

# Emerging Market Business Cycles: The Role of Labor Market Frictions\*

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## Abstract

Labor markets in emerging economies are characterized by large fluctuations in wages and subdued fluctuations in employment. A real business cycle model of a small open economy that embeds a Mortensen-Pissarides type of search-matching frictions can account for these regularities. Moreover, search-matching frictions help amplify the countercyclical interest rate shocks leading to a greater response of consumption and current account to those shocks. This inherent propagation mechanism goes a long way in accounting for higher consumption variability relative to output and countercyclical current account that characterize emerging market business cycles.

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# 1 Introduction

Recent evidence emphasizes the role of labor markets in understanding macroeconomic dynamics specific to emerging market economies (EMEs) including recovery from financial crises and output fluctuations.<sup>1</sup> Despite the rapid development of emerging market business cycle models over the past decade—which, in general, aim to explain large swings in consumption relative to output and countercyclical current account dynamics prevalent in EMEs—we have limited understanding about the labor market dynamics in these countries and their role in business cycle fluctuations.<sup>2</sup> To our knowledge, this paper makes the first attempt to fill this gap.

First, we begin by systematically documenting the business cycle properties of key labor market variables (i.e., real earnings, unemployment, hours worked) for EMEs and comparing them to those of developed economies. Our empirical analysis reveals a striking feature of the labor markets in EMEs: the fluctuations in prices are large while those in quantities are subdued compared to developed economies. In particular, real wages, on average, are almost twice as variable as output and have a positive correlation with contemporaneous output (0.22). Conversely, the variability of employment is about half the variability of output. These regularities stand in contrast with the developed economies where variability of wages is lower than that of output, and wages in developed economies are less procyclical than those in emerging economies. Further, the variability of employment in developed economies is close to that of output.<sup>3</sup> These findings suggest that there may be a crucial interaction between the labor market and other observed business cycle characteristics of EMEs.

Our second objective is to illustrate this interaction in an augmented workhorse Small Open Economy Real Business Cycle (SOE-RBC) model, where labor market conditions and employer-employee relationships are explicitly modeled and wage is determined by Nash bargaining. Examining this interaction requires moving away from the frictionless spot labor market, where wage is simply pinned down by the labor productivity. To do so, we incorporate labor search-matching frictions à la Mortensen and Pissarides (1994) (MP) and Pissarides (2001) into an otherwise standard SOE-RBC model. Differently from the previous models of EMEs, our setting allows the workers'

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<sup>1</sup>See Bergoing, Kehoe, Kehoe and Soto (2002), Kehoe and Ruhl (2009).

<sup>2</sup>Perhaps one exception is Neumeyer and Perri (2005) which do not focus on labor markets *per se* but document labor market statistics such as the variability and cyclicalities of employment and total hours worked.

<sup>3</sup>These empirical findings have important implications on welfare and monetary policy. For example, high wage volatility suggests that workers bear more risks than firms, and monetary policy may not have a large aggregate impact if prices are relatively flexible. These issues are interesting for future research, but, are not the focus of this paper.

outside option—which depends on labor market tightness, external wealth and interest rates—to influence wage determination. Changes in the expected returns to searching induce equilibrium responses in labor market conditions, the effects of which are propagated over time through changes in the stock of unemployment. These changes directly impact household’s precautionary saving motives and hence other macroeconomic variables such as output, consumption and the current account.

More specifically, consider an emerging economy that is hit by a negative aggregate Total Factor Productivity (TFP) shock and assume that only noncontingent international bonds exist. Typically, EMEs also face an increase in interest rates on external debt due to the rising default risk premium (Neumeyer and Perri, 2005) when a negative TFP shock hits.<sup>4</sup> The higher interest rates make it optimal to postpone consumption and increase savings, partly offsetting the negative effect of lower TFP on saving. In other words, countercyclical interest rate shocks help curb the standard consumption smoothing result in the business cycles literature that cause savings to decrease in bad times. This is important because EME data suggest a countercyclical current account, i.e., higher savings in bad times. From a quantitative perspective, findings of the earlier literature (Neumeyer and Perri, 2005, Uribe and Yue, 2006 and Oviedo, 2005) imply that countercyclical interest rates alone are not sufficient for the model to generate a countercyclical current account and a highly variable consumption.<sup>5</sup>

In the search-matching framework, the rising interest rates also reduce the discounted future return on recruiting, leading to a decline in employer recruiting efforts and higher subsequent unemployment rates. In the presence of uncertainty and labor market frictions—which imply that unemployed workers have to take time and necessarily experience an unemployment spell to find a job—it becomes optimal for workers to further decrease consumption and accumulate a larger buffer of precautionary savings to smooth future income fluctuations. Moreover, because it takes time for output to recover when the economy is hit by negative shocks, the permanent income falls more than in the case without search frictions. As a result of the combined effects of lower permanent income and strong precautionary saving incentive, consumption drops and the current account increases significantly. Further, the slackened labor market and a substantial fall in consumption

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<sup>4</sup>This is in sharp contrast with the developed economies’ experiences where interest rates tend to be acyclical. The detailed discussions on interest rate shocks in emerging economies are in Neumeyer and Perri (2005), Uribe and Yue (2006).

<sup>5</sup>This literature typically resort to working capital constraints to amplify the effect of countercyclical interest rate shocks. But, as discussed later, data do not support the existence of working capital constraints in the orders of magnitude in those papers.

make non-market activity less attractive and lower workers' outside option in the Nash bargaining, leading to a large wage cut.

We quantify the degree of endogenous propagation induced by search-matching frictions relative to a canonical SOE-RBC model by simulating model economies facing both TFP and interest rate shocks, which are estimated using Mexican data.<sup>6</sup> Spot labor markets in the canonical SOE-RBC imply that wages are perfectly correlated with output as they are equal to the marginal product of labor in equilibrium. When we feed the same shock processes, the canonical SOE-RBC model generates a relatively low level of wage variability and perfect correlation with output that are at odds with the data. In contrast, wage in the search-matching model is determined not only by the current labor productivity, but also the value of being unemployed, enjoying leisure in the current period and searching in the following period. The value of the outside option not being perfectly correlated with output leads to a lower and a more realistic correlation of wage with output.

The canonical SOE-RBC with interest rate shocks requires working capital constraints to account for the high volatility of consumption and the negative correlation between current account and output (Oviedo, 2005). Our model delivers these observations—in addition to the labor market regularities documented here—in a different setting and through a different channel without resorting to working capital constraints. This is an important step forward, because as Mendoza and Yue (2010) point out, working capital loans, estimated using the observed bank credit to the private sector as a share of output, are rather small in EMEs. In our model, negative TFP shocks coupled with positive interest rate shocks have a lasting effect on the economy via search-matching frictions as the stock of employment does not adjust instantaneously and searching and matching are costly. This gives rise to a higher degree of savings as the uncertainty spreads out into the future, causing large drops in consumption and wages.<sup>7</sup>

Lastly, in an illustrative exercise, we show how incorporating matching efficiency shocks further brings the model closer to data. Our motivation to explore the effects of matching efficiency shocks is based on the labor market observations during Sudden Stop episodes.<sup>8</sup> During Sudden Stops, real exchange rate depreciations generate large reallocations across sectors (e.g., from nontradable

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<sup>6</sup>Using Mexican wage and employment data, Garcia-Cicco (2009) explores the extent in which a real business cycle model can explain the data. He concludes that the model's main weakness is with regards to wage and employment fluctuations despite the inclusion of various exogenous shocks.

<sup>7</sup>Our results do not undermine the importance of financial frictions, terms of trade shocks or trend shocks highlighted by earlier studies. On the contrary, our findings complement these studies by proposing an additional amplification/transmission mechanism through which external shocks can feed into variability in consumption and real wages.

<sup>8</sup>"Sudden Stop", a term coined by Calvo (1998), refers to sudden reversals in capital inflows that are typically accompanied by sharp declines in output, asset prices and the price of nontradable goods relative to tradables.

goods sectors to tradable goods sectors (Kehoe and Ruhl, 2009) and from investment goods sector to consumption goods sector (Benjamin and Meza, 2007)). The different nature and skill requirement of jobs across sectors might make matching more difficult during these periods of massive sectoral reallocations. This difficulty can be captured by a reduction in the technical efficiency of the matching function at the aggregate level. By extending our baseline search-matching model to incorporate these fluctuations, we show that these matching efficiency shocks can help bring the wage variability predicted by the model further closer to data and account for the high variability of unemployment observed in the data.

We argue that labor market frictions such as the cost of search and matching, congestion and trading externalities are especially important for EMEs. For example, high transportation costs might lead to a regional mismatch. And low penetration of internet and communication technology might create inefficient communication and information sharing between workers and employers. Further, the underdeveloped legal system might induce uncertainty and cause difficulties in contract enforcement. We do not compare the severity of search-matching frictions between the two country groups in the data or in our model. This is mainly because these frictions are difficult to identify in the data and are hard to summarize with one parameter in a model environment.<sup>9</sup>

This paper connects two strands of literature—the emerging market business cycles literature and the search-matching literature. In the emerging market business cycles literature, Mendoza (1991, 1995) and Correia, Neves and Rebelo (1995) among others provide the early contributions. More recently, Neumeyer and Perri (2005) and Uribe and Yue (2006) study the role of countercyclical interest rate shocks in EMEs that are amplified through the working capital constraints. Aguiar and Gopinath (2007) examines the role of trend growth shocks and argue that these shocks can explain the high variability of consumption relative to output and the countercyclical current account.<sup>10</sup> These papers, however, are largely silent about labor market dynamics and our paper complements these studies by proposing an additional mechanism through which external shocks can feed into the variability in consumption and real wages and affect current account fluctuations. As for analyzing labor markets, Li (2009) presents the first contribution on this front by document-

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<sup>9</sup>In the data, the closest variables that might relate to these frictions could be the time it takes to fill a vacancy, unemployment duration or estimates for labor adjustment costs. The evidence on these series suggests mixed results. As for our model, there are several parameters that are related to these frictions and increasing the severity using some of the parameters generates more emerging market-like business cycles, while we find the opposite results with other parameters. See Section 4.5.

<sup>10</sup>In more recent work, Garcia-Cicco, Pancrazzi and Uribe (forthcoming) find that trend growth shocks are not important if one uses longer time series data. Boz, Daude and Durdu (2008) emphasize that severe informational frictions in EMEs can explain the stylized facts without resorting to large trend growth shocks.

ing the cyclical wage movements in EMEs. Unlike our setup, Li (2009) considers a hybrid utility function that allows for flexible parameterization of the income effects on labor supply in a spot labor market model to account for the higher variability and procyclicality of wages. In addition, in Li’s framework, interest rate shocks work through a working capital requirement, affecting labor demand directly.

In the closed-economy macroeconomics literature, the MP search-matching model has been widely used to study various employment related issues. Andolfatto (1996) and Merz (1995) were among the first to integrate the search environment into a closed-economy business cycle model with risk-averse agents and document its improved performance in explaining U.S. business cycles. When we introduce search-matching frictions into a small open economy—which is subject to TFP and countercyclical interest rate shocks—an additional propagation mechanism arises because of the interaction between the labor market conditions and consumption/saving decisions. Our model is closely related to the aforementioned closed-economy models and, essentially, is a first-generation MP-type model, in which wage is determined by Nash bargaining and is applied to both existing workers and new hires.<sup>11</sup> Considering alternative wage setting could possibly lead to interesting implications. However, our model is an important first step that deviates from the standard SOE-RBC models. In fact, our framework can be extended to include heterogeneous agents, endogenous job separation, alternative bargaining concepts to study policy related questions for EMEs such as labor regulation, unemployment insurance, the role of institutions, etc.

The rest of the paper is organized as follows. Section 2 documents the business cycle properties of labor market variables both for emerging economies and developed economies, as well as empirical evidence motivating the matching efficiency shock. Section 3 lays out our model. Section 4 explains our calibration, solution, and main quantitative findings. Section 5 extends the model to analyze matching efficiency shocks. Finally, Section 6 concludes.

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<sup>11</sup>Among the recent contributions in the search literature is Hall (2005) who considers an alternative wage setting where sticky or even constant wages can be sustained in the equilibrium. Hall and Milgrom (2008) introduce an alternating offer bargaining model which leads to weaker feedback from current unemployment to wage. Both models can generate greater variation in the employer surplus, vacancy postings and employment than the Nash bargaining model. However, given the objective of this paper and volatile wage observations in EMEs, we choose to use the simple flexible wage bargain setup.

## 2 Empirical Evidence on Emerging Economy Labor Markets

In this section, we document the business cycle properties of key labor market variables, in particular, real earnings, the unemployment rate, and employment level for a group of EMEs.<sup>12</sup> In summary, we find that the variability of prices, i.e., real earnings, is strikingly high in EMEs and this kind of variability is absent in quantity variables such as employment, unemployment and hours worked.

Table 1 reports the statistics related to hourly real earnings. The median standard deviation of real earnings, calculated by deflating the nominal earnings by the CPI, is significantly greater than the standard deviation of real output, with the ratio between the two being 2.42. The real earnings are procyclical as evidenced by a correlation of 0.22 with contemporaneous output. To check the robustness of these findings, we also report real earnings variability relative to manufacturing output variability, the nominal earning variability and the real earnings variability calculated by using the PPI deflator. Manufacturing output is more variable than GDP for all countries; therefore, the median real earning variability relative to manufacturing output variability falls to 1.70 from 2.42.<sup>13</sup> The nominal wages behave similarly to real wages in the sense that they are highly variable. Finally, when using the PPI to calculate real earnings instead of the CPI, we find similar results.

The first three columns of Table 2 report the statistics regarding the unemployment rate while the remaining three report those for employment.<sup>14</sup> The correlations of these two variables with output deliver consistent results: the median correlation of unemployment with output is  $-0.46$  while that for employment is 0.39. Unemployment appears to have higher variability than employment but note that we are reporting percentage deviations. Since we consider the unemployment rate (as opposed to unemployment), this variable is already normalized by the labor force leading to higher percentage deviations from the mean. The median standard deviation of the unemployment rate is 9.64 while that for employment is 0.58 relative to the standard deviation of output.<sup>15</sup>

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<sup>12</sup>We use data at quarterly frequency and our sample selection criterion for EMEs is availability of quarterly data. For example, we excluded Argentina from our sample because the data are available only at semi-annual frequency. U.S. is excluded since we focus only on small open economies. All series are deseasonalized using U.S. Census Bureau's X-12 ARIMA, and then HP-filtered with a smoothing parameter of 1600 after taking the logarithm when appropriate. See the Data Appendix for more details on sources and calculations.

<sup>13</sup>Note that the difference between the two country groups remains.

<sup>14</sup>We analyze employment data in addition to the unemployment rate because unemployment statistics suffer from several deficiencies including the inaccurate measurement of discouraged workers.

<sup>15</sup>We report a set of statistics for hours worked in manufacturing sector in columns 1-3 of Table 3 and approximate aggregate hours worked in columns 4-6 of the same table. Hours worked in manufacturing normalized by the standard deviation of output has a variability of 1.58. Similarly, aggregate hours worked variability approximated in the aforementioned fashion when normalized by output variability is 1.24. Also in terms of correlations with output, these two statistics yield similar results, 0.57 and 0.47.

A broad comparison between EMEs and developed economies can be made based on the results reported in the aforementioned tables. The high variability of real earnings emerges as an EME-specific result; this variability for developed economies is lower than real output for the CPI-based definition of real earnings. As for the other definitions, the developed economies also display much lower variability and less procyclicality in their real earnings compared to EMEs. All of the statistics related to earnings reported in Table 1 are statistically significantly different for EMEs than developed economies (at 5 percent confidence level) as evidenced by small  $p$ -values reported at the bottom of this table in parentheses. The variabilities of unemployment rate and employment normalized by output variability are somewhat higher in developed countries compared to EMEs as suggested by Table 2. These two variables also are more procyclical in developed economies. Compared to the differences between EMEs and developed countries established for earnings, the differences with regards to unemployment and employment are less significant from a statistical perspective except the standard deviation of employment relative to the standard deviation of output. Hours worked in manufacturing and aggregate hours worked appear to be somewhat more procyclical in developed economies compared to EMEs.

To our knowledge, the only study that provides statistics on labor markets in the emerging market business cycles literature so far is Neumeyer and Perri (2005). Our findings on employment and hours are roughly in line with theirs; they also find that employment and hours are less variable and less correlated with output in EMEs.<sup>16</sup> In this paper, we conduct a more comprehensive analysis than Neumeyer and Perri (2005) by reporting real earnings and unemployment rate statistics. In addition, we expand the set of EMEs used in the calculation of employment, unemployment rate, and earnings statistics and we also expand the set of developed countries that is used as a comparison group. Expanding the EME set for hours worked is difficult because the relevant data are available for only a few countries. Nevertheless, we report the comparison of available statistics of working hours in the Appendix.

Some research has suggested that the relatively lower variability in EMEs' employment statistics could be due to a relatively high portion of employees working in the public sector, given the less variable public sector employment. In particular, Kydland and Zarazaga (2002) argue that public sector employment in Argentina often serves as unemployment insurance. Although Argentina is not included in our sample, this might still be an issue for other EMEs we consider. Therefore,

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<sup>16</sup>Our statistics are not fully comparable with those reported by Neumeyer and Perri (2005) because they report labor market statistics using semi-annualized data to make all other countries comparable with Argentina. Our statistics are based on quarterly data.

we investigate if there are EMEs that have data on the decomposition of public and private employment. For Turkey, this decomposition is available during 2000-2006 at quarterly frequency.<sup>17</sup> We compare the variabilities of the public and private sector employment and find that, contrary to the previous finding mentioned above, public sector employment is in fact more variable (3.12 vs. 1.77 percent). It is difficult to argue that the public sector employment does not function as unemployment insurance in these countries based on seven years of data only for one country, but the limited data do not confirm the initial expectation of the public sector being less variable.

Finally, it is worth noting that an important difference between these two country groups is the size of the informal sector and therefore the size of the working population that is not included in most of our data. In fact, OECD (2008) reports that the informal sectors in Hungary, Korea, Mexico and Turkey are quite substantial with the number of employees in informal jobs reaching or exceeding 20 percent of total non-farm employment in all four countries.<sup>18</sup> These ratios appear to be larger than those for the developed small open economies.<sup>19</sup>

We argue that the informal sector being larger in EMEs is not detrimental to our empirical analysis. First, part of our data for quantities of EMEs (employment, unemployment rate) are constructed based on household surveys implying that those data would capture the informal sector. Second, although our data on earnings are based on establishment surveys and therefore do not include the informal sector, we conjecture that the difference between these two country groups regarding wages would be even larger if our data were able to capture the informal sector. OECD (2008) documents the earnings distribution of full-time, non-farm employees for the formal and informal sectors for Mexico and Turkey. Based on their estimates of these distributions, we find that earnings in the informal sector are more variable than those in the formal sector. Specifically, the standard deviation of earnings in the formal sector is 0.89 (0.54) while that in the informal sector is 1.13 (0.90) in Mexico (Turkey). Hence, if the informal sector were to be included in our analysis of the earnings, we would have found an even stronger contrast between EMEs and developed economies.

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<sup>17</sup>The data source is TURKSTAT.

<sup>18</sup>This is based on the informal employees defined as those not registered for mandatory social security.

<sup>19</sup>Although not exactly comparable with these ratios, OECD (2004) documents that the “black hours worked as a portion of white working hours” for Denmark, Norway, and Sweden are 3.8 percent, 2.6 percent and 2.3 percent, respectively, significantly smaller than the aforementioned figures for EMEs.

### 3 A Small Open Economy Model with Search-Matching Frictions

Our framework nests a labor market search-matching friction into an otherwise standard SOE-RBC model. There is an infinitely-lived representative household, which consists of employed workers and unemployed workers at each point in time, and also a continuum of identical competitive firms. Job matches result from a Cobb-Douglas matching technology given by  $M(u_t, v_t) = \omega u_t^\alpha v_t^{1-\alpha}$ , where  $\omega$  governs the matching or allocative efficiency,  $u_t$  and  $v_t$  stand for the unemployment rate and the vacancies posted by the firms in period  $t$ , respectively. The vacancy to unemployment ratio,  $\theta_t = \frac{v_t}{u_t}$ , captures the market tightness. There is a flow cost,  $\kappa$ , associated with posting a vacancy, as firms often have to put out job advertisement and undertake screening and reviewing processes. The probability that a searching worker finds a job is  $\phi(\theta_t) = \frac{M(u_t, v_t)}{u_t} = \omega \theta_t^{1-\alpha}$ . Correspondingly, the probability that an employer succeeds in filling a vacancy is given by  $\frac{M(u_t, v_t)}{v_t} = \frac{\phi(\theta_t)}{\theta_t}$ . Existing employer-worker pairs end at an exogenous break-up rate  $\psi$ .

To keep the analysis simple and allow minimum deviation from the standard SOE-RBC model, we consider a large extended family scenario. That is, even though some family members are employed, and others are searching for a job, they all pool the income together for equal consumption.<sup>20</sup> Under this assumption, the household's optimization problem can be represented by a social planner's problem. That is, the wage determination is repressed and the social planner maximizes welfare using one-period, non-state contingent international bonds that facilitate the borrowing and lending in the international financial markets. Following the emerging market business cycle literature, we assume that the interest rate on the international bond holdings is exogenous and subject to shocks. Financial markets for hedging against aggregate TFP and interest rate shocks are incomplete. We discuss later in this section how the wage is determined by the Nash bargaining between workers and firms. The full-fledged decentralized economy is described and characterized in the Appendix.

For each period  $t$ , the aggregate state is captured by endogenous state variables (bond holdings,  $b_t$ , and unemployment rate,  $u_t$ ), as well as the vector of exogenous state variables,  $\varepsilon_t = [\varepsilon_t^z, \varepsilon_t^r]$ .  $\varepsilon_t^z$  denotes TFP shocks and  $\varepsilon_t^r$  denotes interest rate shocks. The set  $\{b_t, u_t, \varepsilon_t\}$  summarizes the state space of the economy at each point in time.

The representative agent derives utility from consumption and leisure through a time-separable constant relative risk aversion (CRRA) utility function.  $U(c_t) = c_t^{1-\sigma}/(1-\sigma)$  denotes the utility

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<sup>20</sup>Another interpretation is that markets for the idiosyncratic unemployment risk are complete so that family members can fully diversify this risk using state-contingent claims.

derived from consumption, and  $H(1 - l_t) = (1 - l_t)^{1-\nu}/(1 - \nu)$  denotes the utility derived from leisure,  $1 - l_t$ .  $\sigma$  denotes the CRRA coefficient, and  $1/\nu$  governs the (Frisch) elasticity of labor supply. The per-period utility function, thereby, is  $U(c_t) + \varphi^i H(1 - l_t)$ ,  $i = E, U$  for employed and unemployed workers respectively, which implies that the value of leisure depends on the employment status.

Population is normalized to one and production is carried out using a Cobb-Douglas production technology,  $y_t = F[k, (1 - u_t)l_t, z_t] = z_t k^\zeta [(1 - u_t)l_t]^{1-\zeta}$ , where  $\zeta$  represents the capital share of production.  $z_t$  denotes the total factor productivity (TFP) and  $z_t = (1 + \varepsilon_t^z)z$ . To keep our focus on the dynamics of the extensive margin of labor supply, we first follow Hansen (1985) and assume that labor is indivisible,  $l_t = l$ .<sup>21</sup> Once offered a job, workers always supply a fixed amount of labor. In an extension of the model, we endogenize working hours to allow for better comparison with the standard SOE-RBC model.<sup>22</sup>

In line with some of the earlier small open economy models by Mendoza and Smith (2006), Durdu and Mendoza (2006), and Durdu et al. (2009), we assume that the capital stock is time-invariant with zero depreciation. We resort to this strategy mainly to make a global solution possible by containing the size of the state space. Intuitively, in doing so, we restrict the role of interest rate shocks to mainly intertemporal substitution of consumption and savings. Since our main motivation is to explore how the behavior of international borrowing feeds into consumption and wage dynamics, this simplification is not detrimental to our analysis. The so-called ‘‘Fisher separation,’’ which is present in this class of models, induces consumption and borrowing decisions to be largely independent of investment and capital accumulation. To the extent that the output fluctuations due to investment fluctuations can be captured by larger TFP shocks in an environment without investment, we conjecture that shutting down of investment would not distort consumption and debt dynamics.

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<sup>21</sup>In the Mexican data, 81 percent of the variance in manufacturing total hours is accounted for by changes in employment rather than hours per worker.

<sup>22</sup>Similar to the previous case where working hours are fixed, workers and employers only bargain over wage. Optimal working hours are pinned down by the efficiency condition of labor supply.

**Social Planner's Problem.** The social planner chooses a state-contingent plan of consumption, bond holdings, unemployment, and vacancies to solve the following optimization problem:

$$\begin{aligned}
V(b_t, u_t, \varepsilon_t) = & \max_{c_t, b_{t+1}, u_{t+1}, v_t} U(c_t) + (1 - u_t)\varphi^E H(1 - l_t) + u_t\varphi^U H(1) \\
& + \beta(c_t)\mathbb{E}_t V(b_{t+1}, u_{t+1}, \varepsilon_{t+1}) \\
\text{s.t. } & c_t + b_{t+1} + \kappa v_t \leq F(k, (1 - u_t)l_t, z_t) + b_t(1 + r_t), \\
& u_{t+1} \geq [u_t - M(u_t, v_t)] + (1 - u_t)\psi, \\
& b_{t+1} \geq \bar{B}.
\end{aligned} \tag{1}$$

where  $\beta(c_t)$  denotes the endogenous discount factor, which we introduce to induce stationarity to bond holdings.<sup>23</sup> Using Epstein's (1983) stationary cardinal utility formulation, this function boils down to  $\beta(c_t) = (1 + c_t)^{-\gamma}$ , where  $\gamma$  is the elasticity of the rate of time preference.<sup>24</sup> The optimal choices of  $c_t, b_{t+1}, u_{t+1}$  and  $v_t$  are as follows:

$$U'(c_t) - \mu_t = \beta(c_t)\mathbb{E}_t U'(c_{t+1})(1 + r_t), \tag{2}$$

$$U'(c_t)\kappa = \beta(c_t)M_{v,t}\mathbb{E}_t \left[ -\frac{\partial V(b_{t+1}, u_{t+1}, \varepsilon_{t+1})}{\partial u_{t+1}} \right], \tag{3}$$

where  $\mu_t$  denotes the multiplier associated with the borrowing constraint and  $M_{v,t} = (1 - \alpha)\phi(\theta_t)/\theta_t$ . The first equation governs the intertemporal substitution of consumption. The second equation equates the marginal cost of posting an additional vacancy to the marginal benefit, i.e., the discounted future value created by the marginal job match, as a vacancy can only be turned into a job with a one-period lag.

By the Envelope condition, the surplus  $S_t$  that results from the marginal job match is:

$$S_t = -\frac{\partial V(b_t, u_t, \varepsilon_t)}{\partial u_t} = \varphi^E H(1 - l_t) - \varphi^U H(1) + U'(c_t)F_{l,t}l_t + (1 - \psi - M_{u,t})\beta(c_t)\mathbb{E}_t S_{t+1}, \tag{4}$$

where  $M_{u,t} = \alpha\phi(\theta_t)$ . The first two terms of the right hand side capture the net loss in the utility of leisure to the newly employed worker compared to being unemployed. The third term stands for the contribution to output that results from one more worker measured in marginal utility terms, and the last term measures the continuation value of future employment.

<sup>23</sup>See Schmitt-Grohe and Uribe (2003) for detailed discussions on other methods that also induce stationarity in small open economy models.

<sup>24</sup>Mendoza (1991) introduced preferences with endogenous discounting to small open economy models. Other formulations used for this purpose can be found at Schmitt-Grohe and Uribe (2003).

**Wage Determination.** In the social planner's problem, wage is absent and the social planner determines and implements the Pareto optimal allocations. In this section, we describe a simple, period-by-period Nash bargaining process, which determines the sequence of wage rates  $\{w_t\}$ . A more detailed description of the decentralized economy can be found in the Appendix. For workers, suppose that the value associated with being employed is given by  $E_t$ , and the value of being unemployed and actively searching for a new job is  $U_t$ . For employers, let  $J_t$  denote the value of a filled position after making the wage payment. Free-entry indicates that, given the probability of successfully filling a position,  $\phi(\theta_t)/\theta_t$ , employers' anticipated payoff from a match is completely offset by the recruiting cost:

$$\kappa = \phi(\theta_t)/\theta_t \mathbb{E}_t \rho_{t,t+1} J_{t+1}. \quad (5)$$

$\rho$  is the stochastic discount factor of the household and is defined as  $\rho_{t,t+1} = \beta(c_t)U'(c_{t+1})/U'(c_t)$ . The transition equation for  $J_t$  is

$$J_t = \pi_t + (1 - \psi) \mathbb{E}_t \rho_{t,t+1} J_{t+1} \quad (6)$$

where the flow profit of an active job is  $\pi_t = F_l(\frac{k_t}{n_t}, l_t; z_t)l_t - w_t l_t$ . Equations (6) and (5) together imply

$$J_t = F_{l,t} l_t - w_t l_t + (1 - \psi) \frac{\kappa \theta_t}{\phi(\theta_t)}. \quad (7)$$

Assuming that employed workers' bargaining power is  $\xi \in (0, 1)$ , the matched worker-firm pair negotiates over wage by solving the following Nash bargaining problem:

$$\max_{w_t} (E_t - U_t)^\xi J_t^{1-\xi},$$

subject to the joint surplus given by  $J_t U'(c_t) + E_t - U_t = S_t$ . The optimal allocation is for the firms and the household to divide the total matching surplus according to the Nash bargaining power of each party. Therefore,

$$J_t = (1 - \xi) \frac{S_t}{U'(c_t)}. \quad (8)$$

Combining Equation (4) with Equation (8), we have

$$J_t = \frac{(1 - \xi)}{U'(c_t)} [\varphi^E H(1 - l_t) - \varphi^U H(1) + U'(c_t) F_{l,t} l_t] + (1 - \psi - \alpha \phi(\theta_t)) \frac{\kappa \theta_t}{\phi(\theta_t)}. \quad (9)$$

Based on the above Equation (7) and Equation (9) and imposing Hosios' (1990) efficiency condition,

which requires that the bargaining power of firms must correspond to the elasticity of the matching technology with respect to recruiting effort,  $\alpha = \xi$ , we have

$$w_t = \xi \left( F_{l,t} + \frac{\kappa \theta_t}{l_t} \right) + (1 - \xi) \frac{\varphi^U H(1) - \varphi^E H(1 - l_t)}{l_t U'(c_t)}. \quad (10)$$

Equation (10) suggests that the wage is determined not only by the marginal product of labor  $F_{l,t}$ , but also the value of staying unemployed and searching in the next period. In other words, the wage is a convex combination of the maximum value to a firm that succeeds in activating a job and the minimum value necessary for the household to send an unemployed worker to a new employment relationship. The second term in the first bracket of Equation (10) can be further rewritten as:

$$\xi \frac{\kappa \theta_t}{l_t} = (1 - \xi) \frac{\phi(\theta_t) \beta(c_t)}{l_t} \mathbb{E}_t \frac{(E_{t+1} - U_{t+1})}{U'(c_{t+1})}, \quad (11)$$

which captures the value of forward-looking aspect of reentering the job market and possibly getting employed in the next period. The last term in Equation (10) is the value of leisure associated with being unemployed in units of marginal consumption. As consumption plunges, the marginal utility of leisure in consumption terms becomes less valuable, and workers are more willing to accept a lower wage to compensate the same amount of hours worked. These two terms together constitute the value of being unemployed, enjoying more leisure, and searching again next period.

## 4 Quantitative Analysis

### 4.1 Calibration

**Parameters.** We calibrate our model to quarterly Mexican data. Given the scarcity of data on labor markets for many of the EMEs including Mexico, we utilize information from other emerging market countries when needed, and also take some of the standard parameter values directly from the existing literature. The implied parameter values are listed in Table 4. The average international interest rate is set to 1.74 percent, the average of Emerging Market Bond Index (EMBI) yields for Mexico over the sample period.<sup>25</sup> The risk aversion parameter  $\sigma$  is 2 as commonly used in the literature. We calibrate the consumption-gross output ratio to be  $c^*/y^* = 0.69$  for Mexico. Since our model does not have investment or government expenditures, we subtract a fixed amount of  $1 - 0.69$  from the budget constraint to capture the share of investment and government expenditures

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<sup>25</sup>EMBI yields for Mexico cover 1993Q4:2008Q4.

in output. According to the OECD Annual Hours and Productivity data, an average worker in Mexico spent 32 percent of their non-sleeping time on market activities. Therefore, the working hours  $l$  is set to 0.32. For the case with endogenous labor hours, the intertemporal (Frisch) elasticity of labor supply is set to 1.6, which is commonly used in SOE-RBC models (Mendoza, 1991; Aguiar and Gopinath, 2007). Given our utility function and steady state working hours, this would imply  $\nu = 1.42$ .

We set the natural breakup rate,  $\psi$ , to 0.06, based on the range of estimates provided in Bosch and Maloney (2008) for Mexico. Using the unemployment rate data for Mexico for the period 1988 – 2006, we set the steady-state unemployment rate to 8.21 percent so that the mean unemployment rate in the stochastic steady state matches the average unemployment rate in the data.<sup>26</sup> Combining this information with the natural breakup rate implies a steady state value of 0.055 for matches formed,  $m^* = (1 - u^*)\psi$ . Due to a lack of evidence on the probability that a vacant position becomes an active job by the end of the quarter, we assume job finding rate,  $\frac{\phi(\theta)}{\theta} = 0.7$ —corresponding to an average vacancy duration of 45 days—slightly lower than Andolfatto (1996).

In our baseline experiment, the recruiting expenditure to GDP ratio,  $\kappa v^*$ , is assumed to be as small as 0.01, which is in line with Andolfatto (1994). The unit cost of posting a vacancy becomes  $\kappa = 0.01/v^* = 0.127$ . We set the capital share parameter  $\zeta$  to 0.36 following the SOE-RBC literature. To be more precise, in a search economy, the labor’s share of output is given by  $(1 - \zeta) - [1 - (1 - \sigma)\beta(c_t)]\kappa v^*/(\beta(c_t)\sigma)$ . Our parameters imply this expression to be 0.63, very similar to the standard value in the literature and also to  $(1 - \zeta)$ .

The elasticity of the matching rate with respect to aggregate unemployment rate,  $\alpha$ , needs to be the same as the bargaining power  $\xi$ , in order for the wages implied by Nash bargaining to support the allocations obtained from the social planner’s problem. We follow Andolfatto (1994) and set  $\alpha$  to 0.5. Given the values for  $v^*$ ,  $m^*$ ,  $u^*$ , and  $\alpha$ , we can calculate the matching efficiency parameter,  $\omega$ , using the steady state condition  $\omega = \frac{m^*}{u^*\alpha v^*(1-\alpha)} = 0.687$ . The remaining parameters  $\varphi^E$  and  $\varphi^U$  are jointly determined by the efficiency condition of labor hours and the optimality condition for unemployment.

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<sup>26</sup>In the data from International Financial Statistics, the unemployment rate for Mexico is 3.65 percent. Notice that due to precautionary savings incentives, the unemployment rate in the stochastic steady state is lower than that in the deterministic steady state.

**Shock processes.** In the benchmark case, we consider TFP shocks and interest rate shocks as in Neumeyer and Perri (2005) and Uribe and Yue (2006). We estimate a joint VAR process using the TFP and international interest rate for Mexico, in particular, Solow residuals and EMBI yields.<sup>27</sup> We construct interest rate series by deflating the dollar denominated EMBI yields by adaptive U.S. inflation.<sup>28</sup> We then feed in the corresponding transition probability matrix and shock realizations using Tauchen and Hussey’s (1991) quadrature procedure to our model. EMEs typically face relatively variable and countercyclical real interest rates mainly due to the default risk that is negatively correlated with output (see Neumeyer and Perri, 2005, Uribe and Yue, 2006). In our calibration, interest rate and TFP shocks are significantly negatively correlated with a correlation of  $-0.8$ .

The VAR representation of the shock processes and their estimates are summarized below:

$$\varepsilon_t = RHO \cdot \varepsilon_{t-1} + e_t, \tag{12}$$

where

$$\varepsilon_t \equiv \begin{bmatrix} \varepsilon^z \\ \varepsilon^r \end{bmatrix}, \quad RHO = \begin{bmatrix} \rho_z & \rho_{z,r} \\ \rho_{r,z} & \rho_r \end{bmatrix}, \quad e_t \equiv \begin{bmatrix} e_t^z \\ e_t^r \end{bmatrix}.$$

$$RHO = \begin{bmatrix} 0.61 & -0.17 \\ 0.19 & 0.69 \end{bmatrix}, \quad covar(e_t e_t') = \begin{bmatrix} 0.0004 & -0.00048 \\ -0.00048 & 0.0009 \end{bmatrix}.$$

## 4.2 Solution: Nonlinear Methods

We solve for the recursive competitive equilibrium using value function iterations. This solution method preserves the nonlinear dynamics of the model which is important to capture precautionary saving. A nonlinear solution method, however, forces us to keep our model relatively stylized due to curse of dimensionality.

As a first step in our solution algorithm, we solve for the social planner’s problem (Equation (1)) discretizing the bond grid in  $[-1.0, 4.0]$  interval with 200 equidistant nodes and the unemployment grid in  $[0.02, 0.07]$  interval with 20 equidistant nodes. Our solution is robust to the number of

<sup>27</sup>See the appendix for TFP calculation for further details.

<sup>28</sup>As pointed out by Neumeyer and Perri (2005), large swings in local inflation sometime make it difficult to interpret and construct sensible real interest rates using local currency nominal interest rates. Moreover, EMEs typically borrow a significant amount from the external market and the emerging market bonds—which reflect the intertemporal terms of trade faced by locals—are denominated in dollars, and can be used to construct real interest rates without using domestic expected inflation.

nodes used in each grid. Once we derive the decision rules, we use the decentralized equilibrium conditions to evaluate the wage function.

Figure 1 shows the limiting distributions of bond holdings and unemployment in the baseline model with search-matching frictions. As these graphs illustrate, the solution delivers ergodicity in both of these dimensions.

### 4.3 The Model Dynamics

Impulse responses of main aggregate variables to exogenous shocks help develop intuition about key mechanism of our model. Figures 2 and 3 plot the impulse responses to a *negative* one-standard-deviation TFP shock (dashed line), a *positive* one-standard-deviation interest rate shock (dash-dotted line) and a case that incorporates both of these shocks at the same time (solid line) in our baseline search-matching model. In order to add no other impetus to responses, individual shocks scenarios feature zero correlation in the innovations to TFP shocks and interest rate shocks:  $\text{corr}(e_t^z, e_t^r) = 0$ . The scenario with both of the shocks, however, features  $\text{corr}(e_t^z, e_t^r) < 0$ , as estimated in our baseline calibration.

In response to the negative TFP shock, on impact, firms reduce vacancies created, leading to fewer matches—as the current unemployment rate is predetermined in the previous period—and consequently causing a higher unemployment rate in the following period.<sup>29</sup> With slackened labor market and less attractive outside option of non-market activities, equilibrium wage drops. Output falls on impact due to lower productivity. In order to smooth consumption, households borrow from the international capital markets and accumulate debt. Due to markets for aggregate shocks being incomplete the borrowing from abroad cannot entirely offset the decline in output hence, consumption decreases and the economy runs a current account deficit. Similar to the standard SOE-RBC models—where interest rates are acyclical or constant (see Mendoza, 1991)—TFP shocks alone cannot account for volatile consumption relative to output and strongly countercyclical current account.

Interest rate shocks affect the optimal bond holdings and the current account to GDP ratio differently from TFP shocks, which motivates the use of these shocks as a vehicle to account for EME regularities. In particular, in response to a positive interest rate shock, households increase savings, causing an increase in current account to output ratio. This is because higher interest rates

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<sup>29</sup>The noise-like fluctuations in unemployment and vacancy rates at the top panel of Figure 3 are due to the discretization of unemployment with relatively low number of nodes while solving the model.

imply that current consumption is more expensive relative to future consumption (Equation (2)) and make it optimal for consumers to postpone consumption and increase saving. As a result, the current account is in surplus. To benefit from the high interest rate by saving more, the household cuts on consumption to the magnitude of 6 percent on impact. The decline in output as a result of the interest rate shock is minuscule because TFP does not change and unemployment increases only marginally.

Figure 3 shows that equilibrium responses of labor market variables to the positive interest rate shock are qualitatively similar to the corresponding responses to the negative TFP shock. Higher interest rate depresses the discounted future return to recruiting (Equations (2) and (6)). The immediate effect is a decline in recruiting efforts, a lower job-finding rate, and a slacker labor market with higher unemployment. Equation (10) on wage determination suggests that although there is no direct impact on labor productivity, the higher interest rate leads to a lower wage through a deterioration in labor market conditions and a lower value of unemployment. A low level of consumption in bad times leads to an increase in the marginal utility of consumption that reduces the net gain of leaving the negotiation process and enjoying more leisure. The interest rate shock has quantitatively larger effects on labor market variables particularly on wages.

When both interest rate and TFP shocks hit the economy simultaneously, the effect of interest rate shock on savings dominates the incentives to borrow to smooth consumption in the face of a negative TFP shock. Interacting with the search frictions, the joint driving forces of interest rate and TFP shocks lead to a higher volatility of consumption relative to output and strongly countercyclical current account. Labor market frictions play an important role in driving these dynamics. First, search-matching frictions imply that workers, once laid off, have to go through a necessary spell of unemployment and the changes in the vacancies are only reflected in employment with a lag. The prospect of higher unemployment strengthens the precautionary saving motive in the search environment. Second, it takes time for output to recover when the economy is hit by a negative shock. This means that the lower life-time income is even lower due to the search frictions. The large drop in the permanent income and stronger precautionary saving incentive lead to a large fall in consumption.

To sum, our experiments show that TFP shocks play an important role in generating realistic output responses which interest rate shocks alone cannot achieve. However, the interest rate shocks are necessary to generate consumption to respond more than output and to generate current account dynamics consistent with those observed in emerging markets. Search-matching frictions in this

environment provide the necessary propagation by strengthening the precautionary savings motive and persistence since new matches take time to form and unemployment declines only gradually.

#### 4.4 Main Findings

Table 5 reports the statistics describing the cyclical behavior of the Mexican economy, the moments in the canonical SOE-RBC economy, and in our baseline search economy. All model economies are subject to correlated TFP and interest rate shocks estimated except those in columns 4-5 where we shut down one shock at a time to isolate the importance of each shock. The model with endogenous labor reported in the last column features endogenous labor choice. We introduce endogenous labor mainly to examine if the main differences between our baseline search-matching model and the canonical SOE-RBC model depends on the difference in the behavior of intensive margin. Note that our baseline search-matching model features indivisible labor whereas the canonical SOE-RBC model features endogenous labor.

The first column of Table 5 suggests that the salient features of EME business cycles are preserved in the Mexican data. In particular, consumption is more variable than income, and the current account-output ratio is strongly countercyclical. As for the labor market variables, as thoroughly discussed in Section 2, wage is procyclical and more variable than income, and unemployment is countercyclical and highly variable. Unfortunately, due to data limitations, we are not able to obtain an empirical measure for vacancies in Mexico, and thus cannot compare our model with data in this dimension.

**Canonical SOE-RBC.** We consider a canonical RBC model in which we feed in the same TFP and interest rate shock processes as in our baseline search-matching model. We study a spot labor market economy with Greenwood, Hercowitz and Huffman (1988) (GHH) preferences. With GHH preferences, we allow the canonical SOE-RBC model the “best chance” in replicating the Mexican data, because the GHH preferences appear crucial in replicating small open economy business cycles (see Correia et al. 1995).

As shown in column two of Table 5, the SOE-RBC model falls short of explaining the key emerging market regularities regarding consumption and the current account. In particular, consumption is less variable than output and current account to GDP ratio is only weakly countercyclical (correlation with output equals  $-0.13$  compared with  $-0.75$  in the data). Even in the presence of interest rate shocks, assuming a reasonable value of the intertemporal elasticity, the intertemporal

substitution effect is not sufficient to cause a response of consumption that exceeds the response of output. This is also because the SOE-RBC model we consider here does not include working capital constraints. And, as shown by Oviedo (2005), the RBC model with interest rate shocks can quantitatively explain regularities on consumption and the current account simultaneously only when the variability of interest rate shocks is high and the impact of interest rate shocks is amplified through a working capital constraint. Also note that the RBC model with GHH preferences falls short of accounting for wage dynamics. It yields wages that are significantly less variable than those in the data ( $\sigma(w)/\sigma(y)=0.31$ ) and perfectly correlated with output, as the wage is tightly connected to the marginal product of labor in a spot labor market.

**Search-Matching Model.** Our baseline model with search-matching frictions is able to replicate the cyclical behavior of the Mexican macroeconomic aggregates. It generates a consumption profile that is more variable than income, wage fluctuations that are more variable than income and strongly countercyclical current account (note that correlation of current account with output is  $-0.46$ ), all which are consistent with the observed patterns in the data. The main discrepancy between the baseline model and data is the unemployment displaying considerably less movement (standard deviation equals 3.24 in the model compared to 14.70 in the data). In the next section, we extend our model to incorporate matching efficiency shocks—which reflect the “allocative disturbances” and discuss how this extension helps us bring the model predictions closer to data with regards to employment.

The “Only Prod” column reports the results of a scenario in which only aggregate productivity shocks are prevalent. In this case, external adjustments are useful for consumption smoothing: households borrow and save to prevent large fluctuations in consumption. Thus, the model generates less variable consumption (the ratio of standard deviation of consumption to standard deviation of output equals 0.79) and strongly procyclical current account adjustments (correlation with output equals 0.97). The model with only TFP shocks also cannot account for volatile wage movements (the ratio of standard deviation of wage to standard deviation of output equals 0.83, compared to 2.22 in the data), because borrowing from international capital markets provides a cushion for consumption and the worker’s outside option does not fluctuate as much in the wage bargaining in response to TFP shocks.

The “Only interest rate shocks” column shows that interest rate shocks contribute to generating higher variability for the labor market variables as well as consumption. As also shown in Figure

2, compared to TFP shocks of the same magnitude, interest rate shocks drive large fluctuations in consumption, as it directly affects intertemporal decision of consuming and saving, but has little impact on output. As a result of negligible movements of output in response to interest rate shocks, the standard deviation of output is very small and hence we do not report the consumption standard deviation relative to output.

As for the labor market dynamics, this setup with only interest rate shocks generates countercyclical vacancies and slightly procyclical unemployment that appears at odds with the data. The positive correlation of unemployment with output seems puzzling at first sight. If there are no TFP shocks and the only source of output fluctuations is changes in employment, it seems counterintuitive to have higher output when unemployment is high. This puzzle is resolved when we consider that the correlation reported in Table 5,  $\rho(y, u) = 0.10$  is in fact  $\rho(y_t, u_{t+1})$ , that is, the correlation of the choice of unemployment at time  $t + 1$  with output at time  $t$ . In the production function however,  $y_t = F(k, (1 - u_t)l; z_t)$ . Therefore  $y_t$  would be perfectly negatively correlated with  $u_t$  but its correlation with  $u_{t+1}$  would be the negative of the autocorrelation of  $u$ . As reported in Table 5,  $\rho(u, u_{-1}) = -0.10$  while  $\rho(y, u) = 0.10$ .

To demonstrate that the different business cycle dynamics generated by the search-matching model compared to the standard RBC model comes from the endogenous transmission mechanism instead of the difference in labor supply elasticities, we extend our baseline model to include endogenous labor hours and fix the elasticity of working hours to be the same as in the standard RBC case. The results are reported in Column “Endog Labor.” In the “RBC” column in Table 5, the model generates a weakly countercyclical current account ( $-0.13$ ) and less variability of consumption relative to output implying that in the face of a negative TFP shock and a positive interest rate shock, the household increases savings, but overall, the decrease in consumption is not larger than the decline in output. With a large adjustment in the labor supply, wage variability remains low and consumption is less variable than income. In contrast, in our search-matching model with endogenous labor hours, consumption declines more in response to the same set of shocks. This comes from two effects of labor market frictions: the strengthened precautionary saving motive and lower expected life-time income due to endogenous persistence built into the responses. The large drop in consumption reflects a significant increase in saving (in the form of accumulating foreign bonds), thus the current account becomes more countercyclical in our search model ( $\rho(y, ca/y) = -0.56$ ) than the canonical RBC.

The variability of consumption generated in our search-matching model (both indivisible labor

and endogenous labor hours) leads to a larger decline in wages. Since the equilibrium wage is a convex combination of marginal product of labor and the value of remaining unemployed and searching in the next period, a low consumption in bad times leads to an increase in the marginal utility of consumption that reduces the net gain of leaving the negotiation process and enjoying more leisure. A much tighter job market during the downturn makes it harder to find a job successfully in the following periods, lowering workers' threatening point in the wage bargaining. Overall, wages are significantly more variable in the search-matching model. In addition, the fact that the value of being unemployed is not perfectly correlated with output leads to a lower procyclicality of wages in the search-matching model, which constitutes another improvement to the prototype SOE-RBC models. The model also does a good job in delivering a negative unemployment and vacancy rate correlation, consistent with the "Beveridge Curve."<sup>30</sup>

#### 4.5 Sensitivity Analysis

We now discuss our sensitivity analysis that focuses on the importance of parameters related to the search-matching frictions. The results are presented in Table 6. First, we reduce the unit cost of posting a vacancy,  $\kappa$ , from 0.127 to 0.1. As the search cost of firms is lowered, more vacancies would be posted one period after a negative TFP shock, inducing more rapid reversion of the vacancy and consequently, unemployment. Since the prospect of being unemployed and searching in the next period is not as bad as in the baseline case, the household builds less savings. Hence, consumption drops less and the current account does not increase as much. In addition, compared to the baseline scenario, workers' threatening point of wage bargaining becomes higher due to the higher possibility of finding a job in the following period and a higher value of leisure in consumption terms. Therefore, wage variability relative to that of output becomes lower.

In the second experiment, we raise the natural separation rate,  $\psi$ , from 6 percent to 8 percent. Similar to the previous sensitivity analysis, raising  $\psi$  decreases the workers' continuation value of being currently employed as the employment duration becomes shorter. For the firm, the continuation value of posting a vacancy is also reduced as an existing match may end with a higher probability. *Ceteris paribus*, the total surplus from a successful new match decreases with the higher natural breakup rate. Hence, vacancy responds less to exogenous shocks, and consequently,

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<sup>30</sup>Our search-matching model implies a negative and small autocorrelation for vacancies. Since we do not have vacancy data for any EMEs, we cannot judge whether this is an inability of the model to account for emerging economies' labor market dynamics. However, the evidence provided by Shimer (2005) (Table 1) suggests a strong positive autocorrelation (0.94) for vacancies in the case of the U.S. labor markets.

unemployment rate also becomes less responsive. Both vacancy and unemployment becomes less variable and more persistent compared to the benchmark case. Consistent with the slightly more stable labor market, the variabilities of consumption and wage decline.

Next, we examine the importance of the matching efficiency parameter,  $\omega$ , by raising it to 0.85 from 0.778. In this case, more matches are formed for the same pair of unemployment and vacancy, which implies that the search friction becomes less severe. The results indicate that both consumption and wage become less variable and the current account becomes weakly countercyclical. In an extreme case when matching is infinitely efficient, the probability of finding a job and filling a vacancy is close to one.<sup>31</sup> An unemployed worker would still experience a necessary unemployment spell but only for one period. Therefore, vacancy and unemployment both revert quickly, increasing the variability of both variables and reducing the risk of unemployment. As a consequence, the household does not need to reduce its consumption as much in response to a negative TFP shock, which, in turn, implies a lower wage reduction than in the benchmark scenario due to the increased bargaining power.

Finally, we examine the importance of the workers' Nash bargaining weight,  $\xi$ . In order for the decentralized equilibrium to be the first best, the elasticity of matching function with respect to unemployment,  $\alpha$ , also has to change accordingly with  $\xi$ . As shown in the last column of Table 5, when  $\xi$  and  $\alpha$  increase from 0.5 to 0.7, unemployment rate varies less while vacancy varies more. This is because matching is more sensitive to unemployment and less so to vacancy. Moreover, as shown in the wage determination in Equation (10), as workers' bargaining power increases, the equilibrium wage gets closer to the maximum value to a firm of a filled vacancy and moves further away from the minimum value necessary for an unemployed worker to join a new employment relationship.

As we discussed in the introduction, the evidence as to whether labor market frictions are more or less severe for EMEs compared to developed economies is mixed in the data.<sup>32</sup> In line with this mixed evidence, our sensitivity analysis delivers mixed results. When we make labor market frictions less prevalent by reducing the cost of posting a vacancy or increasing matching efficiency, the household can enjoy both more stable wage and consumption, and the current account becomes less countercyclical making the business cycle more like those in developed economies. For the case

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<sup>31</sup>In this case, the matching function would become  $M(u_t, v_t) = \min(u_t, v_t)$  and as long as  $u$  and  $v$  do not substantially deviate from each other, the probability of finding a job or filling a vacancy is close to one.

<sup>32</sup>As mentioned earlier, laws that make firing and hiring difficult contribute to the rigidity of labor markets for emerging economies. However, some evidence suggests that labor unions might be less powerful in poorer countries, which may contribute to the flexibility of labor markets in those countries.

of the higher separation rate and the higher bargaining power of the workers, it is difficult to tell whether these scenarios generate results that are closer to developed countries or to the emerging economies. Therefore, we cannot draw robust conclusions as to whether labor market frictions are more or less prevalent for EMEs. However, these sensitivity exercises show that our results are generally robust to the changes in the key search-matching parameters. Hence, MP type search frictions appear to better characterize the labor markets of EMEs than the Walrasian labor markets.

## 5 Matching efficiency shocks

In our baseline model, the allocative or matching efficiency,  $\omega$ , is a fixed parameter. In this section, we explore the quantitative implications of introducing a random disturbance  $\varepsilon_t^\omega$  to the matching efficiency. More specifically, we add shocks  $\varepsilon^\omega$  to our matching function  $M_t = \omega_t u_t^\alpha v_t^{1-\alpha}$ ,  $\omega_t = (1 + \varepsilon_t^\omega)\omega$ . For a given pair of  $u_t$  and  $v_t$ , fluctuations in  $\omega_t$  affect the number of matches formed. These matching efficiency shocks could be allowed to interact with the other fundamental shocks as in Andolfatto (1996).<sup>33</sup> We consider these shocks and their interaction with the other shocks of the economy to be particularly relevant for emerging economies, as these countries often experience structural changes and cross-sectoral reallocations during large economic fluctuations. Moreover, the labor markets tend to be more segmented across sectors in developing countries (see Agenor and Montiel (2008)). In fact, resources are often not instantaneously mobile or perfectly substitutable across different sectors. Even within sectors but across establishments, different jobs involve various skills and may require specific training. If the aggregate shocks affect different sectors in an asymmetric way, the difficulties associated with searching and matching with jobs from different sectors can be interpreted as an efficiency loss at the aggregate level.

Empirically, matching efficiency shocks can be motivated by the following observations regarding the Sudden Stop episodes. Kehoe and Ruhl (2009) document that substantial reallocations, which are often costly, take place from nontradable to tradable goods sectors following Sudden Stops. For example, in the aftermath of the Mexican crisis in 1994-1995, massive sectoral reallocations took place as the depreciation of real exchange rate drove down the relative price of nontradable goods. In the case of Mexico, the employment share of traded goods sector in total employment stopped following a downward sloping trend and even rose somewhat after the crisis. Figure 4 shows that similar patterns of cross-sectoral allocations are observed in other Sudden Stop episodes: e.g.,

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<sup>33</sup>When calibrated to the U.S., Andolfatto (1996) finds that including matching efficiency shocks changes the variability of wage in the opposite direction than desired.

Chile 1981-84, 1998-99 and Colombia 1998-99.<sup>34,35</sup> Moreover, Benjamin and Meza (2007) argue that the Sudden Stops raise the cost of imported intermediate input in the investment sector and often lead to reallocation of labor from the investment sector to the consumption sector suggesting that there are differential effects on the labor variables across sectors. We study the potential impact of matching efficiency shock on the business cycle variables when matching across sectors are inherently more difficult than matching within sectors.

Unfortunately, data on the direct measures of new hires and vacancy rate do not exist for emerging economies, making it impossible to estimate matching efficiency shocks. However, Andolfatto (1996) estimates a joint VAR(1) process of productivity shocks and matching efficiency shocks using the U.S. data and shows that the innovations to the matching shock is almost ten times the innovations to the technology shock and these two shocks are positively correlated. In line with this observation, we experiment with matching efficiency shocks that are positively correlated with TFP shocks. That is, at the aggregate level, times of high matching efficiency are associated with economic expansions and periods of low reallocation efficiency are accompanied by economic downturns. Our calibration strategy with regards to the matching efficiency shocks is to pin down  $\rho_\omega$  and  $var(e^\omega)$  in order to match  $\sigma(u)$  and  $\rho(y, u)$ . Specifically, the standard deviation of the innovation to the matching efficiency shock is set to be 10 percent with a persistence parameter of 0.6, and the correlation with the innovation to TFP is 0.5.<sup>36</sup> Other ingredients of the VAR involving the matching efficiency shock were set to zero.

The results with matching efficiency shocks are presented in Table 7. The first column copies the baseline scenario results, the second column reports the findings of the scenario with matching efficiency shocks that are positively correlated with TFP and finally the last column documents the case with uncorrelated matching efficiency shocks. In the positively correlated matching efficiency shock scenario, since the matching efficiency is likely to be low when TFP is low, as discussed before, the stock of unemployment can be eliminated at a slower pace. This generates a more persistent unemployment (notice that the autocorrelation of unemployment (0.31) is higher than the baseline

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<sup>34</sup>We date the Sudden Stops using the definition by Gallego and Tessada (2008): a period that a. annual capital flow falls at least two standard deviation below its sample mean at least once; b. begins as the first time the annual drop in capital flow is one standard deviation below the sample mean and c. ends when it rises one standard deviation above the mean. The employment data is obtained from International Labour Organization. We categorize the agriculture, mining, manufacturing and utility supply as the tradable sector and construction and services as the nontradable sector.

<sup>35</sup>Net job creations also display similar dynamics. Using the sectoral job creation and destruction data provided by Haltiwanger et al (2004), we find that the ratio of net job creations in the tradable sector relative to that in the nontradable sectors increases in both Mexico and Brazil in the aftermath of crises.

<sup>36</sup>We also analyzed a case when the correlation of matching efficiency shocks and TFP is set to zero.

case (0.10)) and a significantly higher variability for unemployment and vacancy (16.24 and 14.56 compared to 3.24 and 5.59 in the baseline case). If the matching efficiency is low, the firms cut vacancies significantly because the probability of forming a match is smaller while the cost of keeping the vacancy is constant. Hence, vacancies fall dramatically leading to higher unemployment with one period lag. In the scenario with uncorrelated matching efficiency shocks, the only significant difference is with regard to the correlation of unemployment with output that becomes closer to zero. This is intuitive as the uncorrelated matching efficiency shocks lead to a decoupling of the matching process from the TFP process.

The conventional search models of closed economies have difficulty in generating the high unemployment rate variability found in the data, unless the replacement rate is high.<sup>37</sup> In our model extended to include matching efficiency shocks, an adverse matching efficiency shock directly reduces the job creation rate and leads to higher unemployment rate for the following period. Given that the steady state level of unemployment is about 8 percent and the other factor inputs are fixed, a one percentage point rise of unemployment rate leads to only a 0.056 percentage decrease of output, which is about one twentieth the size of the change in unemployment. This implies that the matching efficiency shock, itself, can lead to high relative variability of unemployment rate (relative to output) without affecting the variability of output and consumption significantly.

## 6 Conclusion

A SOE-RBC model with search-matching frictions in the labor market can perform well in accounting for the dynamics of consumption, the current account and the wages simultaneously. Quantitative results showed that our model improved upon the standard RBC model in many dimensions, underscoring the dynamic interaction of search-matching frictions along with countercyclical interest rates in accounting for EMEs stylized facts. As an illustrative extension, we augmented our baseline model to include shocks to the matching efficiency. With this feature, we showed that the model brought the unemployment variability significantly closer to data.

Exploring emerging market labor market dynamics using general equilibrium models is ripe for further research. This paper showed how far the modeling of the transitions from unemployment-employment (extensive margin) takes us in terms of explaining the key regularities. Our paper emphasizes the interaction between countercyclical interest rates and labor market frictions in

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<sup>37</sup>See Marcus and Manovskii (2005) and Nakajima (2008) for a detailed explanation.

understanding the labor market dynamics and other business cycle features. Our framework can be extended to examine important policy relevant questions such as the role of institutional and social arrangements in labor markets (e.g., trade unions, unemployment insurance, minimum wages, labor contract enforcement, long-term contract etc.) in EMEs.

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## A Data Appendix

The dates in square brackets are the beginning date of a data series and the end date is 2007 unless otherwise stated. Our sample period is 1976-2007. All detrending is done using the HP filter with a smoothing parameter of 1600 and deseasonalizations are done using the U.S. Census Bureau's X-12. Only those series that seemed to have seasonality were deseasonalized.

### **GDP**

All data are from the International Financial Statistics (IFS). Availability varies across countries. Countries that have the data for the entire sample: Australia, Austria, Canada, Finland, France, Israel, Japan, Korea, Norway, Spain, Sweden.<sup>38</sup>

Countries with shorter samples: Belgium [1980], Brazil [1991], Chile [1980], Denmark [1977], Ecuador [1991], Hungary [1995], Ireland [1997], Malaysia [1988], Mexico [1980], the Netherlands [1977], New Zealand [1982Q2], the Philippines [1981], Portugal [1977], Turkey [1988].

### **Manufacturing Output**

Manufacturing output data are in real terms and from Haver Analytics. Data for the entire sample are available for Australia, Austria, Chile, Norway and Spain. For others, the availability varies: Belgium [1990], Brazil [1991], Canada [1981], Denmark [1985], Ecuador [1990], Finland [1995], Hungary [1997], Ireland [1980], Israel [1990], Mexico [1980], New Zealand [1987Q2], Philippines [1998], Portugal [2000], Sweden [2000], Turkey [1985].

### **Aggregate Hours, Manufacturing Hours, Employment**

*All countries:* Hours worked data are available only for the manufacturing sector. We report a set of statistics using those data. In addition, we approximate aggregate hours worked by multiplying the hours worked per worker in manufacturing by total employment. Some countries do not report hours worked per worker but only total hours worked in manufacturing. In that case, we divide total hours in manufacturing by the number of employees in manufacturing to approximate hours worked per worker.

*Australia, Austria, Canada, Finland, Japan:* All series are from OECD and available for the entire sample.

*Brazil:* Monthly hours worked in manufacturing is from OECD [1992] and 1987Q1-1991Q4 was calculated using data from the Confederation of Industries. Civilian employment data are from Neumeyer and Perri (2005) for 1991-2002 and 2003-2007 was extrapolated using "formal employ-

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<sup>38</sup>In the calculation of the GDP standard deviation for Israel, we excluded 1976-1980 because of large fluctuations observed in this period.

ment” series from Ministerio do Trabalho e Emprego (MTE) assuming that civilian employment grows at the same rate with formal employment. Employment in manufacturing are from MTE.

*Chile, Malaysia, The Netherlands, Philippines:* No data is available on hours worked. Employment data is from IFS and start at different years for these countries, Netherlands [1984], Chile [1983Q3], the Philippines [1992], Malaysia [1998].

*Ecuador:* No data is available on hours worked. Employment data is short in quarterly frequency, available in IFS only for 2000-2003 and therefore was not included in the employment statistics.

*Hungary:* All series are from OECD. Hours worked per worker in manufacturing are available starting 1984, civilian employment and employment in manufacturing from 1992.

*Ireland:* Weekly hours worked in manufacturing per worker is from OECD (entire sample). However, the number of employees in manufacturing data start in 1998 and therefore, total hours worked in manufacturing could be calculated only starting in 1998. The number of employees in manufacturing and civilian employment are also from OECD [1998].

*Israel:* Hours worked in manufacturing data are from International Labor Organization (ILO) and covers the entire sample (series named weekly hours actually worked in non-agricultural activities per worker). Employment is from IFS [1992]. Number of employees in manufacturing was not available.

*Korea:* Monthly hours worked in manufacturing is from OECD [1993]. Number of employees in manufacturing and total employment are from the Korean Statistical Institute [1976].

*Mexico:* Employment data are from Neumeyer and Perri (2005) covering 1987-2001. We used two different data for monthly hours worked in manufacturing, from INEGI [1980] and from OECD [1987]. The data from OECD is an index (2000=100) and is used in the calculation of the statistics related to the hours worked in manufacturing. The series from INEGI is in units of hours and is used to compute the approximate aggregate hours worked as explained above. Number of employees in manufacturing data are from INEGI [1987].

*New Zealand:* Hours worked in manufacturing data are from ILO [1980] (series called weekly hours actually worked in non-agricultural activities per worker). Employment and employment in manufacturing are from OECD [1985Q4].

*Norway:* All series are from OECD and available for the entire sample except hours worked manufacturing that starts in 1988Q2.

*Sweden:* All series are from OECD and available for the entire sample except hours worked

manufacturing that starts in 1987.

*Turkey:* Total hours worked in manufacturing is from OECD [1977]. Number of employees in manufacturing and total employment are from TURKSTAT [1988Q4] and are semi-annual (April and October) in 1988Q4-1999Q4 and quarterly afterwards. The semi-annual series were used to calculate quarterly series using linear interpolation.

### **Unemployment Rate**

From OECD: Austria [1976], Belgium [1976], Brazil [1981], Canada [1976], France [1976], Japan [1976], Korea [1976], Mexico [1987], the Netherlands [1987], Norway [1986], Sweden [1976], Turkey [1976].

From the Economist Intelligence Unit: Australia [1993], Chile [1993], Ecuador [1998], Finland [1993], Hungary [1994], Ireland [1997Q4], Israel [1996], Malaysia [1998], New Zealand [1993], the Philippines [1993], Spain [1993].

### **Earnings**

For countries that only report monthly or weekly earnings, we divide by the hours worked in that time period to get hourly earnings. If hours worked data are not available, we report weekly or monthly earnings and mark these countries with an asterisk in Table 1.

From OECD: Brazil and Mexico's earnings statistics are reported in OECD both in real and nominal terms, and we deflate all other countries' data by the corresponding countries' CPI. For Australia, Brazil, New Zealand, and Spain, earnings statistic captures all activities, for Belgium and France it captures the private sector. For all other countries, it is the earnings only for manufacturing. Data for the entire sample is available for Canada, Denmark, Finland, Germany, Ireland, Japan, Norway, and Sweden. For other countries, availability varies: Australia [1983Q4], Belgium [1996], Brazil [1989], France [1996], Hungary [1995], Korea [1992], Mexico [1980], New Zealand [1987], Spain [1981], and Turkey [1990]. Nominal earnings data for Brazil and Mexico start in 1994Q3 and 1980Q1, respectively.

From ILO: Chile [1982], Israel [1985], the Philippines [2001].

From IEO: Ecuador [1993].

### **Prices**

All CPI data used to deflate earnings are from IFS and are available for the entire sample period with the exception of Brazil [1980].

All PPI data used to deflate earnings are from Haver Analytics. Data for the entire sample are available for Australia, Canada, Korea, Spain, Sweden. For others, the availability varies: Austria

[1996], Belgium [1980], Brazil [1991Q4], Chile [2003Q2], Denmark [1985], Ecuador [1998], Finland [1995], Hungary [1986], Ireland [1995], Israel [1980], Mexico [1981], New Zealand [1977Q4], Norway [2000], Philippines [2000], Portugal [1995], Turkey [1986].

## B TFP computation

Assume that output ( $Y_t$ ) can be represented by the following Cobb-Douglas production function:

$$Y_t = K_t^\alpha (h_t L_t)^{1-\alpha} A_t,$$

where  $K_t$  is the capital stock in year  $t$ ,  $L_t$  is labor which is augmented its relative efficiency due to schooling ( $h_t$ ), and  $A_t$  is TFP.

We constructed the capital stock series using the perpetual inventory approach following Easterly and Levine (2001). In particular, the law of motion for the capital stock is given by:

$$K_{t+1} = K_t(1 - \delta) + I_t,$$

where  $I_t$  denotes investment and the rate of depreciation of the capital stock which is set equal to 0.07. In steady state, the initial capital-output ratio is:

$$k = \frac{i}{g + \delta},$$

where  $i$  is the steady state investment-output ratio and  $g$  the steady state growth rate. We use annual investment data from the Penn World Tables, version 6.2. In order to compute  $k$ , we approximate  $i$  by the country's average investment-output ratio in the first ten years of the sample and  $g$  by a weighted average between world growth (75 percent) and the country's average growth in the first ten years of the sample. The initial capital level  $K_0$  is obtained by multiplying the three-year average output at the beginning of the sample.

For labor, we use the labor force implied by the real GDP per worker and real GDP (chain) series from the Penn World Tables. Follow Hall and Jones (1999) and consider human capital  $h$  to be the relative efficiency of a unit of labor with  $E$  years of schooling. In particular,  $h$  is constructed by:

$$h = e^{\varphi(E)},$$

where  $\varphi(\cdot)$  is a function that maps the years of schooling into efficiency of labor with  $\varphi(0) = 0$  and  $\varphi'(E)$  equal to the Mincerian return to schooling. We assume the same rates of return to schooling for all countries: 13.4 percent for the first four years, 10.1 percent for the next four, and 6.8 percent for all years of schooling above eight years (following Psacharopoulos, 1994). The data on years of schooling is obtained from the Barro-Lee database and linear extrapolations are used to complete the five-year data.

Output per worker is given by:

$$\frac{Y_t}{L_t} = \left( \frac{K_t}{L_t} \right)^\alpha h_t^{1-\alpha} A_t$$

The log TFP is thus calculated according to

$$\ln(A_t) = \ln(Y_t) - \ln(L_t) + \alpha(\ln(k_t) + \ln(L_t)) + (1 - \alpha)\ln(h_t).$$

## C Decentralized Economy

In this section, we characterize a decentralized world, where the sequence of wage rates is determined by the Nash Bargaining between workers and firms.<sup>39</sup> In our setting, the markets for aggregate shocks are incomplete but the household may partially insure against these shocks through precautionary savings.

There are externalities generated by each side of the labor market, for both employers and firms. When the number of vacancies posted by the firms increases, there is a positive externality for workers who are actively seeking a job and a negative externality for firms that are trying to fill up a position. More specifically, an individual household takes the probability of being hired,  $M/u = \phi(\theta)$ , as given without considering the impact of its own employment on the general market tightness. Similarly, the individual firm takes the probability of filling a vacancy,  $M/v = \phi(\theta)/\theta$ , as given.

**Household.** Let  $V_t^H$  denote the value of the representative household at period  $t$ . The household owns the firms. In this “large” family, every family member enjoys the same level of consumption

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<sup>39</sup>Important deviations of our model from the standard Mortensen-Pissarides type of search models (e.g., Shimer, 2005) are that the production technology has curvature, the household is risk-averse with access to international financial markets and the economy is subject to shocks to the interest rate at which they can borrow from the rest of world.

regardless of his employment status. Suppose that the value of being employed is given by  $E_t$ , and the value of being unemployed and actively searching for a new job is  $U_t$ . For the household, the following relationship holds:

$$-\frac{\partial V_t^H}{\partial u_t} = E_t - U_t. \quad (13)$$

We can obtain the marginal value associated with an additional job from the following household optimization problem. Given the wage rate, interest rate and the prevailing probability of finding a job, the household solves the following optimization problem:

$$\begin{aligned} V^H(b_t, u_t, \varepsilon_t) &= \max_{c_t, b_{t+1}} U(c_t) + (1 - u_t)\varphi^E H(1 - l) + u_t\varphi^U H(1) \\ &\quad + \beta(c_t)\mathbb{E}_t V^H(b_{t+1}, u_{t+1}, \varepsilon_{t+1}) \\ \text{s.t.} \quad c_t + b_{t+1} &\leq \pi_t + w_t l(1 - u_t) + b_t(1 + r_t), \\ u_{t+1} &= u_t(1 - \phi(\theta_t)) + (1 - u_t)\psi, \\ b_{t+1} &\geq \bar{B}. \end{aligned}$$

With a similar interpretation as in the Social Planner's problem, we can lay out the Envelope condition as follows:

$$-\frac{\partial V_t^H}{\partial u_t} = \varphi^E H(1 - l_t) - \varphi^U H(1) + U'(c_t)w_t l + \beta(c_t)\mathbb{E}_t \left(-\frac{\partial V_{t+1}^H}{\partial u_{t+1}}\right) [(1 - \phi(\theta_t)) - \psi].$$

**Firms.** Firms are owned by the household and therefore discount expected future profits according to the same stochastic discount factor as the household,  $\rho_{t,t+1} = \beta(c_t)U'(c_{t+1})/U'(c_t)$ . Given the wage rate and the probability of filling a vacancy, the firms choose the optimal number of vacancies to be posted to maximize their profits:

$$V^F(u_t, \varepsilon_t) = \max_{v_t, u_{t+1}} F(k, (1 - u_t)l, z_t) - w_t l(1 - u_t) - \kappa v_t + \mathbb{E}_t \rho_{t,t+1} V^F(u_{t+1}, \varepsilon_{t+1})$$

subject to the law of motion that governs employment:

$$u_{t+1} = u_t - v_t \frac{\phi(\theta_t)}{\theta_t} + (1 - u_t)\psi.$$

The Envelope theorem implies the standard job-creation condition

$$-\frac{\partial V^F(u_t, \varepsilon_t)}{\partial u_t} = F_{2,t}l_t - w_t l_t + \mathbb{E}_t \rho_{t,t+1} \frac{\partial V^F(u_{t+1}, \varepsilon_{t+1})}{\partial u_{t+1}} (1 - \psi),$$

and the first order condition w.r.t.  $v_t$  implies

$$\kappa = \frac{\phi(\theta_t)}{\theta_t} \mathbb{E}_t \rho_{t,t+1} \frac{\partial V^F(u_{t+1}, \varepsilon_{t+1})}{\partial u_{t+1}}. \quad (14)$$

Putting the above two equations together, one can equivalently write

$$-\frac{\partial V^F(u_t, \varepsilon_t)}{\partial u_t} = F_{2,t}l - w_t l + (1 - \psi) \frac{\kappa \theta_t}{\phi(\theta_t)}.$$

That is, the marginal value the firms associate with filling one more position is given by the marginal product of an extra worker net of the wage cost plus the asset value of activating one more job and enjoying a pre-exiting relationship with a worker in the next period. Let  $J$  denote the value of filling a position and  $Q$  the value of posting a vacancy. Then,

$$-\frac{\partial V^F(u_t, \varepsilon_t)}{\partial u_t} = J_t - Q_t. \quad (15)$$

**Nash Bargaining.** Assuming that employed workers' bargaining power is  $\xi \in (0, 1)$ , the matched worker-firm pair negotiates over wage by solving the following Nash Bargaining problem:

$$\max_{w_t} (E_t - U_t)^\xi (J_t - Q_t)^{1-\xi}.$$

At the optimum, the firms and the household divide the total matching surplus according to the Nash Bargaining power of each party.

$$J_t - Q_t = \frac{1 - \xi}{\xi} \frac{E_t - U_t}{U'(c_t)}. \quad (16)$$

Combining Equation (16) with Equations (13), and (15), we have

$$\begin{aligned} & \frac{1 - \xi}{\xi} (\varphi^E H(1 - l) - \varphi^U H(1) + U'(c_t) w_t l_t + \beta(c_t) \mathbb{E}_t (E_{t+1} - U_{t+1}) [(1 - \phi(\theta_t) - \psi)]) \\ &= [F_{2,t}l - w_t l + (1 - \psi) \frac{\kappa \theta_t}{\phi(\theta_t)}] U'(c_t). \end{aligned}$$

Now substitute the term,  $(E_{t+1} - U_{t+1})$ , with  $\xi/(1 - \xi)(J_{t+1} - Q_{t+1})U'(c_{t+1})$ , and using Equation (14) and (15), after rearranging the terms we have

$$w_t = \xi(F_{2,t} + \frac{\kappa\theta_t}{l}) + (1 - \xi)\frac{\varphi^U H(1) - \varphi^E H(1 - l)}{lU'(c_t)}$$

which is the same as Equation (10).

## D Canonical SOE-RBC

The recursive representation of the social planner's problem in the canonical SOE-RBC model is:

$$\begin{aligned} V(b_t, \varepsilon_t) &= \max_{c_t, b_{t+1}} u(c_t, l_t) + \beta(c_t)\mathbb{E}_t V(b_{t+1}, \varepsilon_{t+1}) \\ \text{s.t. } c_t + b_{t+1} &\leq F(k, l_t, z_t) + b_t(1 + r_t), \\ b_{t+1} &\geq \bar{B}. \end{aligned}$$

where  $l_t$  stands for labor supply. Per-period utility is takes the GHH form,  $u(c_t, l_t) = \frac{(c_t - \chi l_t^\eta)^{1-\sigma}}{1-\sigma}$  where  $\frac{1}{\eta-1}$  captures the elasticity of labor supply. Under the spot labor market, wage equals the marginal product of labor and marginal rate of substitution between consumption and leisure.

We use the same values for all preference related parameters as in our baseline search-matching model as documented in Table 4. The only additional parameter that appears in the canonical SOE-RBC is  $\eta$  which we set to 1.6 following Mendoza (1991) and Aguiar and Gopinath (2007). As mentioned in the text, we feed in the same TFP and interest rate shocks as in our baseline search-matching framework.

Table 1: Real earnings

	$\sigma(W)$	$\sigma(W)/\sigma(Y)$	$\rho(W, Y)$	$\sigma(W)/\sigma(Y^{man})$	$\sigma(W^{nom})$	$\sigma(W^{PPI})$	$\rho(W^{PPI}, Y)$
Emerging Markets:							
Brazil	6.46	3.92	-0.03	1.97	6.40	7.13	-0.11
Chile*	1.77	0.61	0.13	0.47	1.92	2.81	-0.05
Ecuador*	7.16	3.36	0.53	0.99	-	-	-
Hungary	1.79	1.72	0.19	0.51	1.91	2.77	-0.11
Israel	3.64	1.78	0.24	1.43	6.15	3.01	-0.06
Korea	3.74	1.47	0.57	0.85	3.22	4.61	0.76
Malaysia	-	-	-	-	-	-	-
Mexico	9.96	4.26	0.35	2.83	7.51	5.27	0.36
Philippines*	1.53	0.55	-0.33	0.54	1.46	3.06	-0.72
Turkey	10.43	3.05	0.19	2.31	7.34	12.00	0.22
<b>Mean:</b>	<b>6.00</b>	<b>2.70</b>	<b>0.25</b>	<b>1.65</b>	<b>5.42</b>	<b>5.80</b>	<b>0.18</b>
<b>Median:</b>	<b>5.10</b>	<b>2.42</b>	<b>0.22</b>	<b>1.70</b>	<b>6.27</b>	<b>4.94</b>	<b>0.08</b>
Developed Markets:							
Australia	2.06	1.55	0.20	0.83	1.90	2.76	0.10
Austria	0.75	0.74	0.23	0.27	0.65	1.19	-0.49
Belgium	0.64	0.53	-0.20	0.35	0.80	2.05	-0.48
Canada	0.90	0.58	-0.24	0.23	1.31	2.40	-0.61
Denmark	0.96	0.67	0.07	0.28	0.91	2.42	-0.15
Finland	1.67	0.80	0.27	0.62	1.56	1.81	-0.51
Ireland	1.58	0.96	-0.11	0.44	1.28	2.73	-0.56
Netherlands	-	-	-	-	-	-	-
New Zealand	0.98	0.87	0.25	0.36	1.17	1.65	0.047
Norway	1.37	0.88	-0.38	0.72	1.45	6.72	-0.41
Portugal	-	-	-	-	-	-	-
Spain	1.19	1.05	-0.23	0.46	1.46	2.08	-0.28
Sweden	1.54	1.10	0.25	0.59	1.06	2.22	-0.26
<b>Mean:</b>	<b>1.24</b>	<b>0.89</b>	<b>0.01</b>	<b>0.47</b>	<b>1.23</b>	<b>2.55</b>	<b>-0.33</b>
	(0.005)	(0.002)	(0.046)	(0.005)	(0.001)	(0.043)	(0.005)
<b>Median:</b>	<b>1.19</b>	<b>0.87</b>	<b>0.07</b>	<b>0.44</b>	<b>1.27</b>	<b>2.22</b>	<b>-0.41</b>
	(0.000)	(0.000)	(0.216)	(0.001)	(0.000)	(0.001)	(0.004)

Notes: This table shows 1) standard deviation of real earnings, 2) standard deviation of real earnings as a ratio of output standard deviation, 3) correlation of real earnings with output, 4) standard deviation of real earnings as a ratio of manufacturing output standard deviation, 5) standard deviation of nominal earnings, 6) standard deviation of real earnings calculated using the PPI instead of CPI, 7) correlation of real earnings calculated using the PPI with output. All series are HP-filtered using a smoothing parameter of 1600. See Data Appendix for more information about data sources and coverage. For countries marked with an asterisk earnings data were available for weekly or monthly earnings and not hourly. These countries are excluded from the calculation of means and medians. The numbers in parenthesis report  $p$ -values of Student's  $t$  (for means) and Mann-Whitney (for medians) tests of equality of means and medians of emerging market and developed economy statistics.

Table 2: Unemployment rate and employment

	$\sigma(U)$	$\sigma(U)/\sigma(Y)$	$\rho(U, Y)$	$\sigma(E)$	$\sigma(E)/\sigma(Y)$	$\rho(E, Y)$
Emerging Markets:						
Brazil	12.26	7.43	-0.49	1.20	0.73	0.54
Chile	11.01	3.77	-0.67	1.68	0.58	0.28
Ecuador	16.26	7.63	-0.55	-	-	-
Hungary	5.29	5.09	-0.25	1.21	1.16	0.12
Israel	5.73	2.81	-0.67	1.15	0.56	0.51
Korea	5.26	2.06	0.01	1.60	0.63	0.87
Malaysia	8.27	3.28	-0.42	1.26	0.50	0.39
Mexico	14.70	6.28	-0.78	1.16	0.50	0.50
Philippines	8.01	2.90	-0.35	1.49	0.54	0.38
Turkey	27.18	7.95	0.10	1.42	0.64	0.39
<b>Mean:</b>	<b>11.40</b>	<b>4.92</b>	<b>-0.41</b>	<b>1.42</b>	<b>0.64</b>	<b>0.39</b>
<b>Median:</b>	<b>9.64</b>	<b>4.43</b>	<b>-0.46</b>	<b>1.26</b>	<b>0.58</b>	<b>0.39</b>
Developed Markets:						
Australia	8.76	6.59	-0.66	1.24	0.93	0.65
Austria	9.65	9.55	-0.00	0.80	0.79	0.11
Belgium	10.10	8.35	-0.37	-	-	-
Canada	8.64	5.54	-0.04	1.16	0.74	0.67
Denmark	-	-	-	0.64	0.45	0.40
Finland	4.29	2.06	-0.13	1.71	0.82	0.73
Ireland	9.77	5.96	-0.5	-	-	-
Netherlands	14.7	10.14	-0.52	1.45	1.00	0.33
New Zealand	7.94	7.03	-0.60	1.42	1.26	0.22
Norway	9.36	6.04	-0.14	1.09	0.70	0.39
Portugal	10.76	7.27	-0.51	1.87	1.13	0.46
Spain	6.46	5.72	-0.27	1.47	1.30	0.79
Sweden	6.30	4.50	-0.19	1.23	0.88	0.47
<b>Mean:</b>	<b>8.89</b>	<b>6.56</b>	<b>-0.33</b>	<b>1.25</b>	<b>0.91</b>	<b>0.47</b>
	(0.284)	(0.099)	(0.498)	(0.359)	(0.018)	(0.451)
<b>Median:</b>	<b>9.06</b>	<b>6.31</b>	<b>-0.32</b>	<b>1.24</b>	<b>0.88</b>	<b>0.46</b>
	(0.627)	(0.202)	(0.538)	(0.551)	(0.015)	(0.602)

Notes: This table shows 1) standard deviation of unemployment rate, 2) standard deviation of unemployment as a ratio of output standard deviation, 3) correlation of unemployment rate with output, 4) standard deviation of employment, 5) standard deviation of employment as a ratio of output standard deviation, 6) correlation of employment with output. All series are HP-filtered using a smoothing parameter of 1600. See Data Appendix for more information about data sources and coverage. The numbers in parenthesis report  $p$ -values of Student's  $t$  (for means) and Mann-Whitney (for medians) tests of equality of means and medians of emerging market and developed economy statistics.

Table 3: Hours worked: manufacturing and aggregate

	$\sigma(H_m)$	$\sigma(H_m)/\sigma(Y)$	$\rho(H_m, Y)$	$\sigma(H_a)$	$\sigma(H_a)/\sigma(Y)$	$\rho(H_a, Y)$
Emerging Markets:						
Brazil	3.42	2.07	0.57	2.71	1.61	0.54
Chile	-	-	-	-	-	-
Ecuador	-	-	-	-	-	-
Hungary	1.83	1.76	0.23	-	-	-
Israel	-	-	-	2.35	1.15	0.47
Korea	1.83	0.72	0.32	2.16	0.85	-0.42
Malaysia	-	-	-	-	-	-
Mexico	3.70	1.58	0.78	1.72	0.74	0.59
Philippines	-	-	-	-	-	-
Turkey	4.83	1.41	0.59	5.82	1.70	0.41
<b>Mean:</b>	<b>3.12</b>	<b>1.51</b>	<b>0.50</b>	<b>2.95</b>	<b>1.23</b>	<b>0.32</b>
<b>Median:</b>	<b>3.42</b>	<b>1.58</b>	<b>0.57</b>	<b>2.35</b>	<b>1.24</b>	<b>0.47</b>
Developed Markets:						
Australia	2.98	2.24	0.72	2.21	1.66	0.68
Austria	1.88	1.86	0.37	1.25	1.24	0.22
Belgium	-	-	-	-	-	-
Canada	3.05	1.96	0.74	1.57	1.01	0.71
Denmark	-	-	-	-	-	-
Finland	3.10	1.49	0.68	2.44	1.17	0.65
Ireland	2.24	1.37	0.48	1.54	0.94	0.55
Netherlands	-	-	-	-	-	-
New Zealand	3.19	2.82	0.43	1.70	1.50	0.40
Norway	2.31	1.49	0.35	1.69	1.09	0.38
Portugal	-	-	-	-	-	-
Spain	2.72	2.41	0.68	1.85	1.64	0.66
Sweden	2.98	2.13	0.68	1.89	1.35	0.68
<b>Mean:</b>	<b>2.72</b>	<b>1.97</b>	<b>0.57</b>	<b>1.79</b>	<b>1.29</b>	<b>0.55</b>
	(0.511)	(0.120)	(0.534)	(0.144)	(0.739)	(0.264)
<b>Median:</b>	<b>2.98</b>	<b>1.96</b>	<b>0.68</b>	<b>1.70</b>	<b>1.24</b>	<b>0.65</b>
	(0.699)	(0.189)	(0.518)	(0.041)	(0.797)	(0.239)

Notes: This table shows 1) standard deviation of hours worked in manufacturing, 2) standard deviation of hours worked in manufacturing as a ratio of output standard deviation, 3) correlation of hours worked in manufacturing with output, 4) standard deviation of aggregate hours worked, 5) standard deviation of aggregate hours worked as a ratio of output standard deviation, 6) correlation of aggregate hours worked with output. All series are HP-filtered using a smoothing parameter of 1600. See Data Appendix for more information about data sources and coverage. The numbers in parenthesis report  $p$ -values of Student's  $t$  (for means) and Mann-Whitney (for medians) tests of equality of means and medians of emerging market and developed economy statistics.

Table 4: Calibrated Parameters

Parameter	Value	Explanation	Source
<i>Preferences:</i>			
$\sigma$	2	relative risk aversion	literature
$\beta$	0.983	steady-state discount factor	inverse of gross real interest rate
<i>Production Technology:</i>			
$z$	1	total factor productivity	normalization
$\zeta$	0.36	capital's share in output	literature
<i>Search Technology:</i>			
$\omega$	0.778	matching efficiency	$\omega = \frac{m^*}{u^* \alpha v^* (1-\alpha)}$
$\alpha$	0.5	elasticity of matching function	Petrongolo and Pissarides (2001), Shimer (2004)
$\kappa$	0.127	unit cost of posting vacancy	recruiting expenditure as 1% of GDP
$\psi$	0.06	natural breakup rate	Bosch and Maloney (2008)
$\xi$	0.5	bargaining power	the same as $\alpha$
<i>Other:</i>			
$r$	1.74	world interest rate	EMBI data
$\bar{b}$	-1/3	steady state bond holdings	data

Notes: This table shows the parameter values used in the analysis.

Table 5: Business Cycle Moments

	Data	RBC	Search and Matching			
			Baseline	Only Prod	Only Int Rate	Endog Labor
Standard Deviation						
$\sigma(u)$	14.70	n.a.	3.24	2.10	3.04	5.47
$\sigma(v)$	n.a.	n.a.	5.59	3.90	5.51	10.3
$\sigma(\theta)$	n.a.	n.a.	17.53	10.34	15.62	26.8
$\sigma(w)/\sigma(y)$	2.22	0.31	1.67	0.83	n.a.	1.81
$\sigma(c)/\sigma(y)$	1.26	0.78	1.35	0.79	n.a.	1.55
Correlation with $y$						
$\rho(y, ca/y)$	-0.75	-0.13	-0.46	0.97	-0.09	-0.56
$\rho(y, u)$	-0.78	n.a.	-0.68	-0.26	0.10	-0.44
$\rho(y, v)$	n.a.	n.a.	0.51	0.16	-0.41	0.27
$\rho(y, w)$	0.56	1.00	0.83	0.82	0.01	0.73
$\rho(y, \theta)$	n.a.	n.a.	0.77	0.33	0.16	0.59
$\rho(u, v)$	n.a.	n.a.	-0.94	-0.96	-0.95	-0.96
Autocorrelation						
$\rho(c)$	0.70	0.75	0.60	0.87	0.56	0.64
$\rho(y)$	0.75	0.64	0.63	0.67	1.00	0.65
$\rho(ca/y)$	0.72	0.41	0.45	0.65	0.45	0.42
$\rho(u)$	0.84	n.a.	0.67	-0.32	-0.10	-0.35
$\rho(v)$	n.a.	n.a.	n.a.	-0.65	-0.52	-0.65
$\rho(w)$	0.85	0.64	0.63	0.54	0.34	0.44
$\rho(\theta)$	n.a.	n.a.	n.a.	0.09	0.27	0.06

Notes: This table shows the business cycle moments. The columns show the moments in the data, in the RBC model with Walrasian labor markets, in the baseline search-matching model with shocks to TFP and interest rate, the search-matching model only with TFP shocks, and the search-matching model only with interest rate shocks. This table shows that in the data wage is more variable than income, unemployment is countercyclical, consumption is more variable than income, current account-GDP ratio is countercyclical. The baseline scenario accounts for these regularities reasonably well.

Table 6: Sensitivity Analysis

	Baseline	$\kappa = 0.1$	$\psi = 0.08$	$\omega = 0.85$	$\xi = 0.7$
Standard Deviation					
$\sigma(u)$	3.24	3.79	2.79	3.71	1.75
$\sigma(v)$	5.59	5.86	4.77	5.69	6.62
$\sigma(\theta)$	17.53	23.17	15.04	17.91	9.41
$\sigma(w)/\sigma(y)$	1.67	1.64	1.57	1.64	1.82
$\sigma(c)/\sigma(y)$	1.35	1.23	1.30	1.22	1.30
Correlation with $y$					
$\rho(y, ca/y)$	-0.46	-0.23	-0.53	-0.23	-0.54
$\rho(y, u)$	-0.68	-0.63	-0.67	-0.66	-0.79
$\rho(y, v)$	0.51	0.48	0.50	0.51	0.66
$\rho(y, w)$	0.83	0.86	0.82	0.86	0.69
$\rho(y, \theta)$	0.77	0.79	0.75	0.81	0.75
$\rho(u, v)$	-0.94	-0.93	-0.94	-0.96	-0.91
Autocorrelation					
$\rho(c)$	0.53	0.52	0.55	0.52	0.58
$\rho(y)$	0.65	0.65	0.65	0.65	0.65
$\rho(ca/y)$	0.40	0.37	0.40	0.38	0.42
$\rho(u)$	0.10	-0.06	0.15	-0.02	0.56
$\rho(v)$	-0.33	-0.38	-0.26	-0.35	0.16
$\rho(w)$	0.50	0.52	0.51	0.53	0.54
$\rho(\theta)$	0.40	0.43	0.42	0.45	0.40

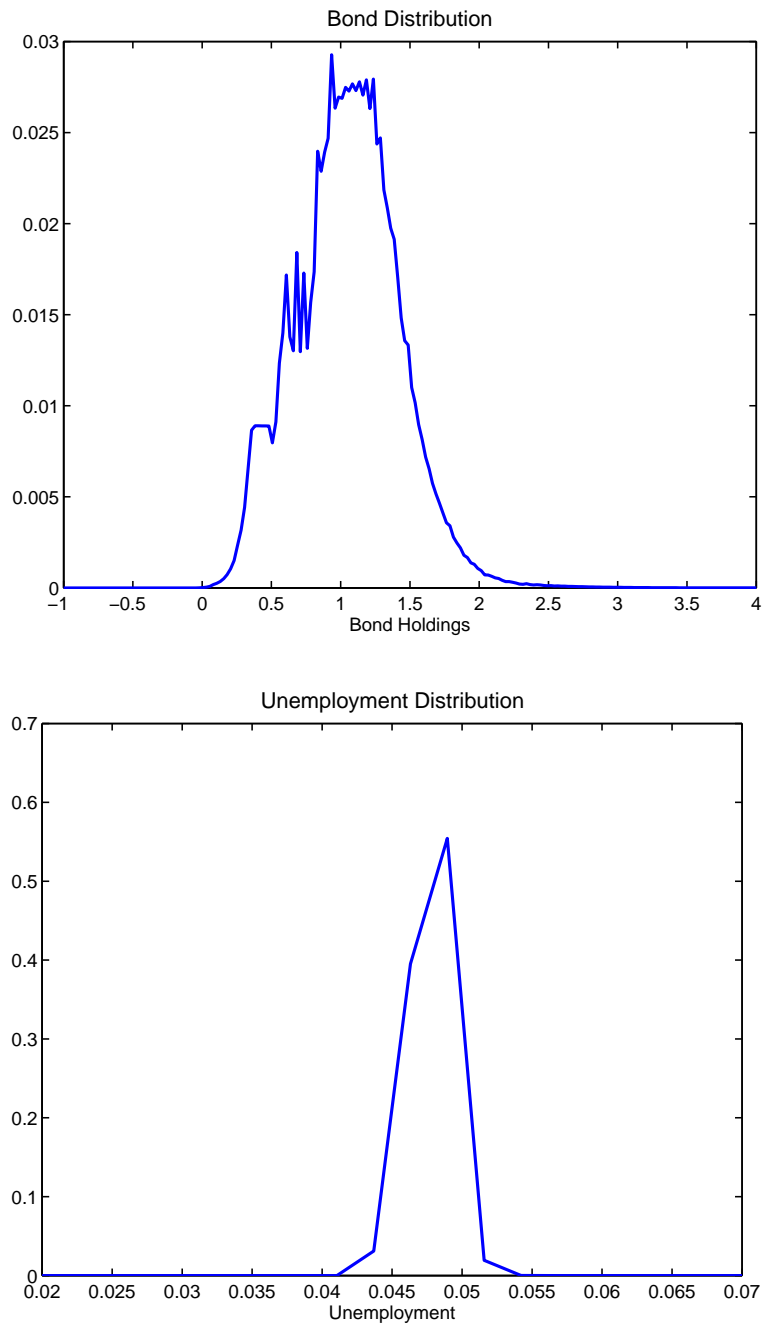
Notes: This table shows the results of the sensitivity analysis. The columns show the moments of the baseline case and those of the scenarios with  $\kappa = 0.1$ ,  $\psi = 0.08$ ,  $\omega = 0.85$ , and  $\xi = \alpha = 0.7$ .

Table 7: Matching Efficiency Shocks

	Baseline	w/ MES	
		$\rho(\varepsilon^z, \varepsilon^\omega) = 0.5$	$\rho(\varepsilon^z, \varepsilon^\omega) = 0$
Standard Deviation			
$\sigma(u)$	3.24	16.24	15.59
$\sigma(v)$	5.59	14.56	13.96
$\sigma(\theta)$	17.53	33.02	30.31
$\sigma(w)/\sigma(y)$	1.67	1.82	1.77
$\sigma(c)/\sigma(y)$	1.35	1.20	1.27
Correlation with $y$			
$\rho(y, ca/y)$	-0.46	-0.20	-0.34
$\rho(y, u)$	-0.68	-0.57	-0.20
$\rho(y, v)$	0.51	-0.01	0.01
$\rho(y, w)$	0.83	0.88	0.78
$\rho(y, \theta)$	0.77	0.76	0.49
$\rho(u, v)$	-0.94	-0.34	-0.29
Autocorrelation			
$\rho(c)$	0.53	0.51	0.50
$\rho(y)$	0.65	0.68	0.64
$\rho(ca/y)$	0.40	0.41	0.37
$\rho(u)$	0.10	0.31	0.32
$\rho(v)$	-0.33	-0.32	-0.28
$\rho(w)$	0.50	0.52	0.51
$\rho(\theta)$	0.40	0.50	0.51

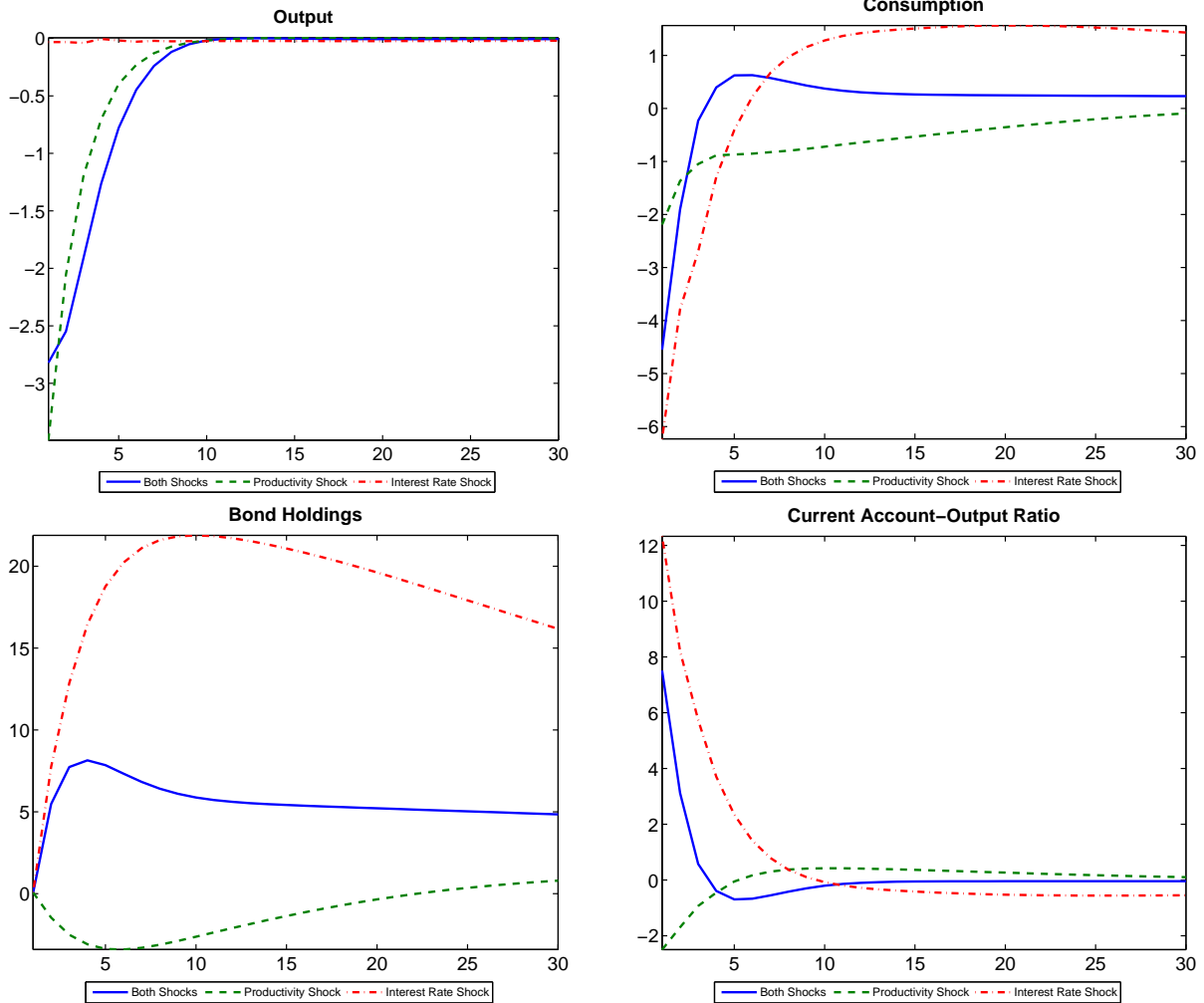
Notes: This table shows the results of the setup with shocks to the matching efficiency. The columns show the moments of the baseline case and those of the scenarios with procyclical ( $\rho(\varepsilon^z, \varepsilon^\omega) = 0.5$ ) and acyclical ( $\rho(\varepsilon^z, \varepsilon^\omega) = 0$ ) matching efficiency shocks.

Figure 1: Limiting Distributions of Endogenous State Variables



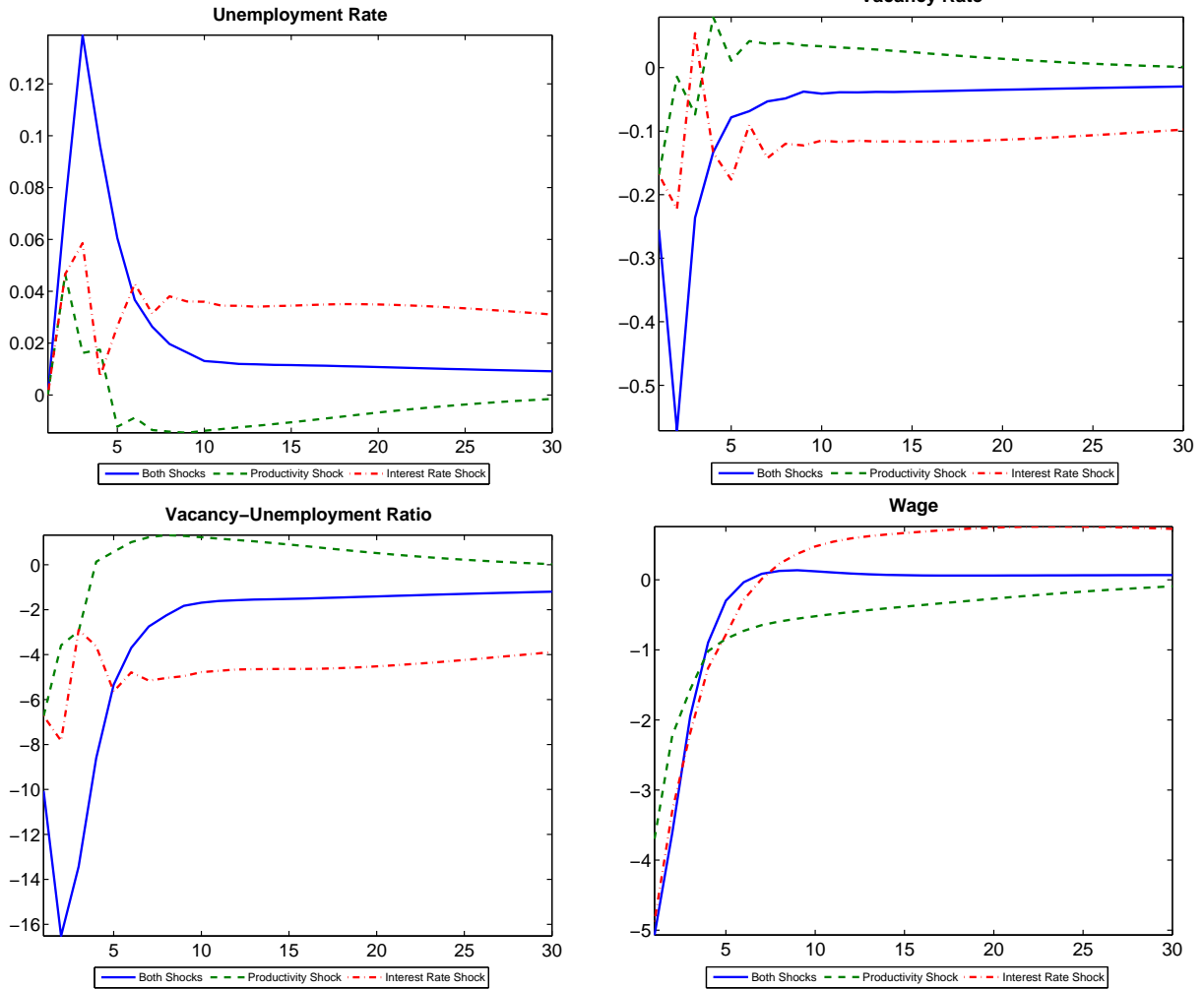
Notes: The charts plot the limiting distributions of bond holdings and unemployment.

Figure 2: Impulse Response Functions: Main Macroeconomic Variables



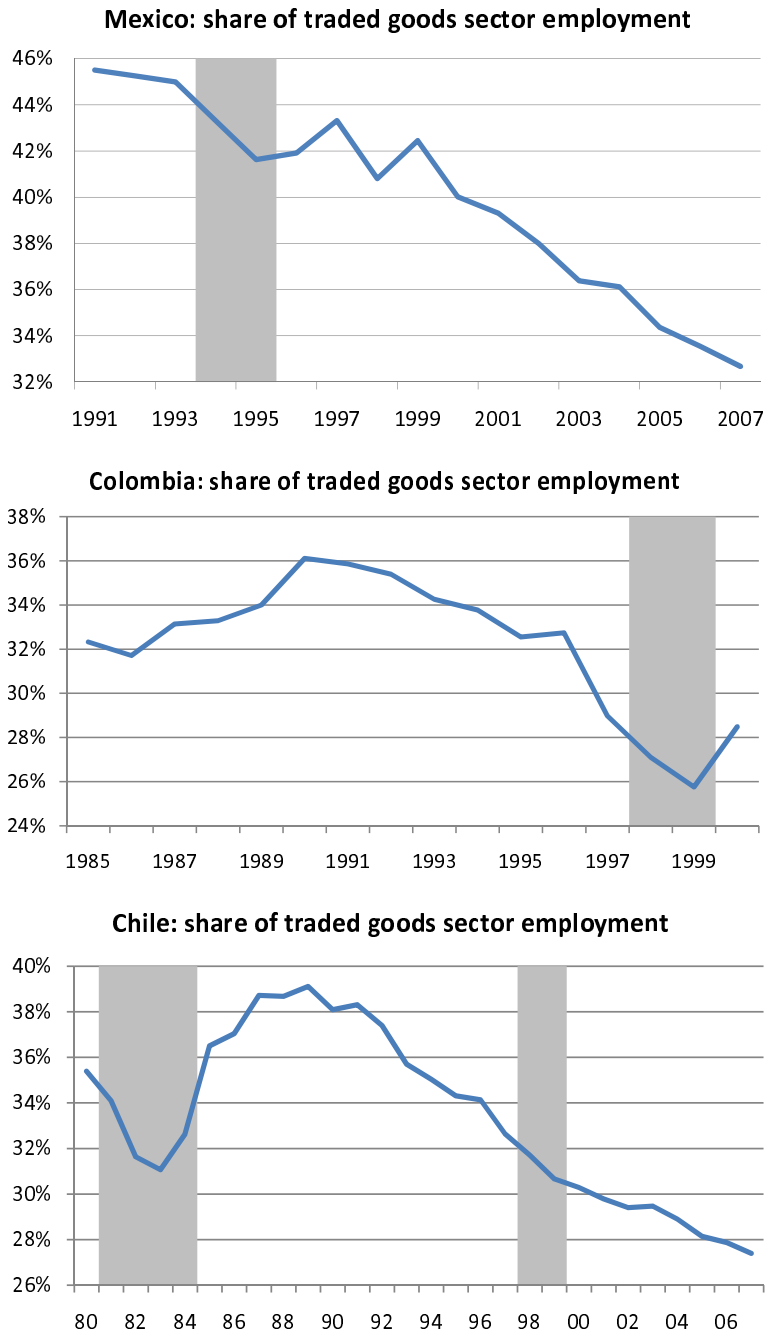
Notes: The figures show the impulse responses of main macroeconomic variables in response to one-standard-deviation negative TFP (dashed line), one-standard-deviation positive interest rate (dash-dotted line), and simultaneous one-standard-deviation negative TFP and positive interest rate shocks (solid line).

Figure 3: Impulse Response Functions: Labor Market Variables



Notes: The figures show the impulse responses of main macroeconomic variables in response to one-standard-deviation negative TFP (dashed line), one-standard-deviation positive interest rate (dash-dotted line), and simultaneous one-standard-deviation negative TFP and positive interest rate shocks (solid line).

Figure 4: Sectoral Decomposition of Employment



Notes: Shaded areas show the corresponding sudden stop episodes in respective countries.