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Emerging Market Business Cycles: The Role of Labor Market Frictions

Emerging economies are characterized by higher variability of consumption and real wages relative to output and a strongly countercyclical current account. A small open economy model with search-matching frictions and countercyclical interest rate shocks can account for these regularities. Search-matching frictions affect permanent income, and increase future employment uncertainty, heightening workers' incentives to save and generating a greater response of consumption and the current account. The greater consumption response feeds into larger fluctuations in workers' willingness to work, while interest rate shocks lead to variations in firms' willingness to hire; both of these outcomes contribute to highly variable wages.

JEL codes: E24, E44, F41, F43
Keywords: emerging markets, labor markets, business cycles, search frictions.

RECENT EVIDENCE EMPHASIZES THE importance of labor markets for understanding macroeconomic dynamics specific to emerging market economies (EMEs), including recovery from financial crises and output fluctuations (see

An early version of this paper was circulated with the title "Labor Market Search in Emerging Economies." We would like to thank numerous colleagues and seminar participants at the Bank of Canada, the Federal Reserve Board, the Federal Reserve Banks of Dallas, Philadelphia, and New York, Georgetown University, Indiana University, the International Monetary Fund, the Institute for Advanced Studies, Ohio State University, Singapore Management University, the National University of Singapore, the World Bank, the EEA meetings, the Midwest Macro Meetings, the North American Summer Meetings of the Econometric Society, and the SED Meetings for valuable comments and suggestions. All remaining errors are exclusively our responsibility. The views expressed in this paper are those of the authors and should not be attributed to the International Monetary Fund or the Board of Governors of the Federal Reserve System.

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Received September 24, 2012; and accepted in revised form January 30, 2014.

Journal of Money, Credit and Banking, Vol. 47, No. 1 (February 2015)

Bergoeing et al. 2002, Kehoe and Ruhl 2009). 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 of the labor market dynamics in these countries and their role in business cycle fluctuations.[1] To our knowledge, this paper makes one of the earlier attempts to fill this gap.

We begin by systematically documenting the business cycle properties of key labor market variables (i.e., real earnings, unemployment, and 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: fluctuations in prices are large while those in quantities are subdued. In particular, real wages, on average, are almost twice as variable as output and have a positive correlation with contemporaneous output (0.38).[2] Conversely, the variability of employment is about half the variability of output. These regularities stand in contrast to developed economies, where wages are less variable than output and in general are acyclical. Furthermore, the variability of employment in developed economies is close to that of output. Combined with the findings of the earlier literature on the importance of the behavior of interest rates in EMEs, our findings suggest that there may be a crucial interaction between the labor market and financial markets in EMEs that contributes to the salient business cycle characteristics of those economies.[3]

We then move on to our main objective and illustrate how the interaction between the labor market and exogenous driving forces such as total factor productivity (TFP) and interest rate shocks (the latter as a proxy for financial conditions) affect macroeconomic fluctuations in an augmented workhorse small open economy real business cycle (SOE-RBC) model. In our model, labor market conditions and employer–employee relationships are explicitly modeled and wages are determined by Nash bargaining. Examining the interaction between labor markets and financial markets requires us to move away from the frictionless spot labor market, where wages are simply pinned down by labor productivity. To do so, we incorporate labor search-matching frictions à la Mortensen and Pissarides (1994) (hereafter, MP) and Pissarides (2001) into an otherwise standard SOE-RBC model. Unlike previous models of EMEs, our setting allows workers' 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

1. Perhaps one exception is Neumeyer and Perri (2005), who do not focus on labor markets *per se* but document labor market statistics such as the variability and cyclicality of employment and total hours worked.

2. Our wage data are based on establishment surveys and thus do not consider informal sectors. If informal sectors were to be included, the contrast between wage dynamics in EMEs and those in developed economies would be potentially even more evident.

3. When we refer to business cycle characteristics throughout our analysis, we focus on not only the cyclical fluctuations of output but also those of consumption, current account, and wages as well.

saving behavior, and lifetime wealth and, hence, other macroeconomic variables such as wages, consumption, and the current account. Using our model, we quantify the effects of propagation induced by search-matching frictions vis-à-vis a canonical SOE-RBC model by calibrating the economy and computing the equilibrium numerically using a nonlinear method.

We find that the interaction of TFP shocks and countercyclical interest rate shocks with search-matching frictions contributes significantly to driving the joint behavior of consumption, the current account, and wages observed in EMEs.[4] Two important forces play a role. First, in the search-matching framework, a high interest rate that accompanies a negative TFP shock reduces the discounted future return on matching, leading to a decline in employer recruiting efforts and higher subsequent unemployment rates. Since future revenues from a match are now discounted at a high rate, firms have less to lose from not making a match, leading to a higher decline in wages than in a Walrasian labor market. The second force that puts downward pressure on wages in this scenario is a decline in the value of workers' outside option. During recessions, higher interest rates lead to a decrease in consumption and an increase in saving. With labor market frictions—which imply that unemployed workers necessarily experience an unemployment spell before finding a job—the decline in consumption and the increase in saving are amplified because of an increase in future employment uncertainty and the associated decline in permanent income. Furthermore, the slackened labor market and a substantial fall in consumption make nonmarket activity less attractive, lowering workers' outside option. Therefore, wages fall markedly. The decline in wages and consumption and the increase in saving together bring the model implications very much in line with the EME data.[5]

Our paper connects two strands of the 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 Rebello (1995), among others, provide the earliest contributions. Besides the papers mentioned earlier, Aguiar and Gopinath (2007), Garcia-Cicco, Pancrazzi, and Uribe (2010), and Boz, Daude, and Durdu (2011) examine the role of trend growth shocks. These papers, however, are largely silent on labor market dynamics; our paper complements these studies by proposing an additional mechanism through which external shocks can

4. We treat TFP and countercyclical interest rate shocks as the main exogenous driving forces, motivated by the findings of earlier studies including those of Neumeyer and Perri (2005), Uribe and Yue (2006), and Arellano (2008). Neumeyer and Perri (2005) and Uribe and Yue (2006) found that the existence of working capital constraints in conjunction with countercyclical interest rates is crucial to account for the combination of the high variability of consumption relative to output and the countercyclicality of the current account jointly. Although working capital constraints do exist in the data, they appear to be small. Mendoza and Yue (2012) point out that, working capital loans, estimated using the observed bank credit to the private sector as a share of output, are rather small in EMEs.

5. Our result that search-matching frictions contribute to higher wage variability might sound puzzling at first, because earlier studies, such as those of Andolfatto (1996) and Merz (1995), found that incorporating search-matching frictions in a setup with only TFP shocks would lower wage variability. A version of our model with only TFP shocks also preserves this feature. However, when the model economy is subject to countercyclical interest rate shocks along with TFP shocks, like the model we consider here, search-matching frictions contribute significantly to the variability of wages on account of the mechanism highlighted above.

feed into the variability of consumption and real wages and affect current account fluctuations. As for analyzing labor markets, Li (2011) presents the first contribution on this front by documenting the cyclical wage movements in EMEs. Unlike our setup, Li 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 to document the improvement in the model's performance in explaining U.S. business cycles. When we introduce search-matching frictions into an SOE—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 interest rate fluctuations. Our model is closely related to the aforementioned closed-economy models and is, essentially, a first-generation MP-type model, in which wages are determined by Nash bargaining applied to both existing workers and new hires.[6]

The rest of the paper is organized as follows. Section 1 documents the business cycle properties of labor market variables for both emerging economies and developed economies, as well as the empirical evidence motivating the matching efficiency shock. Section 2 lays out our model. Section 3 explains our calibration, solution, and main quantitative findings. Section 4 extends the model to analyze matching efficiency shocks. Finally, Section 5 concludes.

1. 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 the employment level—for a group of EMEs.[7] We also consider a group of developed economies for comparison. We use data at a quarterly frequency and our sample selection criterion is

6. 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 that leads to weaker feedback from current unemployment to wages. 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 bargaining setup. Considering alternative wage settings could possibly lead to interesting implications. However, our model takes an important first step by deviating from the standard SOE-RBC models. In fact, it can be extended to include heterogeneous agents, endogenous job separation, or alternative bargaining concepts to study policy-related issues for EMEs such as labor regulation, unemployment insurance, the role of institutions, etc.

7. The group of EMEs includes Brazil, Chile, Ecuador, Hungary, Israel, Korea, Malaysia, Mexico, the Philippines, and Turkey.

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	6.92	4.19	0.27	2.11	5.30	7.14	−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	1.36	1.31	0.36	0.39	1.45	2.43	−0.07
Israel	3.72	1.82	0.40	1.46	5.57	4.86	0.71
Korea	3.63	1.42	0.81	0.83	3.16	4.66	0.82
Malaysia	—	—	—	—	—	—	—
Mexico	5.20	2.22	0.56	1.48	8.75	5.92	0.50
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
Mean	4.64	2.06	0.32	1.18	4.23	5.36	0.16
Median	3.68	1.62	0.38	1.00	3.16	4.76	0.09
Developed markets							
Australia	1.95	1.47	0.36	0.79	1.72	2.61	0.22
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
The Netherlands	—	—	—	—	—	—	—
New Zealand	0.98	0.87	0.25	0.36	1.17	1.65	0.05
Norway	1.67	1.08	0.13	0.87	1.76	6.49	−0.28
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
Mean	1.19	0.84	0.04	0.45	1.23	2.50	−0.36
	(0.015)	(0.037)	(0.100)	(0.029)	(0.001)	(0.050)	(0.043)
Median	1.54	0.96	0.13	0.46	1.28	2.40	−0.28
	(0.000)	(0.047)	(0.115)	(0.001)	(0.000)	(0.001)	(0.035)

Notes: This table shows (i) standard deviation of real earnings, (ii) standard deviation of real earnings as a ratio to standard deviation of output, (iii) correlation of real earnings with output, (iv) standard deviation of real earnings as a ratio the standard deviation of manufacturing output, (v) standard deviation of nominal earnings, (vi) standard deviation of real earnings calculated using the PPI instead of the CPI, and (vii) correlation of real earnings, calculated using the PPI, with output. All series are HP-filtered using a smoothing parameter of 1600. See Appendix A for more information about data sources and coverage. The numbers in parentheses 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.

the availability of quarterly data.[8] All series are deseasonalized using the U.S. Census Bureau's X-12 ARIMA software, and then HP-filtered with a smoothing parameter of 1600 after taking the logarithm when appropriate.[9] See the Appendix A for more details on sources and calculations. In summary, we find that the variability of prices, that is, real earnings, is strikingly high in EMEs and that 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 nominal earnings by the Consumer Price Index (CPI), is significantly greater than the standard deviation of real output;

8. For example, we excluded Argentina from our sample because the data are available only at semi-annual frequency. The U.S. is excluded since we focus only on small open economies.

9. We also experimented with linear filtering and found that results are robust to the filtering technique.

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
Mean	11.40	4.92	−0.41	1.42	0.64	0.39
Median	9.64	4.43	−0.46	1.26	0.58	0.39
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	—	—	—
The 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
Mean	8.89	6.56	−0.33	1.25	0.91	0.47
	(0.284)	(0.099)	(0.498)	(0.359)	(0.018)	(0.451)
Median	9.06	6.31	−0.32	1.24	0.88	0.46
	(0.627)	(0.202)	(0.538)	(0.551)	(0.015)	(0.602)

NOTES: This table shows (i) standard deviation of unemployment rate, (ii) standard deviation of unemployment as a ratio of the standard deviation of output, (iii) correlation of unemployment rate with output, (iv) standard deviation of employment, (v) standard deviation of employment as a ratio of the standard deviation of output, and (vi) correlation of employment with output. All series are HP-filtered using a smoothing parameter of 1600. See Appendix A for more information about data sources and coverage. The numbers in parentheses 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.

the ratio between the two is 1.62. Real earnings are procyclical, as evidenced by their correlation of 0.38 with contemporaneous output. To check the robustness of these findings, we also report the ratio of real earnings variability to manufacturing output variability, nominal earning's variability, and real earnings variability calculated by using the Producer Price Index (PPI) deflator. Manufacturing output is more variable than GDP for all countries; therefore, the ratio of median real earnings variability to manufacturing output variability falls to 1.0 from 1.62. 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 statistics regarding the unemployment rate while the remaining three report those for employment.[10] The correlations of these

10. We analyze employment data in addition to the unemployment rate because unemployment statistics suffer from several deficiencies, including the inaccurate measurement of discouraged workers.

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 value for the ratio of standard deviation of the unemployment rate to standard deviation of output is 9.64 while that for employment is 0.58.[11]

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, 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 for developed economies (at the 5% confidence level) as evidenced by the small *p*-values of tests of equality of the means and medians of emerging market and developed economy statistics (Student's *t* for means and Mann–Whitney for medians), 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 are also more procyclical in developed economies. Compared to the differences between EMEs and developed countries established for earnings, the differences with regard to unemployment and employment are less significant from a statistical perspective except for the ratio of the standard deviation of employment 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.

The final set of empirical results are on the dynamics of hours worked both in the manufacturing sector and in the aggregate. These are reported in Table 3. Note that the data on hours worked are limited, particularly for EMEs, making it difficult to reach robust conclusions or to establish any statistically significant difference between EMEs and developed economies. That said, the available data suggest that hours are more variable than output and are procyclical, with a correlation to output of around 0.5. Developed economies display slightly more variable hours relative to output than EMEs, though the difference is not statistically significant. The correlations of hours with output in developed economies are very similar to those observed in EMEs.

To our knowledge, the only study that provides statistics on labor markets in the emerging market business cycles literature so far is that of Neumeyer and Perri

11. We report a set of statistics for hours worked in the manufacturing sector in columns 1–3 of Table 3 and approximate aggregate hours worked in columns 4–6 of the same table. The variability of hours worked in manufacturing normalized by the standard deviation of output is 1.58. Similarly, aggregate hours worked 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.

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
Mean	3.12	1.51	0.50	2.95	1.23	0.32
Median	3.42	1.58	0.57	2.35	1.24	0.47
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
The 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
Mean	2.72	1.97	0.57	1.79	1.29	0.55
	(0.511)	(0.120)	(0.534)	(0.144)	(0.739)	(0.264)
Median	2.98	1.96	0.68	1.70	1.24	0.65
	(0.699)	(0.189)	(0.518)	(0.041)	(0.797)	(0.239)

Notes: This table shows (i) standard deviation of hours worked in manufacturing, (ii) standard deviation of hours worked in manufacturing as a ratio of output standard deviation, (iii) correlation of hours worked in manufacturing with output, (iv) standard deviation of aggregate hours worked, (v) standard deviation of aggregate hours worked as a ratio of output standard deviation, and (vi) correlation of aggregate hours worked with output. All series are HP-filtered using a smoothing parameter of 1600. See Appendix A for more information about data sources and coverage. The numbers in parentheses 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.

(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.[12] 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.

12. Our statistics are not fully comparable with those reported by Neumeyer and Perri (2005) because they report labor market statistics using semiannualized data to make all other countries comparable with Argentina. Our statistics are based on quarterly data.

Nevertheless, we report the comparison of available statistics for working hours in Appendix A.

Some research has suggested that the lower variability in EMEs' employment statistics could be due to a relatively high proportion of employees working in the public sector, given the lower variability of 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 the other EMEs we consider. Therefore, we investigate whether there are EMEs that have data on the decomposition of public and private employment. For Turkey, this decomposition is available during the 2000–06 period at a quarterly frequency. We compare the variabilities of 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% versus 1.77%). It is difficult to argue that public sector employment does not function as unemployment insurance in the EMEs in our sample based on 7 years of data for only one country, but the limited data do not confirm the initial expectation that the public sector is 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, the Organisation for Economic Co-operation and Development (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% of total nonfarm employment in all four countries. These ratios appear to be larger than those for the developed small open economies.[13]

We argue that the larger size of informal sector in EMEs is not detrimental to our empirical analysis. First, some of our data for quantity variables for EMEs (employment, unemployment rate) are constructed based on household surveys, which implies that those data do 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 the two country groups with regard to wages would be even larger if our data were able to capture the informal sector. The OECD (2008) documents the earnings distributions for full-time, nonfarm employees in the formal and informal sectors in Mexico and Turkey. Based on its 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's of earnings in the formal sector in Mexico and Turkey, respectively, are 0.89 and 0.54, while those in the informal sector are 1.13 and 0.90. Hence, if the informal sector were included in our analysis of earnings, we would find an even stronger contrast between EMEs and developed economies.

13. The OECD (2004) documents that "black hours worked as a portion of white working hours" for Denmark, Norway, and Sweden are 3.8%, 2.6%, and 2.3%, respectively, significantly smaller than the informal-sector ratios for EMEs, although not exactly comparable with those figures.

2. AN SOE 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 that 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 ω governs the matching or allocative efficiency, and 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, $\theta_t = v_t/u_t$, captures the market tightness. There is a flow cost, κ, associated with posting a vacancy, as firms often have to put out a job advertisement and undertake screening and review processes. The probability that a searching worker finds a job is $\phi(\theta_t) = M(u_t, v_t)/u_t = \omega_t \theta_t^{1-\alpha}$. Correspondingly, the probability that an employer succeeds in filling a vacancy is given by $M(u_t, v_t)/v_t = \phi(\theta_t)/\theta_t$. Existing employer–worker pairs end at an exogenous breakup rate, ψ.

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 their income together for equal consumption.[14] 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, nonstate-contingent international bonds that facilitate borrowing and lending in international financial markets. Following the emerging market business cycle literature, we assume that the interest rate on international bond holdings is exogenous and subject to shocks. Financial markets for hedging against aggregate TFP and interest rate shocks are incomplete. In the following section, we return to discussing the decentralized economy with employed workers, unemployed workers, and firms, where wages are determined by the Nash bargaining between workers and firms.

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, $\varepsilon_t = [\varepsilon_t^z, \varepsilon_t^r]$. ε_t^z denotes TFP shocks and ε_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 derived from consumption, and $H(1-l_t) = (1-l_t)^{1-\nu}/(1-\nu)$ denotes the utility derived from leisure, $1 - l_t$. σ denotes the CRRA coefficient, and $1/\nu$ governs the (Frisch) elasticity of labor supply. The per period utility function, therefore, is $U(c_t) + \varphi^i H(1-l_t)$, where $i = E, U$ for employed and

14. Another interpretation is that markets for idiosyncratic unemployment risk are complete so that family members can fully diversify this risk using state-contingent claims.

unemployed workers, respectively, which implies that the value of leisure depends on a worker's 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 ζ represents the capital share of production. z_t denotes TFP and is equal to $(1+\varepsilon_t^z)z$. 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; $l_t = l$.[15] Once offered a job, workers always supply a fixed amount of labor.

In line with some other SOE models—for example, those of Mendoza and Smith (2006), Durdu and Mendoza (2006), Durdu, Mendoza, and Terrones (2009), and Mendoza and Yue (2012)—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 saving. 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. So-called "Fisher separation," which is present in this class of models, causes 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 investment would not distort consumption and debt dynamics significantly.

2.1 The 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:[16]

$$V(b_t, u_t, \varepsilon_t) = \max_{c_t, b_{t+1}, u_{t+1}, v_t} U(c_t) + (1-u_t)\varphi^E H(1-l) + u_t \varphi^U H(1) + \beta(c_t)\mathbb{E}_t V(b_{t+1}, u_{t+1}, \varepsilon_{t+1}) \quad (1)$$

$$\text{s.t.} \quad c_t + b_{t+1} + \kappa v_t \le F(k, (1-u_t)l, z_t) + b_t(1+r_t), \quad (2)$$

$$u_{t+1} \ge [u_t - M(u_t, v_t)] + (1-u_t)\psi, \quad (3)$$

$$b_{t+1} \ge \bar{B}, \quad (4)$$

15. In the Mexican data, 81% of the variance in total hours worked in manufacturing is accounted for by changes in employment rather than changes in hours per worker.

16. Using a separable utility function allows the social planner to allocate consumption independently of employment status.

where $\beta(c_t)$ denotes the endogenous discount factor, which we introduce to induce stationarity of bond holdings.[17] Using Epstein's (1983) stationary cardinal utility formulation, this function boils down to $\beta(c_t) = (1 + c_t)^{-\gamma}$, where γ is the elasticity of the rate of time preference.[18] The optimal choices of c_t, b_{t+1}, u_{t+1}, and v_t are as follows:

$$U'(c_t) - \mu_t = \beta(c_t)\mathbb{E}_t U'(c_{t+1})(1 + r_t), \tag{5}$$

$$U'(c_t)\kappa = \beta(c_t)M_{v,t}\mathbb{E}_t\left[-\frac{\partial V(b_{t+1}, u_{t+1}, \varepsilon_{t+1})}{\partial u_{t+1}}\right], \tag{6}$$

where μ_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—that is, 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.

Define S_t as the marginal increase in utility that results from an additional job match (expressed in terms of final goods). By the envelope condition, we have

$$\begin{aligned} S_t = -\frac{\partial V(b_t, u_t, \varepsilon_t)}{U'(c_t)\partial u_t} &= \frac{\varphi^E H(1-l) - \varphi^U H(1)}{U'(c_t)} \\ &+ F_{l,t}l + (1 - \psi - M_{u,t})\mathbb{E}_t\rho_{t,t+1}S_{t+1}, \end{aligned} \tag{7}$$

where ρ is the stochastic discount factor of the household when the borrowing constraint does not bind and is defined as $\rho_{t,t+1} = \beta(c_t)U'(c_{t+1})/U'(c_t)$, and $M_{u,t} = \alpha\phi(\theta_t)$. The first term on the right-hand side captures the net loss in the utility of leisure to the newly employed worker compared to being unemployed. The second term stands for the contribution to output, measured in marginal utility terms, the employment of one more worker, and the last term measures the continuation value of future employment. S_t can be interpreted as the joint matching surplus of employers and workers.

Note that when the interest rate rises, equation (5) implies that future consumption becomes less expensive and the household consume less today and save more. In addition, other things being equal, equation (7) suggests that the joint surplus from future employment is discounted at a higher rate, thus, the value of making a match declines.

17. See Schmitt-Grohe and Uribe (2003) for detailed discussions on other methods that also induce stationarity in SOE models.

18. Mendoza (1991) introduces preferences with endogenous discounting to SOE models. Other formulations used for this purpose can be found in Schmitt-Grohe and Uribe (2003).

2.2 Decentralized Economy with Wages Determined by Nash Bargaining

In the social planner's problem, wages are absent and the social planner decides and implements the Pareto optimal allocations. In this section, we analyze a decentralized world, where the sequence of wage rates $\{w_t\}$ is determined by Nash bargaining between workers and firms.[19] In our setting, the markets for aggregate shocks are incomplete but the household may partially insure against these shocks through precautionary savings.

The externality generated by each side of the labor market—both employers and firms—is a crucial aspect of the labor market's behavior. When the number of vacancies posted by 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, an 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 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:

$$-\frac{\partial V_t^H}{\partial u_t} = E_t - U_t. \tag{8}$$

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:

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

19. Important ways in which our model deviates from the standard MP type of search model (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 the household can borrow from the rest of the world.

With a similar interpretation as in the social planner's problem, we can lay out the envelope condition as follows:

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

Firms. Firms are owned by the household and therefore discount expected future profits according to the same stochastic discount factor used by 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

$$-\frac{\partial V^F(u_t, \varepsilon_t)}{\partial u_t} = F_{2,t}l - w_t l + \mathbb{E}_t \rho_{t,t+1} \frac{\partial V^F(u_{t+1}, \varepsilon_{t+1})}{\partial u_{t+1}}(1-\psi), \tag{9}$$

and the first-order condition with respect to v_t implies that

$$\kappa = \frac{\phi(\theta_t)}{\theta_t}\mathbb{E}_t \rho_{t,t+1} \frac{\partial V^F(u_{t+1}, \varepsilon_{t+1})}{\partial u_{t+1}}. \tag{10}$$

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 preexisting 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,

$$-\frac{\partial V^F(u_t, \varepsilon_t)}{\partial u_t} = J_t - Q_t. \tag{11}$$

Nash bargaining. Wages of new and existing workers are set by period by period Nash bargaining. Assuming that employed workers' bargaining power is $\xi \in (0, 1)$, the matched worker–firm pair negotiates over wages 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.

$$J_t - Q_t = \frac{1-\xi}{\xi}\frac{E_t - U_t}{U'(c_t)}. \tag{12}$$

Combining equation (12) with equations (8), (10), and (11), we have the wage determination

$$w_t = \xi\left(F_{2,t} + \frac{\kappa\theta_t}{l}\right) + (1-\xi)\frac{\varphi^U H(1) - \varphi^E H(1-l)}{lU'(c_t)}. \tag{13}$$

Based on (10), (11), and (12), we also have

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

which captures the value of reentering the job market and possibly becoming employed in the next period. Thus, equation (13) can be further rewritten as

$$w_t l = \xi l F_{2,t} + (1-\xi)\left[\frac{\varphi^U H(1) - \varphi^E H(1-l)}{U'(c_t)} + \phi(\theta_t)\beta(c_t)\mathbb{E}_t\frac{(E_{t+1} - U_{t+1})}{U'(c_{t+1})}\right]. \tag{14}$$

That is, wage compensation is determined not only by the product of labor $lF_{2,t}$, but also by the value of being unemployed, enjoying more leisure, 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.

In addition, as is well known in the search-matching literature, in order for the decentralized equilibrium to correspond to the social planner's result, the Hosios

(1990) condition must hold: $\alpha = \xi$. That is, the bargaining power of firms must correspond to the elasticity of the matching technology with respect to recruiting effort (see Appendix C for the proof of this).

2.3 Equilibrium Definition

DEFINITION 1. *Given the exogenous state* $(\varepsilon_t^z, \varepsilon_t^r)$*, the search equilibrium is defined as time paths of allocations* $(c_t, y_t, b_t, u_t, v_t, l)$ *that satisfy social planner's resource constraint, optimal intertemporal substitution conditions, and an optimal law of motion of unemployment (equations (2), (3), (4), (5), and (6)) and the output function, as well as, time paths of prices* (r_t, w_t) *that satisfy equations (5) and (13).*

3. QUANTITATIVE ANALYSIS

3.1 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%, the average of Emerging Market Bond Index (EMBI) yields for Mexico over the sample period.[20] The risk aversion parameter, σ, is 2, the value 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 equaling $1 - 0.69$ from the budget constraint to capture the share of investment and government expenditures in output. According to the OECD's Annual Hours and Productivity data, an average worker in Mexico spent 32% of his or her nonsleeping time on market activities during the sample period. Therefore, working hours, l, is set to 0.32.

We set the natural breakup rate, ψ, 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% so that the mean unemployment rate in the stochastic steady state matches the average unemployment rate in the data.[21] Combining this information with the natural breakup rate implies a steady-state value of 0.055 for matches formed, $m^* = (1 - u^*)\psi$. Faced with a lack of evidence on the probability that a vacant position becomes an active job by the end of the quarter, we assume that the

20. EMBI yields for Mexico cover 1993Q4–2008Q4.

21. In the data from International Financial Statistics (IFS), the unemployment rate for Mexico is 3.65%. Notice that because of precautionary savings incentives, the unemployment rate in the stochastic steady state is lower than that in the deterministic steady state.

TABLE 4
CALIBRATED PARAMETERS

Parameter	Value	Explanation	Source
Preferences			
σ	2	Relative risk aversion	Literature
β	0.983	Steady-state discount factor	Inverse of gross real interest rate
ν	3.54	Elasticity of leisure	Frisch elasticity of labor supply is 0.6
φ^E	1.1599	Coefficient of leisure in utility (employed)	Calculation
φ^U	0.1915	Coefficient of leisure in utility (unemployed)	Calculation
Production technology			
z	1	Total factor productivity	Normalization
ζ	0.36	Capital's share in output	Literature
Search technology			
ω	0.778	Matching efficiency	$\omega = \frac{m^*}{u^{*\alpha} v^{*(1-\alpha)}}$
α	0.5	Elasticity of matching function	Petrongolo and Pissarides (2001), Shimer (2005)
κ	0.127	Unit cost of posting vacancy	Recruiting expenditure as 1% of GDP
ψ	0.06	Natural breakup rate	Bosch and Maloney (2008)
ξ	0.5	Bargaining power	The same as α
Shock processes			
ρ_z	0.61	Persistence of TFP shocks	VAR estimation
ρ_r	0.69	Persistence of int. rate shocks	VAR estimation
$\rho_{z,r}$	−0.17	Effect of lagged int. rate on TFP shocks	VAR estimation
$\rho_{r,z}$	0.19	Effect of lagged TFP on int. rate	VAR estimation
e_z	0.0004	Covariance of TFP shocks	VAR estimation
e_r	0.0009	Covariance of int. rate shocks	VAR estimation
$e_{z,r}$	−0.00048	Cross covariance	VAR estimation
Other			
r	1.74	World interest rate	EMBI data
$\overline{b}$	−1/3	Steady-state bond holdings	Data

job finding rate, $\frac{\phi(\theta)}{\theta}$ equals 0.7—corresponding to an average vacancy duration of 45 days, slightly shorter than in Andolfatto (1996).

In our baseline experiment, the recruiting expenditure to GDP ratio, κv^*, is assumed to be as small as 0.01, which is in line with Andolfatto (1996). The unit cost of posting a vacancy becomes $\kappa = 0.01/v^* = 0.127$. We set the capital share parameter, ζ, 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 that this expression equals 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 the aggregate unemployment rate, α, must be the same as the bargaining power, ξ, in order for the wages implied by Nash bargaining to support the allocations obtained from the social planner's problem. We follow Andolfatto (1996) and set α to 0.5. Given the values for v^*,

m^*, u^*, and α, we can calculate the matching efficiency parameter, ω, using the steady-state condition $\omega = \frac{m^*}{u^{*\alpha} v^{*(1-\alpha)}} = 0.687$. The remaining parameters, φ^E and φ^U, are jointly determined by the efficiency condition of labor hours and the optimality condition for unemployment.

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 rates for Mexico—in particular, Solow residuals and EMBI yields.[22] We construct interest rate series by deflating the dollar-denominated EMBI yields by adaptive U.S. inflation.[23] We then feed into 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 ($\rho_{z,r} = -0.8$).

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

$$\varepsilon_t = RHO \cdot \varepsilon_{t-1} + e_t, \tag{15}$$

where

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

3.2 *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 for capturing precautionary saving and large deviations in the equilibrium net foreign asset position in the stochastic steady state relative to its deterministic counterpart because of the presence of interest rate shocks.[24] A nonlinear solution method, however, forces us to keep our model relatively stylized because of curse of dimensionality.

As a first step in our solution algorithm, we solve for the social planner's problem discretizing the bond grid in the interval $[-1.0, 4.0]$ with 200 equidistant nodes and

22. See Appendix B for further details.

23. As pointed out by Neumeyer and Perri (2005), large swings in local inflation 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 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.

24. We also experimented with log-linear approximation and found that the dynamics captured with that method markedly differ from our nonlinear approximation in the presence of countercyclical interest rate shocks. Log-linear approximation appears to capture the dynamics relatively better when there are only TFP shocks. Our results with log-linear approximation are available upon request.

the unemployment grid in the interval [0.02, 0.07] interval with 20 equidistant nodes. Our solution is robust to the number of 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.

3.3 Model Dynamics

The impulse responses of the main aggregate variables to exogenous shocks help develop intuition about the 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: $\text{corr}(e^z_t, e^r_t) = 0$. The scenario with both of the shocks, however, features $\text{corr}(e^z_t, e^r_t) < 0$, as estimated in our baseline calibration.

In response to the negative TFP shock, on impact, firms reduce their vacancy postings, 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.[25] With slackened labor market and a less attractive outside option of nonmarket activities, the equilibrium wage drops. Output falls on impact because of lower productivity. In order to smooth consumption, households borrow from the international capital markets and accumulate debt. Because markets for aggregate shocks are incomplete, 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—TFP shocks alone cannot account for volatile consumption relative to output or for the strongly countercyclical current account.

Interest rate shocks affect the optimal bond holdings and the current account to GDP ratio differently from TFP shocks. In particular, in response to a positive interest rate shock, households increase saving, causing an increase in current-account-to-GDP ratio. This is because higher interest rates imply that current consumption is more expensive relative to future consumption (equation (5)) and make it optimal for consumers to postpone consumption and increase saving. The increase in saving is further amplified because of search-matching frictions. With lower future employment prospects (as discussed next) and a large fall in wages, workers' incentives to save for the future are boosted. As a result, the economy runs a large current

25. The noise-like fluctuations in unemployment and vacancy rates in the top two panels of Figure 3 are due to the discretization of unemployment with a relatively low number of nodes while solving the model.

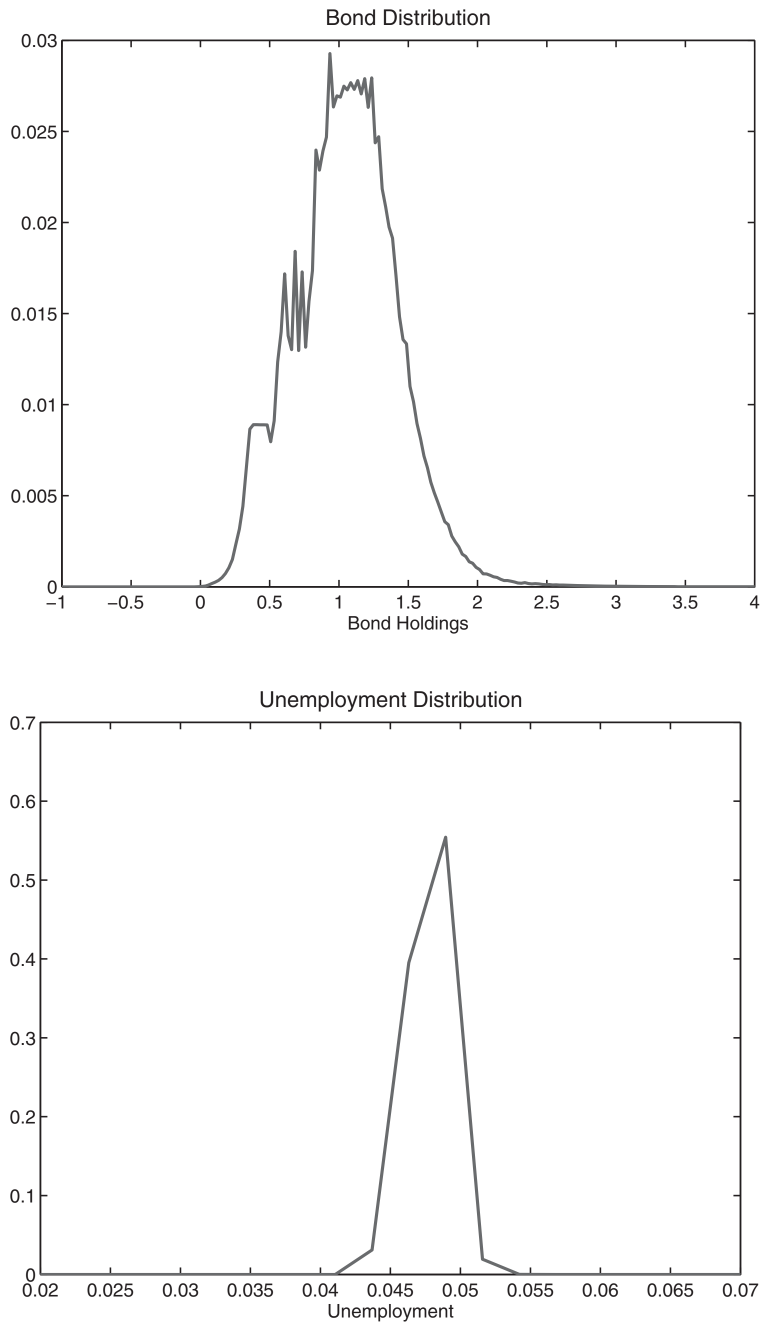

FIG. 1. Limiting Distributions of Endogenous State Variables.

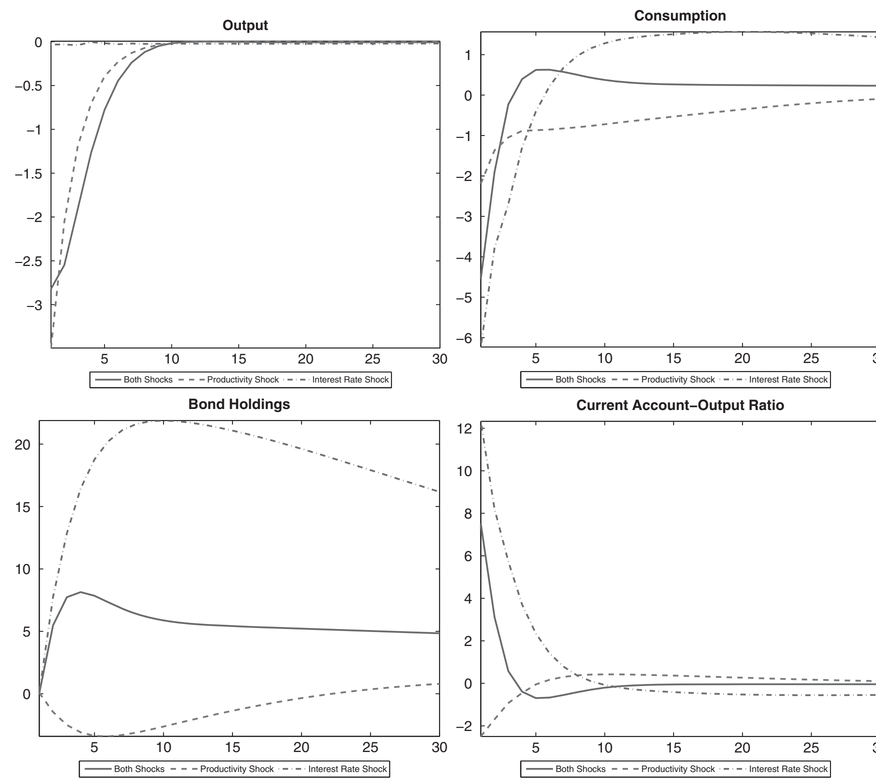

FIG. 2. Impulse Response Functions: Main Macroeconomic Variables.

NOTES: The figures show the impulse responses of the main macroeconomic variables to one-standard-deviation negative TFP shocks (dashed line), one-standard-deviation positive interest rate shocks (dash-dotted line), and simultaneous one-standard-deviation negative TFP and positive interest rate shocks (solid line) in our baseline model with search-matching frictions. With TFP shocks, output falls on impact because of lower productivity. Households borrow from the international capital markets and accumulate debt to smooth consumption. With incomplete markets, the borrowing from abroad cannot entirely offset the decline in output; hence, consumption decreases and the economy runs a current account deficit. In response to a positive interest rate shock, households increase saving, causing an increase in the current account–GDP ratio. The decline in output as a result of the interest rate shock is minuscule because TFP does not change and unemployment increases only marginally.

account surplus and consumption drops significantly (by 6%) 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.[26]

26. Our finding that the decline in output as a result of interest rate shocks is only minuscule is very much in line with the earlier literature. Mendoza (1991), for instance, finds that interest rate shocks alone would lead to very little movements in output. Findings of Neumeyer and Perri (2005) and Uribe and Yue (2006) also imply that without additional amplification—for instance, because of working capital constraints—interest rate shocks would lead to small output fluctuations.

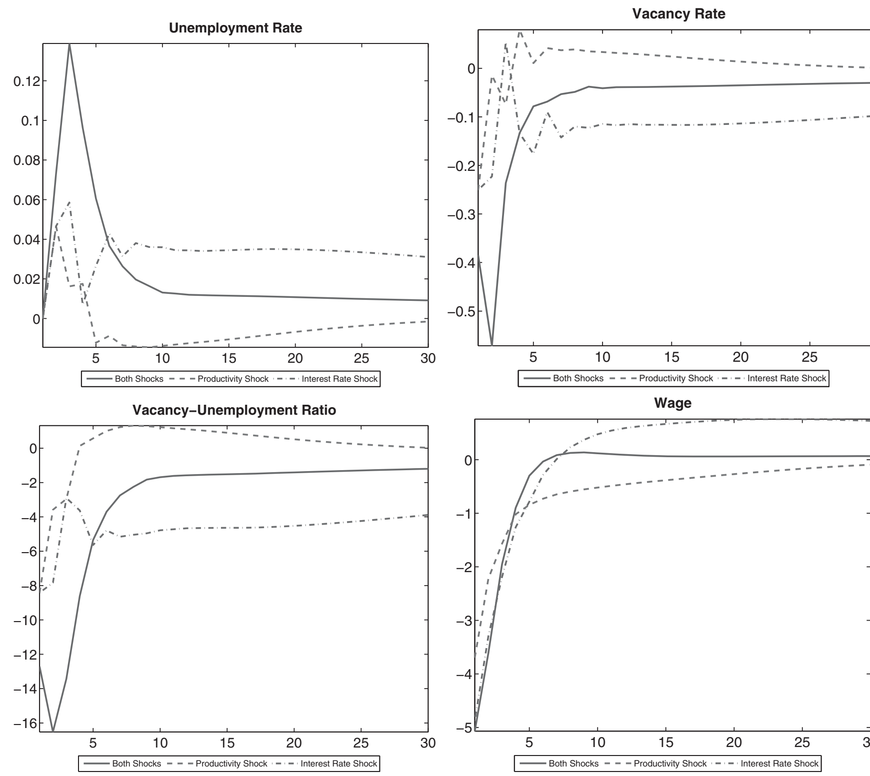

FIG. 3. Impulse Response Functions: Labor Market Variables.

NOTES The figures show the impulse responses of the main macroeconomic variables to one-standard-deviation negative TFP (dashed line), one-standard-deviation positive interest rate shocks (dash-dotted line), and simultaneous one-standard-deviation negative TFP and positive interest rate shocks (solid line) in our baseline model with search-matching frictions. A higher interest rate depresses the discounted future return to recruiting, leading to a decline in recruiting efforts, a lower job-finding rate, and a slacker labor market with higher unemployment. The higher interest rate leads to a lower wage because the value to firms of making a match declines and the value to workers of becoming unemployed also declines (with a low level of consumption the marginal value of becoming unemployed falls). The interest rate shock has quantitatively larger effects on labor market variables than the TFP shocks, particularly on wages.

Figure 3 shows that the equilibrium responses of labor market variables to the positive interest rate shock are qualitatively similar to the corresponding responses to the negative TFP shock. A higher interest rate depresses the discounted future return to recruiting (equations (5) and (9)). The immediate effect is a decline in recruiting efforts, a lower job-finding rate, and a slacker labor market with higher unemployment. Equation (13) on wage determination suggests that since firms discount future revenues with a higher weight, they have less to lose from not making a match, which also puts downward pressure on wages. The immediate effect is a deterioration in labor market conditions, a lower value of unemployment from the perspective of workers, and a lower value of creating a match from the perspective of firms.

Furthermore, a low level of consumption in bad times because of higher interest rate leads to an increase in the marginal utility of consumption that reduces the net gain to workers from leaving the negotiation process and enjoying more leisure. Overall, the interest rate shock has quantitatively larger effects on labor market variables than the TFP shocks, particularly on wages.

When both interest rate and TFP shocks hit the economy simultaneously, the effect of the interest rate shock on saving dominates the incentives to borrow in order to smooth consumption that arise from the 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 a 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 that changes in vacancies are only reflected in employment with a lag. The prospect of higher unemployment strengthens the precautionary savings 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 lifetime income becomes even lower because of the search frictions. The large drop in the permanent income and incentives for stronger precautionary saving lead to a large fall in consumption.

In sum, our experiments show that TFP shocks play an important role in generating realistic output responses that interest rate shocks alone cannot achieve. However, interest rate shocks are necessary to cause consumption to respond more than output, to cause real wages to respond more than output, and to cause 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 increasing persistence, since new matches take time to form and unemployment declines only gradually.

3.4 Main Findings

Table 5 reports statistics describing the cyclical behavior of the Mexican economy as well as 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 except those in columns 4 and 5, where we shut down one shock at a time to isolate the importance of each shock.

The first column of Table 5 suggests that the salient features of EME business cycles are preserved in the Mexican data.[27] 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 1, wages are procyclical and more variable than income, and unemployment is countercyclical and highly variable. Unfortunately, because of data limitations, we are not able to obtain an

27. Note that when we refer to business cycle features, we focus on not only the cyclical fluctuations of output, but also those of consumption, the current account, and the labor market.

TABLE 5

BUSINESS CYCLE MOMENTS

		RBC	Search and matching		
	Data	Prod and int rate	Baseline	Only prod	Only int rate
Standard deviation					
$\sigma(u)$	14.70	n.a.	3.24	2.10	3.04
$\sigma(v)$	n.a.	n.a.	5.59	3.90	5.51
$\sigma(\theta)$	n.a.	n.a.	17.53	10.34	15.62
$\sigma(w)/\sigma(y)$	2.22	0.31	1.67	0.83	n.a.
$\sigma(c)/\sigma(y)$	1.26	0.78	1.35	0.79	n.a.
Correlation with y					
$\rho(y, ca/y)$	−0.75	−0.13	−0.46	0.97	−0.09
$\rho(y, u)$	−0.78	n.a.	−0.68	−0.26	0.10
$\rho(y, v)$	n.a.	n.a.	0.51	0.16	−0.41
$\rho(y, w)$	0.56	1.00	0.83	0.82	0.01
$\rho(y, \theta)$	n.a.	n.a.	0.77	0.33	0.16
$\rho(u, v)$	n.a.	n.a.	−0.94	−0.96	−0.95
Autocorrelation					
$\rho(c)$	0.70	0.75	0.60	0.87	0.56
$\rho(y)$	0.75	0.64	0.63	0.67	1.00
$\rho(ca/y)$	0.72	0.41	0.45	0.65	0.45
$\rho(u)$	0.84	n.a.	0.67	−0.32	−0.10
$\rho(v)$	n.a.	n.a.	n.a.	−0.65	−0.52
$\rho(w)$	0.85	0.64	0.63	0.54	0.34
$\rho(\theta)$	n.a.	n.a.	n.a.	0.09	0.27

NOTES: This table shows business cycle moments. The columns show the moments, respectively, in the data, the RBC model with both productivity and countercyclical interest rate shocks but Walrasian labor markets, the baseline search-matching model with both TFP and countercyclical interest rate shocks, the search-matching model only with TFP shocks, and the search-matching model only with interest rate shocks. The RBC model features GHH preferences, whereas the search-matching model features time-separable CRRA preferences. This table shows that in the data wages are more variable than income, unemployment is countercyclical, consumption are more variable than income, and current account–GDP ratio is countercyclical. The baseline scenario accounts for these regularities reasonably well.

empirical measure for vacancies in Mexico, and thus cannot compare our model against data in this dimension.

Canonical SOE-RBC model. We consider a canonical RBC model into which we feed the same TFP and interest rate shock processes as in our baseline search-matching model (see Appendix D). 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" of replicating the Mexican data when the model economy is subject to TFP and countercyclical interest rate shocks (the GHH preferences appear crucial for replicating SOE business cycles; see Correia, Neves, and Rebello 1995). However, we do not consider incorporating any further frictions or shock processes (e.g., trend shocks, terms of trade shocks) that the literature has found useful in replicating some of the EME macroeconomic regularities. Our rationale for not doing so is to isolate the extent to which search-matching frictions help amplify the effect of TFP and countercyclical interest rate shocks and to bring the model implications closer to the data.

As shown in column 2 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 the current-account-to-GDP ratio is only weakly countercyclical (the correlation with output equals -0.13 compared to -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 in 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. Note also 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 are perfectly correlated with output, as wages are tightly connected to the marginal product of labor in a spot labor market.

Search-matching model with TFP and countercyclical interest rate shocks. Our baseline model with search-matching frictions, TFP, and countercyclical interest rate shocks 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 a strongly countercyclical current account (note that correlation of current account with output is -0.46), all of 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 regard to employment.

The "Only prod" column of Table 5 reports the results of a scenario in which only aggregate productivity shocks are prevalent. In this case, external adjustments are useful for smoothing consumption: households borrow and save to prevent large fluctuations in consumption. Thus, the model generates less variable consumption (the ratio of the standard deviation of consumption to the 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 the standard deviation of wages to the 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 workers' outside option does not fluctuate as much in the wage-bargaining process in response to TFP shocks.

The "Only int rate" 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 larger fluctuations in consumption, as they directly affect intertemporal decisions on consuming and saving, but have little impact on output.[28] As a result of the negligible movements in output in response to interest rate shocks, the standard deviation of output is very small and hence we do not report the ratio of the standard deviations of consumption and output.

As for the labor market dynamics, this setup with only interest rate shocks generates countercyclical vacancies and slightly procyclical unemployment, which appear to be 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 $\rho(y, u) = 0.10$.

The variability of consumption generated in our search-matching model leads to a larger decline in wages. Since the equilibrium wage is a convex combination of the 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 for workers from leaving the negotiation process and enjoying more leisure. A much tighter job market during the downturn makes it harder to find a job in the following periods, lowering workers' threatening point in the wage bargaining. Wage variability is further reinforced by the variations in firms' expected return from a match because of variations in the interest rate. 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 of delivering a negative correlation between the unemployment and the vacancy rate, consistent with the "Beveridge curve."[29]

3.5 Sensitivity Analysis

We now discuss our sensitivity analysis, which 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, κ, from 0.127 to 0.1. As the

28. As discussed earlier, this is very much in line with the earlier literature.

29. 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 indicates 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.

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 with alternative parameterizations highlighted in respective column headings.

search cost of firms is lowered, more vacancies are posted one period after a negative TFP shock, inducing more rapid reversion of the vacancy rate 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 in the wage bargaining process rises because of the greater probability of finding a job in the following period and the higher value of leisure in consumption terms. Therefore, the variability of wages decreases relative to that of output.

In the second experiment, we raise the natural separation rate, ψ, from 6% to 8%. Similar to the previous sensitivity analysis, raising ψ decreases workers' continuation value of being currently employed as employment duration becomes shorter. For firms, the continuation value of posting a vacancy is also reduced as an existing match has a higher probability of ending. *Ceteris paribus*, the total surplus from a successful new match decreases with the higher natural breakup rate. Hence, the vacancy rate responds less to exogenous shocks, and consequently, the unemployment rate also becomes less responsive. Both vacancy and unemployment become less variable and more persistent compared to the benchmark case. Consistent with the slightly more stable labor market, the variabilities of consumption and wages decline.

Next, we examine the importance of the matching efficiency parameter, ω, by raising it from 0.778 to 0.85. In this case, more matches are formed for the same pair of unemployment and vacancy, which implies that search frictions become less severe.

The results indicate that both consumption and wages become less variable and the current account becomes weakly countercyclical. In an extreme case where matching is infinitely efficient, the probability of finding a job or filling a vacancy is close to one.[30] An unemployed worker still experiences 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 because of workers' increased bargaining power.

Finally, we examine the importance of workers' Nash bargaining weight, ξ. In order for the decentralized equilibrium to be the first best, the elasticity of the matching function with respect to unemployment, α, also has to change accordingly with ξ. As shown in the last column of Table 5, when ξ and α increase from 0.5 to 0.7, the unemployment rate varies less while the vacancy rate 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 (13), 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. Overall, these sensitivity exercises show that our results are generally robust to changes in the key search-matching parameters. Hence, MP-type search frictions appear to better characterize the labor markets of EMEs than Walrasian labor markets.

3.6 EMEs versus Developed Countries

Our experiments show that the countercyclicality of interest rate shocks contributes significantly to the salient features of EMEs relative to developed countries. Table 7 provides a comparison of the business cycle moments in the data on one of each of these two types of countries (Mexico and Canada) and then reproduces the results of the baseline search-matching model with both interest rate and productivity shocks as well as those of the case with interest rates shut down. Since we do not recalibrate our model to a developed country, the comparison here is more qualitative than quantitative in spirit and rests on the idea that interest rate shocks play a smaller role in developed economies and, hence, the case without those shocks can be expected to roughly match developed economy business cycle patterns. In relying on the countercyclicality of interest rate to differentiate EMEs from developed countries, we follow existing studies such as those of Neumeyer and Perri (2005) and Uribe and Yue (2006), among others.[31]

30. In this case, the matching function becomes $M(u_t, v_t) = \min(u_t, v_t)$, 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.

31. As we discussed in the Introduction, while we emphasize the importance of the interaction of countercyclical interest rate shocks with search-matching frictions in driving EME business cycles, by no means, do we rule out the importance of other driving forces, such as the existence of trend shocks, greater uncertainty, or terms of trade shocks, which earlier research has emphasized.

TABLE 7

Emerging versus Developed Economies

	EME data	Dev. data	Baseline	Only prod
Standard deviation				
$\sigma(u)$	14.70	8.64	3.24	2.10
$\sigma(v)$	n.a.	n.a.	5.59	3.90
$\sigma(\theta)$	n.a.	n.a.	17.53	10.34
$\sigma(w)/\sigma(y)$	2.22	0.58	1.67	0.83
$\sigma(c)/\sigma(y)$	1.26	0.74	1.35	0.79
Correlation with y				
$\rho(y, ca/y)$	−0.75	−0.12	−0.46	0.97
$\rho(y, u)$	−0.78	−0.04	−0.68	−0.26
$\rho(y, v)$	n.a.	n.a.	0.51	0.16
$\rho(y, w)$	0.56	−0.24	0.83	0.82
$\rho(y, \theta)$	n.a.	n.a.	0.77	0.33
$\rho(u, v)$	n.a.	n.a.	−0.94	−0.96
Autocorrelation				
$\rho(c)$	0.70	0.80	0.60	0.87
$\rho(y)$	0.75	0.93	0.63	0.67
$\rho(ca/y)$	0.72	0.66	0.45	0.65
$\rho(u)$	0.84	0.91	0.67	−0.32
$\rho(v)$	n.a.	n.a.	n.a.	−0.65
$\rho(w)$	0.85	0.43	0.63	0.54
$\rho(\theta)$	n.a.	n.a.	n.a.	0.09

Notes: This table compares the business cycle moments of emerging and developed economies. The first two columns show the moments in the EME and developed economy data, and the third and fourth columns reproduce the moments in the baseline search-matching model with both TFP and countercyclical interest rate shocks and the search-matching model only with TFP shocks, respectively.

As Table 7 demonstrates, when we shut down the countercyclical interest rate shocks, the variability of consumption becomes lower than that of output, as does the variability of wages, and the countercyclicality of the current account vanishes. These changes bring the moments closer to those observed in the Canadian business cycles reported in the second column. More specifically, the ratio of the variability of consumption to that of output declines from 1.35 in the baseline to 0.79 in the case without interest rate shocks, bringing the model very close to the value of 0.74 observed in the Canadian data. Similarly, the ratio of the variability of wages to that of output also declines, and the case with only productivity shocks comes fairly close to the data, 0.83 versus 0.58. With regard to the current account, the model without interest rate shocks predicts strong procyclicality, which is a move in the right direction, but overshoots since for Canada the current account is not procylical but acyclical.

While the presence of interest rate shocks is crucial in differentiating EMEs from developed economies, our sensitivity analysis shows that the severity of the search-matching frictions is less so. That said, it is important to note that there is no single parameter that governs the severity of these frictions; instead, there are several parameters that capture different aspects. We investigate each one in turn and find that, in line with the predictions of our model, the data do not suggest more severe search-matching frictions for either type of economy.

Reducing the cost of posting a vacancy or increasing the matching efficiency makes labor market frictions less prevalent. With more intensive use of Internet technology and online social networks, it seems plausible that developed economies enjoy a higher matching efficiency. Similarly, better access to these technologies may make it less costly to post a vacancy. Both of these parameter changes bring the model closer to the data on developed economies, as reported in Table 6. Looking at the key moments, wages and consumption become less variable and the current account less countercyclical.

As for the separation rate, while a higher separation rate lowers the variablity of wages and consumption, it makes the countercyclicality of the current account more prominent. Hence, while two of the key moments get closer to those of developed economies, the third does not. As explained in detail in the section on sensitivity analysis, the main change that occurs as a result of a higher separation rate is lower variability in unemployment; in this sense, the model gets closer to capturing developed economy patterns because as shown in Table 7, the standard deviation of unemployment is significantly smaller for Canada than for Mexico. From an empirical standpoint, it is not clear whether the separation rate should be higher in EMEs or in developed economies. For instance, laws that make firing and hiring difficult may contribute to the rigidity of labor markets in emerging economies. However, some evidence suggests that labor unions may be less powerful in poorer countries, which may make it easier to fire workers, contributing to the flexibility of labor markets in EMEs.

Greater bargaining power for workers pushes the variability of wages and consumption in opposite directions while strengthening the current account's countercyclicality. Similar to the separation rate, our model provides mixed evidence, with consumption dynamics getting closer to developed economy moments while the other two key moments move further away. On the one hand, weaker labor unions may imply less bargaining power for workers in EMEs. On the other hand, some EMEs may have regulations that empower workers through some form of social protection.

4. MATCHING EFFICIENCY SHOCKS

Our baseline model performs well in accounting for EME business cycles generally but falls short of accounting for the variability of unemployment. On this front, we inherit the typical drawback of search-matching frictions, in line with Shimer's (2005) critique. In this section, we illustrate how incorporating matching efficiency shocks could bring the model's implications for unemployment variability closer to the data. For this purpose, we introduce a random disturbance, ε_t^{ω}, to the matching efficiency, which was a fixed parameter in our baseline experiments. More specifically, we add shocks ε^{ω} 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 ω_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).[32] We consider these shocks and their interaction with the other shocks to 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, 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 different 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 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 1994–95, massive sectoral reallocations took place as the depreciation of real exchange rates drove down the relative price of nontradable goods. The employment share of the tradable 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 reallocation are observed in other Sudden Stop episodes: for example, Chile 1981–84, 1998–99 and Colombia 1998–99.[33,34] Moreover, Benjamin and Meza (2007) argue that Sudden Stops raise the cost of imported intermediate inputs 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 shocks on business cycle variables when matching across sectors is inherently more difficult than matching within sectors.

Unfortunately, data on direct measures of new hires and the 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 are almost 10 times more variable than those to the technology shock and that these two shocks are positively correlated. In line with this observation, we experiment with matching efficiency shocks that are positively

32. When his model is calibrated to U.S. data, Andolfatto (1996) finds that including matching efficiency shocks changes the variability of wages in the opposite of desired direction.

33. We date the Sudden Stops using the definition of Gallego and Tessada (2008): a Sudden Stop is a period (i) annual capital flow falls at least two standard deviations below its sample mean at least once, (ii) that begins the first time the annual drop in capital flow is one standard deviation below the sample mean, and (iii) that ends when it rises one standard deviation above the mean. The employment data are obtained from the International Labour Organization (ILO). We categorize agriculture, mining, manufacturing, and utility supply as the tradable sector and construction and services as the nontradable sector.

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

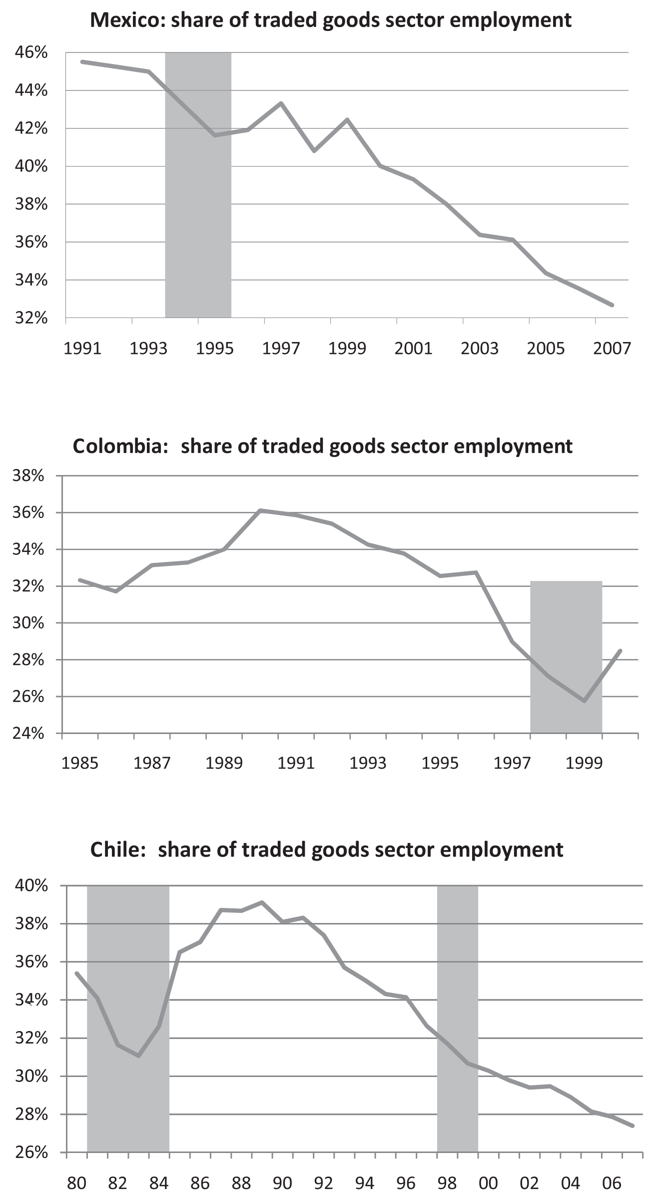

Fig. 4. Sectoral Decomposition of Employment.

Notes These charts show the share of the tradable sector employment relative to the nontradable sector employment. Shaded areas show the corresponding Sudden Stop episodes in respective countries. The large depreciation of the real exchange rate in those countries drove down the relative price of nontradable goods, which in turn led to a massive sectoral reallocations; in Mexico, the employment share of tradable goods sector in total employment stopped following a downward sloping trend and even rose somewhat after the crisis. Similar patterns of cross-sectoral allocations are observed in other Sudden Stop episodes as well.

TABLE 8
MATCHING EFFICIENCY SHOCKS

	Baseline	w/MES $\rho(\varepsilon^z, \varepsilon^\omega) = 0.5$	w/MES $\rho(\varepsilon^z, \varepsilon^\omega) = 0$
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.

correlated with TFP shocks. That is, at the aggregate level, periods of high matching efficiency are associated with economic expansions and periods of low reallocation efficiency are accompanied by economic downturns. Our calibration strategy with regard to the matching efficiency shocks is to pin down ρ_ω and var(e^ω) 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% with a persistence parameter of 0.6, and the correlation with the innovation to TFP is 0.5.[35] Other ingredients of the VAR involving the matching efficiency shock were set to zero.

The results with matching efficiency shocks are presented in Table 8. The first column replicates the baseline scenario results, the second column reports the findings from 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 scenario with positively correlated matching efficiency shocks, since the matching efficiency is likely to be low when TFP is low, as discussed before, the stock of unemployment is eliminated at a slower pace. This generates more persistent unemployment (notice that the autocorrelation of unemployment (0.31) is higher than in the baseline case (0.10)) and significantly higher variability for unemployment and vacancy (16.24 and 14.56 compared to 3.24 and 5.59 in the

35. We also analyzed a case when the correlation of matching efficiency shocks and TFP is set to zero.

baseline case). If the matching efficiency is low, firms cut vacancies significantly because the probability of forming a match is smaller while the cost of keeping the vacancy open is constant. Hence, vacancies fall dramatically, leading to higher unemployment with a one-period lag. In the scenario with uncorrelated matching efficiency shocks, the only significant difference is in the correlation of unemployment with output, which becomes closer to zero. This is intuitive because 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 generating the high unemployment rate variability found in the data, unless the replacement rate is high.[36] In our model extended to include matching efficiency shocks, an adverse matching efficiency shock directly reduces the job creation rate and leads to a higher unemployment rate in the following period. Given that the steady-state level of unemployment is about 8% and the other factor inputs are fixed, a 1 percentage point rise in the unemployment rate leads to only a 0.056 percentage point 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.

5. CONCLUSION

An SOE-RBC model featuring countercyclical interest rate shocks and search-matching frictions can account well for the dynamics of consumption, the current account, and wages simultaneously. Quantitative results showed that our model improved upon the standard RBC model in many dimensions, underscoring the importance of the dynamic interaction of search-matching frictions with countercyclical interest rates in accounting for stylized facts on EMEs. 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 variability of unemployment significantly closer to the data.

Exploring emerging market labor market dynamics using general equilibrium models is an area that is ripe for further research. This paper showed how far the modeling of the transitions from unemployment to employment (the extensive margin) takes us in terms of explaining the key regularities. Our paper emphasizes the importance of interaction between countercyclical interest rates and labor market frictions in explaining 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 the labor markets (e.g., trade unions, unemployment insurance, minimum wages, labor contract enforcement, long-term

36. See Hagedorn and Manovskii (2008) and Nakajima (2012) for a detailed explanation.

contracts, etc.) of EMEs. Our framework can also be extended to investigate the effect of political regime changes on labor markets as well as the role of labor market regulation.

APPENDIX A: DATA APPENDIX

The dates in square brackets below are the beginning dates of data series; 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 ARIMA software. Only those series that seemed to have seasonality were deseasonalized.

GDP

All data are from 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, and Sweden.[37]

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], and Turkey [1988].

Manufacturing Output

Manufacturing output data are in real terms and are 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], the Philippines [1998], Portugal [2000], Sweden [2000], and Turkey [1985].

Aggregate Hours, Manufacturing Hours, Employment

All countries: Data on hours worked 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 those cases, we divide total hours worked 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 period.

Brazil: Monthly hours worked in manufacturing is from the OECD [1992]; hours worked for the period 1987Q1–91Q4 was calculated using data from the Confederation of Industries. Civilian employment data are from Neumeyer and Perri (2005) for 1991–2002; data for 2003–07 were extrapolated using the "formal employment"

37. In the calculation of the standard deviation of GDP for Israel, we excluded 1976–80 because of large fluctuations observed in this period.

series from the Ministerio do Trabalho e Emprego (MTE) with the assumption that civilian employment grows at the same rate as formal employment. Data on employment in manufacturing are from MTE.

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

Ecuador: No data are available on hours worked. Employment data at a quarterly frequency are available on for a short period, 2000–03, and therefore were not included in the employment statistics.

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

Ireland: Weekly hours worked in manufacturing per worker is from the OECD (for the entire sample period). However, data on the number of employees in manufacturing 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 the OECD [1998].

Israel: Data on hours worked in manufacturing are from the International Labour Organization (ILO) and cover the entire sample period (the series is named "weekly hours actually worked in nonagricultural activities per worker"). Employment is from IFS [1992]. Number of employees in manufacturing was not available.

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

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

New Zealand: Data on hours worked in manufacturing are from the ILO [1980] (the series is called "weekly hours actually worked in nonagricultural activities per worker"). Employment and employment in manufacturing are from the OECD [1985Q4].

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

Sweden: All series are from the OECD and are available for the entire sample period except hours worked in manufacturing, which starts in 1987.

Turkey: Total hours worked in manufacturing is from the OECD [1977]. The number of employees in manufacturing and total employment are from TURKSTAT [1988Q4] and are semiannual (April and October) from 1988Q4 to 1999Q4 and quarterly afterward. The semiannual series were used to calculate quarterly series using linear interpolation.

Unemployment Rate

From the OECD: Austria [1976], Belgium [1976], Brazil [1981], Canada [1976], France [1976], Japan [1976], Korea [1976], Mexico [1987], the Netherlands [1987], Norway [1986], Sweden [1976], and 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], and Spain [1993].

Earnings

From the OECD: Brazil's and Mexico's earnings statistics are reported by the OECD 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 captures the earnings only for manufacturing. Data for the entire sample period are 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 the ILO: Chile [1982], Israel [1985], and the Philippines [2001].

From the 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 period are available for Australia, Canada, Korea, Spain, and Sweden. For other countries, 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], the Philippines [2000], Portugal [1995], and Turkey [1986].

APPENDIX B: TFP COMPUTATION

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

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

where K_t is the capital stock in year t, l is labor, the relative efficiency of which is augmented by 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 δ denotes the rate of depreciation of the capital stock, which is set equal to 0.07. In the steady state, the initial capital–output ratio is $k = i/(g + \delta)$, where i is the steady-state investment–output ratio and g is 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 10 years of the sample period and g by a weighted average between world growth (75%) and the country's average growth in the first 10 years of the sample. The initial capital level, K_0, is obtained by calculating the 3-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. We 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 years of schooling into the 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% for the first 4 years, 10.1% for the next 4 years, and 6.8% for all years of schooling above 8 years (following Psacharopoulos, 1994). The data on years of schooling are obtained from the Barro-Lee database and linear extrapolations are used to complete the 5-year data.

Output per worker is given by

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

The log TFP is thus calculated according to

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

APPENDIX C: EFFICIENCY CONDITION FOR THE DECENTRALIZED ECONOMY

Let the total surplus of a match be denoted by S_t defined by $S_t = J_t + \frac{E_{t-U_t}}{U'(c_t)}$. Then, by Nash bargaining, we have the value of filling a job as a fraction of total surplus $J_t = (1-\xi)S_t$. From the social planner's problem, the total surplus of a job match $S_t U'(c_t) = -\frac{\partial V(b_t, u_t, \varepsilon_t)}{\partial u_t} = -V_{u,t}$. In addition, we know that

$$V_{u,t} = -\varphi^E H(1-l) + \varphi^U H(1) - U'(c_t)F_{l,t}l - \eta_t(1 - \psi - \alpha\phi(\theta_t)),$$

and η_t is the expected marginal aggregate benefit of an additional job match $\eta_t = -\beta(c_t)\mathbb{E}_t V_{u,t+1}$. Substituting this definition into the above equation and rearranging the terms, we get

$$S_t = \frac{\varphi^E H(1-l) - \varphi^U H(1)}{U'(c_t)} + F_{l,t}l + (1 - \psi - \alpha\phi(\theta_t))\beta(c_t)\mathbb{E}_t S_{t+1}.$$

In terms of J_t

$$J_t = \frac{(1-\xi)}{U'(c_t)}[\varphi^E H(1-l) - \varphi^U H(1) + U'(c_t)F_{2,t}l] + (1-\psi-\alpha\phi(\theta_t))$$

$$\mathbb{E}_t \frac{\beta(c_t)U'(c_{t+1})}{U'(c_t)} J_{t+1} = \frac{(1-\xi)}{U'(c_t)}[\varphi^E H(1-l) - \varphi^U H(1) + U'(c_t)F_{2,t}l]$$

$$+ (1-\psi-\alpha\phi(\theta_t))\frac{\kappa\theta_t}{\phi(\theta_t)}.$$

Also, the flow profit of an active job is $\pi_t = \max_k F\left(\frac{k_t}{n_t}, l; z_t\right) - r_t\frac{k_t}{n_t} - w_t l = F_2\left(\frac{k_t}{n_t}, l; z_t\right) l - w_t l$. The value transition equations are

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

$$Q_t = -\kappa + \mathbb{E}_t\rho_{t,t+1}[\phi(\theta_t)/\theta_t J_{t+1} + (1-\phi(\theta_t)/\theta_t)Q_{t+1}].$$

By free entry $Q_t = 0$ for every t. This implies that

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

Therefore,

$$J_t = \pi_t + (1-\psi)\mathbb{E}_t\rho_{t,t+1}J_{t+1} = F_{t,2}l - w_t l + (1-\psi)\frac{\kappa\theta_t}{\phi(\theta_t)}.$$

Based on the above equation, wages, can be written as

$$w_t = F_{2,t} + \frac{1}{l}[(1-\psi)\frac{\kappa\theta_t}{\phi(\theta_t)} - J_t] = F_{2,t} + \frac{1}{l}\Bigg[(1-\psi)\frac{\kappa\theta_t}{\phi(\theta_t)}$$

$$- \frac{(1-\xi)}{U'(c_t)}[\varphi^E H(1-l) - \varphi^U H(1) + U'(c_t)F_{2,t}l] - (1-\psi-\alpha\phi(\theta_t))$$

$$\frac{\kappa\theta_t}{\phi(\theta_t)}] = \xi F_{2,t} + \frac{1}{l}[\alpha\kappa\theta_t - (1-\xi)\frac{\varphi^E H(1-l) - \varphi^U H(1)}{U'(c_t)}\Bigg] = \xi F_{2,t}$$

$$+ \frac{1-\xi}{l}[\frac{\alpha\kappa\theta_t}{1-\xi} - \frac{\varphi^E H(1-l) - \varphi^U H(1)}{U'(c_t)}].$$

Therefore, in order for the decentralized economy result to correspond to the social planner's result, we need $\alpha = \xi$. That is, the bargaining power of firms must equal the elasticity of the matching technology with respect to recruiting effort.

APPENDIX D: THE CANONICAL SOE-RBC MODEL

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

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

where l stands for labor supply. Per period utility takes the Greenwood, Hercowitz and Huffman (1988) (GHH) form, $u(c_t, l) = (c_t - \chi l^{\eta})^{1-\sigma}/(1-\sigma)$ where $1/(\eta - 1)$ captures the elasticity of labor supply. Under the spot labor market, wages equal the marginal product of labor and the 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, documented in Table 4. The only additional parameter that appears in the canonical SOE-RBC model is η, 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.

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