Employment Protection and Business Cycles in Emerging Economies

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Abstract

We build a small open economy, real business cycle model with labor market frictions to evaluate the role of employment protection in shaping business cycles in emerging economies. The model features matching frictions and an endogenous selection effect by which inefficient jobs are destroyed in recessions. The model provides a link between labor regulation, modelled as a separation cost, and measured TFP. In a quantitative version of the model calibrated to the Mexican economy we find that reducing separation costs to a level consistent with developed economies would reduce significantly TFP and output volatility. We also use the model to analyze the Mexican crisis episode of 2008 and conclude that an economy with lower separation costs would have experienced a smaller output loss, equivalent to 2 percent of annual GDP, with almost no change in aggregate employment.

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1 Introduction

Business cycles in emerging economies are more volatile than in developed countries. As shown in Table 1, GDP volatility is almost twice larger in emerging economies, and this excess volatility is largely accounted for by the volatility of total factor productivity (TFP) as measured by the standard Solow residual. In an influential paper, Aguiar and Gopinath (2007) show that, compared to developed economies, a more volatile and more persistent stochastic process for TFP is needed in emerging economies in order to account for the business cycle properties of output, consumption and net exports.

To a large extent, the literature on business cycles in emerging economies explains the excess volatility of output by adding external shocks. For instance, Neumeyer and Perri (2005) and Mendoza (2010) argue that business cycles in emerging economies are amplified by changes in the access to international credit markets combined with domestic financial frictions. However, in these models productivity is exogenous, so their mechanism is unable to explain the differences in the time series properties of Solow residuals between emerging and developed economies. The question of which policies can affect measured TFP remains also open.

Some recent studies have highlighted the importance of misallocation of resources in order to generate endogenously TFP changes.¹ In Pratap and Urrutia (2012), financial frictions to the purchase of intermediates can propagate interest rate shocks into measured TFP fluctuations by distorting the use of inputs in the economy. Adding a similar mechanism to a model of sovereign default, Mendoza and Yue (2012) show that domestic technology shocks can simultaneously generate country risk-premia volatility and excess volatility of measured TFP in emerging economies.

All these explanations, however, overlook one important difference between developed and emerging economies: The dynamics of labor markets. Table 1 also shows that emerging economies face more restrictive labor regulations, measured as a larger number of weeks of

¹There is a vast literature starting with Restuccia and Rogerson (2008), Hsieh and Klenow (2009), and Bartelsman, Haltiwanger and Scarpetta (2013) exploring the role of firm specific distortions and the resulting misallocation of resources for understanding differences in TFP across countries. To the extent of our knowledge, their insights have not been used systematically to understand changes in TFP over time at business cycle frequencies.
<table>
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<td>Average</td>
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Table 1: Business Cycle Properties and Employment Protection Across Countries

wages paid by firms in the event of a separation, and less employment volatility relative to output.\(^2\) One implication of an excessive labor regulation is that it limits the process of adjustment of labor flows in response to shocks. Moreover, the lack of flexibility of labor markets also mitigates the natural process of selection of firms in the economy, generating potentially large misallocation of resources.

We develop a small open economy model with labor matching frictions and evaluate the role of labor market regulation in shaping business cycles in emerging economies. Key to

\(^2\)The Heckman and Pages indicator (H&P) measures the costs of advance notice and compulsory severance payments expressed in present value, assuming up to 20 years of tenure. Also, the World Bank publishes as part of the Doing Business Indicators a measure of the monetary costs in terms of weeks of severance payments due for firing a worker, averaged across workers of 1, 5, and 10 years of tenure. We report both indicators as they capture different dimensions of employment protection.
our story is a selection effect by which the most inefficient jobs are destroyed in recessions.\(^3\) By reducing the volatility of job destruction, employment protection mitigates the selection effect and its cleansing impact, resulting in more protracted recessions. This basic mechanism allows us to connect labor market regulations and the volatilities of measured TFP, output and employment. We explicitly evaluate the predictions of each of these three variables with the data.\(^4\)

There are two technologies in the economy. One produces intermediate inputs using only labor and the other produces a final good using intermediate inputs and capital. The final good technology is subject to an exogenous aggregate technology shock. For intermediate inputs, there is a continuum of jobs or matches between one firm and one worker. Each match is indexed by an idiosyncratic labor efficiency which evolves randomly over time. Entrepreneurs post vacancies each period to hire new workers. As in Mortensen and Pissarides (1994), a matching function determines the probability of filling a vacancy as a function of the overall labor market tightness in the economy. Labor regulation is introduced as a fixed cost of breaking an existing match, i.e., a separation or firing cost, transferred to the worker as a severance payment. Wages are set through repeated bilateral Nash-bargaining, precluding the use of bonding schemes to undo the distortion introduced by severance payments.

After observing the shocks at the beginning of the period, entrepreneurs can decide to destroy a job if the quality is too low. The optimal separation rule implies an endogenous threshold level depending on the aggregate state of the economy, such that matches with labor efficiency below it are destroyed. The most inefficient jobs are then destroyed in recessions, increasing the average productivity of the remaining matches. Recessions have a cleansing effect reflected on the volatility of aggregate productivity in the economy. With larger firing costs, the same initial drop on the exogenous technology component would lead to fewer separations and therefore a bigger fall in measured TFP.

\(^3\)Caballero and Hammour (1994) present a model in which recessions have a cleansing effect due to the exit of firms with older technologies. We follow Mortensen and Pissarides (1994) in interpreting the cleansing effect of recessions as arising from the destruction of low quality job matches.

\(^4\)It is unclear whether the benchmark business cycles models for emerging economies are consistent with some basic facts about the labor market adjustment. As shown in Fernandez and Meza (2012), Aguiar and Gopinath (2007)’s calibration imply a countercyclical labor input in emerging economies, contrary to the data. In Neumeyer and Perri (2005), on the other hand, the excess volatility in output for emerging economies depends on the labor input, not TFP, being more volatile.
We calibrate the model to Mexico, which has been used as a benchmark emerging economy by Aguiar and Gopinath (2007), among others. In particular, we use information on employment protection from Table 1 and labor flows to pin down the separation cost in Mexico.\(^5\) The baseline model is consistent with a set of business cycle moments in Mexico, in particular the volatility and persistence of GDP and the volatility of employment relative to output, although it over-predicts the correlation between employment and output.

Our calibrated model allows us to perform counterfactual experiments. To illustrate the impact of reducing labor market regulations we consider an alternative economy with lower separation costs, broadly consistent with the level of employment protection in Canada. This alternative economy would feature less measured TFP and output volatility than the baseline. According to the experiment, firing costs are responsible for about thirty percent of the excess volatility in output in Mexico with respect to Canada. Moreover, the differences in the standard deviation and the first auto-covariance of measured TFP obtained endogenously for the economies with high and low separation costs are consistent with the differences in the observed Solow residuals between Mexico and Canada. As expected, firing costs also reduce the volatility of labor flows.

We also analyze a particular episode, the Great Recession of 2008, through the lens of our theory. In Mexico the downturn was particularly sharp, exhibiting a 9 percent drop in GDP below trend and a cumulative loss of output of 10 percent of the pre-crisis annual GDP between 2008:Q3 and 2010:Q2. Measured TFP was responsible for most of the drop in output, while employment fell much less. We calibrate the sequence of exogenous technology shocks in order to reproduce in the baseline model the evolution of GDP during this episode. We then perform the counterfactual experiment of reducing separation costs. We find that an economy similar to Mexico but with the level of employment protection in Canada would have experienced a smaller drop in output and a faster recovery. In terms of the cost of the crisis, the economy with low firing costs would have experienced a cumulative loss of output of only 8 percent, 2 percentage points smaller than in the baseline case.

\(^5\)One important caveat is that, because of the informal sector, a fraction of the labor force in emerging economies are not subject to labor regulation. In our setup we evaluate the impact of average separation costs on business cycles, capturing the effect of informality in the calibration by a lower firing cost. However, we recognize that the co-existence of workers subject to employment protection with workers with no protection at all might matter for the analysis.
We borrow from an extensive literature which incorporates labor matching friction to a standard, closed economy, real business cycle model, including the seminal works by Merz (1995) and Andolfatto (1996). These papers focus though on developed economies and include neither endogenous separations nor a selection mechanism like ours. Lagos (2006) explicitly analyzes the connection between labor market policies, selection of firms, and measured TFP. However, his focus is on steady state levels, not on short-run fluctuations. In this sense we relate more to the work of Veracierto (2008) and Samaniego (2008), who analyze business cycle fluctuations in a model with firm dynamics and conclude that firing costs dampen the response of the economy to aggregate shocks.\footnote{Following a similar approach, Den Haan et. al. (2000) show how the combination of endogenous job destruction and capital adjustment costs increases significantly the persistence of productivity shocks in the Mortensen and Pissarides framework.} Our setup is different in that we include search frictions in the labor market and work with constant returns to scale technologies in order to isolate the impact of the selection effect on TFP from issues related to the optimal size of firms. Also, compared with the previous authors, we treat aggregation of heterogeneous firms in a different, much simpler framework, and are able to obtain a tractable expression for measured TFP.\footnote{Other related work includes Boz, Durdu and Li (2009), who also analyze labor matching frictions in a small open emerging economy with exogenous exit, hence with no role for a selection effect. Also, we introduce separation costs and use these institutional features to distinguish between emerging and developed economies. Christiano et al. (2010) estimate a model combining financial and labor market frictions for the Swedish economy and find this interaction is able to reproduce the business cycle facts of this small open economy without resorting to investment shocks or wage markup shocks.}

The paper is organized as follows. Section 2 describes the model, highlights the main mechanism and provides some supporting evidence. Section 3 discusses the calibration and the business cycle properties of the baseline economy. Section 4 analyzes the role of separation costs in business cycle moments and in the 2008 crisis episode. Finally, we conclude.

\section{A Small Open Economy with Labor Market Frictions}

We introduce a one-sector small open economy model with labor market frictions. The model captures the type of matching frictions in Mortensen and Pissarides (1994) and includes as an institutional constraint a cost to destroy an ongoing work relationship, modelled as a severance payment. Matches producing intermediate goods are heterogeneous in productiv-
ity, which follows an i.i.d. stochastic process. Together with an endogenous separation rule, this implies that aggregate TFP is endogenous and depends on the institutional constraints imposed on the environment.

2.1 Production

There are two technologies in the economy. One to produce intermediate inputs using only labor, and one to produce a final good, using intermediate inputs and capital. This structure allows us to derive a simple expression for the aggregate production function of the economy in which TFP has an endogenous component.

Final Good Production Intermediate inputs and capital are combined to produce a final good using a constant returns to scale technology:

\[ Y_t = A_t (K_t)^\alpha (M_t)^{1-\alpha}, \]  

where \( A_t \) is an aggregate technology shock in the final good sector following the stochastic process:

\[ \log(A_t) = \rho_A \log(A_{t-1}) + \varepsilon_t^A, \]

in which \( \varepsilon_t^A \) is i.i.d. with mean zero and variance \( \sigma_A^2 \). We assume that the final good production is carried on by a representative firm under perfect competition. Hence, the rental price of capital and the price of the intermediate input satisfy the marginal conditions:

\[ r_t = \alpha A_t \left( \frac{K_t}{M_t} \right)^{\alpha-1}, \quad p_t^M = (1 - \alpha) A_t \left( \frac{K_t}{M_t} \right)^\alpha. \]

Intermediate Goods Production The intermediate good is produced by a continuum of jobs or matches between an entrepreneur and a worker. Workers are ex-ante identical, but jobs are subject to i.i.d shocks so that a match of quality \( \omega \) produces \( \omega \) units of intermediate goods. In the quantitative experiment we use a Pareto distribution for the idiosyncratic
productivity shocks $\omega$ with cumulative distribution function

$$G(\omega) = 1 - \left(\frac{\bar{\omega}}{\omega}\right)^{\sigma_{\omega}}.$$ 

**Optimal Separation Rule and the Value of a Match** After observing the current period shocks, entrepreneurs can destroy the match if it becomes unprofitable, paying a separation cost $\kappa$. Given prices $p_t^M$, $w_t(\omega)$, and the stochastic process for aggregate and idiosyncratic shocks, we can define recursively the value of a match of quality $\omega$ for the entrepreneur as

$$J_t(\omega) \equiv U_{c,t} \left( p_t^M \omega - w_t(\omega) \right) + \beta E_t \int \max \left\{ J_{t+1}(\omega') , -\kappa U_{e,t+1} \right\} dG(\omega').$$

The match is destroyed by the entrepreneur whenever $J_t(\omega) < -\kappa U_{c,t}$. The optimal separation decision discussed in the Appendix implies a state-dependent threshold level $\tilde{\omega}_t$ such that matches with quality below $\tilde{\omega}_t$ would be destroyed. Hence, we can write

$$J_t(\omega) = U_{c,t} \left( p_t^M \omega - w_t(\omega) \right) + \beta E_t \left[ \int_{\omega \geq \tilde{\omega}_t} J_{t+1}(\omega') dG(\omega') - \kappa G(\tilde{\omega}_t) U_{c,t+1} \right]. \quad (3)$$

**Aggregation** Using the optimal separation rule, the combined output of all matches producing intermediate goods is given by

$$M_t = \left[ \frac{\Gamma(\tilde{\omega}_t)}{1 - G(\tilde{\omega}_t)} \right] L_t,$$

with $\Gamma(x) \equiv \int_x^{\infty} \omega dG(\omega)$. Combining with (1), this implies a simple aggregate production function for the economy

$$Y_t^{\text{GDP}} = \left[ A_t \left( \frac{\Gamma(\tilde{\omega}_t)}{1 - G(\tilde{\omega}_t)} \right)^{1-\alpha} \right] (K_t)^{\alpha} (L_t)^{1-\alpha}, \quad (5)$$

8
where the term in brackets represents measured TFP and includes both an exogenous \((A_t)\) and an endogenous component. Also, the average wage per worker can be defined as

\[
w_t = \frac{\int_{\omega > \overline{\omega}} w_t(\omega) dG(\omega)}{1 - G(\overline{\omega})}.
\] (6)

### 2.2 Matching and Labor Flows

At the beginning of the period, and before shocks are realized, a mass \(N_t\) of workers are matched with a firm. After separation decisions are taken, a fraction \(s_t \equiv G(\overline{\omega}_t)\) of those are dismissed, according to the optimal separation rule, and become immediately unemployed. Hence, the mass of productive matches (or employed workers) at period \(t\) is given by

\[
L_t = (1 - s_t) N_t.
\] (7)

Unemployed workers \(U_t\) (unmatched workers from last period plus new dismissed workers) search for jobs; entrepreneurs post vacancies \(V_t\). New matches are created through a standard, constant returns to scale, matching function combining both inputs according to \(DU_t^\phi V_t^{1-\phi}\). These matches would become active next period, so

\[
N_{t+1} = (1 - s_t) N_t + DU_t^\phi V_t^{1-\phi}.
\] (8)

From the matching function specification, the probabilities \(p_t\) of a worker finding a match and \(q_t\) of a vacancy meeting a worker are given by

\[
p_t = D \left( \frac{U_t}{V_t} \right)^{\phi - 1}, \quad q_t = D \left( \frac{U_t}{V_t} \right)^{\phi}.
\] (9)

**Zero Profit Condition for Vacancy Posting** Entrepreneurs can post vacancies at cost \(\eta\). A vacancy only lasts for a period. If the vacancy meets a worker, with probability \(q_t\), the match becomes active in the next period. Assuming competitive entrepreneurs, the zero
profit-condition for vacancy posting implies

\[ U_{c,t} = q_t \beta E_t \left[ \int_{\omega \geq \omega_{t+1}} J_{t+1} (\omega') dG (\omega') - \kappa G (\omega_{t+1}) U_{c,t+1} \right]. \]  

(10)

### 2.3 Households and Workers

The consumer’s side of the economy is modelled as a continuum of identical households, each comprising a continuum of ex-ante identical workers. There is perfect risk-sharing among the members of the households, so each worker has the same level of consumption and the value of leisure is also equally allocated among workers. Households derive income from the labor earnings of employed workers, external savings, and capital.

**Preferences** Household’s preferences are described by the expected discounted lifetime utility function:

\[ E_0 \sum_{t=0}^{\infty} \beta^t \left[ C_t - \varphi \frac{L_t^{1+\nu}}{1+\nu} \right]^{1-\sigma}, \]

where \( C_t \) represents consumption and \( L_t \) the mass of employed workers. The parameter \( \sigma \) is the intertemporal elasticity of substitution. This utility function is non-separable in consumption and leisure, as in Greenwood, Hercowitz, and Hoffman (1988).\(^8\) The parameter \( \varphi \) governs the disutility of labor and \( \nu \) is the inverse of the Frisch elasticity of labor supply.

**Labor Supply** Households have a constant endowment of labor \( \bar{L} \) each period. Individuals who do not work \( (L_t) \) are unemployed \( (U_t) \). We abstract from individuals not participating in the labor force, so the household’s time constraint is \( L_t + U_t = \bar{L} \). From the point of view of the household, labor supply follows the law of motion

\[ L_{t+1} = (1 - s_{t+1}) [L_t + p_t U_t], \]

which is equivalent to (8) with \( N_t = L_t / (1 - s_t) \).

\(^8\)This utility function, also known as GHH, has been used extensively in small open economy models to mitigate the impact of wealth effects on labor supply.
**Savings and Investment**  Households own the capital stock $K_t$ and holds one-period, risk free foreign bonds $B_t$. Investing $I_t$ units of the final good increases the capital stock according to the law of motion

$$K_{t+1} = (1 - \delta) K_t + I_t - \frac{\vartheta}{2} \left( \frac{I_t}{K_t} - \delta \right)^2 K_t.$$  

Foreign bonds earn a return $r_t^* = (1 + i_t^*) \Theta(B_t)$, where $i_t^*$ follows the stochastic process

$$\log (1 + i_t^*) = \rho_i \log (1 + i_{t-1}^*) + (1 - \rho_i) \log (1 + i^*) + \varepsilon_t^i,$$

in which disturbances $\varepsilon_t^i$ are i.i.d. with mean zero, variance $\sigma_i^2$ and covariance $\sigma_{i,j}$ with the technology shock. As it is standard in small open economy models, $\Theta(B_t)$ is an endogenous risk premium, which has a very small elasticity with respect to the net foreign asset position to ensure stationarity in the model (see Schmitt-Grohé and Uribe, 2003).

**Budget Constraint**  Each period, households faces the budget constraint

$$C_t + I_t + B_{t+1} = w_t L_t + r_t K_t + (1 + r_t^*) B_t + \kappa s_t N_t + \Pi_t,$$

where $\kappa$ is the separation cost (severance payment) received by dismissed workers and $\Pi_t$ captures any profits made by entrepreneurs. Since there is perfect risk-sharing among workers, households care only about the average wage $w_t$.

**Optimization**  Given initial conditions $B_0$, $K_0$, $N_0$, sequences for contingent prices $w_t$, $r_t$, job finding rates $p_t$, profits $\Pi_t$, separation rates $s_t$ and the stochastic process for aggregate shocks, the representative household chooses contingent plans for aggregate variables $C_t, I_t, K_{t+1}, B_{t+1}, L_t, U_t, N_{t+1}$ in order to maximize utility subject to the budget constraint, the time constraint, and the laws of motion for labor and capital.
Value of Workers  We denote $\lambda_t^U$ and $\lambda_t^L$ the net utility values for the household of having an unemployed and an employed worker, respectively. We define these values recursively as

$$
\lambda_t^U \equiv p_t \beta E_t [(1 - s_{t+1}) \lambda_{t+1}^L + \kappa s_{t+1} U_{c,t+1}],
$$

$$
\lambda_t^L \equiv U_{c,t} (w_t - \varphi L_t^\nu) - \lambda_t^U + \beta E_t [(1 - s_{t+1}) \lambda_{t+1}^L + \kappa s_{t+1} U_{c,t+1}],
$$

where $U_{c,t}$ is the marginal utility of consumption\(^9\). Similarly, we define the net marginal value for the household of keeping a worker in a match of quality $\omega$ as

$$
W_t (\omega) \equiv U_{c,t} (w_t (\omega) - \varphi L_t^\nu) - \lambda_t^U + \beta E_t [(1 - s_{t+1}) \lambda_{t+1}^L + \kappa s_{t+1} U_{c,t+1}],
$$

from which

$$
W_t (\omega) = \lambda_t^L + U_{c,t} (w_t (\omega) - w_t). \quad (11)
$$

2.4 Wage Determination

To close the model, we need to specify how wages are determined in this economy. As is standard in the literature, we assume that wages are determined by repeated bargaining between the entrepreneur and the worker using the Nash protocol. Our wage setting mechanism precludes both parties to commit on a bonding scheme to undo the distortion introduced by the severance payment.

Every period, after observing the shocks, the wage $w_t (\omega)$ solves

$$
w_t (\omega) = \text{arg max} \left\{ W_t (\omega)^\gamma [J_t (\omega) + U_{c,t} \kappa]^{1-\gamma} \right\},
$$

where $\gamma$ is the weight assigned to the worker in the negotiation protocol. The value function $J_t (\omega)$, as defined in (3), captures the value for an entrepreneur of keeping a match of quality $\omega$. The entrepreneur’s outside option is closing the match at a utility cost $U_{c,t} \kappa$. On the other hand, $W_t (\omega)$, as defined in (11), represents the net value for the household of keeping a

\(^9\)Under this definition, $\lambda_t^L$ and $\lambda_t^U$ correspond to the optimal values of the Lagrange multipliers for the time constraint and the law of motion of labor supply, according to the first order conditions for household’s optimization. See the Appendix for details.
worker in a match of quality $\omega$, net of the unemployment outside option. From this problem we obtain the standard sharing rule

$$ (1 - \gamma) W_t (\omega) = \gamma [J_t (\omega) + U_{c,t\kappa}] . \tag{12} $$

### 2.5 Equilibrium

An equilibrium with Nash-bargaining for this economy is a set of contingent plans for aggregate quantities and prices such that:

1. Consumers solve their optimization problem;

2. Input prices satisfy the marginal conditions in (2);

3. The threshold productivity level satisfies $J_t (\omega_t) = -\kappa U_{c,t}$, given the value function for the entrepreneur defined in (3), and aggregation conditions (4), (5), and (6) hold;

4. Labor flows follow the law of motion (7), (8), and meeting probabilities are given by (9); vacancy posting satisfies the zero profit condition (10);

5. The Nash sharing rule (12) determines the wage schedule, with values for entrepreneur and the worker given by (3) and (11), respectively; and

6. Markets clear

$$ Y_t = C_t + I_t + \eta V_t + NX_t, $$

$$ B_{t+1} = (1 + r_t^s) B_t - NX_t, $$

$$ \Pi_t = M_t - w_t L_t - \eta V_t - \kappa s_t N_t. $$

### 2.6 Selection and the Cleansing Effect of Recessions

Before moving to a quantitative version of the model it is useful to discuss the main mechanisms at play and discuss some supporting evidence. Expansion and recessions in the model would be driven by exogenous technology shocks ($A_t$) and by foreign interest rate shocks.
(\(i_t^e\)). A negative technology shock would reduce the value of keeping a job, leading the entrepreneurs to break some existing matches. Our particular choice of preferences ensures that aggregate employment falls in a recession. The subsequent fall in consumption is mitigated by the household’s desire to smooth consumption over time, which would be reflected in a large drop in investment and a worsening of the current account.

So far, this is the standard story behind small open economy real business cycle models. Our model introduces a selection mechanism: In a recession, entrepreneurs would not choose randomly which jobs to close, but follow an endogenous exit rule in which matches with the lowest idiosyncratic productivity are destroyed first. Hence, the more jobs are destroyed, the higher the average productivity of the remaining matches. Recessions have a *cleansing* effect that mitigates the initial negative technology shock on measured TFP.

Table 2 provides some support for this mechanism. It is constructed using Mexican labor market data obtained from ENEU household’s survey.\(^\text{10}\) We divide individuals in four occupational status: Employed, Self-Employed, Unemployed, and Out of the Labor Force, and compute quarterly transition matrices between these four categories. Also, for individuals who were either employed or self-employed in one quarter we compute the average hourly wage ratio *in that quarter* between those who changed categories to unemployed or out of labor force in the following quarter and those who remained in their original category. We call this variable the *selection* effect; if less than one, it means that workers who lose their jobs are selected from the bottom of the productivity distribution inside the category, measuring productivity by their wages previous to the change in occupational status. We also compute the same selection ratio after controlling for differences in age and education, according to a standard Mincer specification, and report the results in parenthesis.

In Table 2 we report a few of the transitions estimated and their corresponding selection variables. We average these indicators for the whole available sample (1988-1999) and also for the recession year of 1995. For example, averaging the whole sample, 1.86 percent of all

\(^{10}\)ENEU (Encuesta Nacional de Empleo Urbano) is a rotating panel of workers in urban areas. It includes both formal and informal workers. This data set has been used extensively to document labor market facts for Mexico. See, for instance, the studies of Pratap and Quintin (2011) and Bosch and Maloney (2007). We are very grateful to Sangeeta Pratap for giving us access to a cleaned version of this dataset. We also computed similar statistics using ENOE, a new, larger survey including all Mexican workers and starting in 2005. The results, available upon request, show the same picture.
employed workers in one quarter were unemployed in the following quarter and, on average, the hourly wage of those workers losing their employed status was 26 percent lower than those who remained employed. Once we control for differences in age and education between the two groups of workers, we still obtain a 7 percent wage differential that can be attributed to unobservable characteristics. The overall table is consistent with: (i) separations being higher during recessions; (ii) a selection effect in which workers at the bottom of the wage (productivity) distribution are more likely to lose their jobs; and (iii) the selection effect being stronger during recessions. This is exactly the mechanism that we explore in our model.

Separation costs play an important role due to this selection effect. In the model, higher firing costs imply that breaking a match is costlier, therefore reducing separations in a recession. But fewer separations also means that more inefficient matches remain active, dampening the selection effect and its cleansing impact. Consistent with our story, Table 2 also shows that the selection effect is weaker for self-employed workers, for which labor regulation has less of a bite. Hence, with higher separations costs, the same initial drop in exogenous aggregate productivity component would lead to a bigger fall in measured TFP. Notice, finally, that separation costs also have an impact on hiring decision. By reducing the value of a match, higher firing costs also imply fewer vacancies posted and fewer jobs
created. The net effect of separation costs on employment is, therefore, ambiguous.

In the following sections we use a calibrated version of the model to quantify these mechanisms and evaluate their importance in explaining business cycles in emerging economies.

3 The Baseline Economy

To evaluate the quantitative predictions of the model we log-linearize the equations around the steady state. As explained before, to ensure stationarity of the model we introduce a risk premium term that depends on the net foreign asset position (see Schmitt-Grohé and Uribe, 2003). We use the algorithm proposed by Schmitt-Grohé and Uribe (2004) to solve the rational expectations model, which provides an efficient implementation of the solution method proposed by Blanchard and Kahn (1980). The model is calibrated to match some features of the Mexican data, as an example of a small and fairly open emerging economy.

3.1 Calibration

Table 3 summarizes the calibration results. Each period is equivalent to one quarter. A few parameters have a direct empirical counterpart. The discount factor implies an annual real interest rate of 4 percent and the depreciation rate is set to 5 percent per year. We take other parameters from the literature and perform sensitivity analysis with respect to some of their values at the end of Section 4. In the baseline case we use a risk aversion coefficient of one, as it is standard in the RBC literature. The elasticity of the matching function \( \theta \) is taken from the study of Blanchard and Diamond (1989) for the US. Following Hagedorn and Manovskii (2008), we use a very low bargaining power (0.052) of workers to induce higher wage rigidity and obtain a large volatility in employment. Finally, we use the same curvature of the Pareto distribution \( \sigma_w \) for idiosyncratic productivity shocks as in Lagos (2006) and we normalize the hiring cost to one.\(^{11}\)

A second set of parameters is jointly calibrated so that the deterministic steady state

\(^{11}\)Only the relative value of hiring to firing costs affects the labor markets dynamics in the model. In our calibration strategy we normalize the hiring costs to one, and then calibrate the hiring costs to be consistent with average costs in the Mexican data. In our baseline model, hiring costs amount to less than 0.2 percent of GDP.
### Table 3: Parameters for the Baseline Economy

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Source/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount Factor</td>
<td>$\beta$</td>
<td>0.99</td>
<td>From Outside the Model</td>
</tr>
<tr>
<td>World average Interest Rate</td>
<td>$i^*$</td>
<td>$1 / \beta - 1$</td>
<td>From Outside the Model</td>
</tr>
<tr>
<td>Depreciation Rate</td>
<td>$\delta$</td>
<td>1.25%</td>
<td>From Outside the Model</td>
</tr>
<tr>
<td>Capital Share</td>
<td>$\alpha$</td>
<td>0.3</td>
<td>From Outside the Model</td>
</tr>
<tr>
<td>Curvature Pareto Distribution</td>
<td>$\sigma_\omega$</td>
<td>1.5</td>
<td>From Outside the Model</td>
</tr>
<tr>
<td>Elasticity of Matching Function</td>
<td>$\theta$</td>
<td>0.40</td>
<td>From Outside the Model</td>
</tr>
<tr>
<td>Workers’ Bargaining Power</td>
<td>$\gamma$</td>
<td>0.052</td>
<td>From Outside the Model</td>
</tr>
<tr>
<td>Hiring Cost</td>
<td>$\eta$</td>
<td>1</td>
<td>Calibrated to Steady State Statistics</td>
</tr>
<tr>
<td>Disutility of Labor</td>
<td>$\varphi$</td>
<td>11.7</td>
<td>Calibrated to Steady State Statistics</td>
</tr>
<tr>
<td>Efficiency of Matching Function</td>
<td>$D$</td>
<td>0.54</td>
<td>Calibrated to Steady State Statistics</td>
</tr>
<tr>
<td>Scale of Pareto Distribution</td>
<td>$\omega$</td>
<td>1.54</td>
<td>Calibrated to Steady State Statistics</td>
</tr>
<tr>
<td>Capital Share in Production Function</td>
<td>$\alpha$</td>
<td>0.32</td>
<td>Estimated from EMBI Data for Mexico</td>
</tr>
<tr>
<td>Firing Cost</td>
<td>$\kappa$</td>
<td>5.6</td>
<td>Estimated from EMBI Data for Mexico</td>
</tr>
<tr>
<td>S.D. of World Interest Rate</td>
<td>$\sigma_i$</td>
<td>1.38%</td>
<td>Estimated from EMBI Data for Mexico</td>
</tr>
<tr>
<td>Persistence of World Interest Rate</td>
<td>$\rho_i$</td>
<td>0.96</td>
<td>Estimated from EMBI Data for Mexico</td>
</tr>
<tr>
<td>Covariance Interest Rate and Productivity Shock</td>
<td>$\sigma_{A,i}$</td>
<td>-0.24</td>
<td>Calibrated to Business Cycle Volatilities</td>
</tr>
<tr>
<td>S.D. of Exogenous Productivity Shock</td>
<td>$\sigma_A$</td>
<td>1.24%</td>
<td>Calibrated to Business Cycle Volatilities</td>
</tr>
<tr>
<td>Persistence of Exogenous Productivity Shock</td>
<td>$\rho_A$</td>
<td>0.96</td>
<td>Calibrated to Business Cycle Volatilities</td>
</tr>
<tr>
<td>Frisch Elasticity of Labor Supply</td>
<td>$1 / \nu$</td>
<td>1.16</td>
<td>Calibrated to Business Cycle Volatilities</td>
</tr>
<tr>
<td>Adjustment Cost of Capital</td>
<td>$\vartheta$</td>
<td>58</td>
<td>Calibrated to Business Cycle Volatilities</td>
</tr>
</tbody>
</table>
of the model reproduces some key labor market statistics in Mexico. The disutility of labor parameter $\varphi$, the efficiency of the matching process $D$, the capital share in the production function $\alpha$ and the scale of the Pareto distribution for idiosyncratic productivity shocks $\overline{w}$ are pinned down by an unemployment rate of 5 percent, a quarterly separation rate of 1.9 percent, a labor share of income of $2/3$, and a probability of filling a vacancy of $0.7$.\footnote{The unemployment rate corresponds to an average unemployment rate for Mexico adjusted as to make it comparable to other OECD countries. The separation rate equals the average quarterly transition rate from employment to unemployment for the 1988-99 period, as reported in Table 2. The probability of filling a vacancy is taken from Den Haan et al. (2000). Changing this number would only affect the ratio $U/V$ in equilibrium, which is meaningless for labor markets dynamics once we target the unemployment rate.}

Arguably, our most important calibrated parameter is the separation cost $\kappa$. The study by Heckman and Pages (2000) calculates a comprehensive measure of employment protection for Mexico equivalent to 13 weeks of wages (see Table 1). However, due to the important size of self-employment and informality in the Mexican economy, we conservatively target half of this value in our calibration reflect the average effective labor regulation faced by Mexican firms. Hence, we choose the value of $\kappa$ to obtain a firing cost equal to 6.5 weeks of the average steady state wage.

Finally, a third set of parameters is jointly calibrated so that the business cycle properties of the model are consistent with the Mexican data. We first estimate the $AR(1)$ process for the interest rate that Mexico faces in international markets, using the EMBI as the empirical counterpart, as in Neumeyer and Perri (2005). Then, we jointly calibrate the covariance between productivity and interest rate shocks $\sigma_{A,i}$, the persistence $\rho_A$ and the standard deviation of the exogenous technology shock $\sigma_A$, the curvature of leisure in the utility function $\nu$, and the adjustment cost of capital $\vartheta$ to match the observed correlation between interest rates and output, the persistence in GDP and the volatilities of GDP, employment, and investment, respectively.

### 3.2 Business Cycle Properties

The first column in Table 4 reports several business cycle statistics for the Mexican economy computed using a set of twenty year HP-filtered quarterly time series (1987:Q1 - 2007:Q3). The second column shows a similar set of statistics computed from data simulated from the
baseline model. We solve the model using log-linearization techniques and perform a large number of simulations to compute average statistics.

The baseline model reproduces by construction the volatilities of GDP, investment and employment, and the persistence of GDP. The baseline model is also calibrated to reproduce the observed, negative correlation between interest rates and output in Mexico. Countercyclical interest rates are a key feature of emerging economies, as discussed by Neumeyer and Perri (2005). We impose this feature of the data into our model by assuming a negative correlation between interest rates and technology shocks. This helps us to match qualitatively two important business cycles properties of emerging economies: A relative volatility of consumption to output greater than one, and a countercyclical trade balance. Turning off interest rate shocks in our model overturns these results (see the last column of the table).

The volatility of measured TFP is mitigated in the model by the endogenous selection mechanism, by which inefficient matches are destroyed in recessions. Everything else constant, the destruction of inefficient matches increases TFP, which partially compensates any contraction of exogenous productivity during recessions. A limitation with this mechanism is that procyclicality of employment is too high in the model, while in the data the correlation of employment and output is less than half. We still obtain a highly procyclical measured TFP, as in the data, but less volatile.
4 Separation Costs and Business Cycles

We now analyze the impact of reducing separation costs on business cycles. In all the experiments, the starting point is the baseline economy calibrated to the Mexican data. The main experiment is to reduce the firing costs from 6.5 to 2 weeks of wages, keeping all other parameters constant. Looking again at Table 1, the latter corresponds to Heckman and Pages’ (2000) measure of employment protection in Canada. We compare the business cycle statistics for the baseline economy and the counterfactual with low firing costs, and analyze one particular episode, the Great Recession of 2008.

4.1 Business Cycle Moments

Starting from the baseline economy, we simulate the model for an alternative economy with the same stochastic processes for aggregate shocks but lower separation costs. The mid columns on Table 5 report the results of the experiment. The first and fourth columns on this table report the corresponding business cycle statistics for Mexico and Canada, computed using HP-filtered data for the same time interval (1987:Q1 - 2007:Q3).

Reducing the separation costs reduces the overall volatility of the economy. For the \textit{same} process for the aggregate technology shock, the volatility of measured TFP decreases due to the selection mechanism: With lower separations costs, more inefficient matches are destroyed in recessions, increasing the average productivity of the remaining jobs. Therefore, output fluctuates less than in the baseline case. Notice that the effects are large. Reducing separation costs from the current level to a level more consistent with labor regulation in developed economies would reduce GDP volatility in Mexico by about 0.2 percentage points, closing 30 percent of the difference in GDP volatilities with Canada.

Separation costs have also an impact on the the first auto-covariance of the measured TFP process, which is higher in the economy with high firing costs. Consistent with our story, this statistic is also larger in Mexico than in Canada. The estimated TFP processes for these two countries in Aguiar and Gopinath (2007) also feature a higher standard deviation and higher first auto-covariance in Mexico than in Canada, which is key for their results. We account for about 20 percent of the observed difference in these statistics between the
two countries through the endogenous selection mechanism, starting from the same process for technology shocks.

Firing costs have a small impact on employment volatility. The quantitative effects on job creation and job destruction almost cancel out. Therefore, reducing separation costs increases the relative volatility of labor with respect to GDP, which is consistent with the observed differences between Mexico and Canada. However, the experiment cannot explain the differences in the volatility of consumption and in the correlation of net exports with output between the two countries. Reducing firing costs actually makes consumption more volatile relative to output. This is because of the complementarity between consumption and labor supply induced by the GHH preference specification. Notice, however, that in the experiment we are comparing economies subject to the same interest rate shocks. Table 4 suggests that if interest rate shocks were less volatile and less countercyclical in Canada the volatility of consumption would be significantly reduced.

In summary, starting from the baseline model calibrated to Mexico, reducing separation costs move qualitatively the business cycle moments in the direction of the Canadian economy. Quantitatively, the results are mixed, which is expected given that the only difference between Canada and Mexico that we are allowing in the model is labor regulation or separation costs.

### 4.2 Accounting for the Mexican Recession of 2008

We analyze now through the lens of the model a particular episode, the Great Recession of 2008. In Mexico the downturn was particularly sharp, exhibiting a drop in GDP of 9 percent (compared to trend) between 2008:Q3 and 2009:Q2. Measured TFP was responsible for most

<table>
<thead>
<tr>
<th></th>
<th>Data Mexico</th>
<th>Baseline Model</th>
<th>Model with low $\kappa$</th>
<th>Data Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma(y)$</td>
<td>2.17</td>
<td>2.17</td>
<td>1.90</td>
<td>1.28</td>
</tr>
<tr>
<td>$\sigma(l)/\sigma(y)$</td>
<td>0.53</td>
<td>0.53</td>
<td>0.57</td>
<td>0.67</td>
</tr>
<tr>
<td>$\sigma(tfp)$</td>
<td>1.98</td>
<td>1.37</td>
<td>1.17</td>
<td>0.88</td>
</tr>
<tr>
<td>$\text{Cov}(tp,tfp_{-1})$</td>
<td>3.02</td>
<td>1.52</td>
<td>1.17</td>
<td>0.88</td>
</tr>
<tr>
<td>$\sigma(c)/\sigma(y)$</td>
<td>1.15</td>
<td>1.67</td>
<td>1.95</td>
<td>0.54</td>
</tr>
<tr>
<td>$\text{Corr}(nx/y,y)$</td>
<td>-0.78</td>
<td>-0.16</td>
<td>-0.21</td>
<td>-0.01</td>
</tr>
</tbody>
</table>

Table 5: Separation Costs and Business Cycle Statistics
of the drop in output, with a 8.5 percent fall below trend. Employment felt much less, about
3.5 percent below trend, suggesting a mild adjustment of the labor market. Mexico also
exhibited a quick recovery from the crisis; one year after reaching its through the economy
was back to trend. Overall, the cost of the crisis was high, with a cumulative loss of output
from 2008:Q3 and 2010:Q2 of 10 percent of the pre-crisis annual GDP.

We use the baseline model calibrated in Section 3 to perform an accounting exercise
for the period between 2007:Q4 and 2010:Q2. We know the observed sequence of interest
rates for Mexico in international markets for this period, using again the EMBI spread as a
proxy for the country risk premium. We choose the sequence of the exogenous technology
shock in order to reproduce the observed evolution of GDP. Given these two sequences of
realizations of the exogenous shocks, we compute the corresponding time series for employ-
ment, consumption, investment, and so on, generated by the optimal decision rules of the
model. Figure 1 reports the results of the exercise and compares it with the Mexican data\textsuperscript{13}.

By construction, the model generates the same fall in GDP as the one observed in Mex-
ico. More interestingly, the model is also consistent with the observed fall in consumption,
investment and employment. Notice, however, that the model overpredicts the size of the
fall in employment, which is about 5 percent in the model compared with 3.5 percent in the
data. The labor market frictions in the model generate a decrease in measured TFP which
is also observed in the data.

We now perform the following counterfactual experiment: How different would have
been the 2008 recession in an economy facing the same exogenous shocks as Mexico but
with lower separation costs? The experiment implies reducing the firing costs from 6.5 to
2 weeks of wages, keeping all other parameters constant. Figure 2 reports the results of the
counterfactual experiment.

The economy with lower firing costs suffers a smaller recession and recovers faster.
GDP falls 7.5 percent below trend between 2008:Q3 and 2009:Q2, compared with 9 percent
in the baseline economy with high separation costs. Overall, the cumulative loss of output

\textsuperscript{13} We first HP-filtered the time series from the data using the whole 1987:Q1 to 2010:Q2 sample. The
 plotted sequences for the interval 2007:Q4 to 2010:Q2 should then be interpreted as deviations from a long
 run trend. Notice that the calibration of the model discussed in Section 3 only used Mexican data from
 1987:Q1 to 2007:Q3, making the results this experiment an \textit{out-of-sample} prediction of the model.
Figure 1: Accounting for the Mexican Recession of 2008: Model and Data Comparison

Figure 2: Counterfactual Experiment: The 2008 Mexican Crisis with Lower Separation Costs
during the crisis episode is 8 percent of the pre-crisis annual GDP with lower firing costs, compared to 10 percent in the baseline model. This is due to the selection mechanism in the model. For the same sequence of exogenous aggregate productivity, measured TFP falls more in a recession with high firing cost because these costs allow more inefficient jobs to stay active.

As discussed in the previous sections, having low separation costs does not imply a bigger fall in employment. Indeed, employment falls by almost the same amount in both economies, about 5 percent below trend. This is not to say that firing costs do not have important effects on labor flows. The separation rates increase sharply during the recession, and they increase about 2 percentage points more in the economy with low separation costs. This reinforces the idea that labor regulation has an impact not only on job destruction, but also on job creation. In our experiment, the net effect on employment is negligible.

According to our experiment, facing similar shocks, an economy with lower firing costs would have experienced a smaller drop in GDP and measured TFP with a similar drop in employment. Figure 3 compares the impact of the Great Recession of 2008 in Mexico and
Canada using detrended (HP-filtered) data. Of course it is hard to argue that the shocks were indeed similar in both countries. Still, it is remarkable that the predictions of the model are broadly consistent with the experience of these two economies.

4.3 Sensitivity Analysis

In this section we evaluate the sensitivity of our results with respect to three parameter values. These are the labor supply elasticity \( (1/\nu) \), the curvature of the Pareto distribution \( (\sigma_\omega) \) for idiosyncratic productivity shocks, and the bargaining weight of workers \( (\gamma) \). For this, we repeat the 2008 crisis simulation under the scenarios of high and low firing costs. In figure (4) we present the results for GDP.\(^{14}\) The qualitative results obtained from the benchmark model do not change with these alternative parametrizations.

**Labor Supply Elasticity**  Panels A and B show the effects of reducing firing costs for different labor supply elasticities. When labor supply elasticity is 2 \( (\nu = 0.5) \) two effects operate. On the one hand there is a larger decline of employment in response to technology shocks. As a result of less employment, the selection effect is stronger. In response to scarcer labor input firms increase their threshold a select the matches with higher idiosyncratic productivity, resulting in a more stable profile of measured TFP during the recession. The overall effect results in a faster output recovery from the crisis when firing costs are lower. When the labor supply elasticity is 0.5 \( (\nu = 2) \) the opposite effect operates. Employment is less sensitive to the cycle, and firms can afford to produce with workers with a lower idiosyncratic productivity, resulting in a slower output recovery. None of these parameter values affect the qualitative properties of the model.

**Pareto Distribution**  Panels C and D show the effects for alternative calibrations of the Pareto distribution. The lower the exponent of the Pareto distribution \( (\sigma_\omega) \), the higher the mass density in the tail of distribution, increasing the opportunity to select more matches with higher idiosyncratic productivity. When \( \sigma_\omega = 1.2 \) TFP is higher compared to the benchmark model due to the stronger selection effect, which leads to a less pronounced cycle.

\(^{14}\)In all cases, the simulations under the assumption of high firing costs (6.5 weeks of wages) matches the observed path of detrended GDP. All other parameters remain constant across simulations.
under lower firing costs. When $\sigma_\omega = 1.7$ the opposite result holds. Firms have a smaller mass of workers with higher idiosyncratic productivity, which leads to a relatively slower recovery compared to the case of a lower $\sigma_\omega$. Under these alternative parametrizations of the Pareto distribution, still is the case that the output recovery is faster under lower firing costs.

**Bargaining Weight**  Panel E and F show the effect of alternative calibrations of the bargaining weight. As shown in Hagerdon and Manovskii (2008), the lower bargaining weight, the larger is the adjustment of the labor market through employment rather than real wages. Quantitatively, the bargaining weight is similar to an increase in the labor supply elasticity. When $\gamma = 0.01$ there is a larger adjustment in employment, that is compensated with faster TFP gains resulting in a more stable GDP profile. When $\gamma = 0.10$, employment is more stable and hence firms engage in the production process with workers that have a lower idiosyncratic productivity, resulting in a slower output recovery. Also under these
parametrization the model retains the property of less pronounced business cycle when firing costs are lower.

5 Conclusions

Labor market outcomes impose some discipline to small open economy models of business cycles. They also provide new insights in understanding the differences across countries. We have explored a particular story. High separation costs in emerging economies dampen the selection effect and its cleansing impact during recessions, making these economies more volatile in terms of output and measured TFP. According to our analysis, this mechanism seems to be quantitatively important in explaining business cycle differences between emerging economies and more developed, less restricted, countries.

Even though we have used Mexico and Canada as examples to illustrate our story, we think that the model can be used in more general cases. One interesting application is to compare developed economies with different levels of employment protection. Ohanian (2010) shows that the Great Recession of 2008 had a very different impact on measured TFP in the U.S. and Europe. This could be rationalized in the context of our model assuming different separation costs in these two economies.

Most of the previous literature explains differences in business cycles across countries using different shocks, in particular different stochastic processes for technology, or different preferences. We believe that taking into account institutional features, which differ across countries and propagate shocks differently, provides more structure to identify the sources of business cycles and to conduct policy analysis. Our results point out to labor market regulation as a potential explanation for these differences.
References


A Solving the Equilibrium with Nash-Bargaining

A.1 Consumer’s Problem

Given initial conditions $B_0, K_0, N_0$, prices $w_t, r_t$, job finding rates $p_t$, profits $\Pi_t$, separation rates $s_t$ and the stochastic process for aggregate shocks, the representative household chooses contingent plans for aggregate variables $\{C_t, I_t, K_{t+1}, B_{t+1}, L_t, U_t\}_{t=0}^{\infty}$ in order to solve

$$\max \ E_0 \sum_{t=0}^{\infty} \beta^t \left[ \frac{C_t - \varphi \frac{L_t^{1+\nu}}{1+\nu}}{1-\sigma} \right],$$

s.t. $C_t + I_t + B_{t+1} = w_t L_t + r_t K_t + (1 + r_t^*) B_t + \kappa s_t N_t + \Pi_t, \quad (\beta^t \lambda^C_t)$

$$K_{t+1} = (1 - \delta) K_t + I_t - \frac{\vartheta}{2} \left( \frac{I_t}{K_t} - \delta \right)^2 K_t, \quad (\beta^t \lambda^K_t)$$

$$L_t = (1 - s_t) N_t, \quad (\beta^t \lambda^L_t)$$

$$L_t + U_t = \bar{L}, \quad (\beta^t \lambda^U_t)$$

$$N_{t+1} = L_t + p_t U_t. \quad (\beta^t \lambda^N_t)$$

(the stationary Lagrange multipliers are in parenthesis) with first order conditions:

$$\lambda^C_t = \left[ C_t - \varphi \frac{L_t^{1+\nu}}{1+\nu} \right]^{-\sigma} \equiv U_{c,t},$$

$$\lambda^K_t = \lambda^K_t \left( 1 - \frac{\vartheta}{2} \left( \frac{I_t}{K_t} - \delta \right) \right),$$

$$\lambda^K_t = \beta E_t \left\{ \lambda^K_{t+1} r_{t+1} + \lambda^K_{t+1} \left( 1 - \delta - \frac{\vartheta}{2} \left( \frac{I_{t+1}}{K_{t+1}} - \delta \right) \frac{I_{t+1}}{K_{t+1}} - \frac{\vartheta}{2} \left( \frac{I_{t+1}}{K_{t+1}} - \delta \right)^2 \right) \right\},$$

$$\lambda^K_t = \beta E_t \lambda^K_{t+1} (1 + r_{t+1}^*),$$

$$\lambda^L_t = \beta E_t \left[ (1 - s_{t+1}) \lambda^L_{t+1} + \kappa s_{t+1} \lambda^C_{t+1} \right],$$

$$\lambda^L_t = w_t \lambda^C_t - U_{c,t} \varphi L_t^\nu - \lambda^U_t + \lambda^N_t,$$

$$\lambda^U_t = p_t \lambda^N_t.$$

From the last three first order conditions, using $\lambda^C_t = U_{c,t}$, we obtain the marginal value of an unemployed member of the household

$$\lambda^U_t = p_t \beta E_t \left[ (1 - s_{t+1}) \lambda^L_{t+1} + \kappa s_{t+1} \lambda^C_{t+1} \right],$$

and a recursive expression for the net marginal value of a worker for the household

$$\lambda^L_t = \lambda^C_t (w_t - \varphi L_t^\nu) - \lambda^U_t + \beta E_t \left[ (1 - s_{t+1}) \lambda^L_{t+1} + \kappa s_{t+1} \lambda^C_{t+1} \right].$$
We can finally define the net marginal value for the household of keeping a worker in a match of quality $\omega$ as

$$W_t(\omega) \equiv \lambda_t^C (w_t(\omega) - \varphi L_t^\omega) - \lambda_t^U + \beta E_t \left[ (1 - s_{t+1}) \lambda_{t+1}^L + \kappa_{t+1} \lambda_{t+1}^C \right]$$

$$= \lambda_t^L + \lambda_t^C (w_t(\omega) - w_t).$$

(A)

### A.2 Producers’ Problem and Match Values

#### A.2.1 Final Good Production

Given prices $p_t^M$, $r_t$, the representative firm solves

$$\max \quad Y_t - r_t K_t - p_t^M M_t$$

s.to. $Y_t = A_t (K_t)^\alpha (M_t)^{1-\alpha}$

from which we obtain the equilibrium prices

$$r_t = \alpha A_t \left( \frac{K_t}{M_t} \right)^{\alpha-1} \quad p_t^M = (1 - \alpha) A_t \left( \frac{K_t}{M_t} \right)^\alpha$$

#### A.2.2 Intermediate Goods Production

**Value of a Match** Given prices $p_t^M$, $w_t(\omega)$, and the stochastic process for aggregate and idiosyncratic shocks, we can define recursively the value of a match of quality $\omega$ as

$$J_t(\omega) \equiv U_{c,t} \left( p_t^M \omega - w_t(\omega) \right) + \beta E_t \max \{ J_{t+1}(\omega') , -\kappa U_{c,t+1} \} dG(\omega'),$$

where the match is destroyed whenever $J_t(\omega) < -\kappa U_{c,t}$. We will show that the optimal separation decision implies a state-dependent threshold level $\hat{\omega}_t$ such that matches with quality below $\hat{\omega}_t$ would be destroyed. Hence, we can write

$$J_t(\omega) = U_{c,t} \left( p_t^M \omega - w_t(\omega) \right) + \beta E_t \left[ \int_{\omega \geq \hat{\omega}_t} J_{t+1}(\omega') dG(\omega') - \kappa G(\hat{\omega}_t) U_{c,t+1} \right].$$

**Aggregation** Using the cut-off rule, the combined output of all matches producing intermediate goods is given by

$$M_t = \left[ \frac{\Gamma(\hat{\omega}_t)}{1 - G(\hat{\omega}_t)} \right] L_t \equiv \Omega_t L_t,$$

with $\Gamma(x) \equiv \int_{\omega \geq x} \omega dG(\omega)$. Also, the aggregate separation rate is $s_t = G(\hat{\omega}_t)$, the average wage per worker is

$$w_t = \frac{\int_{\omega \geq \hat{\omega}_t} w_t(\omega) dG(\omega)}{1 - G(\hat{\omega}_t)},$$

and aggregate profits are

$$\Pi_t = M_t - w_t L_t - \eta V_t - \kappa s_t N_t.$$
We also define the *ex-ante* value of a productive match as

\[ J_t^N = \frac{\int_{\omega \geq \hat{\omega}_t} J_t(\omega) \, dG(\omega)}{1 - G(\hat{\omega}_t)}, \]

so that we can write, with \( \lambda_t^C = U_{c,t} \)

\[ J_t(\omega) = \lambda_t^C \left( p_t^M \omega - w_t(\omega) \right) + \beta E_t \left[ (1 - s_{t+1}) J_{t+1}^N - \kappa s_{t+1} \lambda_t^C \right], \]

and, integrating both sides of this expression,

\[ J_t^N = \lambda_t^C \left( p_t^M \Omega_t - w_t \right) + \beta E_t \left[ (1 - s_{t+1}) J_{t+1}^N - \kappa s_{t+1} \lambda_t^C \right]. \]

**Zero Profit Condition for Vacancy Posting** Entrepreneurs can post vacancies at cost \( \eta \). A vacancy only lasts for a period. If the vacancy meets a worker, with probability \( q \), the match becomes active in the next period. The zero profit-condition for vacancy posting then implies

\[ U_{c,t} \eta = q_t \beta E_t \left[ \int_{\omega \geq \hat{\omega}_{t+1}} J_{t+1}(\omega') \, dG(\omega') - \kappa G(\hat{\omega}_{t+1}) U_{c,t+1} \right], \]

or, using the previous definitions and \( \lambda_t^C = U_{c,t} \),

\[ \lambda_t^C \eta = q_t \beta E_t \left[ (1 - s_{t+1}) J_{t+1}^N - \kappa s_{t+1} \lambda_t^C \right]. \]

**A.3 Nash Bargaining**

The wage \( w_t(\omega) \) is determined by Nash-bargaining between the entrepreneur and the worker, so that

\[ w_t(\omega) = \arg \max \left\{ W_t(\omega)^\gamma [J_t(\omega) + U_{c,t} \kappa]^{1-\gamma} \right\}, \]

from which we obtain the sharing rule

\[ (1 - \gamma) W_t(\omega) = \gamma \left[ J_t(\omega) + U_{c,t} \kappa \right]. \]

Integrating both sides, we can write

\[ (1 - \gamma) \frac{\int_{\omega \geq \hat{\omega}_t} W_t(\omega) \, dG(\omega)}{1 - G(\hat{\omega}_t)} = \gamma \left[ \frac{\int_{\omega \geq \hat{\omega}_t} J_t(\omega) \, dG(\omega)}{1 - G(\hat{\omega}_t)} + U_{c,t} \kappa \right], \]

from which, using (A) and \( \lambda_t^C = U_{c,t} \),

\[ (1 - \gamma) \lambda_t^L = \gamma \left[ J_t^N + \lambda_t^C \kappa \right]. \]

where \( \lambda_t^L \) is the net marginal value of a worker obtained from the first order conditions of the household.
A.4 Optimal Separation Rule

The match would be destroyed if $J_t(\omega) < -\kappa U_{c,t}$. From (A) and (E), $J_t(\omega)$ is increasing in $\omega$. Therefore, as assumed, the optimal separation decision implies a state-dependent threshold level $\hat{\omega}_t$ such that matches with quality below $\hat{\omega}_t$ would be destroyed, where

$$ J_t(\hat{\omega}_t) + \kappa U_{c,t} = 0, $$

or, using the expression for $J_t(\omega)$ in (B),

$$ p_t^M \hat{\omega}_t - w_t(\hat{\omega}_t) + \beta E_t \left( \frac{\lambda_t^C}{\lambda_t^C} \right) \left[ (1 - s_{t+1}) \frac{J_{t+1}^N}{\lambda_{t+1}^C} - \kappa s_{t+1} \right] = -\kappa. $$

Notice also that, for workers exactly at the cut-off productivity $\hat{\omega}_t$, the Nash bargaining sharing rule in (E) implies $W_t(\hat{\omega}_t) = 0$, so that, from (A),

$$ w_t(\hat{\omega}) = w_t - \frac{\lambda_t^L}{\lambda_t^C}, $$

and replacing back in the optimal separation rule, gives us

$$ p_t^M \hat{\omega}_t - w_t + \frac{\lambda_t^L}{\lambda_t^C} + \beta E_t \left( \frac{\lambda_t^C}{\lambda_t^C} \right) \left[ (1 - s_{t+1}) \frac{J_{t+1}^N}{\lambda_{t+1}^C} - \kappa s_{t+1} \right] = -\kappa. \quad (G) $$

A.5 Closing the Model

The model is closed by the following market clearing conditions

$$ Y_t = C_t + I_t + \eta V_t + N X_t, $$

$$ B_{t+1} = (1 + r_t^*) B_t - N X_t, $$

together with the matching probabilities

$$ p_t = D \left( \frac{U_t}{V_t} \right)^{\phi-1} \quad q_t = D \left( \frac{U_t}{V_t} \right)^{\phi}. $$

A.6 Summarizing

The equilibrium with Nash Bargaining is characterized by the following system of equations in the following 22 sequences: $\lambda_t^C, \lambda_t^K, \lambda_t^L, \lambda_t^U, J_t^N, Y_t, C_t, I_t, K_{t+1}, L_t, U_t, N_{t+1}, V_t, B_{t+1}, w_t, r_t, p_t^M, p_t, q_t, \hat{\omega}_t, s_t, \Omega_t$:

1. $\lambda_t^C = \left[ C_t - \frac{\phi \lambda_t^C}{1+\nu} \right]^{-\sigma}$
2. $\lambda_t^C = \beta E_t \lambda_{t+1}^C (1 + r_{t+1}^*)$
3. $\lambda_t^C = \lambda_t^K \left( 1 - \vartheta \left( \frac{I_t}{K_t} - \delta \right) \right)$

4. $\lambda_t^K = \beta E_t \left\{ \lambda_{t+1}^C r_{t+1} \cdot \lambda_t^K \left( 1 - \vartheta \left( \frac{I_{t+1}}{K_{t+1}} - \delta \right) \frac{J_{t+1}}{K_{t+1}} - \frac{\vartheta}{2} \left( \frac{I_{t+1}}{K_{t+1}} - \delta \right)^2 \right) \right\}$

5. $K_{t+1} = (1 - \delta) K_t + I_t - \frac{\vartheta}{2} \left( \frac{I_t}{K_t} - \delta \right)^2 K_t$

6. $\lambda_t^U = p_t \beta E_t \left[ (1 - s_{t+1}) \lambda_{t+1}^L + \kappa s_{t+1} \lambda_{t+1}^C \right]$

7. $\lambda_t^L = \lambda_t^C \left( w_t - \varphi L_t^u \right) - \lambda_t^U + \beta E_t \left[ (1 - s_{t+1}) \lambda_{t+1}^L + \kappa s_{t+1} \lambda_{t+1}^C \right]$

8. $J_t^N = \lambda_t^C \left( p_t^M \Omega_t - w_t \right) + \beta E_t \left[ (1 - s_{t+1}) J_{t+1}^N - \kappa s_{t+1} \lambda_{t+1}^C \right]$

9. $\lambda_t^C \eta = q_t \beta E_t \left[ (1 - s_{t+1}) J_{t+1}^N - \kappa s_{t+1} \lambda_{t+1}^C \right]$

10. $(1 - \gamma) \lambda_t^L = \gamma \left[ J_t^N + \lambda_t^C \kappa \right]$

11. $p_t^M \bar{\omega}_t - w_t + \frac{\lambda_t^L}{\lambda_t^U} + \beta E_t \left( \frac{\lambda_{t+1}^C}{\lambda_t^U} \right) \left[ (1 - s_{t+1}) J_{t+1}^N - \kappa s_{t+1} \right] = -\kappa$

12. $Y_t = A_t (K_t)^\alpha \left( \Omega_t L_t \right)^{1-\alpha}$

13. $B_{t+1} = (1 + r_t^*) B_t - Y_t + C_t + I_t + \eta V_t$

14. $N_{t+1} = L_t + DU_t V_t^{1-\phi}$

15. $L_t = (1 - s_t) \bar{N}_t$

16. $L_t + U_t = \bar{L}$

17. $r_t = \alpha A_t \left( \frac{K_t}{M_t} \right)^{\alpha-1}$

18. $p_t^M = (1 - \alpha) A_t \left( \frac{K_t}{M_t} \right)^\alpha$

19. $p_t = D \left( \frac{U_t}{V_t} \right)^{\phi-1}$

20. $q_t = D \left( \frac{U_t}{V_t} \right)^\phi$

21. $s_t = G \left( \bar{\omega}_t \right)$

22. $\Omega_t = \frac{\Gamma(\omega_t)}{1 - G(\omega_t)}$