ABSTRACT

Title of dissertation: ESSAYS IN LABOR AND POLITICAL ECONOMICS

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This dissertation consists of three chapters. The first chapter provides an overview of the dissertation by summarizing the two papers presented in the following chapters.

The paper in the second chapter contributes to the labor-macro literature. More specifically, I develop a general equilibrium model with labor market search and matching frictions, endogenous labor force participation and on-the-job search, which can replicate the labor market dynamics observed in the U.S. data. Most existing real business cycle models with labor market frictions assume that all agents in the economy are part of the labor force, therefore these models allow for only two possible labor market states: employment and unemployment. This is a highly problematic and unrealistic assumption. Studies that extend the basic model by incorporating being out of the labor force as a third state, through allowing for a work-home production (or leisure) decision, find that the model generates counterfactual business cycle statistics: labor force participation is very volatile, while unemployment is weakly procyclical or acyclical, and has a high positive correlation

with vacancies. The failure of this three-state model to replicate the labor market dynamics observed in the U.S. data is mainly due to the excessive responsiveness of labor force participation to labor market conditions determined by aggregate shocks to productivity. In order to dampen the movements along the labor market participation margin in the simple three-state model, I introduce an on-the-job search mechanism that serves as a second margin along which the household's labor market adjustments can take place. The proposed model successfully generates countercyclical unemployment and the Beveridge Curve relationship between unemployment and vacancies. Additionally, the business cycle statistics reproduced by the modified model are quantitatively more in line with their empirical counterparts.

The third chapter presents a joint study with Mauricio Cárdenas. We analyze the determinants of the government's decision to invest in fiscal state capacity, which refers to the state's power to raise tax revenue. Using a model we highlight some political and economic dimensions of this decision, and conclude that political stability, democracy, income inequality, as well as the valuation of public goods relative to private goods, are all important variables to consider. We then test the main predictions of the model using cross-country data and find that fiscal state capacity is higher in more stable and equal societies, both in economic and political terms, and in countries where the chances of fighting an external war are high, which is a proxy for the value of public goods.

ESSAYS IN LABOR AND POLITICAL ECONOMICS

by

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Chapter 1

An Overview of the Dissertation

This dissertation consists of two papers, whose topics are in two distinct areas. The first paper contributes to the labor-macro literature by building a general equilibrium model with labor market frictions, endogenous labor force participation and on-the-job search that can replicate the labor market dynamics observed in the U.S. data.

It has now become a standard exercise for macroeconomists to incorporate labor market search and matching frictions a la Mortensen and Pissarides (1994) and Pissarides (2000) into the basic real business cycle model. In these models, the standard Walrasian labor market is replaced with a search-theoretic one, where both workers and firms need to search in order to be matched and begin production. An important shortcoming of these models is that all agents in the economy are assumed to be part of the labor force. One interpretation of this structure is that the out-of-the-labor-force state is completely ignored; therefore, only the dynamics of and flows between employment and unemployment can be studied. However, flows into and out of the labor force are quantitatively as big as flows between employment and unemployment in the U.S. labor market. Another interpretation is that unemployment and out of the labor force are lumped into a single state. This is also problematic, since these two labor market states do not have the same business cycle properties.

Existing studies that extend the basic model by incorporating an out-of-the-labor-force state, through allowing for a work-home production (or leisure) decision, find that the model generates counterfactual business cycle statistics. More specifically, the model generates highly volatile labor force participation, weakly procyclical or acyclical unemployment, and a high positive correlation between unemployment and vacancies. The failure of the extended basic model to replicate the labor market dynamics observed in the U.S. data is mainly due to the excessive responsiveness of labor force participation to labor market conditions determined by aggregate shocks to productivity. In order to bring the three-state model closer to the data, there is need for a mechanism that dampens the movements along the participation margin and breaks the close relationship between labor force participation and employment.

It is a well-established fact that job-to-job transitions are a crucial part of U.S. labor market dynamics. These flows are as big as flows between out of the labor force and employment, while they are twice as big as flows between unemployment and employment. Using this empirical evidence, I introduce an on-the-job search mechanism to the basic three-state model that serves as a second margin along which the household's labor market adjustments can take place. The modified model successfully generates countercyclical unemployment and the Beveridge Curve relationship between unemployment and vacancies. Quantitatively, the business cycle statistics reproduced by the modified model are more in line with the U.S. data.

The second paper, which I co-author with Mauricio Cárdenas, explores a topic in the field of political economics. We analyze the determinants of the government's decision to invest in state capacity, where state capacity is defined as the state's ability to tax its people.

We use a two-period, two-group political economy model based on the theoretical framework developed in Besley and Persson (2009). We name the two groups as elites and citizens, and assume that the elites constitute the minority group. In each period the group holding political power maximizes the weighted sum of the utilities of the groups and determines the group-specific tax rates, spending in public goods and the level of investment in state capacity. The maximum tax rate is determined by the capacity of the state. State capacity does not depreciate, but it can be increased with costly investments by the government. We assume that the system is politically unequal when the utility of a particular group is weighted disproportionately. We also allow for political instability, and assume that the political system is unstable if the ruling group is likely to lose political power to the opponent group, which can occur, for example, as a result of a civil war. Finally, we allow for income inequality between the two groups.

Using this theoretical framework we show that the effects of external and civil (internal) wars go in the opposite directions. While the future risk of fighting external wars leads to higher investment in state capacity, fighting civil wars (which is a measure of political instability) causes the government to invest less in state capacity. In the case of political inequality, our model predicts that more democratic political systems (lower political inequality) invest more in state capacity. If there is no income inequality, then these results are independent of which group holds political power. However, if there is income inequality the investment decision becomes group-specific. That is, when the elites are in power and there is political instability, both income and political inequality lead to lower investment in state capacity. Conversely, if the citizens are the rulers, we find that the combination of high political and income inequality results in higher state capacity. However, this is not always true; in some cases, inequality can lead to lower investment in state capacity, rationalizing the failed social revolutions.

We then test the main predictions of the model using cross-country data and several different measures of state capacity, which cover different and complementary aspects, ranging from fiscal to bureaucratic dimensions. We find empirical evidence that state capacity is higher in more stable and equal societies, both in economic and political terms, and in countries where the chances of fighting an external war are high, which is a proxy for the value of public goods. Lastly, when the interactions of income inequality with political stability and democracy are considered, our results indicate that, in the presence of income inequality, the magnitudes of the positive correlations of democracy and political stability with state capacity are significantly reduced.

Chapter 2

Labor Market Dynamics with Endogenous Labor Force Participation

2.1 Introduction

Previous studies that incorporate endogenous labor force participation in a simple business cycle framework with labor market frictions find that this three-state model fails to replicate the labor market dynamics observed in the U.S. data. More specifically, the model is unable to generate strongly countercyclical unemployment and the negative correlation between unemployment and vacancies, also known as the Beveridge Curve relationship. In this chapter I develop an alternative general equilibrium business cycle model that also features labor market frictions and endogenous labor force participation. Based on the empirical evidence that job-to-job flows are high in the U.S. labor market, I introduce an on-the-job search mechanism, which serves as an additional margin along which the labor market adjustments can take place. I show that the proposed model with on-the-job search generates labor market dynamics that are significantly different from those presented in the previous studies. More specifically, the model successfully generates countercyclical unemployment and the Beveridge Curve relationship observed in the data.

Incorporating labor market search and matching frictions a la Mortensen and Pissarides (1994) and Pissarides (2000) into the basic real business cycle model has become a common exercise for macroeconomists. Merz (1995, 1999), Andolfatto (1996), Den Haan, Ramey and Watson (2000) and others replace the standard Walrasian labor market with a search-theoretic one, where both workers and firms need to search in order to be matched and begin production. This two-sided search mechanism has been shown to improve the quantitative properties of the basic real business cycle model.

The aforementioned studies assume that all agents in the economy are in the labor force (or, equivalently, that the labor force participation decision is exogenous). In these models there are only two possible labor market states: unemployment and employment. One interpretation of this structure is that the out-of-the-labor-force state is completely ignored. In this environment only the dynamics of and flows between employment and unemployment can be studied. However, empirical evidence shows that flows into and out of the labor force are quantitatively as important as flows between employment and unemployment in the U.S. labor market. It is also important to consider the participation margin in models focusing on other aspects of labor markets, for example the effects of policies, such as unemployment benefits and minimum wages on labor market outcomes and dynamics. Another interpretation of the two-state model is that unemployment and out of the labor force are lumped into a single state. This is problematic as well, since these two states do not have the same business cycle properties. Unemployment is highly countercyclical, whereas participation is weakly procyclical. Unemployment is seven times more volatile than output, while the volatility of participation is much lower than that of output.

In an attempt to address the above criticisms, several studies have included being out of the labor force as a third state. Shi and Wen (1999) develop a three-state model in order to examine the dynamic effects of taxes and subsidies. Tripier (2003) considers a real business cycle version of the Mortensen and Pissarides search and matching model with three states in order to investigate the business cycle properties of the major labor market variables. His results indicate that the model can match the behavior of employment, but, it cannot match the empirical properties of unemployment and labor force participation. When the economy is subject to only aggregate technology shocks, the model fails to generate the observed strong countercyclicality of unemployment and the observed strong negative relationship between vacancies and unemployment.

More recently, Veracierto (2008) extends the Lucas and Prescott (1974) islands model by adding an out-of-the-labor-force state, as well as endogenous job acceptance and job separation decisions. As in Tripier (2003), Veracierto (2008) investigates the dynamic properties of the labor market variables, and concludes that the model fails in many directions when the third state is introduced. The volatility of unemployment turns out to be very low and unemployment becomes weakly procyclical, while labor force participation becomes strongly procyclical and turns out to be as volatile as employment.[1]

The main reasons why these three-state models fail to match the data are

[1]There are other important studies that consider the three-state model, such as Pries and Rogerson (2008) and Krusell et al. (2009). However, they consider heterogenous worker environments and study mainly the flows into and out of the labor force.

that labor force participation follows employment too closely and search decisions respond too much to aggregate productivity shocks. When the economy is hit by a positive productivity shock, labor force participation increases and more workers begin to search for jobs, since it is a bad time to be out of the labor force, whether engaging in home production or enjoying leisure. In turn, labor force participation becomes strongly procyclical. Since forming matches takes time, not all agents searching for jobs get placed at jobs initially. Unemployment increases sharply at first and follows an acyclical (or a weakly procyclical) pattern overall. As firms open more vacancies employment increases and unemployment decreases. The decrease in unemployment results in lower incentive for firms to open vacancies, and vacancy creation decreases as well. Since both vacancies and unemployment increase on impact with the positive and persistent technology shock, and then fall quickly to levels around their steady states, the model cannot generate the downward-sloping Beveridge curve.

The above mechanism suggests that, in order to bring the three-state model closer to the data, we need a mechanism that dampens the movements along the participation margin and breaks the close relationship between labor force participation and employment.

Empirical evidence shows that job-to-job transitions are a crucial part of U.S. labor market dynamics. These flows are as big as flows between out of the labor force and employment, and they are twice as big as flows between unemployment and employment. In light of this evidence, I enrich the basic three-state model with an on-the-job search mechanism. The intuition for why on-the-job search affects the performance of the three-state model is as follows. In the simpler model without on-the-job search, adjustments to aggregate economic conditions mainly take place at the participation margin. In response to a positive productivity shock, the representative household increases labor market participation by assigning more members to search for jobs. However, when an on-the-job search mechanism is introduced, there is a second margin along which the household's labor market adjustments can take place. In addition to the unemployed searchers, the employed household members can also be assigned to search for better jobs. As long as job finding and wage rates remain high, the overall utility of the household can be increased without big adjustments at the participation margin.

The model I propose is an extension of the real business cycle model with labor market search and matching frictions as in Merz (1995, 1999) and Andolfatto (1996). It differs from these models by allowing agents to be out of the labor force, as well as being employed, or being unemployed and searching for a job. In introducing endogenous labor force participation I follow the model in Tripier (2003). There is also on-the-job search, which gives the employed agents the ability to switch to better-paying jobs. In a recent study Krause and Lubik (2010) develop a two-state search and matching model with on-the-job search in order to address the Shimer (2005) puzzle. I follow their approach in introducing the on-the-job search mechanism.

The results can be summarized as follows. With the introduction of the on-the-job search mechanism, the three-state model performs better in matching the dynamic properties of the major labor market variables. The business cycle statistics calculated from the series produced by simulating the model are more in line with their empirical counterparts. Most importantly, the model can generate countercyclical unemployment and the negative correlation between unemployment and vacancies observed in the data.

The organization of this chapter is as follows: A brief literature review is presented in Section 2.2. Section 2.3 provides some empirical facts on U.S. labor market flows. I present the theoretical model in Section 2.4. Section 2.5 explains the calibration strategy and displays the impulse responses. Section 2.6 presents the U.S. business cycle statistics. I discuss the main results in Section 2.7. Finally, Section 2.8 concludes.

2.2 Related Literature

This study is related to three strands of literature. First, it builds on the existing studies that integrate the canonical two-state Mortensen and Pissarides search and matching model into a real business cycle environment, such as Merz (1995, 1999), Andolfatto (1996), Den Haan, Ramey and Watson (2000).

Second, it is related to papers that consider a three-state labor market structure. As discussed earlier, the leading studies in this group, Tripier (2003) and Veracierto (2008), both conclude that when an out-of-the-labor-force state is added to the basic two-state model, the model generates counterfactual results, which is puzzling, since the two-state model is reasonably successful in generating the observed labor market dynamics. This study attempts to solve this puzzle by proposing an alternative three-state model with on-the-job search, which allows for job-to-job flows. Another paper which studies this puzzle is Ebell (2010). Different from my approach, she relies solely on alternative parametrization to improve the results of the three-state model.[2]

Finally, this study is related to the literature that studies on-the-job search and job-to-job transitions observed in the U.S. labor market. In an early study, Burdett (1978) constructs a model where both the employed and the unemployed workers engage in search activity. He shows that workers move to better-paying jobs when possible with the help of on-the-job search, and that the probability of a separation from a job is negatively related to its wage rate. He uses this framework to explain the wage-tenure relationship observed in the data. Pissarides (1994) and Burdett and Mortensen (1998) integrate a similar on-the-job search mechanism in a general equilibrium setting. The former study argues that on-the-job search influences the composition of jobs, which leads firms to open relatively more jobs for the employed job seekers. He suggests that this mechanism can amplify the response of vacancies, while muting that of unemployment in response to changes in aggregate economic conditions. The latter study uses a version of the basic job-ladder model to explain wage differentials across ex-ante identical workers. In a more recent study, Nagypal (2005) shows that a basic job-ladder model is unable to account quantitatively for the features of observed job-to-job transitions. She proposes an alternative theoretical framework, where job-switching is used as a way to escape from unemployment. Nagypal (2004) and Krause and Lubik (2010) both

[2] See Subsection 2.7.3 for further details on her study.

address the Shimer (2005) puzzle using on-the-job search. The former study shows that the preference of firms to hire the employed workers can help explain the large fluctuations in the vacancy-unemployment ratio, which cannot be generated by the two-state search and matching model. The latter paper takes a similar approach, but integrates on-the-job search in a real business cycle model with labor market frictions. It also finds that adding an on-the-job search mechanism helps to increase the volatility of vacancies and unemployment, and enhances the overall amplification and propagation properties of the basic two-state model.

The theoretical framework presented in Section 2.4 follows closely Krause and Lubik (2010) in developing a two-sector economy where the workers are allowed to flow between jobs. The main difference is that, while Krause and Lubik (2010) build on a two-state labor market framework, I also consider an out-of-the-labor-state and endogenize the labor market participation decision.

2.3 Flows in the U.S. Labor Market

In this section I present the basic facts on job-to-job transitions and movements in and out of the labor force in the U.S. labor market, which motivate the theoretical framework to be introduced in the next section.

Empirical evidence shows that flows in the U.S. labor market are large. Previous studies have mainly focused on flows of workers between employment, unemployment and out-of-the-labor-force states. However, the efforts to measure job-to-job flows have been limited. Fallick and Fleischman (2004) is the first study that provides reliable empirical measures of employer-to-employer flows (employer-to-employer flows correspond to job-to-job flows in this study; therefore, I use the two terms interchangeably). In order to construct their dataset, they utilize the dependent interviewing method used in the monthly Current Population Survey (CPS). Since 1994, the CPS has asked the respondents who continue to be employed in consecutive months whether they have stayed with the same employer or not. Using the responses to this question, Fallick and Fleischman construct a series for aggregate monthly employer-to-employer flows, in addition to aggregate flows between employment, unemployment and out-of-the-labor-force states. Their updated dataset provides information on all labor market flows for 1994-2009 and it is publicly available. I use this CPS-based dataset to construct Table 2.1, which summarizes U.S. labor market flows.[3]

Table 2.1: Flows in the U.S. Labor Market: 1994-2005 Monthly Data

	State in the 2nd Period			
	Percentage of Population			
State in the 1st Period	Same Employer	New Employer	Unemployed	Out of the Labor Force
Employed	58.81	1.61	0.81	1.70
Unemployed	-	0.97	1.69	0.81
Out of the Labor Force	-	1.58	0.81	31.20
	Percentage of State in the 1st Period			
State in the 1st Period	Same Employer	New Employer	Unemployed	Out of the Labor Force
Employed	93.45	2.56	1.29	2.70
Unemployed	-	27.95	48.70	23.34
Out of the Labor Force	-	4.70	2.41	92.88

[3] I use data through 2005 in calculating the U.S. business cycle statistics later in the chapter; therefore, flows presented here are calculated through 2005 as well.

The survey results indicate that on average, 2.56 percent of the employed workers change employers each month. These flows constitute almost 40 percent of all separations from employment, are twice as big as flows from employment to unemployment and are comparable to flows from employment to out of the labor force. The number of individuals changing employers is almost equal to the number of unemployed staying unemployed (1.69 percent of the total population) and is more than the number of unemployed finding jobs (0.97 percent of the total population) or dropping out of the labor force (0.81 percent of the total population).

Table 2.1 also shows that flows into and out of the labor force are as large or larger on average as flows between employment and unemployment. More specifically, while 2.70 percent of the employed leave the labor force each month, only 1.29 percent of the employed become unemployed. Similarly, flows from unemployment to out of the labor force (23.34 percent of the unemployed) are almost as big as flows from unemployment into employment (27.95 percent of the unemployed). As for flows into the labor force, each month 2.39 percent of the total population move into the labor force, of which 66 percent become employed and the rest become unemployed.

As documented in Fallick and Fleischman (2004), employer-to-employer flows are procyclical. Procyclicality also holds when the quit series in the Job Openings and Labor Turnover Survey (JOLTS) is used as an alternative measure. On the contrary, the number of workers out of the labor force is only slightly countercyclical, compared to the strong countercyclicality of unemployment.

In light of the empirical evidence presented in this section, I conclude that it is highly misleading to assume only two states (employment and unemployment) in a model focusing on labor market dynamics. Employer-to-employer flows, as well as flows into and out of the labor force, are quantitatively as important as flows between employment and unemployment. Therefore, I enrich the simple search and matching model by including an out-of-the-labor-force state and allowing for job-to-job transitions. The next section introduces the proposed theoretical model.

2.4 The Model

I study a real business cycle model with labor market frictions which has two non-standard features: on-the-job search, which leads to job-to-job transitions, and endogenous labor force participation. The economy consists of a continuum of measure one of identical households, and heterogenous firms owned by the households. I follow Acemoglu (2001) and Krause and Lubik (2010) in introducing two types of firms, which open vacancies for high-wage (good) and low-wage (bad) jobs for the workers. Vacancy creation is costly, and I assume that the vacancy creation cost is higher for a high-wage firm than for a low-wage firm. Heterogeneity in wages between high-wage and low-wage jobs provides the motive for on-the-job search. The heterogenous firms produce two types of intermediate goods. These goods are then used by the final goods sector to produce the single consumption good in the economy. The details of the model are explained in the following subsections.

2.4.1 The Representative Household and the Labor Markets

The representative household consists of a continuum of homogenous household members with a total measure of one. A household member can be employed, unemployed and searching for a job, or out of the labor force. The household members who are not participating in the labor force engage in home production, which increases the utility of the whole household. The resources of the household are pooled by its members, and there is complete risk-sharing within the household. In each period, the household decides how many of its members will work, how many will search for a job, and how many will stay out of the labor force. The employed household members work at two possible types of jobs: high-wage (good) jobs and low-wage (bad) jobs. A measure n_t^g of household members work at a high-wage job, where the wage rate is w_t^g in period t. A measure n_t^b of household members work at a low-wage job at the wage rate of w_t^b. From workers' point of view, the two jobs differ only in the wages that they pay. All members working at low-wage jobs search for high-wage jobs with an endogenous search intensity, s_t, which is subject to a time cost of $\kappa(s_t)$.[4] A measure u_t^g of the unemployed household members search for high-wage jobs, while measure u_t^b search for low-wage jobs in period t. That is, job search is directed. All unemployed members search with intensity one and there is no direct utility cost associated with their search.

Given the above specification, the degree of search activity by the unemployed is equal to $u_t^g + u_t^b$. Each unemployed member of the representative household re-

[4]This is a real world interpretation of the on-the-job search in the model. Literally, the search activity results in less members engaging in home production, which will become clearer later.

ceives a fixed unemployment benefit of d. These benefits are financed by the government via collecting a lump-sum tax from the household. The household members who are out of the labor force provide $l_t = 1 - u_t^g - u_t^b - n_t^g - [1 + \kappa(s_t)]n_t^b$ units of home production. While I do not model the intensive margin of hours per worker, the interpretation of this equation is similar to a time allocation story. The household allocates some members to work, some to search for jobs, and the rest contributes to home production. With the on-the-job search cost added, the time cost of a household member working at a low-wage job becomes $[1 + \kappa(s_t)]$, resulting in less household members engaging in home production. This can be interpreted as on-the-job searchers spending time to look for jobs in addition to their work hours.[5]

The consumption good of the household is purchased from the final goods sector and its price is normalized to unity. The household owns a capital stock of k_t at the beginning of period t, rents its capital to firms at the competitive rental rate of r_t, and decides the level of capital investment i_t. The capital stock depreciates at rate δ. The household also owns the firms and receives profits of π_t in the form of lump-sum payments. Finally, the transfer between the household and the government is in the form of lump-sum taxation T.

The frictional matchings between workers and firms are represented by the matching functions for each type of job. High-wage firms open v_t^g measure of vacancies for high-wage jobs in period t. Unemployed workers who are looking for high-wage jobs are matched with these vacancies with an endogenous probability

[5] In an alternative version, I model the cost of on-the-job search as a pecuniary cost in the household's budget constraint. The results are not affected by this change.

equal to p_t^g. This probability is equal to $s_t p_t^g$ for job-switchers. All matches (including the newly formed matches) are destroyed with an exogenous probability of ψ at the end of each period, while all surviving matches become productive in the next period. The matching function, evolution of employment, workers' job finding probability, firms' vacancy filling probability and labor market tightness in the market for high-wage jobs can be represented as:

$$m_t^g = m(v_t^g, u_t^g + s_t n_t^b) \tag{2.1}$$

$$n_{t+1}^g = (1-\psi)[n_t^g + p_t^g(u_t^g + s_t n_t^b)] \tag{2.2}$$

$$p_t^g = \frac{m(v_t^g, u_t^g + s_t n_t^b)}{u_t^g + s_t n_t^b} \tag{2.3}$$

$$q_t^g = \frac{m(v_t^g, u_t^g + s_t n_t^b)}{v_t^g} \tag{2.4}$$

$$\theta_t^g = \frac{v_t^g}{u_t^g + s_t n_t^b} \tag{2.5}$$

Similarly, low-wage firms open v_t^b measure of vacancies for low-wage jobs in period t. Unemployed workers who are looking for low-wage jobs get matched with these vacancies with an endogenous probability equal to p_t^b. Moreover, some working at low-wage jobs get exogenously separated or move to high-wage jobs at the end of each period. The matching function, evolution of employment, workers' job finding probability, firms' vacancy filling probability and labor market tightness in the market for low-wage jobs are:

$$m_t^b = m(v_t^b, u_t^b) \tag{2.6}$$

$$n_{t+1}^b = (1-\psi)\left[(1-p_t^g s_t)n_t^b + p_t^b u_t^b\right] \tag{2.7}$$

$$p_t^b = \frac{m(v_t^b, u_t^b)}{u_t^b} \tag{2.8}$$

$$q_t^b = \frac{m(v_t^b, u_t^b)}{v_t^b} \tag{2.9}$$

$$\theta_t^b = \frac{v_t^b}{u_t^b} \tag{2.10}$$

The optimization problem of a representative household is then to choose c_t, u_t^g, u_t^b, i_t and s_t, taking as given $\left\{w_t^g, w_t^b, p_t^g, p_t^b, r_t\right\}$, to maximize the value function:

$$V_t^h(n_t^g, n_t^b, k_t) = max\left\{u(c_t) + h(l_t) + \beta E_t[V_{t+1}^h(n_{t+1}^g, n_{t+1}^b, k_{t+1})]\right\} \tag{2.11}$$

subject to the budget constraint, the laws of motion for capital and employment, and the definition of home production:

$$w_t^g n_t^g + w_t^b n_t^b + r_t k_t + d(u_t^g + u_t^b) + \pi_t = c_t + i_t + T_t \tag{2.12}$$

$$i_t = k_{t+1} - (1-\delta)k_t \tag{2.13}$$

$$n_{t+1}^g = (1-\psi)\left[n_t^g + p_t^g(u_t^g + s_t n_t^b)\right] \tag{2.14}$$

$$n_{t+1}^b = (1-\psi)\left[(1 - p_t^g s_t)n_t^b + p_t^b u_t^b\right] \tag{2.15}$$

$$l_t = 1 - u_t^g - u_t^b - n_t^g - [1 + \kappa(s_t)]n_t^b \tag{2.16}$$

where $u(c_t)$ is the utility derived from the consumption of goods and $h(l_t)$ is the utility derived from home production. I assume that $0 < \beta < 1$, $u_c(c_t) > 0$, and $h_l(l_t) > 0$. In this section, I discuss only the optimality conditions derived by solving the household's problem. All first order conditions (FOCs) and derivations are presented in Appendix A.1.

Combining the FOCs with respect to c_t and i_t yields the standard Euler equation for consumption:

$$u_c(c_t) = \beta E_t\{u_c(c_{t+1})(r_{t+1} + 1 - \delta)\} \tag{2.17}$$

where $u_c(c_t)$ is the derivative of the household's utility function with respect to consumption at time t. Using this Euler equation, I derive the household's stochastic discount factor as:

$$\Xi_{t+1|t} = \beta \frac{u_c(c_{t+1})}{u_c(c_t)} \tag{2.18}$$

The FOC with respect to u_t^g yields the following optimality condition, which represents the household's participation decision in the market for high-wage jobs:

$$\frac{h_l(l_t) - u_c(c_t)d}{p_t^g} = (1-\psi)\beta E_t\left\{u_c(c_{t+1})w_{t+1}^g - h_l(l_{t+1}) + \frac{h_l(l_{t+1}) - u_c(c_{t+1})d}{p_{t+1}^g}\right\} \tag{2.19}$$

Once the household allocates a member to look for a high-wage job, she joins the pool of the unemployed in the market for good jobs. In this state, the household has one less member engaging in home production, but one more member receiving unemployment benefits. The left hand side of the above equation represents this marginal cost of searching for a good job, which is the disutility due to reduced home production net of the unemployment benefits received by the searcher. Note that this cost is scaled by the endogenous job finding rate, since with probability p_t^g the unemployed worker gets matched with a high-wage job. The right hand side stands for the household's expected marginal benefit from having one more member with a high-wage job in the next period. Since production takes place one period after the matches take place, the wage income and the marginal disutility of work are inside the expectations sign. The last term on the right hand side is the asset value of having one less household member search for a job in the next period. In order to write down all expressions in terms of goods, the wage rate and the unemployment benefits are multiplied by $u_c(c_t)$, which is the value of the Lagrange multiplier associated with the budget constraint of the household.

Similarly, the FOC with respect to u_t^b yields the optimality condition that represents the household's participation decision in the market for low-wage jobs:

$$\begin{aligned} \frac{h_l(l_t) - u_c(c_t)d}{p_t^b} &= (1-\psi)\beta E_t\left\{u_c(c_{t+1})w_{t+1}^b - [1+\kappa(s_{t+1})]h_l(l_{t+1})\right\} \\ &+(1-\psi)\beta E_t\left\{p_{t+1}^g s_{t+1}\frac{h_l(l_{t+1}) - u_c(c_{t+1})d}{p_{t+1}^g}\right\} \\ &+(1-\psi)\beta E_t\left\{(1-p_{t+1}^g s_{t+1})\frac{h_l(l_{t+1}) - u_c(c_{t+1})d}{p_{t+1}^b}\right\} \quad (2.20) \end{aligned}$$

Again, the left hand side of this equation shows the household's marginal cost of having a member search in the market for low-wage jobs. The right hand side stands for the household's expected marginal benefit of having a member work at a low-wage job next period. The first part on the right hand side is the marginal gain from having a member work at a low-wage job, which is the wage income net of cost for search effort and disutility of work. I assume that all household members working at low-wage jobs search with the same endogenous search intensity, so they all suffer from the search cost. The last two terms on the right hand side represent the asset value of the employed worker participating in the market for low-wage jobs. With probability $p_{t+1}^g s_{t+1}$ the worker will switch to a high-wage job, otherwise she will stay in the current low-wage job. As long as the worker is not separated exogenously, she will continue to work at one of the two types of jobs. Again, the terms representing the marginal cost of participation are scaled by the endogenous job finding rate, and all monetary terms are expressed in terms of goods.

Finally, the FOC with respect to the search intensity s_t yields the following optimality condition:

$$\kappa_s(s_t) = \frac{(1-\psi)p_t^g}{h_l(l_t)}\beta E_t\left\{V^h_{n^g}(n^g_{t+1}, n^b_{t+1}, k_{t+1}) - V^h_{n^b}(n^g_{t+1}, n^b_{t+1}, k_{t+1})\right\} \tag{2.21}$$

Equivalently, we can write this condition as:

$$\kappa_s(s_t) = \left(1 - \frac{p_t^g}{p_t^b}\right)\left[1 - \frac{u_c(c_t)d}{h_l(l_t)}\right] \tag{2.22}$$

Equation (2.21) determines the optimal level of search intensity for the workers who are currently employed at low-wage jobs. I assume $\kappa(s_t)$ to be increasing and convex in s_t. Then, Equation (2.21) states that the search intensity increases with the difference between the asset values of high-wage and low-wage jobs. Also note that, as long as the probability of finding a high-wage job is less than that of a low-wage job ($p_t^g < p_t^b$), and as long as being unemployed carries a net utility cost ($h_l(l_t) > u_c(c_t)d$), it is always optimal for the household to choose a positive search intensity for on-the-job search.

2.4.2 The Firms

There are two types of firms, which offer high-wage and low-wage jobs. All firms use the same constant returns to scale production function and are subject to an aggregate technology shock z_t. Labor and capital are the inputs of production. I assume that the two firms differ in the cost they face when opening new vacancies.

The vacancy creation cost for high-wage firms is assumed to be higher than that for low-wage firms, that is $\gamma^g > \gamma^b$. The two outputs are imperfect substitutes in final goods production. The production functions of the heterogenous intermediate goods and the final goods firms are given as:

$$Y_t^g = e^{z_t}(N_t^g)^{\alpha}(K_t^g)^{(1-\alpha)}, \quad Y_t^b = e^{z_t}(N_t^b)^{\alpha}(K_t^b)^{(1-\alpha)} \tag{2.23}$$

$$Y_t = (Y_t^b)^{\varrho}(Y_t^g)^{1-\varrho} \tag{2.24}$$

The price of the final consumption good is normalized to unity. The prices of the goods produced by the intermediate goods firms are Pr_t^g and Pr_t^b, which can be further expressed as:

$$Pr_t^g = (1-\varrho)\left(\frac{Y_t}{Y_t^g}\right) \tag{2.25}$$

$$Pr_t^b = \varrho\left(\frac{Y_t}{Y_t^b}\right) \tag{2.26}$$

Firms' vacancy filling rates depend on the matching functions for each type of job. High-wage firms fill their vacancies with an endogenous probability of $q_t^g = \frac{m_t^g}{v_t^g}$, whereas this probability is $q_t^b = \frac{m_t^b}{v_t^b}$ for low-wage firms.

The optimization problem of a high-wage firm is to choose v_t^g and K_t^g, taking $\{w_t^g, q_t^g, Pr_t^g, r_t, z_t\}$ as given, to maximize:

$$V_t^{fg}(N_t^g, z_t) = \tag{2.27}$$

$$max\left\{Pr_t^g e^{z_t}(N_t^g)^{\alpha}(K_t^g)^{(1-\alpha)} - w_t^g N_t^g - r_t K_t^g - \gamma^g v_t^g + E_t[\Xi_{t+1|t} V_{t+1}^{fg}(N_{t+1}^g, z_{t+1})]\right\}$$

subject to the law of motion for employment in the market for high-wage jobs:

$$N_{t+1}^g = (1-\psi)\left[N_t^g + q_t^g v_t^g\right] \tag{2.28}$$

where $\Xi_{t+1|t}$ is the stochastic discount factor defined earlier. All FOCs and derivations are presented in Appendix A.2.

The market for capital is competitive; therefore, the rental price of capital is equal to the marginal product of capital:

$$r_t = (1-\alpha)Pr_t^g \frac{Y_t^g}{K_t^g} \tag{2.29}$$

Using the FOC with respect to vacancies, I derive the job creation equation for a high-wage firm, which reads as:

$$\frac{\gamma^g}{q_t^g} = (1-\psi)\beta E_t \left\{ \frac{u_c(c_{t+1})}{u_c(c_t)} \left[\alpha Pr_{t+1}^g \frac{Y_{t+1}^g}{N_{t+1}^g} - w_{t+1}^g + \frac{\gamma^g}{q_{t+1}^g} \right] \right\} \tag{2.30}$$

The left hand size of this job creation equation represents the firm's average cost of opening a high-wage vacancy and searching for a worker. The vacancy creation cost is divided by q_t^g, the endogenous probability of filling the vacancy. The right hand side represents the discounted expected benefit of hiring a worker. The first term is the expected marginal benefit of having a worker engaged in the job, the second one is the expected wage rate paid to the worker, and the last term is the asset value of having the vacancy filled in the next period. All terms on the right hand side are multiplied with $(1-\psi)$ to account for the exogenous separation probability.

Similarly, the optimization problem of a low-wage firm is to choose v_t^b and K_t^b, taking $\left\{w_t^b, q_t^b, p_t^g, s_t, Pr_t^b, r_t, z_t\right\}$ as given, to maximize the the value function:

$$V_t^{fb}(N_t^b, z_t) = \tag{2.31}$$

$$max \left\{ Pr_t^b e^{z_t} (N_t^b)^{\alpha} (K_t^b)^{(1-\alpha)} - w_t^b N_t^b - r_t K_t^b - \gamma^b v_t^b + E_t[\Xi_{t+1|t} V_{t+1}^{fb}(N_{t+1}^b, z_{t+1})] \right\}$$

subject to the law of motion for employment in the market for low-wage jobs:

$$N_{t+1}^b = (1-\psi)\left[(1-p_t^g s_t)N_t^b + q_t^b v_t^b\right] \tag{2.32}$$

See Appendix A.2 for all FOCs and derivations presented here. Again, the rental price of capital is equal to the marginal product of capital:

$$r_t = (1-\alpha)Pr_t^b \frac{Y_t^b}{K_t^b} \tag{2.33}$$

Solving the firm's problem yields the following job creation equation:

$$\frac{\gamma^b}{q_t^b} = (1-\psi)\beta E_t \left\{ \frac{u_c(c_{t+1})}{u_c(c_t)} \left[\alpha Pr_{t+1}^b \frac{Y_{t+1}^b}{N_{t+1}^b} - w_{t+1}^b + (1-p_{t+1}^g s_{t+1}) \frac{\gamma^b}{q_{t+1}^b} \right] \right\} \tag{2.34}$$

The interpretation of this job creation equation is similar to the interpretation of Equation (2.30). The only difference is that now the firm takes into account the probability that the worker currently engaged in a low-wage job may switch to a high-wage job. The left hand side shows the average cost of opening a vacancy in the current period. Since the worker becomes productive in the next period, the gains from hiring the worker are expressed in expectations. The first two terms represent the expected gain of hiring the worker net of wages paid. The last term is the expected gain of keeping the vacancy occupied in the next period, accounting for the probability that the worker can leave for a high-wage job. All terms on the right hand side are multiplied by $(1-\psi)$, since there is also the possibility of an exogenous separation.

2.4.3 Wage Bargaining

The wage rates in the markets for high-wage and low-wage jobs are determined through Nash bargaining between matched worker and firm pairs. I let μ and $(1-\mu)$ represent the bargaining weights for the worker and the firm, respectively. The Nash bargaining problem in both markets is to choose the corresponding wage rates to solve:

$$max_{w_t^i}\left[\frac{V_{n^i}^h(n_t^g, n_t^b, k_t)}{u_c(c_t)}\right]^{\mu}\left[V_{N^i}^{fi}(N_t^i, z_t)\right]^{(1-\mu)} \tag{2.35}$$

where $i = g, b$ stands for the type of the job, $V_{n^i}^h(n_t^g, n_t^b, k_{t+1})$ is the marginal value for the household of having a member working at a type i job, and $V_{N^i}^{fi}(N_t^i, z_t)$ is the marginal value for the firm of hiring a worker for a type i job.

Solving the above Nash bargaining problem for each type of job gives the corresponding wage rates. The derivations are presented in Appendix A.3. The resulting wage rates are:

$$w_t^g = \mu\left[\alpha Pr_t^g\frac{Y_t^g}{N_t^g}\right] + (1-\mu)\left[\frac{h_l(l_t)}{u_c(c_t)}\right] \tag{2.36}$$

$$w_t^b = \mu\left[\alpha Pr_t^b\frac{Y_t^b}{N_t^b} - p_t^g s_t\frac{\gamma^g}{q_t^g}\right] + (1-\mu)\left[[1+\kappa(s_t)]\frac{h_l(l_t)}{u_c(c_t)}\right] \tag{2.37}$$

For high-wage jobs, the wage rate is the weighted sum of the threshold values for the worker and the firm. On the one hand, the firm's marginal benefit from hiring a worker for a high-wage job is $\alpha Pr_t^g\frac{Y_g^t}{N_t^g}$, which is thus the firm's threshold level. The firm would not agree to pay a wage rate higher than this amount. On the other hand, the threshold level for the worker to accept a good job is the disutility from giving up home production $\frac{h_l(l_t)}{u_c(c_t)}$, expressed in terms of goods. The worker would not agree to work for a wage rate below this value. Note that the weights that multiply the threshold levels correspond to the bargaining weights for the worker and the firm.

Similarly, the wage rate for a low-wage job is the weighted sum of the threshold values for working and hiring. When the worker and the firm are engaged in a low-wage job relationship, they both incur some additional costs. By assumption, the worker searches for a high-wage job; therefore, she pays for the cost of her search activity. On the other hand, the firm faces the risk of having an unfilled vacancy due to the possibility of the worker leaving to work at a high-wage job. Therefore, the threshold values are adjusted to compensate for the costs of a possible endogenous termination of the employment relationship.

2.4.4 Closing the Model and the Competitive Equilibrium

There is no government consumption. The government collects taxes to finance the unemployment benefits. The aggregate resource constraint for the economy reads as:

$$Y_t = c_t + \gamma^g v_t^g + \gamma^b v_t^b + i_t \tag{2.38}$$

The logarithm of the aggregate technology shock follows an AR(1) process of the form:

$$z_{t+1} = \rho^z z_t + \epsilon_{t+1}^z \tag{2.39}$$

with $\epsilon^z \sim (0, \sigma_z^2)$ and $0 < \rho^z < 1$.

I close this subsection by defining a competitive equilibrium of the model.

Definition 2.1. A competitive equilibrium of the model is defined as the decision rules for the stochastic processes coming from the household's problem $\left(c_t, n_t^g, n_t^b, u_t^g, u_t^b, i_t, s_t\right)$, and from the firms' problems $\left(N_t^g, N_t^b, K_t^g, K_t^b, v_t^g, v_t^b\right)$, given the factor prices $\left\{w_t^g, w_t^b, r_t, Pr_t^g, Pr_t^b\right\}$, the probabilities of matching $\left\{p_t^g, p_t^b, q_t^g, q_t^b\right\}$, and the stochastic technology shock $\{z_t\}$, such that:

1. Labor markets clear: $n_t^b = N_t^b$, $n_t^g = N_t^g$;

2. The capital market clears: $k_t = K_t^g + K_t^b$;

3. Household choices satisfy Equations (2.17)-(2.22);

4. Firms' choices satisfy Equations (2.30) and (2.34);

5. The law of motion for capital, Equation (2.13), and the laws of motion for employment, Equations (2.14) and (2.15), or (2.28) and (2.32) are satisfied;

6. Definitions of the matching functions, Equations (2.1) and (2.6), of the job finding and vacancy filling probabilities, Equations (2.3), (2.4), (2.8) and (2.9), and of labor market tightness, Equations (2.5) and (2.10) are satisfied;

7. Wage rates and the rental rate of capital satisfy Equations (2.36), (2.37), (2.29) and (2.33);

8. The aggregate resource constraint, Equation (2.38), is satisfied.

2.4.5 The Workers' Indifference Condition

Since both jobs coexist in the equilibrium, it must be the case that an unemployed household member is indifferent between looking for a high-wage and a low-wage job. In other words, the asset values of both types of unemployment have to be equal. This leads to the following equilibrium result.

Proposition 2.1. In the equilibrium, the relative labor market tightness for the two types of jobs is inversely proportional to their relative vacancy creation costs.

$$\frac{\theta_t^b}{\theta_t^g} = \frac{\gamma^g}{\gamma^b} \tag{2.40}$$

Since we assume that $\gamma^g > \gamma^b$, labor market tightness must be higher in the market for low-wage jobs in the equilibrium.

Proof. Setting the asset values of unemployment in the two sectors equal to each other gives:

$$p_t^b \frac{\gamma^b}{q_t^b} = p_t^g \frac{\gamma^g}{q_t^g} \tag{2.41}$$

Note that labor market tightness in the two sectors can be defined as $\theta_t^b = \frac{p_t^b}{q_t^b}$ and $\theta_t^g = \frac{p_t^g}{q_t^g}$. Then, the derived arbitrage condition simplifies to $\frac{\theta_t^b}{\theta_t^g} = \frac{\gamma_t^g}{\gamma_t^b}$. QED.

2.5 Calibration and Impulse Responses

In this section I present the calibration of the main parameters of the model. I calibrate the proposed model to the U.S. data for the period 1951-2005. First, I choose the parameters that can be set without solving the model. Next, I choose the remaining parameters so that the model matches relevant first-order and second-order moments calculated from the data. Based on the calibration, I conduct a variety of numerical analyses. I present the implied impulse response functions in this section, leaving the business cycle statistics to the next section. In all analyses I compare the proposed model's results with the simpler three-state model without on-the-job search.

The period length is one quarter. Household preferences are taken as:

$$u(c_t) + h(l_t) = ln(c_t) + \bar{H}\left(\frac{l_t^{(1-\phi)}}{1-\phi}\right) \tag{2.42}$$

where $\bar{H}$ is a constant and ϕ is an elasticity parameter. The matching functions for both types of jobs have the usual Cobb-Douglas specifications of:

$$m_t^b = \bar{m}[u_t^b]^{\epsilon}[v_t^b]^{(1-\epsilon)} \tag{2.43}$$

$$m_t^g = \bar{m}[u_t^g + s_t n_t^b]^{\epsilon}[v_t^g]^{(1-\epsilon)} \tag{2.44}$$

I use $\kappa(s_t) = Bs_t^{\sigma}$ as the functional form for the search cost, where B is a positive constant and $\sigma > 1$, so that the cost of on-the-job search is strictly increasing and convex in the search intensity s_t.

2.5.1 Parameters Taken from Various Sources

The household discount factor β is 0.99, which corresponds to a 4 percent annual interest rate. Veracierto (2008) calculates the steady state level of monthly investment-to-capital ratio as 0.006. This implies a quarterly capital depreciation rate of 0.018; therefore, $\delta = 0.018$. Following earlier studies in the real business cycle literature, the elasticity of output with respect to capital in the intermediate goods production function $(1-\alpha)$ is 0.36, and the persistence parameter in the AR(1) process of the logarithm of the aggregate technology shock is 0.95.

The elasticity parameter ϵ in the matching functions is 0.40, which is the estimated value in Blanchard and Diamond (1989). In order to satisfy the Hosios

(1990) condition, the bargaining power of workers in the Nash bargaining problem μ is also set equal to 0.40.

Next, I calculate the exogenous and endogenous separation rates in the data. In the model, total separations consist of both exogenous and endogenous separations. Using the dataset compiled by Fallick and Fleischman (2004), I showed earlier that employer-to-employer flows correspond to almost 40 percent of total separations from employment. Davis, Faberman, Haltiwanger and Rucker (2008) examine the JOLTS data, adjust the worker flow rates and report a monthly total separation rate of 4.96. This corresponds to a quarterly total separation rate of 14.9. Using this information, I set exogenous and endogenous separation rates as 0.095 and 0.059, respectively. All parameter values chosen a priori are reported in Table 2.2.

Table 2.2: Parameters Chosen Without Solving the Model

	Value	Description	Source
β	0.99	Household Discount Factor	Annual Interest Rate = 0.04
δ	0.018	Depreciation Rate	Veracierto (2008)
α	0.64	Elasticity of Output wrt. Labor	RBC Literature
ρ^z	0.95	Persistence of the Agg. Tech. Shock	RBC Literature
ϵ	0.4	Match Elasticity	Blanchard and Diamond (1989)
μ	0.4	Nash Bargaining Share	Hosios (1990)
ψ	0.095	Exogenous Separation Rate	Based on JOLTS and CPS Data

2.5.2 Parameters Set to Match Certain Targets

The remaining parameters are set so that the model solution matches certain data moments. These parameters are reported in Table 2.3. The elasticity of home production in the household preferences ϕ is 0.22, which is calibrated to match the volatility of employment relative to output in the data, as in Tripier (2003) and Veracierto (2008).[6] The preference constant $\bar{H}$ is calibrated to generate an employment to population ratio of 0.59, which is the average quarterly ratio in the U.S. labor market for the period 1951-2005. The resulting value is 1.05.

In order to set the elasticity parameter in the search cost function σ, I choose the volatility of employer-to-employer flows relative to output as my target. I use the data set provided by Fallick and Fleischman (2004) and calculate the volatility of employer-to-employer flows relative to output as 12.25 for 1994-2005 at quarterly frequency.[7] Using this target, the calibrated value for the elasticity parameter in the

[6]Both Tripier (2003) and Veracierto (2008) calibrate of the preference parameter in the household's utility function in the same way. Veracierto (2008) uses three different utility functions, one linear as in Merz (1997), and two non-linear as in Shi and Wen (1999) and Hornstein and Yuan (1998), to evaluate the performance of the basic three-state model. In all three calibrations, he determines the curvature of home production in the utility function by targeting the relative standard deviation of employment calculated from the U.S. data. Veracierto (2008) uses the same utility function specified earlier in this chapter and repeats Tripier's calibration strategy.

[7]The series are logged and HP-filtered (smoothing paramater is 10^5). This is of course an imperfect way to measure the volatility of job-to-job flows, however no employer-to-employer data exists before 1994. Krause and Lubik (2010) use quits from the BLS labor turnover series for the manufacturing sector for 1950-1981 and calculate the relative volatility of quits as 10.06.

Table 2.3: Parameters Chosen by Solving the Model

Parameter	Value	Description
ϕ	0.22	Elasticity of Home Production
$\bar{H}$	1.05	Constant in the HH Pref. for Home Production
σ	1.2	Elasticity of Search Cost
B	0.09	Constant in the Search Cost Function
$\bar{m}$	0.75	Matching Function Constant
γ^g	0.6	High-Wage Vacancy Creation Cost
γ^b	0.2	Low-Wage Vacancy Creation Cost
ϱ	0.4	Low-Wage Firms' Weight in Production
d	0.6	Unemployment Benefit
ϵ^z	0.0074	Std. of Log of Agg. Tech. Shock

Targets
Relative Volatility of Employment
Employment/Population = 0.59
Relative Volatility of E-E Flows
Endogenous Separation Rate = 0.059
Average Firm Matching Probability = 0.78
Ratio of Vacancy Creation Costs = 3
Total Vacancy Cost/Output = 0.05
Employment Share of Low-Wage Firms = 0.4
Benefit to Wage Ratio = 0.7
Volatility of Output

search cost function turns out to be 1.2. The constant in the search cost function B is calibrated to match a steady state endogenous separation rate of 0.059, as was calculated above. The resulting value is 0.09.

Since the matching technologies are the same in the two sectors, the constants in the matching functions are the same as well. Targeting an average quarterly vacancy filling probability of 0.78, the constant becomes 0.75.[8] Vacancy creation costs γ_b and γ_g are calibrated to generate a total vacancy creation cost of 5 percent of total output as in Krause and Lubik (2010).[9] The vacancy creation cost for high-wage firms is assumed to be three times the cost for low-wage firms. Using these two targets, γ_b and γ_g turn out to be 0.2 and 0.6, respectively.

A brief explanation on the ratio of the vacancy creation costs is in order. Davis, Faberman and Haltiwanger (2010) report that not all firms post vacancies in order to attract workers. More specifically, they find that 67.2 percent of hiring occurs without vacancy posting at establishments in the construction sector. In terms of employment, 73.7 percent of employment in the construction sector is at establishments that do not report vacancies. These numbers are 57.8 and 59.2 percent in natural resources and mining, 49.1 and 59.3 percent in retail trade, 47.7 and 54.2 percent in leisure and hospitality, 41.5 and 51.2 percent in transport, wholesales and utilities, and lastly, 54.5 and 70.6 percent in other service sectors. On the contrary, some other sectors, such as manufacturing, education and health seem to attract

[8]I calculate the average vacancy filling probability using Robert Shimer's data for the period 1951-2004. See the next section for further details.

[9]They choose this target a priori.

workers primarily by posting vacancies. In light of this evidence, I relate the firms in these sectors to high-wage firms in the model, while relating the rest to low-wage firms. Krause and Lubik (2010) set the vacancy creation cost ratio $\frac{\gamma_g}{\gamma_b}$ to 4, arguing that vacancy creation costs are linked to the capital intensities of sectors and that the difference between the capital intensity of average high-wage and low-wage jobs is around this level. They do not include capital in their model. However, capital is modeled in my framework; and therefore, I take vacancy creation costs to represent explicit costs of recruitment, such as job advertising, hiring recruiters, screening, interviewing, etc. I am not aware of any data source that reports actual vacancy creation costs in different sectors. In the baseline calibration I set the vacancy creation cost ratio to 3 in order to generate a moderate wage differential across the sectors. I perform sensitivity analysis by varying this ratio and propose an alternative calibration strategy in Subsection 2.7.3.

Next, I set the total production share of low-wage firms ϱ based on the sectoral classification described above. Using employment shares reported in Davis, Faberman and Haltiwanger (2010), I calculate the total employment share of the sectors with the lowest propensity to post vacancies as 40 percent.[10] I use this value to set the steady-state employment share of low-wage firms to 40 percent. The resulting share of low-wage output in final goods production then becomes 0.4.

The unemployment benefit level d is 0.6, which is calibrated to match a ratio

[10]Employment shares are 5.3 percent in construction, 0.5 percent in natural resources and mining, 11.4 percent in retail trade, 9.3 percent in leisure and hospitality, 8 percent in transport, wholesales and utilities, and 4.1 percent in other service sectors.

of benefits to average wages of 0.7. The chosen value for this ratio lies between the two extreme calibration targets used in Shimer (2005) and Hagedorn and Manovskii (2008).

Finally, the standard deviation of the log of the aggregate technology shock is 0.0074, which is calibrated to replicate the observed standard deviation of the total output in the sample.

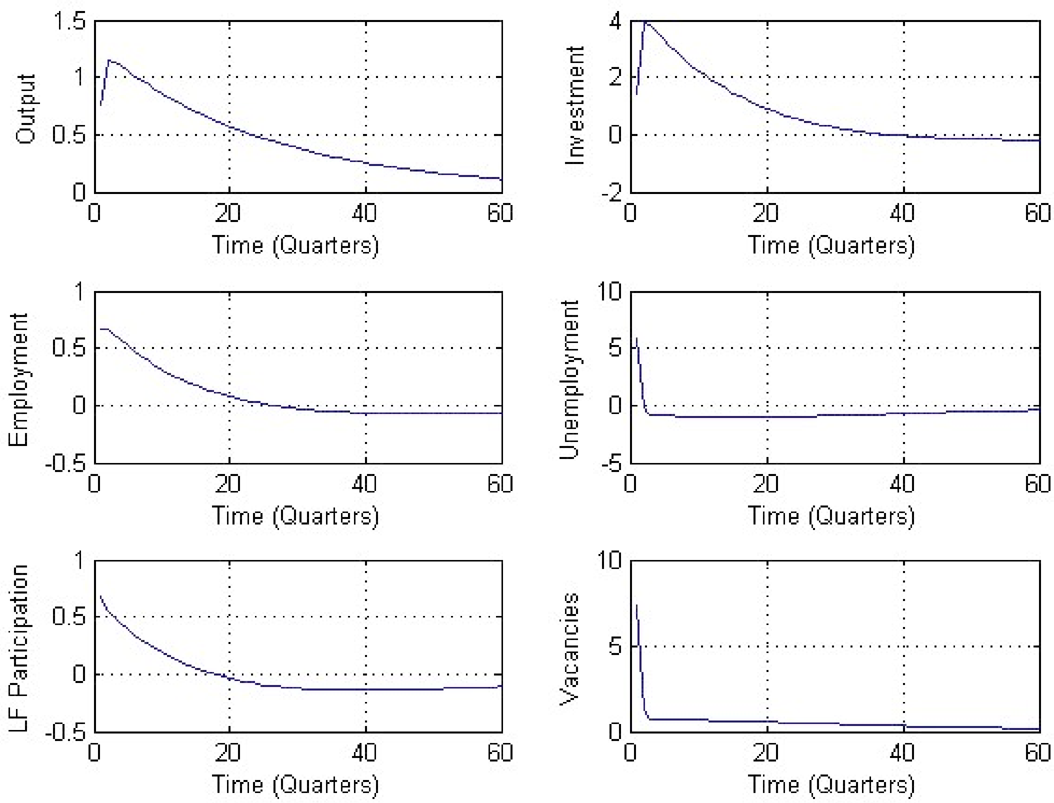
2.5.3 Impulse Responses

I begin my analysis by studying the dynamic properties of the major labor market variables in the three-state model without on-the-job search, which is very similar to the model presented in Tripier (2003). The on-the-job search model described in this study converges to this simpler model when there is no employed search, that is, $s = 0$ and firms are homogenous.[11] I study the dynamics of this basic model in response to a 1 standard deviation positive productivity shock. The resulting impulse response functions are shown in Figure 2.1. Impulse responses are reported as percentage deviations from the steady state values.

On impact, the positive productivity shock leads to an increase in the output level. Firms open more vacancies and the job finding probability of workers increases, which results in higher overall employment. But, note that unemployment also

[11] The calibration strategy used to determine the parameters for this simplified model is identical to the calibration strategy used to set the parameters of the model with on-the-job search described above. There is no endogenous separation and the exogenous separation rate is set to 0.1 as in the earlier studies.

Figure 2.1: Impulse Responses for the Economy Without On-the-Job Search: % Deviations from the Steady State



increases sharply. This is due to the fact that the household sends more members to participate in the labor market, since it is a good time to engage in market work rather than home production. The number of searchers increases as labor force participation goes up. Since it takes time to form matches, not all searchers can find jobs; therefore, unemployment increases. Over time, as the newly-opened vacancies get filled by workers, unemployment falls quickly to a level around its steady state value. This results in a lower incentive for firms to open vacancies, so vacancy creation goes down quickly as well. Both investment and employment follow the output level, increasing on impact and then slowly returning to their steady state levels.

Next, I consider the dynamic properties of the model with on-the-job search developed in this chapter. Job searchers now include not only the unemployed, but also the employed agents who would like to work at better-paying jobs. Impulse responses of the economy to a 1 standard deviation positive productivity shock are presented in Figures 2.2 and 2.3.

First, consider the responses of the aggregate variables. As shown in Figure 2.2, aggregate output and investment both increase on impact in response to the positive productivity shock. This leads to higher aggregate vacancy creation by firms. As in the model without on-the-job search, the household sends more members to search for jobs. The increased labor force participation with new searchers and the time lag for match formations result in an initial increase in aggregate unemployment. However, the subsequent evolution of unemployment is very different compared to the previous case. As firms open more vacancies and workers' job finding proba-

Figure 2.2: Impulse Responses for the On-the-Job Search Economy - Aggregate Variables: % Deviations from the Steady State

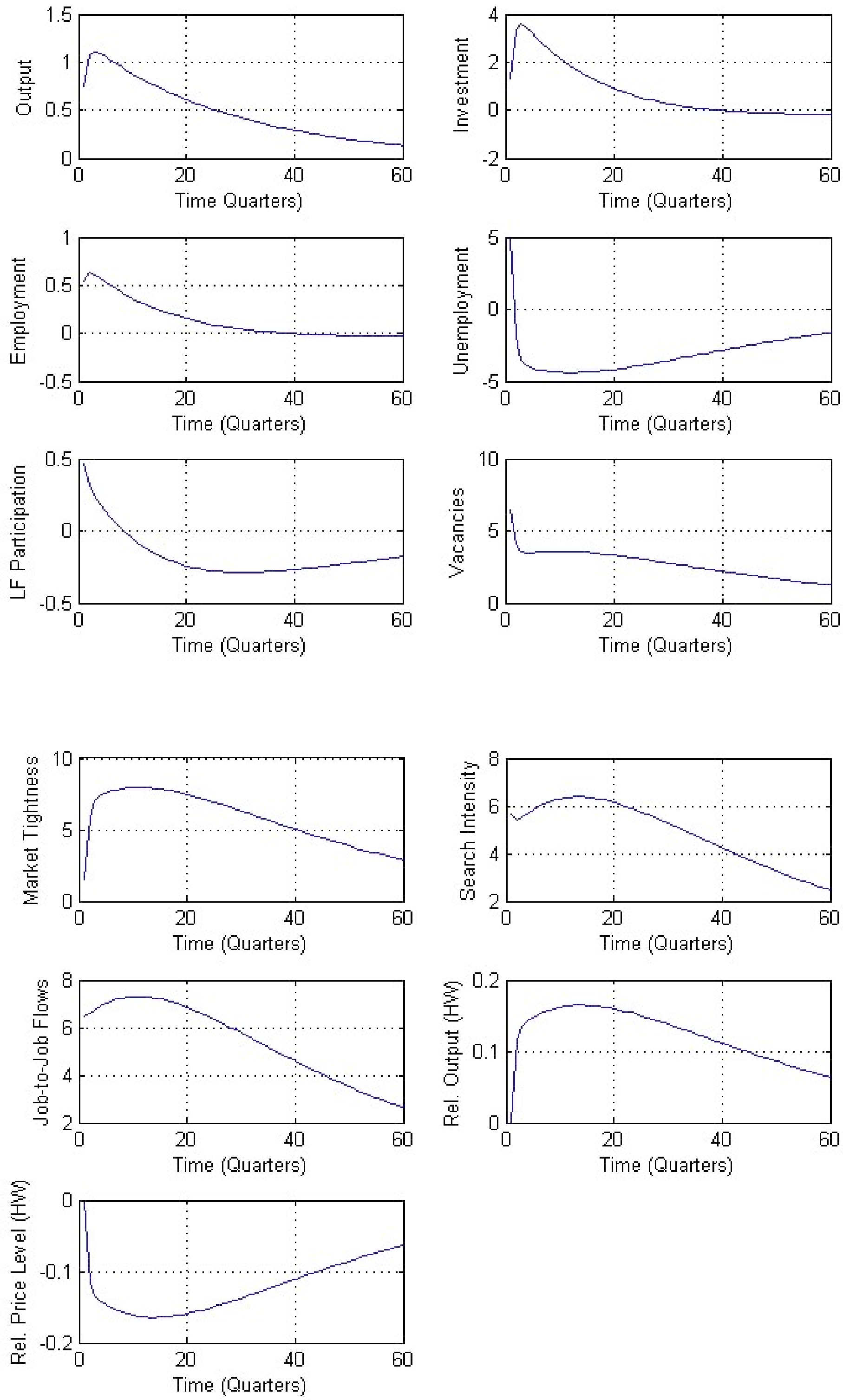
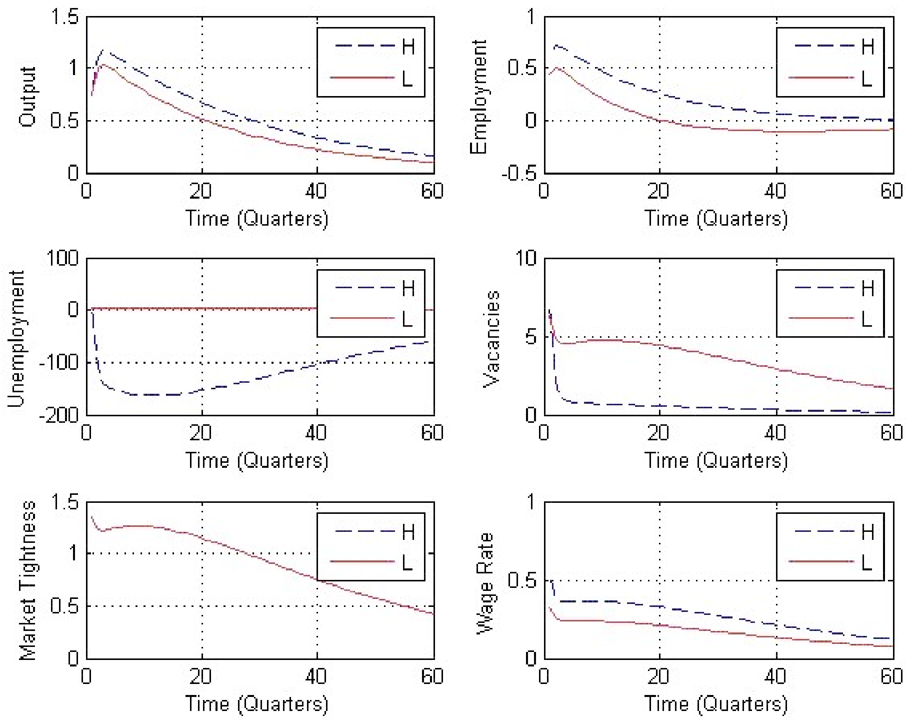


Figure 2.3: Impulse Responses for the On-the-Job Search Economy - Comparison of the Two Sectors: % Deviations from the Steady State



bilities increase, job searchers become employed and the aggregate unemployment level falls quickly below its steady state level. Unemployment stays below its steady state level for a long time because vacancy creation remains high due to on-the-job search. In the model without on-the-job search, the household's only adjustment mechanism to a favorable shock is changing the number of members participating in the labor market. However, with on-the-job search, there is a second margin for labor market adjustments to take place. As job finding rates increase, workers in low-wage jobs get matched with better jobs that pay higher wages. This is why job-to-job transitions increase substantially. Also, vacancy creation remains high, as will become more clear below.

Now, consider the responses in the two sectors separately. As seen in Figure 2.3, the increases in output, employment and wages are higher at high-wage jobs than at low-wage jobs. As workers flow from low-wage jobs to high-wage jobs, the relative output in high-wage jobs increases, and in turn, the relative price of the bad (low-wage) intermediate good increases. This leads to a higher incentive for low-wage firms to keep posting vacancies. Within a few periods after the shock, vacancy creation by high-wage firms falls sharply (similar to the evolution of vacancy creation in the model without on-the-job search), but vacancy creation by low-wage firms remains high.

Almost all the variation in aggregate unemployment is due to the evolution of search effort among workers searching for high-wage jobs. On impact, as output and vacancy creation increase in the high-wage sector, the employed searchers increase their search intensity and move to high-wage jobs. Note that this search activity by the employed leads to congestion in the market for high-wage jobs. Therefore, the unemployed searchers direct their search towards low-wage jobs, resulting in a pronounced fall in the number of unemployed searching for high-wage jobs compared to its steady state level. In contrast, with the increased flow of workers from low-wage jobs to high-wage jobs, more job opportunities become available in the market for low-wage jobs. In turn, the unemployed search in the market for low-wage jobs, where competition is low. This keeps the demand for jobs, vacancy creation and workers' job finding rate high in this market.

2.6 U.S. Business Cycle Properties

Below compare the business cycle properties of the model to their empirical counterparts. First, I construct quarterly U.S. business cycle statistics for the period 1951-2005. These empirical measures are computed using data from different sources and are reported in Table 2.4.

Seasonally adjusted quarterly data on consumption and investment are taken from the U.S. Bureau of Economic Analysis (BEA).[12] Real aggregate consumption is calculated as the sum of real personal consumption expenditures on non-durable goods and services. Real aggregate investment corresponds to real gross private domestic investment. To be consistent with my model, which omits government purchases and trade, real aggregate GDP is calculated as the sum of these investment and consumption measures. Monthly data on the levels of employment, un-

[12]Available from the BEA website at http://www.bea.gov. I calculate the real series in billions of chained (2005) dollars.

employment and labor force participation are taken from the website of the Bureau of Labor Statistics (BLS).[13] The monthly series are transformed into quarterly frequency by taking the average value for a quarter. Quarterly per person wage rates are calculated as $wage = \frac{compensation \times output}{employment \times current\$output}$ using non-farm business series from the BLS. The vacancy data come from the Conference Board's Help Wanted Index.[14] Quarterly averages of job finding and vacancy filling rates are taken from the data set constructed by Robert Shimer (For additional details, see Shimer (2007) and his webpage http://sites.google.com/site/robertshimer/research/flows). The corresponding probabilities are then calculated as $probability = 1 - e^{-rate}$. All data series are logged and detrended with the Hodrick-Prescott (HP) filter before the business cycle statistics are calculated.[15]

The usual properties of the U.S. business cycle statistics are observed. Consumption is half as volatile as output, while investment is 4 times as volatile as output. Of the labor market variables, unemployment and labor market tightness have the highest standard deviations. The volatility of unemployment is more than 7 times that of output, while labor market tightness is 15 times more volatile than output. The least volatile variables are labor force participation and out of the labor force, with relative standard deviations of 0.35 and 0.48, respectively. Finally, the relative standard deviation of employment is 56 percent.

The cross-correlations show that consumption, investment, employment and

[13]See http://www.bls.gov/bls/employment.htm for more details.

[14]I borrow this data from the dataset used in Den Haan and Kaltenbrunner (2009), which is publicly available at http://www1.feb.uva.nl/mint/wdenhaan/data.htm.

[15]The smoothing parameter is chosen as 10^5 given the criticism in Shimer (2005).

labor market tightness are highly positively correlated with output, while unemployment is highly negatively correlated with output. Labor force participation has a small positive correlation with output, while the correlation between out of the labor force and output is small and negative. Numerically, the cross-correlations of output with employment, unemployment, labor force participation and out of the labor force are 0.74, -0.76, 0.14 and -0.23, respectively. Unemployment is also highly negatively correlated with vacancies, labor market tightness and workers' job finding probability, with cross-correlation values of -0.90, -0.97 and -0.95, respectively. Vacancies are highly positively correlated with labor market tightness (0.98) and workers' job finding probability (0.92). Finally, firms' vacancy filling probability has a high positive correlation with unemployment (0.96) and a high negative correlation with vacancies (-0.98).

2.7 Results and Discussion

2.7.1 Simulation Results

In this subsection, I present the simulation results for both the basic three-state model without on-the-job search and the proposed on-the-job search economy. I report the results in Tables 2.4 and 2.5, and compare them with the corresponding U.S. business cycle statistics. The model statistics correspond to averages across 100 simulations of 220 periods (to match the quarterly data for the period 1951-

2005).[16] All series are logged and detrended with the Hodrick-Prescott filter before the statistics are computed.[17]

Table 2.4: Business Cycle Statistics

a. Relative standard deviation ($\frac{\sigma_x}{\sigma_Y}$)

	U.S. BC Stats.	Without OJS	OJS Model
Output (Y)	1	1	1
Consumption (C)	0.56	0.39	0.31
Investment (I)	3.89	3.34	3.17
Employment (N)	0.56	0.56	0.56
Unemployment (U)	7.92	2.78	5.63
Labor Force (L)	0.35	0.65	0.39
Out of LF (OLF)	0.48	1.19	0.74
Wage Rate (W)	0.68	0.48	0.25 & 0.39
Market Tightness (θ)	15.89	1.62	14.57

b. Correlation with Output ($\rho_{x,Y}$)

	U.S. BC Stats.	Without OJS	OJS Model
Output (Y)	1	1	1
Consumption (C)	0.85	0.79	0.73
Investment (I)	0.92	0.97	0.96
Employment (N)	0.74	0.92	0.95
Unemployment (U)	-0.76	-0.12	-0.59
Labor Force (L)	0.14	0.65	0.47
Out of LF (OLF)	-0.23	-0.82	-0.48
Wage Rate (W)	0.58	0.92	0.95 & 0.93
Market Tightness (θ)	0.83	0.91	0.72

First I begin with the simulation results for the model without on-the-job search. Table 2.4 shows that the relative volatilities of unemployment and labor market tightness are small, whereas the relative volatility of labor force participation

[16] I generate 320 periods of data in each simulation, discard the first 100 periods and use the rest for calculations.

[17] Again, the smoothing parameter is chosen as 10^5, given the criticism in Shimer (2005).

Table 2.5: Cross-Correlations of the Major Labor Market Variables

a. U.S. Data

	U	V	θ	p	q
U	1	-0.90	-0.97	-0.95	0.96
V	-	1	0.98	0.92	-0.98
θ	-	-	1	0.96	-0.99
p	-	-	-	1	-0.92
q	-	-	-	-	1

b. Without On-the-Job Search

	U	V	θ	p	q
U	1	0.85	-0.13	-0.13	0.13
V	-	1	0.41	0.41	-0.41
θ	-	-	1	0.99	-0.98
p	-	-	-	1	-0.99
q	-	-	-	-	1

c. On-the-Job Search Model

	U	V	θ	p	q	s	jtj flows
U	1	-0.34	-0.63	-0.58	0.58	-0.54	-0.51
V	-	1	0.65	0.95	-0.94	0.89	0.84
θ	-	-	1	0.74	-0.73	0.82	0.87
p	-	-	-	1	-0.99	0.90	0.85
q	-	-	-	-	1	-0.89	-0.84
s	-	-	-	-	-	1	0.93
$jtj\ \ flows$	-	-	-	-	-	-	1

is large compared to the data. The relative standard deviation of unemployment is 2.78, which is 65 percent lower than the empirical value. Similarly, the relative volatility of labor market tightness is only 1.62, which is 1/10 of the actual value. The relative standard deviation of labor force participation is 0.65, which is almost twice the actual level. The gap between the model generated and the actual statistics is even more pronounced when out of the labor force is considered (1.19 vs. 0.48).

The model correlation of unemployment with output is only -0.12, compared to -0.76 in the data. The correlation of unemployment with vacancies is high at 0.85, but has the opposite sign of its empirical counterpart. The correlations of unemployment and vacancies with workers' job finding probability are both small in absolute value, corresponding to -0.13 and 0.41, respectively. The correlations of unemployment and vacancies with firms' vacancy filling probability are 0.13 and -0.41, respectively; these numbers are again very small in absolute value compared to the data values. Note that in the data unemployment is highly negatively correlated with workers' job finding probability (correlation is -0.95), while it is highly positively correlated with firms' vacancy filling probability (correlation is 0.96). The opposite is true for vacancies (corresponding statistics are 0.92 and -0.98). Finally, the correlations of labor force participation and out of the labor force with output are too high in absolute value compared to the data values (0.65 vs. 0.14 for participation, and -0.82 vs. -0.23 for out of the labor force, respectively).

These results support the conclusions of both Tripier (2003) and Veracierto (2008). The simple three-state model fails to generate strongly countercyclical unemployment and the Beveridge curve relationship between vacancies and unemployment. Moreover, the model generated relative standard deviations of unemployment and labor market tightness are too low, while the correlations of labor force participation and out of the labor force with output are too high.

Next, I simulate the proposed on-the-job search model. The calculated results for the relative standard deviations and the correlations of all major variables with output are reported in the final column of Table 2.4, while the cross-correlations are reported in Table 2.5. Again, the model statistics correspond to the averages across 100 simulations of 220 periods; all series are logged and detrended with the Hodrick-Prescott filter before the statistics are computed.

Compared to the previous model, the relative standard deviations of unemployment and labor force participation implied by the on-the-job search model are much more in line with their empirical counterparts. The relative standard deviation of unemployment with respect to output is 5.63, which is a major improvement compared to the generated value in the model without on-the-job search (2.78). The relative volatility of labor force participation is 0.39, which is very close to the observed value of 0.35. Another major improvement is seen in the relative volatility of aggregate labor market tightness, which is 14.57 (compared to 1.62 previously), close to the data value of 15.89.

As shown in Table 2.4, the model with on-the-job search predicts the correlation of output and unemployment as -0.59. Although this is not as high as its empirical counterpart of -0.76, the fact that the correlation is negative and large is very important, since the three-state model without on-the-job search fails in this dimension. The correlations of unemployment with workers' job finding probability and firms' vacancy filling probability are much higher at -0.58 and 0.58, which are more in line with the data. The results are even more satisfactory when the correlations of vacancies with job finding (0.95) and vacancy filling (-0.94) probabilities are considered.

The model successfully reproduces the negative correlation between unemployment and vacancies, also known as the Beveridge Curve relationship. This correlation is -0.34, which is a major improvement relative to the correlation of 0.85 in the model without on-the-job search. The correlation of labor force participation with output is lower compared to the previous model (0.47 vs. 0.65 earlier). A similar conclusion applies for the correlations between out of the labor force and output (-0.48 and -0.82 for the model with and without on-the-job search, respectively). Finally, the model predicts search intensity and job-to-job flows to be highly positively correlated with vacancies (0.89 and 0.84), labor market tightness (0.82 and 0.87) and workers' job finding probability (0.90 and 0.85). The correlations of search intensity and job-to-job flows with unemployment (-0.54 and -0.51) and firms' vacancy filling probability (-0.89 and -0.84) are highly negative as expected.

Although the model is able to generate the Beveridge Curve relationship, the simulated correlation between vacancies and unemployment is lower in absolute value than the observed correlation in the data. The correlation of labor force participation with output is lower compared to the value in the model without on-the-job search, but it is still higher compared to the empirically observed value. The comparison (in absolute value) is similar for the correlation between out of the labor force and output. These shortcomings are mainly related to the endogenous participation assumption. Although part of the household's labor market adjustments occur through job-to-job transitions, the increase in the number of new searchers following a favorable shock is still high. Lastly, the relative volatilities of wages (especially in the low-wage sector) are found to be low, due to the dampened movements in the labor market tightness in the high-wage sector, which will be discussed in the next subsection.

2.7.2 Discussion

As mentioned earlier, the failure of the basic three-state model without on-the-job search is mainly due to the high responsiveness of participation to aggregate technology shocks. Therefore, I introduce an on-the-job search mechanism as an additional adjustment margin for the household. The proposed model can generate countercyclical unemployment, and it is more successful in matching the relative volatilities of unemployment and labor market participation. Moreover, the model predicts highly volatile aggregate labor market tightness, which is in line with the U.S. data.

How does on-the-job search contribute to the model's success? When a positive productivity shock hits the economy, the incentive of the household to send more workers to search for jobs increases. The incentive for higher labor force participation increases because the return from market activities increases with the favorable shock. However, on-the-job search works as an alternative margin for adjusting the labor market activities of the household. With the positive productivity shock, the household allocates more time for on-the-job search. The increase in the on-the-job search activity dampens the movements along the labor force participation margin. The magnitude of the dampening effect depends on the time cost of on-the-job search, which depends on the elasticity parameter in the search cost function. As the elasticity σ goes from one to infinity, the cost of on-the-job search increases as well. An extremely high level of σ corresponds to shutting down the on-the-job search margin, so that the model becomes similar to the basic three-state model. Overall, the relative volatilities of labor force participation and unemployment become closer to their empirical counterparts due to the labor market movements generated by on-the-job search.

Another important contribution of the on-the-job search mechanism is its impact on the volatility of aggregate labor market tightness. The mechanism generates highly volatile aggregate labor market tightness ($\theta_t = v_t/u_t$) due to the high responsiveness of vacancy creation by low-wage firms. In order to further investigate this point, consider labor market tightness in the market for high-wage jobs:

$$\theta_t^g = \frac{v_t^g}{u_t^g + s_t n_t^b} \tag{2.45}$$

Compared to the model without on-the-job search, this equation has the additional term for the employed job seekers $s_t n_t^b$. From Equation (2.45), on-the-job search reduces the responsiveness of labor market tightness in the high-wage sector to productivity shocks. Recall the wage equations in the two sectors:

$$w_t^g = \mu \left[\alpha Pr_t^g \frac{Y_t^g}{N_t^g} \right] + (1-\mu) \left[\frac{h_l(l_t)}{u_c(c_t)} \right] \tag{2.46}$$

$$w_t^b = \mu \left[\alpha Pr_t^b \frac{Y_t^b}{N_t^b} - s_t \gamma^g \theta_t^g \right] + (1-\mu) \left[[1+\kappa(s_t)] \frac{h_l(l_t)}{u_c(c_t)} \right] \tag{2.47}$$

Labor market tightness in the high-wage sector appears in the wage equation for the low-wage jobs. Any increase in labor market tightness in the high-wage sector results in a reduction of wages in the low-wage sector, since low-wage firms take into account the possibility of losing a worker to a high-wage firm when bargaining for wages. On-the-job search dampens the movements of labor market tightness in the high-wage sector, which also corresponds to dampened movements of wages in the low-wage sector. Since wages are more stable, low-wage firms continue to post vacancies. Moreover, firms have diminishing marginal product of labor, therefore losing a worker raises the marginal benefit of hiring for low-wage firms, which also explains why vacancy creation remains high in this sector. Additionally, there is high competition in the high-wage sector due to congestion caused by the employed searchers. This leads to increased search activity by the unemployed in the low-wage sector following a favorable shock. As more workers search for jobs in the low-wage sector, firms continue to post vacancies. In turn, aggregate vacancy creation and volatility of vacancies in the economy remain high, resulting in a highly responsive aggregate labor market tightness. This helps all searchers to find jobs at a higher rate. Therefore, a few periods after the positive aggregate technology shock hits the economy, unemployment falls quickly below its steady state level and follows a countercyclical pattern.

The persistence of high vacancy creation also explains why the model no longer generates a high positive correlation between unemployment and vacancies. In fact, the correlation now has the correct negative sign.

Lastly, it must be noted that the on-the-job search mechanism also affects relative wages. Given that the vacancy creation cost is higher for the high-wage firms and that both types of firms face downward-sloping demand, the wage rate has to be higher in equilibrium in the high-cost sector than in the low-cost sector. This wage difference provides the incentive for on-the-job search. Additionally, on-the-job search has an effect on the difference between the wage rates. As long as the search cost is elastic ($\sigma > 1$), for any positive search intensity we have $s_t \gamma^g \theta_t^g > \kappa(s_t) \frac{h_l(l_t)}{u_c(c_t)}$. The maximum wage that a low-wage firm is willing to pay is lower, while the minimum wage that the worker would accept is higher due to costly on-the-job search. The decrease in the firm's match value dominates the increase in the worker's match value. This is why the wage gap between the two sectors increases as the search intensity increases.

2.7.3 Sensitivity Analysis

In this section, I perform some robustness checks on the model results by varying the values of important parameters.

First, I change the elasticity parameter in the household's preferences for home production ϕ. As explained earlier, I calibrate this parameter to match the model-generated relative volatility of employment to its empirical value. This is the calibration method used in Veracierto (2008) and Tripier (2003), and I follow this method to make my results fully comparable to theirs.

Similar to this study, Ebell (2010) also aims to improve the puzzling counterfactual results generated by the three-state model. She argues that an alternative calibration strategy allows the model to generate countercyclical unemployment and a negative correlation between unemployment and vacancies observed in the data. She proposes three alternative calibration techniques: calibrating the elasticity of labor supply to match the relative volatility of labor force participation, the small surplus calibration strategy used in Hagedorn and Manovskii (2008), and correcting for a possible time aggregation problem by calibrating to weekly frequency. Since the only common calibration element between this study and hers is the first one, I explore how her strategy would affect the results presented here, by calibrating the elasticity parameter ϕ to target for the relative volatility of labor force participation. I present the resulting statistics in Table 2.6.

Note that, the on-the-job search mechanism introduced in this study already keeps the participation margin stable, resulting in a low relative volatility of labor force participation. Matching the exact data moment has almost no effect on the results of the baseline calibration.

Table 2.6: Varying the Elasticity of Home Production

	Current Calibration ϕ =0.22	Ebell's Calibration ϕ =0.26
σ_U/σ_Y	5.63	5.62
σ_N/σ_Y	0.56	0.54
σ_{LF}/σ_Y	0.39	0.35
$\rho(U,V)$	-0.34	-0.36
$\rho(U,Y)$	-0.59	-0.61
$\rho(N,Y)$	0.95	0.96
$\rho(LF,Y)$	0.47	0.46

Next, I examine how varying the elasticity of search cost σ affects the results.

The target for this parameter is the relative volatility of employer-to-employer flows. Any increase in this elasticity parameter results mainly in reductions in the relative volatilities of job-to-job flows and labor market tightness. On the contrary, as σ approaches one from above, these variables become highly volatile.

Finally, I vary the only free parameter of my calibration, which is the ratio of the vacancy creation costs $\frac{\gamma^g}{\gamma^b}$. In the current calibration the vacancy creation cost for high-wage firms is three times the cost for low-wage firms. This value is chosen to be high enough to guarantee a moderate wage difference across the two sectors. On the one hand, a reduction in the ratio of the vacancy creation costs leads to a decrease in the wage difference across the two sectors and dampens the volatilities of job-to-job flows, unemployment and labor market tightness. On the other hand, an increase in this ratio increases the responsiveness of job-to-job flows, unemployment and labor market tightness without leading to any significant changes in the degree of countercyclicality of unemployment or the Beveridge Curve relationship.

A better way to choose this parameter would be to use micro level data to obtain a wage differential estimate by running a regression of wages of all workers on sectoral dummies and control variables. This regression would give a ratio between the wages paid in the sectors that heavily depend on vacancy creation (such as manufacturing, education, etc.) and the wages paid in the sectors that depend less on vacancy creation (such as construction, retail trade, etc.). Then, the ratio of vacancy creation costs can be calibrated by targeting the estimated wage differential.

2.7.4 Comparison with Krause and Lubik (2010)

As I mention earlier, I follow Krause and Lubik (2010) in modeling the on-the-job search mechanism. Krause and Lubik (2010) introduce on-the-job search into the basic two-state search and matching model in order to address the Shimer (2005) puzzle. Shimer (2005) points that the two-state model underpredicts the volatilities of vacancies, unemployment and labor market tightness. This problem arises because the bargained wage rates follow labor market tightness closely. When a favorable shock hits the economy, labor market tightness increases quickly as the unemployed find jobs, which reduces the firms' incentives to create vacancies. Krause and Lubik (2010) argue that the on-the-job search mechanism dampens the movements in labor market tightness, which leads to more stable wages. In turn, firms continue to create vacancies for longer periods. Their results show that the two-state model enriched with on-the-job search is successful in generating the observed volatilities of unemployment, vacancies and the vacancy-unemployment ratio.

While Krause and Lubik (2010) use on-the-job search to improve the shortcomings of the two-state search and matching model, I use the same mechanism to improve the business cycle properties of the three-state model. In the framework developed here, the primary role of the on-the-job search mechanism is to dampen the movements along the labor market participation margin. Additionally, the mechanism also helps to keep the wage rates more stable, which in turn helps vacancy creation rate to remain high. Overall, the proposed model is able to generate countercyclical unemployment and the observed negative correlation between unemployment and vacancies. Quantitatively, the two-state model with on-the-job search developed in Krause and Lubik (2010) is more successful (than the proposed three-state model with on-the-job search) in matching the observed volatilites and cross-correlations, such as those of and between unemployment and vacancies. This result is not surprising, since the simple two-state model is already superior to the simple three-state model in terms of matching the observed business cycle statistics.

2.8 Conclusion

In this chapter, I develop a general equilibrium business cycle model with labor market frictions, endogenous labor force participation and on-the-job search. Previous studies that incorporate endogenous labor force participation into a real business cycle framework with labor market frictions find that the model fails to replicate the labor market dynamics observed in the U.S. data. In order to improve the shortcomings of the three-state model, I enrich it with an on-the-job search mechanism that leads to job-to-job flows, which are important elements of the U.S. labor market. I show that the on-the-job search mechanism helps the model to generate countercyclical unemployment and the negative correlation between unemployment and vacancies observed in the data. Quantitatively, the business cycle statistics reproduced by the model presented in this study are more in line with their empirical counterparts.

Previous studies had pointed the importance of considering the participation margin in models focusing on labor markets dynamics. However, the failure of the earlier attempts to incorporate the participation margin in real business cycle models with search frictions had been discouraging. This study serves as a promising step. It shows that incorporating an on-the-job search mechanism into the simple three-state model can significantly improve the model's performance in matching the key quantitative facts on the cyclical properties of important labor market variables. Therefore, it suggests that it would be worthwhile to build richer models in this direction.

The model and calibration presented here can be extended in several ways. First, in the current setup, the source of heterogeneity between firms is the difference in the vacancy creation costs. Given the data limitations, it is not an easy task to calculate an empirical value for the difference between the vacancy creation costs in different sectors. In the benchmark calibration, I choose this value to generate a moderate wage differential across sectors. A better approach would be to determine the wage ratio between the sectors using empirical analysis. Then, the ratio of vacancy creation costs could be calibrated by targeting the estimated wage ratio. Second, the model assumes that all workers are homogenous. It would be interesting to introduce worker heterogeneity (for example, heterogeneity due to skill differences or human capital accumulation) to motivate better the directed search assumed here. These issues remain for future research.

Chapter 3

Under-Investment in State Capacity: The Role of Inequality and Political Instability

3.1 Introduction

The most commonly known and the earliest definition of state capacity is the state's power to raise tax revenues. As documented in Acemoglu (2005) and Acemoglu, Ticchi and Vindigni (2010), tax revenues constitute only a small portion of GDP in developing countries, such as those in Latin America, Asia and sub-Saharan Africa. The important consequence of the state's inability to collect taxes is the limited provision of public goods and services, which are crucial for the well-being and the living standards of its citizens, especially those of the poor. If the level of economic development and the welfare of a country are closely related to state capacity, it is critical to understand why certain countries have a low state capacity problem. What are the main determinants of the level of state capacity? When do governments under-invest in state capacity? These are the main questions we aim to answer in this study.

We present a two-period, two-group political economy model based on the theoretical framework developed in Besley and Persson (2009). We name the two groups as elites and citizens, assuming the elites to be the minority group. In each period, the group holding political power chooses its policy vector of taxes, spending in public goods and the level of investment in state capacity. The maximum tax rate is determined by the level of state capacity, which can be increased with costly investments by the government. We associate political inequality with autocratic political systems. Specifically, in a fully democratic political system, the utility weights are equal to the population shares. We assume that the system is politically unequal when the utility of a particular group is weighted disproportionately. We also allow for political instability, and assume that the political system is unstable if the ruling group is likely to lose political power to the opponent group, which can occur as a result of a civil war.

We first investigate how the incidence and the risk of external wars, as well as political inequality and stability, shape the government's decision to invest in state capacity. Then, we include income inequality to analyze its effect on the investment decision.

Our main theoretical results indicate that the effects of external and civil wars go in the opposite directions. While the future risk of fighting external wars calls for building stronger state capacity, fighting civil wars (which is a measure of political instability) causes the government to invest less in state capacity. In the case of an external war, it is in the government's best interest to invest in state capacity, to be able to tax both groups at the maximum possible rate, and use these resources to increase spending in public goods (e.g., defense). However, if the country is fighting a civil war, the political system is highly unstable. In this case, the government's actions are myopic, so the future benefit of having higher state capacity is low. Therefore, political instability (proxied with the incidence of civil wars, or with the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means) leads to lower investment in state capacity. In the case of political inequality, our model predicts that more democratic political systems (lower political inequality) invest more in state capacity. Furthermore, all of these results are independent of which group holds political power.

When we allow for income inequality, the investment decision becomes group-specific. More precisely, when the elites are in power, in the presence of political instability, both income and political inequality lead to lower investment in state capacity. Conversely, if the citizens are the rulers, our theory predicts that the combination of high political and income inequality results in higher state capacity. However, this is not always the case. Under some circumstances, inequality can result in low investment in state capacity, which could be taken as a model of failed social revolutions.

We empirically test the model's main predictions by applying econometric methods on cross-sectional data. We use several different measures to proxy for state capacity, which cover different and complementary aspects, ranging from fiscal to bureaucratic dimensions. Our empirical results support the theoretical predictions. We find that higher incidence of external wars and political stability (lower incidence of civil wars or lower likelihood that the government will be destabilized) are associated with higher state capacity. On the contrary, inequality (political and/or income) is negatively correlated with state capacity. We also consider the interactions of income inequality with political stability and democracy. The estimation results indicate that, when there is income inequality, the magnitudes of the positive correlations of democracy and political stability with state capacity are significantly reduced.

The organization of this chapter is as follows: Section 3.2 reviews the related literature. Section 3.3 introduces the model and discusses the theoretical results. In Section 3.4, we explain in detail the data we use, present the empirical evidence and discuss the regression results. Finally, Section 3.5 concludes.

3.2 Related Literature

Our study is related to three strands of literature. The first strand focuses on the effects of wars on formation and development of state capacity. In one of the earliest studies in this line, Tilly (1990) argues that international wars cause governments to build and invest in state capacity. In order to fight wars, governments need to raise military expenditures, for which more tax revenues have to be collected. The experiences of the countries like Britain and the United States support this view, since these countries strengthened their tax systems during the first and the second World Wars.

While external wars have drawn attention for building stronger states, it is misleading to extend the argument for the case of internal wars, or civil wars.[1] Consider, for example, Latin American countries, where external wars have been rare, while civil wars have been common and long-lasting. Yet, there has been

[1] See Blattman and Miguel (2010) for an extensive literature survey on the causes and consequences of civil wars.

limited investment in state capacity. Amongst others, Centeno (2002) argues that state capacity has remained low in Latin America because civil wars have been highly destructive. Besley and Persson (2008) find evidence that this result is not limited to Latin America, but appears to be a general consequence of civil wars.

In line with this literature, we consider the effects of wars on the government's decision to invest in state capacity. Yet, we argue that the incidence of wars are not the only causes of state capacity differences across countries. There is also a strong negative relationship between state capacity and the levels of political and income inequality. In order to fully grasp the low state capacity problem, we revisit inequality both theoretically and empirically.

Political and development economists have studied extensively the links between income and political inequality and the level of economic development and growth. Some important examples are Alesina and Rodrik (1994), Persson and Tabellini (1994) and Barro (2000) on income inequality; and Acemoglu and Robinson (2000, 2006), Persson and Tabellini (2006) and Acemoglu (2005) on political inequality. Yet, the relationship between inequality and state capacity is not well documented. Our work fills this important gap in the literature by studying the effects of political and income inequality on the government's decision to invest in state capacity. Moreover, we present a unified theoretical framework, where the interactions of the two inequality measures can be analyzed.

Lastly, our work contributes to the literature on institutions. Earlier studies, such as Knack and Keefer (1995), Hall and Jones (1999) and Engerman and Sokoloff (2000), present strong empirical evidence on the positive effect of institutional quality on economic growth, development and wealth of countries. Moreover, they find that institutions persist. But, why do the economic institutions differ across countries and why do they persist? One important explanation is provided by Acemoglu, Johnson and Robinson (2001), who find that colonial origins are important exogenous elements that lead to persistent differences between economic institutions. Our study complements their study by treating institutions as endogenous and analyzing the conditions that lead to persistently low investment in state capacity.

Our study is closely linked to and builds on the recent work by Besley and Persson (2009), who develop a framework where policy choices in market regulation and taxation are constrained by state capacity, as well as the economic institutions inherited from the past. They analyze the economic and political determinants of the government's choice to invest in building legal and fiscal state capacity. Their results show that fighting external wars, political stability and inclusive political institutions are central for building state capacity. Moreover, they find that legal and fiscal capacity are complements.

The important differences between this study and Besley and Persson (2009) are as follows. First, we restrict the definition of state capacity to fiscal capacity. This enables us to analyze the interactions between political and income inequality in a simpler framework. Second, while they focus on the complementarity and the substitutability between fiscal and legal capacity of the state, our main aim is to analyze the individual and combined effects of democracy, income inequality and political stability on state capacity. Third, we present a more detailed comparison between the investment decision and the effects of the determinants of state capacity when the government is run by different income groups (elites and citizens). This is important, because low state capacity is a feature of many failed social revolutions.

3.3 Theoretical Model and Simulations

3.3.1 The Environment

As we mentioned previously, our model follows closely the model in Besley and Persson (2009). Time is discrete and consists of two periods, $s = 1, 2$. There are two groups of agents in the economy, $J = A,\ B$. In each period, one group, say group A, holds political power (becomes the government), and makes the taxation and government spending decisions. Groups differ in their population shares β^A and β^B, and may also differ in their per capita income levels Y^A and Y^B. Total population is normalized to unity. Agents in a given group have the same preferences and income levels. All agents derive utility from consuming private goods that they purchase with their after-tax income and public goods provided by the government.

We denote group-specific tax rates (t_s^A and t_s^B), and allow them to take negative values in order to make full redistribution possible. The maximum tax rate is determined by the stock of state capacity in each period. As in Besley and Persson (2009), we assume that the capacity to tax depends on the previous investments in building institutions, such as the Internal Revenue Service in the United States, which manages and monitors taxation. The government takes the stock of the first period state capacity τ_1 as given and decides the level of investment in state capacity $\triangle\tau = \tau_2 - \tau_1$, which determines the level of state capacity in the second period. The stock of state capacity does not depreciate, but in order to have a higher level of state capacity in the second period, the government needs to make a non-negative investment in the first period.[2] The cost of investment takes a functional form $F(\triangle\tau)$, which is increasing and strictly convex in the level of investment $\triangle\tau$, and has the properties $F(0) = F'(0) = 0$. The investment in state capacity is part of the government spending, and takes place only in the first period, since the world ends at the end of the second period.

The government also uses its resources to provide public goods G_s, from which both groups benefit. The value given to public goods in the utility function is denoted by α_s, which is a continuous random variable with c.d.f H and p.d.f h on the interval $[0, \overline{\alpha}]$, where $\overline{\alpha} \geq 1$.[3] In order to illustrate the stochastic valuation assumption, consider defense as an example of a public good. If a country engages in an external war, defense becomes very valuable, and it is optimal for the government to increase military spending. In the absence of such a conflict, defense is valued less, and the government spends less or no resources for the provision of this public good.

3.3.2 The General Problem

Next, we set up the optimization problem of the group in power, or the government, in each period. Here is the timing of events:

1. Nature determines the value of public goods α_s and which group (A) holds

[2] We assume that $\triangle\tau \geq 0$.

[3] More specifically, α_1 is given and α_2 is unknown as of period 1.

the political control.

2. The government picks its policy vector of taxes t_s^J, spending on public goods G_s and the level of investment in state capacity $\triangle\tau$.

3. Agents consume.

Assuming that preferences are linear in private consumption and public goods provision, the indirect utility for each individual in group J can be written as:

$$v_s^J\left(t_s^J, G_s\right) = \alpha_s G_s + (1 - t_s^J)Y^J \tag{3.1}$$

The government chooses the policy vector that maximizes the sum of the weighted utilities of the two groups. In the case of a utilitarian government, or a fully democratic political system, the weights should be equal to the population shares of the two groups. Yet, many countries do not have fully democratic systems, but rather function as partial democracies, which implies some form of political inequality. In this case, the weights are not equal to the population shares, but instead are the population shares multiplied by two new parameters $\overline{\rho}$ and $\underline{\rho}$, which represent the political weights the government gives to each group. Therefore, the total weight the group in power attaches to its own utility becomes $\overline{\rho}\beta^A$, while that for the opponent group becomes $\underline{\rho}\beta^B$. We say that the system is politically unequal if the group in power favors its own members, which corresponds to $\overline{\rho} > 1$ and $\underline{\rho} < 1$. From now on, we will assume that $\overline{\rho} \geq 1$ and $\underline{\rho} \leq 1$, and define our measure of political inequality as $\psi = \overline{\rho} - \underline{\rho}$. By assumption, the sum of the weights attached to the groups' utilities should satisfy $\overline{\rho}\beta^A + \underline{\rho}\beta^B = 1$. Under a fully democratic political system, there should be no political inequality; therefore, we should have

$\psi = 0$. In this case, each group's weight in the utility is equal to its share in the population, so that $\overline{\rho} = \underline{\rho} = 1$.

Now, we can write down the first period problem of the government as:

$$max_{\{G_1,t_1^A,t_1^B,\triangle\tau\}}\ \overline{\rho}\beta^A v_1^A\left(t_1^A, G_1\right) + \underline{\rho}\beta^B v_1^B\left(t_1^B, G_1\right) + ENP \tag{3.2}$$

$$= max_{\{G_1,t_1^A,t_1^B,\triangle\tau\}}\ (\overline{\rho}\beta^A + \underline{\rho}\beta^B)\alpha_1 G_1 + \overline{\rho}\beta^A(1-t_1^A)Y^A + \underline{\rho}\beta^B(1-t_1^B)Y^B + ENP \tag{3.3}$$

$$s.t.\ \ \sum_J t_1^J \beta^J Y^J = G_1 + F(\triangle\tau) \tag{3.4}$$

$$G_1 \geq 0\ \ and\ \ \tau_1 \geq t_1^J \tag{3.5}$$

where ENP stands for the second period Expected Net Payoff for the group ruling in the first period. This is an expected payoff because the outcome depends on which group holds power in the second period. In what follows, we assume that the ruling group keeps political power in the second period with an exogenous probability of γ. That is, a higher γ means greater political stability.

Similarly, the second period maximization problem of the government is:

$$max_{\{G_2,t_2^A,t_2^B\}}\ \overline{\rho}\beta^A v_2^A\left(t_2^A, G_2\right) + \underline{\rho}\beta^B v_2^B\left(t_2^B, G_2\right) \tag{3.6}$$

$$= max_{\{G_2,t_2^A,t_2^B\}}\ \alpha_2 G_2 + \overline{\rho}\beta^A(1-t_2^A)Y^A + \underline{\rho}\beta^B(1-t_2^B)Y^B \tag{3.7}$$

$$s.t.\ \ \sum_J t_2^J \beta^J Y^J = G_2 \tag{3.8}$$

$$G_2 \geq 0\ \ and\ \ \tau_2 \geq t_2^J \tag{3.9}$$

As in the first period maximization problem, the ruling group takes the value of public goods α_2 and the level of state capacity τ_2 as given, and chooses the optimal level of tax rates and public goods provision.

Before we move on to the results of the maximization problem, let's have a closer look at the indirect utility that the government maximizes in the second period. Assuming that the constraint $G_2 \geq 0$ is non-binding, substituting Equation (3.8) into Equation (3.7) gives:

$$\left[\overline{\rho}\beta^A Y^A + \underline{\rho}\beta^B Y^B\right] + \beta^A t_2^A Y^A(\alpha_2 - \overline{\rho}) + \beta^B t_2^B Y^B(\alpha_2 - \underline{\rho}) \tag{3.10}$$

Note that in order to maximize Equation (3.7) with the choice of any positive provision of public goods in the second period, the condition $\alpha_2 \geq \overline{\rho}$ has to be satisfied.[4] That is, public goods are provided only when the value of public goods is greater than or equal to the value that the group in power assigns to its own private consumption. Given the cumulative distribution of the stochastic variable α_2, this event occurs with probability $[1 - H(\overline{\rho})]$. Conversely, when $\alpha_2 < \overline{\rho}$, the ruling group values public goods less than its own private consumption and, hence, finds it optimal to set $G = 0$. This occurs with probability $H(\overline{\rho})$. To summarize, the value attached to public goods determines whether the government provides public goods, or not. If public goods are provided, then we name the state of the world as 'Common Interest State'. If no public goods are provided, then the world is in the 'Redistribution State', for the reasons that will become clear once we lay out the maximization results.

[4]Since $\overline{\rho} \geq \underline{\rho}$, this condition also guarantees that $\alpha_2 \geq \underline{\rho}$ holds.

3.3.3 Optimal Taxation and Public Goods Provision

Since the maximization problem of the government is linear in the policy variables, we can analyze the optimal taxation and public goods provision decisions separately from the optimal investment in state capacity decision. We first present the optimal tax rates and public goods provision chosen by the government in each state of the world.

If $\alpha_s \geq \overline{\rho}$, then we are at the common interest state, which is observed with probability $[1 - H(\overline{\rho})]$. In this case, the optimal policy is:

$$t_1^A = \tau_1, \quad t_1^B = \tau_1 \tag{3.11}$$

$$t_2^A = \tau_2, \quad t_2^B = \tau_2 \tag{3.12}$$

$$G_1 = \sum_J t_1^J \beta^J Y^J - F(\triangle\tau) \tag{3.13}$$

$$G_2 = \sum_J t_2^J \beta^J Y^J \tag{3.14}$$

Intuitively, since public goods are valued highly, the government taxes both groups at the maximum rate and uses the collected resources for the provision of public goods in both periods and investment in state capacity in the first period.

If $\alpha_s < \overline{\rho}$, then we are at the redistribution state, which occurs with probability $H(\overline{\rho})$, and the optimal policy becomes:

$$t_1^A = \frac{F(\triangle\tau) - \tau_1 \beta^B Y^B}{\beta^A Y^A}, \quad t_1^B = \tau_1 \tag{3.15}$$

$$t_2^A = \frac{-\tau_2 \beta^B Y^B}{\beta^A Y^A}, \quad t_2^B = \tau_2 \tag{3.16}$$

$$G_1 = 0, \quad G_2 = 0 \tag{3.17}$$

In this case, the value attached to public goods is low; therefore, the group in power is only interested in the redistribution of resources. For this purpose, it taxes the opponent group at the maximum possible rate and redistributes the tax revenues amongst its own group members.

3.3.4 Optimal Investment in State Capacity

In order to solve for the optimal investment level, we need to write down the second period Expected Net Payoff (ENP) in detail. The ruling group of the first period is assumed to keep political power in the second period with probability γ, and lose it to the opponent group otherwise. For each case, we use the optimal taxation and public goods provision results presented above to calculate the second period expected payoff for the first period's ruling group. When the group continues to rule in the second period, its expected payoff is:

$$\begin{aligned} V_2^1 \quad = \quad & [1 - H(\overline{\rho})] \left\{ \tau_2 \left[\beta^A Y^A + \beta^B Y^B \right] E \left\{ \alpha_2 | \alpha_2 \geq \overline{\rho} \right\} \right\} \\ & + [1 - H(\overline{\rho})] \left\{ \overline{\rho} \beta^A (1 - \tau_2) Y^A + \underline{\rho} \beta^B (1 - \tau_2) Y^B \right\} \\ & + H(\overline{\rho}) \left\{ \overline{\rho} \beta^A \left(1 + \frac{\tau_2 \beta^B Y^B}{\beta^A Y^A} \right) Y^A + \underline{\rho} \beta^B (1 - \tau_2) Y^B \right\} \end{aligned} \tag{3.18}$$

The first term on the right hand side stands for the sum of the weighted utilities of the two groups in the common interest state, where both groups are taxed at the maximum amount, public goods are provided and investment in state capacity takes place. The first part presents the total utility derived by the two groups from the provision of public goods. The second part is the sum of the after-tax income of the two groups, weighted by the parameters chosen by the ruling group. The second term stands for the total utility in the redistribution state, where the group in power taxes the opponent group at the maximum rate, in order to redistribute resources to its own members. No public goods are provided in this state. The opponent group loses a share of its income due to taxation, whereas the group in power receives the collected taxes and consumes more than its period income.

When the ruling group loses political power to the opponent group, its expected payoff becomes:

$$\begin{aligned} V_2^2 &= [1-H(\overline{\rho})]\left\{\tau_2\left[\beta^A Y^A + \beta^B Y^B\right] E\left\{\alpha_2|\alpha_2 \geq \overline{\rho}\right\}\right\} \\ &\quad + [1-H(\overline{\rho})]\left\{\overline{\rho}\beta^A(1-\tau_2)Y^A + \underline{\rho}\beta^B(1-\tau_2)Y^B\right\} \\ &\quad + H(\overline{\rho})\left\{\overline{\rho}\beta^A(1-\tau_2)Y^A + \underline{\rho}\beta^B\left(1+\frac{\tau_2\beta^A Y^A}{\beta^B Y^B}\right)Y^B\right\} \end{aligned} \tag{3.19}$$

The weights in this expected payoff correspond to the values set by the first period's ruling group, assuming that it no longer runs the government in the second period. Note that the only difference between Equations (3.18) and (3.19) is the last term. When the ruling group loses power to the opponent group, its members get taxed at the maximum rate, and the new ruling group collects the tax revenues.

Now, we can define the Expected Net Payoff (ENP) as:

$$ENP = \gamma V_2^1 + (1-\gamma)V_2^2 - \lambda(\alpha_1)F(\triangle\tau) \tag{3.20}$$

where $\lambda(\alpha_1) = max\{\alpha_1, \overline{\rho}\}$ is the Lagrange Multiplier associated with the government's budget constraint in the first period maximization problem. The sum of the first two terms in the ENP corresponds to the benefit derived from investing in state capacity, whereas the last term is the cost of investment in terms of the value of public funds. When we substitute in the payoff values, the ENP becomes:

$$
\begin{aligned}
ENP \;=\; & [1 - H(\overline{\rho})]\,\tau_2 \left[\beta^A Y^A + \beta^B Y^B\right] E\left\{\alpha_2 | \alpha_2 \geq \overline{\rho}\right\} + H(\overline{\rho}) \left[\overline{\rho}\beta^A Y^A + \underline{\rho}\beta^B Y^B\right] \\
& + [1 - H(\overline{\rho})]\,(1 - \tau_2) \left[\overline{\rho}\beta^A Y^A + \underline{\rho}\beta^B Y^B\right] \\
& + H(\overline{\rho})\tau_2(\overline{\rho} - \underline{\rho}) \left[\gamma\beta^B Y^B - (1 - \gamma)\beta^A Y^A\right] \\
& - \lambda(\alpha_1) F(\triangle\tau) \qquad (3.21)
\end{aligned}
$$

In order to determine the optimal level of investment, we go back to the first period maximization problem and write down the first order condition with respect to $\triangle\tau$, which corresponds to the derivative of the ENP with respect to $\triangle\tau$. We call the resulting optimality condition 'OPT equality', which is satisfied at the optimal investment level.

$$
\begin{aligned}
OPT:\; \lambda(\alpha_1) F'(\triangle\tau) \;=\; & [1 - H(\overline{\rho})] \left[\beta^A Y^A + \beta^B Y^B\right] E\left\{\alpha_2 | \alpha_2 \geq \overline{\rho}\right\} \\
& - [1 - H(\overline{\rho})] \left[\overline{\rho}\beta^A Y^A + \underline{\rho}\beta^B Y^B\right] \\
& + H(\overline{\rho})(\overline{\rho} - \underline{\rho}) \left[\gamma\beta^B Y^B - (1 - \gamma)\beta^A Y^A\right] \qquad (3.22)
\end{aligned}
$$

Equation (3.22) shows that the optimal level of investment in state capacity $\triangle\tau$ depends on the main parameters of the model, namely, α_1, α_2, and γ, as well as the level of inequality. In the next subsection, we investigate the relationship between these variables and the investment decision.

3.3.5 Predictions of the Benchmark Model

This section presents the effects of the key variables of the model on the state capacity investment decision of the government. For this purpose, we begin with the above presented benchmark model, where we only allow for political inequality. Later on, we will also introduce income inequality.

In the benchmark model, the two groups differ only in the population shares. We denote the variables related to the ruling group with the superscript A. We assume that the members of each group have the same income levels, that is $Y^A = Y^B = \overline{Y}$. When the elites are in power, we have $\beta^A < \beta^B$, while this assumption changes to $\beta^A > \beta^B$ when the citizens are in power. We say that there is political instability if the ruling group's probability of keeping political power in the second period is less than or equal to its population share $\gamma \leq \beta^A$. Lastly, we denote the level of political inequality with $\psi = \overline{\rho} - \underline{\rho}$. The results to be presented in Propositions 1-4 do not depend on which group holds political power.

Proposition 3.1. As the expected demand for public goods (or the future risk of an external conflict) increases, investment in state capacity increases as well.

Proof. A increase in the second period demand for public goods, or a first order stochastically dominating shift in α_2, results in a higher value of $E\left\{\alpha_2 | \alpha_2 \geq \overline{\rho}\right\}$. To see the effect of this change on the investment level, take the derivative of the OPT equality with respect to $E\left\{\alpha_2 | \alpha_2 \geq \overline{\rho}\right\}$. This yields to $\frac{\partial(\triangle\tau)}{\partial(E\{\alpha_2|\alpha_2 \geq \overline{\rho}\})} = \frac{[1-H(\overline{\rho})]\overline{Y}}{\lambda(\alpha_1)F''(\triangle\tau)}$, which is positive. QED.

Our first result is very intuitive. When the government foresees that public goods will be more valuable in the second period, it is optimal to increase the stock of state capacity, so that higher tax revenues can be raised and more public goods can be provided. A good example of this case would be an increased expectation of an external conflict in the second period. In this case, the government would like to increase military spending, which calls for building up the tax base in the first period, in order to be able to collect more resources from all groups in the second period.

Proposition 3.2. *A higher current value of public goods (or a higher current threat of an external conflict) leads to lower investment in state capacity.*

Proof. Taking the derivative of the OPT equality with respect to α_1 gives $\frac{\partial(\triangle\tau)}{\partial(\alpha_1)} = -\frac{\lambda'(\alpha_1)F'(\triangle\tau)}{\lambda(\alpha_1)F''(\triangle\tau)}$, which is negative. QED.

This result is exactly the opposite of the first result, but the intuition is the same. If public goods are valued highly in the first period, then the government uses the collected resources immediately to increase the public goods provision, which results in fewer resources left for investment in state capacity. An example similar to the previous one would be the case where the country is involved in an external war in the first period. The military expenses become the government's priority; therefore, the collected resources are used for the provision of this public good immediately.

Proposition 3.3. *A higher level of political stability increases investment in state capacity.*

Proof. The derivative of the OPT equality with respect to γ yields to the following result: $\frac{\partial(\triangle\tau)}{\partial(\gamma)} = \frac{H(\overline{\rho})\psi\overline{Y}}{\lambda(\alpha_1)F''(\triangle\tau)}$, which is positive. QED.

If the government is likely to be in power in the second period, then the incentive to expand the tax base in the first period is high. There is no discounting; therefore, it is the government's best interest to invest in state capacity to be able to raise more tax revenues in the second period, which will lead to higher public goods provision or redistribution. By contrast, if the government is less likely to remain in power, it resists increasing state capacity, because it recognizes the possibility of paying redistributive taxes next period. Therefore, investment in state capacity is higher in a more stable political environment.

Proposition 3.4. *In the presence of political instability, as political inequality increases, investment in state capacity decreases.*

Proof. See Appendix B.1.

If the group in power is likely to lose authority to the opponent group in the second period, then its first period actions are myopic. In addition, if the group also favors its own members, it values the redistribution of resources in the current period more than building a higher state capacity stock and raising higher tax revenues in the second period. Therefore, regardless of which group holds the power, if there is political instability, higher political inequality results in lower investment in state capacity. However, if the political system is stable, that is if $\gamma > \beta^A$, then higher political inequality may lead to higher investment in state capacity. In other words, if the ruling group is highly likely to keep political power in the second period, it is optimal to expand the tax base in the first period, to be able to raise higher taxes in the second period. Note that, when the value of ψ increases, the probability of being in the redistribution state $H(\overline{\rho})$ also increases. A higher level of state capacity, or an expanded tax base, enables the ruling group to tax the other group at a higher tax rate in the second period and redistribute higher tax revenues amongst its own group members.

3.3.6 Predictions of the Benchmark Model with Income Inequality

Now, we introduce income inequality to our benchmark model. We still assume that all agents in a given group have the same income levels, but per capita income levels of the two groups are no longer equal to each other. More specifically, we let the elites have a per capita income level of $\overline{Y} + \epsilon$, and the citizens have a per capita income level of $\overline{Y} - \epsilon$, where $\overline{Y} > \epsilon > 0$. We name refer to ϵ as our measure of income inequality.

First, consider the case where the elites are in power. The main assumptions are:

$$Y^A = \overline{Y} + \epsilon, \quad Y^B = \overline{Y} - \epsilon \;\; \textit{and} \;\; \beta^A < \beta^B$$

In this setting, Propositions 1-3 continue to hold, and additionally we get Propositions 5-7 on the effects of the inequality measures on the investment decision:

Proposition 3.5. When the elites are in power and there is political instability, a higher level of political inequality leads to lower investment in state capacity.

Proof. See Appendix B.1.

As in Proposition 3.4, if there is political instability, then the elites choose to redistribute resources in the current period rather than using resources to invest in state capacity. First, since the elites hold the greater share of the total income, the expected benefit of raising higher tax revenues in the second period is low, which lowers the group's incentive to expand the tax base. Second, when the elites value the benefits of their group more and they are likely to lose political power in the second period, it is optimal to take advantage of the collected resources in the first period and redistribute immediately.

Proposition 3.6. *When the elites are in power, as income inequality increases investment in state capacity decreases.*

Proof. See Appendix B.1.

When income inequality is high, the elites hold a greater part of the total income. They choose to invest less in expanding the tax base for two reasons. First, the amount of resources that they can collect from the citizens is limited. Therefore, they find it more profitable to redistribute resources immediately, rather than building state capacity in the first period. Second, an increased tax base translates into a higher loss of income by the elites, if they lose power to the citizens in the second period. Mainly due to the fear of being taxed at a higher rate in the second period, the elites use the collected resources for immediate redistribution and invest less in state capacity.

Proposition 3.7. *When the elites are in power, higher income inequality reduces the positive effect of political stability on investment in state capacity.*

Proof. See Appendix B.1.

In Proposition 3.3, we stated that greater political stability increases the government's incentive to invest in state capacity. However, since income inequality has an adverse effect on the investment decision when the elites are in power, it decreases the positive impact of political stability. As income inequality increases, the tax revenues that the elites can collect from the citizens next period become more limited. Therefore, the expected benefit from investing in state capacity decreases, which reduces the elites' incentive to expand the tax base.

Now, consider the case where the citizens are the ruling group. The above assumptions change as:

$$Y^A = \overline{Y} - \epsilon, \quad Y^B = \overline{Y} + \epsilon \quad and \quad \beta^A > \beta^B$$

Propositions 3.1-3.4 and 3.7 continue to hold, but we see some changes in Propositions 3.5 and 3.6.[5]

Proposition 3.8. *When the citizens are in power, there is political instability and income inequality is low, higher political inequality leads to lower investment in state capacity. However, if income inequality is high, then higher political inequality leads to higher investment in state capacity.*

Proof. See Appendix B.1.

Proposition 3.9. *When the citizens are in power and political inequality is low, higher income inequality decreases investment in state capacity. However, if political inequality is high, then higher income inequality increases investment in state*

[5] See the Appendix for further explanation on how Proposition 3.7 holds when the citizens rule.

capacity.

Proof. See Appendix B.1.

Propositions 3.8 and 3.9 state that when the citizens are in power, the effects of the inequality measures on the investment decision depend mainly on the interactions between them. We will elaborate more on these propositions in the next subsection.

3.3.7 Numerical Comparative Statics

To illustrate the propositions of the previous subsection, and more specifically, to shed light on the conditional results presented in Propositions 3.8 and 3.9, we examine the optimality condition for investment numerically. Our aim is to see how the level of investment in state capacity changes as ψ, ϵ and γ vary. First, we generate two initial benchmarks (one for each group running the government), where there is positive investment in state capacity. The parametrization for the benchmarks is explained in detail below. Then, we let the political stability and the inequality measures vary, in order to illustrate the results presented in the Propositions.

We choose the parameter values used in the benchmarks by matching some data averages. Accordingly, we set the population share of the elites to 20 percent. The average per capita income level is normalized to unity. We let α be a stochastic variable with truncated normal distribution on the interval $[0, 5]$, with mean 1 and standard deviation 1.2. The value of public goods in the first period α_1 is assigned to be 1.

We assume that, when the elites are in power, the total weights of the groups in the utility function are chosen to be close to the income shares, $\overline{\rho}\beta^A \sim \frac{\beta^A Y^A}{\beta^A Y^A + \beta^B Y^B}$ and $\underline{\rho}\beta^B \sim \frac{\beta^B Y^B}{\beta^A Y^A + \beta^B Y^B}$. That is, there is some political inequality. We further assume that the top quantile in the population, the elites, get 40 percent of the total income. Therefore, when the elites rule, $\overline{\rho}\beta^A$ is assigned a value close to this level (the exact value that we set is 0.34, which makes $\underline{\rho}\beta^B$ equal to 0.66). Then, $\overline{\rho}$ becomes 1.72 and $\underline{\rho}$ becomes 0.82, which gives a political inequality measure ψ of 0.9. Using the assumed population and income shares of the two groups, we calculate the consistent income inequality measure ϵ, which is 0.45. With these parameter values, the probability of being in the common interest state in the second period $[1 - H(\overline{\rho})]$ becomes 0.15.

When the citizens are in power, we arbitrarily set the total utility weight for citizens $\overline{\rho}\beta^A$ to be 0.94, which is greater than the group's population share of 0.8. Holding ψ equal to 0.9, $\overline{\rho}$ and $\underline{\rho}$ become 1.18 and 0.28, respectively. The inequality measure ϵ stays at 0.45, since we continue to assume that the top quantile in the population, the elites, get 40 percent of the total income. With these parameter values, the probability of being in the common interest state in the second period $[1 - H(\overline{\rho})]$ turns out to be 0.33. See Table 3.1 for the summary of all parameter values used in the benchmarks.

Next, we let the political stability and the inequality measures vary. First, consider the effect of political inequality on state capacity investment. In Proposition 3.5, we stated that when the elites are in power, in the presence of political instability and income inequality, higher political inequality leads to lower investment in state

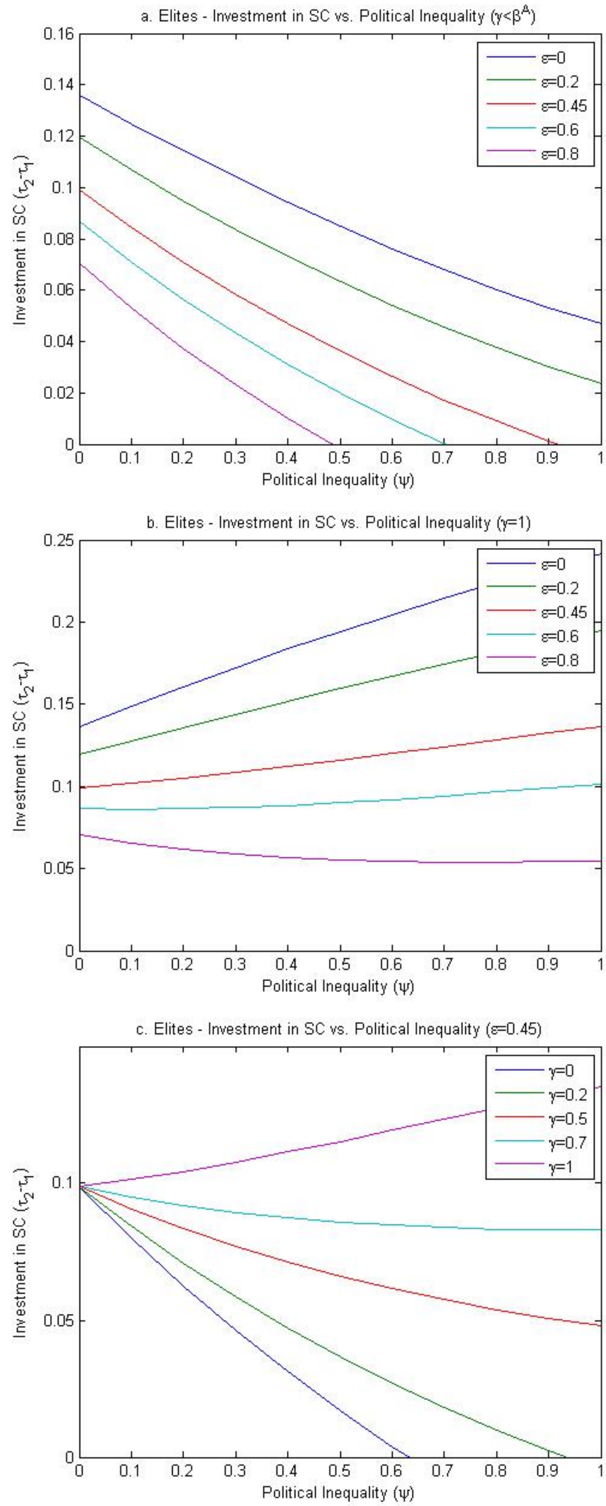
Table 3.1: Parameter Values and Results

Parameter	Description	Value - Elites (Citizens)
β^A	Population share of group A	0.20 (0.80)
β^B	Population share of group B	0.80 (0.20)
$\overline{Y} = \frac{Y^A+Y^B}{2}$	Mean income	1.00
α_1	Value of public goods in period 1	1.00
$\overline{\alpha}$	Upper bound of α_2	5.00
ψ	Level of political inequality	0.90
ϵ	Level of income inequality	0.45
γ	Pol. stability constant for group A	0.19 (0.79)
ω^A	GDP Share for group A	0.40 (0.60)
ω^B	GDP Share for group B	0.60 (0.40)
$\overline{\rho}$	Political weight for group A	1.72 (1.18)
$\underline{\rho}$	Political weight for group B	0.82 (0.28)
$\overline{\rho}\beta^A$	Total weight for group A	0.34 (0.94)
$\underline{\rho}\beta^B$	Total weight for group B	0.66 (0.06)
$[1 - H(\overline{\rho})]$	Prob. of the common interest state	0.15 (0.33)
μ^α	Mean of alpha	1.00
σ^α	Std. of alpha	1.20

capacity. This result is illustrated in Figure 3.1.a. As the political system becomes less democratic, that is, as the value of ψ increases, the probability of being in the redistribution state $H(\overline{\rho})$ increases. In turn, the elites can definitely benefit from collecting higher tax revenues in the second period by increasing the tax base. But, given the presence of political instability, the citizens may take advantage of the increased stock of state capacity and tax the elites at higher rates, if they gain power in the second period. The elites become more concerned about the second period outcome, due to the fear of being taxed at higher rates later as the income gap between the two groups increases. Overall, from the elites' point of view, with higher income inequality and political instability, the current cost of investing in state capacity is higher than the expected benefit from higher tax rates in the second period. As a result, the level of state capacity stays low, even under a more democratic system as reflected by the downward shift in the investment curve with higher income inequality. Also, as income inequality increases the slope of the investment curve becomes steeper. Therefore, when the elites are in power, income inequality seems to amplify the negative effect of political inequality on the investment decision.

As a second exercise, we drop the political instability assumption, and consider the extreme case of full political stability, corresponding to $\gamma = 1$. As shown in Figure 3.1.b, for lower levels of income inequality, the effect of political inequality on the investment decision is positive. Given political stability, the elites choose to invest in expanding the tax base, in order to be able to tax the citizens at higher rates in the second period. However, as income inequality increases, the elites'

Figure 3.1: Elites in Power - Political Inequality



incentive to invest in state capacity is reduced, since the citizens hold only a very small portion of the total income. Then, at very high levels of income inequality, it is optimal for the elites to redistribute the collected tax revenues immediately.

Third, we hold the level of income inequality constant at $\epsilon = 0.45$, and vary the value of the political stability variable. As shown in Figure 3.1.c, as long as there is political instability, higher political inequality leads to lower investment in state capacity. This is mainly due to the elites' fear of being taxed at higher rates in the second period, if the citizens become the ruler. As the level of political stability increases, the investment curve becomes less steep, showing that the positive effect of political stability reduces the negative effect of political inequality on the investment decision. Therefore, even when the elites are in power, a more democratic political system, which is also stable, can lead to higher investment in state capacity.

Next, consider the effect of political inequality on the investment decision when the citizens are in power. Figure 3.2.a shows that, when there is political instability, at low levels of income inequality, political inequality has a negative effect on investment in state capacity (Proposition 3.8). Note that, when there is no income inequality, that is, when $\epsilon = 0$, the two groups become identical, and the citizens behave just like the elites do. However, when income inequality is high, the citizens choose to invest more in state capacity as the political system becomes less equal. As political inequality ψ increases, it is more likely that the world will be in the redistribution state in the second period, since $H(\overline{\rho})$ also increases. Then, the citizens would like to tax the elites at a higher rate to redistribute resources amongst themselves. As income inequality increases, the slope of the investment curve becomes steeper, due to the increasing rate at which they benefit from redistribution.

When there is full political stability, for all levels of income inequality, investment in state capacity increases as the citizens favor their group more, or as political inequality increases. Figure 3.2.b displays that the investment curve becomes steeper as income inequality increases. Since the citizens hold only a small portion of the total income at a high level of income inequality, they have a higher incentive to tax the elites at higher rates in the second period. Hence, given that there is full political stability, they invest more in expanding the tax base.

While this result is very intuitive, it does not reflect reality. In many countries, even when the government is run by the political groups favoring the citizens, we do not observe high levels of investment in state capacity. Figure 3.2.c suggests an explanation for this observation. If we assume a reasonable level of income inequality, say $\epsilon = 0.45$, the citizens choose to make investment in state capacity only when the political system is stable. At low levels of political stability, investment in state capacity decreases with higher political inequality. That is, when the citizens are less likely to be in power in the second period, they choose to redistribute the tax revenues immediately, as many failed social revolutions have done in the past.

Lastly, consider the effect of income inequality on state capacity investment. Proposition 3.6 states that when the elites are in power, investment in state capacity decreases as income inequality increases. This result is robust to the changes in the levels of political inequality and stability. However, Figures 3.3.a and 3.3.b display that, when the citizens are the ruling group the effect of income inequality on the investment decision depends on the level of political inequality (Proposition

Figure 3.2: Citizens in Power - Political Inequality

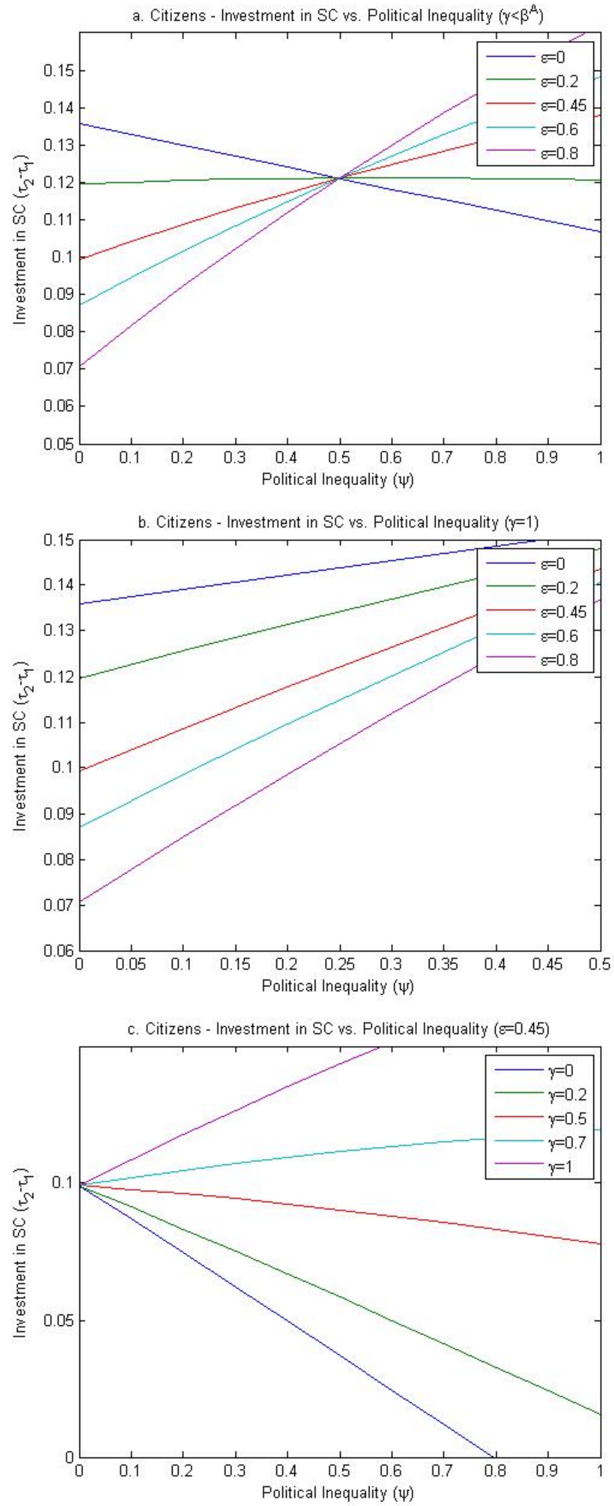
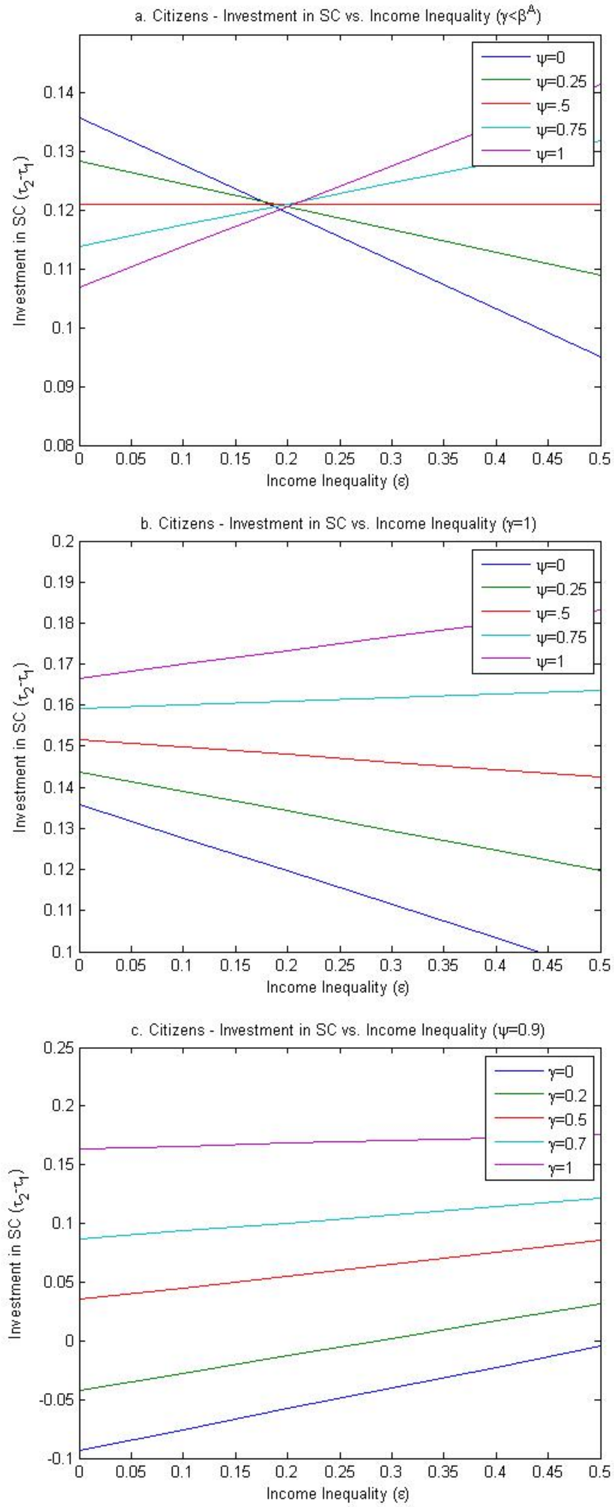


Figure 3.3: Citizens in Power - Income Inequality



3.9). When the political system is more democratic, the government becomes more utilitarian, and thus it keeps the tax rates lower by not increasing the stock of state capacity. But, as the citizens favor their own group, higher income inequality calls for more redistribution. The cost of investment does not change, but a higher income gap between the groups makes investment more profitable from the citizens' point of view, since the amount to be redistributed increases. Therefore, the citizens increase the stock of state capacity in the first period, in order to be able tax the elites at higher rates and transfer more resources to their own group members in the second period. Note that, as the political system becomes less equal, first the slope of the investment curve becomes less steep, then its sign changes. Under a highly undemocratic political system, the value of ψ is high, which corresponds to a higher probability of being in the redistribution state $H(\overline{\rho})$. Since the redistribution motive is high, investment in state capacity increases. Even when there is no political instability, the same result follows, as seen in Figure 3.3.b.

In order to understand the effect of political stability on the relationship between income inequality and the investment decision, we fix the level of political inequality ψ to 0.9. As shown in Figure 3.3.c, when the citizens favor their group, higher income inequality leads to higher investment in state capacity. However, political stability plays an important role as well. The stock of state capacity is higher when the political system is more stable.

3.4 Empirical Analysis

So far, we have qualitatively determined the effects of fighting external wars and political stability, as well as political and income inequality, on the decision of the government to invest in state capacity. We summarize our theoretical results in Table 3.2.

Table 3.2: Summary of Theoretical Results

The Qualitative Effect of Each Determinant on Investment in State Capacity

	α_2 (↑)	α_1 (↑)	γ (↑)	ψ (↑)	ϵ (↑)
Benchmark - Elites Rule	(↑)	(↓)	(↑)	(↓)	NA
Benchmark - Citizens Rule	(↑)	(↓)	(↑)	(↑)	NA
With Income Inequality - Elites	(↑)	(↓)	(↑)	(↓)	(↓)
With Income Inequality - Citizens	(↑)	(↓)	(↑)	(↓↑)*	(↓↑)*

Note: * indicates that the sign depends on the interactions of the inequality measures.

We have found that, if the country is more likely be involved in an external war, the government chooses to invest more in state capacity.[6] Intuitively, the government would like to raise funds to be able to pay for military costs; therefore, it increases the tax base by investing in state capacity. As for the inequality measures and political instability, we showed that political instability and higher levels of political and/or income inequality lead to lower investment in state capacity, except for the case where the citizens are in power, as we discussed in detail previously. If the political system is less democratic and/or the distribution of income is unequal,

[6]We actually state a more general result: a higher expected demand for public goods leads to higher investment in state capacity. Fighting an external war is an example of a situation where the demand for public goods, such as defense, increases.

the government's priorities are shifted towards redistributing the tax revenues immediately, since the benefit from redistribution in the first period outweighs the expected benefit of collecting higher tax revenues in the second period.

In this section, we test the predictions of our model by applying econometric methods on cross-sectional data.

3.4.1 Data

In our theoretical framework, we defined state capacity as the government's ability to raise tax revenues, following the earliest definition of state capacity as in Tilly (1990). Accordingly, we use three different tax measures to proxy for state capacity in the empirical analysis. Additionally, we relate state capacity to state's bureaucratic quality in line with Hendrix (2009), and use two more proxies.[7] Here is a brief description of the five measures of state capacity that we consider:

1. Total tax revenues: Annual average of total tax revenues, reported as percentage share in GDP, for the periods 1980-2006 and 2000-2006. We use the data from Baunsgaard and Keen (2009), which is constructed using Government Finance Statistics (GFS) and IMF country documents.[8] The initial sample contains 125 countries. We also include Mexico and Brazil in our sample and take the tax data for these countries from the dataset used in Lora (2007).

2. Income tax revenues: Annual average of income tax revenues, reported as percentage share in the GDP, for the period 1980-2000. We use the dataset

[7]See Appendix B.2 for the details of Hendrix (2009).

[8]The dataset was generously provided by Thomas Baunsgaard and Michael Keen.

from Baunsgaard and Keen (2005), which is a previous version of the one used in Baunsgaard and Keen (2009). We also add the data for Mexico and Brazil from Lora (2007).

3. Domestic tax revenues: Annual average of the GDP share of total tax revenues net of trade tax revenues, for the period 1980-2006. The resources are the same as those used to construct the dataset for total tax revenues.

4. Government effectiveness index: An index which represents one of the six dimensions of governance, computed for the Worldwide Governance Indicators (WGI) research project and reported in Kaufmann et al. (2009).[9] This particular index measures the quality of public services, the capacity of the civil service and its independence from political pressures, as well as the quality of policy formulation. The index values are computed for every year since 1996, and range between -2.5 and 2.5, where a higher value indicates a more effective government. We use the averages of all the values available for each country, for the periods 1996-2008 and 2002-2008.[10]

5. Ease of doing business ranking: A ranking of the countries according to the Ease of Doing Business category of the Doing Business Project of the World Bank.[11]

[9] See Appendix B.2 for further details.

[10] See http://info.worldbank.org/governance/wgi/.

[11] The data can be found at http://www.doingbusiness.org/. For each economy, the index is calculated as the ranking on the simple average of its percentile rankings on each of the following 10 topics: Starting a business, dealing with construction permits, employing workers, registering property, getting credit, protecting investors, paying taxes, trading across borders, enforcing contracts and closing a business.

We use the 2009 version of the dataset, which covers 181 countries. We modify the rankings, so that each country takes a value between 0 and 1, where the country that is ranked as the best in terms of ease of doing business has a value of 1.

As for the possible determinants of state capacity, we use the following data:

1. Incidence of external wars: We construct a dummy variable that takes a value of 1 if the country has been involved in an external war in a given year, and 0 otherwise. We use the definitions and the data from the Correlates of War database.[12] We define the incidence as the fraction of the years that the country has been involved in an external war for two time periods: 1900-1975 (or since independence if this occurred after 1900) and 1960-1997. Thus, our variable goes

[12]The original data can be reached online at http://correlatesofwar.org/. In the data, there are two variables that refer to external conflict: interstatewar and extrastatewar. To be classified as an interstate war, at least two participants in sustained combat must qualify as members of the interstate system and there must be at least 1,000 battle related fatalities among all of the system members involved. A state involved is regarded as a participant if it incurs a minimum of 100 fatalities or has 1,000 armed personnel engaged in fighting. Extrastate wars are wars between a state and a non-state entity. To be classified as an extrastate war, at least one major participant in the conflict (however irregular and disorganized) must not be a member of the state system and there must be at least 1,000 battle related fatalities in every year for each of the state participants. The year for which either or both of the two indicators are equal to unity is counted as a year in which the country has been involved in an external war. Also, see the discussion of democracy variables for the matching procedure with modern countries. The Correlates of War data report countries that have involved in civil wars or internal disputes in other polities (e.g., European powers that were involved during the Russian civil war after the end of World War I). The data reported here exclude foreign countries from the definition of civil wars.

from 0 to 1, where a country that has been engaged in an external war in all years in the sample has a value of 1. This measure proxies for α used in the theoretical model.

2. Political Instability/Stability: We use two different measures. The first one is the incidence of civil wars, which proxies for political instability (corresponding to $(1-\gamma)$), since the risk of civil war increases with political instability (Hegre et al. (2001), Fearon and Laitin (2003), and Blattman and Miguel (2010)) and the government is likely to be overthrown as a result of a civil war. We construct a dummy variable that takes a value of 1 if the country has been involved in an internal war that took place in its own territory in a given year, and 0 otherwise.[13] Again, our dataset comes from the Correlates of War. The incidence is then defined as the fraction of the years from 1900 to 1975, or from 1960 to 1997, that the country has been engaged in an internal war, reported only for the time period that the country has been independent since 1900. The result is a variable that ranges from 0 to 1, where 1 represents that a country that has been in an internal war in all years in the sample. Our second proxy is the Political Stability and Absence of Violence/Terrorism

[13] In order to be classified as a civil war, the central government must be actively involved in military action with effective resistance for both sides and there must be at least 1,000 battle related deaths. In order to constitute effective resistance, both sides must have been initially organized for violent conflict, or the weaker side must be able to inflict upon the stronger opponents at least five percent of the number of fatalities it sustains. We add the additional territory restriction, because in many cases countries got involved in civil wars or internal disputes that took place in other polities (e.g., some European powers were involved during the Russian civil war after the end of World War I).

index computed for the Worldwide Governance Indicators (WGI) research project and reported in Kaufmann et al. (2009).[14] It is constructed to 'capture perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism.' Higher index values indicate more stable political environments (higher γ). We use the data for 1998.[15]

3. Incidence of Democracy (Political equality): We assume that the political system is more equal if it is more democratic (lower ψ). We proxy for political equality with each country's Polity2 score in the Polity IV database.[16] The Polity2 score captures the regime authority on a spectrum of a 21-point scale ranging from -10 (hereditary monarchy) to 10 (consolidated democracy). The score is constructed by calculating the difference between the regime's democracy and autocracy scores for a given year. Since we are interested in capturing the regimes that are likely to represent low levels of political inequality, we define a country to be democratic in a certain year, if the Polity2 score is greater than 3.[17] As in the case of the conflict variables, we compute the fraction of the years that a country has a Polity2 score greater than 3 for the period between 1900 and 1975 (or since independence if this occurred after 1900) and the period between 1960 and 1999.[18]

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[14]See Appendix B.2 for the details on the construction of this variable.

[15]The averages for 1996 and 1998 are also used as a robustness check.

[16]The data can be accessed online at http://www.systemicpeace.org/polity/polity4.htm.

[17]We also use a second definition that considers a country to be democratic in a certain year if the Polity2 score is greater than 0.

[18]Here we note how we match the country classifications used in the Polity IV and Correlates of War databases to current classifications. We first take all the countries that currently exist

4. Gini coefficient (Income inequality): We use gini coefficient for the total population of the country, as a proxy for ϵ in our model. We use the data from the 2008 World Income Inequality Database of the United Nations University - World Institute for Development Economics Research (UNU-WIDER). The data cover the time period 1867-2006, and include, in the more recent years, 186 countries. The reported gini coefficients come from surveys which can differ greatly, in ten dimensions, such as area (e.g., national, rural, urban, metropolitan areas, cities, etc.), population group (e.g., all, workers, taxpayers, certain age groups, etc.), unit of analysis (e.g., individual, household, etc.) and measure of economic conditions (e.g., income or expenditures). Given the heterogeneity in the original data, we use the gini measures derived from national surveys covering all the population. If more than one observation per country/year meets these criteria, then we choose the higher quality observation (based on a quality index included in the database). Finally, if there are still several reported gini coefficients for the same country and year,

and match them to their equivalent country in the above mentioned datasets. We then match some of the current countries to their previous political entities, if the current country is clearly a continuation of the previous one. For example, Germany is matched to West Germany and to the original German state classified in Polity IV and Correlates of War (the same is done with Ethiopia and Vietnam-North Vietnam). Finally, if the current countries were part of a larger independent political entity before 1975, we assign the polity2 and war indicators of the older country to the new ones. For example Czech and Slovak Republic are both assigned the value of Czechoslovakia. The same procedure is applied to Bangladesh and Pakistan, and the countries that originated from the USSR and Yugoslavia. The Baltic countries and Serbia, which did exist before they were absorbed by the USSR and Yugoslavia, are not matched to their historical equivalents.

we choose those with a common characteristic (among the remaining 7 dimensions) with more observations in the original database. Our resulting data have information for 88 countries for the period 1890-1975, and consist of 338 observations in total. From this dataset, we construct and use the average gini coefficient for the periods 1900-1975 and 1960-1999.[19]

The descriptive statistics for the measures and the determinants of state capacity are presented in Tables B.1 and B.2 in Appendix B.2.

3.4.2 Empirical Results

We first graphically present the cross-correlations between the measures and the determinants of state capacity. The following three measures are used as proxies for state capacity in this exercise: the GDP share of total tax revenues (2000-2006), the government effectiveness index (2002-2008) and the ease of doing business ranking (2009). The cross-correlations are plotted in Figures 3.4 and 3.5.

The democracy scores and the incidence of external wars are positively correlated with each measure of state capacity we consider. On the contrary, the incidence of internal wars and the gini coefficients are negatively correlated with the measures of state capacity. The data show that, countries with more democratic political systems (less political inequality) and higher valuation of public goods (higher incidence of external wars) have higher levels of state capacity. However, higher incidence of

[19]For 31 countries there is only one data point. The country with the maximum number of observations between 1900 and 1975 is the United States. The median country has 2 observations in that period.

Figure 3.4: Cross Correlations - Measures vs. Determinants of State Capacity

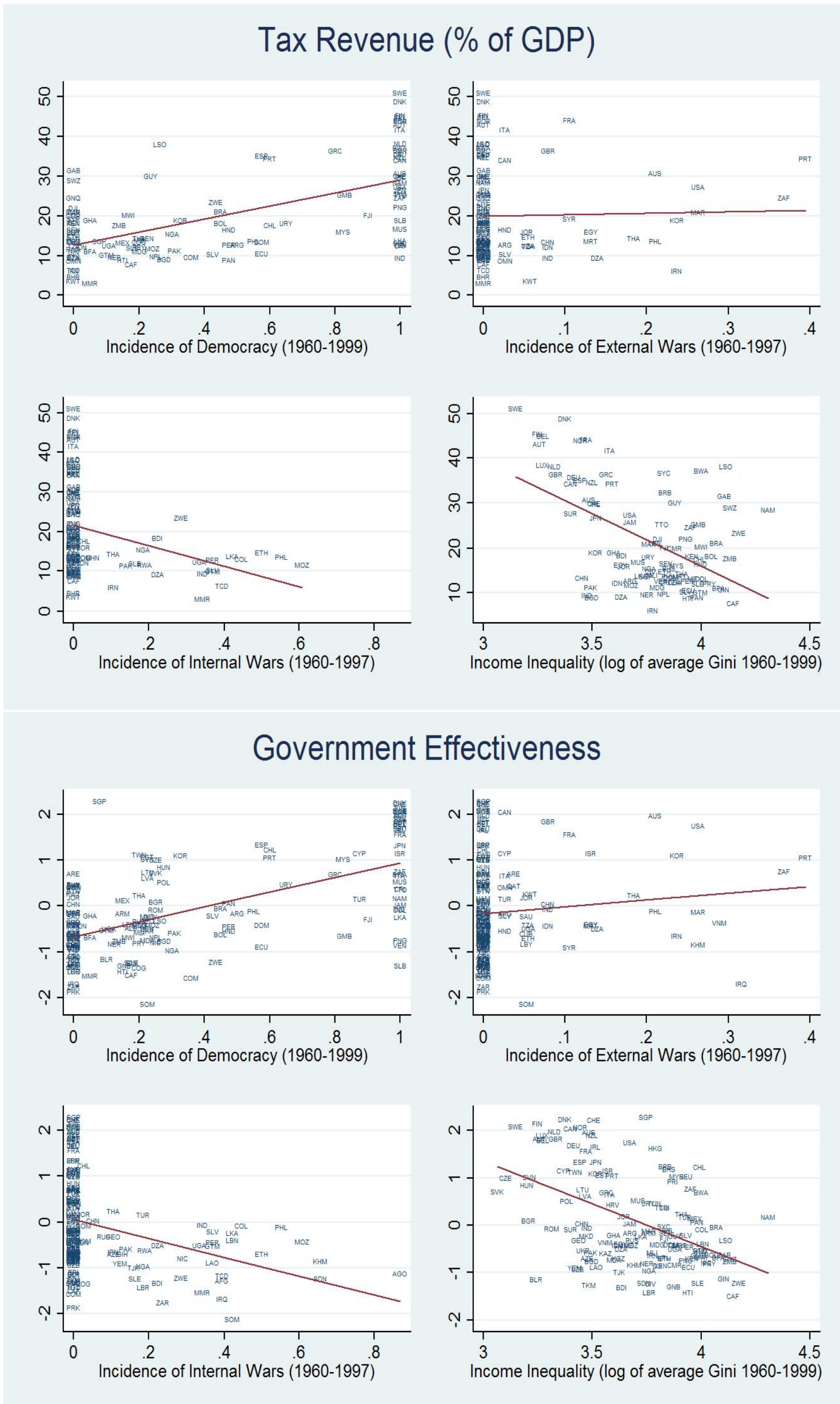

Figure 3.5: Cross Correlations (Cont.) - Measures vs. Determinants of State Capacity

internal wars (higher political instability) and higher levels of income inequality are related to lower levels of state capacity. This empirical evidence is line with our earlier theoretical predictions.

Next, we move on to more formal econometric analysis. Our primary empirical tests are based on the ordinary least squares (OLS) regressions of the following form:

$$SC_i = \beta_0 + \beta_{ew} ExtWar_i + \beta_{iw} IntWar_i + \beta_{pol} Polity_i + \beta_{gini} Gini_i + \varepsilon_i \qquad (3.23)$$

where SC_i is a measure of state capacity for country i. $ExtWar_i$ and $IntWar_i$ stand for the incidence of external and internal wars, respectively. As discussed earlier, we use the incidence of internal wars as a proxy for political instability. To check for the robustness of our results, in a second set of regressions, we replace $IntWar_i$ with $PolStab_i$, which stands for the political stability and absence of violance/terrorism index. $Polity_i$ measures the incidence of democracy, which proxies for the level of political equality. $Gini_i$ is the gini coefficient, which measures the level of income inequality. Finally, ε is an error term capturing all other omitted factors, with $E(\varepsilon) = 0$ for all i.

We are aware that there may be potential endogeneity and simultaneity problems. Our explanatory variables may have been jointly determined with the different measures of state capacity, through channels that our model fails to capture. We deal with these potential problems by measuring all explanatory variables before the years when the proxies for state capacity are observed and measured. For a better treatment of the endogeneity issues, see the panel data study in Cárdenas, Ramírez and Tüzemen (2011).

We use the data from two different sample periods in the estimations. The first sample considers a long-run perspective, and the average values of the explanatory variables correspond to the period 1900-1975. The purpose of the regressions using the long term sample is to see to what extent the historical levels of democracy, inequality and wars have had an impact on the average values of state capacity, which are measured after 1980. The second sample is constructed with more recent measures: the average values of the explanatory variables are calculated for the periods 1960-1997 and 1960-1999, while state capacity is measured after 2000.

Table 3.3 reports the results for the first set of regressions, where the long term data are used. The estimates in Panel a indicate that countries with more democratic political systems have, on average, higher levels of state capacity, compared to the countries with less democratic political systems. Quantitatively, a one standard deviation increase in our measure of democracy is associated with a 4.1 percentage point increase in the GDP share of total taxes, and a 3.5 percentage point increase in the GDP share of income taxes. A country with a one standard deviation decrease in the level of political inequality has a 0.4 increase (in a scale that ranges between -2.5 and +2.5) in the government effectiveness index, while the ease of doing business ranking increases by 0.1 (in a scale ranging from 0 to 1).

As for the incidence of external wars, we find that countries that have spent more years fighting external wars have higher state capacity. More precisely, a country with one standard deviation higher incidence of external wars has a 2.6 percentage points higher GDP share of total taxes, a 2 percentage points higher GDP share of income taxes, and a 5.2 percentage points higher share of domestic taxes in total taxes. When we use the non-fiscal proxies of state capacity, a one standard deviation increase in the incidence of external wars turns out to be associated with a 0.2 increase in the government effectiveness index, and a 0.1 increase in the ease of doing business ranking.

The estimates in Table 3.3.a further indicate that countries engaged in internal wars have, on average, lower state capacity. Since the incidence of internal wars is used as the proxy for political instability, we conclude that higher political instability is related to lower state capacity. Quantitatively, a one standard deviation increase in the incidence of internal wars corresponds to a 1.7 percentage point decrease in the GDP share of total taxes.[20] A country with one standard deviation higher incidence of internal wars reduces the government effectiveness index and the ease of doing business ranking by 0.2 and 0.1, respectively.

These results generally hold when we also control for income inequality. However, as reported in Table 3.3.b, when state capacity is proxied with the GDP share of total taxes, the statistically significant relationship between the incidence of internal wars and state capacity is no longer observed.[21] Nevertheless, we find that countries with more equal distribution of income are associated with higher levels

[20] The statistically significant relationship between the incidence of internal wars and state capacity is no longer observed when we use the other two fiscal proxies.

[21] The problem that we face when we include the gini coefficient as an additional regressor is the loss of some of our observations. We use between 104 and 154 observations for the set of regressions for the benchmark model. The number of observations we can use decreases to a number between 67 and 80, when we add the gini as an additional explanatory variable. This reduction in the sample size may be responsible for the insignificance of some of our results.

Table 3.3: Determinants of State Capacity: Long-Run Perspective

a. Without Income Inequality

	Tot. Taxes (% of GDP) 1980-2006	Inc. Taxes (% of GDP) 1980-2000	Dom. Taxes (% of Tot.Taxes) 1980-2006	Government Effectiveness 1996-2008	Ease of Doing Business 2009
Democracy 1900-1975	10.670*** (2.888)	9.160*** (2.561)	5.817 (4.939)	1.045*** (0.228)	0.233*** (0.068)
Ext. Wars 1900-1975	23.480*** (8.638)	18.410** (7.593)	46.870*** (11.470)	1.914*** (0.520)	0.580*** (0.150)
Int. Wars 1900-1975	-13.020* (7.498)	-3.735 (4.357)	12.130 (11.390)	-1.516*** (0.440)	-0.501*** (0.144)
Constant	14.030*** (0.932)	3.829*** (0.606)	73.370*** (1.936)	-0.538*** (0.086)	0.306*** (0.032)
No. of Obs.	104	104	104	154	147
Adj. R-sq.	0.520	0.562	0.234	0.473	0.427

b. With Income Inequality

	Tot. Taxes (% of GDP) 1980-2006	Inc. Taxes (% of GDP) 1980-2000	Dom. Taxes (% of Tot.Taxes) 1980-2006	Government Effectiveness 1996-2008	Ease of Doing Business 2009
Democracy 1900-1975	7.864** (2.985)	6.879** (2.631)	7.327 (5.910)	1.145*** (0.233)	0.288*** (0.088)
Ext. Wars 1900-1975	28.970*** (9.038)	22.320*** (7.626)	40.380*** (14.080)	1.866*** (0.551)	0.542*** (0.182)
Int. Wars 1900-1975	-14.270 (9.712)	-4.171 (5.160)	0.017 (11.020)	-2.244*** (0.413)	-0.583*** (0.192)
Ln of Gini 1900-1975	2.345 (5.675)	-0.876 (4.059)	3.408 (10.480)	-0.833** (0.381)	-0.054 (0.115)
Constant	6.585 (21.830)	7.668 (15.540)	63.280 (40.140)	2.771* (1.518)	0.532 (0.450)
No. of Obs.	67	67	67	80	78
Adj. R-sq.	0.549	0.561	0.210	0.595	0.485

Note: Standard errors are reported in parentheses: * $p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

of state capacity when we use the government effectiveness index as the measure of state capacity.

Table 3.4 reports the regression results for the more recent measures. While the data for the measures of state capacity are for the 2000s, the data for democracy and inequality are for the period 1960-1999, and the data for external wars are for the period 1960-1997. The GDP share of total taxes, the government effectiveness index and the ease of doing business ranking are used as the proxies for state capacity. We replace the incidence of internal wars with the political stability and absence of violance/terrorism index (1998). So, our focus changes from the effect of political instability to the effect of political stability on state capacity. The basic results, presented in columns 1, 5 and 9 of Table 3.4, show that democracy is positively correlated with the recent measures of state capacity. Similarly, the coefficient estimate of the political stability index is highly significant and positive, confirming that political stability is an important element of stronger states.[22]

While these results support the conclusions drawn from the previous regressions, there are some differences as well. First, the positive correlation between the incidence of external wars and state capacity vanishes in the case of the GDP share of total taxes (shown in column 1), suggesting that external conflict no longer plays the role (for taxation) it had played in the earlier part of the 20th century. Second, the results in columns 2, 6 and 10 of Table 3.4 show that income inequality is highly

[22]We repeat the analysis by using the averages for the political stability variable for 1996 and 1998. Our results are robust to this change. The corresponding estimation results are available upon request.

negatively correlated with state capacity in the recent time period (except for the case of the GDP share of total taxes).

We also introduce two new terms corresponding to the interaction of income inequality with political equality (ln of the gini coefficient and the incidence of democracy), and the interaction of income inequality with political stability (ln of the gini coefficient and the political stability index). The coefficient estimates of the two interacted terms are both negative and significant, when the GDP share of total taxes and the government effectiveness index are used to proxy for state capacity (shown in columns 3, 4, 7 and 8 of Table 3.4). In the case of the first interacted term, the estimation results indicate that income inequality reduces the magnitude of the positive correlation between democracy and state capacity, which is line with the prediction of our theory (Proposition 3.7). Similarly, the negative significance of the second interacted term shows that, in the presence of income inequality, the positive correlation between political stability and state capacity is dampened.

In the last set of regressions, we use the recent measures, but proxy political instability with the incidence of internal wars as in the long term regressions. The results are reported in Table 3.5. In line with our previous results, we find that countries with higher democracy scores and higher incidence of external wars (except for the case of the GDP share of total taxes) have higher state capacity.

Table 3.4: Determinants of State Capacity: Recent Measures, Interactions of Inequalities and an Alternative Measure of Political Instability

	Total Taxes (% of GDP) 2000-2006				Government Eff. Index 2002-2008				Ease of Doing Buss. Rank 2009			
Democracy 1960-1999	8.453*** (2.609)	5.072* (2.603)	104.100** (43.120)	4.144 (2.552)	0.755*** (0.171)	0.711*** (0.194)	4.455** (1.898)	0.700*** (0.192)	0.219*** (0.066)	0.259*** (0.074)	0.072 (0.695)	0.260*** (0.074)
Ext. Wars 1960-1997	4.083 (7.649)	-2.192 (8.429)	2.627 (8.849)	-0.358 (7.464)	1.430*** (0.485)	1.259** (0.482)	1.324** (0.509)	1.331*** (0.485)	0.377** (0.171)	0.282 (0.184)	0.278 (0.186)	0.278 (0.188)
Pol. St. 1998	3.863*** (0.977)	5.096*** (1.215)	4.246*** (1.365)	48.230*** (15.250)	0.545*** (0.063)	0.509*** (0.077)	0.490*** (0.082)	1.718** (0.713)	0.124*** (0.022)	0.104*** (0.029)	0.105*** (0.029)	0.047 (0.361)
Ln. of Gini 1960-1999	-	-6.725 (4.535)	8.881 (7.502)	-6.021 (4.541)	-	-1.095*** (0.202)	-0.585* (0.302)	-1.071*** (0.200)	-	-0.201** (0.079)	-0.226* (0.116)	-0.202** (0.081)
Dem.*Ln.Gini 1960-1999	-	-	-26.000** (11.340)	-	-	-	-0.995** (0.497)	-	-	-	0.050 (0.186)	-
Pol.St.*Ln.Gini 1998	-	-	-	-11.580*** (4.016)	-	-	-	-0.330* (0.198)	-	-	-	0.015 (0.098)
Constant	15.240*** (1.408)	42.990** (17.320)	-17.470 (28.880)	39.580** (17.370)	-0.388*** (0.097)	3.824*** (0.787)	1.871 (1.194)	3.699*** (0.784)	0.324*** (0.038)	1.076*** (0.299)	1.172*** (0.447)	1.082*** (0.312)
No. of Obs.	107	93	93	93	159	131	131	131	152	129	129	129
Adj. R-sq.	0.536	0.573	0.604	0.604	0.671	0.757	0.762	0.759	0.543	0.564	0.561	0.561

Note: Standard errors are reported in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.5: Determinants of State Capacity: Recent Measures and Interactions of Inequalities - Political Instability Proxied with Internal Wars

	Total Taxes (% of GDP) 2000-2006				Government Eff. Index 2002-2008				Ease of Doing Buss. Rank 2009			
Democracy 1960-1999	12.240*** (2.552)	9.833*** (2.394)	131.600*** (43.620)	9.232*** (2.449)	1.305*** (0.194)	1.184*** (0.188)	7.111*** (2.262)	1.131*** (0.189)	0.341*** (0.060)	0.355*** (0.061)	0.658 (0.694)	0.329*** (0.059)
Ext. Wars 1960-1997	8.650 (8.651)	2.203 (8.495)	7.443 (8.174)	1.942 (8.299)	1.925*** (0.601)	1.722*** (0.428)	1.802*** (0.399)	1.812*** (0.436)	0.494*** (0.165)	0.378** (0.165)	0.382** (0.168)	0.422*** (0.157)
Int. Wars 1960-1997	-18.270*** (4.455)	-18.840*** (4.900)	-16.840*** (5.262)	-280.000** (128.700)	-1.406*** (0.301)	-1.116*** (0.263)	-1.068*** (0.273)	-19.510*** (6.880)	-0.325*** (0.103)	-0.243* (0.128)	-0.240* (0.131)	-9.563*** (3.090)
Ln. of Gini 1960-1999	-	-9.854** (4.709)	10.190 (7.883)	-13.060** (5.124)	-	-1.433*** (0.260)	-0.601 (0.381)	-1.633*** (0.272)	-	-0.271*** (0.079)	-0.229** (0.116)	-0.376*** (0.079)
Dem.*Ln.Gini 1960-1999	-	-	-32.240*** (11.700)	-	-	-	-1.583*** (0.601)	-	-	-	-0.081 (0.188)	-
Int.W.*Ln.Gini 1960-1997	-	-	-	68.360** (33.300)	-	-	-	4.855*** (1.804)	-	-	-	2.460*** (0.821)
Constant	14.150*** (1.218)	53.180*** (18.130)	-23.920 (30.100)	65.500*** (19.770)	-0.680*** (0.100)	4.853*** (1.027)	1.685 (1.489)	5.604*** (1.071)	0.260*** (0.036)	1.292*** (0.304)	1.133** (0.446)	1.683*** (0.307)
No of Obs.	107	93	93	93	159	131	131	131	152	129	129	129
Adj. R-sq.	0.523	0.532	0.587	0.548	0.521	0.650	0.664	0.662	0.456	0.513	0.510	0.556

Note: Standard errors are reported in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Moreover, income inequality has a significant negative correlation with all of the measures of state capacity as shown in columns 2, 6 and 10 of Table 3.5. In the case of wars, our results indicate that internal wars have a significant and negative correlation with all of the measures of state capacity in the recent time period. Therefore, internal wars, rather than external, are more important in explaining the differences in state capacity across countries when state capacity is proxied with the GDP share of total taxes.[23]

We continue to include the interacted terms, which capture the interaction of income inequality with democracy and the incidence of internal wars (used as a proxy for political instability, rather than political stability). As in the previous regressions, the results in columns 3, 7 and 11 of Table 3.5 show that income inequality leads to a reduction in the positive correlation between democracy and state capacity (except for the case of ease of doing business ranking). On the contrary, the coefficient estimate of second interacted term is significant and positive in all regressions (in columns 4, 8 and 12 of Table 3.5), since both income inequality and political instability are negatively correlated with state capacity. In other words, in the presence of income inequality, the negative correlation of internal wars with state capacity, and the positive correlation of political stability with state capacity are reduced.[24]

[23]These results support the panel estimations results in Cárdenas and Eslava (2010). They find that the incidence of internal wars, rather than the incidence of external wars, is the key driver for the changes in state capacity.

[24]The results reported in Tables 3-5 are robust to using the alternative definition of democracy, which considers a country to be democratic in a certain year, if the Polity2 score is greater than

3.5 Conclusion

In this chapter, we studied the economic and political factors that shape the government's decision to invest in state capacity. Our model showed that political stability and equality are the building blocks of stronger states. While political stability calls for higher investment in state capacity, political and income inequality lead to lower investment. In line with the existing literature, we found that wars, whether external or internal, are important determinants as well. While external wars result in higher state capacity, civil wars lead to weaker states.

Our empirical analysis confirmed that countries with more democratic political systems and lower income inequality are associated with higher state capacity. We found that more stable governments (whether measured with the lower incidence of internal wars or a higher political stability index) have higher state capacity. Our results further indicate that the magnitudes of the positive correlations of democracy and political stability with state capacity are significantly reduced with higher income inequality. To conclude, high political and/or income inequality, absence of external wars and high political instability (or the presence of common and long-lasting civil wars) stand out as the main reasons why some governments under-invest in state capacity.

While we have taken important steps to contribute to the recently growing literature on various dimensions of state capacity, we believe that there are many theoretical and empirical issues which deserve further attention. For example, by using

0. The corresponding estimation results are available upon request.

a two-period model, we abstracted from the possible differences in the short-run and the long-run investment decisions of the government. We assumed that the level of political inequality is exogenously determined. This assumption can be relaxed and the model can be improved by considering a dynamic multi-period version, where investment in state capacity, provision of public goods and the representativeness of the political system are simultaneously determined by the government. While we assumed the investment and public goods provision decisions to be dependent on political stability, the causality can go in the opposite direction as well. Finally, civil wars can be re-defined as the rebellious movements by the citizens, which occur when they find the government policies to be unsatisfactory, in terms of redistribution, the level of the provision of public goods and political representation. Such an approach may bring more insight to the trade-offs faced by the government, as well as the consequences of different political and fiscal policies.

Empirically, it would be worthwhile to re-investigate the effects of the interactions between political and income inequality on state capacity, when different income/political groups run the government. On this issue, our theory predicts different results depending on the group in power (elites and citizens). In the data, grouping governments according to their political stance, such as the right wing and the left wing, may be one way to represent such a distinction. It then becomes an empirical challenge to analyze the effects of the interactions of the inequality measures on the government's decision to invest in state capacity.

Appendix A

A.1 Solution to the Household's Optimization Problem

The optimization problem of a representative household is to choose $c_t, u_t^g, u_t^b, i_t, s_t$, taking as given $\{w_t^g, w_t^b, p_t^g, p_t^b, r_t\}$, to maximize the value function:

$$V_t^h(n_t^g, n_t^b, k_t) = max\left\{u(c_t) + h(l_t) + \beta E_t\left[V_{t+1}^h(n_{t+1}^g, n_{t+1}^b, k_{t+1})\right]\right\} \tag{A.1}$$

subject to the budget constraint and the laws of motion for capital and employment:

$$w_t^g n_t^g + w_t^b n_t^b + d(u_t^g + u_t^b) + r_t k_t + \pi_t = c_t + i_t + T_t \tag{A.2}$$

$$i_t = k_{t+1} - (1-\delta)k_t \tag{A.3}$$

$$n_{t+1}^g = (1-\psi)\left[n_t^g + p_t^g(u_t^g + s_t n_t^b)\right] \tag{A.4}$$

$$n_{t+1}^b = (1-\psi)\left[(1 - p_t^g s_t)n_t^b + p_t^b u_t^b\right] \tag{A.5}$$

$$l_t = 1 - u_t^g - u_t^b - n_t^g - [1+\kappa(s_t)]n_t^b \tag{A.6}$$

The FOCs are:

$$FOC\ \ wrt\ \ c_t: \ \ u_c(c_t) = \lambda_t \tag{A.7}$$

$$FOC\ \ wrt\ \ i_t: \ \ \lambda_t = \beta E_t\left\{V_k^h(n_{t+1}^g, n_{t+1}^b, k_{t+1})\right\} \tag{A.8}$$

$$FOC\ \ wrt\ \ u_t^g: \ \ h_l(l_t) - \lambda_t d = (1-\psi)p_t^g \beta E_t\left\{V_{n^g}^h(n_{t+1}^g, n_{t+1}^b, k_{t+1})\right\} \tag{A.9}$$

$$FOC\ \ wrt\ \ u_t^b: \ \ h_l(l_t) - \lambda_t d = (1-\psi)p_t^b \beta E_t\left\{V_{n^b}^h(n_{t+1}^g, n_{t+1}^b, k_{t+1})\right\} \tag{A.10}$$

$$FOC\ \ wrt\ \ s_t: \ \ \kappa_s(s_t) = \frac{(1-\psi)p_t^g}{h_l(l_t)}\beta E_t\left\{V_{n^g}^h(n_{t+1}^g, n_{t+1}^b, k_{t+1}) - V_{n^b}^h(n_{t+1}^g, n_{t+1}^b, k_{t+1})\right\} \tag{A.11}$$

where λ_t is the lagrange multiplier associated with the budget constraint and:

$$h_l(l_t) = \frac{\partial h(l_t)}{\partial l_t} \tag{A.12}$$

$$\kappa_s(s_t) = \frac{\partial \kappa(s_t)}{\partial s_t} \tag{A.13}$$

$$V^h_{n^g}(n^g_{t+1}, n^b_{t+1}, k_{t+1}) = \frac{\partial V^h(n^g_{t+1}, n^b_{t+1}, k_{t+1})}{\partial n^g_{t+1}} \tag{A.14}$$

$$V^h_{n^b}(n^g_{t+1}, n^b_{t+1}, k_{t+1}) = \frac{\partial V^h(n^g_{t+1}, n^b_{t+1}, k_{t+1})}{\partial n^b_{t+1}} \tag{A.15}$$

$$V^h_k(n^g_{t+1}, n^b_{t+1}, k_{t+1}) = \frac{\partial V^h(n^g_{t+1}, n^b_{t+1}, k_{t+1})}{\partial k_{t+1}} \tag{A.16}$$

First, take the derivatives of the Bellman equations with respect to the state variables:

$$V^h_k(n^g_t, n^b_t, k_t) = \lambda_t r_t - (1-\delta)\beta E_t \left\{ V^h_k(n^g_{t+1}, n^b_{t+1}, k_{t+1}) \right\} \tag{A.17}$$

$$V^h_{n^g}(n^g_t, n^b_t, k_t) = -h_l(l_t) + \lambda_t w^g_t + (1-\psi)\beta E_t \left\{ V^h_{n^g}(n^g_{t+1}, n^b_{t+1}, k_{t+1}) \right\} \tag{A.18}$$

$$\begin{aligned} V^h_{n^b}(n^g_t, n^b_t, k_t) &= -[1+\kappa(s_t)]h_l(l_t) + \lambda_t w^b_t + (1-\psi)p^g_t s_t \beta E_t \left\{ V^h_{n^g}(n^g_{t+1}, n^b_{t+1}, k_{t+1}) \right\} \\ &\quad + (1-\psi)(1-p^g_t s_t)\beta E_t \left\{ V^h_{n^b}(n^g_{t+1}, n^b_{t+1}, k_{t+1}) \right\} \end{aligned} \tag{A.19}$$

Substituting in for the values for $V^h_{n^g}(n^g_{t+1}, n^b_{t+1}, k_{t+1})$ and $V^h_{n^b}(n^g_{t+1}, n^b_{t+1}, k_{t+1})$ gives:

$$V^h_{n^g}(n^g_t, n^b_t, k_t) = -h_l(l_t) + \lambda_t w^g_t + \frac{h_l(l_t) - \lambda_t d}{p^g_t} \tag{A.20}$$

$$V^h_{n^b}(n^g_t, n^b_t, k_t) = -[1+\kappa(s_t)]h_l(l_t) + \lambda_t w^b_t + p^g_t s_t \frac{h_l(l_t) - \lambda_t d}{p^g_t} + (1-p^g_t s_t)\frac{h_l(l_t) - \lambda_t d}{p^b_t} \tag{A.21}$$

Update the timing of the above two equations to get expressions for

$V^h_{n^g}(n^g_{t+1}, n^b_{t+1}, k_{t+1})$ and $V^h_{n^b}(n^g_{t+1}, n^b_{t+1}, k_{t+1})$, and then substitute them back into the FOCs to get:

$$\frac{h_l(l_t) - \lambda_t d}{p^g_t} = (1-\psi)\beta E_t \left\{ \lambda_{t+1} w^g_{t+1} - h_l(l_{t+1}) + \frac{h_l(l_{t+1}) - \lambda_{t+1} d}{p^g_{t+1}} \right\} \tag{A.22}$$

$$\begin{aligned} \frac{h_l(l_t) - \lambda_t d}{p^b_t} &= (1-\psi)\beta E_t \left\{ \lambda_{t+1} w^b_{t+1} - [1+\kappa(s_{t+1})] h_l(l_{t+1}) \right\} \\ &\quad +(1-\psi)\beta E_t \left\{ p^g_{t+1} s_{t+1} \frac{h_l(l_{t+1}) - \lambda_{t+1} d}{p^g_{t+1}} \right\} \\ &\quad +(1-\psi)\beta E_t \left\{ (1 - p^g_{t+1} s_{t+1}) \frac{h_l(l_{t+1}) - \lambda_{t+1} d}{p^b_{t+1}} \right\} \end{aligned} \tag{A.23}$$

Finally, substitute for λ_t and λ_{t+1} with $u_c(c_t)$ and $u_c(c_{t+1})$:

$$\frac{h_l(l_t) - u_c(c_t) d}{p^g_t} = (1-\psi)\beta E_t \left\{ u_c(c_{t+1}) w^g_{t+1} - h_l(l_{t+1}) + \frac{h_l(l_{t+1}) - u_c(c_{t+1}) d}{p^g_{t+1}} \right\} \tag{A.24}$$

$$\begin{aligned} \frac{h_l(l_t) - u_c(c_t) d}{p^b_t} &= (1-\psi)\beta E_t \left\{ u_c(c_{t+1}) w^b_{t+1} - [1+\kappa(s_{t+1})] h_l(l_{t+1}) \right\} \\ &\quad +(1-\psi)\beta E_t \left\{ p^g_{t+1} s_{t+1} \frac{h_l(l_{t+1}) - u_c(c_{t+1}) d}{p^g_{t+1}} \right\} \\ &\quad +(1-\psi)\beta E_t \left\{ (1 - p^g_{t+1} s_{t+1}) \frac{h_l(l_{t+1}) - u_c(c_{t+1}) d}{p^b_{t+1}} \right\} \end{aligned} \tag{A.25}$$

These are the two participation conditions shown in the text.

Similarly, using the first two FOCs and the expression for $V^h_{n^g}(n^g_{t+1}, n^b_{t+1}, k_{t+1})$, one gets the Euler equation for consumption:

$$u_c(c_t) = \beta E_t \{ u_c(c_{t+1})(r_{t+1} + 1 - \delta) \} \tag{A.26}$$

Finally, derive the optimal search intensity using the FOC with respect to s_t:

$$\kappa_s(s_t) = \frac{(1-\psi) p^g_t}{h_l(l_t)} \beta E_t \left\{ V^h_{n^g}(n^g_{t+1}, n^b_{t+1}, k_{t+1}) - V^h_{n^b}(n^g_{t+1}, n^b_{t+1}, k_{t+1}) \right\} \tag{A.27}$$

Substituting in the above equalities for λ_t, $V^h_{n^g}(n^g_{t+1}, n^b_{t+1}, k_{t+1})$ and $V^h_{n^b}(n^g_{t+1}, n^b_{t+1}, k_{t+1})$ yields:

$$\kappa_s(s_t) = \left(1 - \frac{p^g_t}{p^b_t}\right)\left[1 - \frac{u_c(c_t)d}{h_l(l_t)}\right] \tag{A.28}$$

A.2 Solutions to the Firms' Optimization Problems

The optimization problem of a high-wage firm is to choose v^g_t and K^g_t, taking $\{w^g_t, q^g_t, Pr^g_t, r_t, z_t\}$ as given, to maximize the value function:

$$V^{fg}_t(N^g_t, z_t) = \tag{A.29}$$

$$max\left\{Pr^g_t e^{z_t}(N^g_t)^{\alpha}(K^g_t)^{(1-\alpha)} - w^g_t N^g_t - r_t K^g_t - \gamma^g v^g_t + E_t[\Xi_{t+1|t}V^{fg}_{t+1}(N^g_{t+1}, z_{t+1})]\right\}$$

subject to the law of motion for employment in the market for high-wage jobs:

$$N^g_{t+1} = (1-\psi)\left[N^g_t + q^g_t v^g_t\right] \tag{A.30}$$

where $\Xi_{t+1|t}$ is the stochastic discount factor. Note that the value of $\Xi_{t+1|t}$ is derived from the solution to the household's problem as:

$$\Xi_{t+1|t} = \frac{\beta u_c(c_{t+1})}{u_c(c_t)} \tag{A.31}$$

The FOCs with respect to K^g_t and v^g_t are:

$$r_t = (1-\alpha)Pr^g_t \frac{Y^g_t}{K^g_t} \tag{A.32}$$

$$\frac{\gamma^g}{q^g_t} = (1-\psi)E_t\left\{\Xi_{t+1|t}V^{fg}_{N^g}(N^g_{t+1}, z_{t+1})\right\} \tag{A.33}$$

where $V^{fg}_{N^g}(N^g_{t+1}, z_{t+1}) = \frac{\partial V^{fg}(N^g_{t+1}, z_{t+1})}{\partial N^g_{t+1}}$ and $Y^g_t = e^{z_t}(N^g_t)^{\alpha}(K^g_t)^{(1-\alpha)}$.

Taking the derivative of the Bellman equation with respect to N_t^g gives:

$$V_{N^g}^{fg}(N_t^g, z_t) = \alpha Pr_t^g \frac{Y_t^g}{N_t^g} - w_t^g + (1-\psi)E_t\left\{\Xi_{t+1|t}V_{N^g}^{fg}(N_{t+1}^g, z_{t+1}]\right\} \tag{A.34}$$

which is equivalent to:

$$V_{N^g}^{fg}(N_t^g, z_t) = \alpha Pr_t^g \frac{Y_t^g}{N_t^g} - w_t^g + \frac{\gamma^g}{q_t^g} \tag{A.35}$$

Updating one period and substituting into the FOC yields:

$$\frac{\gamma^g}{q_t^g} = (1-\psi)E_t\left\{\Xi_{t+1|t}\left[\alpha Pr_{t+1}^g \frac{Y_{t+1}^g}{N_{t+1}^g} - w_{t+1}^g + \frac{\gamma^g}{q_{t+1}^g}\right]\right\} \tag{A.36}$$

Substituting in the value of the stochastic discount factor gives:

$$\frac{\gamma^g}{q_t^g} = (1-\psi)\beta E_t\left\{\frac{u_c(c_{t+1})}{u_c(c_t)}\left[\alpha Pr_{t+1}^g \frac{Y_{t+1}^g}{N_{t+1}^g} - w_{t+1}^g + \frac{\gamma^g}{q_{t+1}^g}\right]\right\} \tag{A.37}$$

which is the job creation condition for high-wage firms.

Similarly, the optimization problem of a low-wage firm is to choose v_t^b and K_t^b, taking $\{w_t^b, q_t^b, p_t^g, s_t, Pr_t^b, r_t, z_t\}$ as given, to maximize the value function:

$$\begin{aligned} &V_t^{fb}(N_t^b, z_t) = && \text{(A.38)}\\ &max\left\{Pr_t^b e^{z_t}(N_t^b)^\alpha (K_t^b)^{(1-\alpha)} - w_t^b N_t^b - r_t K_t^b - \gamma^b v_t^b + E_t[\Xi_{t+1|t}V_{t+1}^{fb}(N_{t+1}^b, z_{t+1})]\right\} \end{aligned}$$

subject to the law of motion for employment in the market for low-wage jobs:

$$N_{t+1}^b = (1-\psi)\left[(1-p_t^g s_t)N_t^b + q_t^b v_t^b\right] \tag{A.39}$$

The FOCs with respect to K_t^b and v_t^b are:

$$r_t = (1-\alpha)Pr_t^b \frac{Y_t^b}{K_t^b} \tag{A.40}$$

$$\frac{\gamma^b}{q_t^b} = (1-\psi)E_t\left\{\Xi_{t+1|t}V^{fb}_{N^b}(N^b_{t+1}, z_{t+1})\right\} \tag{A.41}$$

where $V^{fb}_{N^b}(N^b_{t+1}, z_{t+1}) = \frac{\partial V^{fb}(N^b_{t+1}, z_{t+1})}{\partial N^b_{t+1}}$ and $Y^b_t = e^{z_t}(N^b_t)^{\alpha}(K^b_t)^{(1-\alpha)}$.

Taking the derivative of the Bellman equation with respect to N^b_t gives:

$$V^{fb}_{N^b}(N^b_t, z_t) = \alpha Pr^b_t \frac{Y^b_t}{N^b_t} - w^b_t + (1-\psi)(1-p^g_t s_t)E_t\left\{\Xi_{t+1|t}V^{fb}_{N^b}(N^b_{t+1}, z_{t+1})\right\} \tag{A.42}$$

which is equivalent to:

$$V^{fb}_{N^b}(N^b_t, z_t) = \alpha Pr^b_t \frac{Y^b_t}{N^b_t} - w^b_t + (1-p^g_t s_t)\frac{\gamma^b}{q^b_t} \tag{A.43}$$

Updating one period and substituting into the FOC yields:

$$\frac{\gamma^b}{q_t^b} = (1-\psi)E_t\left\{\Xi_{t+1|t}\left[\alpha Pr^b_{t+1}\frac{Y^b_{t+1}}{N^b_{t+1}} - w^b_{t+1} + (1-p^g_{t+1}s_{t+1})\frac{\gamma^b}{q^b_{t+1}}\right]\right\} \tag{A.44}$$

Substituting in the value of the stochastic discount factor gives:

$$\frac{\gamma^b}{q_t^b} = (1-\psi)\beta E_t\left\{\frac{u_c(c_{t+1})}{u_c(c_t)}\left[\alpha Pr^b_{t+1}\frac{Y^b_{t+1}}{N^b_{t+1}} - w^b_{t+1} + (1-p^g_{t+1}s_{t+1})\frac{\gamma^b}{q^b_{t+1}}\right]\right\} \tag{A.45}$$

which is the job creation condition for low-wage firms.

A.3 Determination of the Wage Rates

The wage rate for high-wage jobs is obtained by solving the following Nash Bargaining Problem:

$$max_{w^g_t}\left[\frac{V^h_{n^g}(n^g_t, n^b_t, k_t)}{\lambda_t}\right]^{\mu}\left[V^{fg}_{N^g}(N^g_t, z_t)\right]^{(1-\mu)} \tag{A.46}$$

The FOC with respect to w^g_t yields:

$$(1-\mu)\left[\frac{V^h_{n^g}(n^g_t, n^b_t, k_t)}{\lambda_t}\right] = \mu\left[V^{fg}_{N^g}(N^g_t, z_t)\right] \tag{A.47}$$

Substituting in the values for $V^h_{n^g}(n^g_t, n^b_t, k_t)$ and $V^{fg}_{N^g}(N^g_t, z_t)$ gives:

$$\begin{aligned}(1-\mu)w^g_t - (1-\mu)\frac{h_l(l_t)}{\lambda_t} + (1-\mu)\frac{(1-\psi)}{\lambda_t}\beta E_t\left\{V^h_{n^g}(n^g_{t+1}, n^b_{t+1}, k_{t+1})\right\} \\ = \mu\left[\alpha Pr^g_t\frac{Y^g_t}{N^g_t} - w^g_t\right] + \mu(1-\psi)\beta E_t\left\{\frac{\lambda_{t+1}}{\lambda_t}[V^{fg}_{N^g}(N^g_{t+1}, z_{t+1})]\right\}\end{aligned} \quad (A.48)$$

Note that:

$$(1-\mu)\left[\frac{V^h_{n^g}(n^g_{t+1}, n^b_{t+1}, k_{t+1})}{\lambda_{t+1}}\right] = \mu\left[V^{fg}_{N^g}(N^g_{t+1}, z_{t+1})\right] \quad (A.49)$$

Substituting this into the above equation and solving for w^g_t gives:

$$w^g_t = \mu\left[\alpha Pr^g_t\frac{Y^g_t}{N^g_t}\right] + (1-\mu)\left[\frac{h_l(l_t)}{u_c(c_t)}\right] \quad (A.50)$$

where λ_t is replaced with $u_c(c_t)$. This is the wage rate the worker receives when working for a high-wage job.

Similarly, the following Nash Bargaining Problem is solved to find the wage rate paid at low-wage jobs:

$$max_{w^b_t}\left[\frac{V^h_{n^b}(n^g_t, n^b_t, k_t)}{\lambda_t}\right]^\mu\left[V^{fb}_{N^b}(N^b_t, z_t)\right]^{(1-\mu)} \quad (A.51)$$

The FOC with respect to w^b_t yields:

$$(1-\mu)\left[\frac{V^h_{n^b}(n^g_t, n^b_t, k_t)}{\lambda_t}\right] = \mu\left[V^{fb}_{N^b}(N^b_t, z_t)\right] \quad (A.52)$$

Substituting for the values of $V^h_{n^b}(n^g_t, n^b_t, k_t)$ and $V^{fb}_{N^b}(N^b_t, z_t)$ gives:

$$\begin{aligned}&(1-\mu)w^b_t - (1-\mu)\frac{[1+\kappa(s_t)]h_l(l_t)}{\lambda_t} \\ &+(1-\mu)\frac{(1-\psi)p^g_t s_t}{\lambda_t}\beta E_t\left\{V^h_{n^g}(n^g_{t+1}, n^b_{t+1}, k_{t+1})\right\} \\ &+(1-\mu)\frac{(1-\psi)(1-p^g_t s_t)}{\lambda_t}\beta E_t\left\{V^h_{n^b}(n^g_{t+1}, n^b_{t+1}, k_{t+1})\right\} \\ = \;&\mu\left[\alpha Pr^b_t\frac{Y^b_t}{N^b_t} - w^b_t\right] \\ &+\mu(1-\psi)(1-p^g_t s_t)\beta E_t\left\{\frac{\lambda_{t+1}}{\lambda_t}[V^{fb}_{N^b}(N^b_{t+1}, z_{t+1})]\right\}\end{aligned} \quad (A.53)$$

Note that:

$$(1-\mu)\left[\frac{V^h_{n^b}(n^g_{t+1}, n^b_{t+1}, k_{t+1})}{\lambda_{t+1}}\right] = \mu\left[V^{fb}_{N^b}(N^b_{t+1}, z_{t+1})\right] \tag{A.54}$$

Substituting this into the above equation gives:

$$\begin{aligned}
& (1-\mu)w^b_t - (1-\mu)\frac{[1+\kappa(s_t)]h_l(l_t)}{\lambda_t} + (1-\mu)\frac{(1-\psi)p^g_t s_t}{\lambda_t}\beta E_t\left\{V^h_{n^g}(n^g_{t+1}, n^b_{t+1})\right\} \\
= \quad & \mu\left[\alpha Pr^b_t \frac{Y^b_t}{N^b_t} - w^b_t\right] \qquad \text{(A.55)}
\end{aligned}$$

Also use the following equality to further simplify:

$$(1-\mu)\left[\frac{V^h_{n^g}(n^g_{t+1}, n^b_{t+1}, k_{t+1})}{\lambda_{t+1}}\right] = \mu\left[V^{fg}_{N^g}(N^g_{t+1}, z_{t+1})\right] \tag{A.56}$$

Substitution yields:

$$\begin{aligned}
& (1-\mu)w^b_t - (1-\mu)\frac{[1+\kappa(s_t)]h_l(l_t)}{\lambda_t} + \mu(1-\psi)p^g_t s_t \beta E_t\left\{\frac{\lambda_{t+1}}{\lambda_t}V^{fg}_{N^g}(N^g_{t+1}, z_{t+1})\right\} \\
= \quad & \mu\left[\alpha Pr^b_t \frac{Y^b_t}{N^b_t} - w^b_t\right] \qquad \text{(A.57)}
\end{aligned}$$

From the firms' problem, it is known that:

$$\frac{\gamma^g}{q^g_t} = (1-\psi)\beta E_t\left\{\frac{\lambda_{t+1}}{\lambda_t}V^{fg}_{N^g}(N^g_{t+1}, z_{t+1})\right\} \tag{A.58}$$

One more substitution gives:

$$(1-\mu)w^b_t - (1-\mu)\frac{[1+\kappa(s_t)]h_l(l_t)}{\lambda_t} + \mu p^g_t s_t \frac{\gamma^g}{q^g_t} = \mu\alpha Pr^b_t \frac{Y^b_t}{N^b_t} - \mu w^b_t \tag{A.59}$$

Replacing λ_t with $u_c(c_t)$ and solving for w^b_t leads to:

$$w^b_t = \mu\left[\alpha Pr^b_t \frac{Y^b_t}{N^b_t} - p^g_t s_t \frac{\gamma^g}{q^g_t}\right] + (1-\mu)\left[\frac{[1+\kappa(s_t)]h_l(l_t)}{u_c(c_t)}\right] \tag{A.60}$$

which is the wage rate the worker receives when working for a low-wage job.

Appendix B

B.1 Proofs of Propositions in Chapter 3

Proof of Proposition 3.4. Using the definition of political inequality, $\psi = \overline{\rho} - \underline{\rho}$

and the constraint, $\overline{\rho}\beta^A + \underline{\rho}\beta^B = 1$,

re-write the weighting parameters as $\overline{\rho} = 1 + \psi\beta^B$, and $\underline{\rho} = 1 - \psi\beta^A$.

Then the OPT equality in Equation (3.22) can be expressed as:

$$\begin{aligned}\lambda(\alpha_1)F'(\triangle\tau) \quad &= \Big\{ \Big[1 - H(1+\psi\beta^B)\Big] E\Big\{\alpha_2|\alpha_2 \geq (1+\psi\beta^B)\Big\} \\ &- \Big[1 - H(1+\psi\beta^B)\Big] \Big[(1+\psi\beta^B)\beta^A + (1-\psi\beta^A)\beta^B\Big] \\ &+ \Big[H(1+\psi\beta^B)\Big] \psi(\gamma - \beta^A)\Big\}\overline{Y} \qquad \text{(B.1)}\end{aligned}$$

The derivative of this equality with respect to ψ gives:

$$\frac{\partial(\triangle\tau)}{\partial(\psi)} \quad = \quad -\frac{\Big[\beta^B h(\overline{\rho})\psi(1-\gamma) + H(\overline{\rho})(\beta^A - \gamma)\Big]\overline{Y}}{\lambda(\alpha_1)F''(\triangle\tau)} \qquad \text{(B.2)}$$

which is negative when $\gamma \leq \beta^A$. QED.

Proof of Proposition 3.5. Having defined the the per capita income levels with the measure of income inequality, re-write the OPT equality in Equation (B.1) as:

$$\begin{aligned}&\lambda(\alpha_1)F'(\triangle\tau) = \\ &\Big[1 - H(1+\psi\beta^B)\Big] \Big[\beta^A(\overline{Y}+\epsilon) + \beta^B(\overline{Y}-\epsilon)\Big] E\Big\{\alpha_2|\alpha_2 \geq (1+\psi\beta^B)\Big\} \\ &- \Big[1 - H(1+\psi\beta^B)\Big] \Big[(1+\psi\beta^B)\beta^A(\overline{Y}+\epsilon) + (1-\psi\beta^A)\beta^B(\overline{Y}-\epsilon)\Big] \\ &+ \Big[H(1+\psi\beta^B)\Big] \psi \Big[\gamma\beta^B(\overline{Y}-\epsilon) - (1-\gamma)\beta^A(\overline{Y}+\epsilon)\Big] \qquad \text{(B.3)}\end{aligned}$$

Then, the derivative of the equality with respect to ψ becomes:

$$\frac{\partial(\triangle\tau)}{\partial(\psi)} = -\frac{\left\{\left[\beta^B h(\overline{\rho})\psi(1-\gamma) + H(\overline{\rho})(\beta^A-\gamma)\right]\left[\overline{Y} + (\beta^A-\beta^B)\epsilon\right] + 2\beta^A\beta^B\epsilon\right\}}{\lambda(\alpha_1)F''(\triangle\tau)} \tag{B.4}$$

which is negative when $\gamma \leq \beta^A$ is assumed. QED.

<u>*Proof of Proposition 3.6.*</u> Taking the derivative of the OPT equality in Equation (B.3) with respect to ϵ and re-arranging the terms gives:

$$\begin{aligned}\frac{\partial(\triangle\tau)}{\partial(\epsilon)} &= -\frac{1}{\lambda(\alpha_1)F''(\triangle\tau)} \\ &\times \Big\{\left[1-H(\overline{\rho})\right](\beta^B-\beta^A)\left[E\left\{\alpha_2|\alpha_2 \geq (1+\psi\beta^B)\right\}-1\right] \\ &+2\left[1-H(\overline{\rho})\right]\psi\beta^A\beta^B + H(\overline{\rho})\psi\left[\gamma\beta^B+(1-\gamma)\beta^A\right]\Big\}\end{aligned} \tag{B.5}$$

which is negative. QED.

<u>*Proof of Proposition 3.7.*</u> Taking the derivative of the OPT equality in Equation (B.3) with respect to ϵ and γ yields to the following second derivative:

$$\frac{\partial(\triangle\tau)}{\partial(\gamma)\partial(\epsilon)} = -\frac{H(\overline{\rho})\psi(\beta^B-\beta^A)}{\lambda(\alpha_1)F''(\triangle\tau)} \tag{B.6}$$

which is negative, since $\beta^B > \beta^A$ when the elites are the ruling group and we assume $F'''(\triangle\tau) = 0$. Previously, it was derived as $\frac{\partial(\triangle\tau)}{\partial(\gamma)} > 0$ and concluded that the effect of political stability on state capacity investment decision is positive. The negative sign associated with the above second derivative shows that, as income inequality increases, the positive impact of political stability on the investment decision decreases. QED.

This proposition holds when the citizens are in power as well. This time the derivative becomes:

$$\frac{\partial(\triangle\tau)}{\partial(\gamma)\partial(\epsilon)} = -\frac{H(\overline{\rho})\psi(\beta^A-\beta^B)}{\lambda(\alpha_1)F''(\triangle\tau)} \tag{B.7}$$

which is negative, since $\beta^A > \beta^B$ when the citizens are the ruling group and we continue to assume $F'''(\triangle\tau) = 0$.

Proof of Proposition 3.8. Using the new assumptions (for the case of the citizens), re-write the OPT equality in Equation (3.22) and take its derivative with respect to ψ:

$$\begin{aligned}
&\lambda(\alpha_1)F'(\triangle\tau) = \\
&\left[1-H(1+\psi\beta^B)\right]\left[\beta^A(\overline{Y}-\epsilon)+\beta^B(\overline{Y}+\epsilon)\right]E\left\{\alpha_2|\alpha_2 \geq (1+\psi\beta^B)\right\} \\
&-\left[1-H(1+\psi\beta^B)\right]\left[(1+\psi\beta^B)\beta^A(\overline{Y}-\epsilon)+(1-\psi\beta^A)\beta^B(\overline{Y}+\epsilon)\right] \\
&+\left[H(1+\psi\beta^B)\right]\psi\left[\gamma\beta^B(\overline{Y}+\epsilon)-(1-\gamma)\beta^A(\overline{Y}-\epsilon)\right]
\end{aligned} \tag{B.8}$$

$$\begin{aligned}
&\frac{\partial(\triangle\tau)}{\partial(\psi)} = \\
&\frac{-\left[\beta^B h(\overline{\rho})\psi(1-\gamma)+H(\overline{\rho})(\beta^A-\gamma)\right]\left[\overline{Y}-(\beta^A-\beta^B)\epsilon\right]+2\beta^A\beta^B\epsilon}{\lambda(\alpha_1)F''(\triangle\tau)}
\end{aligned} \tag{B.9}$$

Note that it is not possible to tell the sign of the derivative analytically. When $\gamma \leq \beta^A$, for low levels of income inequality, higher political inequality leads to lower investment in state capacity. However, when the level of income inequality is high, the sign of the derivative is likely to become positive. The effect of income inequality on the impact of political inequality on the investment decision can be determined as:

$$\frac{\partial^2(\triangle\tau)}{\partial(\psi)\partial(\epsilon)} = \frac{\left[\beta^B h(\overline{\rho})\psi(1-\gamma)+H(\overline{\rho})(\beta^A-\gamma)\right](\beta^A-\beta^B)+2\beta^A\beta^B\epsilon}{\lambda(\alpha_1)F''(\triangle\tau)} \tag{B.10}$$

which is positive, assuming $F'''(\triangle\tau) = 0$. Therefore, when the effect of political inequality is to lower the level of investment in state capacity, then higher income inequality reduces this effect. On the contrary, if the impact of political inequality is positive on the investment decision, then higher income inequality amplifies this effect. QED.

Proof of Proposition 3.9. Taking the derivative of the OPT equality with respect to ϵ yields:

$$\begin{aligned}\frac{\partial(\triangle\tau)}{\partial(\epsilon)} &= \frac{1}{\lambda(\alpha_1)F''(\triangle\tau)} \\ &\times \left\{ -\left[1 - H(\overline{\rho})\right](\beta^A - \beta^B)\left[E\left\{\alpha_2|\alpha_2 \geq (1+\psi\beta^B)\right\} - 1\right] \right. \\ &\left. +2\left[1 - H(\overline{\rho})\right]\psi\beta^A\beta^B + H(\overline{\rho})\psi\left[\gamma\beta^B + (1-\gamma)\beta^A\right]\right\} \qquad \text{(B.11)}\end{aligned}$$

Again, it is not possible to determine the sign of the derivative analytically. However, for low levels of political inequality, the first term is likely to cancel off the positive effect of the last terms. Therefore, it can be concluded that for low levels of political inequality, higher income inequality leads to lower investment in state capacity. However, when the level of political inequality is high, the effect of income inequality on the investment decision is likely to have the opposite sign. The effect of political inequality on the impact of income inequality on the investment decision is:

$$\frac{\partial^2(\triangle\tau)}{\partial(\epsilon)\partial(\psi)} = \frac{\left[\beta^B h(\overline{\rho})\psi(1-\gamma) + H(\overline{\rho})(\beta^A - \gamma)\right](\beta^A - \beta^B) + 2\beta^A\beta^B\epsilon}{\lambda(\alpha_1)F''(\triangle\tau)} \qquad \text{(B.12)}$$

which is positive, assuming $F'''(\triangle\tau) = 0$. Therefore, when the effect of income inequality on the level of investment in state capacity is in the negative direction, higher political inequality reduces this effect. On the contrary, if the impact of income inequality is positive on the investment decision, then higher political inequality amplifies this effect. QED.

B.2 Additional Details on the Data

B.2.1 Measures of State Capacity

The term 'state capacity' has been widely used in the political science, sociology, and more recently in the economics literature. The interpretation varies. According to Hendrix (2009), the use of the term can be grouped into three categories. The first one is military capacity, which represents the states ability to overcome the rebellious actions against its authority with force. The proxies commonly used in this category are military personnel per capita and military spending per capita. The second one is bureaucratic and administrative capacity, which focuses on the professionalization of the state bureaucracy, its ability to protect property rights, and make credible commitments to private investors, as well as its ability to raise revenue from the society. The popular measures used in this category consist of Political Risk Services Groups International Country Risk Guide (ICRG), specifically the measure that assesses the risk of expropriation and repudiation of government contracts. This category also includes measures of fiscal state capacity, such as the GDP share of total taxes, the share of income taxes in total taxes and the share of domestic (non-trade) taxes in total taxes. The third category is the quality and coherence of political institutions, which considers the degree of interference between the democratic and nondemocratic features in the political system. Studies in the civil war literature, such as Hegre et al. (2001), Fearon and Laitin (2003) and DeRouen and Sobek (2004) use the Polity index to represent this concept of state capacity.

All the above mentioned measures of state capacity are highly collinear and endogenous, so it is appropriate to select a few that are highly correlated with the others. Using factor analysis, Hendrix (2009) shows that bureaucratic quality and the GDP share of total taxes stand out as the most representative definitions and measures of state capacity. In total, Hendrix uses 15 different and highly correlated measures of state capacity including military personnel and expenditures (per capita), ICRGs measures of bureaucratic quality and investment profile, GDP share of total taxes, GDP share of total revenue and Polity2 index, among others. Using principal factor analysis to create a smaller set of measures that can account for most of the variance in the 15 measures, he finds that, bureaucratic quality and GDP share of total tax revenues can explain cumulatively 90.6 percent of the variance in all the measures considered, with the first factor alone capturing 53.2 percent. In what follows, the focus here is on the bureaucratic and administrative definitions of state capacity in our empirical analysis. Five different measures are used to proxy for state capacity. The first three measures (GDP share of total taxes, GDP share of income taxes, total tax share of domestic taxes) are related to the state's ability to raise revenue from the public, while the remaining two measures (government effectiveness index and ease of doing business ranking) represent the state's bureaucratic quality.

B.2.2 Construction of the Political Stability and Absence of Violence Index

Kaufmann et al. (2009) organize many individual sources of the data on governance perceptions and assign them to these six broad categories: 1. Voice and Accountability, 2. Political Stability and Absence of Violence, 3. Government Effectiveness, 4. Regulatory Quality, 5. Rule of Law, 6. Control of Corruption. Then, they use an unobserved components model to construct aggregate indicators from these individual measures.

The following data sources are used in the construction of the political stability and absence of violence index:

A. Representative Sources: 1. BRI (Business Environment Risk Intelligence Business Risk Service / Financial Ethics Index): a. Fractionalization of political spectrum and the power of these factions, b. Fractionalization by language, ethnic and/or religious groups and the power of these factions, c. Restrictive (coercive) measures required to retain power, d. Organization and strength of forces for a radical government, e. Societal conflict involving demonstrations, strikes and street violence, f. Instability as perceived by non-constitutional changes, assassinations and guerrilla wars; 2. DRI (Global Insight Global Risk Service): a. Military coup risk, b. Major insurgency/rebellion, c. Political terrorism, d. Political assassination, e. Civil war, f. Major urban riot; 3. EIU (Economist Intelligence Unit Riskwire and Democracy Index): a. Armed conflict, b. Violent demonstrations, c. Social unrest, d. International tensions; 4. GAD (Cerberus Intelligence Gray Area Dynamics):

a. Autonomy and separatism, b. Civil unrest, c. State of emergency/martial law, d. Active terrorist groups in the last two years; 5. GCS (World Economic Forum Global Competitiveness Report): Country terrorist threat : Does the threat of terrorism in the country impose significant costs on firms? 6. HUM (Cingranelli Richards Human Rights Database and Political Terror Scale): a. Frequency of political killings, b. Frequency of disappearances, c. Frequency of torture; 7. IJT (iJET Country Security Risk Ratings): Security risk rating; 8. IPD (Institutional Profiles Database): a. Conflicts of ethnic, religious, regional nature, b. Violent actions by underground political organizations, c. Violent social conflicts, d. External public security; 9. PRS (Political Risk Services International Country Risk Guide): a. Internal Conflict: Assesses political violence and its influence on governance, b. External conflict: The external conflict measure is an assessment both of the risk to the incumbent government and to inward investment, c. Government stability: Measures the governments ability to carry out its declared programs and its ability to stay in office, d. Ethnic tensions: This component measures the degree of tension within a country attributable to racial, nationality or language divisions; 10. PTS (Political terror scale); 11. WMO (Global Insight Business Conditions and Risk Indicators): a. Civil unrest: How widespread political unrest is and how great a threat it poses to investors, b. Terrorism: Whether the country suffers from a sustained terrorist threat and from how many sources.

B. Non-representative Sources: 1. AEO (OECD Development Center African Economic Outlook): Civil tensions, b. WCY (Institute for Management and Development World Competitiveness Yearbook): Risk of political instability.

Table B.1: Descriptive Statistics - Measures of State Capacity

	Obs.	Mean	Std.	Min.	Max.	25th Percentile	75th Percentile	Period Covered
Total Taxes (% of GDP)	127	20.63	10.52	1.86	51.43	13.12	27.02	1980-2006
Total Taxes (% of GDP)	127	20.83	10.84	2.97	51.00	12.67	27.65	2000-2006
Income Taxes (% of GDP)	127	8.64	8.53	0.00	37.30	2.61	11.44	1980-2000
Dom. Taxes (% of Tot. Taxes)	127	77.04	17.56	32.16	99.71	65.19	93.57	1980-2006
Government Eff. Index	210	0.01	0.98	-2.10	2.29	-0.70	0.71	1996-2008
Government Eff. Index	210	0.01	0.99	-2.12	2.27	-0.70	0.70	2002-2008
Ease of Doing Bus. Ranking	181	0.50	0.29	0.00	1.00	0.25	0.75	2009

Table B.2: Descriptive Statistics - Determinants of State Capacity

	Obs.	Mean	Std.	Min.	Max.	25th Percentile	75th Percentile	Period Covered
Democracy ($Polity2 > 3$)(% of Years)	156	0.27	0.38	0.00	1.00	0.00	0.41	1900-1975
Democracy ($Polity2 > 3$)(% of Years)	161	0.35	0.38	0.00	1.00	0.00	0.60	1960-1999
Democracy ($Polity2 > 0$)(% of Years)	156	0.33	0.39	0.00	1.00	0.00	0.68	1900-1975
Democracy ($Polity2 > 0$))(% of Years)	161	0.38	0.38	0	1.00	0.00	0.66	1960-1999
External Wars (% of Years)	156	0.07	0.11	0.00	0.57	0.00	0.12	1900-1975
External Wars (% of Years)	161	0.03	0.08	0.00	0.39	0.00	0.03	1960-1997
Internal Wars (% of Years)	156	0.05	0.13	0.00	1.00	0.00	0.06	1900-1975
Internal Wars (% of Years)	161	0.08	0.16	0.00	0.87	0.00	0.04	1960-1997
Gini (Averages)	88	42.12	9.91	18.42	63.70	33.78	49.50	1900-1975
Gini (Averages)	142	41.34	10.82	21.42	74.33	32.34	49.07	1960-1999
Political Stab. & Absence of Violence/Terrorism	190	-0.09	0.98	-2.60	1.48	-0.69	0.66	1996 & 1998
Political Stab. & Absence of Violence/Terrorism	180	-0.11	1.01	-2.80	1.46	-0.72	.75	1996

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