Interest Rate Shocks, Labor Market Search and Emerging Market Business Cycles

by

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This is to certify that I have examined this copy of a masters thesis by

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and have found that it is complete and satisfactory in all respects,
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To my family

ABSTRACT

This study examines the role of interest rate shocks in explaining emerging market business cycle characteristics in a small open economy real business cycle (SOE-RBC) model augmented with working capital requirement on firms' wage payments and searching and matching frictions in the labor market. The model is parameterized to quarterly Mexican data for the period 1987-2007. The results of the model with working capital requirement indicate that the model can generate some important characteristics of emerging market business cycles such as countercyclical interest rates, countercyclical net exports to GDP ratio and higher volatilities of consumption and wages relative to GDP. Moreover, imposing working capital requirement on wage bill leads to a higher positive correlation between interest rates and unemployment, thus the proposed model can be used to analyze the effects of a financial crisis on real sector.

Keywords: emerging market business cycles, searching and matching frictions, interest rates, working capital

ÖZET

Bu makale yükselen ekonomilerdeki konjonktürel dalgalanmaları açık ekonomi reel iş çevrim dinamik stokastik genel denge modeli ile açıklamaya çalışmaktadır. Önerilen model, standard açık ekonomi reel is çevrim modelinin işletme sermayesi gereklerini ve iş piyasasındaki arama ve eşleştirme faaliyetleri kapsayacak şekilde genişletilmişidir. Modelin parametreleri 1987-2007 Meksika verilerine göre hesaplanmıştır. Elde edilen sonuçlara göre işletme sermayesini modele dahil etmek, yükselen ekonomilerin konjonktür karşıtı reel faiz oranları, konjonktür karşıtı net ihracat üretim oranı ve tüketim ve gelirlerin yüksek oynaklıkları gibi önemli özelliklerinin açıklanabilmesini sağlamaktadır. Ek olarak, işletme sermayesi gerekliliğinin modele dahil edilmesi ile reel faiz oranları ve işsizlik arasındaki pozitif ilişki güçlenmektedir. Bu açıdan, işletme sermayesi gerekliliğini içeren modelin, finans sektöründe ortaya çıkan ve reel faiz oranlarını arttıran bir krizin reel sektörü olumsuz etkileyip işsizliğe neden olma sürecini açıklamada faydalı olacağı düşünülmektedir.

Anahtar Kelimeler: yükselen ekonomilerde konjonktürel dalgalanmalar, arama ve eşleştirme modelleri, faiz oranları, işletme sermayesi

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Chapter 1

INTRODUCTION

There exists numerous recent studies on emerging economies which emphasize the relationship between the changes in the real interest rates countries face in the international financial markets and the business cycle fluctuations those countries experience. However there is less number of studies that take into account the labor market dynamics in explaining emerging market business cycles. Recent crisis originated in financial sector but then transmitted to the real sector through the cost of working capital of firms and caused a rise in unemployment in both developed and emerging economies. This fact pointed out the need to incorporate labor market dynamics into an emerging market business cycle model that can account for the effect of real interest rates on firms operating costs. The studies that incorporated labor market dynamics into a, otherwise, standard SOE-RBC model are insufficient in that dimension since they do not have the mechanism to let changes in real interest rates affect the firm's operating costs. This paper aims to fill this gap in the literature by constructing a SOE-RBC model augmented with search and matching frictions in labor market and working capital requirement on firm's wage bill.

In the literature empirical regularities of emerging economies are documented with their differences from those of developed economies. The data Neumeyer and Perri (2005) analyzed show that in emerging markets real interest rates are countercyclical and lead the business cycle in contrast to real interest rates developed economies face which are acyclical and lag the cycle. Moreover the volatility of consumption relative to output and volatility of output in emerging economies are higher than those in developed economies and net exports appear more strongly countercyclical in emerging economies than in developed economies. In addition to these, Boz, Durdu and Li (2009) documents some regularities in emerging market labor markets such as real wages are almost twice as variable as output and positively correlated with output in contrast to developed economies in which real wages are less variable than

output and acyclical.

Standard SOE-RBC models fail in many dimensions in explaining emerging market business cycles. First of all, the strong relationship between interest rates and business cycles, which is apparent in emerging economies, is in contrast with the minor role played by interest rate shocks in previous SOE-RBC models as in Mendoza (1991). Moreover, the interest rates generated by these models are either acyclical or procyclical, consumption is less volatile than output and countercyclicality of net exports is not strong enough. In addition, these RBC models have to be modified in order to study unemployment dynamics since those models feature Walrasian labor market and everyone in the economy is employed.

To account for aforementioned regularities, we propose a SOE-RBC model with two modifications. The first modification is Mortensen-Pissarides type of search friction in the labor market where the unemployment, unfilled job-vacancies and employer-employee relationships are explicitly modeled and wage is determined by these relationships. The unemployed worker takes time to find a job and necessarily experiences an unemployment spell before finding a job. Employers incur a cost when posting a vacancy to find a suitable worker. The wage is determined by the bargaining between workers and employers given the prevailing market conditions. The model with searching and matching frictions improves upon the standard SOE-RBC model significantly in accounting for higher variabilities of wages relative to output and also the correlations of wages with output. The model with labor market frictions also yields a wage which is not only determined by the marginal product of labor but also the value of being unemployed and searching for another job. Therefore, wage is not perfectly correlated with output in contrast to what standard SOE-RBC model implies.

The second modification is that firms have to pay for a fraction of input costs before production takes place, creating a need for working capital. Since firms cannot rely on internal finance by assumption, they have to borrow abroad and interest

expenses incurred by firms add to their total input costs. The additional mechanism through which interest rate shocks affect business cycles is similar to the mechanism that Christiano and Eichenbaum (1992) introduce to explain the liquidity effect induced by money inflows in a closed economy, in particular, a change in the domestic interest rate, due to a liquidity effect in one case and to an international interest rate shock in the other, not only affects input supplies as it occurs in the standard model, but it also impacts on labor demand through the financial cost of hiring.

In the literature, three different approaches are taken in order to analyze the business cycle characteristics of emerging market business cycles. The first one favors the frictionless SOE-RBC models and claims that introducing productivity shocks with stochastic trend along with a negatively correlated interest rate shock can explain the emerging market dynamics. Aguiar and Gopinath (2005) and Boz, Daude and Durdu (2007) are the recent examples following this approach. In detail, Boz, Daude and Durdu (2007) tries to identify the effect of learning the nature of productivity shocks on the simple model Aguiar and Gopinath (2005) proposed. In this thesis we do not take this direction since financial and labor market frictions are important for the phenomenon we are analyzing.

The second approach considers SOE-RBC models with financial frictions. In particular, Neumeyer and Perri (2005), Uribe and Yue (2006), and Oviedo and Yue (2009) include working capital requirement as a financial friction in their studies in order to examine the role of interest rate shocks in emerging market business cycles. Neumeyer Perri (2005) identifies the effect of interest rate shocks with working capital requirement and negative correlation between shocks which is induced by a simple default model. Uribe and Yue (2006) analyzes the topic more empirically, while Oviedo and Yue (2009) documents the dynamics of the model with different persistence levels of corresponding shocks. This approach is inadequate to study dynamics of unemployment since in Walrasian labor markets every agent is employed.

The last approach considers SOE-RBC models with frictions in the labor market.

Merz (1995)and Andolfatto (1996)are the early closed economy models with labor market frictions and both are applied to US economy. Recently Boz, Durdu and Li (2009) use this approach in order to explain emerging market business cycles. They introduce searching and matching frictions in the labor market to an otherwise standard SOE-RBC model and they document the business cycle characteristics for Mexico together with the dynamics of labor market variables. However, their study does not answer the question to what extent firms are affected by an interest rate shock since working capital is not included. In addition, capital was fixed in their model which is not very realistic.

In the light of existing literature, this thesis combines second and third approaches and incorporates two frictions into the model, namely a working capital requirement and a labor market friction in order to achieve its two objectives. The first one is to match business cycle facts of emerging markets and the second is to illustrate a mechanism in which a positive interest rate shock affects firm's labor demand and creates unemployment. The proposed model is quite successful in matching the listed business cycle facts such as countercyclical interest rates and net exports, more volatile consumption and wages relative to output and high correlation between wages and output. It can also generate the mechanism that creates high positive correlation between interest rates and unemployment.

Chapter 2

EMPIRICAL REGULARITIES

The empirical regularities of emerging market business cycles are different from those of developed markets. Neumeyer and Perri (2005) documents the results of a statistical analysis of business cycles in a set of small open economies such as Argentina, Brazil, Mexico, Korea and Philippines on one hand and a set of small open developed economies such as Australia, Canada, Netherlands, New Zealand and Sweden on the other. The data show that there are some notable differences between two sets of countries. In emerging economies economies real interest rates are countercyclical and lead the business cycle. In contrast, real interest rates in developed economies are acyclical and lag the cycle. Furthermore, emerging economies display high output volatility relative to developed economies, and the volatility of consumption relative to income is on average greater than one and higher than in the developed economies. Finally, net exports appear much more strongly countercyclical in emerging economies than in developed economies.

The empirical analysis of Boz, Durdu and Li (2009) reveals that in emerging economy labor markets, the fluctuations in prices are more pronounced, while the fluctuations in quantities are somewhat subdued compared to those in developed economies. In particular, real wages, on average, are almost twice as variable as output and have a positive correlation with contemporaneous output (0.38). This is in contrast with developed economies, where the real wages are less variable than output and acyclical (0.13). Moreover, the variabilities of employment and unemployment relative to the variability of output are lower in emerging markets than those in the industrialized countries.

The business cycle facts of emerging markets as documented in Neumeyer and Perri (2005) are listed in Table 1.

Table 1: Emerging Market Business Cycle Facts

Moment (%)	Emerging Economies	Developed Economies
I.Standard Deviations		
$\sigma(y)$	2.79	1.37
$\sigma(R)$	2.32	1.66
$\sigma(nx/y)$	2.40	0.92
$\sigma(c)/\sigma(y)$	1.71	1.08
$\sigma(i)/\sigma(y)$	3.29	3.44
II.Correlations with Output		
$\rho(y,c)$	79	68
$\rho(y,R)$	-55	20
$\rho(y,i)$	88	73
$\rho(y,nx/y)$	-61	-23
III.Correlations with Interest Rate		
$\rho(R,c)$	-56	25
$\rho(R,i)$	-48	21
$\rho(R,nx/y)$	51	-22

The empirical motivation of constructing a mechanism in which a rise in interest rates results in a rise in unemployment through the working capital requirement of firms, lies on observing the consequences of recent credit crisis of 2008. In recent crisis, tight credit conditions lead to an increase in both EMBI and corporate bond spreads. In addition, unemployment increased in emerging markets. Figure 1 and 2 indicates that the unemployment seems to follow the increase in interest rates.

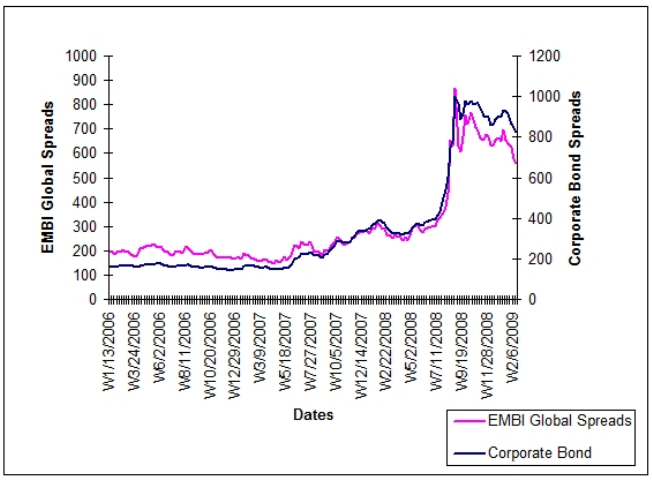


Figure 1: EMBI and Corporate Bond Spreads

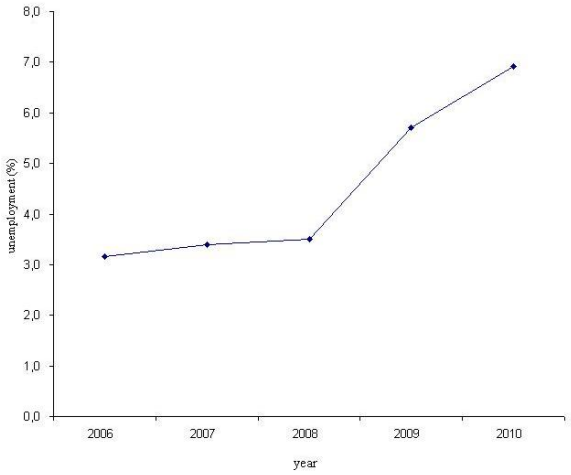


Figure 2: Unemployment in Mexico

We believe that the increased correlation between spreads and unemployment results from the fact that firms have to finance a fraction of their labor costs by borrowing from international market at country interest rate. Thus an increase in country interest rate leads to an increase in cost of labor and consequently firms demand less labor. Hence, higher positive correlation between interest rates and unemployment is expected when working capital requirement is imposed.

Chapter 3

THE MODEL

This section describes an economic environment in which the empirical regularities of emerging markets described in the previous section can be interpreted as the equilibrium of an economy with financial frictions and labor market frictions subject to total factor productivity (TFP) shocks and interest rate shocks. The model incorporates labor market search and matching frictions and a financial friction into an otherwise standard small open economy real business cycle (SOE-RBC) model. We incorporate a Mortensen-Pissarides type of search and matching framework which models the unemployment, unfilled job vacancies and wage determination explicitly. Moreover, the firms face a financial constraint, namely, a working capital requirement, which requires the firms to pay a fraction of the wage bill in advance. The only asset traded in international financial markets is a non-state contingent real bond. Firms also trade in this asset because of the presence of financial friction.

3.1 Firm's Problem

A continuum of large number of competitive firms are producing a single tradable good that sells at a world determined price, which is normalized to 1. Output is produced by a constant returns to scale production technology: $y_t = z_t {k_t}^{\zeta} (n_t l)^{1-\zeta}$. A firm willing to fill a vacancy must undertake recruiting and screening activities which are costly. New matches are formed according to a matching technology, which is a function of posted vacancies and level of unemployment: $M(u_t, v_t) = \omega u_t^{\alpha} v_t^{1-\alpha}$.

The flow cost of posting one vacancy is κ and the probability of a firm succeeds in filling a vacancy is given by $\frac{\phi(\theta_t)}{\theta_t} = \frac{M(u_t,v_t)}{v_t}$, where $\theta_t = \frac{v_t}{u_t}$ is the market tightness. Employment rate evolves according to the following law of motion:

$$n_{t+1} = (1 - \psi) n_t + \frac{\phi(\theta_t)}{\theta_t} v_t \tag{1}$$

According to this law of motion, a vacancy can become productive after a period of time elapsed and this implies the time consuming nature of recruitment for the firm.

Along with the labor market friction, firms are also subject to working capital requirement. They need working capital to pay for a fraction of their wage payments before output is available and in order to do so they borrow from abroad. The fraction of wage bill that has to be paid before cashing the sales is denoted by λ. The expected future profits of firms are discounted with the stochastic discount factor of households which is $\Pi_{t,t+1} = \beta U^{'}(c_{t+1})/U^{'}(c_t)$ since firms are owned by households.

Given the wage w_t, and probability of filling a vacancy $\phi(\theta_t)$, firm chooses how many vacancies to post v_t, and how much capital to use, k_{t-1}. The dynamic programming problem of the firm is given as follows:

$$V_t^F(n_t, \epsilon_t) = \max\{y_t - (1+\lambda(R_{t-1}-1))w_t n_t l - {r^k}_t k_{t-1} - \kappa v_t + E_t \Xi_{t,t+1} V_{t+1}^F(n_{t+1}, \epsilon_{t+1})\} \quad (2)$$

subject to $\quad n_{t+1} = (1-\psi)n_t + \frac{\phi(\theta_t)}{\theta_t} v_t$

The first-order condition with respect to capital is:

$${r^k}_t = z_t \zeta {k_{t-1}}^{1-\zeta} (n_t l)^{\zeta} \quad (3)$$

This condition states that firms borrow capital from households to the extent that marginal product of capital is equal to the rental rate of capital.

The first-order condition with respect to vacancies is:

$$\frac{\kappa \theta_t}{\phi(\theta_t)} = E_t \Pi_{t,t+1} \frac{\partial V_{t+1}^F}{\partial n_{t+1}} \quad (4)$$

Firms choose the number of vacancies such that the cost of posting an additional vacancy κ, equals to the discounted expected future value that the firm takes by filling one more vacancy and this expected payoff is conditional on the probability of filling a vacancy, $\frac{\phi(\theta_t)}{\theta_t}$.

In addition, envelope condition with respect to employment is:

$$\frac{\partial V_t^F}{\partial n_t} = F_n(k_{t-1}, n_t l) l - (1 + \lambda(R_{t-1} - 1)) w_t l + E_t \Pi_{t,t+1} \frac{\partial V_{t+1}^F}{\partial n_{t+1}} (1-\psi) \quad (5)$$

According to the envelope condition, the marginal value that the firm takes by filling one more vacancy is given the marginal product of labor minus the wage payments including the fraction, λ, of the interest paid for working capital plus the asset value of not posting a new vacancy and enjoying a pre-existing relationship with a worker in the next period.

Substituting the first-order condition with respect to vacancies into the envelope condition yields the job creation condition:

$$\frac{\kappa\theta_t}{\phi(\theta_t)} = E_t[\Pi_{t,t+1}(F_n(k_t, n_{t+1}l)l - (1 + \lambda(R_t - 1))w_t l + (1 - \psi)\frac{\kappa\theta_{t+1}}{\phi(\theta_{t+1})})] \tag{6}$$

Marginal value firm gets by filling one more vacancy can also be defined as

$$J_t - Q_t = \frac{\partial V_t^F}{\partial n_t} \tag{7}$$

where J_t is the value of filling a vacancy and Q_t is value of posting a vacancy. This representation will be useful when solving the Nash bargaining problem later.

3.2 Household's Problem

Economy is populated with a large family that consists of a continuum of identical infinitely-lived worker members on the interval [0,1]. Preferences are time-separable constant relative risk aversion (CRRA) type and utility derived from consumption is $U(c_t) = \frac{{c_t}^{1-\sigma}}{1-\sigma}$ while utility derived from leisure is $(1 - l)$, is $H(1 - l) = \frac{(1-l)^{1-\nu}}{1-\nu}$.

Instantaneous utility function of a household member depends on his or her employment status and is given by:

$$U(c_t, l) = U(c_t) + \chi\varphi^E H(1 - l) + (1 - \chi)\varphi^U H(1) \tag{8}$$

where χ is an indicator variable that takes the value of 1 if agent is employed, and 0 if unemployed.

Since economy is populated by large extended families, all family members pool their income together for equal consumption even though some of them are unem-

ployed. In other words, markets for unemployment risk are complete so that family members can fully insure against unemployment risk.

In SOE-RBC models distribution of bond holdings diverge with the standard assumption of an exogenous rate of time preference equal to the world interest rate. To avoid this problem, we follow Schmitt-Grohe and Uribe (2003) and incorporate convex bond holding costs into our model.

$$\Phi(b_t) = \frac{\varphi^b}{2}(y_t)\left(\frac{b_t}{y_t} - \frac{b^{ss}}{y^{ss}}\right)^2 \tag{9}$$

In addition, there is an adjustment cost of capital, which is commonly used in the literature in order to avoid excessive volatility of investment.

$$\Theta(k_t, k_{t-1}) = \frac{\varphi^k}{2}(k_{t-1})\left(\frac{k_t}{k_{t-1}} - 1\right)^2 \tag{10}$$

Households supply fixed amount of labor l, and earn an hourly wage w_t, which is determined by Nash bargaining. Moreover, they supply capital k_{t-1} to firms at a rental rate ${r^k}_t$ and earn interest from previous period's savings $b_{t-1}R_{t-1}$. In addition, households get dividend payments from firms d_t. They use these earnings to make consumption, investment and saving. Thus, the budget constraint of the household is given by:

$$c_t + i_t + b_t + \Phi(b_t) = n_t w_t l + {r^k}_t k_t + d_t + b_{t-1}R_{t-1} \tag{11}$$

Given the wage, w_t, interest rate, R_{t-1}, and probability of finding a job $\frac{\phi(\theta_t)}{\theta_t}$; household chooses consumption, c_t, bond holdings, b_t, and investment,i_t. The dynamic programming of the household is given as follows:

$$V^H(k_{t-1}, b_{t-1}, n_t, \epsilon_t) = \max\{U(c_t) + n_t\varphi^E H(1-l) + (1-n_t)\varphi^U H(1) + \beta E_t V^H(k_t, b_t, n_{t+1}, \epsilon_{t+1})\} \tag{12}$$

subject to

$$c_t + i_t + b_t + \Phi(b_t) = n_t w_t l + {r^k}_t k_t + d_t + b_{t-1}R_{t-1} \tag{13}$$

$$i_t = k_t - (1-\delta)k_{t-1} + \Theta(k_{t-1}, k_t) \tag{14}$$

$$n_{t+1} = (1-\psi)n_t + \frac{\phi(\theta_t)}{\theta_t} v_t \tag{15}$$

where $d_t = n_t \overline{\pi}_t - \kappa v_t$, and $\overline{\pi}_t = z_t \overline{k}_{t-1}{}^{\zeta} l^{1-\zeta} - (1 + \lambda(R_{t-1} - 1))w_t l - r_t \overline{k}_{t-1}$.

In the budget constraint dividend payments from firms is denoted as d_t and equal to aggregate profit of the firms net of total cost of posting vacancies as in Andolfatto (1996). Notice that capital use of a representative firm is denoted as $\overline{k}$ because a representative firm does not use the aggregate capital k_t supplied by the household, but $1/n_t$ fraction of it since there are as many firms as employed household members n_t.

Equilibrium condition with respect to investment is:

$$1 + \frac{\partial \Theta(k_{t-1}, k_t)}{\partial k_t} = \beta E_t[\frac{U^{'}(c_{t+1})}{U^{'}(c_t)}(1 - \delta + r^k{}_{t+1} - \frac{\partial \Theta(k_t, k_{t+1})}{\partial k_{t+1}})] \tag{16}$$

The marginal value of giving up 1 unit of consumption plus the marginal cost incurred by adjusting capital at time t is equal to the expected discounted marginal benefit of $1 - \delta + r^k_{t+1}$ units of consumption minus the $t+1$ marginal cost of incurring capital adjustment since investing at time t increases k_{t+1}.

Equilibrium condition with respect to bond holdings is:

$$1 + \frac{\partial \Phi(b_t)}{\partial b_t} = \beta E_t[\frac{U^{'}(c_{t+1})}{U^{'}(c_t)} R_t] \tag{17}$$

The marginal cost of giving up 1 unit of consumption plus the marginal cost incurred by adjusting bond holdings at time t is equal to the expected discounted marginal benefit of R_t units of consumption at time $t+1$ in marginal utility terms.

Envelope condition with respect to employment is given as:

$$\frac{\partial V_t^H}{\partial n_t} = \varphi^E H(1-h) - \varphi^U H(1) - U^{'}(c_t) w_t l + \beta E_t[\frac{\partial V_{t+1}^H}{\partial n_{t+1}}(1 - \psi - \phi(\theta_t))] \tag{18}$$

It captures the value of having one more worker to the household. The first two terms illustrate the net utility loss to the newly employed worker compared to being unemployed. The third term is the wage payments to the newly employed worker in marginal utility and the last term captures the future value of one more worker.

Marginal value household gets when one more family member finds a job can also be defined as:

$$E_t - U_t = \frac{\partial V_t^H}{\partial n_t} \tag{19}$$

where E_t is the value of being employed and U_t is the value of being unemployed.

3.3 Wage Bargaining

Given the worker's bargaining power ξ, the matched worker-firm pair negotiates over wage by solving the following Nash Bargaining problem:

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

First-order condition with respect to wage is:

$$\xi \frac{\partial(E_t - U_t)}{\partial w_t}\frac{1}{E_t - U_t} = -(1-\xi)\frac{\partial(J_t - Q_t)}{\partial w_t}\frac{1}{J_t - Q_t}$$

Together with the value of a match to a firm, this first-order condition gives us the wage equation as follows:

$$w_t = \frac{\xi(F_n(k, n_t l) + \frac{\kappa\theta_t}{l})}{1 + \xi\lambda(R_{t-1} - 1)} + \frac{(1-\xi)(\varphi^U H(1) - \varphi^E H(1-h))}{U'(c_t)l(1 + \xi\lambda(R_{t-1} - 1))} \tag{20}$$

Wage is not determined by only the marginal product of labor, $F_n(k, n_t l)$, but a weighted average of MPL and value of staying unemployed and searching for a job next period. The term $\frac{\xi\kappa\theta_t}{l}$ captures the value of forward looking aspects of reentering the job market and possibly getting employed in the next period. The last term is the value of leisure associated with being unemployed in units of marginal consumption.

The effect of imposing working capital requirement on wage determination can be discussed by comparing the wage equations for the cases with and without working capital requirements.

Define the wage equation for the case without working capital by w_t^1:

$$w_t^1 = \xi(F_n(k, n_t l) + \frac{\kappa\theta_t}{l}) + \frac{(1-\xi)(\varphi^U H(1) - \varphi^E H(1-h))}{U'(c_t)l} \tag{21}$$

and the wage equation for the case with working capital by w_t^2

$$w_t^2 = \frac{\xi(F_n(k, n_t l) + \frac{\kappa\theta_t}{l})}{1 + \xi\lambda(R_{t-1} - 1)} + \frac{(1-\xi)(\varphi^U H(1) - \varphi^E H(1-h))}{U'(c_t) l (1 + \xi\lambda(R_{t-1} - 1))} \tag{22}$$

It implies that $w_t^2(1 + \xi\lambda(R_{t-1} - 1)) = w_t^1$

Here we can say that firms hire workers to the point at which marginal product of labor combined with value of staying unemployed and searching in the next period (i.e $w^1 t$) equals the wage rate inclusive of financing costs when there is working capital requirement.

As a result of imposing working capital requirement, an interest rate shock affects the economy in the following way. When firms pay for labor in advance, an interest rate shock in period t affects production decisions in $t + 1$ in the same way that productivity shocks do; in particular, an increase in the interest rate reduces the firm's demand for labor for any level of wages.

A **competitive equilibrium** is a list of sequences $\{c_t\}, \{k_t\}, \{b_t\}, \{n_{t+1}\}, \{v_t\}$ [allocations],$\{w_t\}, \{r^k{}_t\}$ [prices], $\{z_t\}, \{R_t\}$ [exogenous shocks] and given k_0, b_0, n_0 [initial conditions] such that

i. Household's optimization problem: Given prices and initial conditions, the allocations solve household's optimization problem via satisfying following equations

$$c_t + k_t - (1-\delta)k_{t-1} + \Theta(k_{t-1}, k_t) + b_t + \Phi(b_t) = n_t w_t l + r^k{}_t k_t + d_t + b_{t-1} R_{t-1}$$

$$n_{t+1} = (1-\psi)n_t + \frac{\phi(\theta_t)}{\theta_t} v_t$$

$$1 + \frac{\partial\Theta(k_{t-1}, k_t)}{\partial k_t} = \beta E_t[\frac{U^{'}(c_{t+1})}{U^{'}(c_t)}(1 - \delta + r^k{}_{t+1} - \frac{\partial\Theta(k_t, k_{t+1})}{\partial k_{t+1}})]$$

$$1 + \frac{\partial \Phi(b_t)}{\partial b_t} = \beta E_t[\frac{U^{'}(c_{t+1})}{U^{'}(c_t)} R_t]$$

$$w_t = \frac{\xi(F_n(k,n_t l)+\frac{\kappa\theta_t}{l})}{1+\xi\lambda(R_{t-1}-1)} + \frac{(1-\xi)(\varphi^U H(1)-\varphi^E H(1-h))}{U^{'}(c_t) l(1+\xi\lambda(R_{t-1}-1))}$$

ii. Firm's optimization problem: Given factor prices and initial conditions, the allocations solve firm's problem via satisfying the following equations

$$n_{t+1} = (1-\psi) n_t + \frac{\phi(\theta_t)}{\theta_t} v_t$$

$$r^k{}_t = z_t \zeta {k_{t-1}}^{1-\zeta} (n_t l)^{\zeta}$$

$$\frac{\kappa\theta_t}{\phi(\theta_t)} = E_t[\Pi_{t,t+1}(F_n(k_t, n_{t+1} l) l - (1+\lambda(R_t-1)) w_t l + (1-\psi)\frac{\kappa\theta_{t+1}}{\phi(\theta_{t+1})})]$$

$$w_t = \frac{\xi(F_n(k,n_t l)+\frac{\kappa\theta_t}{l})}{1+\xi\lambda(R_{t-1}-1)} + \frac{(1-\xi)(\varphi^U H(1)-\varphi^E H(1-h))}{U^{'}(c_t) l(1+\xi\lambda(R_{t-1}-1))}$$

iii. Market Clearing: Market clears via

$$c_t + k_t - (1-\delta) k_{t-1} + \Theta(k_{t-1}, k_t) + b_t - b_{t-1} R_{t-1} + \Phi(b_t) + \lambda(R_{t-1}-1) n_t w_t l + \kappa v_t = y_t$$

$$n_t + u_t = 1$$

iv. Exogenous Shocks: Economy is subject to following exogenous shocks

$$R_t = R(1+\epsilon^R{}_t), \qquad \epsilon_t^R \text{ is distributed with } N(0, \sigma_t^R)$$

$$z_t = z(1+\epsilon^Z{}_t), \qquad \epsilon_t^Z \text{ is distributed with } N(0, \sigma_t^Z)$$

3.4 Shock Processes

We consider TFP and interest rate shocks as driving forces of emerging market business cycles. The observed negative correlation between these shocks is explained with a simple default model by Neumeyer and Perri (2005) such that when country is subject to a negative productivity shock, its output declines and the probability of default on its foreign debt increases, which makes it costly for the country to borrow abroad. This leads to an increase in country interest rate. We also accept this explanation, however we do not separate the country interest rate into world interest rate and country spread components since we do not hit the world interest rate with a shock. Instead we assume that fluctuations in the country interest rate result from the fluctuations in the country spread only.

Boz Durdu and Li (2009) estimates a joint VAR process using Solow residuals and EMBI yield spreads for Mexico and documents the following process:

$$\epsilon_{t+1} = RHO * \epsilon_t + e_t$$

$$\epsilon_t = \begin{bmatrix} \epsilon_t^Z \\ \epsilon_t^R \end{bmatrix},\ RHO = \begin{bmatrix} \rho_Z & \rho_{Z,R} \\ \rho_{R,Z} & \rho_R \end{bmatrix},\ e_t = \begin{bmatrix} e_t^Z \\ e_t^R \end{bmatrix}$$

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

Chapter 4

QUANTITATIVE ANALYSIS

The model is parameterized so that deterministic steady state of model matches several average ratios of macroeconomic aggregates of Mexican economy documented in the literature. The model is solved by log-linearizing the equilibrium conditions around the steady state, which we have calculated explicitly. The program DYNARE, which is a pre-processor and a collection of MATLAB routines that solve non-linear models with forward looking variables, is used to carry out computations.

4.1 Parameterization

Average real interest rate Mexico faces in the international financial markets, R is 1.059 (Uribe Yue (2006)). β is set to satisfy the equilibrium condition with respect to bond holdings at steady state, so $\beta = 1/R = 0.9443$. Frisch elasticity of labor supply is set to 0.6 following Boz Durdu Li (2009). According to OECD Annual Hours and Productivity data, workers in Mexico spend 0.32 of their non-sleeping time on working, therefore we set $l = 0.32$. The implied elasticity of leisure is obtained as $\nu = 3.54$ by solving $\frac{1-l}{l}\nu^{-1} = 0.6$.

Steady state unemployment ratio is set to $u = 0.0821$ (Boz Durdu Li(2009)) based on unemployment rate data of Turkey for the period 1988-2006 taken from IFS. Exogenous separation rate is not available for Mexico thus it is taken from Tasci and Tansel (2005) for Turkey as $\psi = 0.06$. These imply that at steady state $\omega u^{\alpha} v^{1-\alpha} = 0.0551$ matches are formed.

Job finding rate is assumed to be $\frac{\phi(\theta)}{\theta} = 0.7$ as in Boz, Durdu and Li (2009), which implies an average vacancy duration of 45 days. Then level of vacancies has to be $v = 0.0787$ and with the assumption of recruiting expenditure to GDP ratio, $\frac{\kappa v}{y}$, is 0.01, cost of posting a vacancy, κ, becomes 0.127.

Elasticity of matching rate with respect to aggregate unemployment rate, α, needs

to be the same as bargaining power ξ in order for the wages implied by Nash bargaining to support the allocations obtained from social planner's problem (Hosios (1990) condition). Following Andolfatto (1996), α and ξ are set 0.5. and the matching efficiency, ω is obtained as 0.6855.

Remaining parameters φ^E and φ^U are determined by using the following three conditions such that (i) the normal efficiency condition of hours worked (i.e. wage is equal to MRS bet. consumption and leisure) is assumed to hold at steady state, (ii) the equilibrium condition with respect to vacancies is assumed to hold at steady state, and (iii) consumption level at steady state is assumed to be 0.6983% of output.

Table 2 and 3 summarize the parameter values and steady state values used in the analysis with their sources.

Table 2: Parameter Values

Parameter	Value	Explanation	Source
I.Preferences			
β	0.9443	$= 1/(1+R)$	discount factor targeted to match R
σ	2	relative risk aversion	literature
η	3.54	elasticity of leisure	Frisch elasticity of labor=0.6
φ^E	0.7302	coefficient of leisure (emp.)	calculation
φ^U	-0.9063	coefficient of leisure (unemp.)	calculation
II.Production Technology			
z	1	total factor productivity	normalization
ζ	0.36	capital's share in output	literature
III.Search Technology			
ω	0.6855	matching efficiency	$= \frac{M}{(1-n)^{\alpha} v^{1-\alpha}}$
α	0.5	elasticity of matching function	Pissarides (2001)
κ	0.127	unit cost of posting vacancy	recruiting expenses as 0.01 of GDP
ψ	0.06	job separation rate	Tasci and Tansel (2005)
ξ	0.5	bargaining power	same as α
IV.Other			
φ^b	0.01	bond holding cost parameter	literature
φ^k	25	capital adjustment cost parameter	literature
δ	0.025	depreciation rate	literature
λ	1	working capital fraction	Neumeyer and Perri (2005)

Table 3: Steady State Values

Variable	Value	Source
R	1.059	Uribe and Yue (2006),Durdu, Mendoza and Terrones (2009)
y	1	normalization
c	0.693	Boz Durdu and Li(2009)
b	-0.42	Durdu, Mendoza and Terrones (2009)
n	0.9179	unemployment data of Turkey (1988-2006) from IFS
k	8.8283	calculation
v	0.0787	calculation
w	2.3522	calculation

4.2 Results

Main results of the model in terms of business cycle moments are summarized in Table 4. The first column shows the respective moments in the data. For comparison, the second column documents the moments implied by the replication of Boz, Durdu and Li (2009) model, which includes fixed capital formation, labor market search but no working capital requirement. The results of our replication differ from what they documented in their study mainly because of the technical differences. In particular, we avoided the divergence of bond holdings by introducing convex bond holding costs while in their model endogenous discount factor is used. In addition, they solved the model with value function iteration, which is a non-linear method, while we solve the corresponding model with log-linearization. The remaining columns reveal the results of the proposed model with and without working capital requirement. The last column is the preferred model since its results imply more countercyclical net exports and it can demonstrate the more negative relation between interest rate and unemployment. Along with these findings, the proposed model is also successful at matching the other business cycle facts of emerging market economies such that consumption and wages are more volatile than output and interest rates are countercyclical.

Table 4: Selected Business Cycle Moments

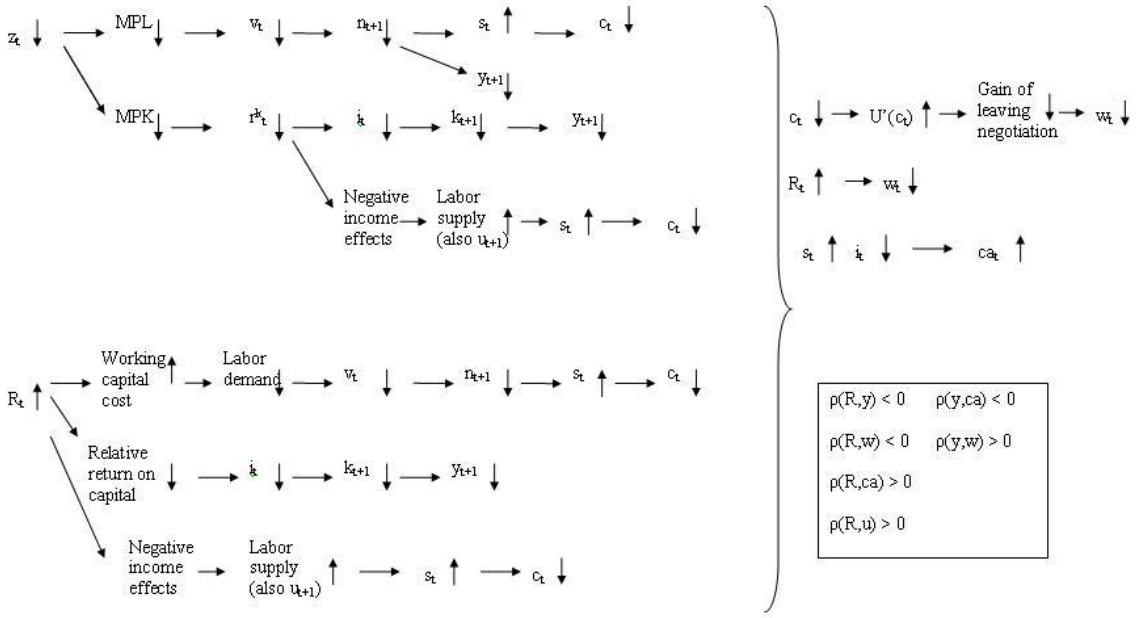
Moment(%)	Data	BDL	Model without w.c.	Model with w.c.
I.Standard Deviations				
$\sigma(c)$	3.02	4.59	4.13	5.52
$\sigma(y)$	2.40	3.04	3.39	3.79
$\sigma(i)$	9.33	N.A.	11.49	14.27
$\sigma(u)$	14.70	2.12	2.78	4.85
$\sigma(v)$	N.A.	3.10	4.36	8.05
$\sigma(w)$	5.20	5.07	5.29	8.67
$\sigma(nx/y)$	2.27	1.81	2.61	3.24
$\sigma(c)/\sigma(y)$	1.26	1.50	1.21	1.45
$\sigma(i)/\sigma(y)$	3.89	N.A.	3.38	3.76
$\sigma(w)/\sigma(y)$	2.16	1.66	1.56	2.28
II.Autocorrelations				
c	70	60.80	60.16	67.42
b	N.A.	92.47	86.96	83.46
y	75	74.58	79.29	80.82
i	N.A.	N.A.	55.74	62.29
u	84	86.75	85.00	80.44
v	N.A.	65.91	60.79	50.33
w	85	66.17	68.50	76.99
nx/y	N.A.	44.93	38.97	45.89
III.Correlations with Output				
$\rho(y,c)$	92	81.26	82.18	87.25
$\rho(y,i)$	91	N.A.	77.79	83.87
$\rho(y,R)$	-50	-74.18	-70.19	-72.33
$\rho(y,u)$	-78	-61.84	-86.01	-85.03
$\rho(y,v)$	N.A.	62.68	77.88	69.31
$\rho(y,w)$	56	93.30	93.34	92.65
$\rho(y,nx/y)$	-80	-24.16	-23.05	-50.93
IV.Correlations with Interest Rate				
$\rho(R,c)$	-58	-93.79	-91.05	-89.94
$\rho(R,i)$	-59	N.A.	-97.10	-96.04
$\rho(R,u)$	N.A.	42.89	78.41	89.14
$\rho(R,v)$	N.A.	-54.26	-94.00	-97.23
$\rho(R,w)$	N.A.	-92.47	-89.06	-90.65
$\rho(R,nx/y)$	68	74.23	75.38	88.07

The responses of variables to one standard deviation positive productivity and interest rates shocks separately are given with the impulse response graphs in the Appendix. The impulse responses are calculated both for with and without working capital requirement cases. The most notable differences between these two cases are in the responses of unemployment and wages to a positive interest rate shock. In Figure 5 we can see that unemployment rises to 0.5% above its steady state level and wages fall to about 2.5% below it steady state level when the economy without working capital requirement is hit by a one standard deviation positive interest rate

shock. The response of the economy with a working capital requirement is shown in Figure 7. Here we can see that the responses of unemployment and wages are more pronounced. In response to a positive interest rate shock, unemployment rises to 2% above its steady state level while wages fall to 4% below to its steady state level. These results support our claim that considering working capital requirement of firms results in a larger decrease in unemployment in response to a positive interest rate shock.

The mechanism producing these results can be explained as follows. When a negative productivity shock occurs, worker's productivity decreases. Since workers are less productive, firms' demand for labor decreases, which leads them to post less number of vacancies this period. We know that vacancies posted this period can only become productive next period, thus a decrease in this period's vacancies causes the next period's employment fall. Next period firms will use less employed workers as the input of production, thus next period's output declines. On the other hand, a negative shock causes the marginal product of capital to decline. This results in a decline in rental rate of capital, which has two effects. First, since rental rate of capital is lower households would not want to invest as much as before, thus investment falls. A decrease in investment means a decrease in next period's capital, which leads to a decline in next period's output. Second, a decrease in the rental rate of capital creates negative income effects since households receive rent from capital. These negative income effects create incentives for household to supply more worker in the labor market and consequently next period's unemployment increases. When household's tend to increase next period's unemployment by supplying more labor this period, their probability of finding a job next period declines and households make precautionary savings this period in order to smooth consumption. Saving more this period leads to a decline in consumption.

Figure 3: The Propagation of Shocks



Since the productivity and interest rate shocks are negatively correlated and a recession is likely to occur when the economy is hit by a negative productivity shock and a positive interest rate shock, it is useful to analyze the response of the economy to a positive interest rate shock. First, a positive interest rate shock decreases the return on capital relatively, which leads household to invest less this period and to get less capital next period. This results in less production next period. Second, an increase in the interest rate decreases the present value of household's wealth and creates negative income effects. Again households tend to supply more labor this period and decrease their probability of finding a job, which results in precautionary savings and less consumption this period. Last, due to the presence of working capital requirement, an increase in interest rates rises the cost of labor input for the firms since they have to borrow abroad at this interest rate to finance the wage bill in advance. In this case, firms' demand for labor decreases and they post less vacancies, thus the next period's employment decreases. This decreases the household's probability of finding a job decreasing next period, hence they make precautionary savings, and this

period's consumption falls.

These two shocks together result in a fall in consumption, which increases the marginal utility of consumption and decreases the wage since the gain of leaving the negotiations and taking an outside option is negatively related with marginal utility of consumption. Moreover, the rise in savings and the fall in investment causes current account to increase since current account is defined as savings minus investment. In addition, unemployment increases next period in response to the shocks this period, which justifies the observed lag between EMBI and corporate spreads and unemployment in Mexico. According to Figures 1 and 2, spreads take their highest value in 2008 but unemployment increases significantly in 2009. This propagation mechanism of shocks can be briefly explained with a flow chart as given in Figure 3.

Chapter 5

CONCLUSION

In this study, matching business cycle facts of emerging markets, then illustrating a mechanism in which a positive interest rate shock affects firm's labor demand and creates unemployment were aimed. In order to do so a SOE-RBC model enriched with working capital requirement and search and matching frictions in the labor market is parameterized and solved. The results indicate that the proposed model is successful in matching the business cycle facts such as countercyclical interest rates and net exports, more volatile consumption and wages relative to output and high correlation between wages and output. It also features the mechanism that creates high positive correlation between interest rates and unemployment, which can be used to analyze the effects of a financial crisis on real sector, especially on unemployment.

In future, the model can be solved by non-linear methods (i.e. value function iteration) in order to avoid the shortcomings of linear methods documented by Oviedo Yue (2009), such as the inaccuracy of results obtained from linear methods when economy is not close to steady state initially. In addition, matching efficiency shocks can be embedded into the model, as in Boz Durdu and Li (2009), or job separation can be endogenized in order to reflect sectoral reallocations in the labor market when a crisis occur.

Appendix A

IMPULSE RESPONSE FUNCTIONS

A.1 The Model without Working Capital Requirement

Figure 4: Responses to 1 Std. Dev. Productivity Shock

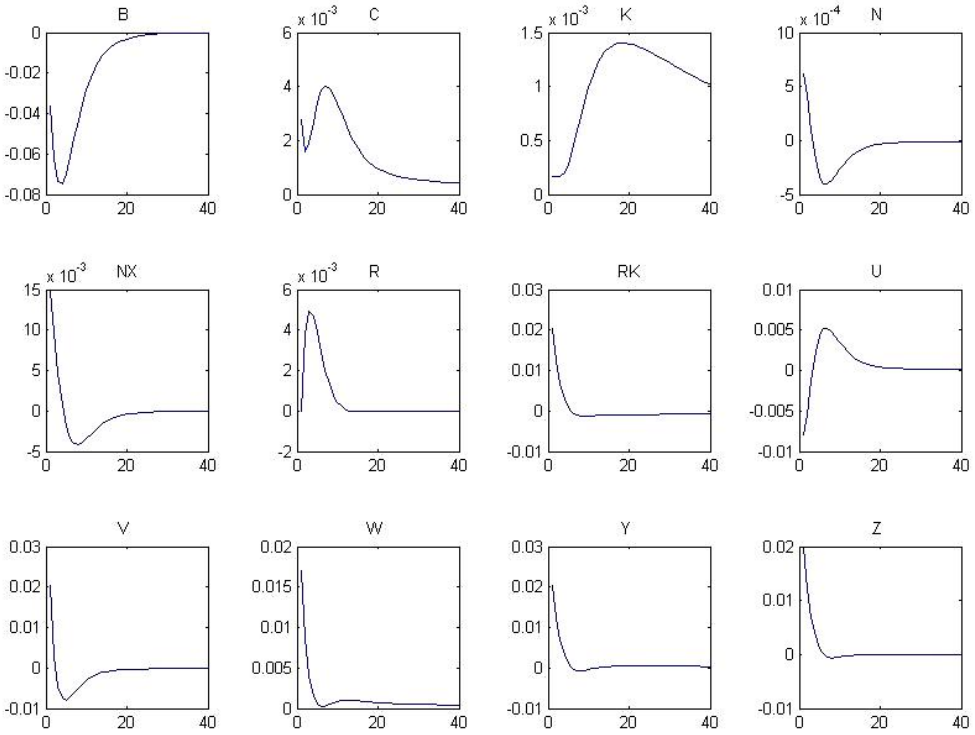
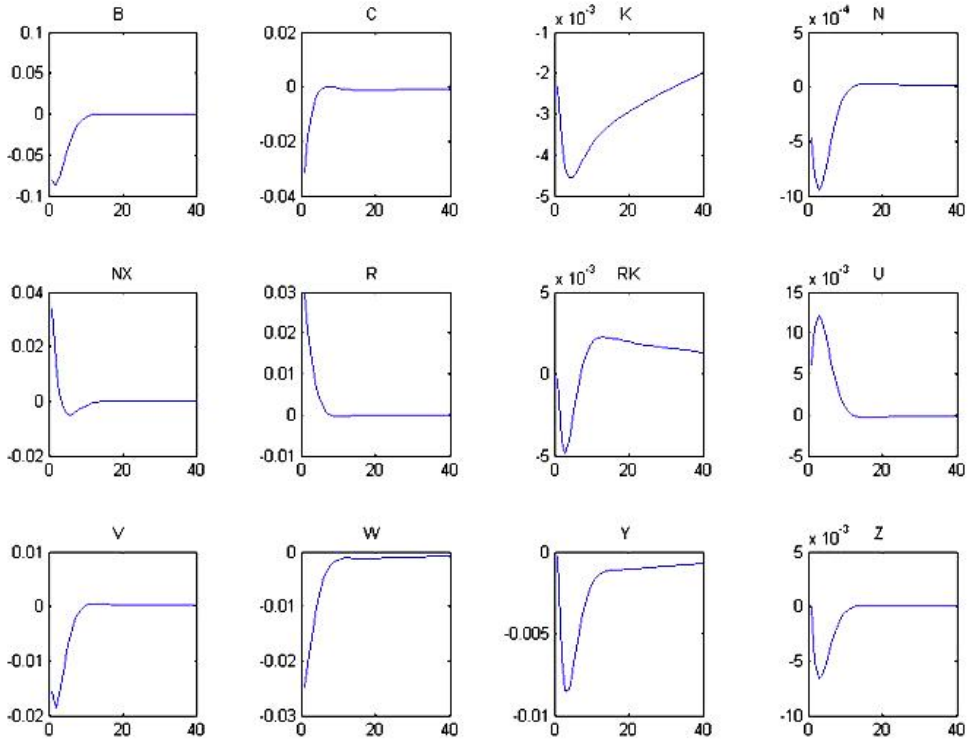


Figure 5: Responses to 1 Std. Dev. Interest Rate Shock



A.2 The Model with Working Capital Requirement

Figure 6: Responses to 1 Std. Dev. Productivity Shock

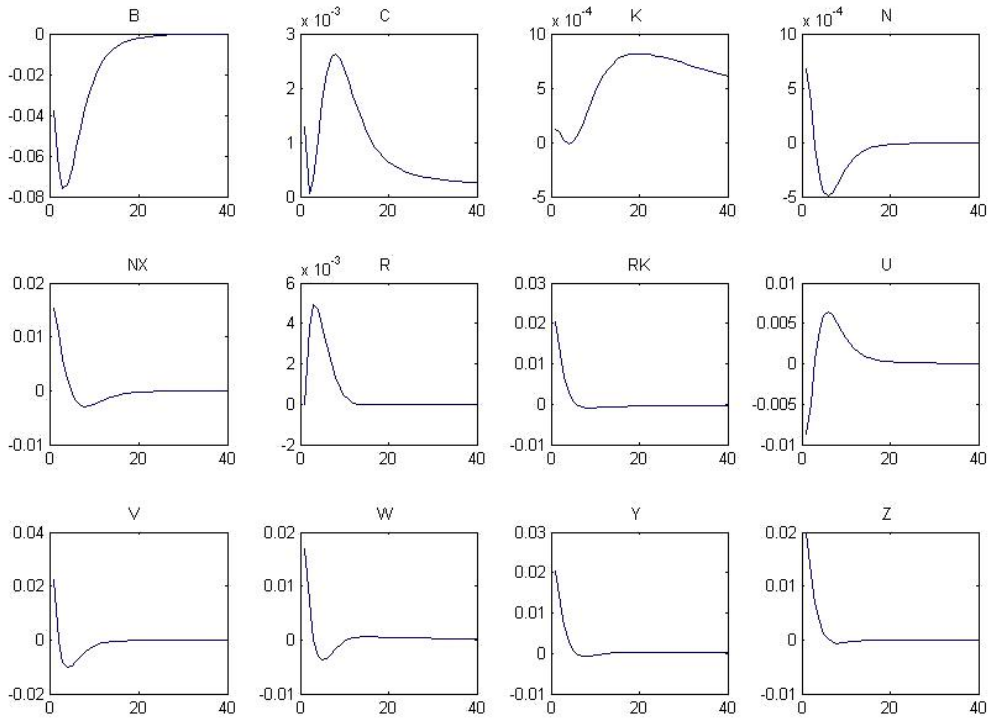
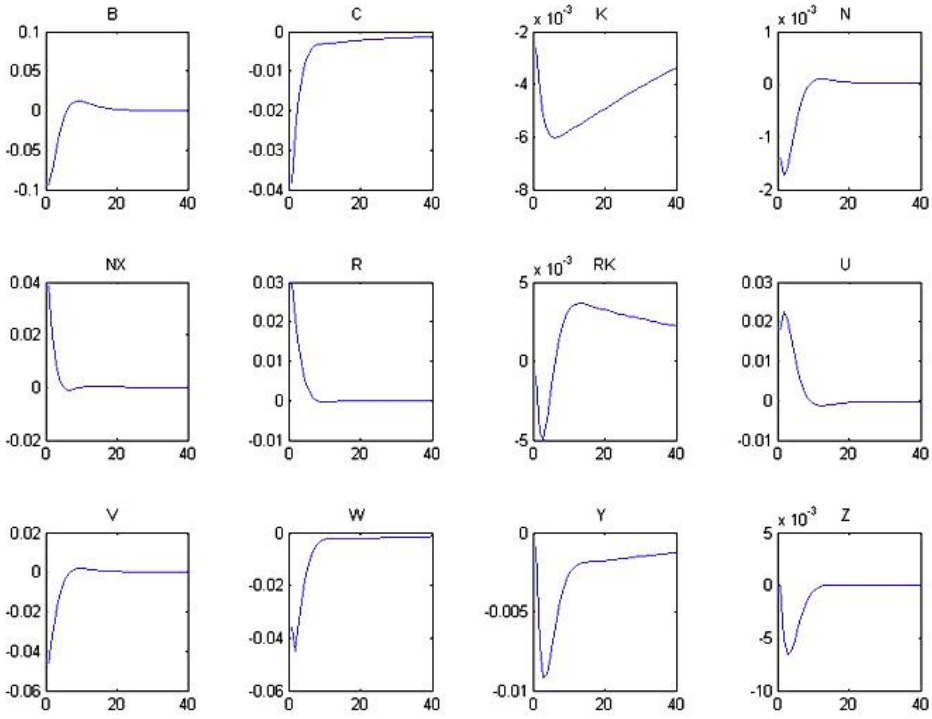


Figure 7: Responses to 1 Std. Dev. Interest Rate Shock



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