuum: workers and firms. Workers have preferences defined over stochastic streams of income $\{y_t\}_{t=0}^{\infty}$ which they discount at rate $\delta \in (0,1)$. They maximize their expected lifetime utility $E_0 \sum_{t=0}^{\infty} \delta^t y_t$.

At any point in time a worker is either matched with a firm or not. Unmatched workers are said to be unemployed and search for jobs while receiving a utility flow of z. Matched workers are said to be employed and while they are not allowed to search, they earn a period wage w_t. This wage rate is the outcome of a generalized Nash bargaining problem where firms and workers bargain over the match surplus. We let the worker's bargaining power be denoted by $\beta \in (0,1)$. Firms and workers get separated with probability s. Firms are free to enter the market but have to pay a vacancy posting cost of c to be able to obtain a match.

Let v_t denote the measure of vacancies posted, and n_t denote the measure of employed people. Then, $u_t = 1 - n_t$ denotes the unemployment rate. The vacancy-to-unemployment ratio, $\theta_t = \frac{v_t}{u_t}$, or market tightness, will turn out to be a key variable in the model, as it fully describes the state of the economy. We assume the flow of new matches is given by a Cobb-Douglas function $m_t = A u_t^{\alpha} v_t^{1-\alpha}$. The rate at which workers find a new job is:

$$f_t = \frac{m_t}{u_t} = A\left(\frac{v_t}{u_t}\right)^{1-\alpha} = A\theta^{1-\alpha},$$

while the rate at which firms fill vacancies is

$$q_t = \frac{m_t}{v_t} = A\left(\frac{u_t}{v_t}\right)^{\alpha} = A\left(1/\theta\right)^{\alpha} = \frac{f_t}{\theta_t}.$$

Employment evolves according to $n_{t+1} = (1-s)n_t + m(u_t, v_t)$, while unemployment's law of motion is $u_{t+1} = u_t + s(1-u_t) - f_t u_t$. In this model, there exists a unique equilibrium in which the vacancy-to-unemployment ratio, and consequently all other variables, depends exclusively on p and not on u, as shown in Mortensen and Nagypál (2007). This is the equilibrium we focus on.

The value of a filled position for a firm is given by:

$$J(p_t) = p_t - w(p_t) + \delta E_t \left\{(1-s)J(p_{t+1}) + sV(p_{t+1}t)\right\},$$

where the value of an unfilled vacancy for the firm is given by:

$$V(p_t) = -c + \delta E_t \left\{q(p_t)J(p_{t+1}) + (1-q(p_t))V(p_{t+1})\right\}.$$

The value of a job for a worker is:

$$W(p_t) = w(p_t) + \delta E_t \left\{sU(p_t) + (1-s)W(p_{t+1})\right\},$$

where the value of being unemployed is:

$$U(p_t) = z + \delta E_t \left\{f(p_t)W(p_{t+1}) + (1-f(p_t))U(p_{t+1})\right\}.$$

The firms' free entry condition implies that, in equilibrium, entry will occur until the value of a vacancy is driven all the way down to zero: $V(p_t) = 0$ for all p_t. This means the match surplus is given by $S(p_t) = W(p_t) + J(p_t) - U(p_t)$. Given the Nash bargaining weights, this means the firm gets $J(p_t) = (1-\beta)S(p_t)$, and the worker gets $W(p_t) - U(p_t) = \beta S(p_t)$. Noting that the free entry condition implies $c = \delta q_t(p_t) E_t J(p_{t+1})$, this means that $w(p_t) = \beta p_t + (1-\beta)z + \beta c\theta(p_t)$. Finally, replacing this and the free entry condition into the value of a filled position for a firm yields a first-order difference equation that can be used to compute the equilibrium:

$$\frac{c}{\delta q(p_t)} = E_t \left[(1-\delta)(p_{t+1} - z) - \beta c\theta(p_{t+1}) + (1-s)\frac{c}{q(p_{t+1})}\right]. \tag{1}$$

4 Calibration

As we discuss in section 1, the model's ability to replicate the data will ultimately depend on modeling extensions and on the calibration details. Our choice in section 3 was to use the standard formulation of the model, and here we will also opt for the standard calibration procedure.[6] We

[6] By this we mean the one employed by Shimer (2005).

do this to establish a benchmark for each country against which to test potential solutions to the puzzle.

While most of the parameters are country specific, some are common across countries. In particular, we choose a model period to be a week and we set δ, the discount rate, such as to generate a yearly interest rate of of 4%. The standard calibration uses the Hosios condition, which in the context of our model means $\alpha = \beta$. Although there are a wealth of studies estimating matching functions across different countries, not all the countries in our sample, as far as we could find, were the subject of such studies, and more importantly, different studies often use different underlying data, estimation methods, etc., making it hard to compare across countries.[7] As result we set $\alpha = \beta = 0.72$ for all countries. This is the value used in Shimer (2005).

The remaining parameters are set on a country-by-country basis. The data on replacement rates, z_i, are from the OECD and capture the average total benefit payable in a year of unemployment in 2009.[8] Even though the OECD measures compute net (not gross) replacement rates and try to take into account housing and child support related benefits, comparisons across countries may not be warranted for the reasons laid out in Whiteford (1995). Again, recall that the goal of the exercise is not a cross-country comparison, but a comparison *country-by-country* between data and simulated data.

The separation and job-finding rates, s_i and f_i, are from Hobijn and Şahin (2009) who use data on job-tenure and unemployment duration to obtain their estimates.[9] Table 4 shows the replacement rates and the monthly job-finding and separation rates.

Since the level of the vacancy-to-unemployment ratio is meaningless in this calibration of the model, we normalize its steady-state value to to one, which means setting $A_i = f_i$. Normalizing the steady-state value of productivity $\bar{p}_i = 1$, we can recover the vacancy posting cost, c_i, from the analogue of (1) in steady-state.

Finally, the parameters governing productivity's law of motion, ρ_i and σ_{ε_i}, are set such that the autocorrelation and the standard deviation of H-P filtered productivity in the model and the data is the same for each country. The model does not account for movements in and out of the labor force, as it assumes the labor force to be constant. Therefore, our variables should be adjusted by the labor force. When we do that, the statistics we obtain do not change much, probably because most labor force movements are filtered out. As a result, all the statistics presented in tables 5 to 21 are unadjusted for the labor force.

[7] A very nice survey of where this literature stood at the start of the decade can be found in Petrongolo and Pissarides (2001).

[8] Please see the appendix for further details.

[9] Since the estimate for the U.S. separation rate in Hobijn and Şahin (2009) is considerably below others in the literature, we use the estimates from Hagedorn and Manovskii (2008) for the U.S.'s separation and job-finding rates.

5 Results

5.1 Cross-country lack of amplification

For all countries without exception, the model is unable replicate the volatility in labor market variables by an order of magnitude. This extends the finding of Shimer (2005) from the U.S. to a broad set of OECD countries. Tables 5 to 21 present the details for each country. While in the data the standard deviation of unemployment is higher than the standard deviation of productivity by a factor that ranges between 4.5 (Japan) and 17.6 (Germany), in the model, the range is between 0.03 (Spain) and 0.6 (Sweden). For the volatility of vacancies the ranges are between 6.8 (Japan) and 27.9 (Spain) in the data and between 0.3 (Portugal) and 2 (Japan) in the model.

In addition to this result, the cross-section of moments we obtain from the model and the data lends itself to tests of the model's performance in dimensions other than the aforementioned puzzle. One simple way to conduct such tests is to perform the same cross section regressions on model and data steady-states.

We illustrate this approach with an example that restates the Shimer puzzle through a cross-section lens: regress the standard deviation of unemployment in the model, $std(u)^m$, a vector of the size of our country sample, on all the exogenous variables X (standard deviation of productivity, auto-correlation of productivity, job finding rates, separation rates, and replacement rates).

$$std(u)^m = \alpha + \beta^m X^m + \varepsilon^m.$$

The 95% confidence interval for the coefficient on the standard deviation of productivity is $[0, 0.3]$ and centered at 0.15. When we run the same regression in the data, where X^d is just X^m augmented with GDP levels:

$$std(u)^d = \alpha + \beta^d X^d + \varepsilon^d,$$

we get that the corresponding interval is $[2.2, 10.3]$, centered at 6.3 (significative at the 1% level). We are mindful of all the pitfalls that come with running cross-country regressions of this type, and in the future we plan to include other control variables (like the average unemployment rate and other institutional indicators for the labor market) as well as instruments. Even so, such pronounced differences in magnitude are unlikely to go away. We also ran an analogous experiment for the volatility of vacancies with similar results.

While this cross-sectional scrutiny can be used to confirm known dimensions in which the model performs poorly, it can also be used to find new ones. In the model, the effect of changes in the job finding rate on the volatility of unemployment is negligible, while in the data it is not. The coefficient on the job finding rate is 0.04 in the model, while it is 0.57 in the data (both are significative at the 5% level). Again, the coefficient we find for the regression in the data may be biased, so before we come up with more controls and instruments these results should be interpreted as an illustration of the possible use of this approach.

5.2 Targeting the elasticity of wages

Another way the cross-sectional data can be of use is in helping us evaluate the relative plausibility of the different resolutions for the Shimer puzzle that have been suggested in the literature. Here we start by subjecting one of the most prominent proposals, the one in Hagedorn and Manovskii (2008), to this cross-country scrutiny.

Hagedorn and Manovskii (2008) think of the DMP model as a linear approximation to a more complex model economy with heterogeneous agents and curvature both in utility and in production. As a result, they suggest an alternative mapping between the data and a slightly modified version of the model above. Here we follow their work closely, and change the matching function to

$$m(u_t, v_t) = \frac{u_t v_t}{\left(u_t^{1/l} + v_t^{1/l}\right)^l},$$

in order to have job-filling rates and vacancy filling rates that lie between zero and one.

In addition, the vacancy posting cost is no longer constant and is the sum of a capital cost component and and a labor cost component that are both cyclical:

$$c_p = c_k p + c_w p^{\varepsilon_{w,p}},$$

where $\varepsilon_{w,p}$ is the elasticity of wages with respect to productivity, and c_k and c_w are endogenous objects that depend on the steady-state values of unemployment, vacancies, production, filling rates and income factor shares.[10]

Regarding the mapping between data and model, we set values for parameters β_i, l_i, and $\varepsilon^i_{w,p}$, for each country, so as to match the average job finding rate, the average labor market tightness, and the elasticity of wages with respect to productivity that we obtain from the data. From the previous experiment we already have data for the average job-finding rate in each country, f_i. To compute the average market tightness we use the fact that $\theta_i = f_i/q_i$. We don't have country specific data for the vacancy-filling rate q_i, so we use the value reported by den Haan, Ramey, and Watson (2000), $q_i = q = 0.71$ for all countries.[11] To compute the labor share of income we use use

[10] For the exact form of c_k and c_w, please see Hagedorn and Manovskii (2008).

[11] van Ours and Ridder (1992) also find a similar value for the Netherlands.

OECD data. For each country and quarter we take employee compensation and subtract indirect taxes and then divide this by GDP minus indirect taxes.[12] We then multiply this share by labor productivity; this gives us total wages per worker. We then H-P filter this series and compute its elasticity with respect to productivity. The results appear in figure 1 for all the countries in our sample for which data was available. The measure varies widely across countries. We find the U.S. exhibits mild procyclicality, and our estimate is little higher than the one obtained by Hagedorn and Manovskii (2008) (0.56 versus 0.46), which can be attributed to the the different data source.

The calibration is able to match all targets except for Finland because of its negative wage elasticity. The business-cycle statistics are shown from tables 22 to 31. While the model, under this calibration strategy, is more than able to account for the volatility of labor market variables in some of the countries Australia, it is unable to do so for others, notably Portugal and Spain, and to a lesser extent, Germany. It is well known from Hagedorn and Manovskii (2008) that a replacement rate sufficiently close to average productivity (roughly one) is needed to generate the amplification needed. The replacement rate z that matches the Portuguese and Spanish targets is, in this sense, too low.

To understand why this is the case, it will be useful to write down the expression for accounting profits under no aggregate uncertainty and take two countries, say Australia and Spain:

$$p - w = \frac{(1-\beta)(1-\delta)(1-s)}{1-\delta(1-s)+\delta f(\theta)\beta}(p-z).$$

Profits, the left-hand-side of the equation, are roughly similar for Australia and Spain. To simultaneously match a much larger elasticity of wages and a much smaller job-finding rate in Spain, compared to Australia, the bargaining weight has to increase ten-fold, which means that the term that appears as a fraction in the expression above falls by roughly a factor of four, implying the distance between p and z has to increase by this same factor. As this distance increases, the model's ability to replicate the observed volatility in unemployment and vacancies decreases.

6 Conclusion

A standardly-calibrated, stochastic, search and matching model cannot deliver the sort of volatility in unemployment and vacancies we see in the data. While this fact was well known for the U.S. and some other selected economies, namely Canada and Japan, we establish that it holds for a large set of OECD countries.

[12] A better measure would subtract other ambiguous components of income. Unfortunately the OECD does not report proprietors' income separately from corporate profits, so that our measure apportions the totality of proprietors' income to capital income.

Comparing the model's performance in a cross-section of countries relative to the data seems to be a promising way of finding out other dimensions in which the standard model may be lacking. At the same time, this type of analysis can also be used to shed light on variations of the standard model that, the literature has argued, improve on the model's ability to match the observed labor market volatility. To this end, we subject the calibration strategy proposed in Hagedorn and Manovskii (2008) to this type of cross-country scrutiny and find that it does not work for all countries. The next step in this research is to subject other answers to the Shimer puzzle proposed in the literature to the same kind of cross-country scrutiny.

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Table 1: **Vacancies**

Countries	Start date	End date	Std. dev.	Autocorr.
Australia	Q2-1979	Q3-2011	0.1642	0.8689
Austria	Q1-1955	Q3-2011	0.1577	0.9251
Belgium	Q1-1955	Q1-2004	0.2888	0.9106
Canada	Q1-1962	Q3-2011	0.1545	0.9155
Czech Rep.	Q1-1991	Q2-2011	0.2649	0.9132
Finland	Q1-1961	Q2-2010	0.2385	0.8948
France	Q1-1989	Q2-2011	0.0692	0.8124
Germany	Q1-1962	Q2-2010	0.1954	0.9387
Hungary	Q1-1992	Q2-2011	0.1690	0.5244
Japan	Q1-1957	Q2-2011	0.0997	0.9014
Netherlands	Q1-1988	Q4-2009	0.2239	0.9219
Norway	Q1-1955	Q3-2011	0.1874	0.8803
Poland	Q1-1990	Q2-2011	0.1824	0.8524
Portugal	Q1-1974	Q3-2011	0.2588	0.8927
Spain	Q1-1977	Q1-2005	0.2065	0.8031
Sweden	Q3-1961	Q2-2011	0.2234	0.9104
Turkey	Q1-1955	Q2-2011	0.1614	0.4055
U.K.	Q3-1958	Q3-2011	0.1991	0.9205
U.S.	Q1-1955	Q3-2011	0.1353	0.9036

Table 2: **Unemployment**

Countries	Start date	End date	Std. dev.	Autocorr.
Australia	Q1-1964	Q2-2011	0.1100	0.8424
Austria	Q1-1969	Q2-2011	0.1098	0.6433
Belgium	Q1-1970	Q2-2011	0.0855	0.8994
Canada	Q1-1955	Q3-2011	0.1069	0.8785
Czech Rep.	Q1-1990	Q2-2011	0.2535	0.6704
Finland	Q1-1958	Q4-2010	0.1872	0.8856
France	Q1-1978	Q2-2011	0.0526	0.9284
Germany	Q1-1956	Q2-2011	0.1985	0.9188
Hungary	Q1-1990	Q2-2011	0.0590	0.7658
Japan	Q1-1955	Q2-2011	0.0699	0.7993
Netherlands	Q1-1970	Q2-2011	0.1351	0.9151
Norway	Q1-1972	Q2-2011	0.1564	0.7573
Poland	Q4-1991	Q2-2011	0.1223	0.9352
Portugal	Q1-1983	Q2-2011	0.0994	0.9155
Spain	Q1-1977	Q2-2011	0.0842	0.9405
Sweden	Q2-1961	Q3-2011	0.1522	0.8674
Turkey	Q1-2000	Q2-2011	0.1113	0.8155
U.K.	Q1-1971	Q2-2011	0.1163	0.9320
U.S.	Q1-1955	Q3-2011	0.1177	0.8994

Table 3: **Productivity**

Countries	Start date	End date	Std. dev.	Autocorr.
Australia	Q1-1964	Q2-2011	0.0118	0.5541
Austria	Q1-1960	Q2-2011	0.0104	0.6239
Belgium	Q1-1999	Q2-2011	0.0099	0.3737
Canada	Q1-1960	Q2-2011	0.0090	0.7111
Czech Rep.	Q1-1994	Q2-2011	0.0214	0.7282
Finland	Q1-1960	Q2-2011	0.0159	0.6774
France	Q1-1960	Q2-2011	0.0094	0.5165
Germany	Q1-1960	Q2-2011	0.0112	0.5918
Hungary	Q1-1995	Q4-2010	0.0119	0.8385
Japan	Q1-1960	Q2-2011	0.0143	0.7385
Netherlands	Q1-1984	Q2-2011	0.0108	0.8132
Norway	Q1-1960	Q2-2011	0.0124	0.5472
Poland	Q1-1995	Q2-2011	0.0102	0.4515
Portugal	Q2-1983	Q2-2011	0.0112	0.4684
Spain	Q3-1972	Q2-2011	0.0078	0.6428
Sweden	Q1-1960	Q2-2011	0.0120	0.8650
Turkey	Q1-2000	Q2-2011	0.0356	0.7675
U.K.	Q1-1960	Q2-2011	0.0119	0.7322
U.S.	Q1-1960	Q2-2011	0.0093	0.7544

Table 4: **Country-specific parameters**

Countries	Replacement	Separation	Job-Finding
Australia	0.5353	0.0175	0.1705
Austria	0.6182	0.0106	0.1561
Belgium	0.6598	0.0092	0.0345
Canada	0.5535	0.0178	0.2890
Czech Rep.	0.5535	0.0094	0.0806
Finland	0.6984	0.0138	0.1336
France	0.5943	0.0140	0.0669
Germany	0.6375	0.0106	0.0698
Hungary	0.4919	0.0099	0.0641
Japan	0.7459	0.0060	0.1907
Netherlands	0.7241	0.0099	0.0468
Norway	0.7068	0.0134	0.3053
Poland	0.4617	0.0099	0.0720
Portugal	0.6042	0.0096	0.0388
Spain	0.4726	0.0203	0.0398
Sweden	0.6606	0.0087	0.2517
Turkey	0.0905	0.0150	0.0925
U.K.	0.6142	0.0153	0.1127
U.S.	0.3346	0.0260	0.4772

Table 5: **Australia**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.095	0.165	0.240	0.010	0.003	0.011	0.012	0.010
Autocorr.		0.907	0.869	0.903	0.719	0.896	0.649	0.715	0.715
Correlation	u	1	-0.681	-0.864	0.056	1	-0.672	-0.770	-0.770
	v	-	1	0.957	0.230	-	1	0.990	0.990
	v/u	-	-	1	0.136	-	-	1	1.000
	p	-	-	-	1	-	-	-	1
Dates:	Q2-1979 : Q2-2011								

Table 6: **Austria**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.110	0.163	0.254	0.011	0.002	0.012	0.012	0.011
Autocorr.		0.643	0.929	0.879	0.639	0.880	0.567	0.640	0.640
Correlation	u	1	-0.713	-0.892	-0.387	1	-0.591	-0.704	-0.703
	v	-	1	0.953	0.480	-	1	0.989	0.989
	v/u	-	-	1	0.477	-	-	1	1.000
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1969 : Q2-2011								

Table 7: **Canada**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.091	0.155	0.239	0.009	0.003	0.012	0.014	0.009
Autocorr.		0.888	0.916	0.919	0.717	0.850	0.643	0.716	0.716
Correlation	u	1	-0.876	-0.950	-0.247	1	-0.783	-0.862	-0.862
	v	-	1	0.983	0.299	-	1	0.990	0.990
	v/u	-	-	1	0.288	-	-	1	1.000
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1962 : Q2-2011								

Table 8: **Czech Republic**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.137	0.275	0.399	0.021	0.003	0.018	0.017	0.021
Autocorr.		0.927	0.927	0.931	0.728	0.944	0.684	0.728	0.727
Correlation	u	1	-0.867	-0.939	-0.435	1	-0.512	-0.619	-0.619
	v	-	1	0.985	0.631	-	1	0.991	0.991
	v/u	-	-	1	0.583	-	-	1	1.000
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1994 : Q2-2011								

Table 9: **Finland**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.187	0.238	0.407	0.016	0.004	0.021	0.021	0.016
Autocorr.		0.899	0.895	0.915	0.665	0.900	0.603	0.667	0.667
Correlation	u	1	-0.826	-0.944	-0.282	1	-0.581	-0.690	-0.690
	v	-	1	0.966	0.408	-	1	0.990	0.990
	v/u	-	-	1	0.369	-	-	1	1.000
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1961 : Q2-2010								

Table 10: **France**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.055	0.069	0.098	0.008	0.002	0.011	0.010	0.008
Autocorr.		0.926	0.812	0.858	0.863	0.974	0.836	0.864	0.864
Correlation	u	1	-0.231	-0.725	-0.203	1	-0.638	-0.726	-0.726
	v	-	1	0.838	0.559	-	1	0.993	0.993
	v/u	-	-	1	0.510	-	-	1	1.000
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1989 : Q2-2011								

Table 11: **Germany**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.199	0.195	0.373	0.011	0.001	0.007	0.007	0.011
Autocorr.		0.921	0.939	0.938	0.591	0.924	0.550	0.592	0.592
Correlation	u	1	-0.794	-0.948	-0.376	1	-0.409	-0.506	-0.506
	v	-	1	0.946	0.445	-	1	0.994	0.994
	v/u	-	-	1	0.433	-	-	1	1.000
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1962 : Q2-2010								

Table 12: **Hungary**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.057	0.112	0.112	0.012	0.002	0.011	0.011	0.012
Autocorr.		0.838	0.383	0.340	0.839	0.971	0.806	0.837	0.837
Correlation	u	1	0.269	-0.244	-0.053	1	-0.578	-0.676	-0.676
	v	-	1	0.868	0.068	-	1	0.992	0.992
	v/u	-	-	1	0.095	-	-	1	1.000
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1995 : Q4-2010								

Table 13: **Japan**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.065	0.101	0.150	0.014	0.008	0.029	0.034	0.014
Autocorr.		0.789	0.905	0.891	0.738	0.900	0.668	0.739	0.739
Correlation	u	1	-0.620	-0.849	-0.482	1	-0.696	-0.798	-0.798
	v	-	1	0.941	0.634	-	1	0.988	0.988
	v/u	-	-	1	0.635	-	-	1	1.000
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1960 : Q2-2011								

Table 14: **The Netherlands**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.129	0.224	0.313	0.011	0.003	0.017	0.015	0.011
Autocorr.		0.959	0.922	0.944	0.837	0.976	0.812	0.836	0.836
Correlation	u	1	-0.542	-0.799	-0.071	1	-0.521	-0.614	-0.613
	v	-	1	0.938	0.645	-	1	0.994	0.993
	v/u	-	-	1	0.491	-	-	1	1.000
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1988 : Q4-2009								

Table 15: **Norway**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.156	0.187	0.328	0.013	0.005	0.019	0.022	0.013
Autocorr.		0.757	0.877	0.879	0.501	0.731	0.400	0.502	0.502
Correlation	u	1	-0.828	-0.948	-0.038	1	-0.681	-0.787	-0.787
	v	-	1	0.964	0.056	-	1	0.988	0.988
	v/u	-	-	1	0.050	-	-	1	1.000
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1972 : Q2-2011								

Table 16: **Poland**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.132	0.168	0.253	0.010	0.000	0.003	0.003	0.010
Autocorr.		0.948	0.862	0.925	0.451	0.896	0.406	0.451	0.450
Correlation	u	1	-0.416	-0.797	0.244	1	-0.352	-0.445	-0.445
	v	-	1	0.881	0.271	-	1	0.995	0.995
	v/u	-	-	1	0.052	-	-	1	1.000
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1995 : Q2-2011								

Table 17: **Portugal**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.099	0.188	0.251	0.011	0.000	0.003	0.003	0.011
Autocorr.		0.915	0.884	0.908	0.468	0.932	0.445	0.470	0.470
Correlation	u	1	-0.491	-0.760	-0.082	1	-0.278	-0.346	-0.346
	v	-	1	0.940	0.282	-	1	0.997	0.997
	v/u	-	-	1	0.243	-	-	1	1.000
	p	-	-	-	1	-	-	-	1
Dates:	Q2-1983 : Q2-2011								

Table 18: **Spain**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.059	0.206	0.231	0.007	0.000	0.003	0.002	0.007
Autocorr.		0.941	0.803	0.831	0.605	0.942	0.582	0.605	0.605
Correlation	u	1	-0.299	-0.523	0.472	1	-0.379	-0.441	-0.440
	v	-	1	0.970	-0.076	-	1	0.998	0.998
	v/u	-	-	1	-0.188	-	-	1	1.000
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1977 : Q1-2005								

Table 19: **Sweden**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.153	0.223	0.357	0.012	0.008	0.024	0.030	0.012
Autocorr.		0.867	0.910	0.919	0.866	0.936	0.819	0.865	0.865
Correlation	u	1	-0.789	-0.923	-0.154	1	-0.857	-0.915	-0.915
	v	-	1	0.965	0.462	-	1	0.992	0.992
	v/u	-	-	1	0.355	-	-	1	1.000
	p	-	-	-	1	-	-	-	1
Dates:	Q3-1961 : Q2-2011								

Table 20: **U.K.**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.116	0.196	0.293	0.012	0.003	0.016	0.015	0.012
Autocorr.		0.932	0.918	0.926	0.767	0.937	0.717	0.767	0.767
Correlation	u	1	-0.749	-0.897	-0.185	1	-0.627	-0.726	-0.726
	v	-	1	0.965	0.625	-	1	0.991	0.991
	v/u	-	-	1	0.491	-	-	1	1.000
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1971 : Q2-2011								

Table 21: **U.S.**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.115	0.132	0.243	0.009	0.003	0.009	0.011	0.009
Autocorr.		0.915	0.913	0.920	0.754	0.824	0.705	0.756	0.756
Correlation	u	1	-0.932	-0.980	-0.242	1	-0.898	-0.941	-0.941
	v	-	1	0.985	0.408	-	1	0.994	0.994
	v/u	-	-	1	0.337	-	-	1	1.000
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1960 : Q2-2011								

Figure 1: **Wage elasticities**

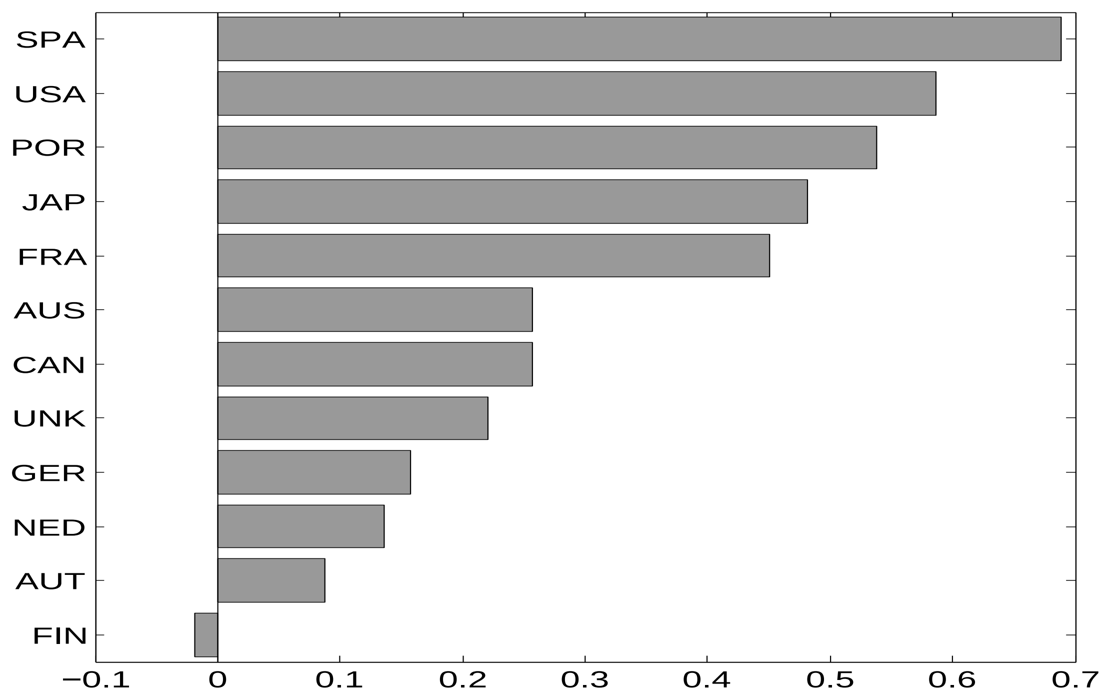

Table 22: **Australia (HM calibration)**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.095	0.165	0.240	0.010	0.107	0.200	0.081	0.010
Autocorr.		0.907	0.869	0.903	0.719	0.879	0.581	0.713	0.719
Correlation	u	1	-0.681	-0.864	0.056	1	-0.440	-0.735	-0.740
	v	-	1	0.957	0.230	-	1	0.932	0.905
	v/u	-	-	1	0.136	-	-	1	0.982
	p	-	-	-	1	-	-	-	1
Dates:	Q2-1979 : Q2-2011								

Table 23: **Austria (HM calibration)**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.110	0.163	0.254	0.011	0.078	0.161	0.052	0.011
Autocorr.		0.643	0.929	0.879	0.639	0.853	0.505	0.636	0.639
Correlation	u	1	-0.713	-0.892	-0.387	1	-0.354	-0.666	-0.669
	v	-	1	0.953	0.480	-	1	0.933	0.923
	v/u	-	-	1	0.477	-	-	1	0.993
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1969 : Q2-2011								

Table 24: **Canada (HM calibration)**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.091	0.155	0.239	0.009	0.100	0.141	0.113	0.009
Autocorr.		0.888	0.916	0.919	0.717	0.838	0.534	0.713	0.717
Correlation	u	1	-0.876	-0.950	-0.247	1	-0.583	-0.847	-0.844
	v	-	1	0.983	0.299	-	1	0.926	0.908
	v/u	-	-	1	0.288	-	-	1	0.986
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1962 : Q2-2011								

Table 25: **Finland (HM calibration)**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.187	0.238	0.407	0.016	0.006	0.046	0.012	0.016
Autocorr.		0.899	0.895	0.915	0.665	0.918	0.645	0.666	0.666
Correlation	u	1	-0.826	-0.944	-0.282	1	-0.207	-0.334	-0.334
	v	-	1	0.966	0.408	-	1	0.991	0.990
	v/u	-	-	1	0.369	-	-	1	0.999
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1961 : Q2-2010								

Table 26: **Germany (HM calibration)**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.199	0.195	0.373	0.011	0.037	0.139	0.017	0.011
Autocorr.		0.921	0.939	0.938	0.591	0.882	0.534	0.589	0.590
Correlation	u	1	-0.794	-0.948	-0.376	1	-0.201	-0.428	-0.430
	v	-	1	0.946	0.445	-	1	0.971	0.967
	v/u	-	-	1	0.433	-	-	1	0.997
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1962 : Q2-2010								

Table 27: **Japan (HM calibration)**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.065	0.101	0.150	0.014	0.171	0.321	0.125	0.014
Autocorr.		0.789	0.905	0.891	0.738	0.889	0.588	0.718	0.738
Correlation	u	1	-0.620	-0.849	-0.482	1	-0.392	-0.711	-0.732
	v	-	1	0.941	0.634	-	1	0.925	0.833
	v/u	-	-	1	0.635	-	-	1	0.937
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1960 : Q2-2011								

Table 28: **Portugal (HM calibration)**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.099	0.188	0.251	0.011	0.004	0.030	0.002	0.011
Autocorr.		0.915	0.884	0.908	0.468	0.869	0.443	0.467	0.467
Correlation	u	1	-0.491	-0.760	-0.082	1	-0.113	-0.251	-0.251
	v	-	1	0.940	0.282	-	1	0.990	0.990
	v/u	-	-	1	0.243	-	-	1	0.999
	p	-	-	-	1	-	-	-	1
Dates:	Q2-1983 : Q2-2011								

Table 29: **Spain (HM calibration)**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.059	0.206	0.231	0.007	0.004	0.025	0.002	0.007
Autocorr.		0.941	0.803	0.831	0.605	0.897	0.574	0.605	0.605
Correlation	u	1	-0.299	-0.523	0.472	1	-0.210	-0.360	-0.360
	v	-	1	0.970	-0.076	-	1	0.988	0.987
	v/u	-	-	1	-0.188	-	-	1	1.000
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1977 : Q1-2005								

Table 30: **U.K. (HM calibration)**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.116	0.196	0.293	0.012	0.143	0.559	0.092	0.012
Autocorr.		0.932	0.918	0.926	0.767	0.922	0.648	0.716	0.768
Correlation	u	1	-0.749	-0.897	-0.185	1	-0.326	-0.564	-0.655
	v	-	1	0.965	0.625	-	1	0.961	0.792
	v/u	-	-	1	0.491	-	-	1	0.870
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1971 : Q2-2011								

Table 31: **U.S. (HM calibration)**

		Data				Model			
		u	v	v/u	p	u	v	v/u	p
Std. Dev.		0.115	0.132	0.243	0.009	0.070	0.081	0.145	0.009
Autocorr.		0.915	0.913	0.920	0.754	0.816	0.602	0.752	0.754
Correlation	u	1	-0.932	-0.980	-0.242	1	-0.788	-0.936	-0.924
	v	-	1	0.985	0.408	-	1	0.954	0.941
	v/u	-	-	1	0.337	-	-	1	0.986
	p	-	-	-	1	-	-	-	1
Dates:	Q1-1960 : Q2-2011								