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Julen ESTEBAN-PRETEL
National Graduate Institute for Policy Studies

NAKAJIMA Ryo
Yokohama National University

TANAKA Ryuichi
Tokyo Institute of Technology

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Japan's Labor Market Cyclicality and the Volatility Puzzle[*]

Julen ESTEBAN-PRETEL[†] (National Graduate Institute for Policy Studies)
Ryo NAKAJIMA[‡] (Yokohama National University)
Ryuichi TANAKA[§] (Tokyo Institute of Technology)

Abstract

The search and matching model has recently come under criticism for its inability to account for some of the cyclical properties of the U.S. labor market. Shimer (2005) has shown that the basic version of the model is incapable of reproducing the volatility of the market tightness for reasonable movements in productivity. This paper considers whether the so-called "Shimer Puzzle" also holds for the Japanese economy. We present empirical evidence on the cyclical properties of the labor market variables in Japan and compare these to their U.S. counterparts. We then build, parametrize, and simulate three different versions of the search and matching model (with exogenous job destruction, with endogenous job destruction, and embedded in a Real Business Cycle model) and compare the simulated statistics to the data. We find that the "Shimer Puzzle" does hold for Japan, since the model is unable to generate as much volatility on the market tightness as in the data.

Keywords: unemployment, Japanese labor market, and Shimer Puzzle.
JEL Classification: E2; E13; O4; J6

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[†] National Graduate Institute for Policy Studies, Roppongi 7-22-1, Minato-ku Tokyo, 106-8677 Japan. E-mail: julen@grips.ac.jp; Tel: +81-3-6439-6108.

[‡] Faculty of Economics, 156 Tokiwadai Hodogaya-ku Yokohama 240. Email: rn231@ynu.ac.jp.

[§] Corresponding Author: Graduate School of Information Science and Engineering, 2-12-1 O-okayama Meguro-ku, Tokyo 152-8552, Japan. Email: tanaka@mei.titech.ac.jp; Tel / Fax: +81-3-5734-3760.

1 Introduction

The search and matching model has become the standard method for modeling equilibrium unemployment in the labor market. While traditionally used to address questions related the steady state, it has also become widely used for studying cyclical issues. It is for the latter use that the model has been criticized in recent years.

Shimer (2005) has shown that the search and matching model is unable to reproduce some basic cyclical properties of the U.S. labor market data. This failure of the model when used at business cycle frequencies has come to be known as the "Shimer Puzzle," which states that the basic search and matching model is not able, using empirically plausible movements in productivity, to generate as much volatility in the ratio of unemployment to vacancies as is observed in the data. The paper has started a strand of the literature that studiesthe countries and conditions for which the puzzle holds, and the types of features that might be be added to the model.

The aim of this paper is to analyze whether this volatility puzzle, which was originally found for the U.S., holds for the Japanese economy. We first provide empirical evidence on the cyclical properties of the Japanese labor market in the last three decades. We then build a search and matching model that nests three different versions of the model; we calibrate the model parameters to match the long-run evidence of the Japanese economy, and we simulate the three versions of the model to assess whether the "Shimer Puzzle" holds for Japan. [1]

We show empirically that the Japanese and U.S. labor markets exhibit some important differences in terms of the levels of the variables. Unemployment was, until the 1990s, much lower in Japan than in the U.S., but so were the job-finding and separation rates. These variables seem to be more stable for Japan than the U.S. when considering the evolution of their levels over time. However, these differences in levels do not translate into substantial discrepancies when analyzing the cyclical properties of the variables. We find that the volatility of unemployment, vacancies, job-finding and separation rates, and productivity are not very different between the two countries. Perhaps the biggest difference between the two economies is the fact that the job-finding and separation rates are much less autocorrelated for Japan, and that the job separation rate shows a clear counter-cyclical pattern. This negative correlation between productivity and the job separation rate leads us to build the theory such that it includes not only exogenous and time-invariant job separation rates (as in Shimer, 2005), but also a possible endogenous destruction.

Our model nests three basic but important versions of the search and matching model. The first

[1] Note that the aim of this paper is to study whether the volatility puzzle holds for Japan - that is, if the basic and standard versions of the search and matching model fail or succeed in reproducing the cyclical patterns of the Japanese labor market variables, particularly, the market tightness, as is the case for the U.S. We do not intend to analyze which of the different solutions that have been put forward in the literature could solve the puzzle for Japan, and therefore leave this problem for future research.

version (Model 1) is a simple exogenous job destruction search and matching model, very similar to the one used in Shimer (2005). The second version (Model 2) is constructed along the same lines of the first, but allows for time-varying endogenous job destruction, which captures the previously mentioned empirical counter-cyclical job separation rate of the Japanese economy. The third version (Model 3) is a more elaborate Real Business Cycle (RBC) model with labor market search frictions. We study this general equilibrium version of the search and matching model, since the RBC model has become the workhorse in modern macroeconomics for studying business cycle fluctuations. All three versions of the model are nested in the general model presented below and calibrated to match the long-run empirical evidence from the Japanese economy, which is assumed to correspond to the steady state of the model. We then simulate the model and compare it to the data.

We find that that the "Shimer Puzzle" does indeed hold for the Japanese economy. None of the three versions of the model is able to generate the empirically observed volatility in the market tightness. Model 1 is unable to produce sufficient volatility in either unemployment or vacancies, which in the Japanese calibration of the model is due, as Shimer (2005) points out for the U.S., to the fact that wages are too responsive to productivity movements.[2] In Models 2 and 3, the inclusion of endogenous job separation renders unemployment and vacancies more volatile, but generates a counter-factual positive correlation between unemployment and vacancies that in turn keeps the volatility of the market tightness much lower than in the data. The intuition for this result is that since unemployment is much more responsive due to the possibility of adjusting the separation margin, and the incentive to post vacancies is positively correlated with the number of unemployed workers,[3] the effect of the movement in unemployment (and hence in the probability of matching for a vacant firm) dominates the effect of productivity on future profits, and makes unemployment and vacancies move closely together. This effect is even more important in the RBC model, which includes capital and hours of work, where the unemployment rate is more sensitive to productivity movements.

The original articles by Shimer (2005) spawned a large and growing literature assessing the conditions under which the volatility puzzle holds. Some papers attempt to study which features of the model are necessary to reconcile theory and data. A known example of this literature is Hagedorn and Manovskii (2008), which shows that a large flow value of unemployment restores the incentive for firms to post vacancies, even under Nash bargaining. Since the Nash bargaining for wages is at the core of the mechanism that generates the "Shimer Puzzle," papers such as Hall (2005), Gertler and Trigari (2005), or Hall and Milgrom (2005) study different wage arrangements that help reconcile the model with the data. Other publications question whether the "Shimer Puzzle" holds at all for the U.S. economy: Fujita and Ramey

[2]This in turn is due to the assumption of Nash bargaining for wages, which allows for wage changes whenever there is a change in the economy.

[3]For instance, the larger the number of unemployed workers, the greater the chance for every vacant firm to match with a worker, and therefore the larger the incentive to post vacancies.

(2009) is exemplary of this strand of the literature. Finally, there are papers that study whether the "Shimer Puzzle" holds for other countries. Our paper falls into this category. Other works, such as Sala and Silva (2007), and Sala, Silva and Toledo (2007), study how the model is able to explain the data for Spain, or the OECD countries, respectively.

For Japan, a recent paper by Miyamoto (2009) studies a question similar to ours.[4] Our paper differs in the following points: first, we construct the Japanese unemployment and job worker flows data directly from the LFS micro data; second, we put the Japanese empirical evidence in perspective by comparing it with that of the U.S. for the same sample period; third, we perform numerical simulations of the model to be able to thoroughly compare the model implications with the data. While the methodology to answer the question in both papers is different, the conclusion is the same. The "Shimer Puzzle" does hold for the Japanese economy.

The remainder of the paper is organized as follows: Section 2 provides the empirical evidence for Japan and compares it with that of the U.S.; Section 3 develops the model that nests the three different versions studied; Section 4 explains the calibration of the model parameters; Section 5 shows the simulation results and compares them to the data; finally, Section 6 summarizes and concludes.

2 Empirical Evidence

This section studies the empirical properties of the Japanese labor market, both in levels and in terms of deviations from trend. To put the Japanese numbers in perspective, we compare them with their U.S. counterparts. We first explain the sources for the U.S. data and the data for Japan is constructed; we then proceed to analyze the latter.

2.1 Data Construction

For the U.S., the data on unemployment and output per worker[5] comes from the Bureau of Labor Statistics. The data on vacancies in the Help Wanted Advertising Index series is from the Conference Board and collected by the Federal Reserve Bank of St. Louis. The job-finding and separation rates are from Fujita and Ramey (2009); we have undone the continuous-time transformation explained in equation (2), p. 418, in order to obtain discrete time rates, which are consistent with the model we use. Finally, the data on Total Factor Productivity (TFP) is from Braun, Esteban-Pretel, Okada, and Sudou (2006).

For Japan, the data on unemployment and worker flows are constructed using micro data from the Labor Force Survey (LFS) of the Japanese Statistics Bureau and Statistics Center. The data on vacancies comes from the Job Placement Survey (JPS) of the Ministry of Health, Labour and Welfare. The data

[4]Both papers were developed simultaneously and without knowledge of each other.

[5]The series used is output per person in non-farm business.

on productivity, both output per worker and TFP, is from Esteban-Pretel, Nakajima, and Tanaka (2010). Let us now explain in more detail the construction of the labor market data using the LFS.

The LFS is a monthly household survey, where each household is surveyed for two consecutive months, is excluded from the survey for the next ten months, and then included again for another two consecutive months. In its structure, the LFS is comparable to the Consumer Population Survey (CPS) in the United States. Like the CPS, the LFS provides the necessary information to calculate the labor market flows. In the survey structure, 50 percent of those sampled each month are in their second month of the survey. Hence, it is possible to observe the transition among the three statuses of employment: employed (E), unemployed (U), or not-in-the-labor-force (I) by matching the information with the employment status in the previous month.[6] With three employment statuses, we have nine categories of worker flows; EE, EU, EI, UU, UI, UE, II, IE and IU.

Given the survey design of the LFS, we follow the matching method used by Shimer (2007) and Fujita and Ramey (2009) to construct the worker flow data. Individual records are matched over two consecutive months using selected information: unique household identifiers,[7] individual line numbers, gender, and age. We then compute the sample-weighted gross flows across three states, employment E, unemployment U, and not-in-the-labor-force I, so that the flows between the three states are obtained for the nine categories mentioned above. If we let Ω_{it} be the sample weight of worker i at month t in the LFS, and Γ_t^{XZ} be the number of workers who move from state $X \in \{E, U, I\}$ to state $Z \in \{E, U, I\}$ at month t, then the gross flow from state X to state Z is given by

$$F_t^{XZ} = \sum_{i \in G_t^{XY}} \Omega_{it}.$$

The transition probabilities follow from the flows. For example, the transition probability from employment state E to unemployment state U at time t is computed by

$$P_t^{EU} = \frac{F_t^{EU}}{\sum_{Z \in \{E,U,I\}} F_t^{EZ}}.$$

Since our paper focuses on worker flows between employment and unemployment, we restrict our attention to p_t^{UE} and p_t^{EU}, which we refer to as job-finding and separation rates, respectively, in the subsequent text.

Finally, the time series of unemployment is based on the flow data and is not identical to that obtained using the stock data, as the former is calculated with a subset of samples from the latter. To construct

[6]The LFS is conducted in the final week of each month. In the LFS, the unemployed are defined as those without a job and who did not work at all during the reference week, those who would beready to work if work were available, and those engaged in any job-seeking activity or preparing to start business during the same week. This definition of unemployment is consistent with the definition by the International Labour Organization.

[7]We construct the unique household identifiers using the sample area code, interview period, and household characteristics.

flow data consistent with the stock data, we adjust the flow data using the correction method employed by the Ministry of Labor (1985). This method has been used by many authors, including Ohta and Teruyama (2003a) and Sakura (2005), and is similar to that applied by Fujita and Ramey (2009) in the U.S.

All data, both for Japan and the U.S., has been seasonally adjusted using the Census Bureau X-12 method, logged and HP filtered with a smoothing parameter of 1600.

2.2 Cyclical Properties of Japan's Labor Market Variables

We now proceed to analyze the cyclical characteristics of the Japanese labor market. We are mainly interested in the cyclical behavior of four of the main labor market variables: the unemployment rate, vacancies, and the job-finding and separation rates. In order to put these cyclical properties into a global context, we compare these variables, both with regard to levels and in deviations from trend, with their U.S. counterparts.

Figures 1 to 4 and Table 1 summarize the evolution over time and the cyclical properties of the labor market variables of interest, as well as two measures of productivity: output per worker and TFP.

Levels

We can see in the top-left panel of Figure 1 that the unemployment rate in Japan was historically lower than in the U.S. until the end of the 1990s. In the post-war period,[8] Japan's unemployment rate was seemingly more stable than that of the U.S., with levels between 1 and 2.5 percent until the beginning of the 1990s, when it started to increase, reaching a maximum of 5.4 percent in 2002. The U.S. unemployment rate fluctuated between 2 and 11 percent during the same period.

If we consider the worker flows underlying the previously explained low levels of Japanese unemployment in comparison with the U.S., we find that workers in Japan transition much less frequently between employment and unemployment. Figure 3 shows that both the monthly job-finding and separation rates are lower in Japan than in the U.S., although these differences have decreased in recent years for the separation rate. These low worker flow rates in Japan are a well known fact that was sustained for many years by the traditional employment practice of lifetime employment at a firm. With the Lost Decade, such lifetime employment guarantees are no longer as widespread, which partially explains the rise in the level of the job separation rate.

[8]The available Labor Force Survey micro data for Japan does not allow us to calculate the unemployment rate before 1983. Hence the data prior to 1983 is obtained from the Statistics Bureau of Japan's Ministry of Internal Affairs and Communication at http://www.stat.go.jp/english/data/roudou/index.htm

Cyclicality

While the previously explained level differences in the labor market variables between Japan and the U.S. have been well documented in the literature, their cyclical properties are less well known. When we calculate the log-deviations from trend of the variables of interest, we observe that these major level differences are smaller when analyzing their cyclical behavior. Note that for consistency in the comparison of the data, we restrict the attention of cyclical properties of the variables to the common sample between the U.S. and Japan, namely from 1983q1 to 2005q4. All of the analysis that follows is performed for this sample period.

The unemployment rate, which had seen greater level movements for the U.S. than for Japan, shows much smaller differences in terms of the cyclical changes. The bottom-left panel of Figure 1 shows the high-frequency movements of the unemployment rate for both countries; it indicates that while Japan's unemployment figures seem to move less, the difference is much smaller that one might expect considering the level movements. Table 1 shows that in fact the deviations from trend of unemployment in Japan are only slightly less volatile than those for the U.S., with standard deviations of 5 and 8 percent, respectively. Japan's unemployment rate is also less auto-correlated than that of the U.S., 0.81 versus 0.88 first-order auto-correlation. Finally, unemployment in Japan is more counter-cyclical than the U.S. value, both with respect to output per worker and TFP.[9]

The counterpart to workers looking for a job is firms looking for workers, which can be analyzed through the vacancies posted in the economy. The cyclical properties of vacancies in Japan are not very different from those of the U.S. The bottom-left panel of Figure 1 displays the log-deviations from trend for both countries, and Table 1 summarizes the properties. Vacancies are almost equally volatile in both countries, with a standard deviation of 0.09 for Japan and 0.1 for the U.S.. At the same time, vacancies are more auto-correlated and more pro-cyclical in Japan than in the U.S.

The job-finding and separation rates are also not dissimilar in terms of their cyclical variability between the two countries, with a slightly higher volatility in Japan. The standard deviation of the finding and separation rates are 0.08 and 0.09, respectively, for Japan, and 0.05 and 0.06 for the U.S. These two countries do differ, however, in terms of the auto-correlation and cross-correlation of the finding rate with productivity, although less so for the separation rate. The autocorrelation for Japan is almost zero, and it is more pro-cyclical than that of the U.S. The separation rate also has a very small first-order autocorrelation for Japan, and is more counter-cyclical. The U.S. has more auto-correlated finding and separation rates, but these two rates are nearly acyclical. Hence, while Shimer (2005) argues the use of a

[9] Note that the U.S. data shows a positive correlation between cyclical unemployment and output per worker for this period. This correlation is negative when a longer horizon is used. One reason for this change in the correlation sign, which is not seen when using TFP as the measure of productivity, may be what has come to be known as the 'jobless' recoveries that the U.S. has experienced in recent decades.

model with exogenous destruction by referring to the acyclicality of the separation rate in the data, for the U.S. this rate is clearly counter-cyclical and more volatile for Japan. This is the reason that, in this paper, we study versions of the model with endogenous job destruction, in addition to the version with exogenous destruction.

One important variable in the labor market, which affects the chances that workers and firms meet, is the so-called market tightness. This variable, which is the ratio of unemployment to vacancies, is more volatile than either of the two values individually, with a standard deviation of 0.13 for Japan and 0.18 for the U.S. Underlying this behavior of the market tightness is the negative correlation between unemployment and vacancies, known as the Beveridge Curve, which can be observed for both countries in Figure 2. One can clearly see that both variables move in opposite directions over time and have a negative cross-correlation of 0.69 for Japan and 0.91 for the U.S.

The phenomenon commonly known as the "Shimer Puzzle," formulated in Shimer (2005), relates to the inability of the simple search and matching model to reproduce the U.S. cyclical volatility of the market tightness for empirically reasonable movements of productivity. It is thus important to understand the magnitude of the productivity changes in the economy. The last two columns of Table 1 show that productivity has almost identical variability in both countries, with a standard deviation of 0.01 for both output per worker and TFP.

In summary, considering the levels of the labor market variables, we find substantial differences between Japan and the U.S. However, in terms of the cyclicality of these variables, the discrepancies are less striking. The main differences are that the unemployment rate and the market tightness are less volatile for Japan than for the U.S., and that the cyclicality and auto-correlation of the finding and separation rates also differ between the two countries. Given these dissimilarities, we question whether the "Shimer Puzzle" holds for the Japanese economy. In other words: are the stylized versions of the search and matching model, when calibrated to match the long-run levels of the labor market variables in Japan, able to reproduce its cyclical properties, particularly the volatility of the market tightness? Or, as is the case for the U.S., does the model fail to generate enough volatility? We address these questions in the following section by building the model, which will later be simulated and compared to the data.

3 The Model

We wish to analyze the ability of three different versions of the search and matching model to reproduce the previously explained empirical facts for the Japanese economy. The model presented below nests all three versions; Section 4 explains the parameterization of the model such that it collapses into each of the three submodels.

The first model, Model 1, is a discrete-time version of the simple textbook search and matching model with exogenous job destruction, as used in Shimer (2005).[10] Given that for the Japanese economy, the separation rate is not as acyclical as that claimed by Shimer for the U.S., we then analyze a second version of the model, Model 2, in which the separation rate is allowed to vary over the cycle. This second model is a discrete-time version of the textbook model with endogenous destruction. Finally, since the goal of this paper is to study whether the model can account for the cyclical properties of the data, in Model 3 we use what has become the workhorse model in macroeconomics for analyzing business cycle fluctuations, the Real Business Cycle model, but with the labor market modeled with search frictions (using the features of Model 2) to generate equilibrium unemployment and worker flows between employment states.

In what follows, we present the general version of the model which nests Models 1, 2, and 3.

3.1 Environment

The model is a stationary discrete-time Real Business Cycle model with search frictions in the labor market. The economy is composed of two types of infinitely-lived agents: consumers/workers and firms. There is only one good, which is produced using capital and labor and sold by the firms to the consumers. The labor market is modeled in the style of the search and matching literature, with endogenous job destruction. The replacement of the traditional Walrasian labor market for one with search frictions allows the model to display involuntary unemployment in equilibrium, essential to the focus of this paper.

The labor market is modeled in the style of Mortensen and Pissarides (1994) where search frictions exist, and workers and firms try to match and form employment relationships. Firms produce using capital, labor, and available technology; matches are destroyed endogenously as an optimal decision by the firm and the worker, or exogenously when hit by a negative shock.

Employment relationships are comprised of one worker and one firm, and matching occurs randomly according to a constant returns to scale matching function, $m(u_t, v_t)$, where u_t is total unemployment and v_t is the number of vacancies. We define the market tightness as the ratio of vacancies to unemployed workers, $\theta_t \equiv \frac{v_t}{u_t}$, and the probability that a firm meets a worker in any given period as $q_t(\theta_t) \equiv m\left(\frac{1}{\theta_t}, 1\right)$. Similarly, the probability that a worker matches with a firm is $\theta_t q_t(\theta_t)$.

A job is destroyed for reasons exogenous to the match with probability λ. We model endogenous destruction by assuming that productive firms need to pay, in addition to labor and capital costs, a non-productive intermediate input cost x_t, which is idiosyncratic to each match. The firm-specific intermediate input cost is independent and identically distributed across firms and time, with distribution function $G : [x_{min}, x_{max}] \to [0, 1]$. A new idiosyncratic cost is drawn every period by existing matches, and if the cost is too high, it may be beneficial for the firm and the worker to discontinue the employment

[10] Given that the model´s most complete version requires discrete-time, all versions of the models are in discrete time.

relationship. The value of x_t that dissolves the match is denoted by $\bar{x}_t$. The probability of endogenous job destruction is therefore $1 - G(\bar{x}_t)$.

In a productive employment relationship, the firm produces output according to a constant returns to scale production function which has hours and capital as inputs. The production function of the individual firm is $y_t = A_t f(k_t, h_t)$, where A_t is total factor productivity (TFP), and y_t, k_t, and h_t are output, capital, and hours per worker, respectively.[11] Hence, y_t and k_t are related to aggregate output and capital according to the following equations:[12]

$$Y_t = n_t y_t \quad \text{and} \quad K_t = n_t k_t. \tag{1}$$

The timing of the model is as follows. At the beginning of each period, the level of technology of the economy is revealed, and every matched firm draws an idiosyncratic cost. These two variables determine the number of productive and unproductive matches for the period. After endogenous destruction takes place, the levels of employment and unemployment are determined. At that point, production starts at firms, and vacancies and unemployed workers try to meet in the labor market. At the end of the period, wages are paid and the firms' profits are distributed to the households, which decide how much to consume and how much to save. Finally, the exogenous destruction shock takes place, which dissolves some of matches.

3.2 The Agents' Problems

Problem of the Household

The household chooses $\{C_{t+i}, K_{t+i}\}_{i=0}^{\infty}$ to max

$$E_t \left\{ \sum_{i=0}^{\infty} \beta^i \left[u(C_{t+i}) - n_{t+i} H(h_{t+i}) \right] \right\} \tag{2}$$

subject to

$$C_{t+i} + K_{t+i} = W_{t+i} + \Pi_{t+i} + (1-\delta) K_{t+i-1} + r_{t+i} K_{t+i-1} + (1 - n_{t+i}) b, \tag{3}$$

for $i = \{0, ..., \infty\}$, where $\beta \leq 1$ is the discount rate of the economy; C_t is the consumption level of the household; n_t is the number of employed workers; $H(h_t)$ is the disutility suffered by each working member of the family, where h_t are the individual hours worked, chosen optimally between the firm and the worker; K_t is the total capital in the economy, which is owned by the household; W_t are the total

[11] Matches differ in terms of their idiosyncratic cost, which is assumed to be additive. This assumption, also used in Cooley and Quadrini (1999) and Trigari (2009), implies that the equilibrium optimal levels of capital and hours do not depend on this cost and are the same across firms, which greatly simplifies the model.

[12] As is shown later, every firm chooses the same amount of capital and hence produces the same quantity of output.

wages paid to the workers of the household; Π_t are the total profits of the firms; r_t is the rental rate of capital and δ is its depreciation rate; b is the flow utility from leisure.

This problem yields the standard consumption Euler equation, which shows how in equilibrium, the individual is indifferent between saving or consuming one more unit.

$$u'(C_t) = \beta E_t \{(1 + r_{t+1} - \delta) u'(C_{t+1})\}. \tag{4}$$

Problem of the Firm

Let us now analyze the problem of the firm. Denote by V_t and $J_t(x_t)$, measured in terms of consumption, the value of posting a vacancy and hiring a worker, respectively.

Firms enter the labor market by posting vacancies and, when matched with a worker, implement optimal production plans in order to maximize their profits. Posting a vacancy has a flow cost of ϕ for the firm. A vacant firm matches with a worker with probability $q_t = \frac{m(\theta_t)}{\theta_t}$. If the firm is matched and the idiosyncratic cost is low enough, the firm obtains the value of being filled in the following period, otherwise it remains as a vacancy. The value of a vacancy is hence

$$V_t = -\phi + E_t \beta_t \left[q_t \int_{x_{min}}^{\bar{x}_{t+1}} dG(x_{t+1}) + (1 - q_t G(\bar{x}_{t+1})) V_{t+1} \right], \tag{5}$$

where $\beta_t = \beta \frac{u'(C_{t+1})}{u'(C_t)}$ is the stochastic discount factor, which firms and workers use to discount the future. $\bar{x}_{t+1}$ is the value for x that makes the firm willing to hire the worker.

In equilibrium, we assume the free entry of firms, which implies that the value of posting a vacancy is zero. We can now write equation (5) as:

$$0 = -\phi + E_t \beta_t q_t \int_{x_{min}}^{\bar{x}_{t+1}} J_{t+1}(x_{t+1}) dG(x_{t+1}) \tag{6}$$

The value for the filled firm is

$$J_t(x_t) = A_t f(k_t, h_t) - r_t k_t - x_t - w_t(x_t) h_t + E_t \beta_t (1 - \lambda) \int_{x_{min}}^{\bar{x}_{t+1}} J_{t+1}(x_{t+1}) dG(x_{t+1}). \tag{7}$$

The interpretation of the previous equation is as follows. During the current period, given the idiosyncratic cost x_t, the firm produces output and pays wages, the rental cost of capital, and intermediate inputs, x_t. The following period, if the match is not exogenously destroyed, which occurs with probability λ, and if the idiosyncratic cost is below the threshold, the match is still productive, with a value of $J_{t+1}(x_{t+1})$, otherwise the match is destroyed and becomes a vacancy, which has a value of zero. The firm chooses capital k_t to maximize the value of the match, which implies the traditional condition that capital is rented to the point where its marginal cost equals its marginal product. Therefore

$$r_t = A_t f_k(k_t, h_t). \tag{8}$$

We can now define the total profits of the firms, which are rebated to the workers, as

$$\Pi_t = n_t \left[A_t f\left(k_t, h_t\right) - w_t\left(x_t\right) h_t - r_t k_t - \tilde{x}_t\right] - v_t \phi,$$

where $\tilde{x}_t = \frac{1}{G(\bar{x}_t)} \int_{x_{min}}^{\bar{x}_t} x dG\left(x\right)$.

Problem of the Worker

Consider now the worker's perspective. Denote by U_t and $N_t\left(x_t\right)$, measured in terms of consumption, the value of being unemployed and being matched with a firm.

An unemployed worker obtains b utility from leisure, home production, or unemployment benefits. If he matches with a firm, which happens with probability $p_t = m\left(\theta_t\right)$, and the idiosyncratic cost for the firm is below the threshold, $\bar{x}_{t+1}$, the worker becomes productive in the following period. If he does not enter into an employment relationship with a firm, he remains unemployed. Hence, the value of being unemployed at period t is:

$$U_t = b + E_t \beta_t \left[p_t \int_{x_{min}}^{\bar{x}_{t+1}} N_{t+1}\left(x_{t+1}\right) dG\left(x_{t+1}\right) + \left(1 - p_t G\left(\bar{x}_{t+1}\right)\right) U_{t+1} \right] \tag{9}$$

As in the case of the firm, the match value for a worker is a function of the idiosyncratic shock x_t. The value of employment for a worker is composed of the wage, the disutility in terms of consumption from supplying labor, and the continuation value, which is the value of being employed if the match is not destroyed (either endogenously or exogenously), or the value of being unemployed if it is destroyed.

$$N_t\left(x_t\right) = w_t\left(x_t\right) h_t - \frac{H\left(h_t\right)}{u'\left(C_t\right)} + E_t \beta_t \left\{ \left(1 - \lambda\right) \int_{x_{min}}^{\bar{x}_{t+1}} N_{t+1}\left(x_{t+1}\right) dG\left(x_{t+1}\right) + \left[1 - \left(1 - \lambda\right) G\left(\bar{x}_{t+1}\right)\right] U_{t+1} \right\} \tag{10}$$

3.3 Surplus, Wages, Hours, and the Destruction Threshold

When an employment relationship takes place, it creates a surplus that is shared between the firm and the worker. The surplus of the match is defined as the sum of the values of a filled job for a firm and a worker minus their outside options, which are the value of a vacancy and the value of unemployment, respectively. As there is free entry of firms, the expression for the surplus is $S_t\left(x_t\right) = J_t\left(x_t\right) + N_t\left(x_t\right) - U_t$.

Wages and hours in the economy are chosen as the Nash solution to a bargaining problem, where η is the bargaining power of the worker.

$$\max_{w_t(x_t), h_t} \left(N_t\left(x_t\right) - U_t\right)^{\eta} \left(J_t\left(x_t\right) - V_t\right)^{1-\eta}.$$

The solution to the previous problem with respect to wages delivers a pair of conditions for sharing the surplus, according to which the worker and firm receive constant shares of the surplus equal to their bargaining power. These expressions are

$$N_t(x_t) - U_t = \eta S_t(x_t), \quad J_t(x_t) = (1-\eta) S_t(x_t). \tag{11}$$

Surplus

Combining the previous two conditions with equations (7) to (10), the surplus for a match can be expressed as:

$$S_t(x_t) = A_t f(k_t, h_t) - r_t k_t - x_t - \frac{H(h_t)}{u'(C_t)} - b + E_t \beta_t (1 - \lambda - p_t \eta) \int_{x_{min}}^{\bar{x}_{t+1}} S_{t+1}(x_{t+1}) \, dG(x_{t+1}) \tag{12}$$

Wages

Using the expression for the surplus (12), along with the sharing rules in (11) and the job-creation condition (6), we can derive the wage paid to the worker. The expression for the wage is:

$$w_t(x_t) h_t = \eta [A_t f(k_t, h_t) - r_t k_t - x_t + \phi \theta_t] + (1-\eta) \left(b + \frac{H(h_t)}{u'(C_t)} \right) \tag{13}$$

The worker is compensated for a fraction η of the flow of profits to the firm, and for a measure of the saved cost of searching for new matches. It is also compensated for a proportion $(1-\eta)$ of the home production lost and the disutility of supplying hours of work.

Hours

As in the case of wages, hours are chosen to maximise the Nash product. At the optimum, hours worked satisfy the condition that the marginal disutility of supplying one extra hour is equal to its marginal product:

$$\frac{H'(h_t)}{u'(c_t)} = A_t f'(k_t, h_t) \tag{14}$$

Destruction Threshold

An employment relationship is terminated when the idiosyncratic productivity of the firm is so low that it drives the surplus to zero. This determines the threshold productivity below which both worker and firm agree to dissolve the match and search for better options. Using equation (12) and equating it to zero, we obtain the expression for the threshold:

$$\bar{x}_t = A_t f(k_t, h_t) - r_t k_t - \frac{H(h_t)}{u'(C_t)} - b + E_t \beta_t (1 - \lambda - p_t \eta) \int_{x_{min}}^{\bar{x}_{t+1}} S_{t+1}(x_{t+1}) \, dG(x_{t+1}) \tag{15}$$

3.4 Worker Flows and Transition Rates

Given the timing of the labor market as explained earlier and all of the decisions of the agents in the economy, we can obtain the flows in and out of the different states for the workers:

$$u_t = (1 - p_{t-1} G(\bar{x}_t))\, u_{t-1} + [1 - (1 - \lambda)\, G(\bar{x}_t)]\, n_{t-1} \tag{16}$$

$$n_t = 1 - u_t \tag{17}$$

In this more general version of the model, the probability of a worker transitioning from unemployment to employment, commonly known as the finding rate, is $p_{t-1} G(\bar{x}_t)$. Similarly, the probability of transitioning from employment to unemployment, or the separation rate, is $1 - (1 - \lambda)\, G(\bar{x}_t)$.

3.5 Equilibrium

A competitive equilibrium is a set of prices $\{r_t, w_t(x_t)\}_{t=0}^{\infty}$ and allocations $\{Y_t, K_{t+1}, C_t, k_t, n_t, u_t, v_t, \theta_t, \bar{x}_t\}_{t=0}^{\infty}$ which satisfy that (i) agents optimize, i.e. the household's optimal condition (4), the value functions in the labor market (6) to (10), the capital rental optimal condition (8), the optimal hours condition (14), and the optimal surplus sharing rules (11) are satisfied; and (ii) markets clear for consumption goods, $Y_t = C_t + K_{t+1} - (1 - \delta)\, K_t - (1 - n_t)\, b + \phi v_t + n x_t^T$; capital, equation (1); and labor, equations (16) and (17).

4 Parameterization

We now proceed to explain the method used to parameterize the model, and how the previously presented model is collapsed into Models 1, 2, and 3.

We choose functional forms that are standard in the literature and then calibrate the parameters of the model to match the Japanese empirical evidence for the average of the sample period, which is assumed to represent the steady state of the model. We set the length of the period to one month, as in the data presented in Section 2.

The per-period utility function for consumption is assumed to be linear for Models 1 and 2, $u(C_t) = C_t$, and logarithmic in Model 3, $u(C_t) = log(C_t)$. The disutility from work takes the form $a_n \frac{1}{\zeta} L_t^{\zeta}$ for the latter, where for Models 1 and 2, we set $a_n = \zeta = 0$. Following Trigari (2006), we set $\zeta = 10$ for Model 3, and we calibrate a_n such that using the optimal hours equation (14), the implied steady state value of hours is 1/3. We set $a_n = 2.3e^5$. The discount factor, β, is set to 0.99, which is a standard value for a monthly model.

The production function for the firms is assumed to have a standard Cobb-Douglas form, $f(k_t, h_t) = k_t^{\alpha} h_t^{\chi}$. For Models 1 and 2, we set $\alpha = \chi = 0$. For model 3, following Braun, Esteban-Pretel, Okada, and

Sudou (2006), we set $\alpha = 0.38$ and $\chi = 0.62$. We also follow that paper in setting the depreciation rate of capital, δ, to 0 in Models 1 and 2, and to 0.0094 in Model 3.

In the labor market, we assume that the worker's bargaining power, η, is 0.5, as is conventional in the literature. The matching function in the labor market is Cobb-Douglas, $m(u_t, v_t) = \mu u_t^{\xi} v_t^{1-\xi}$. We follow the norm in these types of models and set the elasticity of matching with respect to unemployment, ξ, to 0.5, so as to satisfy the Hosios condition. The exogenous destruction probability, λ, is set to 0 in Models 2 and 3. For Model 1, we calibrate it to be $\lambda = 0.0042$, which is the monthly separation rate in Japan for the sample studied. For the models with endogenous destruction, Models 2 and 3, the idiosyncratic cost to the firm is drawn from an exponential distribution, $x \sim \frac{1}{\varphi} e^{-\frac{x}{\varphi}}$, which only requires the calibration of one parameter, the mean of the distribution, φ. Hence, $x_{min} = 0$ and $x_{max} = \infty$. For Model 1, which has only exogenous destruction, we assume that $x_{min} = x_{max} = 0$, so that the idiosyncratic costs are 0 at all times and produce no endogenous separation. φ is jointly calibrated with the scaling parameter in the matching function, μ, and the cost of posting a vacancy, ϕ, to match the unemployment rate and the probability of leaving unemployment in Japan over the sample period, respectively 0.034 and 0.13, and a market tightness of unity.[13] We set $\mu = 0.12$ in all three models; $\phi = 0.48$ in Model 1, $\phi = 0.17$ in Model 2, and $\phi = 0.19$ in Model 3; $\varphi = 0.65$ and $\varphi = 1.76$ in Models 2 and 3, respectively.

We assume that the value of leisure, home production, or unemployment benefit, b, is a fraction of the output that the average worker would produce in the firm, identical in standard search and matching models to the marginal product of one worker. We follow Shimer (2005) in setting this fraction to 0.4 in all three versions of the model.[14] The implied values of b are 0.4 in Model 1, 0.15 in Model 2, and 0.24 in Model 3.

Finally, productivity is assumed to follow an autoregressive process of order 1, $A_t = A^{(1-\rho)} A_{t-1}^{\rho} e^{\epsilon_t}$, where $\epsilon_t \sim N(0, \sigma_\epsilon^2)$. We set $\rho = 0.755$ and $\sigma_\epsilon = 0.0085$ in Models 1 and 2 in order to match the first-order autocorrelation and standard deviation in the data on output per worker. For Model 3, since the measure of productivity in the model is TFP, we match those two moments of TFP in the data and set $\rho = 0.9$ and $\sigma_\epsilon = 0.0063$.

The values of the model parameters are summarized in Table 2.

[13] As explained in Shimer (2005), changing the value of the market tightness only rescales the value of μ, leaving all other values unchanged.

[14] We use this number for the flow value of unemployment to render our results comparable with those of Shimer (2005). As we later argue, increasing this value changes the results of the model, concordant with the findings ofpublications such as Hagedorn and Manovskii (2008).

5 Simulation Results

We now proceed to explain how the simulations of the model, in its three different versions, compare to the data. These results are shown in Table 3 with the empirical moments, for easy comparison.[15]

The second line of each panel in Table 3 shows the simulation results for Model 1, which is the simple exogenous destruction version of the model. We see that the model fails to account for the volatility of all of the variables, explaining less than 5% of the variability in the data for most variables. In particular, the model generates around 2% of the volatility of unemployment (0.0013 standard deviation in the model versus 0.049 in the data), and slightly more for vacancies (0.0054 standard deviation in the model versus 0.13 in the data). Despite the fact that the model correctly generates a downward sloping Beveridge curve, as seen in the cross-correlation of unemployment and vacancies of -0.4 in the model, this correlation is smaller than in the data (-0.69). More importantly, the market tightness in the model has less variability.

As is the case for the U.S., the simple exogenous destruction search and matching model is not able to replicate the empirical volatility of the market tightness for Japan. The reasons for this failure are the same as those noted by Shimer (2005). The assumption of Nash bargaining for wage determination makes wages too sensitive to movements in productivity. Wages in the model absorb an inordinate fraction of the potential increases in profits due to increases in productivity (in the case of a positive shock), and this mechanism reduces the incentive for firms to post new vacancies, which in turn reduces the response of unemployment to productivity shocks. The low variability of both vacancies and unemployment in the model generates the low volatility of the modelled market tightness compared to the data. As shown by Hagedorn and Manovskii (2008), one way to reconcile this simple model with the empirical findings is to assume that the flow value of unemployment, b, is much larger, and very close to the steady-state productivity level. While we do not report it in the table, increasing the value of b in the model to 95 % of the steady-state productivity level also brings the Japanese calibration of the model close to the data.[16]

Hence, despite the observed differences between Japan and the U.S. highlighted in Section 2, the simple exogenous version of the model fails to reproduce the Japanese data, as is also the case for the U.S. However, Model 1 assumes constant and exogenous job destruction. As we showed in Section 2, this deviates from the data for Japan, where the separation rate is clearly counter-cyclical. For this reason, we now consider the simulation results when allowing for variable and endogenous changes in the

[15] The model is simulated for 264 months, the equivalent of the data sample. We then calculate quarterly averages of the monthly rates and detrend using the HP filter with a smoothing parameter of 1600. We repeat the simulation 1000 times and calculate the average and standard deviation of all the simulations. The model is simulated using the Dynare package, version 3.065.

[16] These simulation results are available from the authors upon request.

job-destruction rate.

Model 2, which allows for endogenous movements in the separation rate, is able to generate more volatility for unemployment and vacancies than Model 1. The volatility of unemployment is in fact within two standard deviations of the data, and the model accounts for around half of the volatility of vacancies. However, the inclusion of endogenous separation in the model, while generating higher volatility in these two variables, has the negative side effect of inverting the sign of the correlation between unemployment and vacancies, 0.8 in this version of the model. This implies that the volatility of the market tightness in the model is still much lower than in the data, 0.015 versus 0.13.

Allowing for time-varying endogenous separations generates higher volatility in unemployment and vacancies, since two margins (hiring and firing) are at work in the model. In times of prosperity, more workers are hired and fewer are separated, with the opposite occurring during recessions. However, in this version of the model, the vacancies are slightly countercyclical, which produces the positive correlation with unemployment. This positive correlation in the model can best be understood by observing the impulse response functions of these two variables to a positive technology shock. We can see in Figure 5 how after a positive technology shock, the expectation of future profits causes firms to post more vacancies and reduce firing (lowering the job-separation rate), both of which reduce unemployment. The drop in unemployment is larger than that observed in Model 1, as the separation margin also operates. Shortly after the initial shock, the drop in unemployment, which reduces the probability of a given firm meeting a worker, lowers the incentive to post vacancies and brings this variable below the steady state level. Thereafter, as unemployment returns to the steady state level, so do vacancies. The impulse response functions show that the larger drop in unemployment due to the time-varying endogenous separation in the model, which produces the larger volatility, is what drives vacancies to move in a similar direction to unemployment and produces the counter-factual upward-sloping Beveridge curve in the model.

Finally, Model 3, which includes a general equilibrium structure with curvature in the utility function, capital accumulation, and hours in the production function, generates even more volatility than Model 2 for unemployment and vacancies. This version of the model produces an excess of volatility for these two variables. However, since it once more generates a counter-factual positive correlation between unemployment and vacancies, it is still unable to generate enough volatility in the market tightness compared to the Japanese data.

In Model 3, the inclusion of capital and hours in the production function generates the larger movements in unemployment. In this case, in order to take full advantage of the productivity shocks, firms have greater incentives to retain workers, which produces a larger drop in the separation rate and in unemployment. However, the great decrease in unemployment means that firms have little incentive to post vacancies, given the competition for the available unemployed workers. In this model, vacancies and unemployment are highly positively correlated, and despite the higher volatility of these two variables, the market tightness displays hardly any variability.

In summary, we have shown that despite the differences between the Japanese and U.S. labor markets, the volatility puzzle asserted for the U.S. economy also holds for Japan. We have shown this failure in three fairly standard versions of the model. Future research should explore particular features that might be introduced to the model to reconcile the theory with the Japanese empirical evidence presented in Section 2. As mentioned earlier, there are fixes proposed in the literature when discussing the puzzle for the U.S. that are applicable for Japan, such as increasing the flow value of unemployment. Specifically for Japan, Miyamoto (2009) studies whether introducing training costs in the simple exogenous separation version of the model helps to reconcile theory and data. An analysis of all possible features of the model explored in this growing literature and their effects is beyond the scope of this paper, and is left for subsequent research.

6 Conclusions

In recent years, the standard method of modelling equilibrium unemployment has been criticised due to its inability to reproduce some important cyclical elements in the data. Shimer (2005) and Hall (2005) show that the simple search and matching model is incapable of reproducing the U.S. empirical volatility of the market tightness for reasonable movements in productivity. Other authors have studied whether this so-called "Shimer Puzzle" also holds for other economies. This paper considers the case of the Japanese economy.

There are known differences between the labor markets of Japan and the U.S. We document the differences and similarities of the two economies in terms of unemployment rates, worker flow probabilities, and productivity. We examine the differences in levels, as well as in the cyclical properties of the main labor market variables. We find that in both economies, the differences in the levels of the two labor market variables are more notable than their deviations from the steady state, although the cyclical properties of these variables differ enough to ask whether the "Shimer Puzzle" also holds for Japan.

We build, parameterize, and simulate three different versions of the search and matching model to study the puzzle's validity for Japan: one with exogenous job destruction, one with endogenous job destruction, and a more elaborate Real Business Cycle model with a search and marching labor market.

We find that the "Shimer Puzzle" does indeed also hold for Japan. None of the three versions of the model is able to generate as much volatility for the market tightness as is present in the data. The model fails either because produces too little volatility in unemployment and vacancies, or because it generates a counter-factual upward-sloping Beveridge curve.

Recent literature has considered various ways of reconciling the model with the data for the U.S. Some of the proposed fixes, such as that of Hagedorn and Manovskii (2008), also function for Japan. Future work should explore more Japan-specific features of the model that could help to bring it closer to the data.

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Table 1: Japan and U.S. Labor Market Cyclical Properties

	Japan							U.S.						
	u	v	v/u	f	s	Prod. y/n	Prod. TFP	u	v	v/u	f	s	Prod. y/n	Prod. TFP
Std. Dev.	0.05	0.09	0.13	0.08	0.09	0.01	0.01	0.08	0.10	0.18	0.06	0.05	0.01	0.01
Autocorr.	0.81	0.93	0.93	-0.08	0.10	0.41	0.62	0.88	0.85	0.87	0.71	0.59	0.70	0.64
Cross-corr.														
u	1	-0.69	-0.75	-0.24	0.32	-0.47	-0.54	1	-0.91	-0.97	-0.87	0.79	0.13	-0.19
v		1	0.99	0.34	-0.51	0.46	0.70		1	0.98	0.83	-0.76	0.11	0.15
v/u			1	0.33	-0.51	0.50	0.72			1	0.87	-0.79	0.004	0.17
f				1	-0.59	0.16	0.26				1	-0.58	-0.11	0.22
s					1	-0.23	-0.37					1	-0.06	-0.09
Prod. y/n						1	0.91						1	0.30
Prod. TFP							1							1

Notes: u is the unemployment rate; v is vacancies; f is the monthly probability of moving from unemployment to employment, or the job-finding rate; s is the monthly probability of moving from employment to unemployment, or the job separation rate; y/n is output per worker; and TFP is total factor productivity. All data are quarterly (f and s are quarterly averages of the monthly rates), from 1983q1 to 2005q4, seasonally adjusted using the X-12 method of the Census Bureau, logged and HP filtered with a smoothing parameter of 1600.

Table 2: Parameter Values

Exogenous parameters	β	ξ	η	ζ	α	χ	δ	$\bar{A}$
Model 1: Exog. Dest.	0.99	0.5	0.5	0	0	0	0	1
Model 2: Endog. Dest.	0.99	0.5	0.5	0	0	0	0	1
Model 3: RBC + Endog. Dest.	0.99	0.5	0.5	10	0.38	0.62	0.0094	1

Endogenous parameters	μ	λ	φ	ϕ	b	a_n	σ_ε	ρ_ε
Model 1: Exog. Dest.	0.12	0.0042	0	0.48	0.4	0	0.0085	0.75
Model 2: Endog. Dest.	0.12	0	0.65	0.17	0.15	0	0.0085	0.75
Model 3: RBC + Endog. Dest.	0.12	0	1.76	0.19	0.24	$2.33e^5$	0.0063	0.9

Table 3: Simulation Results

Std. Dev.	u	v	v/u	f	s	Prod. y/n	Prod. TFP
Data	0.049	0.087	0.13	0.084	0.091	0.010	0.010
Model 1: Exog. Dest.	0.0013	0.0047	0.0054	0.0027		0.010	
	(0.0002)	*(0.0005)*	*(0.0006)*	*(0.0003)*		*(0.0011)*	
Model 2: Endog. Dest.	0.025	0.021	0.015	0.008	0.044	0.010	
	(0.0046)	*(0.0032)*	*(0.0016)*	*(0.0008)*	*(0.0048)*	*(0.0011)*	
Model 3: RBC + Endog. Dest.	0.282	0.270	0.018	0.011	0.507		0.010
	(0.055)	*(0.053)*	*(0.002)*	*(0.001)*	*(0.063)*		*(0.001)*

Autocorr.	u	v	v/u	f	s	Prod. y/n	Prod. TFP
Data	0.82	0.93	0.93	-0.083	0.097	0.41	0.62
Model 1: Exog. Dest.	0.78	0.33	0.41	0.41		0.41	
	(0.047)	*(0.100)*	*(0.100)*	*(0.100)*		*(0.100)*	
Model 2: Endog. Dest.	0.78	0.65	0.41	0.41	0.41	0.41	
	(0.046)	*(0.075)*	*(0.10)*	*(0.10)*	*(0.10)*	*(0.100)*	
Model 3: RBC + Endog. Dest.	0.82	0.82	0.51	0.51	0.51		0.62
	(0.043)	*(0.042)*	*(0.094)*	*(0.094)*	*(0.094)*		*(0.083)*

Cross-corr with u	u	v	v/u	f	s	Prod. y/n	Prod. TFP
Data	1.00	-0.69	-0.75	-0.24	0.32	-0.47	-0.54
Model 1: Exog. Dest.	1.00	-0.40	-0.60	-0.60		-0.60	
		(0.027)	*(0.034)*	*(0.034)*		*(0.034)*	
Model 2: Endog. Dest.	1.00	0.80	-0.57	-0.57	0.57	-0.57	
		(0.039)	*(0.038)*	*(0.038)*	*(0.038)*	*(0.038)*	
Model 3: RBC + Endog. Dest.	1.00	1.00	-0.66	-0.65	0.63		-0.72
		(0.0004)	*(0.041)*	*(0.041)*	*(0.040)*		*(0.026)*

Notes: u is the unemployment rate; v is vacancies; f is the monthly probability of moving from unemployment to employment, or the job-finding rate; s is the monthly probability of moving from employment to unemployment, or the job separation rate; y/n is output per worker; and TFP is total factor productivity. The data spans 88 quarters from 1983q1 to 2005q4. The model is simulated for 264 months and then averaged by quarter to obtain 88 quarters of simulated data. Both the data and the model simulations are seasonally adjusted using the X-12 method of the Census Bureau, logged and HP filtered with a smoothing parameter of 1600.

Figure 1: Unemployment and Vacancies

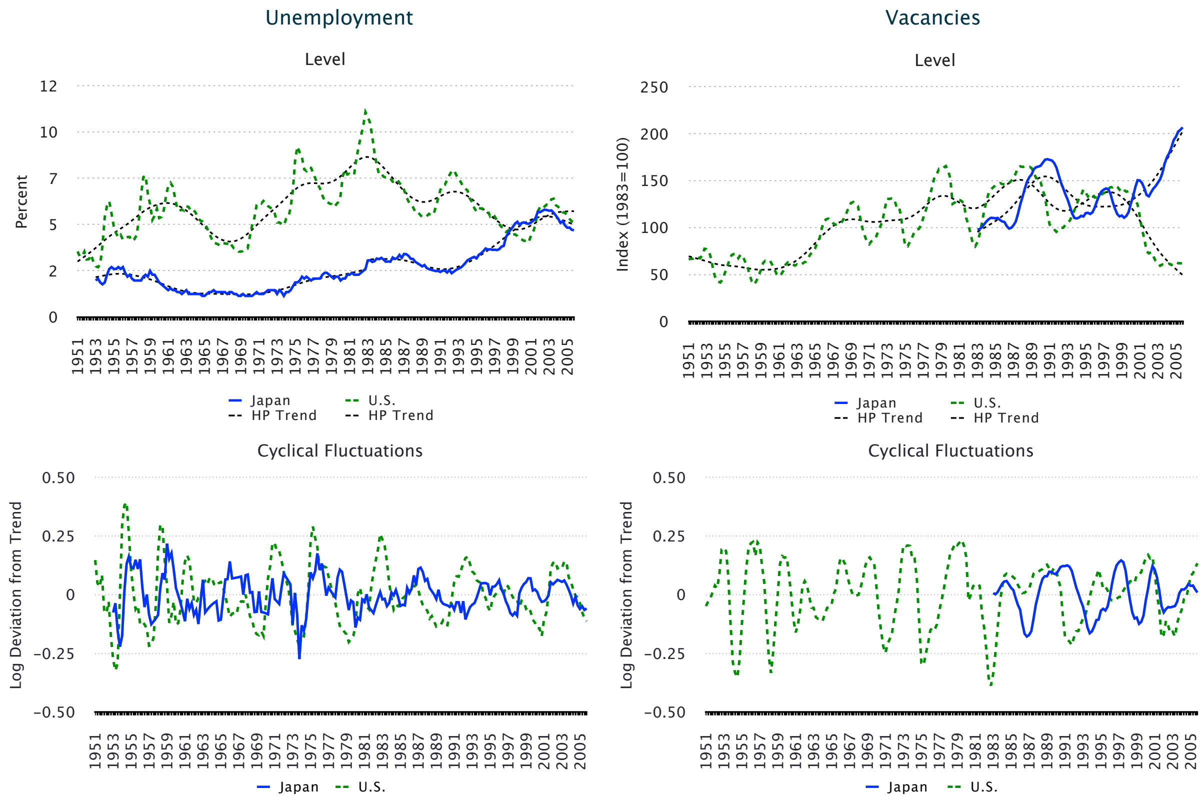

Figure 2: Relation between Unemployment and Vacancies

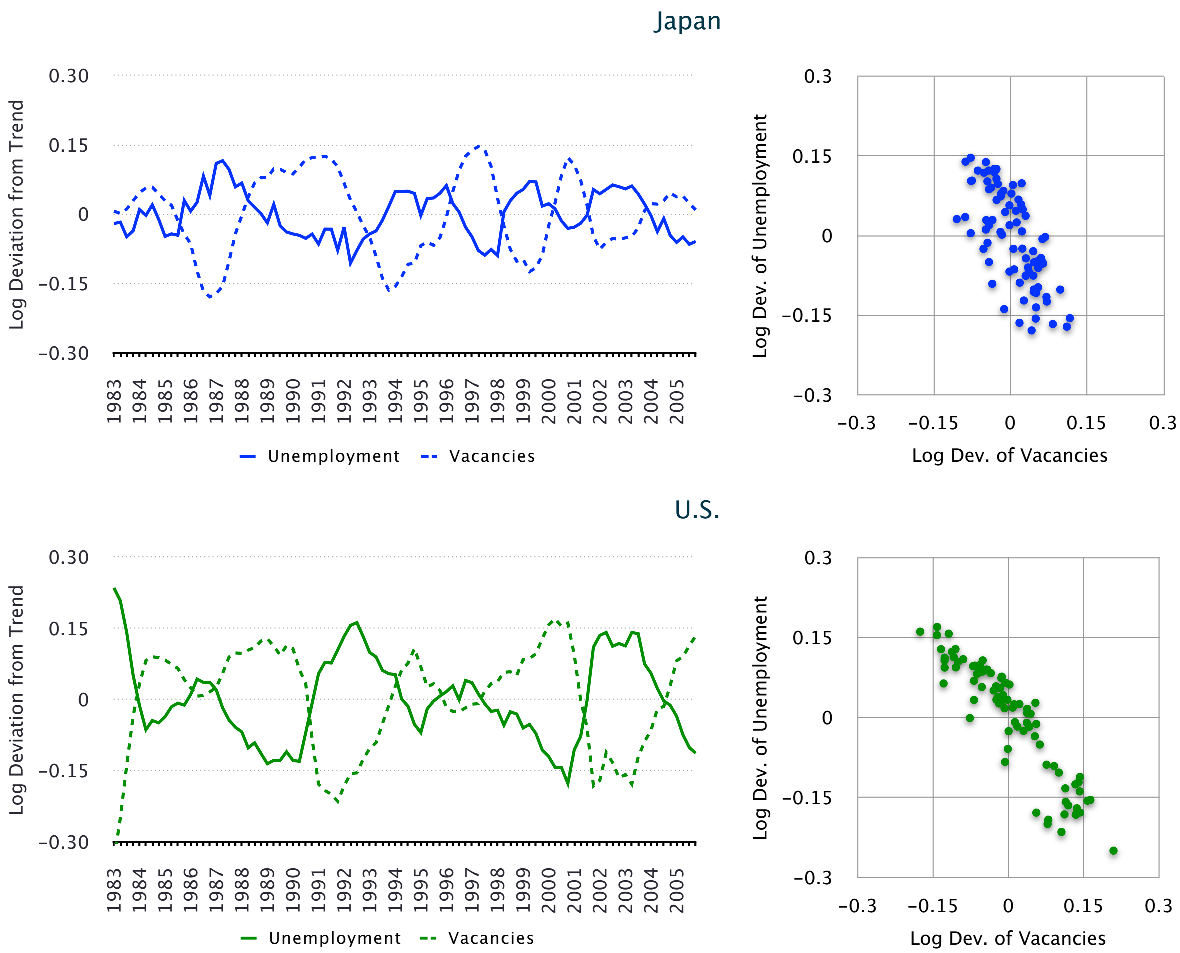

Figure 3: Monthly Job Finding and Separation Rates

Figure 4: Productivity

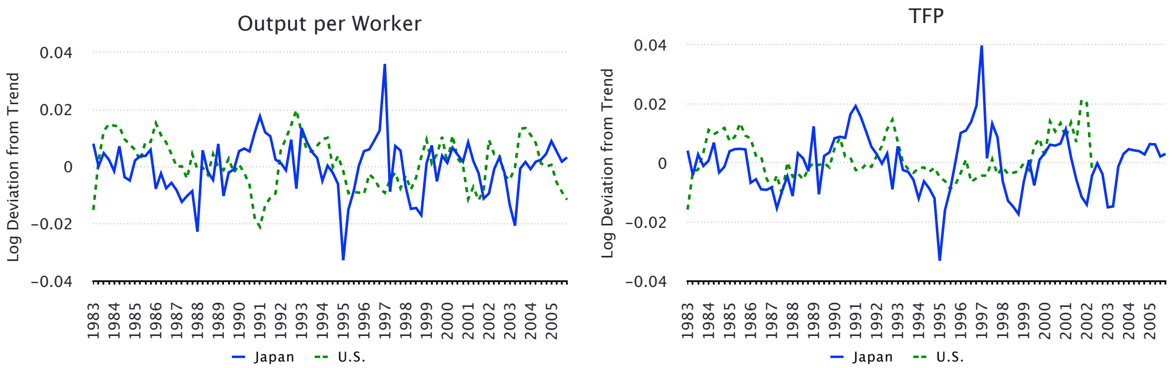

Figure 5: Model Simulation Impulse Response Functions to a 1 percent Positive Productivity Shock