Japan's Labor Market Cyclicality and the Volatility Puzzle*

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Abstract

The search and matching model has come under recent criticism for its inability to account for some of the cyclical properties of the Labor Market in the US. Shimer (2005) shows that the basic version of the model is not capable of reproducing the volatility of the market tightness for reasonable movements of productivity. This paper studies if 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 them to their U.S. counterparts. We then build, parametrize and simulate three different versions of the search and matching model (exogenous job destruction, 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 not able to generate as much volatility on the market tightness as in the data.

Keywords: Unemployment, Japanese Labor Market, Shimer Puzzle

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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 to study cyclical issues. It is on the latter use that the model has come under criticism in recent years.

Shimer (2005) shows that the search and matching model is not able 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". This puzzle states that the basic search and matching model is not able to generate, using empirically plausible movements in productivity, as much volatility in the ratio of unemployment to vacancies as is observed in the data. This paper has started a recent strand of the literature that studies under which conditions the puzzle holds, and what type of features can be added to the model.

This paper studies whether this volatility puzzle, which was originally found for the U.S., holds also for the Japanese economy. We first provide empirical evidence on the cyclical properties of the Japanese labor market in the last two decades. We then build a search and matching model, which 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 the three versions of the model to assess whether the "Shimer Puzzle" holds for Japan.

From the empirical point of view we show that the Japanese and U.S. labor markets show some important differences in terms of the levels of the variables. Unemployment was, up to the 1990s, much lower in Japan than the U.S., but at the same time so where the job finding and separation rates. These variables also seem to be more stable for Japan than the U.S. when looking at the evolution over time of their levels. However, these differences in levels do not translate in substantial differences when analyzing the cyclical properties of these variables. We find that the volatility of unemployment, vacancies, job finding and separation, and productivity are not very different between the two countries. Maybe 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 so that it not only includes exogenous and time-invariant job separation rate (as in Shimer, 2005), but also possible endogenou destruction.

The model we build nests three basic, but important versions of the search and matching model. The first 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 in the lines of the first one, but it 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-ran empirical evidence of the Japanese economy, which is assumed to correspond to the steady state of the model. We then simulate the model and compare the it to the data.

We find that that the "Shimer Puzzle" does 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 not able to produce enough volatility in neither unemployment nor vacancies, which in the Japanese calibration of the model is due, as Shimer (2005) points for the U.S., to the fact that wages are too responsive to productivity movements.[1] In Model 2 and 3, the inclusion of endogenous job separation makes unemployment and vancancies more volatile, but it generates a counter-factual positive correlation between unemployment and vacancies, which in turns 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 ability to adjust the separation margin, and the incentive to post vacancies is positively correlated with the number of unemployed workers,[2] the effect of the movement in unemployment (and hence in the probabilty 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, that includes capital and hours of work and the unemployment rate is more sensitive to productivity movements.

The original papers of Shimer (2005) created a large and growing literature assessing under which conditions the volatility puzzle holds. There are papers that try to study what 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 brings back 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 arragements that may bring back the model to the data. There are other papers that question whether the "Shimer Puzzle" holds at all for the U.S. economy. Fujita and Ramey (2009) is a primary example of this strand of the literature. Finally, there are papers that study whether the "Shimer Puzzle" holds for other countries. Our paper falls in this category. For instances, sapers 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, there is a recent paper, Miyamoto (2009) which studies a very similar question to ours.[3] Our paper differs from his in the following points: first, we construct the Japanese unemploment 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 thourughly 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 organize as follows: Section 2 provides the empirical evidence for Japan

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

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

[3] Both papers were developed simultaneously and without the knowledge of each other's.

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. counterpart. We first explain how the sources for the U.S. data as well as how we construct the data for Japan. We then proceed to analyze it.

2.1 Data Construction

For the U.S., the data on unemployment and output per worker[4] is from the Bureau of Labor Statistics. The data on vacancies in the Help Wanted Advertising Index series 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), where we have undone the continous-time transformation explained in equation (2), page 418, in order to obtain discrete time rates, which are consitent 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 on the Labor Force Survey (LFS) of the Japanese Statistics Bureau and Statistics Center. The data on vacancies is from the Job Placement Survey (JPS) of the Ministry of Health, Labour and Welfare. The data 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 out of the survey for the next twelve months, and then in again for another two consecutive months. From this survey structure, the LFS is comparable to the Consumer Population Survey (CPS) in the United States. Like CPS, the LFS provides the information on labor market flows. With the survey structure, 50 percent of the sample in each month is in their second month of the survey. Hence, it is possible to observe the transition among the three status of employment: employed (E), unemployed (U), or not-in-labor-force (I) by matching the information with the employment status in the previous month.[5] With three employment status, 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. That is, individual records are matched over two

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[4] The series used is output per person in nonfarm business.

[5] The LFS is conducted in the last week of each month. The definition of unemployed in the LFS is given by those who has no job and did not work at all during the reference week, who is ready to work if work is available, and who is engaged in any job-seeking activity or was preparing to start business during the same week. This definition of unemployment is consistent with the definition by the International Labour Organization.

consecutive months using information of unique household identifiers,[6] individual line numbers, sex 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 between-three-states flows are obtained for the following nice categories : EE, EU, EI, UU, UI, UE, II, IE and IU. 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 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

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

Since the focus of our papers is on worker flows between employment and unemployment, we restrict our attention to p_t^{UE} and p_t^{EU} , which in what follows we refer to as job finding and separation rates.

Finally, the time series of unemployment (and other stock variables) based on the flow data is not exactly same as one calculated with stock data, because the former is calculated with subset of the samples used for the latter. To construct a flow data consistent with the one based on the stock data, we adjust the flow data based on the correction method by Ministry of Labor (1985). The method used by many authors such as Ohta and Teruyama (2003a) and Sakura (2005), and similar to the one used by Fujita and Ramey (2009) in the U.S.

All data, both for Japan and the U.S., has been seasonally adjusted using the X-12 method of the Census Bureau, 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 in a global context, we compare these variables, both in 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

In terms of levels, we can see in the top-left panel of Figure 1 that the unemployment rate has been historically lower in Japan than in the U.S. until the end of the 1990s. In the post-war period,[7] Japan's

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[6] We construct the unique household identifier by employing the information of the sample area code, interviewed period and household's characteristics.

[7] 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 Communicaiton at http://www.stat.go.jp/english/data/roudou/index.htm

unemployment rate was seemingly more stable than that of the U.S., with levels between 1 and 2.5 percent until the start of the 1990s, when it started to increase and reached a maximum of 5.4 percent in 2002. The U.S. unemployment rate has fluctuated between 2 and 11 percent.

If we look at the worker flows underlying the previously explained low levels of the Japanese unemployment rate compared to the U.S., we find that workers in Japan transition much less often between employment and unemployment. Figure 3 shows that both the 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 flows rates in Japan are a well known fact that was sustained for many years by the traditional employment practices of life-time employment at a firm. With the Lost Decade such life-time employment warranties have ceased to be so widespread, which partially explains the rise in the level of the job separation rate.

Cyclicality

While the previously explained level differences of the labor market variables between Japan and U.S. had been well documented in the literature, less well known are their cyclical properties. When we calculate the log-deviations from trend of the variables of interest, we observe that these big level differences are not so large 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. Therefore, all the analysis that follows is performed for that sample period.

The unemployment rate, which had seen larger 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, and it shows that while Japan's unemployment seem to move less, the difference is much smaller that what one could expect looking at the level movements. Table 1 shows that in fact that 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 respectively. Finally, unemployment in Japan is more counter-cyclical than its U.S. value, both with respect to output per worker and TFP.[8]

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

The job finding and separation rates are also not very different in terms of their cyclical variability

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[8] 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 in recent years, which is not seen when using TFP as the measure of productivity, may be what has come to be known as job-less recoveries that the U.S. has experienced in recent decades.

between the two countries, with a slightly higher volatility in Japan. The standard deviation of the 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 however differ in terms of the auto-correlation and cross-correlation with productivity of the finding rate, although not so much for the separation rate. The autocorrelation of Japan's is almost zero, and it is more pro-cyclical than that of the U.S. The separation rate has also a very small first-order autocorrelation for Japan, and it is more counter-cyclical. The U.S. has a more auto-correlated finding and separation rates, but these two rates are almost acyclical. Therefore, while Shimer (2005) defends the use of a model with exogenous destruction by refering to the acylicality of the separation rate in the data, for the U.S. this rate is clearly counter-cyclical and more volatile. That is the reason why we study in this paper versions of the model with endogenous job destruction besides the exogenous destruction version.

One important variables in the labor market, and that affects the chances of workers and firms to 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 of them separated, with standard deviation of 0.13 for Japan and 0.18 for the U.S. Underlying this behavior of the market tightness lies the negative correlation between unemployment and vacancies, which is known as the Beveridge Curve, and that can be observed for both countries in Figure 2. We can clearly see that both variables move in opposite directions over time, and have a negative cross-correlation of 0.69 and 0.91 for Japan and the U.S. respectively.

What has come to be commonly known as the "Shimer-puzzle", which is stated both in Shimer (2005) and Hall (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. We can see in the last two columns of Table 1 that productivity has almost identical variability in both countries, with standard deviation of 0.01 for both output per worker and TFP.

In summary, looking at the levels of the variables in the labor market we find substantial differences between Japan and the U.S.. However, the differences in terms of the cyclicality of these variables does not seem so large, even if it still the case that unemployment and the market tightness is slightly less volatile for Japan than for the U.S., except for the cyclicality and auto-correlation of the finding and separation rates. Hence, it is reasonable to ask if the "Shimer-puzzle" holds for the Japanese economy. In other words, is a model calibrated to match the long-run levels of the labor market variables in Japan able to reproduce its cyclical properties, in particular the volatility of the market tightness? or, as in the case of the U.S., does it fail to generate enough volatility? We start to 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 want 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, and Section 4 explains how to parametrize the presented model so that it collapses into either of the three models.

The first model, Model 1, is a discrete-time version of the simple text-book search and matching model with exogenous job destruction used in Shimer (2005).[9] Given that for the Japanese economy the separation rate is not as acyclical as Shimer claims for the U.S., we then analyze a second version of the model, Model 2, where the separation rate is allowed to vary over the cycle. This second model is a discrete-time version of the text-book model with endogenous destruction. Finally, since the goal of the paper is to study if 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, namely the Real Business Cycle model, but where the labor market is modeled with search frictions (with the features of Model 2) to generate equilibrium unemployment and worker flows.

In what follows, we present the general version of the model which nests Model 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 there exist search frictions, and workers and firms try match and form employment relationships. Firms produce using capital, labor and available technology, and matches are destroyed endogenously as an optimal decision by the firm and worker, or exogenously when hit by a negative shock.

Employment relationships are 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 further define 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 exogenous reasons to the match with probability λ. We model endogenous destruction by assuming that productive firms need to pay, on top of the 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 $G : [x_{min}, x_{max}] \rightarrow [0, 1]$. 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 relationship. The value of x_t which 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

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

respectively output, capital and hours per worker. Hence, y_t and k_t are related to aggregate output and capital according to the following equations:[10]

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

The timing of the model is as follows. At the beginning of every 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 firm's profits are distributed to the household, which decides how much to consume and how much to save. Finally, the exogenous destruction shock takes place, which dissolves some of matches.

3.2 Agent's Problems

Problem of the Household

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

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

subject to

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

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; $H_t\left(h_t\right)$ is the disutility suffered by each working member of the family, where h_t are the individual hours worked; K_t is the total capital in the economy, which is own by the household; W_t is the total wages paid to the workers of the household; Π_t is the total profits of the firms; r_t is the rental rate of capital and δ is its depreciation rate; and 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.

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

Problem of the Firm

Let us analyze now the problem of the firm. Denote by V_t and $J_t\left(x_t\right)$, 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

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

the firm. A vacant firm matches with a worker with probability $q_t = \dfrac{m(\theta_t)}{\theta_t}$. If the firm is matched, and the idiosyncratic cost is low enough, the following period the firm obtains the value of being filled, otherwise it remains as a vacancy. Hence the value of a vacancy is

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

where $\beta_t = \beta \frac{u'(C_{t+1})}{u'(C_t)}$ is the discount stochastic discount factor, which is what 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 free entry of firms, which implies that the value of posting a vacancy is zero. We can now write the equation (5) as:

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

The value for the filled firm is

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

The interpretation of the previous equation is as follows. During the current period, given the firm's idiosyncratic cost, x_t, it produces output and pays wages, the rental cost of capital and such intermediate inputs, x_t. The following period, if the match does not get 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 it becomes a vacancy, which has value 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 is rebated to the workers as

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

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

Problem of the Worker

Consider now the side of the worker. Denote by U_t and $N_t(x_t)$, 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 it matches with a firm, which happens with probability $p_t = m(\theta_t)$, and the idiosyncratic cost for the firm is below the threshold, $\bar{x}_{t+1}$, he becomes a productive worker 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 value of a match for a worker is a function of the idiosyncratic shock x_t. The value of employment for a worker is composed by 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.

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

3.3 Surplus, Wages, Hours and the Destruction Threshold

When an employment relationship takes place it creates a surplus which 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. Since 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.

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

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

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

Surplus

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

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

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 expressions for the wage is:

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

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

Hours

As in the case of wages, hours are chosen to maximise the previous 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 to 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 explained earlier, and all the decisions of the different 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 for a worker to transition from unemployment to employment, what is 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 Parametrization

We now proceed to explain the method used to parametrize the model, and how to collapse the previously presented model into Model 1, 2 and 3.

We choose functional forms which are standard in the literature and then calibrate the parameters of the model to match the empirical evidence for Japan 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 in consumption is assumed to be linear, $u(C_t) = C_t$, for Model 1 and 2, and logarithmic, $u(C_t) = log(C_t)$, in Model 3. The disutility from work takes the following form, $a_n \frac{1}{\zeta} L_t^{\zeta}$, where for Model 1 and 2, we set $a_n = \zeta = 0$. For Model 3 we set $\zeta = 10$ following Trigari (2006), and we calibrate a_n so 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 of the firms is assumed to have a standard Cobb-Douglas form, $f(k_t, h_t) = k_t^{\alpha} h_t^{\chi}$. For Model 1 and 2 we set $\alpha = \chi = 0$. For model 3, we follow Braun, Esteban-Pretel, Okada, and Sudou (2006) and set $\alpha = 0.38$ and $\chi = 0.62$. We also follow the previous paper and set the depreciation rate of capital, δ, to 0 in Models 1 and 2, and to 0.0094 for Model 3.

In the labor market, we assume that the bargaining power of the worker, η, is 0.5, as has become standard 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 what is standard in these types of models and set the elasticity of matching with respect to unemployment, ξ, to 0.5, 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 of study. For the models with endogenous destruction, Models 2 and 3, the idiosyncratic cost to the firm is drawn from an exponential distribution, $x \sim \dfrac{1}{\varphi} e^{-\frac{x}{\varphi}}$, which only requires to calibrate one parameter, the mean of the distribution, φ. Hence, $x_{min} = 0$ and $x_{max} = \infty$. For Model 1, which only has exogenous destruction, we assume that $x_{min} = x_{max} = 0$, so that the idiosyncratic costs is 0 at all times and produces no 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, 0.034 and 0.13 respectively, and a market tightness of unity.[11] 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; and $\varphi = 0.65$, and $\varphi = 1.76$ in Model 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, or what is the same in standard search and matching models, the marginal product of one worker. We follow Shimer (2005) and set this fraction to 0.4 in all three versions of the models. The implied values of b are 0.4 in Model 1, 0.15 in Model 2, and 0.24 in Model 3.

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[11] As explained in Shimer (2005), changing the value of the market tightness only rescales the value of μ, leaving everything else unchanged.

Finally, productivity is assumed to follow and autoregressive process of order 1, $A_t = A^{(1-\rho)} A_{t-1}^{\rho} e^{\epsilon_t}$, where $\epsilon_t \sim N\left(0, \sigma_\epsilon^2\right)$. We set $\rho = 0.755$ and $\sigma_\epsilon = 0.0085$ in Model 1 and 2, so that the model matches the first order autocorrelation and standard deviation in the data for 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 , and $\rho = 0.9$ and $\sigma_\epsilon = 0.0063$.

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

5 Simulation Results

We now proceed to explain how the simulations of the previous model, in its three different versions, compare to the data. These results are shown in Table 3, along with the empirical moments for easy comparison.[12]

The second line of each panel of Table 3 shows the simulation results for Model 1, which is the simple exogenous destruction version of the model. We see that the model falls short to account for the volatility of all the variables, explaining less than 5% of the variability of the data for most variables. In particular, the model generates around 2% percent of the volatility of unemployment (0.0013 std. dev. in the model, versus 0.049 in the data), and slightly more for vacancies (0.0054 std. dev. 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 does not have as much variability in the model.

As is the case for the U.S., the simple exogenous destruction search and matching model is not able to match the empirical volatility of the market tightness for Japan. The reasons for the failure are the same as those noted by Shimer (2005). The assumption of Nash bargaining for wage determination makes the wages too sensitive to movements in productivity. Wages in the model absorve too large a fraction of potentical increase in profits due to the increse 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 market tightness in the model compared to the data. As shown by Hagedorn and Manovskii (2008), one way to reconcile this simple model with the data 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 show it in the table, for the Japanese calibration of the model, increasing the value of b in the model to 95 percent of the steady state productivity level also brings the model very close to the data.[13]

Hence, despite the differences in the data between Japan and the U.S. highlighted in Section 2, the simple exogenous version of the model fails to reproduce the data for Japan, as is the case for the U.S.

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[12] 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 packagae, version 3.065.

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

However, Model 1 assumes a constant and exogenous job destruction. As we showed in Section 2 this does not correspond to what the data shows for Japan, where the separation rate is clearly counter-cyclical. For this reason, we now move to show the simulation results when we allow for variable and endogenous changes in the 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 the two margins (hiring and firing) are at work in the model. In good time more workers are hired and less workers are separated, with the reverse occurring in 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 be best understood by looking at the impulse response functions of these two variables to a positive technology shock. We can see if Figure 5 how after a positive technology shock, the expectation of future profits makes firms post most vacancies and reduce firing (lower job separation rate), both of which reduce unemployment. The drop in unemployment is larger than the one observed in Model 1, since now the separation margin is also operating. Shortly after the initial shock, the drop in unemployment, which produces a reduction in the probability for a given firm to meet a worker, lowers the incentive to post vacancies and brings this variable below the steady state level. After that, as unemployment increases to go back to the steady state level, so do vacancies. Hence, we can see through the impulse response functions that the larger drop in unemployment due to the time-varying endogenous separation in the model, which is what 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 too much 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 the firm have higher incentives to retain workers, which produces a larger drop in the separation rate and in unemployment. However, the drop in unemployment is so large that there is no incentive for firms to post vacancies, since there is too much 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 does not display almost any variability.

Therefore, it seems that despite the differences between the Japanese and U.S. labor market, the volatility puzzle which was stated for the U.S. economy does hold also for Japan. As mentioned earlier, there are fixes proposed in the literature when talking about the puzzle for the U.S. that are still applicable for Japan, such as increasing the flow value of unemployment. For the particular case of Japan, Miyamoto (2009) studies if introducing training costs in the simple exogenous separation version of the model helps to reconcile theory and data. He finds that while training costs do increase the variability of the model, they are not enough to close the gap between the model and the empirical evidence.

6 Conclusions

In recent years the standard way to model equilibrium unemployment has been under criticism due to its inability to reproduce some important cyclical facts in the data. Shimer (2005) and Hall (2005) show that the simple search and matching model is not capable of reproducing the U.S. empirical volatility of the market tightness for reasonable movements in productivity. Other authors have studied if this so-called "Shimer Puzzle" also holds for other economies. This paper studies if it does for the Japanese economy.

There are known differences between the labor markets of Japan and the U.S. This paper starts by documenting the differences and similarities between these two economies in terms of the unemployment rates, the worker flows probabilities and productivity. We look at the differences in levels, as well in the cyclical properties of the main labor market variables. We find that the differences between the two labor market variables in both economies are more notable in their levels than in deviations from the steady state, although the cyclical properties of these variables are different enough to ask if the "Shimer Puzzle" would also hold for Japan.

We build, parametrize and simulate three different versions of the search and matching model to study the validity of the puzzle for Japan. One with exogenous job destruction, another one with endogenous job destruction, and a final 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 in the data. The model fails either because it does not produce enough volatility in unemployment and vacancies, or because it generates a counter-factual upward-sloping Beveridge curve.

The literature has studied ways of reconciling the the model with the data for the U.S. Some of the proposed fixes, such as the one in Hagedorn and Manovskii (2008) also work for Japan. However, future work should explore more Japan-specific features of the model that could help bring the model 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

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)*

Figure 1: Unemployment and Vacancies

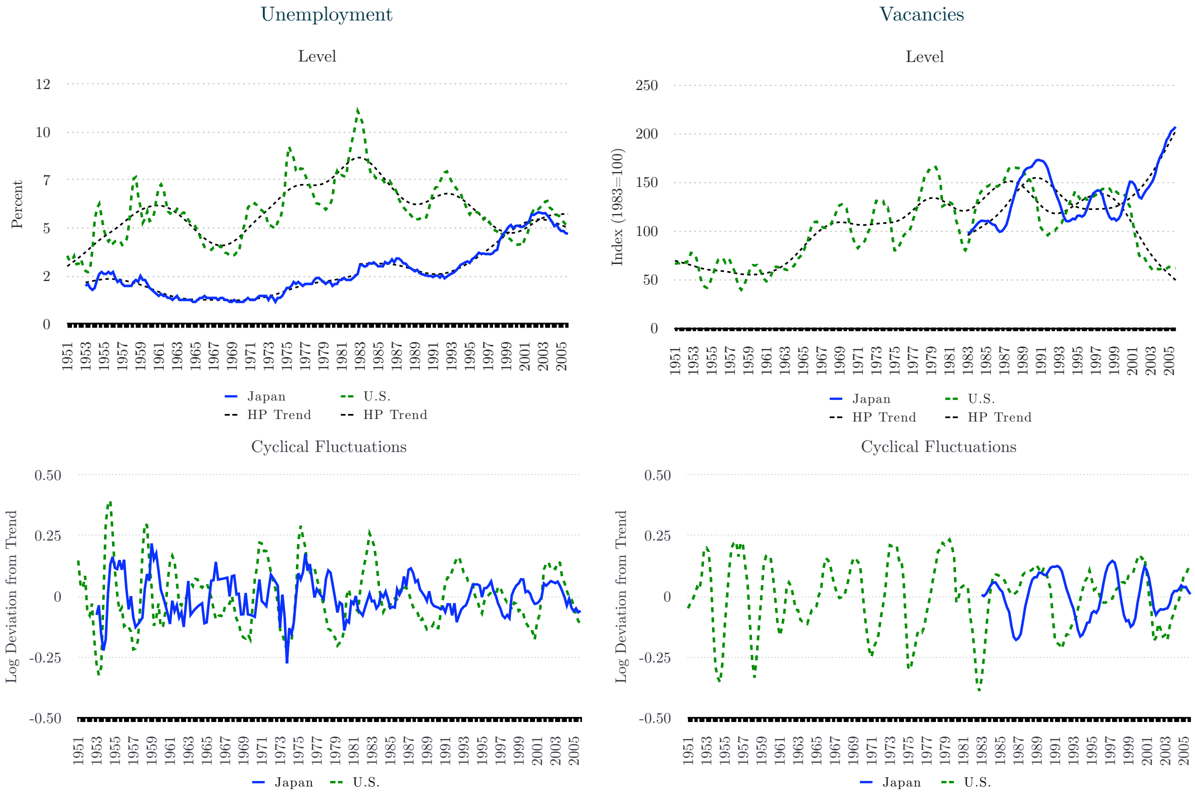

Figure 2: Relation between Unemployment and Vacancies

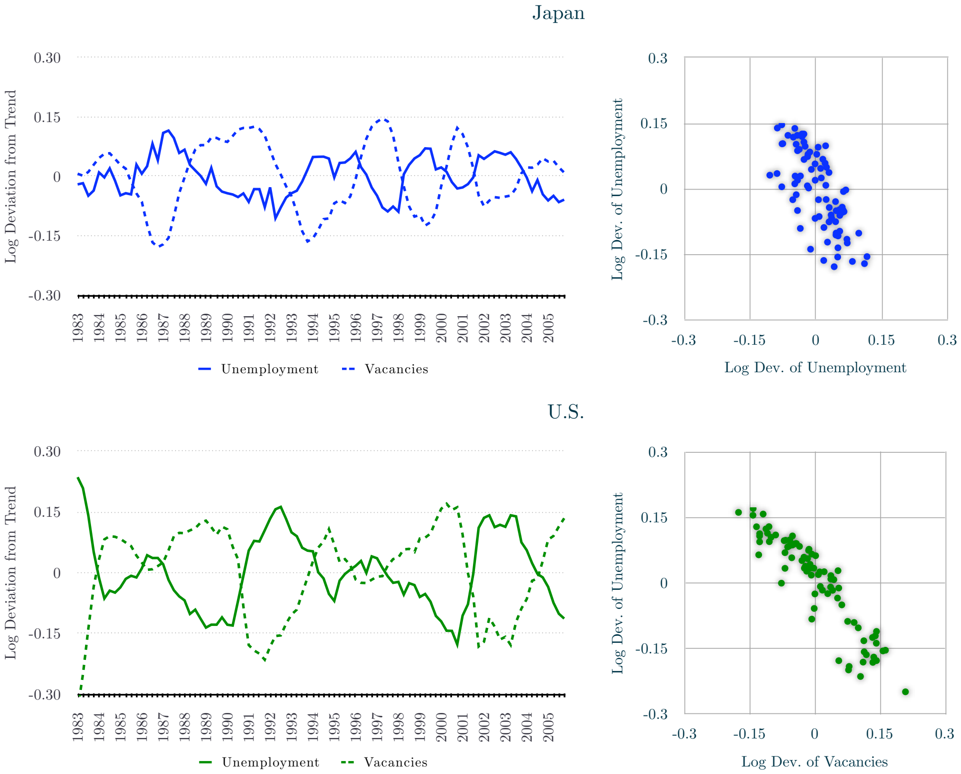

Figure 3: Job Finding and Separation Rates

Job Finding Rate

Job Separation Rate

Level

Cyclical Fluctuations

Figure 4: Productivity

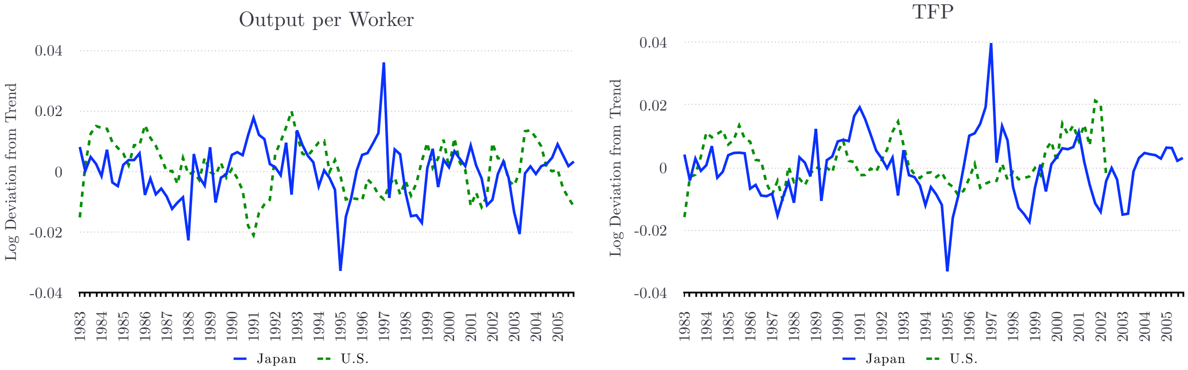

Figure 5: Model Simulation Impulse Response Functions to a 1 percent Positive Productivity Shock