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Abstract[1]

Financial crises in both emerging and developed economies have been characterized by large output drops and spikes in unemployment and interest rates. To account for these stylized facts this paper builds a business cycle model where financial and labor market frictions interact as occasionally binding borrowing constraints and search frictions. The model is calibrated to a Sudden Stop-prone emerging economy and also to some peripheral European economies in the recent crisis. The model accounts for unemployment dynamics both during crises and at regular business cycle frequencies. The paper also assesses the welfare implications of policies that reduce real minimum wages during crises.

JEL Classification: E32,E44, F41

Keywords: Financial Crises, Sudden Stops, Business Cycles, Emerging Economies, Labor Markets, Search Frictions.

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1 Introduction

The global recession triggered by the recent financial crisis made clear that financial frictions are critical when modeling business cycles and should not be confined solely to the analysis of emerging markets crises. A similar point has been stressed by Frankel (2010):

> "Many ask what fundamental rethinking will be necessary to save macroeconomic theory. Some answers may lie with models that have been applied to fit the realities of emerging markets and models that are at home with the financial market imperfections which have now unexpectedly turned up in industrialized countries."

In addition, the large worldwide spikes in unemployment rates that characterized the recession, together with the subsequent jobless recoveries, have shown the need to embed business cycle models with labor market imperfections that deviate from the standard neoclassical approach characterized by full employment.

In this paper we undertake two tasks. First, we empirically document the systematic comovement between the main macro, financial, and labor aggregates in emerging market economies (EMEs) during systemic financial crises. We then assess the extent to which these stylized facts resemble those experienced during historically large recessions in developed economies and currently by some of the peripheral countries in the European Union. The second task is to build an equilibrium business cycle model of a small open economy where financial and labor market frictions interact. In the model, foreign lenders lack the ability to fully monitor the repayment capacity of the domestic economy so a financial friction naturally arises as they impose a debt ceiling at the level of the aggregate economy. We assume individual agents do not internalize that borrowing limit. Credit rationing can thus be an equilibrium if, conditional on a relatively high debt level, a fundamental shock (productivity, in our model) is large enough to make the borrowing constraint bind. In those states a financial crisis materializes in the form of large spikes in the interest rate premium, ensuring that individual borrowing decisions satisfy the credit constraint. To account for unemployment dynamics we add labor market frictions as in Mortensen and Pissarides (1994) where firms post vacancies and job matches result from a matching technology that depends on the number of vacancies and the current unemployment rate. In addition to this, we assume that unemployment generates a loss in human capital as in Pissarides (1992). This divides the labor market into experienced and unexperienced (newly hired) workers. We assume the former are paid their marginal productivity while the latter face a minimum wage that is fixed along the lines of Hall (2005). In such a setting, the two types of frictions can potentially interact, particularly during large crisis episodes: when the borrowing constraint binds, the fall in output makes firms post many fewer vacancies, which in turn makes unemployment increase by a larger amount relative to the case without a debt ceiling.

Our main five findings can be summarized as follows. First, arguably the most well-known crisis in EMEs, the 1995 Mexican Tequila crisis, was characterized by a collapse of output, TFP and consumption, as well as large spikes in unemployment and country interest rates. Using a novel data set with labor and real variables in EMEs, we establish after a systematic analysis that such patterns do indeed replicate in other crises in EMEs. We document how, in the trough of the recession triggered by the financial crisis, EMEs experienced an average fall relative to the trend of roughly 6 percent and 3 percent in aggregate output and consumption, respectively. Such traumatic episodes were also characterized by unemployment being more than 15 percent higher relative to trend. And Spreads reach even higher deviations, up to 30 percent, but two periods in advance.

Second, some of the patterns that characterized crises in EMEs are also documented in developed economies. Large increases in unemployment have also been a distinctive characteristic in other severe recessions in developed economies throughout history. This has also been the case during the recent crisis in peripheral European countries. In addition, in countries like Greece and Ireland there has been a strong co-movement of output and consumption with aggregate TFP while simultaneously exhibiting large increases in unemployment rates. Spreads also have peaked but with a considerably higher lag. Yet the similarities do not extend to all the European countries we studied. Spain's aggregate data do not reveal any close link between TFP and the dynamics of aggregate output or consumption. Moreover, the link between spreads and unemployment is less strong in this country.

Third, we show that under plausible parameterization, our model can account for the main macro dynamics of crisis-type episodes including the large drop in economic activity, the spike in unemployment and the sharp V-type recovery. It is also capable of reproducing some of the unconditional business cycle second moments in the data. Sensitivity analysis further documents the role that some of the parameters governing the search-match process play in accounting for the macro dynamics in the data. A parameter that stands out in generating large cyclical increases in unemployment from its long-run average in crises episodes is the one that governs the elasticity of the matching rate with respect to vacancies.

Fourth, given that our framework is based upon fully optimizing agents, it is amenable to conducting welfare analysis of policy measures. We focus in particular on a policy that reduces the minimum wage of unexperienced workers at the trough of the recession. The results indicate that such a policy can be welfare improving because the costs associated with lower income are more than compensated by the reductions in unemployment. But the welfare gains are non-monotonically increasing. Conditioning on the size of the shock we used, we find that within the wage-drop policies we tried, a 15 percent drop maximizes the welfare gains.

Fifth, we show that the model can indeed be used to account for the recent crisis episodes in peripheral European countries, notably Greece and Ireland. Indeed, when calibrated to data from these two countries the model can reproduce the large increases in the unemployment rate observed at the onset of the crisis. This lends support to the claim by Frankel mentioned above in that some of the models that "fit the realities of emerging markets" may serve as a starting point for studying the current crisis in Europe.

This paper is, to the best of our knowledge, the first attempt to systematically study and compare financial crises in emerging economies with the recent European crisis, while building a model with financial and labor market frictions capable of accounting for some of the observed patterns in the data. It is related to at least three strands of the literature. On one hand, it relates to the recent efforts in combining financial frictions and unemployment into DSGE models (see Christiano, Trabandt and Walentin, 2011) as extensions of the first real business cycle models that included search frictions (Andolfatto, 1996; Merz, 1995). Our work expands this research agenda by incorporating the rich non-linear dynamics that we believe are paramount in accounting for financial crises.[2]

On the other hand, our work contributes to the vast literature on integrating financial frictions and occasionally binding constraints when studying Sudden Stops in emerging economies exemplified by the work of Calvo (1998), Caballero and Krishnamurty (2001), Uribe (2006), Gertler et al. (2007), Mendoza (2010), and Benigno et al. (2011), among others. Our work expands this agenda by integrating recent progress in labor market modeling, thereby allowing to study the unemployment dynamics during sudden stops and its interaction with financial frictions.

Last, our work is also related to the literature that studies labor markets in business cycle models of emerging market economies, particularly those that have added search frictions as a way to account for key business cycle moments of the labor market in these economies as in Boz et al. (2011) and Lama and Urrutia (2011). [3] These works have extended the research agenda of building business cycle models of emerging economies that can account for the distinctive patterns of aggregate fluctuations in these economies.[4] We contribute to this literature by showing that our model can also reproduce some of the distinctive second moments that characterize emerging market economies' business cycles while modeling the interest rate endogenously as an equilibrium price that is affected by the states where the borrowing constraint binds.

The rest of the paper is divided into five sections. In the first section we document some of the main stylized facts in financial crises in emerging economies, and compare them to the recent crisis in Europe. The second section presents our model. In the third section we fit the model to Mexican data and present the main results of the paper in terms of fit, robustness analysis and policy implications. The fourth section explores the extent to which we can extend that framework to analyze the recent crisis in some of the peripheral European economies. Section 5 has our final remarks. Further technical material is collected in an Appendix.

2 Financial Crises: Some Stylized Facts

The goal of this section is twofold. First we document some of the main stylized facts of financial crises in EMEs. In doing so, we pay particular attention to variables in financial and labor markets. Because EMEs have been affected by large financial crises, they seem the natural starting point for this task. However, as the recent world financial crisis clearly demonstrated, financial crises may very well also unfold in developed economies. For this reason, the second goal of this section is to try to draw some parallels between the pathology of systemic financial crises in emerging economies and those observed in developed economies both recently and in the past.

The analysis of financial crisis in EMEs is done in two steps. First we start by studying what is arguably the most distinctive EME-type of systemic financial crisis: the Mexican Tequila crisis of 1995. We then investigate the extent to which some of the distinctive patterns of that crisis can be found in the unconditional business cycle moments of the Mexican economy. Studying

[2] See also Schmitt-Grohé and Uribe (2011) for an account of the recent financial crisis in Europe without explicitly incorporating frictions in the labor market via search and match, but postulating ad hoc real wage rigidities. Our work can also be related to theirs in that real wage rigidities are also at the heart of the dynamics in our model.

[3] See also Garín (2012) for a recent effort in merging financial and labor market frictions but not in the context of emerging economies.

[4] Some of the early contributions in this literature are Kydland and Zarazaga (2002), Neumeyer and Perri (2005) Uribe and Yue (2006), and Aguiar and Gopinath (2007). Further extensions that have refined this framework are, among others, Chang and Fernández (2013), Garcia-Cicco et al. (2010), Li (2011), and Fernández and Meza (2011).

Mexico appears as a natural first step given that it has often been referred to as a representative emerging economy, and also because it offers relatively more available data than other EMEs. In the second step of the analysis we assess how robust the patterns of the Mexican Tequila crisis are when we systematically analyze other crises in EMEs.

Figure 1 plots the dynamics of the main Mexican macroeconomic aggregates during the Tequila Crisis episode of 1995 when capital inflows suddenly stopped and the country experienced severe constraints in its access to world capital markets. Arguably the most distinctive feature of such episode was the fact that the halt in capital flows resulted in a financial crisis where the real interest rate faced by Mexicans in world capital markets jumped from an annual 3 percent in the first quarter of 1994 to 16 percent within the following year. This was the result of the massive increase in the spread of Mexican sovereign bonds over US T-Bills from 200 to 1,500 basis points. The real effects of the crisis were profound, as can also be depicted from further inspection of the plots in Figure 1. Real economic activity, measured as deviations from trend, fell close to 12 percentage points from a peak of four percent to a trough of minus eight percent between July 1994 and April 1995. That abrupt fall in economic activity was accompanied by an even larger drop in private consumption and a sharp drop in total factor productivity, as measured by the Solow residual. It is also important to note that the unemployment rate more than doubled from three to seven percent within that same year but came back to even lower levels than those that preceded the crisis in little less than two years after. The recovery of the other macro variables was actually much faster than that of the labor market.

Can the large increase in unemployment in Mexico in this episode be related to labor supply changes? A look at the labor force participation rate in the Mexican labor market (see Figure 1 in the appendix) displays remarkable stability from 1987 to 2003, particularly during the crisis in 1995. It is thus plausible to argue that the dynamics of the labor market in the Tequila crisis in Mexico ought to be explained by labor demand changes that let to movements within the labor force (from employment to unemployment) instead of movements from inactivity to the labor force.

We now turn to studying the co movement among these variables by exploring unconditional business cycle moments. Table 1 summarizes some of the key second moments of the Mexican business cycle between the first quarter of 1987 and the second quarter of 2003.[5] We focus our attention on the cyclical component of the country's interest rate, aggregate income, private consumption, the Solow residual, employment and the unemployment rate. The results in Table 1 are in line with the fact that interest rates are countercyclical and that fluctuations in consumption are more volatile than those of output. The Solow residual is highly procyclical too. Such business cycle patterns have received substantial analysis elsewhere (see Aguiar and Gopinath (2007), and Chang and Fernandez (2013)). In terms of the labor market, both the labor force and the unemployment rate are mildly procyclical and much less volatile than output (Fernández and Meza, 2011). We also observe that employment and unemployment exhibit strong persistence, similar to that of output.

Do financial crises in other EMEs look like the Mexican Tequila crisis? To answer this question we used the systemic sudden stops (SSS) categorization by Calvo et al (2008). According to this work a SSS is an episode in which the economy exhibits a large and unexpected cut in capital inflows and the initial trigger is financial and external as it takes place together with a sharp rise in

[5] Data on country interest rates for Mexico are available only from 1994.

aggregate interest rate spreads. Based on this metric, Calvo et al. (2008) construct a dataset with the timing of these episodes for 89 developing countries, reporting, on a monthly frequency, the beginning and the end of each of these events. They have a total of 71 of these episodes of which we use 25 of them, for which data of output, consumption, interest rates and unemployment were available (at least partially). We use their timing as the first input in our analysis[6] and computed the average cyclical (Hodrick-Prescott filtered) deviation of the main macro aggregates we studied in the Mexican case for each of these episodes.

The results of this analysis are presented in the panels of Figures 2 and the list of countries and data availability are reported in Table I of the appendix. We define as t the period where the trough of output occurs within each identified episode. Figure 2 shows how the interest rate spread, measured by the EMBI index, displays a large and significant increase which is, on average, around 20 percent. Interestingly, the interest rate spread is the only variable that we study here whose cyclical deviation is not coincident with the trough of output. Indeed, for the average EME, the peak of the spread occurs in $t-2$. Figure 2 also reports that the output cycle of the average economy in our sample falls 5 percent in t but recovers relatively quickly and three quarters after it has returned back to trend levels. During quarters $t-1$, t and $t+1$, the cyclical deviations of output are negative and statistically significant at the 10 percent significance level. In quarter $t+2$ the output cycle is negative although not statistically significant.

On average, consumption falls around 3 percent in t so consumption and output coincide for the average of emerging economies in our sample. Unlike in the Mexican case, consumption's fall is less than output's. Consumption turns negative in period $t-1$ and returns to near-zero values at quarter $t+3$. However, only the fall in the cycle from period t to $t+2$ is statistically significant.

Inference on the unemployment rate is somewhat more difficult to make given the lack of data for emerging economies. Out of the 25 episodes we analyze,we were able to gather unemployment data for only half (see Table 1 in the Appendix). Still, we do find positive and statistically significant variations in the unemployment rate around financial crises as we can see from Figure 2. The average economy presents a cyclical deviation of 15 percent with respect to its trend.[7] The unemployment rate is highly persistent as it stands above its trend from period $t-2$ to period $t+3$, although the smaller number of observations translate into high uncertainty for periods other than t. As we also pointed out for the case of consumption, the higher average cyclical deviation of unemployment also occurs in time t.

Summing up, the evidence shows that financial crises in other EMEs do indeed look like the Mexican Tequila crisis, at least qualitatively. They are characterized by large country interest rates that eithe rlead to or coincide with steep declines in real economic activity. The latter are characterized by sharp falls in output and consumption. Importantly, there is also evidence of dislocation in the labor market, something that had not been fully documented in previous studies. We do find that cyclical unemployment significantly increases and exhibits a somewhat a higher persistence than the other real variables.

Based on these stylized facts, one interesting dimension to explore is to inquire about the resemblance of the dynamics of economic variables during financial crises in EMEs with those of developed economies during other episodes. We divide this question into two different parts.

[6] Because we work with quarterly data, we turned their monthly timing of the SSS episodes into our used frequency by assuming that an episode had occurred in any given quarter if in any of its three months Calvo et al. (2008) had identified a SSS.

[7] For example, if the Hodrick-Prescott trend in t is 10 percent then the observed unemployment rate is 11.5 percent

First we investigate the behavior of the output cycle and unemployment during large economic contractions, and then we analyze the recent financial crises in peripheral Europe.

We start by analyzing the behavior of the output cycle and unemployment during five historically large output contractions. Our choice of the first four episodes is guided by the literature on Great Depressions by Kehoe and Prescott (2007). The four historical episodes are: United States during the 1930s, the United Kingdom during the 1920s, New Zealand during the 1990s and Finland during the 1990s. As a fifth one, we include the recent Great Recession in the US. While all of these crises have widely been studied, our aim here is to provide a systematic analysis of the joint dynamics of output and unemployment in these episodes. The left panel of Figure 3 summarizes the business cycle derived from a Hodrick-Prescott filter on the annual series of GDP while the right panel presents the dynamics of the unemployment rate. [8] Time t is defined as the period of output's trough in each episode. The figure shows that the cyclical component of output fell between 4 percent and 15 percent during these episodes and that the unemployment rate increased to levels between 10 percent and 25 percent. While these large contractions appear to be associated with stronger economic downturns than the typical EME crises, qualitatively we do find a negative co-movement of unemployment and economic activity in both types of episodes.

We turn now to the question of whether the stylized facts from financial crises in EMEs resemble the patterns recently observed in more developed economies following the financial crisis of 2008/9? To address this question we follow a simple approach. We compare the dynamics of a small sample of European countries known to have suffered the most from the recent crisis to those from the Mexican Tequila crisis. The sample is made up of Greece, Ireland and Spain. These are arguably the countries that, as of today, have been most affected by the crisis in the European Union.

Figure 4 reports the dynamics of the macro variables in Greece, Ireland and Spain between 2001 and 2012.[9] [10] The figure focuses on the same five variables that were analyzed in the Mexican case in Figure 1. A first result that stands out from these plots is the fact that in Greece and Ireland TFP fell together with output and consumption as the crisis unfolded. Such pattern is similar to that of Mexico in 1995 as was documented in Figure 1. Yet the same trend is not present in the Spanish aggregate data as the output and consumption co-movement seems to be independent from the TFP cycle. Such a distinctive pattern for the Spanish economy occurs mainly because the TFP process, in levels, exhibited a downward trend starting in the early 2000s.

Another result that stands out from the panels in this figure is the strong relationship between interest rates and unemployment. Periods of financial distress -defined by spread increases- coincide with bad times for labor markets. This characteristic was also present in Mexico and in the average EME. While the correlation between country spreads and unemployment in Mexico

[8] Historical output data are taken from Maddison (2003) in the case of the US, UK and New Zealand, and from the OECD in the case of Finland. Unemployment data for the US comes from Lucas and Rapping (1972), from Kehoe and Prescott (2007) for the UK, and from the OECD for the other two episodes. Unemployment data for the United States come from BLS and IFS.

[9] As in Figure 1, we report the cyclical components of aggregate TFP, output and consumption and the levels of unemployment and country interest rates. In the former case, we did not use the Hodrick-Prescott filter because it is a two-sided filter and hence it is not suitable to study crisis events that occur in the end points of the empirical sample as it is the case in our sample of European economies. For this reason we chose to compute the cyclical component in these countries' variables as deviation from a log-linear trend.

[10] We build the TFP series using capital series from Vikram and Dhareshwar (1993) until 1990 and then extrapolating the series using the perpetual inventory model.

was 0.83, in Ireland is 0.88. The numbers for Greece and Spain are also large, 0.55 and 0.58, although not as much as in the two other economies.

Figures 5 makes the comparison between today's crises in European countries and the Mexican Tequila episode more explicit. To do so we identify as period t the peak of output before each of the crises in the four countries we analyze.[11] We then analyze the dynamics in the vicinity of t of the same macro variables we have been studying so far.

Some interesting similarities as well as some differences emerge. First, all four cases display a rapid acceleration phase in the run-up to period t, particularly in the cases of Mexico and Ireland. However, the fall of real economic activity appears to have been much more severe in the Tequila case, but the recovery also was much more vigorous then. Second, aggregate consumption exhibits an even stronger similarity in terms of the fast increase in the expansionary phase, but a much faster drop in the contractionary phase too. Third, unambiguously all four cases have been characterized by lagged increases in unemployment rates, but there is large heterogeneity in this trend. While in the Mexican case the increase was sharp, although from a relatively lower level, the unemployment rate gradually displayed mean reversion. This is clearly not the case for any of the other cases, a result that shows the severity of the recent European crisis. Fourth, the spread is clearly a variable in which the recent crisis in Europe differs from the Tequila episode. While in the latter, the fall in economic activity was characterized by a parallel spike in spreads, in the former more recent case of European economies these variables have lagged behind. To be sure, spreads have risen in peripheral European countries, but not with the speed and co-movement with the cycle as one would expect from looking at earlier crises in EME. Last but not least, one common dimension that Greece and Ireland share with the Tequila episode lies in the fact that the sharp fall in economic activity that has distinguished these crises has also been characterized by downturns of aggregate TFP. Spain, however, is not characterized by this, as explained above.

While the previous analysis is only descriptive and evidently partial to the extent that the crisis is still unfolding in the EU zone, it nonetheless serves as a basis for comparing today's crisis with the systematic behavior around financial crises in EMEs. In the following section we offer a model that will help to rationalize some of the patterns described in financial crises episodes.

3 The Model

We now formally present our small open economy, real business cycle model with labor and financial frictions. It describes a one-sector economy populated by a representative household and firm that interact in labor and final good markets. The household derives utility from consumption. It is populated by a continuum of individuals who differentiate from each other only by their labor market status in the previous period. All individuals in a household consume the same amount because they can perfectly insure against idiosyncratic shocks. They exogenously supply one unit of labor at every period.

The firm posts vacancies, and only the individuals who were unemployed in the previous period have access to those vacancies. The search-matching process is both costly, as firms wishing to post vacancies have to pay a cost for it (interviews, advertising, etc.), and dependent on the state of the labor market, as the success probability depends on the number of people looking for a job. We also assume that, due to some implicit training process, individuals who have just been hired

[11] These are 1994.Q3 for the Tequila episode, and, in the European countries, 2008.Q4 (Greece); 2007.Q4 (Ireland); 2009.Q1 (Spain).

will exhibit (transitory) lower productivity. Within this framework equilibrium unemployment arises in the sense that a percentage of the individuals who want to work are not able to find a job, while other markets (i.e., goods and financial markets) clear.

Households also have access to world capital markets where they can borrow funds to smooth consumption by issuing a one-period, non-contingent, bond at an exogenous fixed rate. However, there is a financial friction in the form of an aggregate borrowing constraint which takes the form of a fixed debt ceiling. Hence the constraint may occasionally bind triggering a "financial crisis" in the form of an interest rate premium that emerges to ensure that individual borrowing is compatible with the credit constraint. During the crisis, output, consumption and productivity collapse and unemployment rises.

3.1 The Representative Firm

Let A_t be the productivity level, K the constant fixed capital level, $N_{1,t}$ be the number of experienced employees, and $N_{2,t}$ the number of just-hired employees in period t. A representative firm produces Y_t units of output using the following production technology:

$$Y_t = A_t K^{\alpha}(N_{1,t} + \Psi N_{2,t})^{1-\alpha}$$

Where $\Psi \in (0, 1)$ is a constant which represents the productivity of newly-hired employees relative to the "experienced" employees. We assume A_t follows a Markov process.

The number of experienced employees evolves as follows

$$N_{1,t} = (1 - s)N_{1,t-1} + N_{2,t-1} \tag{1}$$

where s is an exogenous job-separation rate. This separation rate does not depend on the decision of households or firms.[12]

All unemployed workers in the previous period look for a job in the labor market given that they exogenously supply one unit of labor in the market. From the side of the firm we assume that to post a job vacancy in the labor market, they must pay a fixed unit cost of λ.

As is standard in the search literature, we assume that two factors determine the outcome of the search-matching process in the labor market. First, the number of vacancies posted by firms in the labor market, and, second, the number of unemployed workers. If firms do not post vacancies there will be no matches at all. Also, the lower the rate of unemployment, the lower the probability of having a successful match for a constant level of vacancies posted. Formally, the effective number of matches is given by the matching function:

$$N_{2,t} = \min[V_t, U_t, \omega V_t^{v} U_t^{1-v}] \tag{2}$$

where the state variable U_t is the unemployment level at the beginning of period t defined as $U_t = 1 - N_{1,t-1} - N_{2,t-1}$, $v \in (0, 1)$ is the elasticity of the matching function with respect to vacancies and ω is the efficiency parameter of the matching function.

The firm's dividends are given by:

[12] While there is empirical ground to dispute the exogeneity of s (Davis et al., 2008), we do not undertake the task of endogenizing this parameter because this will make the non-linear solution of the model even less tractable. Yet we feel that such a task would produce a separation rate that increases during financial crises, thereby further strengthening the link between labor and financial frictions that we stress. We leave a formal proof of that claim for future work.

$$\pi_t = A_t K^{\alpha}(N_{1,t} + \Psi N_{2,t})^{1-\alpha} - w_{1,t}N_{1,t} - w_{2,t}N_{2,t} - \lambda V_t \quad (3)$$

where $w_{1,t}$ and $w_{2,t}$ are the wages paid to each of the two types of labor (see below for further details).

Because firms are owned by households, the firm's problem is to maximize the expected value of the firm's value, defined as the present value of future dividends, discounted with the stochastic discount factor. Formally, the firm's problem is:

$$\max_{\{\mathrm{V}_t\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} M_{0,t}\pi_t$$

Where $M_{0,t}$ is the stochastic discount factor between 0 and t, to be defined later.[13] The firm solves the problem subject to equations (1), (2) and (3), taking the stochastic discount factor and wage as given.

3.2 Households

The representative household is inhabited by a continuum of individuals characterized by their labor status (employed or unemployed). They all derive utility only from consumption and supply one unit of labor at every period.[14]

The household maximizes the expected present value of utility

$$E_t \sum_{t=0}^{\infty} \beta^t u(C_t)$$

Preferences over consumption are defined by a CRRA utility function:

$$u(C_t) = \frac{C_t^{1-\sigma}}{1-\sigma}$$

where σ denotes the coefficient of relative risk aversion.

All individuals from each household have access to domestic financial securities that allow them to pool their income and insure against idiosyncratic shocks. Thus they all consume the same amount independent of their labor status.

To smooth consumption across time, the household has access to a one-period risk-free international bond. Bond holdings evolve according to the following household's sequential budget constraint:

$$\frac{B_{t+1}}{R_t} = B_t + w_{1,t}N_{1,t} + w_{2,t}N_{2,t} - C_t + \pi_t - \frac{\kappa}{2}(B_{t+1} - B^*)^2$$

where B_t denotes bond holdings in period t and R_t is the gross interest rate on assets held between periods t and $t+1$. The last term, $\frac{\kappa}{2}(B_{t+1} - B^*)^2$, represents portfolio adjustment costs to induce

[13] For further details on the first order conditions of the model, please refer to the Appendix.

[14] While the assumption of inelastic labor supply is evidently a simplification in order to keep tractability, it is nonetheless borne out partially in the data on financial crises in EMEs. As was documented earlier, the Mexican labor force participation rate remained virtually unaffected during the Tequila crisis episode (Figure 1 of the appendix) while the unemployment rate experienced large swings.

stationarity in the path of bond holdings. Since the capital level is fixed in this model, B_t is the only asset that households have to smooth consumption.

The F.O.C with respect to bond holdings and consumption pin down the stochastic discount factor:

$$M_{t,t+1} = \beta \frac{u'(c_{t+1})}{u'(c_t)}$$

which, given the CRRA preferences, is given by:

$$M_{t,t+1} = \beta \left(\frac{c_{t+1}}{c_t} \right)^{-\sigma}$$

3.3 Borrowing Constraint

There is a financial friction that takes the form of a borrowing constraint. As in Uribe (2006), we assume that foreign lenders lack the ability to fully monitor individual investment projects in the domestic economy. They interpret the country's aggregate asset position, $\widetilde{B}_t$, as an indicator of the strength of the country's fundamentals and are willing to lend funds to domestic residents without restrictions as long as this variable does not fall bellow a certain level. Formally, they impose an aggregate borrowing limit on the domestic economy of this form:

$$-\tilde{B}_{t+1} \leq \Omega, \quad \Omega > 0$$

But, because households are homogenous, in equilibrium individual and aggregate variables are identical:

$$\tilde{B}_t = B_t$$

Individual agents also take the evolution of $\tilde{B}_t$ as exogenous and do not internalize the borrowing constraint. In periods in which the borrowing limit is not binding, foreign investors lend to domestic residents at the world interest rate, R^*, which is assumed to be constant and strictly higher than one, $R^* > 1$. When the credit constraint binds, the domestic interest rate adjusts upward to ensure market clearing in the domestic financial market. It follows that R_t must satisfy $R_t - R^* \geq 0$ and the slackness condition:[15]

$$(R_t - R^*)(\Omega + B_{t+1}) = 0$$

In the states of nature when the borrowing limit binds, the difference between R_t and R^* will depend positively on the difference between the chosen level of bond holdings by households and Ω. Hence, a direct consequence of the adjustment in interest rates is a fall in consumption.

3.4 Wages

In the search-match environment the interaction between firms and individuals determines the wage rate. In principle there is an upper and a lower boundary inside of which all wages might

[15] To be precise, we are following the case of Uribe (2006) where the financial rents stemming from the difference $R_t - R^*$ are appropriated by nonresidents.

be considered as equilibrium wages. On one hand, firms would not offer a job that pays a wage higher than the marginal productivity of labor. On the other hand, households would not accept a wage that is lower than the benefits of being unemployed and wait for another match at a later period (adding unemployment benefits, utility derived from leisure, etc). This wedge between the maximum wage a firm would offer and the minimum wage that a prospective hire would accept creates a set of salaries that are equilibrium wages. Wage processes are different representations of the transition of the wages inside the boundary.

Nash bargaining has been a popular mechanism through which the search and match literature has portrayed wage determination inside this set of equilibrium wages. Under such a framework, firms and individuals have constant bargaining power to determine the way in which the gains from the match are allocated. Hence they both receive a constant fraction of the match surplus.[16] However, as Shimer (2004), Hall (2005) and others have demonstrated, Nash bargaining does not offer a plausible explanation of observed fluctuations in unemployment because the payoff to recruiting activity is not very sensitive to the driving forces. Hence it cannot explain the magnitude of movements in recruiting activity nor the large variation in unemployment and vacancy rates in the data.

Because of the previous considerations, and given that a central goal of this work is to account for the dynamics of labor markets around financial crises, we depart from the Nash bargaining mechanism when determining equilibrium wages in our model. Instead, we follow the sticky wages framework of Hall (2005) in which a fixed wage can solve the bargaining problem given that it is located between the two boundaries of the bargaining set. Such an equilibrium wage will be, in every state of nature, higher than the minimum payment that the household would accept and lower than the maximum payment that firms are willing to pay.

The Hall (2005) framework is particularly appealing in that wage stickiness makes recruiting effort, job-finding rates and unemployment more sensitive to changes in the driving forces of business cycles, relative to Nash bargaining. The latter occurs because, with wage stickiness, in a productivity-induced recession, the employer's returns to recruiting efforts will be relatively more depressed. The effect is a decline in recruiting efforts, a lower job-finding rate, and a slacker labor market with higher unemployment, in line with what is observed in the data. Our work hence extends such a framework by combining it with financial frictions in a small open economy that faces a systemic financial crisis that materializes as a binding aggregate borrowing constraint.

We introduce wage stickiness la Hall to our particular model by assuming that such inflexibility is only intrinsic to w_2, the salary earned by newly-hired workers. Hence we view this salary as an institutional arrangement that satisfies the criterion that no employer-worker pair forgoes bilateral opportunities for mutual improvement. Formally, and using Proposition 1 in Hall (2005), we fix w_2 so that it satisfies the following condition

$$\Gamma \leq w_2 \leq \min_{\hat{S}}(1-\beta(1-s))\hat{J}_{\hat{S}}$$

where Γ is the flow value of being unemployed and $\hat{J}_{\hat{S}}$ is the annuity value of the present value of revenues generated by a worker hired when the economy is in the lowest-expected-profit state $\hat{S}$. As proven by Hall (2005), if a constant wage fulfills such a condition then it will be an equilibrium of the model.

[16] For a deeper illustration of the Nash bargaining process in search and match models, see Pissarides (2000).

Given that, in our setting, households do not derive utility from leisure and that there are no unemployment benefits, then $\Gamma = 0$ and the lower boundary is satisfied by construction.[17] However, not any fixed salary may satisfy the equilibrium condition as $\hat{J}_{\hat{S}}$ is not equal to zero in any state. But we can conclude that there will be some salaries that satisfy the condition given. Such a condition will be verified numerically in our experiments.

We close the model by assuming that the salary of those who are already employed is equal to the marginal productivity of labor:

$$w_{1,t} = (1-\alpha)\frac{Y_t}{N_{1,t} + \Psi N_{2,t}}$$

Our choice of which of the two salaries will be fixed is clearly an arbitrary choice and a crude approximation of reality. Nonetheless, we do believe that, to a first order approximation, such a choice is borne out in the data. Figure 6 plots the dynamics of the gap between an aggregate wage index taken from Li (2011) and the minimum wage, arguably the closest proxy for w_2, in the Mexican economy around the time of the Tequila episode. The message that emerges from this plot is that the real minimum wage did fall during the crisis, but by relatively much less, 6 percentage points, relative to an aggregate wage index. Moreover, that a gap is underestimated given that the aggregate index we use include the minimum wage.

3.5 Equilibrium

A stationary equilibrium in this economy is given by a set of prices $\{w_{1,t}, w_{2,t}, R_t\}_{t=0}^{\infty}$, and quantities $\{N_{1,t}, N_{2,t}, C_t, B_{t+1}, Y_t, U_t\}_{t=0}^{\infty}$, given the process for TFP, $\{A_t\}_{t=0}^{\infty}$, and an initial condition for bonds, B_0, such that i) households maximize the discounted sum of utility; ii) firms maximize profits; iii) final goods and financial markets clear; and iv) the borrowing constraint is satisfied.

3.6 Model Solution

We use dynamic programming methods to solve the model and approximate the policy functions. The state has three dimensions: asset holding, B_t, productivity, A_t, and unemployment, U_t. The vector of control variables is defined by household's consumption, C_t, next period asset holdings, B_{t+1}, and the firm's number of vacancies posted, V_t.

We cast the household's and firm's problem in the next two Bellman equations:

$$V_h(U, B, A) = u(c_t) + \beta E_t V_h(U', B', A')$$

$$V_f(U, B, A) = \pi(V_t) + E_t\left(M_t V_f(U', B', A')\right)$$

Where $V_h(.,.)$ and $V_f(.,.)$ are the value functions of the household and firm, respectively. When iterating these two value functions, we make sure that the optimal decisions of the firm are mapped into the problem of the household, and viceversa.

[17] Note that this result does not hold in a setting where households make decisions about participation in the labor market. However changing Γ to reflect the participation decision or unemployment benefits is straightforward.

4 The Mexican Tequila Crisis

In this section we take our model to the data. Specifically, we start by evaluating the fit of our model using Mexican data that include the financial crisis of 1995. In the next sections we will also assess the model's performance when used to account for the recent financial crisis in Europe.

In what follows we describe our calibration strategy. Then we document the performance of the model when the Mexican Solow residual is used as the driving force to simulate the model. We also study some robustness checks. Lastly, we evaluate the effects of a (counterfactual) policy that reduces the minimum wage during a financial crisis.

4.1 Calibrating the Model

We start by describing our calibration of the parameters that determine TFP dynamics. We first estimate an AR(1) process on the Solow residual for Mexico computed by Aguiar and Gopinath (2007) for the period 1987.Q1-2003.Q2. The estimated autocorrelation coefficient and standard deviation of such process are, respectively, $\rho = 0.75$ and $\sigma_A = 1.8\%$. As is well known the variance and persistence of an AR(1) process is related to the variance of the innovations, σ_ε^2, by the equation

$$\sigma_A^2 = \frac{\sigma_\varepsilon^2}{1-\rho^2}$$

from which we calibrate $\sigma_\varepsilon = 1.2\%$. Last, we discretize the AR(1) process using 10 equally spaced points between the min/max values in the Solow residual.

The rest of the parameters are reported in Table 2. Following Uribe (2006), we fix the annual gross interest rate at $R^* = 1.04$ and calibrate the discount factor endogenously as $\beta = 1/R^*$. Using the Lora (2012) minimum wage series, we calibrate the salary for newly-hired workers, using a ratio of minimum wage-to-GDP per capita of 0.28 in Mexico from 1994 to 1996.[18]

In calibrating the debt ceiling, Ω, we first computed the number of quarters in our sample in which, according to Calvo et. al (2008), Mexico suffered a systemic sudden stop. This turns out to be 12 percent of the time, or 8 quarters out of the total 66 periods in our sample. Next, we calibrate Ω such that in the economy without a debt limit, the probability that the debt (i.e., -B) is larger than Ω is about 12 percent. The two parameters governing the relative risk-aversion and share of capital are calibrated at standard values in business cycle models. Following Aguiar and Gopinath (2007) we set $\sigma = 2$ and $\alpha = 0.3$.

We are left only with the five parameters that determine the strength of labor market frictions. In calibrating the first one, the elasticity of the matching function with respect to vacancies, v, we use the estimates of Hall (2005) based on US data from the Job Openings and Labor Turnover Survey. He reports a value of $v = 0.765$. To our knowledge this is the most recent estimate of such an elasticity. We were not able to find any estimates of such parameter for the Mexican case. The second parameter that we calibrate following the literature is the unit cost of issuing a vacancy, λ. Our calibration of this parameter is such that the ratio of total vacancies expenditures to GDP ($\lambda V/Y$) fluctuates around 1%. This number is taken from Andolfatto (1996) and has been used in

[18] Evidently, the minimum salary is not time-invariant. However due to our focus around financial crises episodes we fix it in values of the years around that specific episode.

other works as well. We calibrate the efficiency parameter of the matching function $\omega = 0.778$ as the one used by Boz et al. (2009) in their study of labor markets in emerging economies.[19]

The two remaining parameters are the relative productivity of newly-hired workers, Ψ, and the exogenous matching separation rate, s, for Mexico. To the best of our knowledge, there are no readily available estimates of these two parameters for the Mexican case. Hence we calibrated them by choosing values for these two parameters that would minimize the distance between the observed level of Mexican unemployment and the corresponding time series implied by the model during the crisis (see Figure 1). Formally, let U^e denote the Tx1 vector of observed unemployment rate for Mexico in during the Tequila crisis[20] and $U^m(\Psi, s)$ the corresponding vector implied by the model, which is a function of the parameters we seek to calibrate. Then our calibrated parameters (Ψ, s) and the associated distance between the empirical and the theoretical models, which we denote by Δ, satisfy

$$\Delta \equiv \min_{\{\Psi,s\}} \left[\mathbf{U}^e - \mathbf{U}^m(\Psi, s)\right]' \Lambda \left[\mathbf{U}^e - \mathbf{U}^m(\Psi, s)\right]$$

where Λ is a TxT diagonal matrix containing the relative weight assigned to each period in our dataset. We follow an agnostic approach and set it equal to an identity such that every observation of the unemployment during the crisis receives the same weight in the calibration.

The results yield a calibrated value for the relative productivity of new employees of $\Psi = 0.726$ and the exogenous separation rate at $s = 0.0321$. Although we do not have any benchmark about the size of Ψ, the value of s in our calibration is in broadly in line with the one reported by Tasci and Tansel (2005) for Turkey ($s = 0.06$). We will nonetheless conduct robustness experiments where we explore the sensitivity of our simulations when varying these two parameters, among others as well.

4.2 Simulating the Model

In this section we formally assess the performance of our model when accounting for the aggregate dynamics observed in a financial crisis. We start with the Mexican Tequila crisis but further below we consider more recent crisis episodes. Last, we assess the fit of the model in terms of unconditional business cycle moments.

Figure 7 reports the model-based dynamics of some of the main macro aggregates during the Mexican 1995 crisis and their empirical counterparts. When conducting this simulation, we use the observed time series of the Solow residual as the sole driving force of the model. The top-left panel reports the dynamics of output. It is evident that the model does a good job in closely tracking the sharp drop and recovery of this variable. This, however, should not be a surprise as it has been documented by others that in severe output contractions, including the Tequila crisis episode, the Solow residual follows closely the path of output (Kehoe and Prescott, 2007).

Far more remarkable is the performance of the model in terms of the other endogenous variables. The top-right panel reports the dynamics of consumption. The model accounts for the full extent of the sharp drop in consumption, although with some lag, and it is able to reproduce the subsequent slow recovery.

[19] In our simulations, we verify that under this calibrated value for ω, the matching function becomes standard: $N_{2,t} = \omega V_t^v U_t^{1-v} < V_t, U_t$.

[20] The exact period that we focus on is from 1994.III to 1996.II.

The bottom-left panel reports the dynamics in terms of unemployment. Overall the model delivers a fairly close match of the dynamics in the data. First, it exhibits a jump of unemployment in 1995.Q1-Q3 of the same order of magnitude and with the same velocity. Second, the transitory jump is also captured as the unemployment rate quickly reverses in 1995.Q4-1996.Q3, as was the case with the Mexican unemployment rate. It does not, however, fully reproduce the further drop of unemployment in 1997 in the last part of the crisis.

A last dimension of the experiment that is worth discussing is the extent to which the model can account for a distinctive property of the crisis: the large spike in interest rates. To address this the bottom-right panel reports the endogenous path of the model-based interest rate during the Tequila crisis. In this episode the borrowing constraint becomes active and the equilibrium in capital markets is restored by a higher domestic interest rate. These equilibrium dynamics are characterized by a large and sudden jump in the interest rate that gradually fades away. The persistence in the dynamics of the interest rate comes from the fact that the constraint binds in more than one period. That patterns of the simulated interest rate, i.e., a sudden increase and a gradual mean reversion, are in line with the dynamics of the Tequila episode and other EMEs financial crises as documented earlier.

More importantly, increases in the equilibrium interest rate are highly correlated with increases in unemployment as seen in the data, highlighting the relationship between financial and labor markets during financial crises that the model helps to rationalize. To see this note that, following a negative TFP shock that triggers the borrowing constraint and endogenously increases the interest rate, the optimal response of firms is to reduce vacancies. This pushes unemployment upward and depresses available income. Households are then constrained because of both higher borrowing rates and reduced income. But these forces counteract with the desire to smooth consumption that drives the household to borrow in bad times, thereby further making the constraint bind more tightly.

A last thing to check in our simulation of the Mexican case is the plausibility of the calibrated fixed minimum wage. Indeed, such results might be subject to the critique that the fixed minimum wage is not an equilibrium wage. Previously we showed the necessary conditions for the minimum wage to be an equilibrium wage rate. Figure 8 shows the calibrated level minimum wage is indeed within the boundaries determined by Hall (2005) in every period of the simulation, making it a feasible equilibrium level. Note that, as households do not derive utility from leisure, and there are not any unemployment benefits, the lower boundary is set at zero and is satisfied for each period.

A last experiment that we perform looks at unconditional business cycle moments. In this case we use the entire time series of the Solow residual and compute the model-based standard second moments that the literature on business cycles focuses on and compare them to their empirical counterparts. The results of this exercise are reported in Table 3. We focus here on output, consumption, and the unemployment rate.

The fit of the model in terms of the volatility of unemployment is satisfactory. While we predict a ratio of the volatility of unemployment to output's of 31 percent, we observe a value of almost 30 percent in the data. Our model predicts an unemployment rate slightly more countercyclical than in the data but similar in order of magnitude (-63 percent in the data versus -67 percent in the model). Regarding the cycle of output we obtain a good match to the data. While we estimate a volatility of 2.18 percent, the data shows a volatility of 2.32 percent. Our model correctly predicts a consumption process that is both strongly persistent and more volatile than output, again in line with the data. In terms of the consumption volatility, the financial constraint is key to reproduce a high relative volatility. Without the presence of the debt ceiling, households would smooth consumption, replicating a lower volatility of consumption.[21]

4.3 Robustness Analysis

The results presented in the previous section show that our model can account for some of the main macroeconomic dynamics that have characterized financial crises in emerging economies. The goal of this section is to assess the robustness of these results to changes in some of the structural parameters of the model, particularly those that define the degree of labor market frictions. In doing so, we also hope to shed some light on terms of the importance of each of these parameters in governing the cyclical dynamics of the model, notably those of the unemployment rate. Last, we also evaluate the extent to which Hall's conditions for an optimal equilibrium fixed wage hold.

The top-left panel of Figure 9 presents the model-based dynamics of unemployment if the parameter v, governing the elasticity of the matching function with respect to vacancies, takes lower and higher values, $v = \{0.5, 0.9\}$, relative to the calibrated value used in the benchmark case, $v = 0.765$ using the estimates of Hall (2005). The results show how the response of unemployment increases the higher values this parameter takes. Hence this is evidence that v is a key parameter in determining the high cyclical dynamics of unemployment. The intuition for this result is simple. When the elasticity of the matching function with respect to the number of vacancies is high, the firms's decisions have more impact on the unemployment rate through their decisions on the number of vacancies posted. In low TFP periods firm's optimal level of vacancies is low, making tomorrow's unemployment rate increase. This increase will be greater the higher is v. When v is small, the number of successful matches is more dependent on the state of current unemployment. The higher the unemployment rate, the higher the number of matches. In this case the unemployment rate exhibits high mean reversion and does not respond much to changes in TFP.

In what follows, we fix $v = 0.5$ and let some of the other parameters vary, one by one, so as to assess their role in the benchmark simulations. We do so in order to assess the extent to which parameters other than v can generate cyclical movements in the data. [22] The bottom-left panel shows the same analysis when the parameter that governs the relative productivity of newly-hired employees, Ψ, takes two values (0.721, 0.691)[23] that differ from the calibrated one in opposite directions. The results reported in this figure indicate that this parameter does not have any effect on the cyclical properties of the dynamics of the unemployment rate. Instead, its effect is on the scaling of the unemployment rate *level*. The lower is Ψ, the higher will the unemployment rate be. Here also the economic intuition is straightforward. For a given level of w_2, firms will be less likely to hire workers the lower is their relative productivity. Thus the average unemployment rate gets higher, independent of cyclical fluctuations.

[21] We do not compare the model-based dynamics of wages, w_1 and w_2, because their mapping onto empirical variables is not straightforward. To the best of our knowledge there are no data available for salaries earned by newly-hired workers.

[22] We also analyzed the role of each parameter when we keep v at the calibrated value (Figures 2 to 6 in the appendix). The results shown in that exercise lead us to the same conclusion as the results presented in the paper.

[23] This is arguably a narrow range. Assessing robusteness in values outside this range, however, generates computational shortcomings. In particular, simulations will seldom hit the boundaries of the support of the state variable grids.

A similar result emerges from the right panels where we conduct the same experiment with the parameters that determine the marginal cost of posting a vacancy, λ, and the job separation rate, s, respectively. Changes in these parameters will have significant effects on the level of the unemployment rate, but not on its cyclical behavior. The intuition for this is again simple. Higher costs of issuing vacancies will, ceteris paribus, deter firms from posting them, leading to a higher level of average unemployment. Likewise, higher separation rates will make firms increase recruits of new but inexperienced workers. However, such employees suffer from a lower productivity level, which will make the firm less willing to fully offset the higher separation rate. Hence the unemployment rate will increase in the long run.

We finish our robustness analysis by assessing the extent to which Hall's conditions for an optimal equilibrium fixed wage hold when some of the parameters change. The results of this analysis are, for the sake of brevity, reported in the Appendix (Figures 5 to 8). Overall, the results indicate that our chosen value for the minimum wage w_2 is robust to most of the changes in the parameters that we have explored. Indeed, in none of the values considered for the parameters does the chosen value for w_2 lie outside the Hall's range for feasible equilibrium wages.

4.4 A Policy Experiment

As documented earlier in the empirical section, financial crises are costly episodes. Not only they are characterized by large output drops but also by painful sharp reversals in consumption and spikes in unemployment rates. Is there a policy that can be taken to reduce those costs? If so, how can such a policy be implemented? And by what metric will its impact be measured? Evidently the economic and social hardship associated with financial crises places such questions at the center stage of any macroeconomic analysis of these episodes.

In this section we approach these questions using the analytical machinery that we have built. The policy that we consider is simple, intuitive and straightforward. We consider that a policymaker targets the source of inefficiency in our model by reducing the minimum wage faced by the new workers in the labor market precisely at the peak of the crisis. Importantly, such a policy is fully credible and incorporated in the optimal decisions of firms and households. We implement it by assuming an X percent drop in w_2 in the period where TFP attains the minimum level of the grid. When solving for the value functions of the firm and the household, $V_h(U, B, A)$ and $V_f(U, B, A)$, such probabilistic event is explicitly taken into account.

A direct consequence of such a policy is immediate: unemployment will decrease as firms would be more willing to post vacancies with a lower minimum wage. Yet the welfare implications of such policy action are not straightforward because the earnings of the household will also deteriorate. To assess this formally we simulated the policy experiment under various levels of X and quantifying the change in the household's utility as a direct measure for welfare.

Table 4 reports the findings of this policy experiment. Each of the three rows report the average unemployment rate and the present value of utility and consumption. The first column reports the values if no policy is implemented and the subsequent four columns display the results under $X = \{5, 10, 15, 20\}$. The results indicate that, as expected, unemployment decreases the larger is the drop in the minimum wage. However, such a lower minimum wage does not translate into a drop in consumption. This explains why, as reported in the last row of Table 4, such a policy is actually welfare improving. Indeed, we find that decreasing w_2 is welfare improving as the present value of the utility function increases for all Xs we consider. However, the welfare improvements are not monotonic. We find that a decrease of 15 percent of the minimum salary in the lowest state of productivity (which occurred in one quarter out of 66 in our sample) has the highest impact in welfare (0.6 percent).

The latter results are in line with recent work by Schmitt-Grohé and Uribe (2011) on optimal exchange rate policy in financial crises. They have shown that in a small open economy model with downward nominal wage rigidities the optimal exchange rate policy may entail large devaluations of up to 40 percent per year during the contractionary phase of the crisis. The main purpose of the devaluation is the same as our policy experiment: to lower real labor costs. [24]

5 European Financial Crisis

In this last section, we use the model to study the recent financial crisis in peripheral European countries. We are motivated to undertake this exploration because, earlier in this work, we presented evidence of some clear similarities between the recent crisis and the average dynamics experienced in a typical emerging market crisis. In particular, we showed how some of the recent episodes of financial turmoil in Greece and Ireland have been characterized by sharp decreases in aggregate TFP, the driving force in our model.[25]

The experiment we conduct here is simple and follows from the one presented earlier. We separately recalibrate the model to Greece and Ireland and use the observed Solow residual as the driving force when simulating the model. The simulated series are then compared to their empirical counterparts.

Given that we have already expanded in the explanation of the model, its parameters, and their role in the dynamics around financial crises, we proceed now to present the changes in the calibration for Greece and Ireland. Table 5 reports the list of parameters we changed for these two countries and compares them to those assigned for Mexico. The first line of the table presents the wage-to-GDP per capita for the new hires. We use the same strategy as in the case of Mexico to calibrate this parameter. Using data from the OECD, we set it equal to the minimum wage as a percentage of GDP per capita around the financial crisis that we define between 2009 and the end of our sample (see below for further discussion). We obtain that the parameter values for Greece (39 percent) and for Ireland (48 percent) are both higher than the one we obtained for Mexico (28 percent). Hence according to the discussion above we would expect this difference to be mapped though the model into higher average unconditional unemployment rates in these countries. As will be reported below, this fact, i.e., higher average unemployment rates in Ireland and Greece relative to that of Mexico, is observable in the data.

The second line in Table 5 reports the calibration of the parameter that governs the debt ceiling level. The calibration of this parameter presents a bigger challenge given that it requires a

[24] Unlike in our experiment, in the policy experiment undertaken by Schmitt-Grohe and Uribe (2011) a large devaluation is long-lasting, so the welfare gains are not directly comparable. While they target full employment through devaluations in every state of nature, we reduce the wage rate in a state of nature that is present in just 1 out of 66 quarters in our sample.

[25] We are nonetheless conscious of the limitations of extrapolating our emerging market economy model to the recent crisis in peripheral EU economies. The first is the obvious fact that the crisis in this region is far from over which prevents us from comparing the dynamics in the aftermath of the crisis to other crises. Moreover, there are some structural differences in the labor market across the two types of economies that manifest in different unemployment rate levels. Last, EU countries by definition belong to a monetary union, a characteristic that is not shared with any of the emerging market economies we have also analyzed. Yet, in the spirit of Frankel (2010) we think that the use of tools that have been used in the emerging markets literature such as the model presented here may shed light on the recent crisis episodes of European countries.

precise notion of the share of time that a country experienced a financial crisis (i.e., the number of quarters in which the unconstrained asset-holdings distribution would surpass Ω). Such a measure was readily available for Mexico following Calvo et al. (2008) but for this recent episode the dates are less clear as the crisis is not over yet. We rely instead on a simple criterion: we count the number of quarters as the number of observations since 2007 in which the country TFP cycle was negative.This definition encompasses eight and four quarters in the cases of Ireland and Greece, respectively.[26] Interestingly, this maps into very similar Ω for the three countries, and virtually exact parameter values for the two European economies.

Lines 3 and 4 in Table 5 show the calibrated parameter values for the relative productivity of the new hires (Ψ) and the exogenous separation rate (s). Here again we calibrate these parameters so as to minimize the difference between the realized and simulated unemployment rates around the financial crisis. Both parameters take values of the same order of magnitude as those used for Mexico, although at slightly higher values.

Figure 10 summarizes the results of this experiment. After calibrating the model to Greece and Ireland, we use the observed Solow residual and simulate the dynamics of the model, particularly those of the unemployment rate, and compare them to their empirical counterparts. The most salient finding in both panels is the model's ability to capture the long-lasting trend in unemployment in both countries during the recent period of financial turbulence. Hence, the model allows to rationalize the widespread idea that the large spikes in unemployment observed in EU countries are related to the relatively more stringent financial conditions that they have faced in world capital markets. We view this as evidence in favor of Frankel's claim that, after all, emerging market crises models may be a useful tool in the toolkit of models to study the ongoing situation in developed economies.[27]

6 Concluding Remarks

We integrated financial and labor market frictions into a small open economy real business cycle model. Financial frictions were introduced in the form of occasionally borrowing constraints in world capital markets. Labor market frictions took the form of search-match and real wage rigidity in minimum wages. Such modifications allowed us to properly account for the aggregate behavior of macro variables, especially unemployment, during financial crises in emerging economies as well as some of the recent crises in peripheral EU countries. The model also captures some salient characteristics of unconditional business cycle moments.

We also explored the role of policy in the midst of financial crises. A simple policy of reducing minimum wages may actually be welfare improving to the extent that the income effects are offset by the drop in unemployment.

Several extensions of our simple framework would be worth exploring. First, our model could be used to incorporate the large informal labor market that characterizes most emerging economies. Second, we have only scratched the surface of the kind of policies that may be effective under financial crises. Our model could then be extended to account also for the role of fiscal and monetary policy.

[26] The exact quarters are: 2009.Q4 to 2011.Q3 for Ireland and 2010.Q2 to 2011.Q1 for Greece.

[27] It is worth stressing that in the extrapolation of this model to the EU countries, in some states of nature, the matching function is above either U_t and/or V_t for the same level of ω used.

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Tables and Figures

Table 1. Stylized Facts – Business Cycle Moments in Mexico, 1987.Q1-2003.Q2

Moment	Variable					
	GDP Cycle	Interest Rate	Cons. Cycle	Solow Cycle	Employment Cycle	Unemployment Rate
σ_i	2.32	3.7	3.00	1.79	0.99	0.7
σ_i/σ_y	1.00	1.59	1.29	0.77	0.42	0.30
$\rho(i,y)$	1.00	-0.68	0.92	0.94	0.53	-0.63
$\rho(i)$	0.8	0.79	0.79	0.74	0.79	0.86

Notes: σ refers to standard deviation. ρ refers to correlation. The business cycle moments were constructed using quarterly data from Aguiar and Gopinath (2007) for all the series except the unemployment rate (OECD) and the interest rate (Uribe and Yue). The latter variable is available only from 1994.

Table 2. Calibrated Parameters

Parameter	Description	Value	Source
σ	Relative Risk Aversion Coefficient	2.0	Aguiar and Gopinath (2007)
α	Elasticity of the Production Function	0.3	Aguiar and Gopinath (2007)
R^*	Gross Interest Rate	1.04	Uribe (2006)
β	Discount Factor	$1/R^*$	Endogenous
v	Elasticity of the Matching Function	0.765	Hall (2005)
Ψ	Relative Productivity of new Hires	0.726	Estimated
s	Exogenous Separation Rate	0.032	Estimated
λV	Total Vacancies Expenditure	1% of GDP	Andolfatto (1996)
Ω	Debt Ceiling	0.278[±]	Calvo et al (2008)
w_2	Minimum Wage	28% of GDP per capita	Lora (2012)
ω	Scale Parameter	0.778	Boz et al (2009)

Notes: [±] This parameter was calibrated to truncate the asset holdings in in the same fraction of time as the SS identified by Calvo et al. (2008). The two estimated parameters come from minimizing the distance of the simulated and data series of unemployment during the Tequila crisis in Mexico. See text for further details.

Table 3. Unconditional Business Cycle Moments - Mexico

	GDP Cycle		Consumption Cycle		Unemployment Rate	
Moment	**Data**	**Model**	**Data**	**Model**	**Data**	**Model**
σ_i	2.32	2.16	3.00	2.46	0.70	0.60
σ_i/σ_y	1.00	1.00	1.29	1.13	0.30	0.28
$\rho(i,y)$	1.00	1.00	0.92	0.93	-0.63	-0.62

Notes: Standard deviations are expressed in percentages (1=1%)

Table 4. Welfare Implications of Minimum Wage Policies

	0%	5%	10%	15%	20%
Unemployment	0.05	0.05	0.05	0.05	0.04
Change (%)	0	-0.9	-1.5	-1.7	-2.6
Consumption	10.39	10.43	10.42	10.45	10.43
Change (%)	0	0.03	0.03	0.05	0.03
Utility	-11.62	-11.58	-11.59	-11.56	-11.58
Change (%)	0	0.04	0.03	0.06	0.04

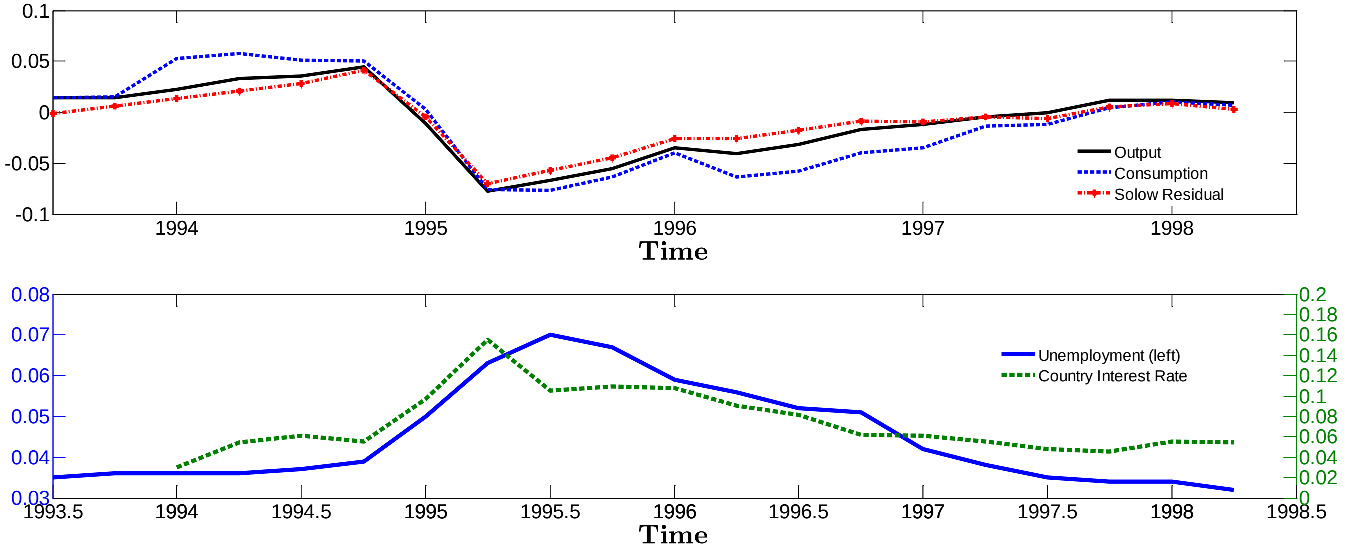
Notes: This table shows the changes in utility, consumption and unemployment when the minimum wage is decreased in the lowest state of the productivity process. We report two values for each variable. The first one is the present value for the case of utility and consumption, and the average for the case of unemployment. The second row reports the percentage change between each column and the scenario without change in the minimum wage.

Table 5. Comparing Calibrated Parameters – Mexico and European Countries

Parameter	Mexico	Greece	Ireland
w_2/Y	0.28	0.39	0.48
Ω	0.278	0.285	0.285
Ψ	0.726	0.6781	0.7725
s	0.032	0.042	0.039

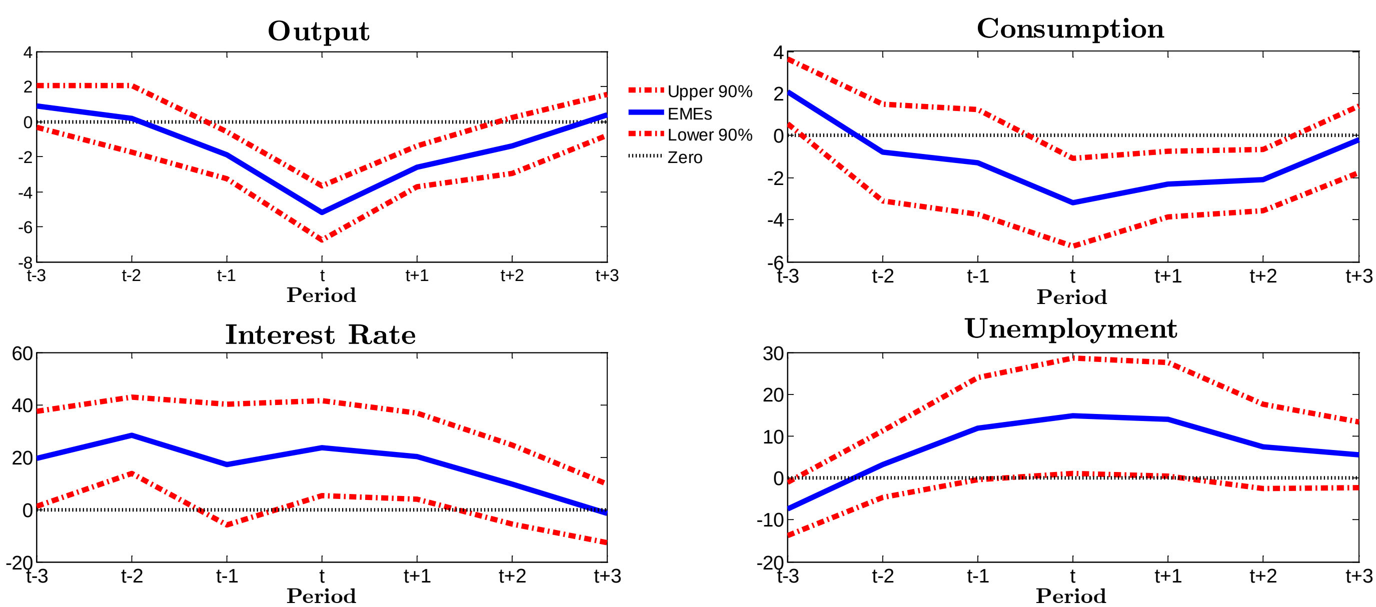
Notes: This table shows the parameters from the baseline calibration that we change in order to provide results for European countries.

Figure 1. Macroeconomic Stylized Facts – Mexican Tequila Crisis



Note: The first panel reports the Hodrick-Prescott filtered deviations of output, consumption and the Solow residual in Mexico around the Tequila Crisis. The second panel report the levels of the unemployment rate and the country interest rate. The latter is computed as in Uribe and Yue (2006) by adding the Mexican EMBI to the real interest rate of US T-bills.

Figure 2. Business Cycle in EMEs



Note: Period t is the quarter with the lowest GDP cycle within individual Sudden Stop episodes.

Figure 3. Output Cycle and Unemployment Rates During Great Depressions

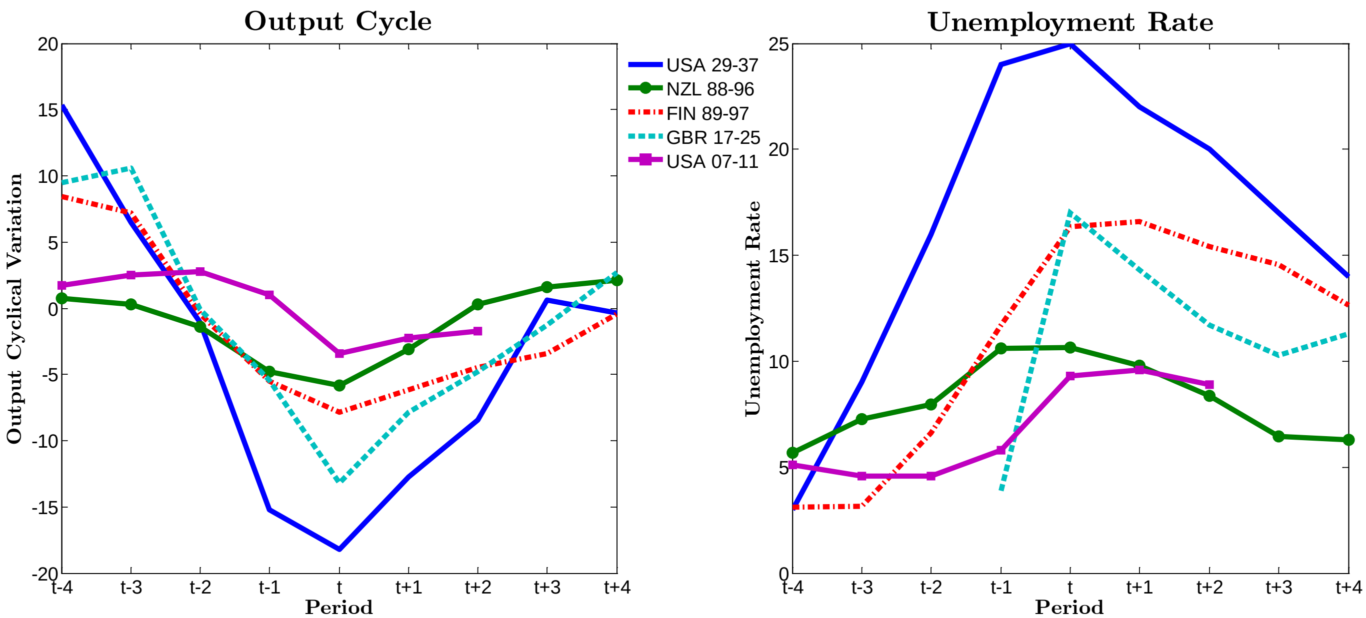


Figure 4. Macro Dynamics in Peripheral Europe

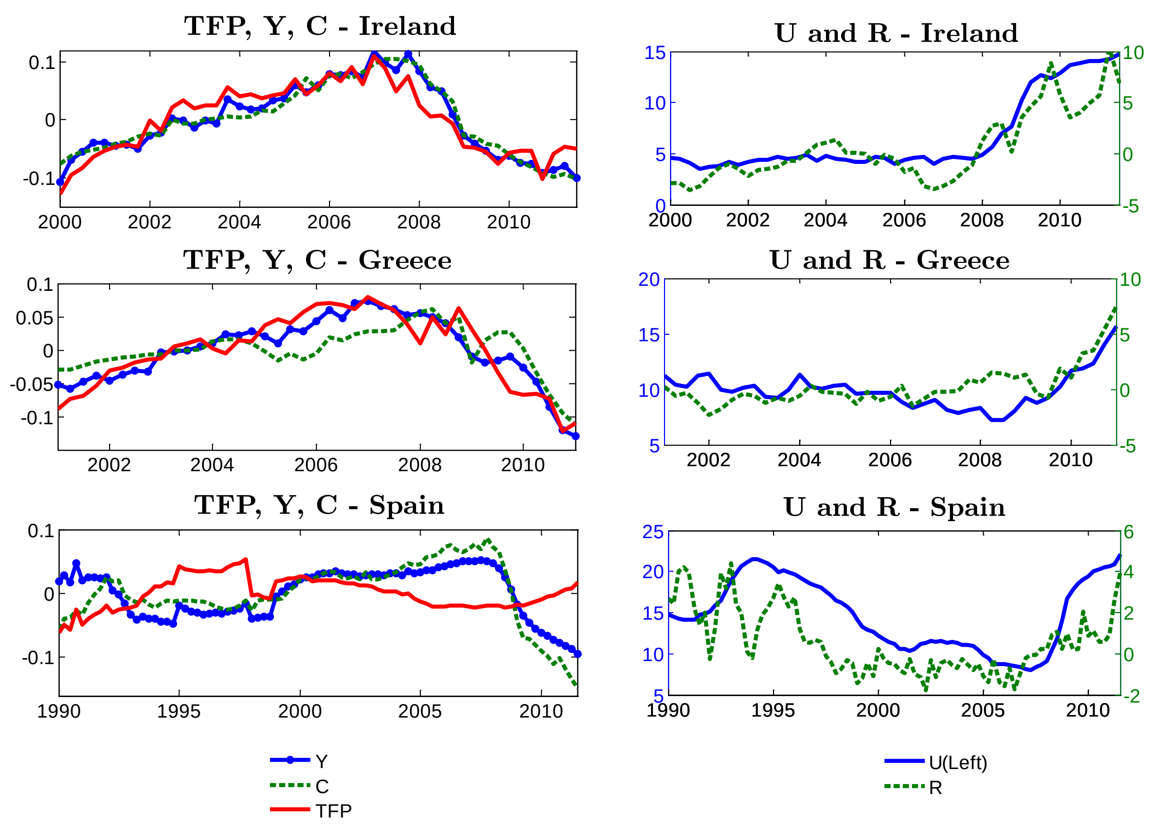


Figure 5. Business Cycle in European Economies and Mexico

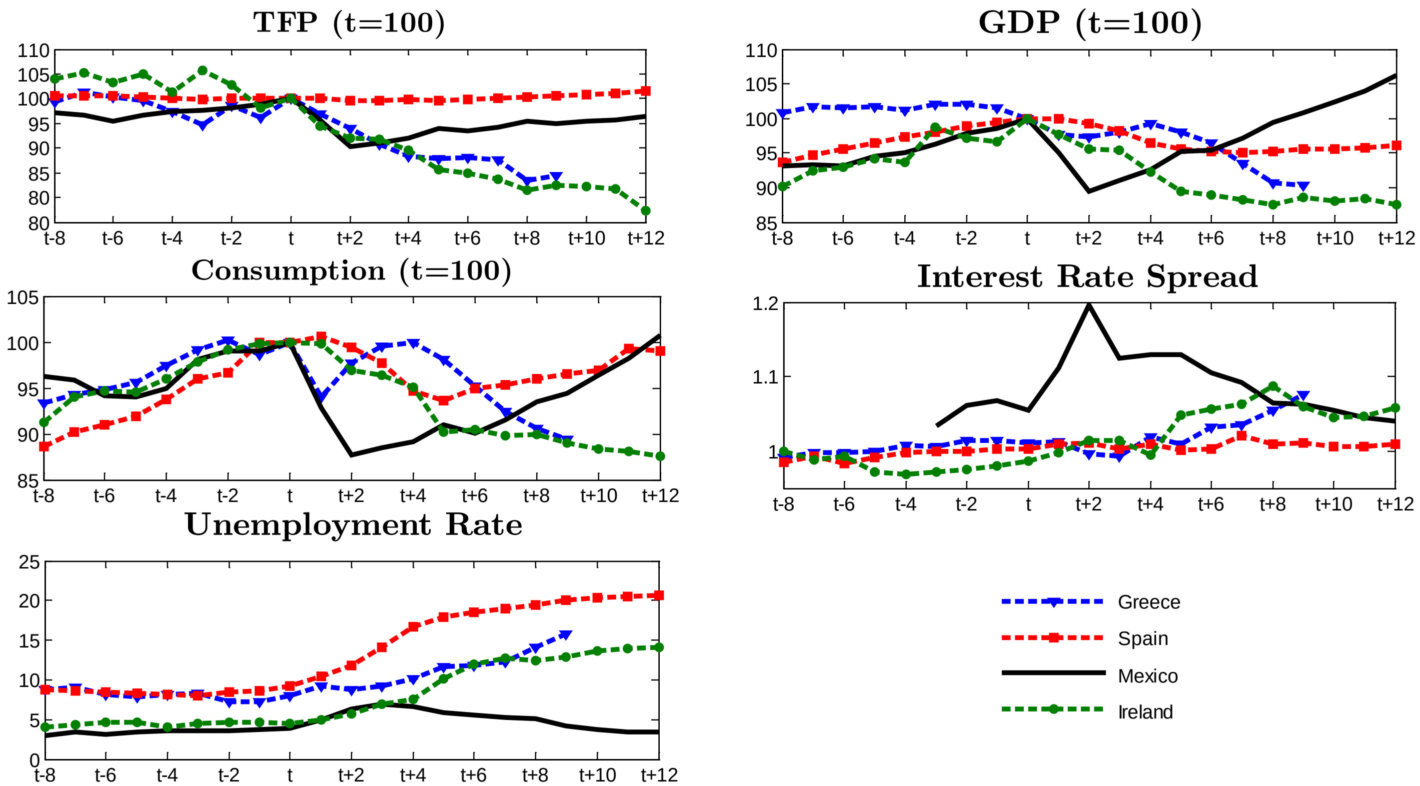


Figure 6. Mean Wage Fall in Excess of Minimum Wage Fall in Mexico

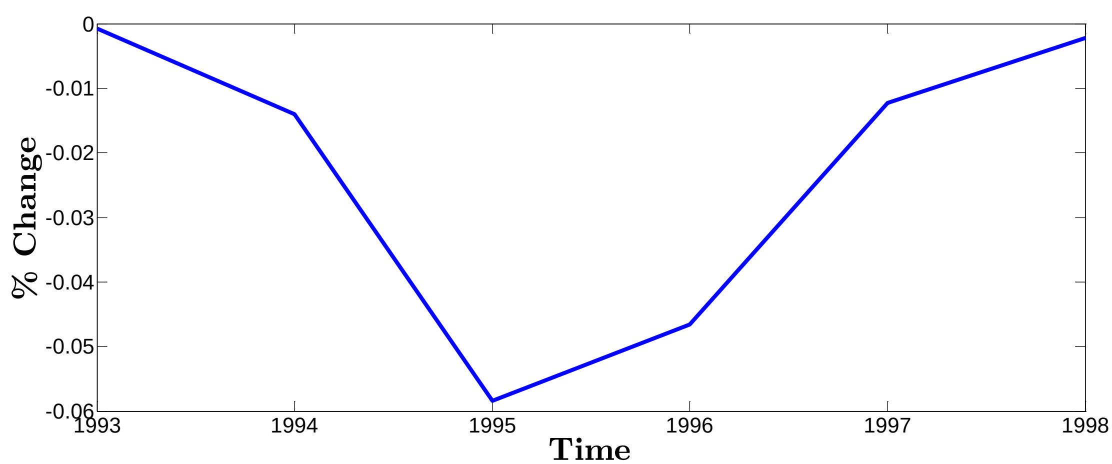


Figure 7. Benchmark Simulations – Mexico

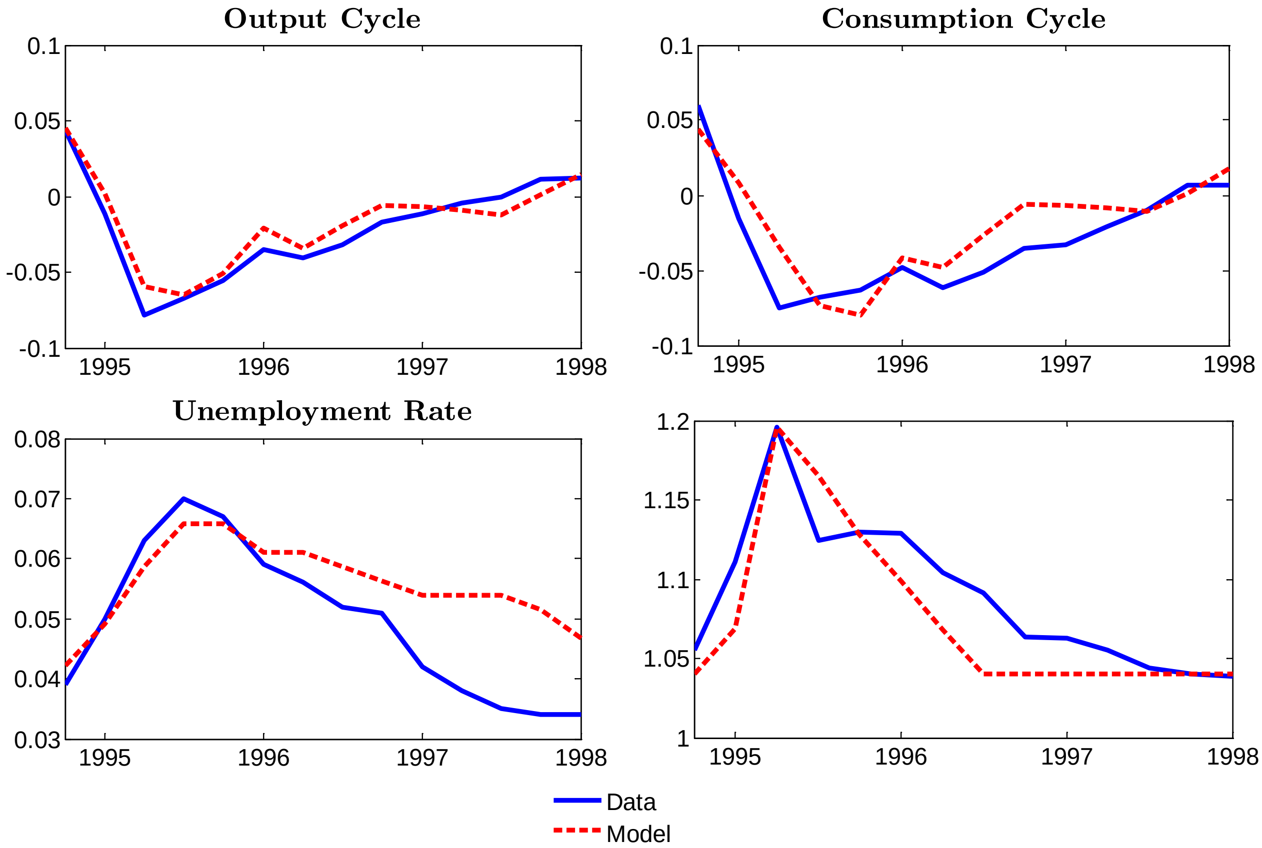


Figure 8. Hall (2005) Boundary Conditions in the Benchmark Calibration

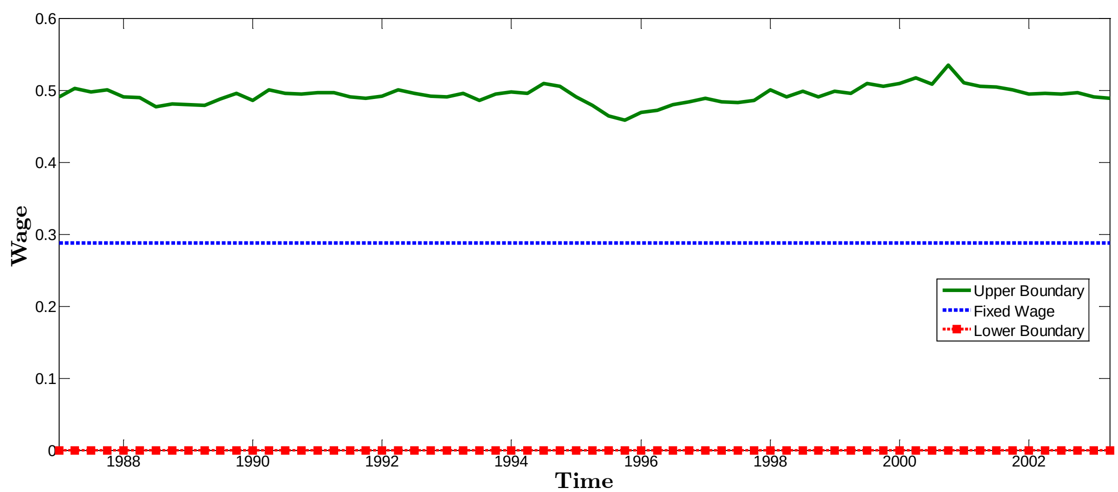
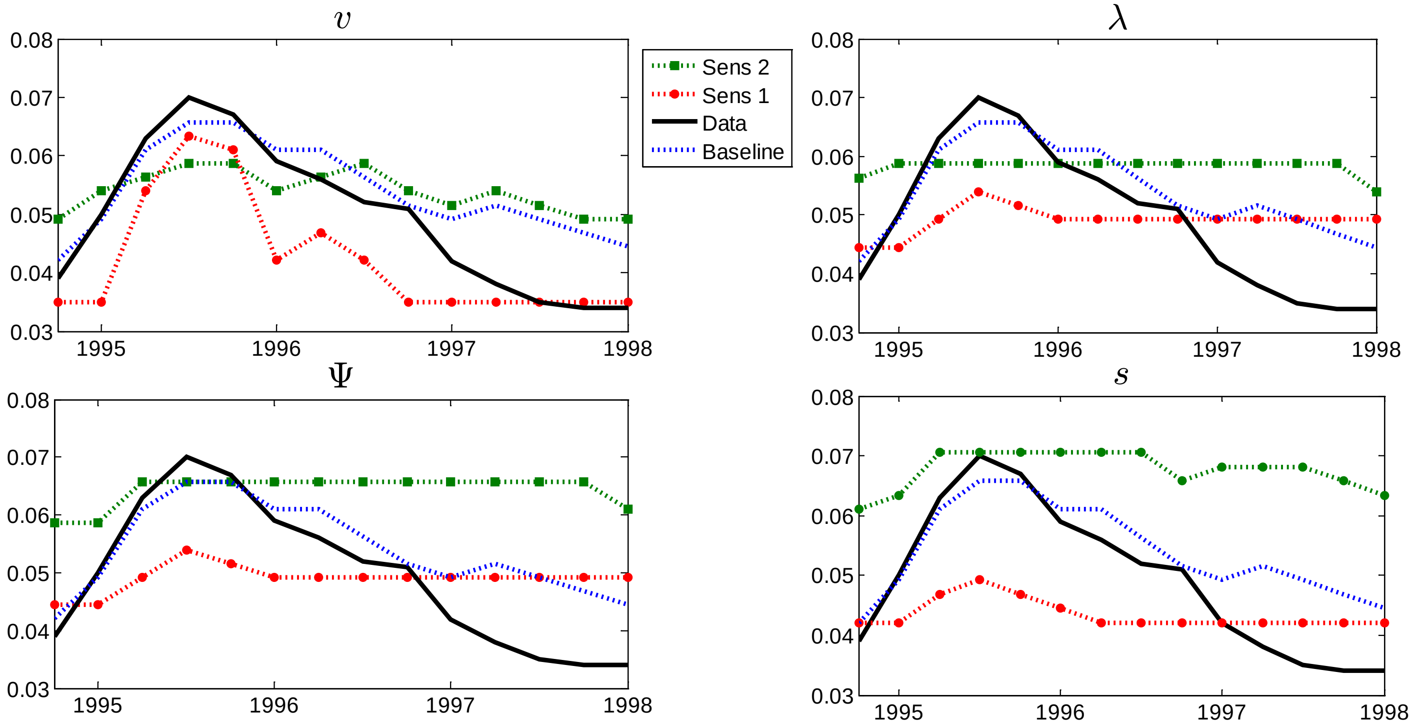
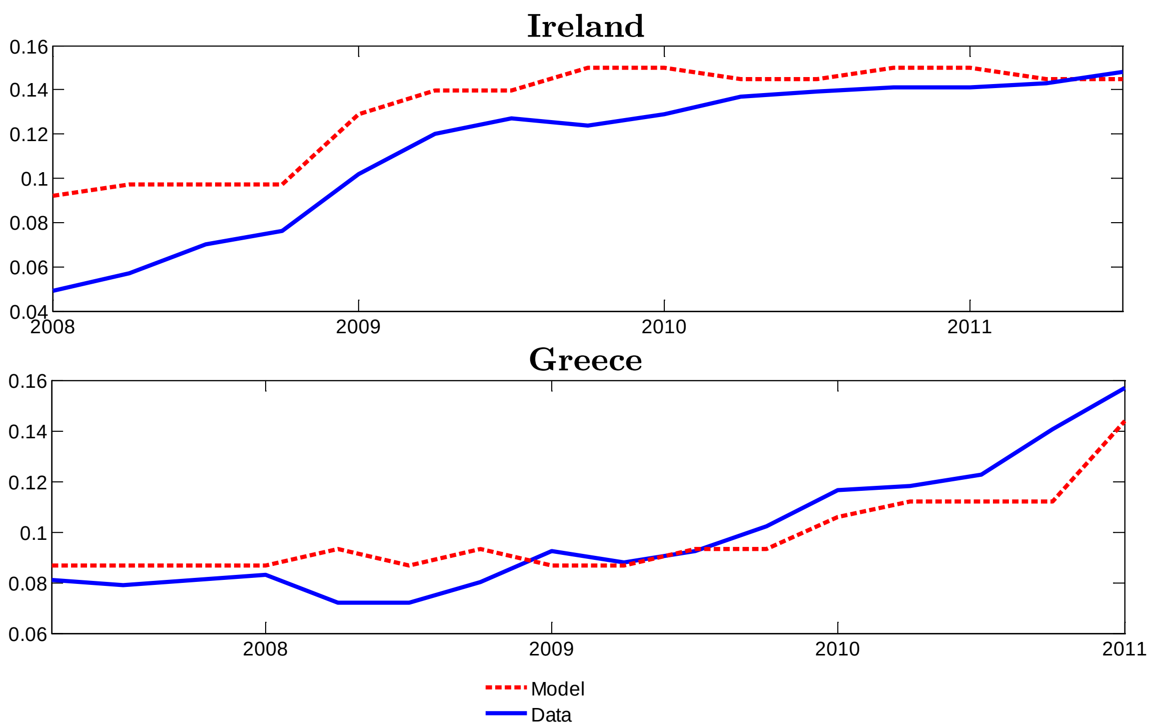


Figure 9. Robustness Analysis



Note: The sensitivity values are [$v_1, v_2, \lambda_1, \lambda_2, \Psi_1, \Psi_2, s_1, s_2$]=[0.9, 0.5, 0.225, 0.275, 0.721, 0.691, 0.025, 0.040]

Figure 10. Equilibrium Unemployment Simulation - Europe



A Technical Appendix

A.1 Labor Market

Effective labor is the sum of the labor of experienced and inexperienced workers, weighted by their relative productivity.

$$N_t = N_{1,t} + \Psi N_{2,t} \tag{4}$$

Where $0 < \Psi < 1$ is the ratio that defines the relative productivity of new workers relative to that of experienced workers.

The vacancies rate (V_t) and the unemployment rate (U_t) determine the number of inexperienced workers the firm can hire given a matching technology.

$$N_{2,t} = V_t^v U_t^{1-v} \tag{5}$$

Inexperienced workers become experienced after one period. Matchings break-up exogenously.

$$N_{1,t} = (1-s)N_{1,t-1} + N_{2,t-1} \tag{6}$$

A.2 Households

Households derive utility from consumption exclusively. Households problem is:

$$\max E_t \sum_{t=0}^{\infty} \beta^t u(C_t)$$

The utility function is:

$$u(C_t) = \frac{C_t^{1-\sigma}}{1-\sigma} \tag{7}$$

Households have access to one single asset denoted by B_t.

$$\frac{B_{t+1}}{R_t} = B_t + w_{1,t}N_{1,t} + w_{2,t}N_{2,t} + \pi_t - C_t - \frac{\kappa}{2}(B_{t+1} - B^*)^2 \tag{8}$$

The household Problem:

$$\max \sum_{t=0}^{\infty} \beta^t u(C_t) \tag{9}$$

The household lagrangian is:

$$\mathcal{L} = \sum_{t=0}^{\infty} \beta^t u(C) + \theta_t (B_t + w_{1,t} N_{1,t} + w_{2,t} N_{2,t} + D_t - C_t - \frac{B_{t+1}}{R_t} - \frac{\kappa}{2}(B_{t+1} - B^*)^2) \tag{10}$$

$$\frac{\partial \mathcal{L}}{\partial C_t} = 0 \to u'(C_t) = \theta_t \tag{11}$$

$$\frac{\partial \mathcal{L}}{\partial B_{t+1}} = 0 \to \theta_t \left(\frac{1}{R_t} + \kappa(B_{t+1} - B^*) \right) = \beta E_t \theta_{t+1} \tag{12}$$

We define $M_{t,t+1}$ as the Stochastic Discount Factor given by:

$$M_{t,t+1} = \beta \frac{u'(C_{t+1})}{u'(C_t)} \tag{13}$$

A.3 Firms

Firms use a Cobb-Douglas Production technology to produce Y_t units of the consumption good, using as input a constant level of capital and effective work.

$$Y_t = A_t K^{\alpha} N_t^{1-\alpha} \tag{14}$$

Firms dividends (π_t) are:

$$\pi_t = Y_t - w_{1,t} N_{1,t} - w_{2,t} N_{2,t} - \lambda V_t \tag{15}$$

The firm problem is:

$$\underset{\{\mathrm{V}_t\}_{t=0}^{\infty}}{max} E_0 \sum_{t=0}^{\infty} M_{0,t} \pi_t \tag{16}$$

The firm lagrangian is:

$$\mathcal{L} = \sum_{t=0}^{\infty} M_{0,t} (A_t K^{\alpha} (N_{1,t} + \Psi q(\theta_t) V_t)^{1-\alpha} - w_{1,t} N_{1,t} - w_{2,t} q(\theta_t) V_t - \lambda V_t + \eta_t (N_{1,t}(1-s) + q(\theta_t) V_t - N_{1,t+1})) \tag{17}$$

$$\frac{\partial \mathcal{L}}{\partial V_t} = 0 \rightarrow \eta_t = \frac{\lambda}{q(\theta_t)} + w_{2,t} - (1-\alpha)\Psi \frac{Y_t}{N_t} \tag{18}$$

$$\frac{\partial \mathcal{L}}{\partial N_{1,t+1}} = 0 \rightarrow \eta_t = E_t\left(M_{t,t+1}\left((1-\alpha)\frac{Y_{t+1}}{N_{t+1}} - w_{1,t+1} + \eta_{t+1}(1-s)\right)\right) \tag{19}$$

Where θ_t is the ratio of vacancies to unemployment and $q(\theta_t)$ is the ratio of unemployed workers attracted to the firm per vacancy.

Wage indeterminacy is common to this kind of models. In this case we use the following salaries.

$$w_{1,t} = (1-\alpha)\frac{Y_t}{N_t} \tag{20}$$

We use fixed wages for inexperienced workers.

$$w_{2,t} = \bar{w}_2 \tag{21}$$

A.4 Financial Frictions

Households cannot borrow over a prespecified level Ω.

$$-\tilde{B}_{t+1} \leq \Omega \tag{22}$$

Where $\tilde{B}_{t+1}$ denotes the aggregate level of asset holdings in the economy. In equilibrium $\tilde{B}_{t+1} = B_{t+1}$. When the financial constraint is binding, then the interest rate spikes. The following slackness condition summarizes this fact:

$$(\Omega - B_{t+1})(R_t - R^*) = 0 \tag{23}$$

Tables and Figures

Table 1
Panel Data Availability

This table shows the countries and dates from which we calculate the averages of the interest variables. The Sudden Stop dates belong to Calvo et al (2008). The ✓ means that we have availability of the data. The x sign means the contrary. The combination of both signs in the same cell means that we have data for some portion of the sudden stop but not for all the periods.

Country	Dates	Y	C	U	R
ARG	1995Q1-1995Q4	✓	✓	x	✓
ARG	1999Q2-1999Q4	✓	✓	x	✓
BRA	1995Q1-1995Q2	✓	✓	✓	✓
BRA	1998Q4-1999Q3	✓	✓	✓	✓
CHI	1995Q4-1996Q3	✓	x ✓	✓	x
CHI	1998Q2-1999Q2	✓	✓	✓	x
COL	1997Q4-2000Q3	✓	✓	✓	✓
ECU	1995Q2-1996Q4	✓	✓	✓	✓
ECU	1997Q3-2000Q4	✓	✓	✓	✓
KOR	1997Q3-1998Q4	✓	✓	✓	✓
MAL	1994Q4-1995Q4	✓	✓	x	✓
MEX	1994Q1-1995Q4	✓	✓	✓	✓
PER	1997Q3-1998Q1	✓	✓	x	✓
PER	1999Q1-1999Q4	✓	✓	x	✓
PHI	1997Q2-1999Q3	✓	✓	x ✓	✓
THA	1996Q4-1998Q3	✓	✓	x	✓
TUR	1994Q1-1995Q1	✓	✓	x	✓
TUR	1998Q4-1999Q4	✓	✓	x ✓	✓
BLR	1999Q1-1999Q4	✓	x	x	x
BGR	1995Q3-1996Q3	x	✓	x	x
LTU	1999Q1-2000Q1	✓	x	✓	x
POL	1998Q4-2000Q1	✓	x	✓	✓
HRV	1998Q3-1999Q3	✓	x	x	x
IDN	1997Q3-1998Q3	✓	x	x	x
IDN	1999Q2-2000Q3	✓	x ✓	x	x

Figure 1

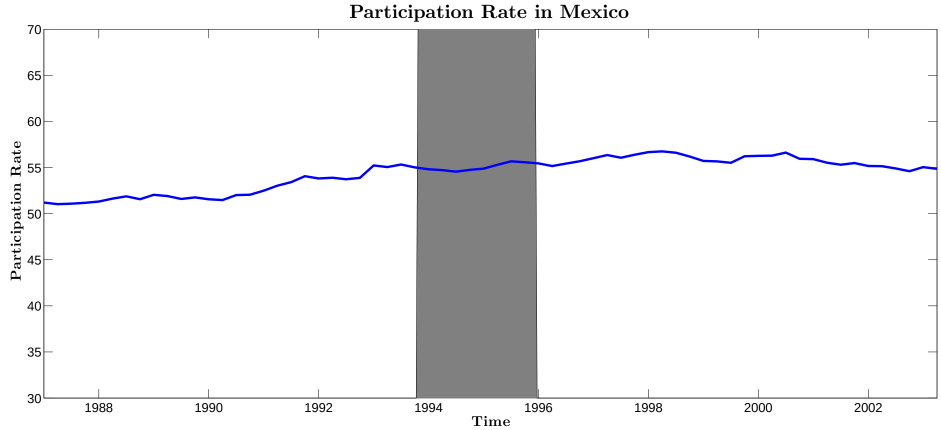


Figure 2

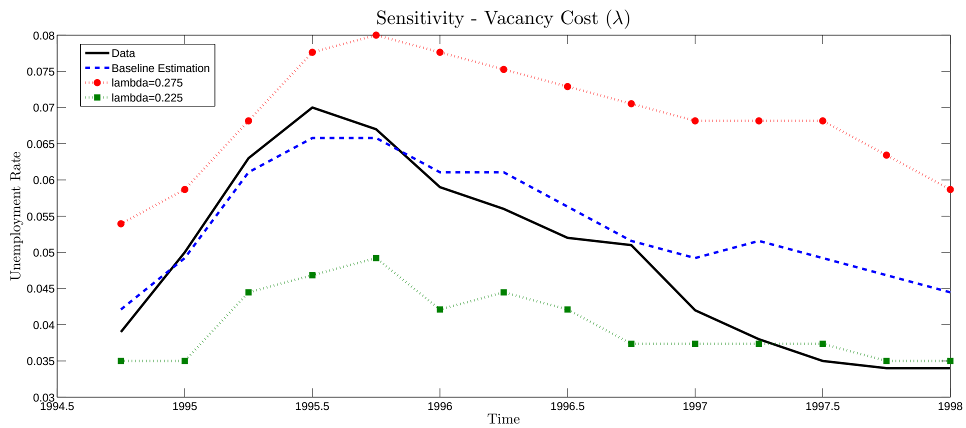


Figure 3

Sensitivity - Relative Productivity (Ψ)

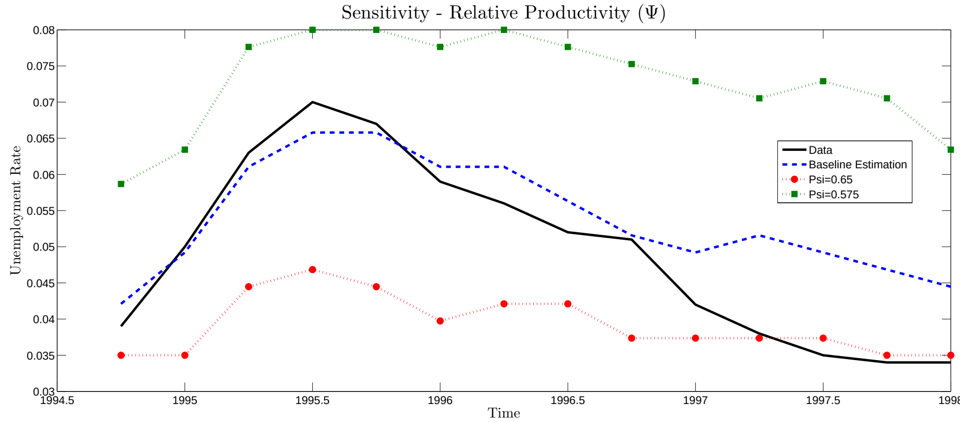


Figure 4

Sensitivity - Exogenous Break-Up Rate (s)

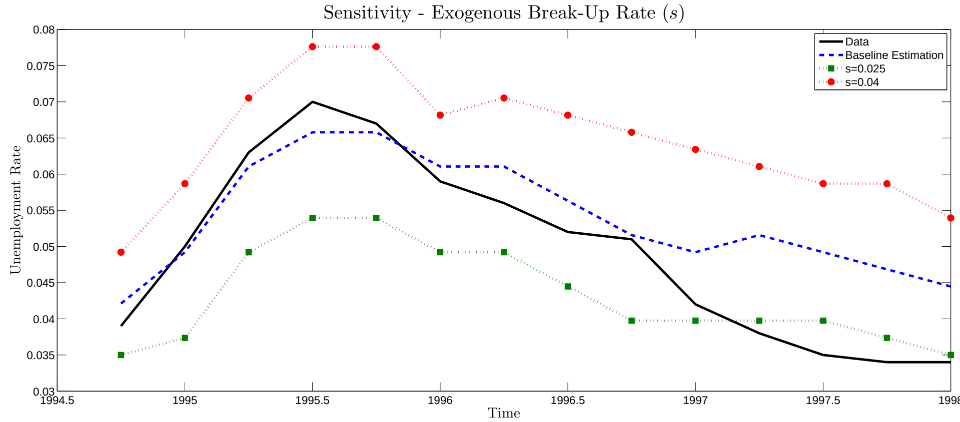


Figure 5

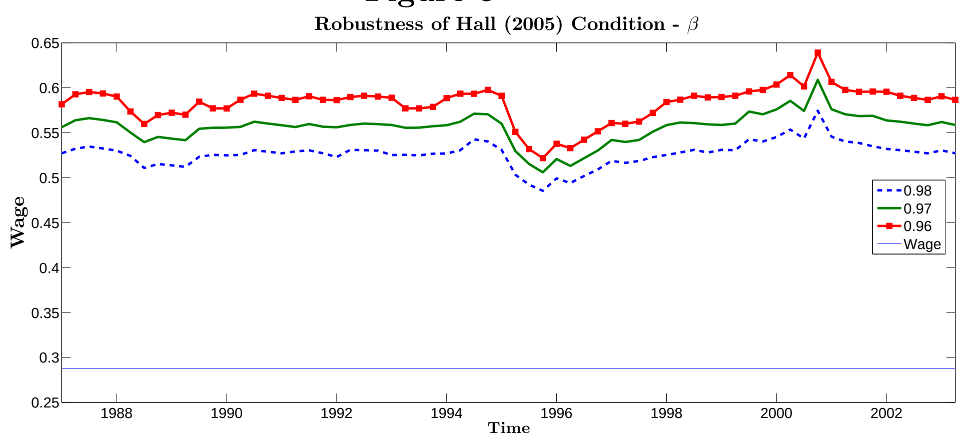


Figure 6

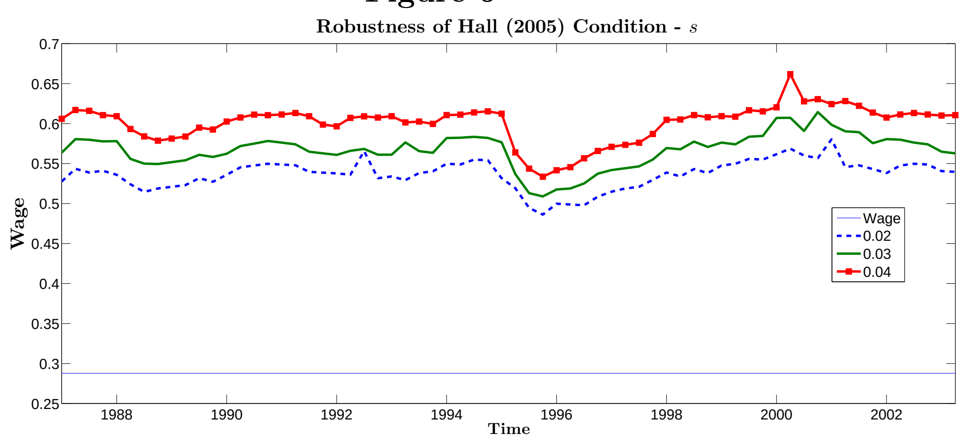


Figure 7

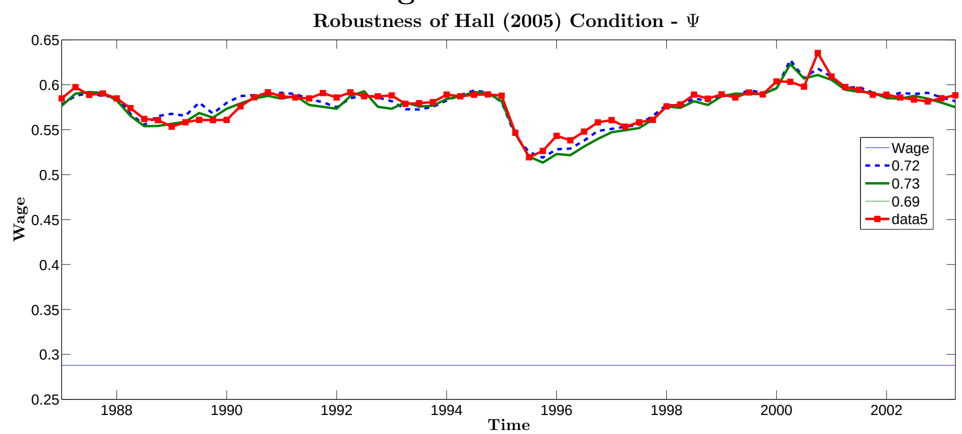


Figure 8